## REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
*Seattle, Wash., December 11, 1897.*

GENERAL: I have the honor to submit the following report of a survey of the "Skagit River from mouth to the town of Sedro, Wash.," made in compliance with the river and harbor act of June 3, 1896, and assigned to my charge by your letter of September 5, 1896.

The Skagit River, which is the largest river in western Washington, rises in the Cascade Range of mountains in British Columbia, and, flowing in a general southwesterly direction, crosses the international boundary line into the United States about 80 miles from the coast of Bellingham Bay. The part of the river included within the United States is something over 130 miles in length. Following the main channel, the length of river embraced within the limits of the survey is about 28 miles.

For the first 18 miles below Sedro the river at ordinary stages flows in one channel. It then forks into two branches, of which the larger, the South Fork, flows in a southerly direction, and the other, the North Fork, in a westerly direction into an arm of Puget Sound, known as Skagit Bay. Each of the two main forks subdivides into several smaller forks that find their way into Skagit Bay through separate mouths. None of these various mouths are navigable at low tide.

The portion of the river affected by the tide depends upon the stage of water in the river. At extreme low water in the river the tide is perceptible as far as the town of Avon, a distance of 15 miles from the main mouth.

Within the territory of the United States the Skagit River is joined by several important tributaries, among which the principal are the Baker and the Sauk. The Baker River, which rises on the west slope of Mount Baker, is joined at some distance from the Skagit by the Hukullum River, which rises on the west slope of Mount Shuksan. Mount Baker and Mount Shuksan, as well as several peaks around the head waters of the Skagit River in British Columbia, are covered with per-

petual snow. The Sauk River rises in the foothills of the Cascade Mountains in a region where the ground is free from snow but a very short time in the late summer.

The whole of the Pacific Northwest is subject to a peculiar warm, moist wind blowing off the ocean, usually from the southwest, which is known as the "chinook." A chinook wind may occur at any time of the year and may be felt by a large or small extent of territory at the same time. A chinook wind striking a snow field causes the snow to melt with abnormal rapidity.

The conditions surrounding the sources of the Skagit River are therefore such that a flood in the lower river is liable to occur almost any day in the year. A chinook wind will usually cause a marked rise in the lower river about thirty-six hours after it begins to blow, the amount of the rise depending upon the intensity and warmth of the wind and the amount of fresh snow upon the mountains.

During the year 1896 no less than three floods occurred in the Skagit River, due to the conditions above described. These occurred in January, June, and November. The flood of January reached a stage of 22 feet above low water on the gauge on the Great Northern Railroad Bridge, 6 miles above Mount Vernon; the flood of June reached a stage of 20 feet, and that of November a stage of nearly 24 feet on the same gauge. The elevation of the river bank in the vicinity is 21 feet above low water, so that during two of the floods in 1896 the river overflowed its banks above Mount Vernon. Protection from these overflows is one of the principal objects which the residents of the Skagit Valley desire to have accomplished by the improvement of the river.

The Skagit River is navigable at all stages of the river and tide from its mouth to Mount Vernon, a distance of 11 miles, and at all stages, except extreme low water, it is navigable to Avon, 3 miles above Mount Vernon. During extreme high water boats in past years have ascended the river as far as "The Portage," which is said to be 95 miles from the mouth. During ordinary high water boats can go as far as Sauk River, which is said to be 68 miles from the mouth, but at present they rarely go above Lyman, which is about 36 miles from the mouth of the river.

The regular navigation of the river is small in amount, being confined to one boat making triweekly trips between Seattle and Avon, but the result of this navigation is important in the regulation of transportation rates. During the higher stages of the river large rafts of logs are towed down from the upper river, and on high tides small boats and scows navigate many of the sloughs or branches of the lower river and take out large quantities of grain, so that the aggregate of the navigation is of considerable magnitude and importance.

The chief obstructions to navigation in the lower river are the snags which accumulate with every freshet. Between Mount Vernon and Avon there is one bar which prevents navigation at the extreme low water.

Between Avon and Sedro there are three bars or riffles, which can not be crossed except at the higher stages of the river. In front of the delta, formed by the mouths of the Skagit River, are extensive tide flats, bare at low water. The waters of the river, as soon as they are outside the high-tide line, spread out over these tide flats in many ill defined and changeable channels. Boats can cross these tide flats and enter the river only when the tide is at or above half-tide stage.

The improvement of the Skagit River, which is of the greatest importance to navigation, is the improvement which has been carried on for

a number of years past, viz, removing the snags which lodge in the river channel. For this purpose a snag boat has been provided, which works on the Skagit River and other rivers flowing into Puget Sound, where the conditions are much the same as on the Skagit. But on account of the larger size of the Skagit River, the greater number of snags, and the greater interests involved the principal part of the snag boat's time when in commission has been spent on this river.

The first snag boat was built in 1882. From that time until the act of June 3, 1896, was passed the appropriations provided for operating the boat were so small that she could not be operated more than a small part of each year, and the time she was in commission was only sufficient to enable her to remove the worst obstructions which were in the actual steamboat channels and rendered navigation hazardous. During her fourteen years of service the boat had also become rotten and weak, so that great care had to be taken in using her. The appropriation of June 3, 1896, was sufficient to permit of rebuilding the snag boat, and providing some additional appliances which experience had demonstrated were necessary, and to permit of operating her continuously throughout the past year. With this boat there have been removed from the Skagit River, since she was put in commission in December, 1896, after rebuilding, a total of 2,745 snags, ranging in diameter from 8 inches to 10 feet, and averaging about 30 feet in length, and 513 leaning trees, which were threatening to fall in and become obstructions, have been cut from the banks and disposed of. In addition to the above, several jams were broken up so that the bulk of them floated off. It is, I believe, admitted by all who are acquainted with the river that it had never been in so good a condition for navigation as it was in the early part of November, 1897. On the 18th and 19th of November, 1897, a freshet occurred which left several bad jams in the river. The snag boat was on the river at the time of this freshet and immediately commenced work on these jams.

During the past year almost the entire time of the snag boat has been given to the Skagit River and but a small part to all the other rivers included in the appropriation for "improving Puget Sound and tributary waters." It is possible that another snag boat may be needed in order that the entire time of one may be devoted to the Skagit River, or both be employed in cases of emergency, and the other be used on the other rivers needing improvement. A few months' more work with the one will settle this question conclusively.

I have carefully considered the advantages to navigation to be derived by other methods of improvement, such as dredging, dike building, revetting the banks, and straightening the river, and have been forced to the conclusion that they are not sufficient to justify the expense.

Dredging could be expected to benefit navigation only at the mouth of the river, as the depth of water from a short distance inside the mouth to Mount Vernon is ample, and above Mount Vernon the character of the river and navigation are such that it is impracticable to benefit navigation by that means. If a channel were dredged from deep water inside the mouth to deep water outside, boats could then enter and leave the river independent of the tide, so that they could run on a fixed time-table. But aside from their more regular hours of leaving I do not believe any material advantage would result. It would not result in the lowering of rates nor the increase of business, unless, possibly, a slight increase in the passenger business, which is a small and unimportant part of the whole. There is now one boat, which is supposed to run according to a time-table varying with the tide, but

which is published each week. As a matter of fact, the time of this boat varies almost as much with the amount of freight which she may pick up as with the tide. Dredging would not change her irregularities due to varying freight business.

The distance from deep water in the river near the mouth of Steamboat Slough, the channel now navigated, to deep water in Saratoga Passage, the nearest deep water in Puget Sound, is about 5 miles, and to obtain a channel 100 feet wide and 4 feet deep at low water about 400,000 cubic yards of dredging would have to be done. Such a channel would also have to be protected by dikes to insure its permanency. Experience with dikes in the vicinity of the Skagit River has demonstrated that they can not be built so as to be of much service for less than $4 per linear foot. Therefore, to dredge such a channel and protect it with a dike on one side would cost about $150,000.

Moreover, steamboats going to and from the Skagit River do not usually go the shortest way to deep water, but cross the tide flats and pass through the sloughs to the Stillaguamish River, where they stop at Stanwood. Hence, a channel dredged straight out to deep water would be but little used.

I am also of the opinion that a channel dredged across the tide flats would rapidly fill up and would require redredging at very frequent intervals.

If a channel 150 feet wide and 6 feet deep at low water were dredged and protected on both sides by dikes, it would undoubtedly afford permanent benefit to navigation, but its cost would be in the neighborhood of $300,000, which is altogether out of proportion to its small benefits.

Except perhaps in a very few places, the benefits to be derived from revetting the river banks would be insignificant. To be of any value a revetment would have to be of a very substantial character, as during freshets immense pieces of drift float down the river, and they would soon tear a weak revetment to pieces. The effect of the drift may be judged from the fact that instances have been known of a floating tree striking end on against a dike with violence enough to penetrate the dike and cause a crevasse. As there is no stone on the navigable part of the Skagit River which could be used in a revetment, the cost of a suitable revetment would be great, and at present I do not think any part of the river worthy of such improvement.

Under date of April 28, 1897, I submitted a project for a cut-off at what is known as Sterling Bend, 2 miles below Sedro. This is a very bad bend, and each year it is an expensive and difficult operation to clear the snags from it. It was proposed to straighten the river at this place, so as to avoid, if possible, the perpetual snagging. At the time the project was submitted I was informed by the settlers living in the vicinity that the right of way and all the required releases from damages would be given freely, but such did not prove to be the case. On account of the damage suits which would have resulted had the cut-off been made, no further action has been taken. Straightening the river would be beneficial in more ways than one, but on account of the complications which would result I do not think it advisable to undertake it.

But, as stated above, the improvement which is most wanted by the people living in the Skagit Valley is such an improvement as will prevent their lands being overflowed with each freshet.

The general opinion seems to be that if all the mouths of the river were opened up so as to afford free exit for the flood waters, the entire valley would be relieved of these disastrous overflows, and it is claimed by many that this condition formerly existed.

It also seems to be the general opinion that a log boom which was

constructed at the mouth of the river was the cause of the shoaling of the different mouths, and consequently is to blame for the overflows of the Skagit Valley.

As nearly as I can ascertain, the following is the history of the Skagit River:

The bottom land along the lower partof the Skagit River was formerly covered with a body of very large and fine cedar trees. The mills on Puget Sound formed a ready market for the timber, which was cut into logs and shingle bolts. These conditions early attracted settlers to the Skagit River bottom. As the land was cleared of the timber it was found to be exceedingly rich and fertile, but much of it, however, was marshy and swampy. The money obtained from the cutting of the timber was used for clearing the land and protecting it with dikes. At first it was necessary only to build low dikes, as the floods did not attain a great height in the lower river.

In the early days what is known as the Old Main River was the principal outlet of the Skagit River. It is reported that in the early days boats drawing 10 to 12 feet could easily navigate this branch as far as Fir, about 5 miles up from the mouth. Prior to 1879 a log jam, which was nearly a mile in length and almost completely covered the river, existed near where the present town of Mount Vernon is located. During freshets this jam obstructed the free flow of water and caught all logs and drift. The obstruction caused by this jam to the free flow of the flood waters prevented the low lands farther down the river from being flooded, but it caused the flooding of the entire country known as the Olympia and Beaver Marsh country, to the west of the Skagit River, between the present location of the town of Avon and Padilla Bay.

About the year 1879 the Mount Vernon log jam was cut by private enterprise. After it was cut up the greater part of it went out, and, from what I have been able to learn, much of the drift which was floated out from this jam lodged in what was then the main steamboat channel, Old Main River, and completely closed it. Since the breaking up of the log jam and the construction of dikes in the river, confining the waters of the river and preventing them to a very great extent from spreading over the adjacent country, the floods in the lower river have naturally increased in height. The country to the west of Avon, however, has been to a very great extent reclaimed, and now contains many of the richest and most valuable farms in the State of Washington.

In order to facilitate the log business on the Skagit River, a boom company was organized and commenced operations in the lower river about the year 1882. The boom was first put in what was known as Tom Moores Slough, where it remained for about two years. At the end of that time Tom Moores Slough was so filled up that logs could not be rafted through it. From Tom Moores Slough the boom was moved to what is known as Freshwater Slough, from Freshwater Slough to Deep Slough, and from Deep Slough to Log Slough. At the time the boom was moved from one slough to another each slough in turn was a navigable slough or entrance to the river, and each in turn filled up with drift so as to prevent boats from passing through it. The one navigable slough which is now left is known as Steamboat Slough. The booms may have helped the shoaling of the various sloughs in which they were located, but, judging from the results of the recent flood, such shoaling would have been brought about by natural causes, whether the booms were there or not.

It appears, therefore, that each of these several sloughs has been navigated, and that in each the boom was placed and soon after the

placing of the boom the slough became unnavigable; but it does not appear that all of these sloughs, or more than one of them, for that matter, were navigable at any one time. I have been informed by an old settler on the river that when he first came there Steamboat Slough was so small that a rowboat could not be rowed through it. It has cut out and enlarged to its present size since the former navigable channels closed up. At the present time Steamboat Slough forms a good navigable channel. If all of the sloughs were opened so as to afford free exit to the waters, it would be but a short time before they would be closed up so that none of them would be navigable.

In my opinion, the only manner in which the farmers of the Skagit Valley can get relief from the disastrous freshets which visit them is by a proper system of diking. The State law is very full and explicit in regard to diking. It fully provides for the formation of diking districts, the appointment of dike commissioners who shall have charge of all matters relating to the dikes, the assessment and collection of taxes and all other matters pertaining to the subject of dikes. I am of the opinion that the greater part of the trouble on the Skagit River is due to the incomplete system of dikes. The river is divided into several diking districts, but I do not understand that any one general and systematic plan for the construction of dikes for the lower river has ever been agreed upon. In some places the dikes seemed to be unnecessarily high, in others dangerously low, and in a good many places they are weak and thin and for long distances they are entirely too near the river banks. The placing of the dikes so near the river banks confines the waters so much that at times of freshets an abnormal rise is produced, and it also exposes the dike to the swift current, which soon washes it away. The greater part of the breaks in the dikes along the Skagit River within the past two or three years have been due to this cause, or to the fact that the dike was so near the bank of the river that the bank gave out underneath and actually tumbled the dike into the river. It appears to me that the proper solution of this problem requires the formation of the entire part of the Skagit Valley needing dike protection into a single diking district and the appointment of a competent experienced civil engineer to take entire charge of the building and maintenance of all the dikes on the river.

On the 18th and 19th of November the Skagit River was visited by the greatest freshet in the history of the river. It has been claimed that had the different mouths of the river been opened up the waters of this freshet would not have risen as high as in previous years and that they would have run off much sooner than they actually did. This freshet was caused by a Chinook wind of unusual warmth and intensity striking a large amount of freshly fallen snow, and the results were felt over the entire State of Washington, the northern part of Idaho, and the western part of Montana. Not only was the Skagit River the highest ever known, but all of the other rivers of Washington reached an unusual height. The Skykomish River rose many feet higher than ever before, the Kootenai River, in Montana, rose 22 feet in twenty-four hours, and the Clearwater River, in Idaho, reached a point higher than has been known at the same season of the year since 1862.

The Everett and Monte Cristo Railroad, running from Everett up the Stillaguamish River to the Monte Cristo mines, was practically wiped out of existence for a distance of 30 miles. The Great Northern Railroad was damaged so that it was two weeks before any trains could run, and the Northern Pacific Railroad was damaged more or less on both its Cascades divisions and Portland divisions.

The town which suffered the most in proportion to its size of any on

the Skagit River was the town of Hamilton, which is so far up the river that no possible opening of the mouths of the river could have had any effect on the height of the water at that place.

From the extent of the floods and the damage caused in other places it is very evident that no amount of opening out of the mouths of the Skagit River would have prevented the floods in this river. As a matter of fact the most disastrous breaks in the dikes of the Skagit River were in the vicinity of Mount Vernon, some 12 miles from the mouth of the river and too far to derive any benefit from the opening of the mouths of the river, and the higher up the river one goes the greater the freshet appears to have been. At Sauk River, 68 miles from the mouth, the water reached a stage 6 feet 8 inches above the freshet of November, 1896; at Lyman, 32 miles below Sauk River, it was 2 feet 9 inches above last year's flood; at Sedro, 8 miles below Lyman, it was 1 foot 6 inches, while in the vicinity of Mount Vernon it was but about 10 inches above last year's flood.

In addition to clearing the mouths of the river, it is desired to have channels dredged out across the tide flats to deep water, so as to take the water off more rapidly.

The Skagit River delta is nearly 8 miles wide. Along this delta the river empties into Skagit Bay through a dozen or more mouths. The cost of dredging a channel from each of these mouths would be tremendous, and a channel dredged from any one of them would increase in so insignificant a proportion the available high water outlets that its effect would not be noticeable. As shown above in this report, to dredge even a small channel suitable for navigation would cost a large sum of money, and to dredge a channel which would carry off the waters of a large river would certainly be a Herculean undertaking. Nor does it appear from a study of the high-water levels that even if a channel large enough to carry the whole river were dredged from the mouth of Steamboat Slough to deep water the high water level would be lowered so as to produce any great benefit. The level of the water in the freshet of November, 1896, at the Mount Vernon Bridge, as shown by the marks on the bank, was 36.2 feet above extreme low water in Skagit Bay, or about 20 feet above extreme high water in Skagit Bay. From this point there was a nearly uniform slope for 1½ miles, in which distance the river fell 1.2 feet, or at the rate of eight-tenths of a foot per mile. There was then a drop of 2.6 feet in 2,000, or at the rate of 6.8 feet per mile. This was probably due to breaks in the dikes. For the next 6¼ miles there was a nearly uniform slope of 1.8 feet per mile; then a drop of 3.8 feet in 5,800 feet, or at the rate of about 3½ feet per mile. From this point to the mouth of the river, about 3 miles, there was a total drop of only about 1 foot. At the mouth of the river the flood level was practically identical with extreme high water in Skagit Bay.

While dredging might possibly increase the slope of the flood water for a short distance back from the mouth at low tide, I do not see how it could be of much benefit during high tides. If dredging would prevent the tide rising in the river it would be of some benefit to dredge, but as long as it does not do this, it does not appear that the dredging would do much good, for no matter what might be the slope of the water surface in the river during low tide, at high tide the slopes and heights would be the same as they are now. As a matter of fact the highest water near the mouth of the river is caused by spring tides, regardless of the stage of the river. The height of these tides can be counted on with considerable certainty, and the dikes are built high enough to

stand them and are rarely ever broken. It is only above the point that the tide reaches during high water in the river, and where no amount of dredging at the mouth of the river would do any good, that the serious troubles begin.

The recent flood has, however, emphasized the importance of the work which the snag boat is doing. This boat was on the river near the town of Sedro at the time the flood occurred. As soon as the flood subsided she started down the river and found a large jam at the Great Northern Railroad Bridge, about 10 miles from Sedro. The jam was so extensive and so solidly packed that it took the boat several days to make a passage for herself through it. The bridge had also been damaged and moved out of place by the weight against it. Against the bridge near Sedro was another jam, and near the mouth of Steamboat Slough was a third one. This latter jam completely blocked the only available entrance to the river, so that until the snag boat had done some work upon it boats could enter the river only with the greatest difficulty.

During the short time before the snag boat could get to work upon the jam near the mouth of the river, much of it had become solidly embedded in sand, and a shoal had commenced to form below it. Had not the boat been upon the river and gone to work immediately upon these jams they would have become solidly packed, and the one at the mouth of the river would have closed Steamboat Slough and caused the river to seek a new outlet. Had the jam against the Great Northern Railroad Bridge been allowed to remain there and another flood occurred, the whole country between the Skagit River and Padilla Bay would have again been flooded.

All the evidence shown by the history of the river, as far as I have been able to ascertain, is that one good navigable channel may be maintained from a short distance inside the tide flats up the river to Mount Vernon, and I am thoroughly convinced that one channel is best, not only for navigation, but also for the protection of the farms along the river banks.

Some small side channels may be allowed to exist as overflows for the surplus water during time of freshets, but if an attempt is made to open up and render navigable any number of these channels, or even more than one, I am of the opinion that it will result in no one of them being navigable. The shoaler the channels become, of course the more easily drift accumulates in them. I believe also that had there been several shoal channels at the beginning of the flood just past, every one of them would have been completely blocked, and that the effects of the flood would have been, if anything, worse than they were.

Very respectfully, your obedient servant,

HARRY TAYLOR,
*Captain, Corps of Engineers.*

Brig. Gen. JOHN M. WILSON,
*Chief of Engineers, U. S. A.*
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
*San Francisco, Cal., December 23, 1897.*

Respectfully forwarded to the Chief of Engineers, U. S. A. I concur in the views of the district officer.

CHAS. R. SUTER,
*Colonel of Engineers, Division Engineer.*