45TH CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. 1, Part 2.

REPORT

OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE SECOND SESSION OF THE FORTY-FIFTH CONGRESS.

VOLUME II.
PART II.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1877.

APPENDIX JJ.

ANNUAL REPORT OF MAJOR JOHN M. WILSON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., June 30, 1877.

GENERAL: I have the honor to transmit herewith my annual reports for the fiscal year ending June 30, 1877, upon the works of river-improvement under my charge.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Major of Engineers.

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

JJ 1.

IMPROVEMENT OF THE LOWER WILLAMETTE AND COLUMBIA RIVERS FROM PORTLAND, OREGON, TO THE SEA.

The difficulties to be overcome in opening the channel for deep-draught vessels through the various bars from Portland to the sea were fully set forth in my annual report for the fiscal year ending June 30, 1876, and the subject of the improvement of this stretch of navigation has been carefully considered by the Board of Engineers of the Pacific coast.

The report of the Board having been submitted to the Chief of Engineers, and approved by him, it is not deemed necessary to again describe the various bars in the Lower Willamette and Columbia Rivers.

OPERATIONS DURING THE FISCAL YEAR.

By the act of Congress approved August 14, 1876, an appropriation of $20,000 was made for this work, which it was determined to expend in excavating channels through the bars at Swan Island, Post-Office Bar, mouth of the Willamette, and Saint Helen's.

The extraordinary freshet of 1876, which reached a height of 28.2 feet above low-water on June 24, 1876, commenced to abate on that day, and on August 11, 1876, the river being still 10 feet above low-water, the work of excavation was commenced with the United States dredge at the bar at the

MOUTH OF THE WILLAMETTE RIVER.

Careful surveys made at this locality show that the fall in the Willamette from the head of Willamette Slough to the mouth of the river, a

distance of 3⅜ miles, is absolutely nothing at ordinary low-water. The consequence is, that when the Columbia commences to rise the whole volume of the Willamette passes through the slough while the Columbia water runs up the Willamette, a large portion passing down through Coon Island Slough, and a still greater portion down the Willamette Slough.

The bar at the mouth of the Willamette is formed by the Columbia freshets, and the filling this year was greater than usual, being from 3 to 6 feet.

Work was commenced with the dredge on August 11 and continued with various interruptions from breakage, &c., until September 1, during which period a channel 700 feet long, 100 feet wide, and 16½ feet deep at low-water was opened by removing 5,875 cubic yards of sand; no trouble was therefore experienced by vessels on this bar throughout the year.

The dredge was then towed to

POST-OFFICE BAR,

about 3 miles above the mouth of the river and just below the entrance to the Willamette Slough, where work was at once commenced and was continued until October 12. During this period a channel 3,000 feet long, 40 feet wide, and 17 feet deep at low-water was opened by removing 10,935 cubic yards of mud and sand. The cause of this bar, and the proposed plan for removing it, are fully set forth in the report of the Board of Engineers; the filling during the winter and spring had been slight compared with that at the mouth of the Willamette, but was sufficient to require the dredge to work for the period mentioned, and had circumstances permitted, the deep channel would have been made 100 feet wide instead of 40 feet.

The dredge was then towed to

SWAN ISLAND BAR,

2½ miles below Portland, and operations were continued until November 15, when they were suspended for the season on account of the freshet in the Willamette River. Much delay occurred here from breakage arising from heavy drift-logs which had lodged in and on the bar; the channel was, however, widened and deepened at various points; 4,475 cubic yards of mud, sand, gravel, &c., having been removed from the bar.

On November 16 the dredge was placed in winter quarters, and the crew, with the exception of the engineer and watchman, discharged.

The river fell again early in December, and work could have been carried on during a portion of that month and January, but the freshets at that season rise so suddenly, that it was not deemed advisable to ship a crew and start work for fear it could be continued only for a day or two. In March, 1877, the Willamette at Portland rose to a height of 19 feet above low-water. With the exception of some slight trouble on Swan Island Bar during the extreme low-water in January, no difficulty was experienced in the Willamette River below Portland with any vessel that could cross.

SAINT HELEN'S BAR, COLUMBIA RIVER.

In the last annual report reference was made to a cut that had been dredged through the upper end of Saint Helen's Bar, and the possibility

of maintaining a channel at that locality. Upon the subsidence of the freshet of 1876, it was found that not only had this cut been filled, but that also the main ship-channel at the lower end of the bar hitherto used by deep-draught vessels had been closed, the depth being reduced from about 16 to 13 feet at low-water; the same freshet, however, opened a new channel a few hundred feet below the cut dredged in 1875–'76, at the narrowest portion of the bar, and increased the depth for a width of about 300 feet from about 12 to 16 feet at low-water.

Buoys were placed at this locality, and the channel was used during the fall and winter of 1876–'77; an examination in the spring of 1877 showed that the line of deepest water had shifted slightly during the winter; considerable change is expected from the freshet of 1877, now in progress.

SURVEYS DURING THE YEAR.

In accordance with instructions from the Board of Engineers of the Pacific coast, extensive and elaborate surveys have been made during the year, under my direction, of the Lower Willamette River, the Willamette Slough, the Columbia River, in the vicinity of Saint Helen's, and of Snag Island Bar, above Tongue Point. These surveys include the shore-lines, soundings, volume, velocity, &c., and the results are fully set forth in the interesting report, transmitted herewith, of Assistant Engineer R. A. Habersham, to whom I am indebted for able, energetic, and earnest assistance not only upon this work, but also upon others under my charge.

The survey of Snag Island Bar gave a depth of not less than 15 feet at low-water, with two flood-tides daily of from 6 to 8 feet.

BAR AT THE MOUTH OF THE COLUMBIA.

There is presented with this report a chart of the bar at the mouth of the Columbia River, Oregon, prepared from surveys made under my direction during the summer of 1876; it is hoped that this chart will be published for the benefit of mariners. It will be observed that there is a wide channel over the bar with a depth of not less than 20½ feet at low-water; there are two tides daily, with a rise of from 7 to 9 feet. This bar has, I believe, an undeservedly bad reputation; properly buoyed, I think it no more dangerous than that at Sandy Hook, New York; of course there are occasions when, from violent southwest gales, it becomes furious and breaks clear across, but the occasions are seldom when a vessel cannot cross with safety.

SURVEY OF SAND ISLAND, MOUTH OF COLUMBIA.

The annual survey of Sand Island was made in May, 1877, and showed an erosion of about 200 feet on the weather face and a gain of from 200 to 400 feet on the lee face since the survey of 1876; this island has moved about 1,800 feet, nearly, due north in the last nine years, its superficial area remaining about the same and its shape being slightly changed.

THE UNITED STATES DREDGE.

This dredge has been steadily engaged during the last five years, whenever the freshets would admit, in excavating the channels through the various bars; it is of the Morris & Cumings pattern, and while excellent for mud, the bucket holds with difficulty the very fine sand of

the Columbia River bars; it seldom, if ever, on this work, excavates more than 350 cubic yards per day.

During the coming season it is proposed to continue work as soon as the freshet will admit, dredging the channels through the various bars between Portland and Saint Helen's; this is necessary in order to keep open navigation, the funds available not being sufficient to construct either of the dams recommended by the Board of Engineers; whenever funds are available, the first work to be undertaken should be that of partially closing the Willamette Slough. Surveys will also be continued for the further investigation of the regimen of the Willamette River in the vicinity of Swan Island Bar, and of that of the Columbia at Saint Helen's Bar.

The following information, required by the act of Congress approved June 23, 1866, is respectfully submitted:

The appropriations for this work have been as follows:

Act of June 23, 1866, Lower Willamette	$15,000 00
Act of March 2, 1867, Lower Willamette	30,000 00
Act of July 25, 1868, Lower Willamette	21,000 00
Act of April 10, 1869, (allotted)	13,365 00
Act of July 11, 1870, Lower Willamette	31,000 00
Act of June 10, 1872, Lower Willamette	50,000 00
Act of March 3, 1873, Lower Willamette and Columbia	20,000 00
Act of June 23, 1874, Lower Willamette and Columbia	20,000 00
Act of March 3, 1875, Lower Willamette and Columbia	20,000 00
Act of August 14, 1876, Lower Willamette and Columbia	20,000 00
Total	240,365 00

Of this amount $221,780.46 has been expended to date, building dredge, scows, and dike, and in dredging and surveying bars.

The project now submitted calls for the construction of dams at Swan Island, Willamette Slough, mouth of the Willamette, and Saint Helen's Bar, the estimated cost of which is $298,974; of this amount $150,000 can be profitably expended during the next fiscal year.

COMMERCIAL STATISTICS.

There are two ports of entry on these rivers: Astoria, 12 miles from the mouth of the Columbia, and Portland, 12 miles from the mouth of the Willamette, or about 120 miles from the mouth of the Columbia.

Astoria statistics.

I am indebted to Mr. J. D. Merryman, deputy collector of customs at Astoria, for the following information, showing the commerce of that port from July 1, 1876, to June 1, 1877:

The amount of revenue collected during the period mentioned was $26,378; the value of the imports was $24,315, and of the exports $1,488,929. The number of vessels entering on the coasting trade was 153, with an aggregate tonnage of 176,798 tons, and on foreign trade 27, with an aggregate tonnage of 23,398 tons. The number of vessels clearing on coasting trade was 144, with an aggregate tonnage of 171,089 tons, and on foreign trade 50, with an aggregate tonnage of 41,475 tons.

Portland statistics.

To Mr. S. N. Shurtleff, deputy collector at Portland, Oreg., I am indebted for the following information in reference to the commerce of this city from July 1, 1876, to June 1, 1877:

The amount of revenue collected during the 11 months of the present fiscal year was $125,317.10.

The value of the imports was as follows:

By American vessels	$193,274 00
By foreign vessels	195,202 00
Total	388,476 00

These were divided as follows:

Free commodities	$245,864 00
Dutiable commodities	142,612 00
Total	388,476 00

The value of the exports was as follows:

By American vessels	$248,575 00
By foreign vessels	2,260,584 00
Total	2,509,159 00

The exports were as follows:

Wheat, 1,840,133 bushels, valued at	$1,965,381 00
Flour, 93,126 barrels, valued at	484,521 00
Bran, 174,856 pounds, valued at	1,812 00
Middlings, 48,378 pounds, valued at	1,007 00
Chops, 9,987 pounds, valued at	146 00
Other commodities	56,292 00
Total	2,509,159 00

The number of vessels entering this port was as follows:

Class.	With cargoes.			In ballast.		
	Number.	Tonnage.	Crews.	Number.	Tonnage.	Crews.
Coastwise	109	104,549	3,989			
American vessels, foreign	10	4,223	179	2	1,923	34
Foreign vessels, foreign	14	9,317	237	42	32,949	816
Total	133	118,089	4,405	44	34,872	850

The number of vessels clearing was as follows:

Class.	With cargoes.		
	Number.	Tonnage.	Crews.
Coastwise	70	85,470	3,433
American vessels, foreign	23	12,864	541
Foreign vessels, foreign	60	45,962	1,132
Total	153	144,296	5,106

Recapitulation.

Total amount of revenue collected at Portland	$125,317
Value of the imports	388,476
Value of the exports	2,509,159

One hundred and seventy-seven vessels, with an aggregate tonnage of 152,961 tons, and crews amounting to 5,255 entered, and 153 vessels, with an aggregate tonnage of 144,296, and crews amounting to 5,106 cleared. The value of the exports exceeded that of the imports by $2,120,683.

GENERAL SHIPPING STATISTICS.

From the report of D. C. Ireland, clerk of the board of pilot commissioners of Oregon, submitted in the report of that board to the legislative assembly at its ninth regular session in 1876, I quote the following:

During the period of 2 years from the date of this report, September 1, 1874, to September 1, 1876, (at which time 23 vessels, with an aggregate tonnage of 13,382 tons, were in port,) 457 vessels have arrived from sea with an aggregate tonnage of 340,907 tons, and the various fleets that have departed for sea within this period have carried an aggregate of 310,961 tons of Oregon's products, embracing wheat, flour, fish, fruits, &c., valued at $11,845,590.27.

This very interesting report gives detailed statements showing the name, tonnage, draught, and value of cargo of each vessel crossing the Columbia River Bar, during the period named, and shows plainly the extensive and growing commerce of this magnificent section of the country. Attention is invited to the fact that on April 21, 1876, the ship Samuel Watts crossed the Columbia River Bar, going to sea, drawing 23½ feet water and having a cargo of 2,034 tons of wheat.

The following table, prepared by Mr. D. C. Ireland, clerk of the board of pilot commissioners, shows the export of breadstuffs from the Columbia River to all ports, by seasons, from 1868 to 1877, each season is from September 1 of one year to August 31 of the next.

Table showing the exports of breadstuffs from the Columbia River to all ports, by seasons, from 1868 to 1877.

	Season, 1868–1869.	Season, 1869–1870.	Season, 1870–1871.	Season, 1871–1872.
Number of centals of wheat exported	69,416	67,489	238,198	506,373
Number of barrels of flour exported	107,671	182,998	195,624	167,908
Total number of bushels* of wheat represented in exports of wheat and flour	600,212	935,972	1,277,304	1,599,541
Total value of wheat and flour exported	$589,812	$1 059,522	$1,546,947	$2,125,352

	Season, 1872–1873.	Season, 1873–1874.	Season, 1874–1875.	Season, 1875–1876.	Season, 1876–1877.
Number of centals of wheat exported	664,359	1,394,310	1,402,871	1,953,018	1,481,790
Number of barrels of flour exported	145,293	230,211	255,868	230,974	195,785
Total number* of bushels of wheat represented in exports of wheat and flour	1,761,083	3,359,799	3,489,525	4,294,413	3,350,682
Total value of wheat and flour exported	$1 747,124	$4,037,093	$3,000,500	$5,769,240	$3,759,170

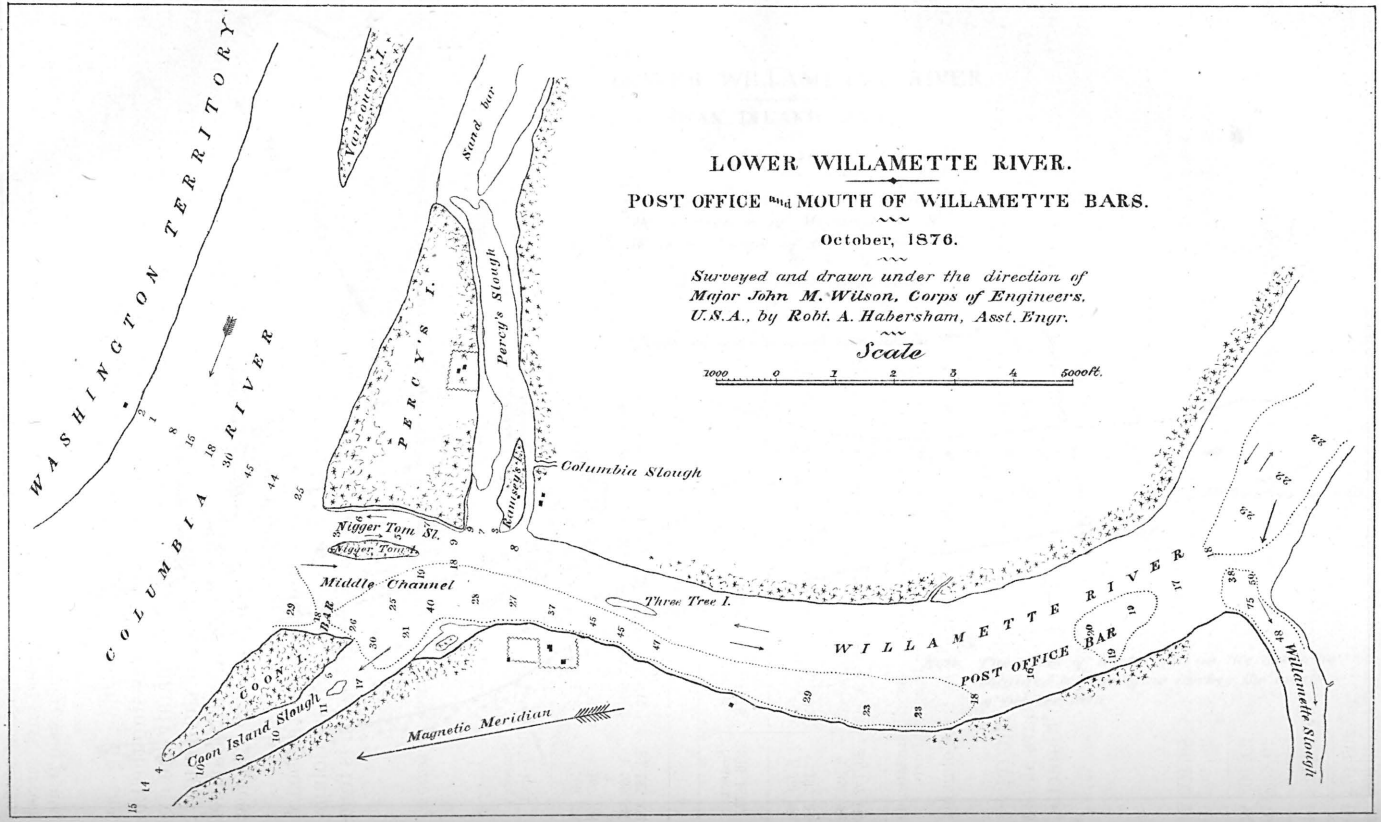
*Centals, reduced to bushels, and in reducing barrels of flour to wheat 4½ bushels is estimated to make one barrel of flour. The season of 1876–'77 not yet being closed the estimate is approximate.

There are two light-houses and two works of defense at the mouth of the Columbia River.

Abstracts of proposals and contracts, a statement of funds, the report of Assistant Engineer R. A. Habersham, and charts of the bars at the mouth of the Columbia, Saint Helen's, the mouth of the Willamette, Post-Office Bar, and Swan Island, are transmitted herewith.

Money statement.

July 1, 1876, amount available	$9,093 24
Amount appropriated by act approved August 14, 1876	20,000 00
	29,093 24
July 1, 1877, amount expended during fiscal year	10,508 70
July 1, 1877, amount available	18,584 54
Amount (estimated) required for completion of existing project	298,974 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	150,000 00


LOWER WILLAMETTE RIVER.
POST OFFICE and MOUTH OF WILLAMETTE BARS.
October, 1876.
Surveyed and drawn under the direction of
Major John M. Wilson, Corps of Engineers,
U.S.A., by Robt. A. Habersham, Asst. Engr.
Scale
7000 0 1 2 3 4 5000ft.
WASHINGTON TERRITORY
COLUMBIA RIVER
Vancouver I.
Sand bar
PERCY'S I.
Percy's Slough
Ranger's I.
Columbia Slough
Nigger Tom St.
Nigger Tom I.
Middle Channel
Three Tree I.
WILLAMETTE RIVER
POST OFFICE BAR
Willamette Slough
COON I.
Coon Island Slough
Magnetic Meridian

LOWER WILLAMETTE RIVER.

SWAN ISLAND BAR.

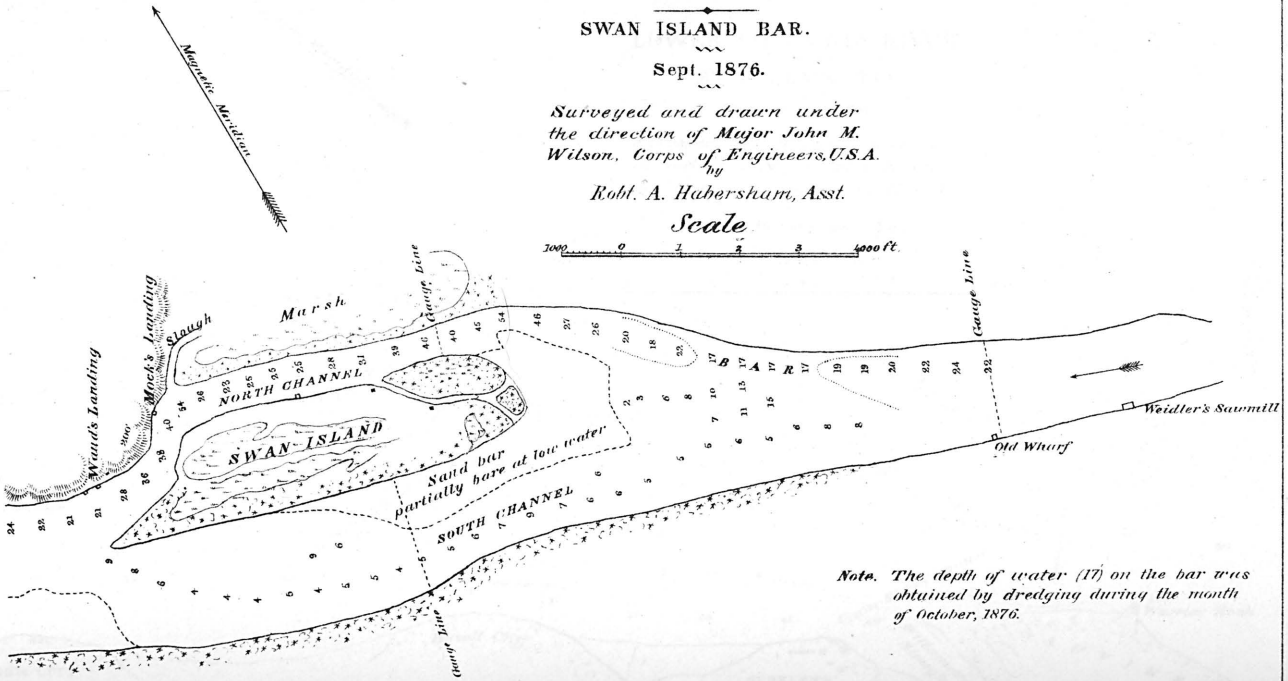
Sept. 1876.

Surveyed and drawn under the direction of Major John M. Wilson, Corps of Engineers, U.S.A. by

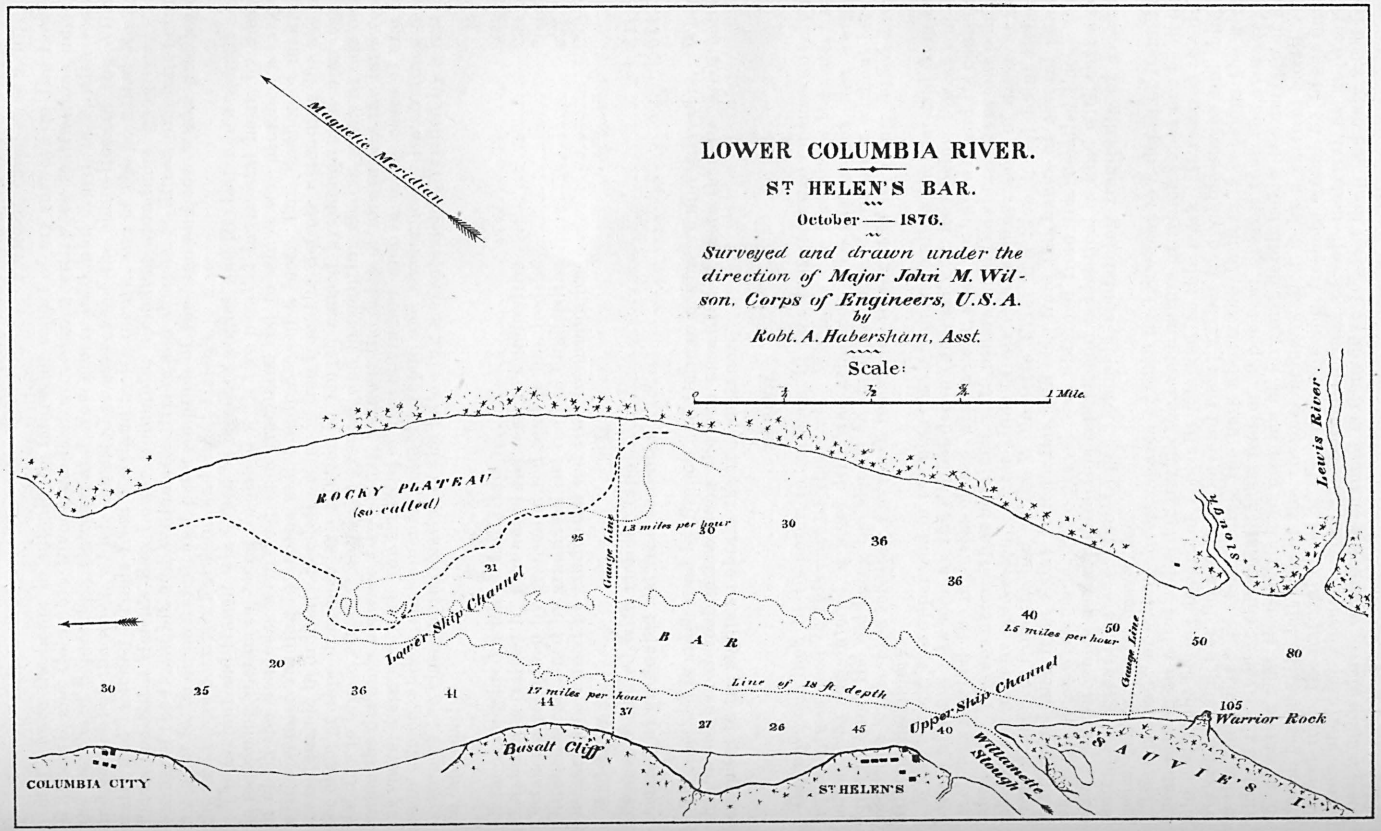
Robt. A. Habersham, Asst.

Scale

3000 0 1 2 3 4000 ft.



Note. *The depth of water (17) on the bar was obtained by dredging during the month of October, 1876.*


Magnetic Meridian
LOWER COLUMBIA RIVER.
ST HELEN'S BAR.
October —— 1876.
Surveyed and drawn under the direction of Major John M. Wilson, Corps of Engineers, U.S.A.
by
Robt. A. Habersham, Asst.
Scale:
1/4
1/2
3/4
1 Mile
ROCKY PLATEAU
(so-called)
Lewis River
Slough
Gauge Line
1.3 miles per hour
Lower Ship Channel
BAR
1.5 miles per hour
Gauge Line
Line of 18 ft. depth
Upper Ship Channel
105
Warrior Rock
Basalt Cliff
Willamette Slough
SAUVIE'S I.
COLUMBIA CITY
ST HELEN'S
25
30
36
31
36
40
50
50
80
20
30
35
36
41
44
37
27
26
45
40

REPORT OF MR. R. A. HABERSHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., June 8, 1877.

SIR: I have the honor to submit the following report of my surveys on the Lower Willamette and Columbia Rivers, made in accordance with your instructions, during the months of September, October, and November, 1876, and April, 1877, with maps and sections of the work, which consisted of surveys of the shore-lines of the Willamette, and included islands from Portland to its mouth, and of the so-called Rocky Plateau on Saint Helen's Bar, Lower Columbia, including soundings, gaugings, and borings of the Columbia and Willamette Rivers and sloughs, at fifteen different points hereafter to be enumerated, and determination of the high and low water profiles of the two rivers between Portland and Saint Helen's.

The sextant and transit were used to measure angles, and the latter instrument also in measuring distances, being furnished with two parallel horizontal hairs, by means of which the distances were read on a graduated rod to which was attached a target with a vernier reading to tenths and hundredths of a foot. This method of making measurements in ordinary geodetic work is free from the defects attending the use of the chain or tape-line, such as variation in length caused by change of temperature, liability to break, errors from rough ground, and in counting chains, gives at one operation the distance between two points, without the delay of measuring the intervening space, dispenses with the services of two chainmen, and in many cases of one or more axmen, and is consequently reliable, rapid, and economical. Its accuracy may be seen by the close approximation of the following measurements, verified by a metallic tape-line:

	Feet.
Distance measured with metallic tape	300.00
Distance ascertained by graduated rod read to hundredths	299.98
Distance ascertained by graduated rod read to hundredths	300.01
Distance ascertained by graduated rod read to hundredths	299.99
Distance ascertained by graduated rod read to hundredths	299.97

And again:

Distance measured with metallic tape	1,644.60
Distance by graduated rod read to tenths	1,644.00

This method is much used by French and German engineers and surveyors. Where the ground has an inclination along the line measured of more than 10°, a correction is applied to the sights to obtain the true distance.

BORING.

Gas-pipe, one inch in diameter, in sections 10 feet long, screwed on successively as required, was used in this part of the work. When, as was sometimes the case, hard bottom was encountered, a steel drill was attached. The instrument was worked down by hand, the rod being too slender to stand the blow of a hammer without bending, and a larger pipe meeting too much resistance to admit of its being forced down without machinery.

While boring, the upper end of the pipe was left open to allow the material from the bottom to enter. As soon as the drilled depth (generally 21 feet below lowest water-level) was reached the pipe was closed with a cork, then withdrawn, and its contents taken out. The specimens thus obtained, with others from the shore at various points, labeled, are in your possession. Three kinds of material appear: sand of different degrees of fineness from the bed of the Willamette River and Slough and Saint Helen's Bar; gravel also from Saint Helen's Bar, and clay from the banks at several points where gaugings were made. The gravel was obtained from the so-called Rocky Plateau, a map of which accompanies this report, and is identical in kind with that composing the gravel bars of the Upper Columbia, containing fragments of granite, gneiss, quartz, agate, basalt, &c.

The "plateau" of gravel covers an area of 7,200 by 1,800 feet to a depth of from 2 to 6 feet, resting on a bed of hard material, the exact nature of which could not be determined without boring apparatus specially adapted to this work. It resisted the drill worked by hand, but did not feel like solid rock; rather like cobble-stones and shingle in this particular; also resembling the bars above the Dalles. I consider the great width of the river at this point (5,000 feet, or 50 per cent. greater than the average) as an indication that there is rock in position at no great depth below the surface of the gravel, because, the left side of the channel being walled in by a vertical basalt cliff 200 feet high, the natural effect of the current during freshets would be to cut out a narrow and deep channel were the bottom formed of soft material, as at Warrior Rock, 2 miles above, where the channel is from 50 to 105 feet deep and only 2,000 feet wide.

We know that the basaltic-rock formation common to this section of the Pacific coast underlies the bed of the Columbia throughout at various depths, also that it is not far from the surface in this locality, as it crops out at several places near Saint Helen's. The depth of water on the plateau varies from 2 to 18 feet. The velocity of current is from 1 to 1½ miles per hour during the low stage, sufficient to carry the small pebbles with which the botton is covered, so that the surface is continually changing shape, the two bars near the lower end moving steadily down stream, deepening the water at this end of the bar, and thus increasing the difficulty of keeping open the ship-channel at the upper end. This constant change in the form of the bottom made it useless to take soundings at the usual short intervals.

Saint Helen's Bar is 2 miles long, crossing the river diagonally from the foot of Sawvie's Island to a point nearly opposite Columbia City, a landing situated 1½ miles below the village of Saint Helen's. The east bank of the river from opposite Warrior Rock to the lower end of the bar is low, from 5 to 10 feet above low-water, and is composed principally of sand, with occasional veins of clay. It has no stability, and yielding each year to the floods, widens the channel, lessening the depth of water on the bar, and hastening the necessity for improvements at this point.

In the bed of the Willamette, at all points where I made borings, I found only sand to a depth of nowhere less than 21 feet below lowest-water mark. In some places the drill entered 30 feet. Occasional layers of gravel from 1 to 2 inches thick, not compact enough to impede the progress of the drill to any extent, were encountered. I found no hard bottom at any point except on the "Rocky Plateau."

GAUGING.

The apparatus selected was substantially the same as that used by General Ellis in gauging the Connecticut River. It consisted of two floats, surface and subsurface, made of tin; the former a double-convex disk, water-tight, and having a socket in the center for holding a small flag or other signal; the latter an annulus, weighted with lead, to be submerged to any required depth, the two connected by a copper wire .036 of an inch in diameter, of a length varying with the depth of water. A full description of the apparatus is given in the report of the Chief of Engineers for the year 1875, vol. 2, p. 306.

The points selected for gauging were generally (always, when practicable) about the center of a reach, the width, depth, and general direction of which were sufficiently uniform to insure a steady flow of the current. The operation was performed in the following manner:

Having first measured the distance from shore to shore on a line at right angles to the general direction of the current, and fixed solid stakes on the edge of the water on each side, and range-stakes, easily seen from any point on the gauge-line, on shore, 100 feet were measured out into the stream, on the gauge-line, with a line, the distance marked by a small anchor with buoy attached, and the depth measured.

Two boats were then anchored, one above, the other below the gauge-line, at the center of the section, or 50 feet from shore, and connected by a non-elastic cord, on which were tags 50 feet apart, this distance being maintained by one oarsman in the lower boat pulling gently down stream, keeping the line taut. The floats, the wire having been adjusted so as to give the required depth to the lower, were then dropped into the stream above the bow of the upper boat, to enable them to attain the full velocity of the current before reaching the upper tag, and allowed to drift down stream, the moment of passing the two tags being noted by an observer in each boat. This operation was repeated without changing the position of the boats until a sufficient number of observations had been taken at various depths to give a close average of the velocity of the volume of water passing through the section at the time of measurement. Another section of equal length was then measured and its velocity ascertained by the same process, and so on until the entire river had been measured; the sum of the volumes of all the sections giving the entire discharge of the river.

In some cases the width of the channel, as measured by sections, did not correspond with that previously ascertained, known to be correct. The discrepancy was found to be due to the necessary tightening of the line in measuring, pulling the boats out of position, and was corrected by distributing the difference among the sections in proportion to the depth of water. In such cases the measurement by sections was always less than the first, and the amount of difference varied with the depth.

Where the channel was narrow and the bottom irregular, the depths and velocities were taken at intervals of 50 feet or less. The depths measured while gauging were corrected from an hourly record of the rise and fall of the tide, kept for that purpose.

At some points near the mouth of the Willamette River and in the Willamette Slough, where the current is controlled to a great extent, if not entirely, by the tides of the Columbia, the flow was so variable as to make it impossible to make a connected measurement of the volume discharged, and I was forced to mark the sections on the gauge-line by small buoys anchored, and take the velocities every hour for a day or more, in order to ascertain the greatest uniform flow. Uncertainty as to the continu-

ance of fine weather, necessary for this kind of work, decided me to adopt this plan instead of waiting for more favorable tides. The season was far advanced, and the winter rains liable to commence at any time, raising the water and bringing down quantities of drift-wood, the former defeating my principal object, which was to gauge the rivers at the various points selected during the same stage of water, while the latter would have made it dangerous, if not impossible, to work at all in boats.

The operations above described are slow and tedious, and subject to many interruptions, such as up-stream winds and the regular changes in the direction of the tides, necessitating a suspension of the work at times, drift-wood carrying away anchors, or floats, waves from passing steamers, &c. But the plan of dividing the channel into sections, and ascertaining, by careful measurement, the volume passing through each, is, upon the whole, the least liable to undetected error.

The questions which belong to this subject have been fully discussed in the report above referred to, in which the various systems and methods in use for gauging streams have been minutely explained, and their respective advantages and defects compared, and I can add little except in the particular of experience in the working of the double-float method. During the last fall I made gaugings at 13 different points, requiring over 1,000 current-measurements, at depths of from 2 to 30 feet, and found that I could determine the speed of a current so slow as to be almost imperceptible to the eye, as, for instance, of 5 feet per minute, or 1 mile in 17½ hours, with almost absolute accuracy; repeated observations at the same point giving within 1 per cent. of the same result. Of course such accuracy can only be expected under the most favorable conditions, such as a smooth channel of uniform area and cross-sections, calm weather, and steady flow of the tide. But the results obtained demonstrate the capability of the apparatus. Its greatest defect is that the surface-float is liable to be retarded or accelerated by waves or wind, affecting the speed of the lower float so much that reliable results can only be obtained when the water is smooth and the weather calm. In case of error, the existence of which will be shown by discrepancies between results of different measurements of the same volume, the cause can be traced, and, if not removable, allowed for.

The gaugings were made during the low stage, the water ranging from 3 to 4½ feet above zero, and the current being slow and irregular. The results are shown in the following table:

Willamette River, one-fourth of a mile below the northern boundary of Portland: discharge in cubic feet, per minute	(1)	786,478
Opposite Swan Island, through the south channel	(2)	530,984
And through the north channel	(3)	284,531
Through both channels		815,515
Deducting the volume due to rise in the river, as shown on the section-sheets annexed		24,042
Leaves		791,473

A difference of 4,995; due principally to the increase of velocity attending the greater height of water, which cannot be stated accurately without more complete current-measurements than I could make. Six weeks later, the water having risen to a height of 6.2 feet above zero, I found the discharge to be—

At (1)	3,095,400
At (2)	1,802,470
At (3)	1,369,138

The increased volume being due almost wholly to accelerated velocity.

During the first week in April last I made additional current-measurements at Swan Island, the water at that time ranging between 10.5 feet and 8.5 feet above zero at Portland.

On the 17th of March the Willamette had been swollen by a freshet, the gauge at Portland indicating a height of 19 feet above zero or low-water mark. From that date it fell at the rate of 1.2 feet per day, until, on the morning of the 24th, having reached 9.5 feet, it commenced rising again, reaching 13 feet on the 26th and 14 feet on the 29th, when the water again commenced to fall slowly at a rate of less than 1 foot per day.

During this high stage, the water at Vancouver, on the Columbia, four miles above the mouth of the Willamette, reached the height of 12.9 feet above low-water, while the gauge at the head of the Willamette Falls, 12 miles above Portland, showed a steady fall. The water of the Willamette was clear, almost entirely free from drift, and with no perceptible tidal changes. It is plain, therefore, that the high-water which prevailed on the Lower Willamette when these measurements were made was due to the rise in the Columbia.

I commenced in the north channel at Swan Island, 200 feet below the Old Wharf shown on the map of my surveys last fall, marked "Lower Willamette, Sheet No. 1." The depths and velocities of the river at this point are extremely uniform, as you will see from the annexed section-sheets. Measurements to ascertain the velocities at different depths, taken in the center of the channel, the water being 35 feet deep, gave the following results:

At 3 feet mean of 6 measurements, 75.9 feet per minute.
At 18 feet mean of 6 measurements, 75.0 feet per minute.
At 30 feet mean of 6 measurements, 65.9 feet per minute.

The danger of the lower float becoming entangled among snags on the bottom deterred me from attempting to measure the current at a greater depth than 30 feet. At this depth the combined pressure of the water and atmosphere flattened the convex side of the lower float, giving it the shape of an imperfect hexagon. This did not, of course, affect its buoyancy.

On April 4 simultaneous measurements of the two channels being impracticable, in the necessary absence of my assistant, the volume in the south channel was measured accurately and the north approximately, the volume in the latter being obtained by the formula $v \times 83 = v^1$ in which v represents the surface velocity at the centre and v' the mean velocity of the entire volume. Of course the result thus found was only approximate. It is seen, however, to accord very nearly with those obtained in the usual way. During this day the water fell 0.2 foot.

On the 5th and 6th the two channels were measured simultaneously by two parties under the charge of myself and an assistant respectively. The current was measured at intervals of about 100 feet from 3 to 6 times at each point, the cross-sections having been previously taken by careful soundings, and the distances marked by buoys. A strong breeze from the northwest on the morning of the 7th prevented a fourth measurement of the south channel, which is exposed and rough in windy weather. The north channel is protected by the promontory back of Wand's Landing.

The volumes and velocities from the 4th to the 7th of April, inclusive, were found to be as follows: (See section-sheets A and B.)

	Height of water above zero.	Mean velocity per minute.	Discharge per minute.
	Feet.	*Feet.*	*Cubic feet.*
April 4, 1877, north channel	$10\frac{1}{2}$	63.75	1,347,802
April 4, 1877, south channel	$10\frac{1}{2}$	48.29	1,223,167
April 5, 1877, north channel	$9\frac{6}{10}$	63.43	1,311,965
April 5, 1877, south channel	$9\frac{6}{10}$	45.75	1,076,308
April 6, 1877, north channel	9	59.64	1,201,891
April 6, 1877, south channel	9	46.67	1,027,366
April 7, 1877, north channel	$8\frac{1}{2}$	57.68	1,142,004

The weather was generally good, and the water smooth during the progress of the work. On the 5th, however, an up-stream wind made the water in the south channel so rough as to affect the speed of the float considerably, the waves causing a bobbing motion, or rather a succession of stops and plunges. Experiments with a wooden float, loaded to sink just below the surface of the water, and started at the same moment with the tin float, showed that the latter lost from 5 to 10 per cent. of the speed of the current when the waves averaged from 2 to 3 inches in height, and a much greater percentage when the water was at all rough; and in the table of results above given it is seen that on the 5th the mean velocity was less in the south and greater in the north channel than the general ratio of decrease shown by the above table. It appears, therefore, that the effect upon the south channel of an up-stream wind is not only to retard the float, and thereby give an observed velocity lower than the actual, but also by backing up the water to lower the actual velocity and reduce the volume, causing a corresponding increase in the north channel, which is, as above stated, protected from northerly winds, and gains in volume and velocity what the other loses.

The general result shows:

1st. That the mean velocity at a high stage of the river is greater in the north than in the south channel.

2d. That while the mean velocities in both channels decrease as the river abates, the rate of decrease is greater in the north than in the south channel, and it follows that at a certain lower stage they will be equal.

My measurements, made during the lowest stage last fall, showed the south channel

to be the more rapid of the two. It will be remembered that some dredging was done through the bar at the head of the north channel after the relative velocities were determined in September and before the rise of October 24, the time at which the velocity in the north channel was found to have increased so much. Assuming, as is probable, that the greater velocity found in the south channel during low water was in part due to the existence of this bar, and consequently that its removal in part before the occurrence of the October freshet contributed to the excess of velocity found in the north channel during that freshet, the ratio of velocities in the two channels during the coming low-water stage (should the cut now again filled with sedimentary deposit be dredged) will be different from that found last year at the same stage, the south losing in proportion as the north gains.

Should you decide to make further examinations of the current and general conditions of the Lower Willamette and Columbia Rivers during the approaching low-water stage, I would suggest that at all points where there are two channels the current-measurements be made in both simultaneously. The relative velocities thus obtained may be accepted as absolutely correct.

Willamette River, half a mile above the head of Sawvie's Island, was	(4)	739,514
Allowing for difference of height of water, and consequently of velocity as shown on section-sheet, the volume discharged would be		794,013
Willamette Slough, quarter of a mile below its head	(5)	950,235
And one mile lower down	(6)	1,040,255

The measurement at (5) was made during the first and at (6) during the last half of ebb-tide. The difference in volume is partly due to the great acceleration in the rate of flow which always occurs in the slough during the last quarter of ebb, for reasons which I will explain under the head of "Velocity of current."

Columbia River, just above Saint Helen's Bar, (7)		9,163,805
And just below the bar, (8)		10,859,446
Deducting from the latter the volume passing through Willamette Slough, which enters the Columbia a short distance above, in round numbers		1,000,000
Leaving for (8)		9,859,446

Being a difference of about 7 per cent. between the results found above and below the bar. I consider the latter to be the most accurate, the work having been done in perfectly calm weather, which was not the case with the former.

Willamette River, 1,000 feet above Three-Tree Island, during spring tides, at three-quarters ebb, (9)		392,033
And at the same point at three-quarters flood		548,846

Showing an excess in the volume carried by the flood-tide over that of the ebb of 156,813 cubic feet per minute, about equal to the excess of the volume of the Willamette Slough over that of the river proper as shown above.

Mouth of Willamette.

Coon Island Slough, (10)		234,125

This was measured during neap-tides, and includes the entire volume of the Willamette, there being no current through middle channel and Nigger Tom Slough at that stage.

Middle Channel during spring tides, (11)		309,453

Very little water then passing through Coon Island Slough.

Nigger Tom Slough.—Here I made several attempts to ascertain the volume, but with no result. The current was scarcely perceptible, and so variable that at no time during the low stage could I find the water flowing in the same direction on both sides of the channel.

Columbia Slough discharges during the spring tides		23,200

On the 22d of November, the water having risen 6 feet in consequence of heavy rains in the Willamette Valley, I returned to the mouth of the river and measured the velocity of the current in the three channels, from which, with the cross-sections previously taken, I obtained the following results:

Coon Island Slough, 10 feet above low-water mark, velocity of current 120 feet per minute; discharge in cubic feet per minute	721,728
Middle Channel, velocity 174 feet per minute, discharge	3,304,608
Nigger Tom Slough, velocity 160 feet per minute, discharge	640,000

Making in all 4,666,336 cubic feet of water per minute discharged through the three mouths of the Willamette at the existing stage of water, the tide-gauge at Portland indicating 11.5 feet above zero, while a still larger volume passed through the Willamette Slough at that time.

You will see from the above statement of the results obtained by gauging that the volume of water passing through the Willamette Slough during the low stage of the river is greater than that brought down by the river proper, and that the amount of this excess is about equal, allowing for error in measurement, to that of the flood-tide over the ebb from the Columbia, as shown by the gauging made just above Three-Tree Island; from which it is apparent that during the low stage a volume of from 150,000 to 170,000 cubic feet per minute from the Columbia enters the mouth of the Willamette during flood-tide, and runs out through the Willamette Slough, re-entering the Columbia at Saint Helen's.

In fact, at that stage of the water the Willamette between its mouth and the head of Sawvie's Island is nothing more than an arm of the Columbia, and upon old charts made 20 years ago, the Willamette Slough is called the Lower Willamette, showing that it has, ever since the country was settled, been known as the principal channel of the river in this locality. I am satisfied, therefore, that any plan for the improvement of Post-Office and mouth of Willamette Bars, in which the erosive force of the current is to be utilized, should include the closing, in part at least, of the Willamette Slough.

DEPTH OF WATER.

During the lowest stage indicated on the gauge at Portland by zero, the depth along the channel, excluding Swan Island, Post-Office, and mouth of Willamette Bars, (where a constant depth of 17 feet is maintained by dredging) varies as follows:

From the northern limit of the city to the head of Swan Island, in the north channel, from 20 to 25 feet; and through the south channel from 5 to 7 feet.

Through the north channel to the foot of Swan Island, from 20 to 54 feet. Thence to Saint John's from 20 to 32 feet, except for a distance of about 400 feet at a point ½ a mile above Saint John's, on the west side of the channel, where there is a bar on which only 18 feet is found at lowest water. From what I can learn the river is gradually shoaling here, and may require attention within a few years.

From Saint John's to the mouth of the river the depth is from 20 to 47 feet.

At the head of Sauvie's Island, just within the Willamette Slough, I found a pool 75 feet deep and about 50 feet across its deepest part. This pool is caused by the scour resulting from the sudden change of direction which the current of the Willamette takes on striking the head of Sauvie's Island, where the bank is nearly vertical from 18 to 20 feet high, and formed of tough clay; 1,500 feet lower down the depth diminishes to 24 feet.

The above are the depths at low tide during the lowest stage of the river, which occurs only at intervals of several years, at the end of unusually long dry seasons. Generally the gradual abatement of the water, which continues through the summer, is checked by the early winter rains at a height of 2 or 3 feet above zero. The lowest point reached during the present fiscal year, so far, 1.2 feet above zero, occurred on December 23, 1876.

VELOCITY OF CURRENT.

The general velocity of the current in the Lower Willamette during the low stage is from 20 to 30 feet per minute, or from one-fourth to one-third of a mile per hour, and when at 6 to 8 feet above zero, from three-fourths to 1½ miles per hour.

The current through the Willamette Slough during the low stage runs at from seven-tenths to nine-tenths of a mile per hour.

Through the mouths of the Willamette, during the low stage, it is very variable, depending on the winds and tides from the Lower Columbia, never during the low stage exceeding 55 feet per minute, or six-tenths of a mile per hour.

In the Willamette Slough the current is nearly uniform, varying from 60 to 80 feet per minute.

The depth varies with the stage of tide, but the current flows outward at all times. This is due to the following conditions:

The fall of the river from the head of Sauvie's Island to Saint Helen's, at low water, is 1.2 feet. The height of the tidal wave is also 1.2 feet during neap tides, and during spring tides from 2 to 3 feet. The distance between the two points by the slough is 23½ miles, and by the mouth of the Willamette only 18⅛ miles. By the latter route, therefore, the shorter by 5 miles, the channel being from 3,000 to 4,000 feet wide, the tide reaches the head of Sauvie's Island much sooner than by the former, which is narrow and crooked and runs out through the slough, maintaining its ascendency with the aid of the current of the Willamette, all of which flows through the slough, as I have shown above.

The velocity of the current of the Columbia River at Saint Helen's Bar was from 39 to 158 feet per minute, or from 0.45 to 1.7 miles per hour, during the low stage, the greater velocity being just below the bar.

INCLINATION.

I ran a line of levels from Portland down the west shore of the Willamette to its mouth, and thence along the east bank of Sauvie's Island to Saint Helen's, for the purpose of determining the comparative elevations of the high and low water marks at the extreme and intermediate points of the line. The high-water profile, representing the freshet in the Columbia of June, 1876, the highest on record, is as follows:

Calling zero of the flood-gauge at the foot of Yamhill street, Portland, 100.000, the elevation of high water at Portland, due to back-water from the Columbia—

June 24, was	128.200
At mouth of the Willamette	127.999
At Willow Bar, Columbia River	127.387
And at Saint Helen's	126.982
Total fall from Portland to Saint Helen's	1.218

During low-water, the flood-gauge at Portland reading 3.0, the following are the elevations at different points, ascertained by means of tide-gauges graduated to feet and tenths of a foot, their bases or zeros being connected by my line of levels:

At Portland	103.000
At head of Willamette Slough	102.200
At mouth of Willamette River	102.200
At Saint Helen's	101.500

During intermediate stages of the Willamette the fall is much greater than during either high or low water, as shown by the heights of the surface of water at the following points on the 22d November:

At Portland	111.50
At head of Willamette Slough	109.94
At mouth of Willamette River	109.80

I think it probable that the difference of 0.201 foot in the heights of the freshet-marks at Portland and at the mouth of the Willamette, which appears above, is due to my having disregarded the correction for the curve of true level, a portion of the line between these two points having been run over a mountain road where I could not equalize the sights, the length of fore sights being in several instances considerably greater than the back sight, causing the observed level, or line of sight, which is a tangent, to deviate so much from the true level curve as to make a difference appear where none exists. The high-water in the Lower Willamette is due solely to the snow-flood of the Columbia, and, as no current is perceptible during its continuance, I am satisfied there is no fall.

DISTANCES.

From Portland to the head of Willamette Slough, 9½ miles; thence to the mouth of the Willamette, 2⅞ miles; thence to Willow Bar, 6 miles; thence to Saint Helen's, 9 miles; the distance from Portland to Saint Helen's, via the Willamette Slough, being 32½ miles.

OTHER ITEMS.

The ridge between the Lower Willamette and Columbia terminates abruptly in a rounded spur 200 feet high, 1½ miles below Saint John's, as shown on the map.

During the June floods the flat lands along the banks of the two rivers, including almost the whole of Sauvie's Island, are overflowed to a depth of from 10 to 20 feet. The seasons at which these floods occur render the bottom-lands almost valueless except for pasturage.

The lower end of Coon Island is being rapidly worn away by the current of the Columbia River, which washes the east side of the island, carrying the eroded material around into the slough, formerly a ship-channel, but now shoaling rapidly at its mouth.

Three-Tree Island, 1 mile above the mouth of the Willamette, is also yielding to the force of the winter floods of the Willamette, and there will probably be very little of it left above the low-water line should any considerable freshet occur during the coming winter. Its highest point is now about 6 feet above extreme low-water mark.

Percy's Slough has no current at low-water, being closed by a sand-bar, which has formed a short distance above the remains of the pile-dam built three years ago. At higher stages, the direction of the current depends upon the relative heights of water in the two rivers. Columbia Slough heads near the mouth of Sandy River, which enters into the Columbia 20 miles above the mouth of the Willamette. Its general direction is parallel to that of the Columbia. At its mouth, at low-water, it is 60 feet wide and 6 feet deep; its width and depth throughout its length vary considerably. When clear of drift and other obstructions, it is navigable for small steamboats from its mouth to Love's bridge, a distance of about five miles; it carries the water of several small

brooks from the northern slope of the ridge between the Columbia and Willamette and runs through a level meadow country, interspersed with numerous lakes and sloughs, overflowed annually by the summer flood of the Columbia.

I omitted to state that I spent several days trying to gauge the Willamette between the head of Sauvie's Island and the foot of Post-Office Bar, but without success, the current being variable and sluggish.

On the section sheets annexed I have allowed for the difference of height of water at various points gauged, in order to make a fair comparison of the results.

Respectfully submitted.

ROBERT A. HABERSHAM,
Assistant Engineer.

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

No. 1.—*Gauging the Willamette River, Oregon, one-quarter of a mile below Portland, September* 12 *and* 13, 1876.

Mean height of water, 3. 6 feet above zero.

Section.	Area, square feet.	Mean velocity, feet, per minute.	Volume in cubic feet per minute.	Section.	Area, square feet.	Mean velocity, feet, per minute.	Volume in cubic feet per minute.
1	960	11. 4	10, 924	10	2, 750	24. 0	66, 000
2	1, 440	17. 2	24, 768	11	2, 745	26. 2	71, 919
3	1, 465	20. 4	29, 886	12	2, 770	27. 8	77, 006
4	1, 525	21. 0	32, 025	13	2, 775	28. 0	77, 700
5	1, 770	19. 2	33, 984	14	2, 370	27. 0	63, 990
6	1, 975	21. 1	41, 672	15	1, 680	39. 2	65, 856
7	2, 220	22. 6	50, 172	16	726	31. 2	22, 645
8	2, 475	22. 5	55, 687				
9	2, 660	23. 4	62, 244	Total			786, 478

Average velocity, 23. 9 feet per minute.

No. 2.—*Gauging Swan Island Channel, (south,) September* 15, 1876—*last half of ebb tide.*

Mean height of tide-gauge, 3'. 9 above zero.

Section.	Area, square feet.	Mean velocity, feet, per minute.	Volume in cubic feet per minute.	Section.	Area, square feet	Mean velocity, feet, per minute.	Volume in cubic feet per minute.
1	555	40. 0	22, 200	12	460	34. 8	14, 008
2	1, 095	44. 2	48, 399	13	410	23. 8	9, 759
3	1, 095	53. 4	58, 473	14	355	No current	
4	1, 130	53. 8	60, 794	15	375	No current	
5	1, 130	53. 4	60, 342	16	450	No current	
6	1, 130	46. 6	52, 658	17	535	No current	
7	1, 065	52. 4	55, 804	18	610	No current	
8	915	54. 6	49, 959	19	560	No current	
9	815	48. 8	39, 772				
10	760	43. 6	33, 136				
11	600	42. 8	25, 680		14, 045	Av. 45. 54	Tot'l 530, 984

1300×.3=390×45.55=17,764 to be deducted. Correction for difference in height of water=513,220 cubic feet per minute.

No. 3.—*Gauging Swan Island Channel (north)—last half of ebb tide.*

Surface of water, September 18, 4.5 above zero.

Section.	Area, square feet.	Mean velocity, feet, per minute.	Volume in cubic feet per minute.	Section.	Area, square feet.	Mean velocity, feet, per minute.	Volume in cub'c feet per minute.
1	143	No current		7	2,507	30.0	75,210
2	420	No current		8	2,632	23.4	61,589
3	778	14.9	11,592	9	2,093	23.1	48,348
4	1,315	14.3	18,805	10	86	No current	
5	1,813	15.0	27,195				
6	2,223	18.8	41,792		14,010	Av. 19.95	Tot'l 284,531

350×.9=315.0×19.95=6.278 cubic feet per mile to be deducted. Correction for difference in height of water= 278,253
Add south channel 513,220

791,473

A correction for increase of velocity will still further reduce the difference.

A.—*Current measurements in north channel, Swan Island, Lower Willamette River.*

Date.	Section.	Height of water above zero, in feet.	Area of sections, square feet.	Mean velocity in feet per minute.	Discharge in feet per minute.
April 4, 1877		10.5	21,142	63.75	1,347,802
April 5, 1877	1	9.6	5,775	67.27	388,484
	2	9.6	8,259	67.07	553,462
	3	9.6	6,503	56.55	360,745
Total			20,537	Av. 63.43	1,302,691
April 6, 1877	1	9.0	5,644	58.06	327,961
	2	9.0	8,115	64.74	525,365
	3	9.0	6,375	54.05	348,569
Total			20,134	Av. 59.64	1,201,895
April 7, 1877	1	8.5	5,535	65.22	361,993
	2	8.5	7,995	57.69	461,232
	3	8.5	6,269	50.85	318,779
Total			19,799	Av. 57.68	1,142,004

B.—*Current measurements in south channel, Swan Island, Lower Willamette River.*

Date.	Section.	Height of water above zero, in feet.	Area of sections, square feet.	Mean velocity in feet per minute.	Discharge in feet per minute.
April 4, 1877	1	10.5	3,895	41.09	160,046
	2	10.5	3,140	41.09	129,023
	3	10.5	3,927	41.09	161,360
	4	10.5	5,113	51.72	264,444
	5	10.5	5,544	54.54	302,370
	6	10.5	3,707	55.55	205,924
Total			25,326	Av. 48.29	1,223,167
April 5, 1877	1	9.6	3,517	39.41	138,605
	2	9.6	2,857	37.99	108,537
	3	9.6	3,644	43.47	158,405
	4	9.6	4,830	50.00	241,500
	5	9.6	5,261	46.15	242,795
	6	9.6	3,419	54.54	186,466
Total			23,528	Av. 45.75	1,076,308
April 6, 1877	1	0.0	3,265	41.67	136,053
	2	9.0	2,668	40.00	106,720
	3	9.0	3,455	44.12	152,435
	4	9.0	4,641	46.09	213,904
	5	9.0	4,915	53.57	262,297
	6	9.0	3,067	50.85	155,957
Total			22,011	Av. 46.67	1,027,366

No. 4.—*Gauging Willamette River, ½ mile above slough.*

Surface of water, September 29, 3.0 feet above zero.

Section.	Area.	Mean velocity.	Volume in cubic feet per minute.	Section.	Area.	Mean velocity.	Volume in cubic feet per minute.
		Ft. per min.				*Ft. per min.*	
1	4,255	20.4	86,802	4	5,671	24.0	136,104
2	9,624	25.3	243,487	5	7,279	21.6	157,226
3	6,250	27.7	115,895				
Total							739,514
Add volume due to difference in height of water 1500 × .0.6 × 23.8, (average velocity)							21,420
							760,934
Allowing 1 foot per minute = loss of velocity from loss of head							33,079
Total							794,013

No. 5.—*Gauging Willamette Slough, ¼ mile below its head.*

Surface of water, September 22, 4.2 feet above zero.

Section.	Area.	Velocity.	Volume discharged.	Section.	Area.	Velocity.	Volume discharged.
		Ft. per min.	*Cu. ft. per min.*			*Ft. per. min.*	*Cu. ft. per min.*
1	680	75.0	51,000	5	1,740	78.7	136,938
2	1,750	71.4	124,950	6	1,695	85.5	144,922
3	2,080	75.0	156,000	7	1,715	78.7	134,970
4	1,800	74.1	133,380	8	865	78.7	68,075
Total							950,235
Average velocity in feet per minute							77.1

No. 6.—*Gauging Willamette Slough, 1¼ miles below its head.*

Surface of water, September 22, 4.2 feet above zero.

Section.	Area.	Velocity.	Volume discharged.	Section.	Area.	Velocity.	Volume discharged.
		Ft. per min.	*Cu. ft. per min.*			*Ft. per min.*	*Cu. ft. per min.*
1	285	62.4	17,784	7	1,712	72.0	123,264
2	1,170	62.4	73,008	8	1,655	67.0	107,535
3	1,725	80.0	138,000	9	1,535	50.0	76,750
4	1,800	82.0	147,600	10	1,205	50.0	60,250
5	1,775	80.0	142,000	11	400	50.0	20,000
6	1,737	72.0	125,064	12	195	50.0	9,000
Total							1,040,255
Average velocity in feet per minute							64.8

No. 7.—*Gauging Columbia River above Saint Helen's Bar.*

Surface of water, October 5, 4.0 feet above zero.

Section.	Area.	Velocity.	Volume discharged.	Section.	Area.	Velocity.	Volume discharged.
		Ft. per min.	*Cu. ft. per min.*			*Ft. per min.*	*Cu. ft. per min.*
1	721	66.7	48,091	11	6,897	103.4	713,150
2	1,626	76.2	123,901	12	6,362	117.6	748,171
3	2,257	96.8	218,478	13	6,138	109.2	670,270
4	2,976	115.3	343,133	14	5,761	95.2	548,447
5	3,421	122.5	419,072	15	5,104	99.0	505,296
6	4,368	133.3	582,254	16	4,428	103.1	456,527
7	5,582	136.4	761,385	17	3,866	88.5	342,351
8	6,521	103.4	674,271	18	3,082	75.2	231,766
9	7,215	115.3	831,889	19	2,121	66.7	141,470
10	7,366	101.7	749.122	20	821	66.7	54,761
Total							9,163,805
Average velocity of current in feet per minute							99.6

No. 8.—*Gauging Columbia River below Saint Helen's Bar, October 6 and 9.*

Surface of water 4.0 above zero.

Section.	Area.	Velocity.	Volume discharged.	Section.	Area.	Velocity.	Volume discharged.
		Ft. per min.	*Cu. ft. per min.*			*Ft. per min.*	*Cu. ft. per min*
1	1,755	100.0	175,500	23	3,333	142.9	276,286
2	4,212	130.4	549,245	24	3,487	136.3	475,278
3	5,440	136.3	741,472	25	3,261	125.0	407,625
4	4,446	125.0	555,750	26	2,761	121.1	334,357
5	3,744	130.4	488,218	27	2,266	125.0	283,250
6	3,275	133.3	436,557	28	1,853	130.4	241,631
7	3,100	127.6	395,560	29	1,406	115.4	162,252
8	2,749	130.4	348,470	30	1,579	127.6	201,480
9	2,164	100.0	216,400	31	1,606	92.3	148,234
10	1,521	93.7	142,518	32	1,683	103.4	174,022
11	1,111	96.8	107,545	33	1,864	103.4	192,738
12	959	78.9	75,665	34	1,805	101.7	183,568
13	907	77.9	70,655	35	1,875	95.2	178,500
14	935	98.3	91,910	36	1,905	101.7	193,738
15	1,128	122.4	138,067	37	1,980	95.2	188,496
16	1,452	107.2	155,654	38	1,890	85.7	161,973
17	1,584	111.1	175,982	39	1,810	84.7	153,307
18	1,584	117.9	186,754	40	1,990	80.0	159,200
19	1,639	127.7	209,300	41	1,885	86.9	163,806
20	2,239	136.4	305,400	42	1,565	78.8	123,322
21	2,673	130.4	348,559	43	1,210	54.5	65,945
22	2,899	157.9	457,752	44	450	38.9	17,505
Total							10,859,446
Average velocity in feet per minute							108.9

No. 9.—*Gauging Willamette River, 1,000 feet above Three-Tree Island.*

Surface of water October 18, 4.2 feet above zero.

Section.	Area.	Velocity.	Volume discharged.	Section.	Area.	Velocity.	Volume discharged.
		Ft. per min.	*Cu. ft. per min.*			*Ft. per min.*	*Cu. ft. per min.*
1	590	0.0		9	1,504	13.8	20,755
2	4,704	21.8	102,547	10	1,851	10.7	19,806
3	4,902	18.4	90,197	11	1,955	0.0	
4	3,349	19.0	63,631	12	1,352	0.0	
5	1,940	18.1	35,114	13	894	0.0	
6	1,134	22.2	25,175				
7	694	23.7	16,448	Total			392,033
8	918	20.0	18,360				
Average velocity, in feet, per minute							18.6
Average velocity, during flood-tide, in feet, per minute							2.60

Measured during spring-tides only. The outward current during neap-tides is so variable that it cannot be accurately measured.

No. 10.—*Gauging Coon Island Slough.*

Surface of water October 13, 3.2 feet above zero.

Section.	Area.	Velocity.	Volume discharged.	Section.	Area.	Velocity.	Volume discharged.
		Ft. per min.	*Cu. ft. per min.*			*Ft. per min.*	*Cu. ft. per min.*
1	104	37.5	3,900	4	940	36.4	34,216
2	950	66.7	63,365	5	925	55.5	51,337
3	990	55.5	54,945	6	475	55.5	26,361
Total							234,124
Average velocity during neap-tides, in feet, per minute							51.2

During the spring-tides there is very little current through this channel.

No. 11.—*Gauging mouth of Willamette.—Middle channel.*

Surface of water October 16, 4.0 feet above zero.

Section.	Area.	Velocity.	Volume discharged.	Section.	Area.	Velocity.	Volume discharged.
		Ft. per min.	*Cu. ft. per min.*			*Ft. per min.*	*Cu. ft. per min.*
1	654	15.1	38,867	8	1,650		
2	1,920			9	1,285		
3	2,285	21.9	94,498	10	870	20.0	91,300
4	2,030			11	560		
5	1,700			12	200		
6	1,695	16.4	84,788				
7	1,775						
Total during spring-tides only							309,453
Average velocity, in feet, per minute							18.4

Abstract of proposals for furnishing the United States with a tug-boat, when required, during the year 1877, *opened by Maj. John M. Wilson, Corps of Engineers, February* 8, 1877.

No.	Names and residence of bidders.	Furnishing boat when required during the year 1877, per month.	Remarks.
1	Bailey & Taylor, Portland, Oreg	$585 00	Contract awarded.
2	S. S. Douglass, Portland, Oreg	600 00	
3	C. R. Wilson & Henry Wilson, Portland, Oreg	700 00	

Abstract of contract for the improvement of the Lower Williamette and Columbia Rivers, in force during the fiscal year ending June 30, 1877.

No.	Names and residence of contractors.	Date of contract.	Subject of contract.	Price per month.
1	Bailey & Taylor, Portland, Oreg	Feb. 12, 1877	Hire of steam-tug as tender to United States dredge, when required, during the year ending June 30, 1877.	$585 00

REPORT OF THE BOARD OF ENGINEERS FOR THE PACIFIC COAST.

OFFICE BOARD OF ENGINEERS PACIFIC COAST,
San Francisco, Cal., April 9, 1877.

GENERAL: In accordance with instructions from the Chief of Engineers, dated July 26, 1876, the Board of Engineers for the Pacific coast met in Portland, Oreg., in August last to consider the project of Maj. John M. Wilson, of the Corps of Engineers, for the improvement of the Lower Willamette and Columbia Rivers, from Portland to the sea.

After personally examining these rivers and Major Wilson's charts and project, the Board presented a preliminary report under date of August 24, 1876, wherein it was recommended that, before final action was taken, certain further surveys and examinations should be made, in order that the Board might be fully informed upon the subject under consideration.

These examinations and surveys were made and charts prepared during the fall of 1876, and on January 17, 1877, the Board reconvened at San Francisco, Cal., all the members being present, including Maj. John M. Wilson, Corps of Engineers, who, in accordance with Department letter of July 26, 1876, became a member of the Board while this subject was under consideration.

The Board has examined the plans of Major Wilson, and, after careful consideration of all the data laid before it, respectfully submit the following

REPORT.

The project of Major Wilson embraces plans for the improvement of Swan Island Bar, Post-Office Bar, and the bar at the mouth of the Willamette, (these three being in the Willamette River,) and also for the improvement of Saint Helen's Bar in the Columbia River.

In presenting its report the Board deems it best to discuss each bar separately, beginning at Portland and proceeding toward the mouth of the Columbia.

Opposite Portland the channel of the Willamette River presents a depth of from 20 to 40 feet at low-water. Lower down the river widens, giving a consequent decreased velocity. It begins to shoal a short distance above Swan Island, 3 miles below Portland.

At this place there are two channels: one, north of the island, the present ship-channel, being about 600 feet wide, and from 20 to 50 feet deep; the other, south of this island, is about 1,900 feet wide, with a depth of from 4 to 7 feet at low-water.

About three-quarters of a mile above the island the bar commences to appear, and through this a channel, about 100 feet wide and 17 feet deep, at low-water, has been cut, connecting deep water in the river above with the deep channel north of Swan Island; and dredging has continued annually for the past nine years, each year's freshet partially filling the cut.

Major Wilson's plan proposed to close one of these channels, and he presented projects for both, favoring, however, the closing of the north, or present, ship-channel.

The gauging of the Willamette River, a quarter of a mile below Portland, September 12 and 13, with the water 3½ feet above zero, showed an average velocity of 23.9 feet per minute, and a volume of 786,478 cubic feet per minute.

September 15, the river being 3.9 feet above zero, the volume passing through the South Swan Island Channel was found to be 530,984 cubic feet per minute, with an average velocity of 45.54 feet per minute.

And September 18, the river being 4½ feet above zero, the volume in the North Swan Island Channel was 267,261 cubic feet per minute, having an average velocity of 19.93 feet per minute.

Thus showing the quantity in the south channel to be nearly twice as large as that in the north channel at this stage of the river.

These determinations are somewhat anomalous, but, being the results of actual measurements, we suppose they must be accepted as correct.

We say anomalous, because while the areas of the sections of the two channels south and north of Swan Island do not greatly vary, (that of the north channel being the larger, however, and having a greater depth,) yet the mean measured velocity of the water in the south channel was more than twice as great as that in the north channel, giving as a result twice as much water through the south as through the north channel, at the stages above mentioned. The usually accepted hydraulic formulæ for the flow of rivers would give directly contrary results.

Again, it seems strange that, if the water in the south channel has twice the velocity of that in the north channel, the south is not the deeper channel of the two.

Accepting the determinations as correct, however, we must conclude that there are certain conditions governing the flow of water through these channels which remain, as yet, undiscovered.

Some six week later, the level of the river being 6.2 feet above zero, it was again gauged, and the discharge found to be as follows:

	Cubic feet per minute.
Just below Portland	3,095,400
South Swan Island Channel	1,802,470
North Swan Island Channel	1,369,138

the increased volumes being attended with accelerated velocities.

This result is again anomalous, for, while we have added much more area of cross-section of water-way to the south channel, on account of

its greater width, than to the north channel, yet, although the flow of water through both channels has been greatly increased by the additional height of the river, the relative increase of flow has been in favor of the north channel. This is contrary to all preconceived ideas on the subject, and contrary to the result given by all formulæ applicable to its determination.

This leads us again to conclude that there must be some unknown factor bearing on the solution of the relative flow through these two channels. Perhaps future researches may discover it, and we recommend further investigations.

Borings were made in each channel to the depth of 21 feet below the plane of low-water.

The material in the south channel was found to be sand, with occasional layers of gravel from one to two inches in thickness.

In the north channel the bottom was blue clay, sand, and gravel at various localities; the filling in the channel already cut through the bar being a coarse sand and gravel, the latter sometimes as large as a pigeon's egg.

After careful consideration, the Board deems it best to close the south channel by a dike of brush and stone 7,000 feet long, running from the upper end of Swan Island to the south shore, the top of the dike to be at ordinary low-water, or about two feet above the level of the river at dead low-water.

In the opinion of the Board such a construction would cause the north channel, through Swan Island Bar, to be scoured out, and would render further dredging unnecessary.

The reasons of the Board for selecting the north channel for navigation and closing or partially closing the south channel are:

1st. The north is the present navigable channel, and it can be more easily and cheaply improved than the south channel.

2d. A dike across the south channel will not interfere with the commerce of the river, whereas one across the north channel would interrupt that commerce, for, if it be decided to close the north channel, it is evident that this closure cannot be completed until a navigable passage is opened through the south channel. This would necessitate a very large quantity of dredging, and consequent expense, in opening and keeping open the south channel for commercial purposes, before closing the north channel.

If the difference of the cost of the two projects be left out of consideration, (and if we could be sure that the sand and gravel to be washed out of the south channel if the north channel be closed would not eventually give trouble in the river below Swan Island,) the Board would prefer to make the south channel the navigable one, being led to this choice by the fact that it is the shorter of the two channels, and the river-bottom here (being mostly sand) would be more easily eroded than in the north channel, where it is of blue clay in certain portions.

The estimated cost of the dike across the south channel, 7,000 feet long, is 34,000 cubic yards, at $1.50 per yard, amounting to $51,000.

From Swan Island to the head of Willamette Slough the river presents an excellent channel, with a depth of from 20 to 47 feet at low-water, except at one locality, about a mile below the island, where, for a distance of about 500 feet, there is a depth of only 18 feet at low-water.

Just below the head of the Willamette Slough Post-Office Bar occurs, and in order to remove this it was proposed to partially close this slough.

A careful examination showed the following to be the case here:

The fall in the Willamette River during low-water is as follows:

Calling the zero of the gauge at the foot of Yamhill street, Portland, 100,000 during low-water, the gauge at Portland reading 3 feet, the elevations at different points are as follow:

At Portland	103,000
At head of Willamette Slough, 9½ miles below Portland	102,200
At mouth of Willamette River, 12⅝ miles below Portland	102,200
At Saint Helen's, 27⅜ miles below Portland, by the rivers	101,500
At Saint Helen's, 32½ miles below Portland, by Willamette Slough	101,500

Showing the fall, at this stage of the rivers, to be:

From Portland to the head of the slough	$\frac{8}{10}$ foot.
From head of slough to mouth of Willamette	None.
From head of slough to Saint Helen's	$\frac{7}{10}$ foot.

The borings showed the material forming Post-Office Bar to be sand, similar to that in the Willamette River near Swan Island.

The gauging of the Willamette River a half mile above the head of the slough, on September 29, the level of the river being 3½ feet above zero, showed a volume of 739,514 cubic feet per minute, while that of the slough, the gauge reading 4.2 above zero, shows a volume of 1,040,255 cubic feet per minute.

Further observations in gauging the Willamette River below the head of the slough showed the volume of the flood to exceed that of the ebb tide about 150,000 cubic feet per minute, and that a large amount of water at this stage of the river, from the Columbia, runs up the Willamette River and then escapes down the slough.

As the distance from Saint Helen's, by way of the rivers, which are wide, to the head of the slough is about 18 miles, and by way of the slough, which is narrow, is about 23 miles, the flood tide by way of the rivers reaches the head of the slough and begins to run down it before the flood reaches that point by way of the slough.

The facts thus presented show that during ordinary low-water the entire volume of the Willamette, in addition to a large quantity from the Columbia, passes down the Willamette Slough.

In the opinion of the Board, the best plan for removing Post-Office Bar would be to entirely close the Willamette Slough by a dam near its head; but as this is a navigable channel, and has many settlers on its banks, and as it is used by steamers running to Astoria when the Columbia River is closed by ice above Saint Helen's, the Board recommends that a dike of brush and stone be built to the height of ordinary low-water, or 2 feet above the zero of the gauge, on the shoal in the slough about 2,300 feet below its head, leaving a channel 100 feet wide in the middle with a depth of 6 feet at low-water, the sides of this channel to be cribs 50 feet long by 25 feet wide, the bottom well paved to prevent erosion.

It is estimated that by this plan at least seven-eighths of the water now passing down the slough will be kept in the Willamette River and will be sufficient not only to cut and keep open a channel through Post-Office Bar, but also to materially aid in removing the bar at the mouth of the river.

Such a dam or dike, 800 feet long, with an average height of 15 feet, except where the opening is left, would contain 17,000 cubic yards, and would cost as follows:

17,000 cubic yards, at $1.50 per yard	$25,500 00
100 feet of crib-work, at $25 per foot	2,500 00
Total	28,000 00

It is believed that after the completion of such a dike further dredging will be unnecessary at Post-Office Bar.

From the lower end of this bar there is a channel with a depth of from 20 to 45 feet, until we reach the mouth of the Willamette River, about 2½ miles distant, where another bar is found.

The river again widens here, and during low-water on the ebb-tide a large volume of water passes through Coon Island Slough, just above the bar.

A careful examination shows this bar to consist of a fine sand almost identical with that of Saint Helen's Bar in the Columbia, showing plainly that it comes from that river.

During the freshets in the Columbia River a large volume of water pours through Percy's and Columbia Sloughs, opposite the bar, meeting another volume passing up the Willamette River, part of which escapes down Coon Island Slough, still more down the Willamette Slough, and the remaining portion of this upward flood assists in raising the Willamette River to a considerable height as far up as the falls at Oregon City, a distance of about 25 miles from its mouth.

During neap-tides it was found that 234,125 cubic feet per minute passed out through Coon Island Slough, while there was no perceptible current through the main channel of the Willamette River. This occurred when the water was 3.2 feet above zero. At a later date when the water was 10 feet above low-water mark the discharge through the main channel was 3,304,608 cubic feet per minute; that through Coon Island Slough, 721,728 cubic feet per minute.

It is the opinion of the Board that the partial closing of Willamette Slough, as above recommended, will deepen the water over the bar at the mouth of the Willamette River, but if sufficient depth is not thereby obtained, then it will become necessary to contract the river here so as to hold the water at the low stage within such limits as will secure the necessary scour.

To do this it is recommended—

1st. That Coon Island Slough be closed at its head by a dike running from Sauvie's Island to Coon Island, the face of the latter island being revetted.

2d. If this construction does not obtain the required depth of water over the bar at the mouth of the river, then a dike should be constructed on the opposite side, as shown on the drawing, from Nigger Tom Island to the main shore just above the mouth of Columbia Slough, the face of Nigger Tom Island being revetted, and, if necessary, a dike run from its lower end into the Columbia River for a distance of about 600 feet.

These dikes should be carried up to the height of ordinary low-water, or say 2 to 3 feet above zero. They will at that stage hold the water of the Willamette River within them, and will, during the season of freshets in the Columbia River, keep behind them and turn into the Columbia the sediment in the water from Percy's and Columbia Sloughs below the plane of the top of the dike.

In the opinion of the Board such constructions would, beyond doubt, keep open the channel at the mouth of the Willamette, and would go far to, if not entirely, prevent the deposits now annually occurring on this bar during the freshets in the Columbia River.

Such constructions would cost as follows:

Coon Island dike, 1,400 feet long, 38,000 cubic yards, at $1.50	$57,000 00
Coon Island revetment, 1,100 feet long, at $4.50 per foot	4,950 00

Nigger Tom upper dike, 2,300 feet long, 12,000 cubic yards, at $1.50	$18,000 00
Nigger Tom lower dike, 600 feet long, 8,000 cubic yards, at $1.50	12,000 00
Nigger Tom revetment, 2,000 feet, at $4.50 per foot	9,000 00
Total	100,950 00

Leaving the Willamette River we pass down the Columbia with a good channel until we reach Saint Helen's Bar, about 27 miles, by the rivers from Portland.

This bar is 2 miles long, crossing the river diagonally from the foot of Sauvie's Island to a point nearly opposite Columbia City, with deep water on each side.

The east bank of the river from opposite Warrior Rock to the lower end of the bar is low, from 5 to 10 feet above low-water, and is composed principally of sand, with occasional veins of clay; it has no stability, and, yielding each year to the floods, widens the channel and lessens the depth of water on the bar.

As we approach the foot of Sauvie's Island, coming down stream, Lewis River and Vancouver Slough empty into the Columbia from the east side, while Warrior Rock, a bold point, juts out from the west shore like a wing-dam, just before the bar is reached. Here the river is only 2,000 feet wide, but has a depth of from 50 to 105 feet, and the volume of discharge, when the river was 4 feet above low-water, on October 5, was found to be 9,163,805 cubic feet per minute. Below Sauvie's Island the Willamette Slough pours out, giving a wide and deep channel on the Oregon side of the bar. The river below Saint Helen's, October 6, the water still being 4 feet above zero, showed a volume of 10,859,446 cubic feet.

Allowing in round numbers 1,000,000 cubic feet for the discharge of the slough, there is a difference of about 7 per cent. in the measurements. The latter is considered the more accurate, the weather having been perfectly calm when it was taken, which was not the case in the former.

On the Washington Territory side, near the lower end, is a plateau covering an area of about 300 acres, having upon it a depth of from 1 to 15 feet of water. The bottom, for a depth of from 2 to 6 feet, consists of gravel containing granite, gneiss, quartz, &c., similar to the bars in the Upper Columbia, resting upon a bed of hard material supposed to be rock.

The ship-channel, until within the past year, has been at the lower end of this bar near the plateau just mentioned, with a depth of about 17 feet at low-water. This has been the best channel over this bar until the fall of 1876. Under ordinary circumstances the Board would have preferred to maintain this channel, but the freshet of 1876 filled it in places about 4 feet and opened another at the upper end of the bar, bringing at the latter place the 18-feet curves within 400 feet of each other, where in 1875 they were 900 feet apart, and gaining a depth of from 15½ to 18 feet at low-water, where in 1875 it was from 12 to 16 feet deep.

Doubtless a good ship-channel may be created by suitable constructions either at the upper or lower end of Saint Helen's Bar, but in view of the recent change the Board considers it best to locate two dikes across the bar on each side of the present ship-channel, about a half mile below the lower end of Sauvie's Island; the dikes to be each about 950 feet long, flaring at the upper end to a width of 800 feet, and narrowing to 300 feet at the lower end. It is possible that eventually it may be necessary to connect the one on the Oregon side with Sauvie's Island.

The Board, Lieutenant-Colonel Stewart dissenting, presents this plan as the best under present circumstances, believing that it will cut out and keep open a channel through the bar at this its narrowest and deepest part. At the same time it deems it possible that future freshets may make such changes before work can be commenced as to prove the lower end of the bar to be the better place for the dikes, the cost and extent of which would be about the same in either case.

The cost of this improvement would be as follows:

1,900 feet dike=58,000 cubic yards, at $1.50 per yard = $87,000.

From Saint Helen's Bar to the sea the only bar now existing that gives trouble is that below Snag Island at the junction of Woody Island and Cordell Channels. As there is a depth of not less than 15 feet on this bar at low-water, and two flood-tides daily, with a rise of from 6 to 8 feet, the Board deems it unnecessary at present to recommend further action here than to scrape the bar occasionally and to have it thoroughly buoyed.

It is thought that if funds were available, the whole of the work above mentioned could be executed in two seasons.

The estimated cost of the foregoing project is as follows:

Swan Island dike	$51,000 00
Willamette Slough dike	28,000 00
Mouth of Willamette—dams and revetments	100,950 00
Saint Helen's dikes	87,000 00
Contingencies and engineering, 12 per cent	32,024 00
Total	298,974 00

Four charts, showing the extent and location of the proposed dikes, are transmitted herewith.

Respectfully submitted.

G. H. MENDELL,
Major of Engineers.
R. S. WILLIAMSON,
Lieutenant-Colonel, Corps of Engineers.
C. SEAFORTH STEWART,
Lieutenant-Colonel of Engineers.
B. S. ALEXANDER,
Lieutenant-Colonel of Engineers, President of the Board.

I coincide in the views of the Board, except in reference to closing the south Swan Island Channel, believing, from all the information before me, that the north should be closed and the south left open.

Further investigations will be made at this place in reference to volume and velocity, and, should similar results be obtained as in September, 1876, I will present my views in full upon the subject.

Respectfully submitted.

JOHN M. WILSON,
Major of Engineers.

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

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., May 21, 1877.

SIR: The report of April 9 from the Board of Engineers for the Pacific coast, which had under consideration your project for the improvement

of the Lower Willamette and Columbia Rivers, is approved, and the conclusions of the Board concurred in. Future appropriations for these works will, therefore, be expended in accordance with the plans and recommendations therein set forth.

In adopting the recommendations of the Board, as to the propriety of closing the south channel of the Willamette at Swan Island, it is not intended that you should discontinue the observations you have in view for the further investigation of the regimen of the river in that vicinity, nor to deprive you of the opportunity of further presenting your views in favor of the closure of the north channel.

By command of Brigadier-General Humphreys.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers.

Maj. JOHN M. WILSON,
Corps of Engineers.

JJ 2.

IMPROVEMENT OF THE UPPER WILLAMETTE RIVER, OREGON.

In my last annual report I described fully this river, its floods, and the causes of the various bars that are impediments to navigation, and will now take up the subject by sections, as then discussed.

1. THE UPPER SECTION FROM EUGENE TO CORVALLIS.

This section of the river, comprising a length of about 56 miles, is subject to constant changes, so much so that even within the last 20 years pilots say that they have never run the same continuous channel in reaches from 5 to 10 miles above Harrisburg for two consecutive seasons. Between Eugene and Harrisburg, a distance of 23½ miles, the fall is 105.9 feet, or at the rate of 4½ feet to the mile; between Harrisburg and Corvallis, a distance of 35 miles, no line of levels has ever been run, to my knowledge, but I believe the fall to be over 3 feet to the mile. No steamboat has ascended to Eugene since the spring of 1876, not on account of lack of water, because the freshets in the winter and spring of 1876 and 1877 filled the stream, rising to a height of over 30 feet above low-water at Salem, but because nearly all the freight from Harrisburg and Eugene had already been sent by railroad. I therefore determined to descend during low-water from Eugene to Albany, a distance of about 68 miles, in a skiff, and made the trip on June 11 and 12 of the present year.

A careful examination showed that many changes had occurred above Harrisburg since the survey of 1875, and that others had taken place since last season. At several points above Corvallis the river separates into two or more channels, its capacity being correspondingly reduced and bars and shoals being formed. These bars are composed of loose gravel washed from the drift formation of the banks, and are constantly changing their shape. In approaching one of the rapids, my skiff, drawing only a few inches, grounded, and the gravel rolling down stream rattled against its sides like hail. The slope of this section of the river is entirely too great to render it permanently navigable at all seasons by contracting the channel, and I believe that the only plan of permanent improvement for it would be by a system of locks and dams, and until the

regimen of the river becomes nearer fixed, I would not recommend that this plan be adopted. I think, however, that if the water should be partially controlled by cutting off certain sloughs and by building a few wing-dams in the vicinity of the worst bars, so as to confine the river as much as possible during low-water in one channel, then, with a self-propelling snag-boat, with a scraper and pile-driver attached, I could keep the river open for light-draught steamers for at least three-fourths, and perhaps the whole year.

I would start this boat from Eugene as the freshet commences to subside, and by the time of low-water the bars would be scraped and the worst snags removed. With the pile-driver the crew could easily and quickly build temporary dams to sluice out a channel where scraping would not be sufficient. The localities in this section where the greatest waste of water occurs, and which first require attention, are at White's Rapid, Saw-mill Bend, Trout Bar, Ohio Chute, Bromley's Bend, Alford's Chute, Wilson's Chute, Peoria, and Centennial Slough; at Ohio Chute and Centennial Slough the channel has vastly improved since last year.

In addition to these troubles snags and drift-logs are numerous, and each freshet adds to their number; annual appropriations will be required to remove these, and will continue to be necessary until the timber shall have been removed from the immediate banks of the river.

For this section I would therefore recommend the construction and maintenance of a steam snag-boat with scraper and pile-driver attached, and that about 6,000 feet of cut-off dams and 8,000 feet of wing dams be built at the localities already mentioned, where the greatest waste of water and the most trouble occurs.

After the construction of these dams, and of the new snag-boat, I think that an annual appropriation of $6,000 will be sufficient to keep this section of the river open for light-draught boats for at least three-fourths, and perhaps the entire year.

Up to this time the only work done above Corvallis consists of the removal of drift and snags at different points, the greater portion having been taken from Booneville Slough, Centennial Slough, mouth of Long Tom, Wilson's and Ohio Chutes, and Harrisburg Bend.

2. THE LOWER SECTION—CORVALLIS TO PORTLAND.

As stated in my last report, but little change has occurred in the general direction of the channel in this section for a number of years; light-draught boats can generally run to Salem at all seasons of the year, and to Corvallis at all times except during lowest water.

The difficulties in the way of navigation consist of numerous gravel-bars, some rocky ledges, and various accumulations of drift and snags. Many of these bars have been greatly improved by constructing wing-dams, but there are several still very troublesome; these will be enumerated in another portion of this report.

I believe that the channel in this section of the river may be maintained so as to be navigable the entire year for boats drawing 2½ feet. To do this, I think, after removing some rocks, the present snag-boat, if supplied with propelling-power, a scraper, and a pile-driver, will be sufficient for the present; the boat can be laid up at Corvallis during high water, and, as the freshet recedes, can drop down, scraping bars, removing snags, and building short dams where necessary to sluice out a channel that cannot be improved by scraping. I do not consider it necessary to continue the construction of extensive dams after this season, but prefer to wait until I can have a complete and accurate sur-

vey made of the whole river between Corvallis and Portland before offering any detailed and elaborate plan for the permanent contraction of the channel. After the completion of work this season, and removing certain rocks above Oregon City hereafter, I think a good snag-boat can keep the river open throughout low-water season by promptly proceeding to any point where trouble may occur. The cost of supplying the present snag-boat with propelling-power, scraper, pile-driver, &c., would be $6,500. A complete survey of the river between Corvallis and Portland, a distance of 114 miles, would cost about $12,000.

BARS, ETC., BETWEEN CORVALLIS AND OREGON CITY.

As previously stated, obstructions to navigation exist at various points in this section of the river. Proceeding from Corvallis down stream we find the first at

HALF MOON BEND, UPPER BAR,

four miles below. The river at this point is 440 feet wide. The left bank is about 15 feet above low-water, nearly vertical, formed of sand and clay, and yields readily to erosion; the right shore is a shelving bank of gravel, of which the obstructing bar is a continuation. During the summer of 1876 two wing-dams of nearly equal length were built just above the bar, one on each side. The good effected by these dams is shown by the fact that the depth over the bar has been increased from 22 to 51 inches. During the high-water last winter the bank on the left side and the gravel on the right, upon which the shore-ends of the dams rested, were cut away, leaving gaps which were closed this season.

The lower bar is situated one-third of a mile farther down. The river here is 450 feet wide, very crooked for some distance above and below the bar, and for several years has been shoaling, until at length a bar has been formed. A survey of this locality was made in June, 1877, and a dam constructed which it is hoped and expected will sluice out a channel very soon.

BOWER'S BAR.

This obstruction, next in order, is situated about 7 miles below Corvallis. A crib-dam was built here in 1872, and a channel obtained 100 feet wide and 42 inches deep, too narrow to afford sufficient water-way at the low stage of the river. The water being unable to erode the hard bottom on which the dam was built, cut a passage through the loose gravel-spit 500 feet above and thus diverted about one-third of the volume of the river from the steamboat-channel.

As this cut was enlarging rapidly, it was decided to close it in the summer of 1876 by means of a dam, to prevent the whole river turning into a circuitous channel. Soon after the completion of the dam and before its acceptance, it was ruptured by the water and a length of 20 feet carried away, causing such a sluice through the opening that in a short time the depth in the gap was increased from 6 to 11 feet; this was speedily repaired, but was again badly injured by the freshet in the fall of 1876. The volume passing through the gap was, however, found to be much less this spring than last year, the greater portion of the river being retained in the straight channel. In June, 1877, the dam was strengthened and repaired and the shore above revetted.

PINE TREE BAR.

The next difficulty heretofore has been encountered at this rapid about 14 miles below Corvallis. The river is 480 feet wide; on the right side

(concave) the bank is 15 feet high, and of sandy soil, overlying gravel which is from 3 to 5 feet thick; under this is a hard-pan, a ledge of which extends out into the river. On the opposite side the bank is low and shelving, composed of loose gravel thinly covered down to the low-water line with willows of recent growth. Dams were built on each side last year, by which the depth was increased from 24 inches to 48 inches. One of the dams was somewhat injured by heavy drift-logs last winter, but has been repaired this season.

UPPER FICKEL'S BAR.

This obstruction is 19 miles below Corvallis. Previous to the construction of the dams at this locality last season, the steamboat-channel was close under the left bank, and so narrow as to make the passage difficult. By building a dam across this channel, and closing a narrow slough which made off from the river half a mile above, the entire volume was made to flow over the middle of the bar, and the consequent erosion produced a channel 4 feet deep, which it is hoped will be permanent.

LOWER FICKEL'S BAR

is one mile lower down, and almost identical in shape and general character with the upper bar of the same name. A subordinate channel, called Black Dog Slough, formerly left the river half a mile above, diverting considerable water. This was closed by a dam last summer, and another dam was built on the left side of the bar, which has greatly improved the channel, increasing the depth from about 2 to over 4 feet.

BUENA VISTA BAR.

The next impediment is 24 miles below Corvallis.

This has always been one of the worst places on the river, if not the very worst. A gravel-bar, 5,000 feet long, extends diagonally from the right toward the left shore. It is from 200 to 800 feet wide, and from 1 to 3 feet above low water. It divides the river into two channels, the left of which is the principal and only one navigable, carrying the whole volume of the water, except a small portion flowing through two streams which come over the head of the bar into the right channel, which is nearly slack-water. The river is from 600 to 900 feet wide, the left shore steep, the bank formed of stiff clay, which resists erosion; the other shore is low, of sand and loam, and subject to overflow. At the lower end of the long bar the obstruction occurs. The surface of the water at the low stage is nearly 2 feet lower in the right channel than in the left, and the tendency of the current is to flow across the whole bar toward the right side.

Last season it was determined to build a dam along the crest of this bar near its lower end, beginning at the point where the water commences to flow over, and running it parallel to the general direction of the stream as far as might be necessary to scour a channel through the lower end of the bar.

The work was staked out and the contractor instructed to commence at the upper end and rapidly build down stream, completing the dam as he progressed. Instead of this, he undertook, against the advice of the inspector of the work, to build from both ends toward the center, leaving the deepest part for the last, and, as a consequence, the current commenced cutting through the gravel, running at the rate of about 5

miles an hour, and before the gap could be closed made a cut 11 feet deep, and damaged his work very much. Assistant Engineer Habersham was at once sent to the locality, and with his energetic assistance, after changing somewhat the general direction of the lower portion of the dam, the work was completed. It was an exceedingly difficult job, and had Mr. Habersham not been on the ground I doubt whether the contractor would have succeeded.

The plan adopted was as follows: A line of piles 5 feet apart was driven to hard bottom throughout the length of the proposed dam. Just above the piles a course of gunny sacks, about three-quarters filled with gravel, was laid close together with their ends up and down stream. Next came a course of fascines of fir boughs, 20 feet long, their butt-ends down stream, resting on the sacks, and each weighted down with 2 or 3 sacks of gravel. Then a second course of sacks doubled the intervals filled with loose gravel. This process was repeated until the dam was built up to within a foot of the surface of the water. Then a line of stringers, logs about a foot in diameter, held by ropes to piles driven about 30 feet up stream, was laid on the crest of the dam and weighted down with fascines and gravel, the latter about 2 feet thick and raked smooth. The ropes holding the stringers were then cut. By building the dam in layers, the water was gradually diverted, but incessant watchfulness was necessary to prevent cutting the gravel around the piles. A scow-load of sacks of gravel was kept ready for immediate use, and this saved the work, as the gravel commenced washing out three times during the construction. This method of building *cheap* dams in swift water appears to be quite satisfactory. The effect of this dam was to wash away the lower end of the long bar, removing two smaller islands covered with young willows which projected above the water, deepening the channel and lessening the inclination over the bar. The winter flood did not injure the work, but in May, 1877, a raft of logs carried away about 60 feet, causing a sensible waste of water through the gap. This will be repaired, and additional work added this season. Two short dams were also built above the bar, cutting off minor channels running behind islands.

The next obstruction has hitherto been found at

LONG-CROSSING BAR,

twenty-seven miles below Corvallis. This is simply a wide portion of the river where the loss of velocity causes a bar. The steamboat-channel, where there was only about 24 inches depth at extreme low water, was formerly under the west shore. In the middle of the river there was only 12 inches. Last summer two wing-dams were built, concentrating the water in the middle of the stream, and sluicing out a channel 4½ feet deep at low water.

HUMPHREY'S ROCKS,

thirty-one miles below Corvallis, is the next obstruction. There are two channels here. The eastern is obstructed by a bar, showing gravel on its surface, and is only navigable during the high stages of the river. Several years ago an attempt was made to divert sufficient water from the west channel to remove this bar, by constructing a wing-dam. The object in view was not accomplished. The west channel is, and will probably continue to be, the best for navigation, and it is possible that it may be necessary to entirely close the other. It is obstructed by a ledge of rocks, which, from all appearances, is the same on which

the gravel-bar at the head of the east channel rests, while the island between the two channels is a deposit of gravel and alluvium dropped below the ledge by the current, and afterward overgrown by vegetation. The gradual growth of this island has contracted the water-way, causing considerable erosion of the banks on both sides of the river. Forty-seven cubic yards of rock were removed from this ledge during the past summer, greatly improving the west channel.

ROCKY RAPID,

about 39 miles below Corvallis, was the next obstruction. A ledge of basaltic rock crops out from the east shore at low-water mark with a dip of about 4 degrees, running under water. On top of the ledge were a number of loose fragments of rocks of various sizes, which had from time to time injured steamers. These pieces were broken up by blasting, and a rough wall built with them on the ledge near the shore. An isolated rock was also removed from the channel. The bar is now in good condition, and has a depth of over 4 feet at low water upon it.

EOLA BAR,

forty-two miles below Corvallis, is the only obstruction between Rocky Rapid and Salem. The channel is shallow and very crooked, and generally gives trouble toward the end of the low-water season. No work has heretofore been done upon it, but wing-dams will be constructed this season.

Salem, the capital of Oregon, is 45 miles below Corvallis, and about 58 miles above the falls at Oregon City.

The first obstruction below Salem occurs at

M'CLOSKEY'S CHUTE,

nine miles distant. The river here divides into two principal channels, the eastern and western. The latter, after losing a large portion of its volume through an arm which leaves it a short distance from its head, spreads over a shallow bar, and the difficulty occurs at that point. Although the volume of the east channel, which is the straighter and must eventually be the main one, has increased somewhat within the last two years, still, as yet, the western carries by far the greater amount of water, and will be used probably for the next two years. As the snag-boat was being towed up the river, it was left here for a day or two and raked the channel, improving it somewhat, and showing what can be done if the boat should be furnished with sufficient power. During the present season wing-dams will be constructed here, which it is hoped will assist materially in sluicing a channel through the bar.

LONE TREE BAR,

eleven miles below Salem, gave a great deal of trouble previous to the fall of 1875. The river is 900 feet wide during ordinary stages, and 400 feet during low water; a wing-dam 1,430 feet long was constructed, under the supervision of my predecessor, which increased the depth on the bar from 18 to 36 inches; the dam was somewhat injured by the freshets of the winters of 1875–'76 and 1876–'77, and will be repaired during the present season.

GERVAIS SLOUGH,

about 18 miles below Salem, is now the only channel at low water, the crooked arm formerly the principal channel, known as Biterman's Bend, having become closed by drift and gravel-bars. During the past winter the floods stripped the vegetation from the lower end of the island, and caused a great deal of erosion at the same point; the next high water will probably complete the removal of this tongue of land, and greatly improve the river here.

BENNETT'S DREAD SLOUGH.

This slough is 22 miles below Salem; the volume of water passing through it is more than triple that of two years since, the minimum depth having increased from 6 to 24 inches; erosion of the bottom is progressing so rapidly that in a year or two more this will probably be the steamboat-channel; the change is due partly to the removal of snags, and partly to the dam constructed at Union Bar in 1875, whereby a greater volume of water passes down the slough; should it become the main channel, as is expected, 1,800 feet in distance will be saved and two difficult bars, "Union" and "Bennett's Dread," avoided. At

CAREY'S BEND,

thirty-six miles below Salem, the channel is more direct than it was last year, and it is probable no work except the removal of snags will be required.

POLALLEY BAR,

fifty-three miles below Salem, gives trouble this season; there are two channels, one in the middle of the river, the other along the west side; two minor channels leading from the main stream above the bar will be closed this season, and a wing-dam constructed so as to deepen the channel in the middle of the river.

A short distance below Polalley Bar basaltic rock again appears, and we find

BISSELL'S ROCK.

The removal of about 100 yards of rock would greatly improve the channel here; hitherto buoys have been located on the rocks, but all have been carried away; new ones have been made which will be placed in position during the present season.

Just below Rock Island, and about 3 miles above Oregon City, we find

DOVE'S ROCK,

a dangerous obstacle at certain stages of the river. This rock is nearly level, and stands about 6 inches on an average out of water, at the lowest stage, but at all times when it is covered with from 1 to 5 feet water the current sweeps over it with such force as to make it very difficult for descending steamers to make the sharp bend in the channel necessary to avoid it; one steamer has been wrecked here, and others injured; at low-water and during floods there is no trouble. I think it best here to widen and straighten the channel so that steamers descending will pass between Dove's Rock and the ledge to the right of it, instead of making the sharp turn now necessary to pass to the left of it;

a channel 75 feet wide can be obtained by removing about 300 cubic yards of rock, which can be blown off into deep water, and the channel raked.

The foregoing completes the list of impediments to navigation between Corvallis and Oregon City.

A careful observation of the river during its lowest stage for the past two years has shown how the obstructions at the gravel-bars occur; take for example McCloskey's Chute, 9 miles below Salem, which always gives trouble during the early part of the season. During the higher stages, the depth of water and the velocity of the current are nearly uniform all over the bar, the small irregularities not affecting sensibly the general flow of the current; but by the time the water has nearly reached its lowest stage, the surface of the bar presents several dry ridges, separated by shallow channels, neither of them deep enough to be navigable; erosion continues most rapidly where the gravel is finest, and here the volume and current increase, the other channels being in proportion, until nearly the whole body of the river passes through one channel, after which there is plenty of water for the rest of the season.

The first flood, however, fills up the new channel, and every season the two processes are repeated from one to three months, each spring and summer being consumed in forming a new channel, navigation during this period being seriously interrupted. A small steamer provided with a scraper and pile-driver could in a few days open each of these channels, and the current following the scraper would keep them open throughout the season.

OPERATIONS DURING THE FISCAL YEAR.

Work has been in progress during the fiscal year, constructing wing-dams and removing rocks under contract, and removing trees, stumps, and snags with the United States snag-boat. The work done under contract in the summers of 1876 and 1877 has been as follows:

Name of locality.	Distance from Portland, in miles.	Cubic yards of rock excavated.	Total length of dams built, linear feet.	Former depth of the steamboat-channel.	Present depth of the steamboat-channel.
				Inches.	*Inches.*
Half-Moon Bend, upper bar	110½	.....	727	22	51
Half-Moon Bend, lower bar	110	.....	189	24	(*)
Bower's Bar	107	.....	423	42	54
Pine-tree Bar	101	.....	583	18	48
Upper Fickel's Bar	95¾	.....	553	36	48
Black-Dog Slough	95½	.....	331	Cut off	.....
Lower Fickel's Bar	95	.....	190	18	53
Above Buena Vista Bar	91	.....	230	Cut off	.....
Buena Vista Bar	90½	.....	750	20	36
Long Crossing Bar	88	.....	756	24	54
Humphrey's Rocks	84	47	.....	22	36
Rocky Rapid	76	24¼	.....	36	54
Total	.....	71¼	4,732	.....	.....

(*) Dam built in June, 1877.

The two last columns show the actual increase of depth gained by the improvements at all bars, except Buena Vista and Lower Fickel's, where it is much greater, the channel at these localities having been entirely

changed, crossing the bars at points where formerly there was from 6 to 12 inches of water only. The total work under contract consisted, therefore, in constructing 4,732 feet of dams, and excavating 71¼ cubic yards of rock.

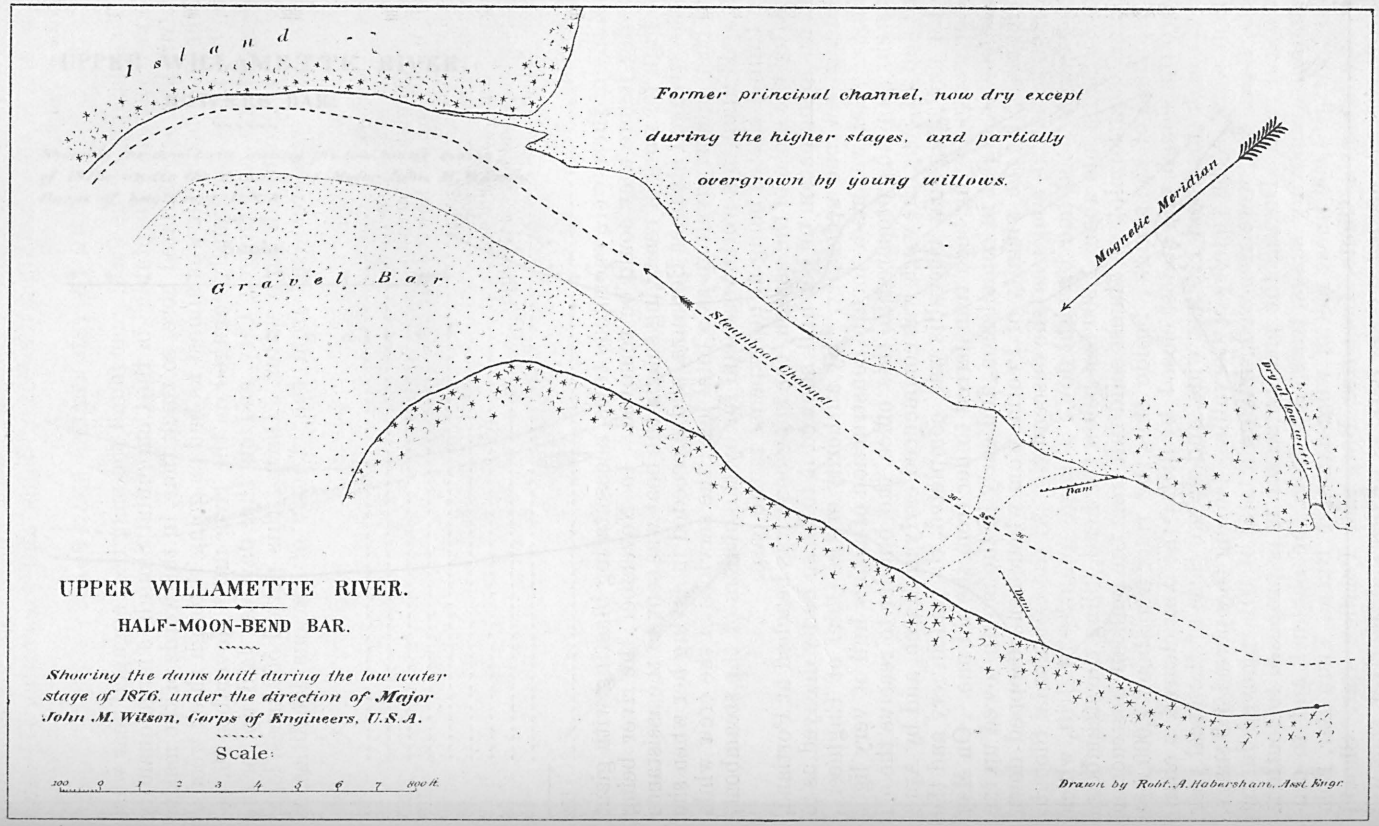
THE UNITED STATES SNAG-BOAT.

The opening of the fiscal year found the snag-boat engaged near what is known as the "Turntable" in the Centennial Slough; a large quantity of drift had accumulated here, so thick that, in the words of the master of the snag-boat, "it was almost as bad as going through thick woods." The boat was continually engaged on the river until November 10, between Peoria and Oregon City, and on that day was laid up for the season on account of high water. During this period 552 trees, logs, roots, &c., were removed from the vicinity of various localities, as follows:

Centennial Slough	34
Foot of Palmer's Prairie	36
Hogue's Slough and Corvallis	195
Half-Moon Bend and Bower's Bar	107
Buena Vista	50
Eola Slough	50
Mouth of the Luckiamute	32
Independence and Gervais Slough	38
Below Salem	10
Total	552

Many of these were enormous trees, necessitating blasting with giant powder before they could be removed. In November, the river being too high for work of removing snags, the boat was sent to the assistance of the wrecked steamer Bonanza, and succeeded in saving her when she had been almost given up as a total loss; the services of the crew while engaged upon this work were paid for by the owners of the steamboat, the United States being at no expense in the case.

After the close of the season, the snag-boat was beached at Portland, and an examination of her hull showed it to be so badly decayed as to render a new one necessary. By authority of the Chief of Engineers, an agreement was made for the construction of a new hull of very light draught on plans prepared in this office, the builder to receive the old hull and $1,800; the work was commenced early in March, and by April 30 the new snag-boat Corvallis was completed, the machinery and the upper works having been transferred to her from the old one. On May 1 the boat was put in commission, and early in the month towed up the Willamette to the vicinity of Peoria, from whence she dropped down stream, removing snags as she descended. At the Centennial Slough, last winter's flood had brought down a large quantity of drift, which had formed a jam about 1,200 feet below the head, filling the steamboat-channel and forming an almost solid raft from the point of obstruction to the head of the slough; beside this, the river for about 1,000 feet above the slough was almost closed by drift; the boat cleared a channel through this about 100 feet wide, and at the close of the fiscal year was at work in the vicinity of Corvallis. During this period 349 snags, roots, trees, &c., were removed, making a total of 901 removed during the fiscal year. During the present season it is proposed to continue operations, removing snags, trees, &c., from the channel, and to construct about 4,000 linear feet of wing-dams at Buena Vista Bar, Eola Bar, McCloskey's Chute, Lone-tree Bar, and Polalley Bar. Should improvements be needed at other bars, as we descend the river, they will be made.



UPPER WILLAMETTE RIVER.

HALF-MOON-BEND BAR.

Showing the dams built during the low water stage of 1876, under the direction of Major John M. Wilson, Corps of Engineers, U.S.A.

Scale:

100 0 1 2 3 4 5 6 7 800 ft.

Drawn by Robt. A. Habersham, Asst. Engr.

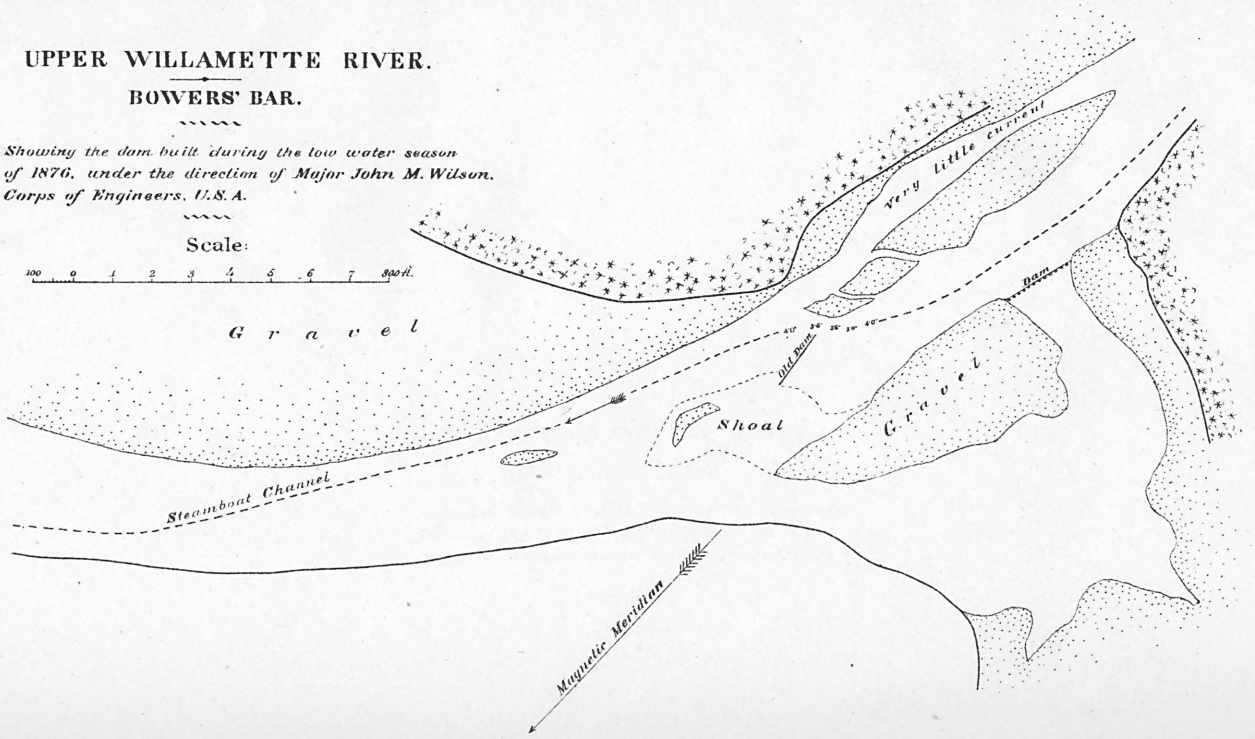
UPPER WILLAMETTE RIVER.

BOWERS' BAR.

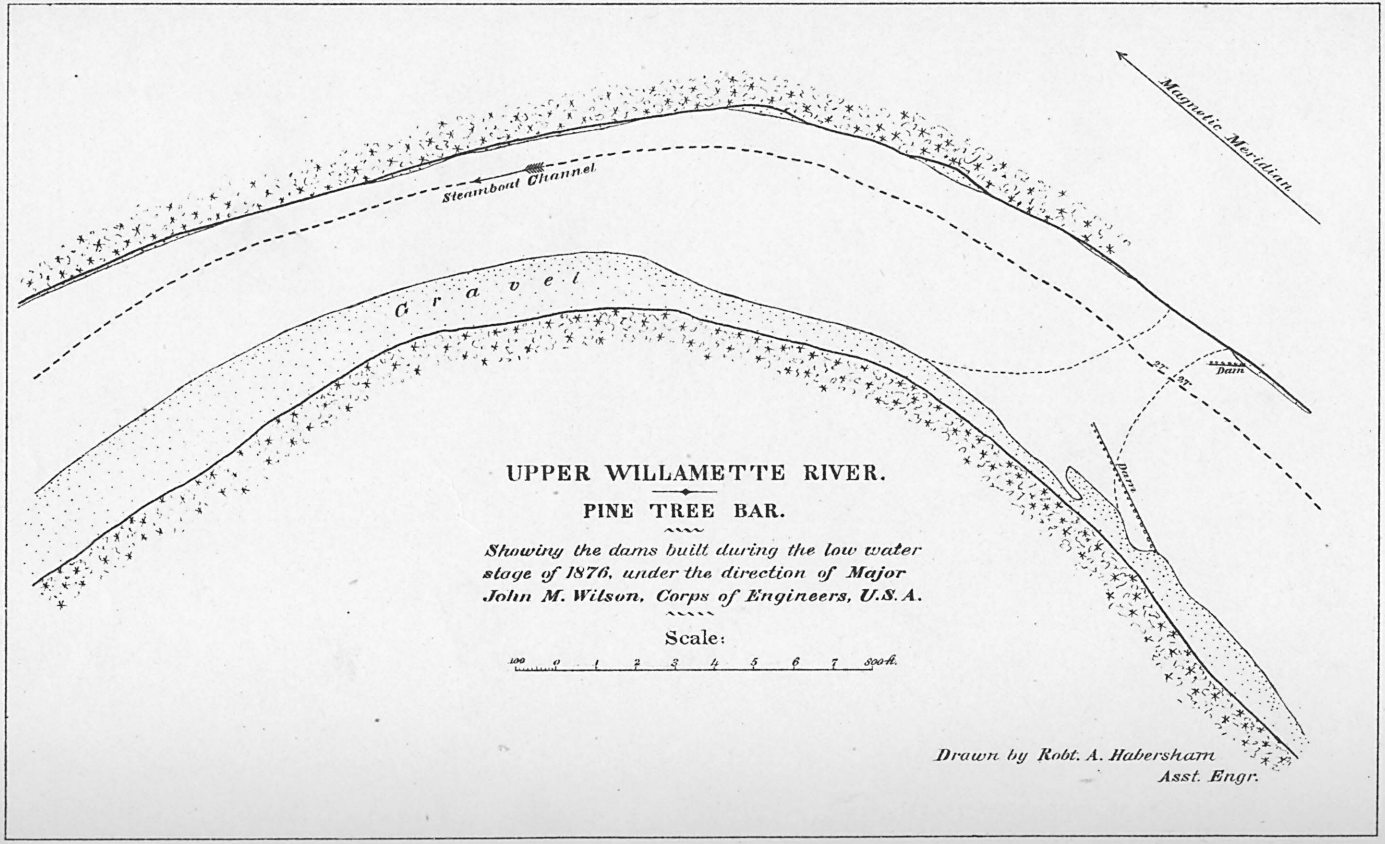
Showing the dam built during the low water season of 1876, under the direction of Major John M. Wilson, Corps of Engineers, U.S.A.

Scale:

100 0 1 2 3 4 5 6 7 800 ft.



Drawn by Robt. A. Habersham, Asst. Engr.



UPPER WILLAMETTE RIVER.

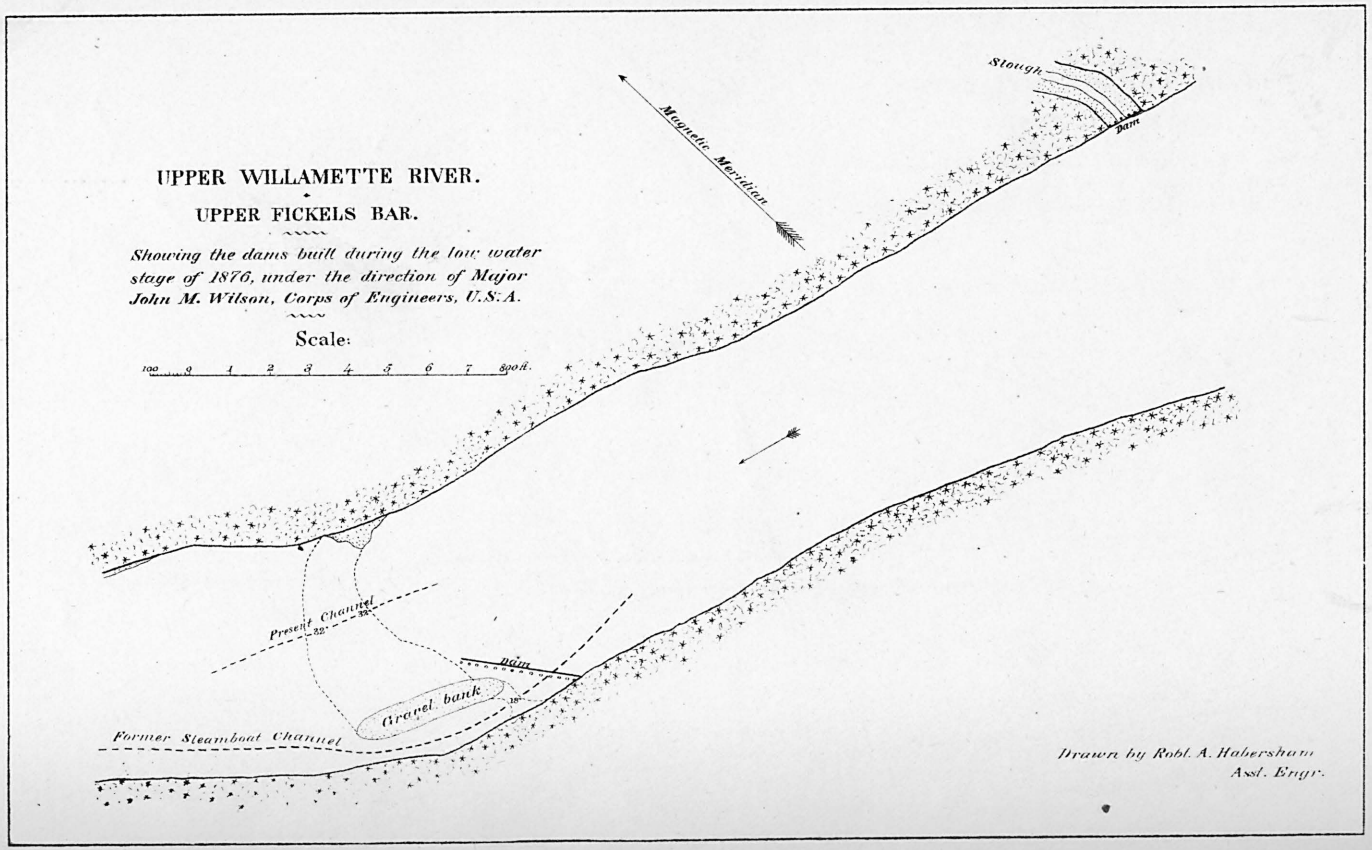
PINE TREE BAR.

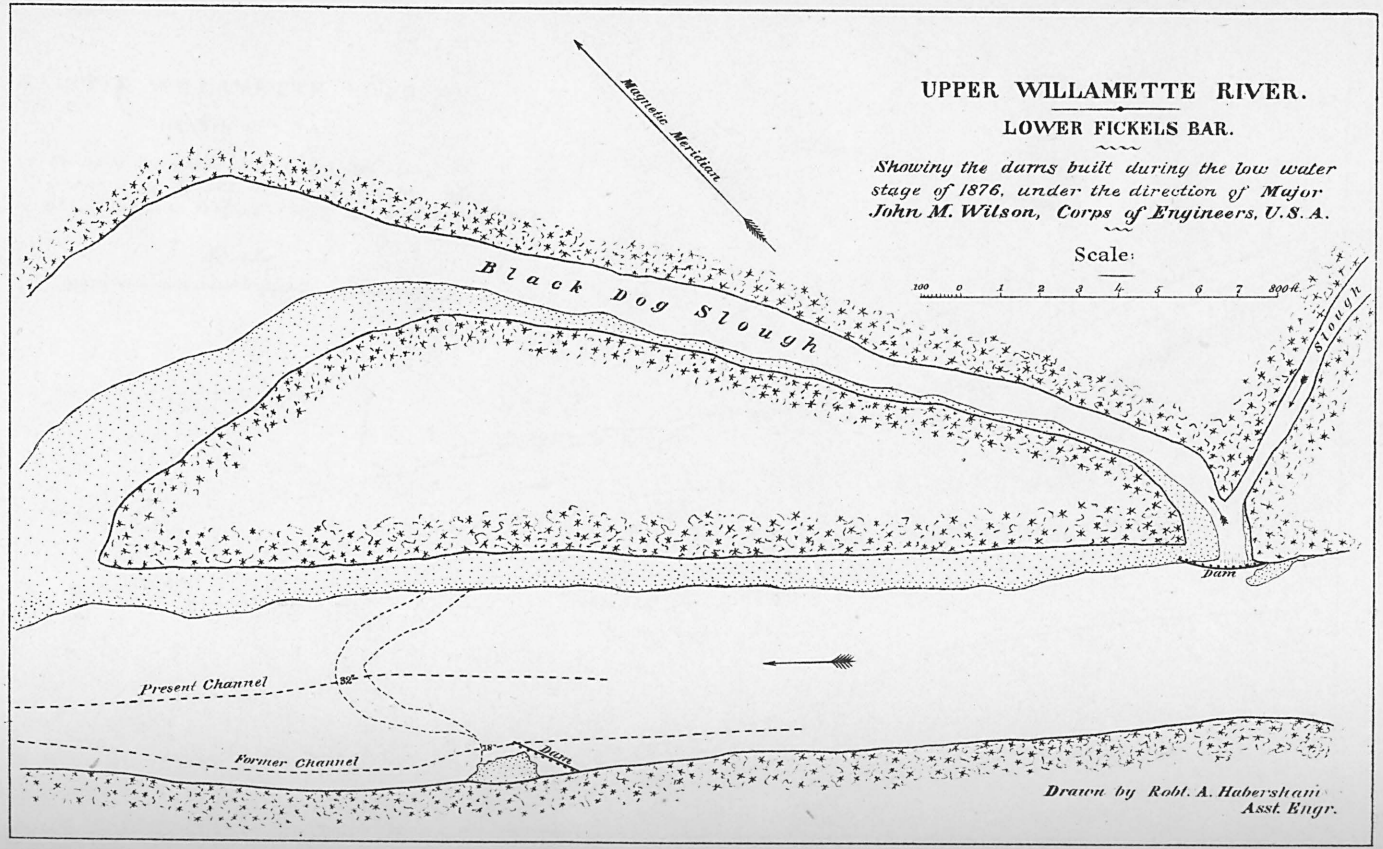
Showing the dams built during the low water stage of 1876, under the direction of Major John M. Wilson, Corps of Engineers, U.S.A.

Scale:

100 0 1 2 3 4 5 6 7 8000ft.

Drawn by Robt. A. Habersham
Asst. Engr.


UPPER WILLAMETTE RIVER.
UPPER FICKELS BAR.
Showing the dams built during the low water stage of 1876, under the direction of Major John M. Wilson, Corps of Engineers, U.S.A.
Scale:
100 0 1 2 3 4 5 6 7 8 Feet.
Magnetic Meridian
Slough
Dam
Present Channel
32°
33°
Dam
Gravel bank
18°
Former Steamboat Channel
Drawn by Robt. A. Habersham
Asst. Engr.



UPPER WILLAMETTE RIVER.

LOWER FICKELS BAR.

Showing the dams built during the low water stage of 1876, under the direction of Major John M. Wilson, Corps of Engineers, U.S.A.

Scale:

100 0 1 2 3 4 5 6 7 800 ft.

Drawn by Robt. A. Habersham Asst. Engr.

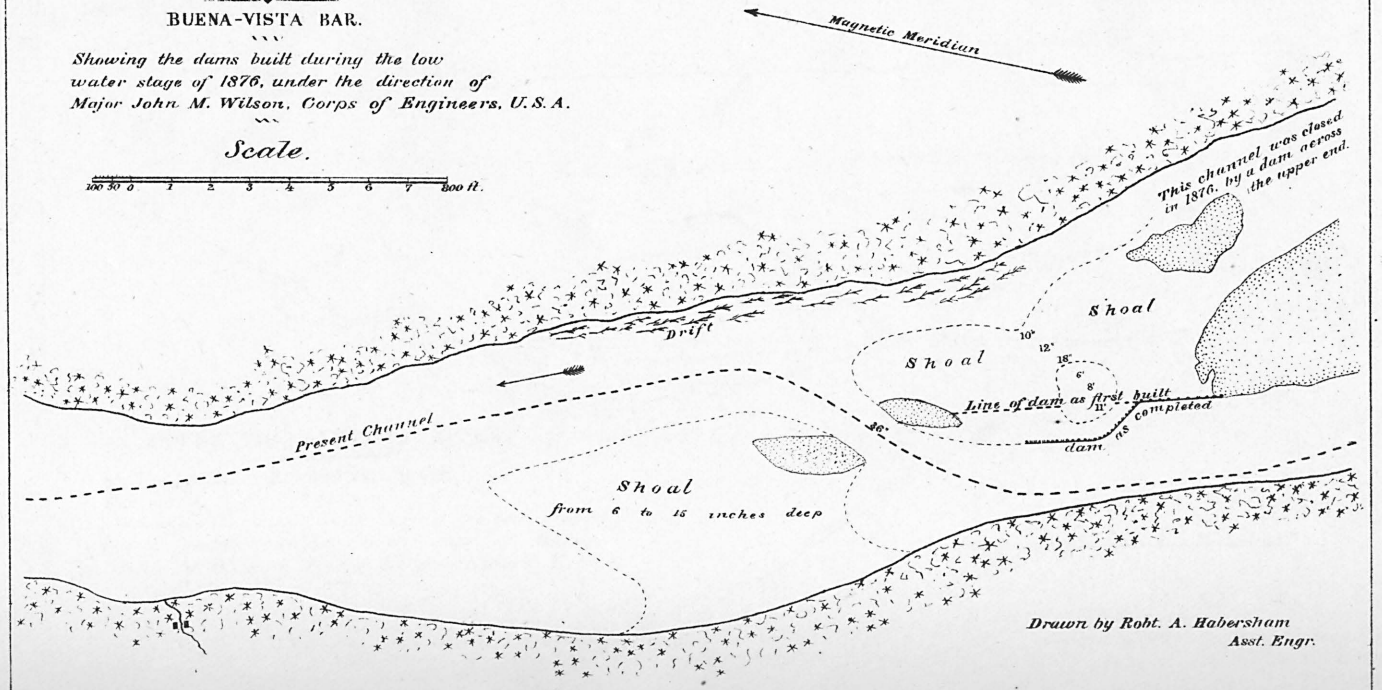
UPPER WILLAMETTE RIVER.

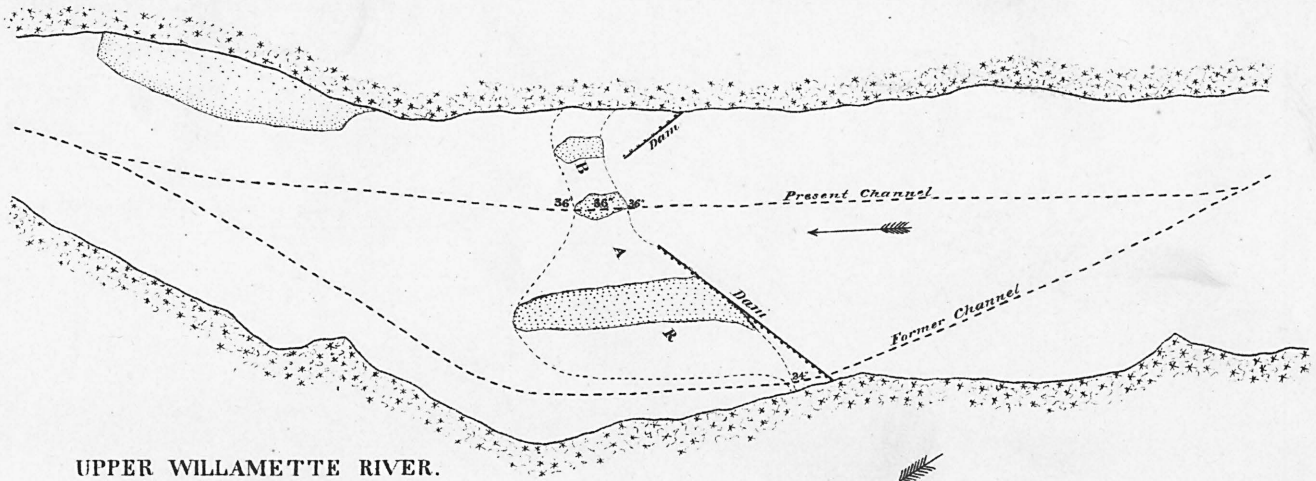
BUENA-VISTA BAR.

Showing the dams built during the low water stage of 1876, under the direction of Major John M. Wilson, Corps of Engineers, U.S.A.

Scale.

100 50 0 1 2 3 4 5 6 7 800 ft.





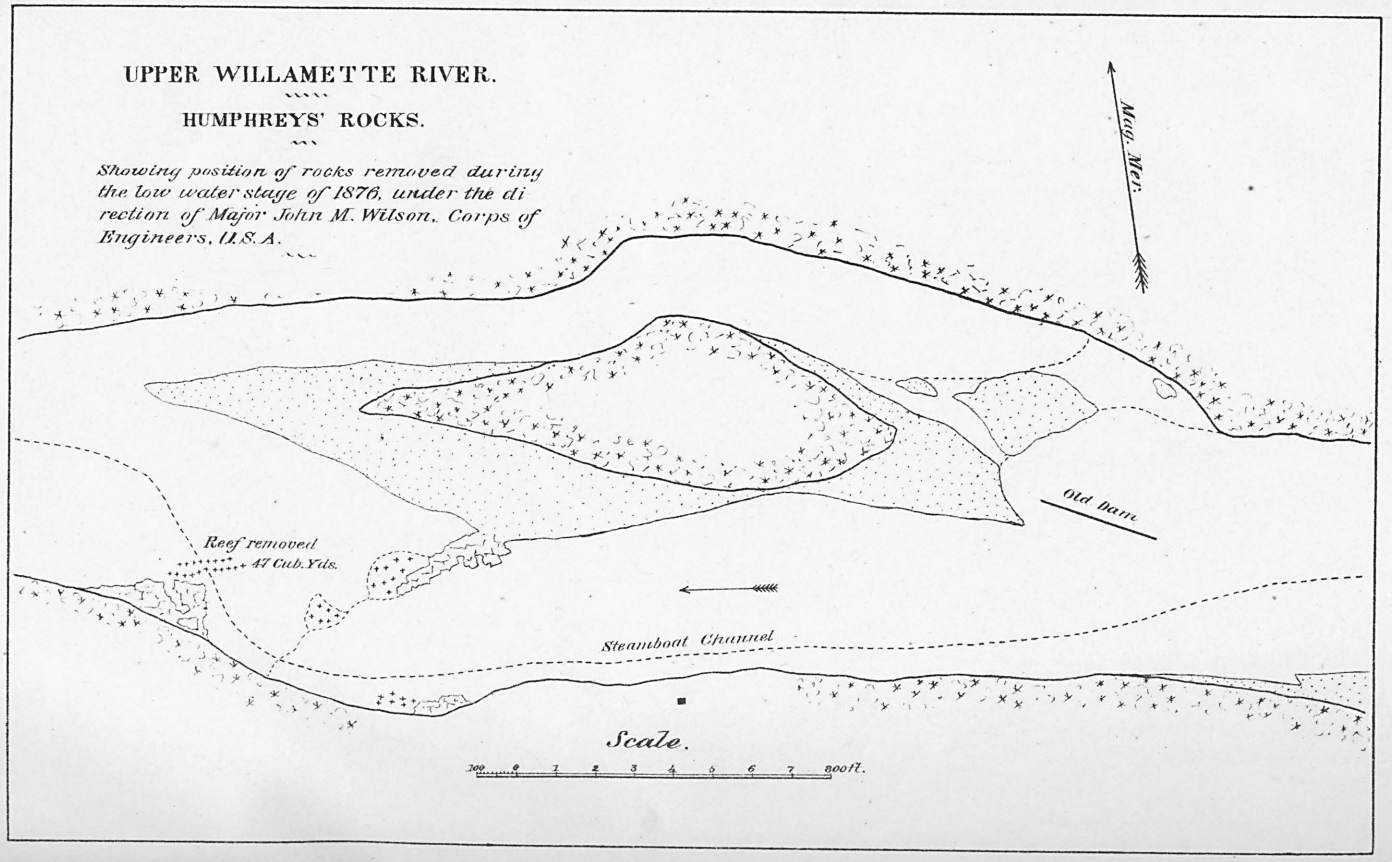
UPPER WILLAMETTE RIVER.

LONG CROSSING BAR.

Showing the dams built during the low water stage of 1876, under the direction of Major John M. Wilson, Corps of Engineers, U.S.A.

Note. The sketch represents the bar before the dams were built. The figures show the depth in September; in the new channel.

Drawn by Robt. A. Habersham Asst. Engr.


UPPER WILLAMETTE RIVER.
HUMPHREYS' ROCKS.
Showing position of rocks removed during the low water stage of 1876, under the direction of Major John M. Wilson, Corps of Engineers, U.S.A.
Mag. Mer.
Old Dam
Reef removed
47 Cub. Yds.
Steamboat Channel
Scale.
100 0 1 2 3 4 5 6 7 800ft.

UPPER WILLAMETTE RIVER.

ROCKY RAPID.

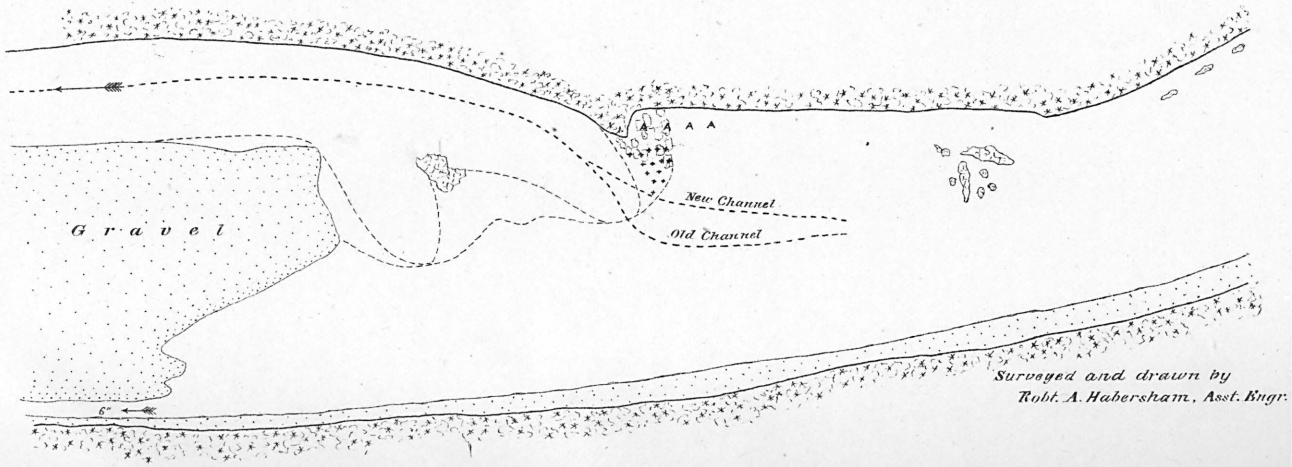
Showing the position of rocks removed during the low water stage of 1876 under the direction of Major John M. Wilson, Corps of Engineers, U.S.A.

Magnetic Meridian

Note.
*Rocks removed from point marked ***, and deposited at A A.*
Volume of rock removed 24.25 C.Yds.

Scale.

100 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 feet.



Surveyed and drawn by
Robt. A. Habersham, Asst. Engr.

The project now presented consists of the following:

To build 6,000 feet of cut-off dams and 8,000 feet of wing-dams, and construct a snag-boat with scraper and pile-driver for work above Corvallis; to add propelling power, scraper, and pile-driver to the present snag-boat for work below Corvallis; to remove portions of Bissel's and Dove's Rocks above Oregon City, and to make a complete survey between Corvallis and Portland, a distance of 114 miles. The estimated cost of this project is as follows:

6,000 feet of cut-off dam, at $3	$18,000 00
8,000 feet of wing-dam, at $2	16,000 00
New snag-boat above Corvallis	12,000 00
Improvement of snag-boat below Corvallis	6,500 00
Survey between Corvallis and Portland, 114 miles	12,000 00
Maintenance of two snag-boats, each six months, at $900 per month, each $5,400	10,800 00
Removing 100 cubic yards Bissel's Rock, at $9	900 00
Removing 300 cubic yards Dove's Rock, at $5	1,500 00
Contingencies and engineering	2,300 00
Total	80,000 00

An annual appropriation of about $12,000 will be required to keep the snag-boats in order and run them.

The following statistics required by the act of June 23, 1866, are respectfully submitted:

The appropriations for this work have been as follows:

Act of March 3, 1871	$16,000 00
Act of March 3, 1873	3,000 00
Act of June 23, 1874	7,500 00
Act of March 3, 1875	25,000 00
Act of August 14, 1876	20,000 00
	71,500 00

Of this amount $57,258.22 has been expended to date. The project now submitted calls for the construction of certain dams, and building, and maintenance for one year, of snag-boats at a cost of $80,000; of this amount $50,000 can be profitably expended during the next fiscal year.

This river is in the collection-district of the Willamette; Portland, Oreg., is the nearest port of entry, and the nearest light-houses and works of defense are at the mouth of the Columbia River.

The amount of revenue collected at the port of Portland, Oreg., during the eleven months ending June 1, 1877, was $125,317; the value of the imports was $388,476, and of the exports $2,509,159; 177 vessels with an aggregate tonnage of 152,961 tons entered, and 153 with a tonnage of 144,296 tons cleared during the same period. There are four companies now running boats on the Upper Willamette River, as follows: the Willamette Transportation and Lock Company, U. B. Scott & Co., the owners of the S. T. Church, and the owners of the McMennville.

During the eleven months from July 1, 1876, to June 1, 1877, the Willamette Transportation and Lock Company carried through their locks at Oregon City the following:

Seven thousand six hundred and seventy-seven up-passengers; 7,141 down-passengers; 6,098 tons of up-freight; 57,452 tons of down-freight; of the latter, 49,699 tons was wheat and flour.

The steamer S. T. Church ran only a few weeks during the year, and carried the following:

One hundred and twenty-five passengers up-stream; 150 passengers down-stream; 100 tons of up-freight; 3,000 tons of down-freight; of the latter, 2,900 tons was wheat.

I was unable to procure information from the other companies in reference to the amount of business done by them.

The commerce of this river is increasing, but I cannot give an estimate of the amount that will be benefited by the completion of this work;

the navigation to be improved extends from Portland to Eugene City, a distance of 172 miles.

Abstracts of proposals and contracts, a statement of funds, and 9 charts, showing location of work done during the year, are transmitted herewith.

Money statement.

July 1, 1876, amount available	$8,038 25	
Amount appropriated by act approved August 14, 1876	20,000 00	
		$28,038 25
July 1, 1877, amount expended during fiscal year	13,796 47	
July 1, 1877, outstanding liabilities	2,157 45	
		15,953 92
July 1, 1877, amount available		12,084 33
Amount (estimated) required for completion of existing project		80,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		50,000 00

Abstract of proposals for building wing-dams in the Upper Willamette River, Oregon, opened by Maj. John M. Wilson, Corps of Engineers, February 8, 1877.

No.	Names and residences of bidders.	5,000 feet wing-dams, more or less, per linear foot.	Remarks.
1	Grant & Stone, The Dalles, Oreg	$1 90	Contract awarded.
2	Joseph Paquet, Oregon City, Oreg	2 40	No guarantee accompanying proposal. Bid thrown out.
3	Peter Paquet, Oregon City, Oreg	2 40	

Abstract of contracts for the improvement of the Upper Willamette River, Oregon, in force during the fiscal year ending June 30, 1877.

Number.	Names and residences of contractors.	Date of contract.	Class I.	Class II.	Class III.
			8,000 feet of wing-dams, more or less, per linear foot.	Removal of rock at certain points, per cubic yard.	5,000 feet of wing-dams, more or less, per linear foot.
1	Peter and F. X. Paquet, Oregon City, Oreg	Sept. 6, 1875	$1 80	$15 00	.....
2	Grant & Stone, The Dalles, Oreg	Feb. 26, 1877	.....	.....	$1 90

JJ 3.

IMPROVEMENT OF THE UPPER COLUMBIA AND SNAKE RIVERS, OREGON AND WASHINGTON TERRITORY.

The portions of these rivers to be considered, and for which appropriations have heretofore been made, consist of the Columbia River from Celilo, 240 miles above its mouth, to its junction with the Snake River, a distance of 117 miles, and the Snake River from its mouth to Lewiston, a distance of 149 miles, making a total length of 266 miles to be improved. Within this stretch of river-navigation there are 25 rapids, nearly all of which will require improvement before the river can be

navigated with safety, and many of which require immediate work in order that steamers may ascend to Lewiston, Idaho, during the low-water season. A careful reconnaissance of all these rapids has been made by myself, and surveys have been made of some of them under my direction during the past fiscal year, and I am now able to give a general description of them, and to present a project for the improvement of these rivers from Celilo, Oreg., to Lewiston, Idaho.

THE COLUMBIA RIVER.

Starting from Celilo, the terminus of the railroad around the Dalles of the Columbia, the first difficulty is encountered at

FIVE-MILE RAPID,

about that distance above. This place requires skillful navigation, but is not considered by pilots very dangerous. To improve it would require a large outlay owing to the length and massive character of the rock. No work is proposed here at present.

LOWER JOHN DAY'S RAPID

is 10 miles further up. At this locality two rocks in the channel, estimated to contain about 100 cubic yards, require removal. One and one-half miles above is

MIDDLE JOHN DAY'S RAPID.

A rock which formerly greatly obstructed the channel here was removed in 1874, and no further work is required at present.

UPPER JOHN DAY'S RAPID

is about a mile above. There are two channels here, one on the north and one on the south side. The improvement of this locality is of first-class importance, and the removal of about 400 cubic yards of rock from the channel is necessary to render it navigable without danger.

INDIAN RAPID,

three miles above, does not require attention at present. At some future day it may be deemed necessary to remove some rock lying at the head of the rapids.

SQUALLY HOOK RAPID

is next in order, and 3 miles above. The lower portion of this rapid has been much improved during the past season. At a low stage of the river loaded boats descending will be obliged to drift around the bend which the channel makes, but this can be done with safety and but little delay, and no trouble will be had by boats ascending. Any further improvement will require the removal of a large quantity of rock, and is not recommended at present.

Four miles above is

ROCK CREEK RAPID,

a place where there are three channels. The main one, which should be used for running down stream, is obstructed by a single rock in mid-

channel; this channel is on the south side, and has too swift a current for running up stream. The middle channel is used by boats ascending, and is good for that purpose, but has too sharp a bend for coming down. The north channel is used at present for boats descending, but is narrow and very shoal at low-water. The rocks to be removed here are the one in the main channel, one which divides the middle from the north channel, and a small one on the lower side of the middle channel, aggregating in all about 100 cubic yards.

OWYHEE RAPID

is 10 miles above. A large rock was removed from the channel here during the winter of 1876–'77, and, although the rapid requires skillful navigation, no further work is deemed necessary at present.

Twenty-three miles above we find

CANOE ENCAMPMENT RAPID.

No material difficulty is experienced in passing this by daylight, and no work is deemed necessary at present.

DEVIL'S BEND,

20 miles beyond, is a difficult and dangerous place, requiring improvement; five rocks should be removed from the channel here, aggregating in all about 150 cubic yards. Four miles above Devil's Bend is the town of Umatilla, from whence a line of stages run, crossing the Blue Mountains and connecting, via Pendleton, Baker City, and Boise, with the Central Pacific Railroad at Kelton, Utah. Six miles above Umatilla we find the

LOWER UMATILLA RAPID.

The channel here is very crooked and its improvement of primary importance; at least 225 cubic yards of rock should be removed; the work can be easily accomplished, as the current at the stage at which it should be done is comparatively slack, not exceeding 4 miles an hour.

A short distance above is

MIDDLE UMATILLA RAPID,

where the channel is difficult and dangerous to navigate; two rocks lie about 60 feet apart, one on each side of the channel at the head of the rapid; the one on the left ascending should be removed; it is about 80 feet long and 10 feet wide, with a depth of about 1½ feet upon it at low-water; there are two other rocks lying directly below it, at a distance of about 200 and 300 feet respectively, both on the same side of the channel, which require removal; the total to be removed from this rapid is about 150 cubic yards.

UPPER UMATILLA RAPID

is a short distance farther up; work has been in progress here for the past three years, improving the high-water channel so as to render it available at all stages of the river; it has now a width of 70 feet at low-water, which should be increased to at least 100 feet; the former low-

water channel is long, crooked, difficult, and dangerous, expecially with a large boat, and a variation of 15 or 20 feet either way from the narrow channel would result in disaster. To complete the high-water channel so as to render it available at all stages of the river will require the removal of about 300 cubic yards of rock in addition to the work now under contract. About 10 miles above is a locality known as

MILL ROCK.

This place is difficult to pass after dark, and requires skillful navigation at all times. It is not, however, considered dangerous by pilots, although in descending with a well-laden boat very careful handling is required. No work is proposed here at present.

The town of Wallula is located 9 miles above. It is the terminus of the Walla-Walla and Columbia River Railroad, a narrow-gauge road, 32 miles long. The only remaining obstruction between Mill Rock and the mouth of the Snake is

HOMLY RAPID,

6 miles above Wallula. The larger and more serious obstacles were removed from this rapid last year, but the river is shoal and bowlders are liable to accumulate, being brought down by floating masses of ice.

To open this channel so as to render it safe at all times will require the removal of about 75 cubic yards of rock. From Homly Rapid the river presents a good channel to the mouth of the Snake.

THE SNAKE RIVER.

Entering this river we find some bowlders a short distance above the mouth which lie in the deeper portion of the channel, and although their removal is not immediately necessary, still at some future day it will be found advantageous to take out at least three of them, and thus permit steamers to pass over a deeper channel than they now use. The first serious obstacle is encountered at

FIVE-MILE RAPID,

situated about that distance above the mouth. This calls most imperatively for improvement, and is not only dangerous, but almost impassable at low-water. There are four rocks requiring removal, aggregating in all about 350 cubic yards.

Five miles above is a locality known as

THREE ISLANDS.

About 60 yards of rock could be removed here with advantage, but as it is not deemed absolutely necessary, it is not recommended for the present.

FISH-HOOK RAPID,

16 miles from the mouth of the Snake, is about 1 mile in length and consists of three belts or reefs. One rock at the head imperatively demands immediate removal, and work is required on each of the reefs, aggregating about 300 cubic yards in all.

The next obstruction is at

LONG CROSSING BAR,

about 15 miles above Fish-Hook Rapid. The channel here is shoal, with a bottom of rock and large bowlders. Two rocks which stand in the channel opposite to about the middle of the island should be removed, and some of the bowlders should be taken from the edge of the reef at the upper end. The aggregate amount to be removed here is about 200 cubic yards.

Two miles beyond is

PINE-TREE RAPID,

a very long and dangerous rapid, exceedingly difficult to navigate except at high-water. While endeavoring to pass this in the autumn of 1876, the steamer upon which I was traveling, although drawing only about 2 feet of water, struck twice and filled four compartments of her hull, and in spite of urgent effort was obliged to return without crossing. The channel, however, was greatly improved during the winter of 1876–'77 by making a cut through the massive reef at the upper end, hitherto impassable at low-water, and removing about fourteen other rocks. Much work is still required here; many bowlders must be removed and the chute through the upper reef widened. The aggregate amount to be taken out is about 650 cubic yards.

MONUMENTAL ROCKS

are about 8 miles above Pine-Tree Rapid. A reef stretches across the river here over which steamers must pass, and at low-water it is a dangerous place. The channel is broad, but crooked and shallow. Some high points of rock on the reef, principally from the right side of the channel ascending, require removal, the aggregate amount being about 250 cubic yards.

FALSE PALOUSE

is about 12 miles farther up. The channel lies between massive rocks and is narrow, but deep and straight. It should be widened by the removal of about 150 cubic yards of rock. Five miles above False Palouse, and nearly opposite the mouth of Palouse River, is

PALOUSE RAPID,

a wild, dangerous place, where the river, at low-water, dashes through a narrow channel, forming a natural canal through the rocks; the current is rapid, and navigation dangerous; at least five rocks, aggregating about 300 cubic yards, urgently call for removal at this place.

About 10 miles above Palouse we find,

TEXAS RAPID.

The river here has the strongest current and greatest fall in a short distance of any place below Lewiston. The rapid is about 1 mile long, and the fall is said to be over 15 feet. No really distinct channel exists at low-water, the river being so much divided by ledges of rock; one line, more distinct than the rest, will be selected for widening, and its improvement will require the removal of about 700 cubic yards of rock.

From Texas Rapid to Lewiston the river is in a favorable condition for navigation, with a good gravel bottom, although shoal, and is tolerably

free from obstructions, except at a point about 4 miles below Lewiston, where several rocks in a bend of the channel may ultimately require removal. This is, however, not immediately necessary. At

STEPTOE RAPID,

20 miles below Lewiston, there is a gravel bar where the construction of a wing dam may eventually be necessary. There are numerous other gravel bars, but they do not give much trouble.

The foregoing shows the various obstructions to navigation between Celilo and Lewiston. To recapitulate, the work required will be the removal of rocks about as follows:

Upper Columbia River.		Snake River.	
Name of rapid.	Amount.	Name of rapid.	Amount.
	Cub. yds.		*Cub. yds.*
Lower John Day Rapid	100	Five-Mile Rapid	350
Upper John Day Rapid	400	Fish-Hook Rapid	300
Rock Creek Rapid	100	Long Crossing Rapid	200
Devil's Bend Rapid	150	Pine-Tree Rapid	650
Lower Umatilla Rapid	225	Monumental Rocks	250
Middle Umatilla Rapid	150	False Palouse	150
Upper Umatilla Rapid	300	Palouse Rapid	300
Homly Rapid	75	Texas Rapid	700
Total	1,500	Total	2,900

Of the places mentioned there are six demanding immediate improvement on the Snake River, namely, Five-Mile, Fish-Hook, Pine-Tree, Monumental Rocks, Palouse, and Texas Rapids, while on the Columbia additional work is much needed immediately at the Umatilla and John Day's Rapids. Upon the completion of work at the six places named on the Snake, the rivers may be pronounced open to Lewiston, but the navigation of the rapids will still require skillful and careful pilots.

OPERATIONS DURING THE PRESENT FISCAL YEAR.

Owing to the river rising earlier than usual in the spring of 1876, Messrs. Grant & Stone were unable to complete their contract of October 29, 1875, within the time prescribed, and, in accordance with authority from the Chief of Engineers, it was extended until April 1, 1877.

In July, 1876, proposals were invited for removing 200 cubic yards, more or less, of rock from the channel at the Upper Umatilla Rapids, and on August 30, the work was awarded to Mr. J. B. Montgomery, of Portland, Oreg., the lowest bidder, at the rate of $31 per cubic yard.

By the act of Congress approved August 14, 1876, an appropriation of $15,000 was made for the improvement of the Upper Columbia and Snake Rivers, and it was determined to apply it to the improvement of Squally Hook Rapid, Columbia River, and Pine-Tree Rapid, Snake River, and to remove about 100 cubic yards of rock from the former and about 480 yards from the latter. As the season for operations was near at hand, by authority of the Chief of Engineers, instead of advertising, letters were at once addressed to the various contractors who had hitherto bid upon work of this character, requesting them to inform the engineer in charge by November 10, 1876, at what rate per cubic yard they would remove the amounts mentioned from Squally Hook and Pine-Tree Rapids.

Proposals were received from three parties, and the work was awarded to Messrs. Grant & Stone, the lowest bidders, for Squally Hook, at $23, United States currency, per cubic yard, and to Mr. J. B. Montgomery, the lowest bidder, for Pine-Tree Rapid, at $24.75, United States currency, per cubic yard, and contracts were made with these parties accordingly.

Operations were commenced under the contract of October, 1875, of Messrs. Grant & Stone, at

OWYHEE RAPID, COLUMBIA RIVER,

early in December, the contractors having been on hand for two or three weeks previously with their men and plank awaiting the necessary fall in the river. The work to be done at this rapid consisted in the removal, to a depth of 6 feet below dead low-water, of a large rock on the south side of the channel. On December 11 this rock was carefully surveyed, and found to contain 67.57 cubic yards. The work of drilling was at once commenced, and was progressing well when, on the 16th, the contractors, who had met with many misfortunes under their contract, were again subjected to a fearful accident, caused by the explosion of dynamite while being thawed, resulting in the killing of two men who were in the powder-house and the entire demolition of the building. The cause of the accident cannot be explained, as the only men in the building were killed. The man in charge of the powder had had considerable experience in its use, and had been employed by the contractors on that account. Operations were temporarily suspended, but again renewed the latter part of the month, and the removal of the rock completed early in January. The crew and plant were then taken down the river, and work commenced at once at

SQUALLY HOOK RAPID.

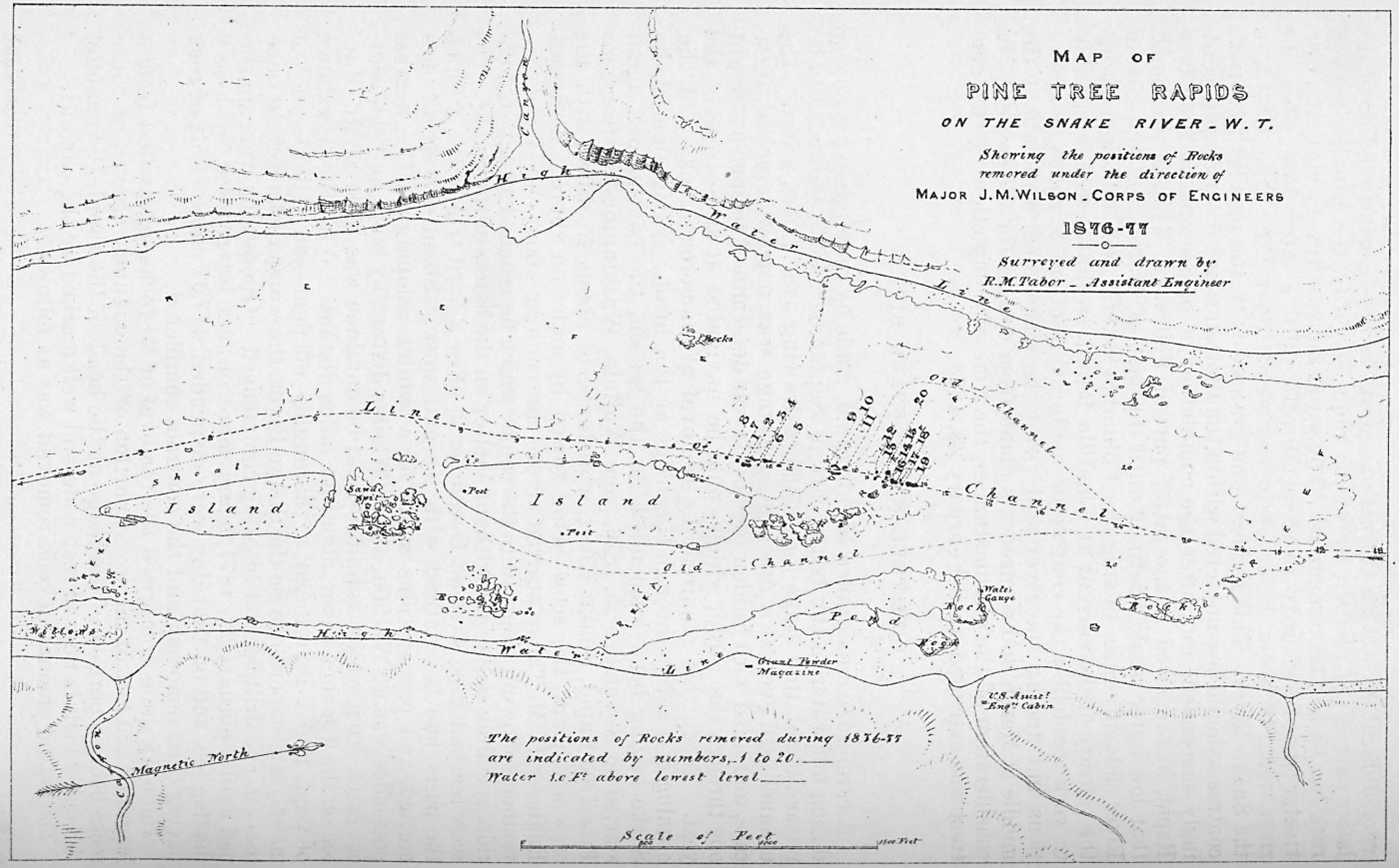
A ledge of rock extending into the channel at this place rendered navigation difficult and dangerous, steamers descending being obliged to drift very close to the ledge. After a careful survey it was determined to apply the remainder of the work to be done under the old contract of Grant & Stone (about 50 yards) and that under their new contract to this locality, and to widen the channel about 40 feet. The work of drilling and blasting was commenced on January 22, 1877, and by the close of February 150.06 cubic yards had been removed, the increased width desired obtained, and, the contracts having been completed, operations were suspended for the season.

The channel here has been greatly improved. Boats descending are, however, still obliged to drift around the bend during low-water, but as this can be done with safety and but slight delay, and, as any further improvement would necessitate the removal of a large quantity of rock, the continuance of work here is not recommended for the present.

The work of improvement at the

UPPER UMATILLA RAPID,

which consisted in widening the high-water channel, was commenced under the contract with Mr. J. B. Montgomery on the 18th of October, 1876. Rocks known as Nos. 18 and 19 were measured, and the work proceeded well, when, on the 24th, the river suddenly rose and rendered it


MAP OF
PINE TREE RAPIDS
ON THE SNAKE RIVER - W. T.
Showing the positions of Rocks removed under the direction of
MAJOR J.M. WILSON - CORPS OF ENGINEERS
1876-77
Surveyed and drawn by
R.M. Tabor - Assistant Engineer
Rocks
Old Channel
Island
Sand Spit
Post
Channel
Water Gauge
Rock
Pond
High Water Line
Grand Tender Magazine
U.S. Assist. Eng.rs Cabin
Magnetic North
The positions of Rocks removed during 1876-77 are indicated by numbers, 1 to 20.
Water 10 Ft above lowest level
Scale of Feet

very difficult to work. Operations were, however, continued until the latter part of November, by which time 50 yards, the greater part of rock No. 18, had been removed. The water being still very high, the contractor asked authority to suspend work until a later date, when the river would be lower, in order to commence upon Pine-Tree Rapid, in the Snake River. This request was granted with the proviso that both contracts should be completed within the allotted time. Work was accordingly suspended, and, after the completion of operations at Pine-Tree Rapid, was renewed in the latter part of February. It was presumed that low-water would continue until the last of March, but the Snake River suddenly rose, raising the Columbia several feet and increasing the velocity of the current at Umatilla Rapid, so that it was impossible to work the drills; the contractor made every effort to continue operations, but finding the river still rising, he suspended work about the middle of March and secured his plant from danger for the season. In consideration of the circumstances, the time of completion of this contract was extended until February 28, 1878.

PINE TREE RAPID, SNAKE RIVER.

A careful reconnaissance of this rapid, made by the engineer in charge during low-water in the latter part of September, 1876, showed it to be impassable at that stage for steamers drawing over 2 feet water. The channel used even at a much higher stage was narrow, crooked, intricate, and filled with hidden rocks. It was determined to open a straight one through the rapid, which could be navigated at all seasons of the year. To do this required the removal of numerous rocks and the opening of a chûte through the ledge at the head. Navigation on the Snake having been suspended for the season, the contractor's agent started on November 25, 1876, from Wallula, Washington Territory, for Pine-Tree Rapid, Snake River, a distance of about 43 miles, with the crew and plant, the scow being towed by mules on shore. Assistant Engineer R. M. Tabor started across the country about the last of November, following the trail to the rapid, which he reached after two days' ride, spending one night without shelter on the banks of the Snake. The scow reached Pine Tree on December 2, after a hard trip, during which the party had to contend with ice and snow. Shanties were at once erected, and preparations made for a winter campaign. The nearest post-office was at Wallula, about 30 miles distant by land, and the nearest ranch from which supplies could be obtained was that of Mr. Marion on the Touchét River, about 22 miles distant. With the assistance of Capt. E. W. Baughman, a thoroughly efficient and reliable pilot of many years' experience on the Snake River, the worst rocks were at once located, and drilling and blasting commenced. Operations were continued until February 22, 1877, being more or less interrupted by heavy floating ice, and on that day were suspended, 477.57 cubic yards of rock having been removed, and the contract completed.

The work done comprised the removal of 20 rocks, excavated from a length of 850 feet of the worst portion of the channel. Seven of these rocks being a portion of the ledge at the head of the rapid, the channel through which is now 49 feet wide and well marked by the current.

The actual amount of rock removed was as follows:

	Cubic yards.		Cubic yards.
Rock No. 1	65.56	Rock No. 4	3.54
Rock No. 2	7.96	Rock No. 5	12.89
Rock No. 3	44.88	Rock No. 6	30.79

	Cubic yards.		Cubic yards.
Rock No. 7	23.71	Rock No. 15	9.77
Rock No. 8	31.41	Rock No. 16	28.54
Rock No. 9	41.40	Rock No. 17	3.64
Rock No. 10	41.79	Rock No. 18	4.99
Rock No. 11	17.56	Rock No. 19	49.51
Rock No. 12	3.86	Rock No. 20	52.45
Rock No. 13	0.87		
Rock No. 14	2.39	Total	477.51

Although much has been done, much yet remains to be accomplished, as the channel, although straight, is still narrow and dangerous; the chûte at the upper end should be widened to at least 80 feet, and all rocks below, for a width of at least 100 feet, should be removed to a depth of 6 feet below the level of the lowest low-water.

The work accomplished, therefore, during the fiscal year consists in the removal of rocks from the rapids, as follows:

COLUMBIA RIVER.

	Cubic yards.
From Squally Hook Rapid	150.06
From Owyhee Rapid	67.57
From Umatilla Rapid	50.00

SNAKE RIVER.

From Pine-Tree Rapid	477.51
Total	745.14

Mr. R. M. Tabor, assistant engineer, deserves credit for the energy, care, and attention he has shown in the progress of the work.

During the coming season it is proposed to complete the work at the Upper Umatilla Rapid, under the contract of J. B. Montgomery, by removing 150 cubic yards of rock. The work will be confined to rocks 19, 20, 25, 26, and 27, on the north side of the upper end of the channel. Buoys will be permanently attached to the rocks on each side at the head of the channel. It is hardly necessary for me to again call attention to the necessity of continuing this work, as so much has already been said. The country east of the cascades is rapidly becoming a magnificent wheat-garden, and the export of grain during the coming season will be enormous. If farmers could only be certain of getting their grain to market in the fall, the vicinity of the Snake River would soon be fully settled, and extensive wheat-fields, yielding from 30 to 40 bushels to the acre, would cover the whole country. The population of this section has been greatly increased during the past year, but the fear of not being able to send their crops to market at once, on account of the impossibility of navigating the Snake River Rapids during low-water, has deterred many settlers from locating there.

The following information, required by the act of Congress approved June 23, 1866, is respectfully submitted:

The appropriations for this work have been as follows:

Act of June 10, 1872	$50,000 00
Act of June 23, 1874	20,000 00
Act of March 3, 1875	35,000 00
Act of August 14, 1876	15,000 00
Total	120,000 00

Of this amount $114,249.91 has been expended to date—$101,694.62 on the Columbia River, at John Day's, Squally Hook, Owyhee, Devil's Bend, Umatilla, and Homly Rapids; and $12,555.29 on the Snake River, at Pine-Tree Rapids. The project now submitted calls for the removal

of 1,500 cubic yards of rock from the Columbia River above Celilo, and 2,900 cubic yards from the Snake River, between its mouth and Lewiston, the estimated cost of the whole of which is $132,000. Of this amount $66,000 can be profitably expended during the next fiscal year.

These rivers are in the collection-district of the Willamette; Portland, Oreg., is the nearest port of entry; the nearest light-houses and forts are at the mouth of the Columbia River, but troops garrison the posts of Walla-Walla, about 32 miles from Wallula, and Lapwai, 12 miles from Lewiston.

I am informed that the number of passengers and the amount of freight carried by the Oregon Steam Navigation Company over their portage road at the Cascades during the first eleven months of the present fiscal year, was greatly in excess of the amount transported by them during the same period in the last fiscal year, the excess arising to a great extent from the increased emigration to the vicinity of the Snake River, and the rapid development of the country east of the Cascade Mountains.

The amount of revenue collected at Portland, Oreg., during the eleven months ending June 1, 1877, was $125,317; the value of the imports was $388,476, and that of the exports was $2,509,159.

The number of vessels entering was 177, with an aggregate tonnage of 152,961 tons; the number of vessels clearing was 153, with an aggregate tonnage of 144,296 tons. It is impossible to give an estimate of the amount of commerce that will be benefited by the completion of this work, as it will increase as the country is developed. The navigation improved will cover the whole of the Columbia and Snake Rivers, from Celilo to Lewiston, a distance of 266 miles.

Abstracts of proposals received and contracts made during the year, a statement of funds, and a chart of Pine-Tree Rapid, Snake River, showing rocks excavated during the year, are transmitted herewith.

Money statement.

July 1, 1876, amount available	$16,007 10	
Amount appropriated by act approved August 14, 1876	15,000 00	
		31,007 10
July 1, 1877, amount expended during fiscal year	25,257 01	
July 1, 1877, outstanding liabilities	155 00	
		25,412 01
July 1, 1877, amount available		5,595 09
Amount (estimated) required for completion of existing project		132,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		66,000 00

Abstract of proposals for excavating rock from the Upper Columbia River, Oregon, and Washington Territory, opened by Major John M. Wilson, Corps of Engineers, August 30, 1876.

Number.	Names and residences of bidders.	Excavating 200 cubic yards rock.		Remarks.
		Price per cubic yard.	Total.	
1	J. B. Montgomery, Portland, Oreg	$31 00	$6,200 00	Contract awarded.
2	Grant & Stone, The Dalles, Oreg	31 50	6,300 00	

Abstract of proposals for excavating rock from the Upper Columbia and Snake Rivers, opened by Major John M. Wilson, Corps of Engineers, November 10, 1876.

Number.	Names and residences of bidders.	Squally Hook Rapid, Upper Columbia River, 100 cubic yards, more or less, per cubic yard.	Pine-Tree Rapid, Snake River, 300 cubic yards, more or less, per cubic yard.	Remarks.
1	Grant & Stone, The Dalles, Oreg	$23 00	$28 00	Contract for Squally Hook awarded.
2	J. B. Montgomery, Portland, Oreg	27 50	24 75	Contract for Pine Tree awarded.
3	Thomas J. Stump, Wallula, Wash. Ter	.....	26 50	No bid for Squally Hook received.

Proposals for this work were invited by letter, without advertising, owing to the lateness of the season, as per letter of authority from the Chief of Engineers, dated September 15, 1876.

Abstract of contracts for the improvement of the Upper Columbia and Snake Rivers, in force during the fiscal year ending June 30, 1877.

Number.	Names and residences of contractors.	Date of contract.	Subject of contract.	At Upper Umatilla Rapids, Columbia River, 200 cubic yards, more or less, per cubic yard.	At Pine Tree Rapids, Snake River, 400 cubic yards, more or less, per cubic yard.	At Squally Hook Rapids, Upper Columbia River, 100 cubic yards, more or less, per cubic yard.
1	J. B. Montgomery, Portland, Oreg.	Sept. 2, 1876	Excavating rock..	$31 00	.....	.....
2	J. B. Montgomery, Portland, Oreg.	Nov. 11, 1876	.....do	.....	$24 75	.....
3	Grant & Stone, The Dalles, Oreg.	Nov. 20, 1876	.....do	.....	.....	$23 00

JJ 4.

CONSTRUCTION OF A CANAL AROUND THE CASCADES OF THE COLUMBIA RIVER, OREGON.

By the act of Congress approved August 14, 1876, an appropriation of $90,000 was made for the construction of a canal around the Cascades of the Columbia River, in the State of Oregon, and by telegram of October 24, 1876, I was instructed to "proceed at once with survey, plan, location, and project of construction."

A preliminary reconnaissance was made in November, and early in December a party was placed in the field, in charge of Assistant Engineer C. M. Bolton, with instructions to make a careful and elaborate survey of the country on the Oregon side of the rapids—*upon which side the law required the canal to be constructed*—an accurate and rapid reconnaissance of the Washington Territory side, a hydrographic survey of the river above and below the rapids, with current-observations, &c., wherever the work could be done without danger to life, and a close examination

of the underlying material upon the line which should be finally selected for the canal.

These instructions were carried out with great energy and skill by Mr. Bolton, who, in spite of the inclement season, kept his party at work steadily, and by the early part of January the field-work was completed, the party disbanded, and the work of preparing charts, plans, and estimates at once commenced.

On February 5, 1877, I submitted a preliminary report, which was laid before Congress on February 26; and on April 12 I forwarded a full report, with estimates, and a chart showing the proposed location of the canal.

PROPOSED ROUTE OF CANAL.

As the law plainly states that the canal shall be in the State of Oregon, the line was at once settled within certain limits by its terms, as the principal conditions would require that it should be upon the shortest available route, have the least number of locks possible, and be fed entirely from the Columbia River.

The route selected, as stated in my report of April 12, commences on the Oregon side, just above the main rapid, runs through a plateau covered with heavy bowlders, mingled with sand and gravel, resting upon bed-rock, and closely hugging the Oregon shore, is continued after the fall is made in the river proper by a crib-work breakwater about 5,000 feet long.

DIMENSIONS OF PROPOSED CANAL.

The dimensions of the proposed canal will be as follows:

	Feet.
Total length, including crib-work breakwater	7,200
Width in cutting at surface at low-water	58
Width in cutting at bottom at low-water	50
Depth at low-water	8

The fall at low-water, 26 feet, will be overcome by two locks; these locks will be 250 feet long, 46 feet wide, with a depth of 8 feet on the miter sill at dead low-water; the lifts will be 12 and 14 feet; there will be a guard-gate at the upper end of the canal, to be closed when repairs are necessary or large quantities of drift running, or for a few days in case extreme high-water equal to that of 1876 should again occur.

Estimates have been presented for a canal navigable at all stages when the river is not closed by ice, and for one navigable when the river is not higher than 25 feet above low-water; in the last nineteen years there have been only two summers—those of 1868 and 1869—when the freshet was not higher than 25 feet above ordinary low-water.

The estimated cost of the high-water canal, as previously submitted, is $1,544,545; that of the canal navigable only when the water is not higher than 25 feet above ordinary low-water is $1,188,680.

SURVEY FOR CANAL ON WASHINGTON TERRITORY SIDE.

By telegraphic instructions from the Chief of Engineers, dated May 18, 1877, confirmed by letter, I was informed that while the act of Congress approved August 14, 1876, upon which my project of April 12, 1877, was based, confined the canal to the Oregon side, still the act of June 23, 1874, required an examination of both sides of the river, and that "before undertaking an improvement of such magnitude a thorough examination of the locality should be made, so as to be possessed of all data bearing upon its most advantageous location."

An allotment of $1,200 was made for a survey on the Washington Territory side, and I was instructed to present a project in detail, with estimates, for a canal on that side at the earliest practical moment.

The telegram reached me on Saturday, May 19, and on Monday, May 21, a careful preliminary reconnaissance on the Washington Territory side was commenced.

As the Columbia River was rising rapidly, being 23 feet above low-water at the Lower Cascades, the object of this reconnaissance was to determine the most available route to be surveyed for a canal as soon as the freshet should subside.

The creek emptying into the Columbia River near the upper steamboat-landing, just above the falls, which was the only apparent available route in this vicinity, was found to have but little rise for the first half mile, but then divided into three smaller streams, which rose to lakes about a mile farther, at heights from 225 to 300 feet, the ridge which it would be necessary to cross being about the same height; a canal by this route was, therefore, deemed impracticable, except at a great expense, necessitating a high summit-level to be fed from the lakes.

The high water prevented an examination of the lower portion of the slope bordering immediately upon the river; but the tendency to slide of the material of which it is composed would render it a dangerous experiment to cut a canal near the base.

From this reconnaissance it was thought that the best plan for a canal on the Washington Territory side would be to build a dam at the narrow part of the river, about 6,000 feet below the head of the main rapid, and to cut a canal about 800 feet long through the land extending out into the river on the Washington side near this locality.

As a plan and estimate for such a work would necessitate a careful and elaborate survey of the river with soundings on the proposed line of the dam, no work could be done on account of the freshet and the consequent increased velocity of the current.

On June 9 telegraphic instructions were received from the Chief of Engineers, directing the suspension of the survey on the Washington Territory side for the present.

During the season of 1877–1878 it is proposed to continue the preparation of detailed plans of locks, gates, crib-work, &c., and to take such action in reference to commencing construction as may be ordered by the Chief of Engineers.

In the survey and the preparation of the plans and estimates for this work, I have been greatly indebted for earnest, able, and energetic assistance to Assistant Engineer C. M. Bolton, who has displayed zeal and ability in the discharge of the duties assigned to him.

The following statistics required by the act of Congress approved June 23, 1866, are respectfully submitted:

Up to this time $90,000 has been appropriated for this work, being the amount named in the act of August 14, 1876; of this sum $4,616.65 has been expended to date in surveys and preparation of charts, plans, estimates, &c.

The estimated cost of the project submitted is $1,544,545; of this amount $500,000 can be profitably expended during the next fiscal year.

The Cascades of the Columbia River are situated in the collection-district of the Willamette. The nearest port of entry is at Portland, Oreg., 65 miles distant; the nearest light-houses and fortifications are at the mouth of the Columbia River, about 160 miles distant.

I am informed that the number of passengers and the amount of freight passed over the portage railroad at the Cascades by the Oregon Steam

Navigation Company during the first eleven months of this fiscal year are largely in excess of the number and amount transported during the same period in the last fiscal year.

The amount of revenue collected at the port of Portland, Oreg., from July 1, 1876, to June 1, 1877, was $125,317; the value of the imports was $388,476, and of the exports $2,509,159; 177 vessels, with an aggregate tonnage of 152,961 tons, entered, and 153, with an aggregate tonnage of 144,296 tons, cleared. At the port of Astoria, Oreg., during the same period as above, the revenue collected was $26,378, the value of the imports $24,315, and of the exports $1,488,929; the number of vessels entering was 180, with an aggregate tonnage of 200,186 tons; the number of vessels clearing was 194, with an aggregate tonnage of 212,564 tons.

By the construction of the Cascade canal, direct navigation of the Columbia will be opened to the Dalles, a distance of 50 miles beyond the Cascades; the amount of commerce to be benefited cannot be given in figures, but its great increase is anticipated from the fact that the very extensive wheat-growing region east of the Cascades is being rapidly settled.

Charts showing the line of the proposed canal and the river in the vicinity, and also a statement of funds, are transmitted herewith.

Money statement.

Amount appropriated by act approved August 14, 1876	$90,000 00
July 1, 1877, amount expended during fiscal year	4,616 65
July 1, 1877, amount available	85,383 35
Amount (estimated) required for completion of existing project	1,459,136 40
Amount that can be profitably expended in fiscal year ending June 30, 1879	500 000 00

JJ 5.

EXAMINATIONS WITH A VIEW TO ESTABLISHING A HARBOR OF REFUGE ON THE PACIFIC COAST.

REPORT OF THE BOARD OF ENGINEERS FOR THE PACIFIC COAST.

OFFICE BOARD OF ENGINEERS FOR THE PACIFIC COAST,
San Francisco, Cal., February 14, 1877.

GENERAL: In compliance with the instructions of the Department of May 9, 1876, enclosing a resolution of the House of Representatives of April 29, 1876, "asking for an examination of the harbors of Mendocino, Humboldt Bay, Trinidad, and Crescent City, in the State of California, with a view of establishing a breakwater and harbor of refuge, with estimate of probable cost," the Board of Engineers for the Pacific coast has the honor to submit the following

REPORT.

The Board sailed from this city on the 9th of August last in the Coast Survey steamer Hassler, and carefully examined all the so-called harbors where it has been thought a harbor of refuge might be constructed, between here and the mouth of the Columbia River, viz: Drake's Bay,