SKAGIT RIVER FLOOD REPORT

by

J.E. Stewart, USGS

July 1918

Retyped Summer 2006

U.S. GEOLOGICAL SURVEY
WATER RESOURCE BRANCH
TACOMA, WASHINGTON

S K A G I T R I V E R

F L O O D R E P O R T

By
J. E. Stewart
Assistant Engineer
July, 1918.

SKAGIT RIVER FLOODS

There have been three large floods on the Skagit River of which there is authentic record. These were November 18-19, 1897, November 29-30, 1909, and December 29-30, 1917. The magnitude and duration of these floods varied considerably on different tributaries of the Skagit River and consequently on the Skagit River itself. Floods closely approaching these three may be expected on an average of once in ten years. In addition to these floods there are sure indications of a much greater flood at the Reflector Bar and Sedro-Woolley gaging stations and also traditions among the Indians.

Taking up the floods on the different tributaries:

Skagit River at Reflector Bar above Marblemount, Wash.

(See Exhibit "A")

Of the three known floods, that of 1909 was the greatest. The floods of 1897 and 1917 were lower than the 1909 flood and practically equal. There is an old cabin on the Davis ranch, one and one-half miles below Reflector Bar, which has been through all three floods. The flood crests of 1897 and 1917 were about one foot above

the floor of this cabin. The high-water mark of 1909, as pointed out near the front door of the Davis house, was found by levels to be 2.5 feet higher than those of 1897 and 1917. By means of flood marks on walls of Canyon Diablo above gage and a drift log below gage in conjunction with high-water mark at the Davis ranch, it was determined that the crest of the 1909 flood exceeded that of 1917 at Reflector Bar gaging station by about 2.5 feet. The crest of the flood for 1909, gage height 15.0 feet, gives 58,800 second feet; 1897 and 1917, gage height 12.5 feet, 41,700 second feet.

In addition to these floods there is a record of a much higher flood a great many years ago. The right stream bank at the gaging station is composed of sand and gravel certainly deposited by the river. This bank slopes both downstream and away from the stream; the downstream slope indicated the slope of the flood crest as it left the canyon; and the slope away from the stream representing the diking effect noticed on many streams that overflow their banks i.e., a stream with high velocity is carrying a large amount of silt, sand, etc., and when this water goes over the bank the velocity drops and its carrying capacity drops even more rapidly. Thus it drops most of its load where it tops the bank. A stream in its upper or middle course finally cuts its stream bed so that it no longer tops these banks; but we

find that this is not the case at Reflector Bar for if the river no longer topped this bank vegetation, leaves, dirt, logs, humus, etc., would have collected over the sand. This deposit, however, is of clear sand, and from appearances it might be judged that the bank had been topped in the last ten or fifteen years. It is certain though that this flood has not occurred in the last forty-five years, for the flood of 1897 was the largest flood until 1909 in the recollection of settlers who arrived in 1873. The drift of the 1909 flood is still along the river in great quantities and very little rotted. The flood mark for 1909 on canyon wall above gaging station is still distinct. Neither drift nor flood marks can be found for this earlier and higher flood. Sixty or eighty years would probably rot away almost all drift except cedar logs. Considering the difference in brightness of the 1909 and 1917 flood marks, it would probably also efface the flood mark on the canyon walls. The lack of humus, etc., on the gravel deposit makes it certain, I think, that the flood has occurred in the last one hundred years. The river probably has cut a little since then, but since the cutting at the gaging station is regulated by the rock canyon below the Davis ranch it is certain that this cutting has been very little, probably not more than one or two-tenths. The flood

at the gage, topped the bank at a gage height of 18.0 feet. The deposit is of very coarse sand or small gravel and is found for two hundred yards away from the bank. The slope away from the river is fairly steep, but to carry this coarse sand through trees, brush, logs, and vegetation it is practically certain that the river must have topped the bank at least one foot; it may have been considerably more, but from the high-water mark at Sedro-Woolley it is not thought that it exceeded one foot materially. It will be estimated that it overtopped the bank one and one-half foot, giving a discharge of 96,000 second-feet. There is no drift above that brought in by the 1909 flood either near the station or between there and the mouth of the canyon seven miles below. It is certain, therefore, that no flood in the last sixty years could have exceeded that of 1909 in this portion of the river. Flood marks at Sedro-Woolley show 1909 to have reached the highest stage since the great flood previously noted, but the discharge probably has been as great at other times at that station.

Skagit River at Power Camp near Marblemount, Wash.

(See Exhibit “B”)

Flood for 1909, gage height 22 feet; 1917, 19 feet; 1897 discharge probably about the same as 1917 but gage height uncertain. Two new provisional rating curves have been drawn up, one applicable up to the flood of 1917,

the other during and after this flood. The first curve gives a maximum discharge for 1909 of 63,500 second-feet; the second curve for 1917, 47,400 second-feet discharge; 1897 estimated the same. The earlier and greater flood must have had a discharge of 100,000 second-feet based on the discharge at Reflector Bar. The gage height for this great flood would have been about 28 feet.

Skagit River below Cascade River at Marblemount, Wash.

(See Exhibit "C")

Flood of 1897 was 2.2 feet higher than 1917 and 1.3 feet higher than 1909, as determined by high-water marks made by residents at Marblemount during each flood. Cascade River was the cause of the great variation from upper stations. The Cascade had an enormous flood in 1897. The flood of 1909 was not nearly so great, and that of 1917 was about midway between the two.

Skagit River at Rockport, Wash.

Flood of 1897 was the highest of the known floods; amount higher than 1909 or 1917 is not known. Flood of 1909 was about .7 foot higher than that of 1917. There is a tradition among the Indians that a number of their tribe were drowned, in a great flood at night, on the bench where the Cuthbert ranch now is. This bench is at least fifteen feet above the flood mark of 1917. This flood

was probably the great flood previously noted at the Reflector Bar gaging station.

Skagit River below Baker River near Concrete.

(See Exhibit “G”)

Flood of 1897 was about three feet higher than flood of 1909. This was determined by running levels from an 1897 high-water mark in old barn (above mouth of Baker River) to a hotel near the cement plant, the footing of which was just touched by 1909 flood. These levels showed a difference of nearly five feet, but there may have been a difference in elevation of the water surface of nearly two feet due to the slope.

Skagit River at Sedro-Woolley

(See Exhibits “H” and “I”)

Flood of 1909 was 1.6 feet higher than 1917 and 0.5 foot higher than 1897. The stream bed is continually shifting at this station and actual flood crests are not strictly comparable, but the curves must draw together in their upper portion. When the river begins cutting across bends velocity in the main stream is checked and changes in control produce less effect than at low stages. When the main channel is choked so that it increases the stage for a given discharge, then the sloughs and over-flowed banks carry proportionally more water than with the channel free and unobstructed. From measurements made by U.S. Army engineers in 1908 and measurements made by Survey

engineers in 1910 there is evidence that a pronounded[1] channel change took place during the flood of 1909. Probably this flood greatly widened the lower river in places and took out log jams and other obstructions. Just how long the river had been in this obstructed condition that a stage of 55 feet would have given as much discharge as 54 feet would have given on the 1917 curve. There have been several changes, due to the hand of man, that affect the discharge somewhat:

First.--The Northern Pacific Railway some time between 1897 and 1909 displaced trestle work with earth embankment on both sides of the river. The trestle extended from the hills on the left side to the Sedro-Woolley yards, so that the earth embankment materially changed the stage-discharge relation above and below the railway crossing, although it probably did not affect that relation greatly at the crossing.

Second.--The dikes along the river tend to raise the stage for a given discharge by prevention of flow and channel storage in the bottom lands. Floods such as 1897, 1909, and 1917 usually break or overtop the dikes; so it is doubtful if their peaks were affected materially. About November 20, 1911, the river cut across Sterling Bend (aided by dynamite) below the N.P. bridge at Sedro-Woolley. This caused a rapid lowering of the stream bed due to cutting

[1] Typist's Note: Probably meant pronounced.

off two and one half-miles of river, and by 1917 three feet less gage height than prior to November 20, 1911, gave practically the same discharge at low and medium stages. A revision of the curve used in 1909 gives, on November 20th, a maximum discharge of 169,000 second-feet. The flood of December 30, 1917, gives a maximum discharge of 157,000 second-feet. It is estimated that the flood of 1897 reached a maximum discharge of 171,000 second-feet.

In addition to the foregoing floods, the mark of an older and much higher flood was found at the same point where the 1909 flood was noted (see exhibit “H”). Referred to the gage at the Northern Pacific bridge this flood would have given a gage height of 60 feet and a discharge of 225,000 second-feet. Mr. Hart who came to the valley in 1878 stated that all of the oldest trees (cedar and fir mostly) showed these marks distinctly but that spruce two and one-half feet in diameter were not so marked. These early settlers could not imagine what made the marks and made inquiries of the Indians. Some of the oldest Indians, judged to be about seventy years of age, told them that when they were small boys a big water came “very quick” and that their tribe did not have time to save their smoked salmon and dried venison; consequently, they nearly starved that winter. Mr. Hart estimated at that time, from the age of the Indians who were able to remember the flood, that this flood must have occurred about sixty years pre-

vious to 1879. This makes the date of the flood about 1820 and is confirmed by my study at Reflector Bar and by the young spruce trees which did not have the high-water mark on in 1879.

Two great summer floods are distinctly remembered by the settlers in this valley. Those were the floods of 1880 and 1894. The bottom lands around Mount Vernon were covered both times for long periods (see exhibit "I"). The river must have reached a stage of about 54 feet at Sedro-Woolley with a discharge of from 130,000 to 150,000 second-feet.

Flood on Tributaries of the Skagit River.

Cascade River

(See Exhibits "C" and "D")

Of the three floods, 1897, 1909, and 1917, that of 1909 was the lowest; the flood of 1897 was the greatest and followed by that of 1917 about half-way between 1909 and 1897. Some settlers claim that of 1917 was the highest, but I think none of them were there in 1897.

Sauk River at Darrington

(See Exhibit "E")

No record of 1897 flood, which was probably the largest. The cascade and South Fork of Skykomish were higher in 1897 than in 1909 or 1917. The flood of 1909 was about one foot higher than 1917.

Suiattle River

Nothing is known directly of this river, but in 1897 from flow of Cascade and South Fork of Skykomish it is thought that it probably reached a flow of 60,000 second-feet. This is confirmed by the high stage at Concrete on the main Skagit. In 1917 the Sauk at Darrington was nearly a foot lower than in 1909, but was said to be higher in 1917 than in 1909 near the mouth of the river. Evidently the Suiattle was much higher in 1917 than in 1909.

General

(See Exhibits “J” and “K”)

Although the floods of 1897, 1909, and 1917 are the only ones given here, it must not be assumed that these are remarkably greater than some others. The floods of 1896 and 1906 were large and did not fall far short of those mentioned above. On some of the tributaries of the Sauk and Suiattle these floods may have been greater than in 1909 or 1917. At Sedro-Woolley it is not probable that such floods as 1820 (approximately) occur upon an average oftener than once in two or three hundred years. It is not certain that it was as high on the tributaries as given on the curves and the tables. The flood may have been due to an extreme “Chinook” wind melting the snow on the upper Skagit, which in other large floods has never been affected. It is more probable though that the extreme “Chinook” was combined with an extraordinary rainfall, which would bring

up the lower tributaries as given. No doubt this flood crest could be traced through the Skagit basin, and thus determine definitely whether this was an extreme flood on all tributaries. The method of determining is simply to examine the old cedars and firs and find out to what elevation the river mud may be found in the crevices of the bark. This, when compared with the flood mark of 1917, will show the magnitude of the 1820 flood. Care must be exercised, of course, in not confusing 1897 or 1909 flood marks with those of the earlier flood. The lack of marks on young trees will be one method of determining this. Another is that the 1897 and 1909 marks will be comparatively bright while the mud of the 1820 flood will only be found in protected crevices.

Due to the limited time on this report errors may be found in the plotting of some of the measurements. Unchecked measurements were also plotted. These facts in no way affect the flood estimates, as the lower portion of the rating curves is only valuable to give a general shape to the curve and to be used as a starting point.

James E. Stewart.

Assistant Engineer

Tacoma, Washington,

July, 1918.

Exhibit “K”

Date						Precipitation at Blaine Wash.		
(a)	1897	(b)	1909	(c)	1917	(a)	(b)	(c)
Nov.	15	Nov.	26	Dec.	26	.00	.00	.48
	16		27		27	.00	.52	1.30
	17		28		28	1.80	2.60	1.44
	18		29		29	1.28	2.00	2.00
	19		30		30	.00	.02	.00
			TOTAL			3.08	5.14	5.22

Date						Maximum Temperature at Seattle, Wash.		
(a)	1897	(b)	1909	(c)	1917	(a)	(b)	(c)
Nov.	15	Nov.	26	Dec.	26	45	44	52
	16		27		27	45	45	57
	17		28		28	56	59	61
	18		29		29	61	67	69
	19		30		30	40	45	58

Date						Minimum Temperature at Seattle, Wash.		
(a)	1897	(b)	1909	(c)	1917	(a)	(b)	(c)
Nov.	15	Nov.	26	Dec.	26	35	36	35
	16		27		27	39	40	51
	17		28		28	43	43	55
	18		29		29	40	43	51
	19		30		30	34	39	49

Exhibit “I”

(Run-off, total in acre-feet.)

Year	Columbia River at The Dalles	Skagit River near Sedro-Woolley
1880	192,000,000	16,000,000 (est.)
1894	225,000,000	17,000,000 (est.)
1911	136,000,000	12,500,000
1912	133,000,000	9,940,000
1913	154,000,000	12,000,000
1914	135,000,000	11,400,000
1915	106,000,000	7,780,000
1916	173,000,000	12,700,000
1917		11,100,000

Exhibit "J"

Location	Drainage area	1820		1897		1909		1917	
		Maximum Discharge	Maximum run-off	Maximum discharge	Maximum run-off	Maximum discharge	Maximum run-off	Maximum discharge	Maximum run-off
	sq. mi.	sec.-ft.	per Sq. Mi.	sec.-ft.	per Sq. Mi.	sec.-ft.	per Sq. Mi.	sec.-ft.	per Sq. Mi.
Skagit River Power Camp	1,090	100,000	92	47,400	43	63,500	58	47,400	43
Cascade R. Power Camp	222	46,000	207	40,000	180	26,000	117	52,000	144
Sauk River at Darrington	293	48,000	164	44,000	150	40,000	137	36,000	123
Suiattle River at mouth	345	60,000	174	55,000	159	38,000	110	45,000	130
Baker R. below Anderson Cr.	184	50,000	272	36,700	199	46,200	251	36,700	199
Total		304,000		222,000		214,000		197,000	
Skagit R. below Baker River		275,000		205,000		185,000		175,000	
Skagit River nr. Sedro-Woollley	2,930	225,000	77	171,000	58	169,000	58	157,000	54

Appendix to Skagit River Flood Report

More data may at some time be desired in regard to the great flood of 1820 (approximate). Therefore, the following notes have been added to the original report.

From the study in the main text and on the curve sheets, it is fairly certain that this flood did not occur previous to 1810 nor subsequent to 1830. Very probably it occurred between 1815 and 1825. The year 1820 is the mean of these figures and has been used in the study. Large floods may occur any time during the winter. The limiting time of disastrous floods is, however, from about November 15 to January 15 for this region. Previous to November 15, the conditions of a large quantity of unpacked snow and a heavy warm rain seldom occur. After January 15 the snow is usually fairly well packed and will absorb a large amount of rain and yet not go off rapidly itself. The great flood, therefore, probably occurred between November 15 and January 15 within the limiting years of 1815 and 1825.

The Hudson Bay Fur Trading Company had posts on the Pacific Coast and in the Columbia and Frasier basins prior to the probable time of this flood. From some of their records now in the home office at London it is thought that the exact date of the flood may be obtained. Records kept by the Catholic Fathers in southern California show that many of the years from 1811 to 1828 were abnormal either as to drouth[2] or floods. (See “Southern California floods of January, 1916,” Water-Supply {Paper 426). It must be remembered in

[2] Typist’s note: Drouth is a Scottish-Irish word for drought.
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this slide reached by the flood of 1820. No. 2 is the point reached by the 1909 flood, and No. 3 is the point reached by the 1917 flood.

In the spring of 1918 a hand level was used to obtain the difference in elevation of the 1909 and 1917 floods. The marks on the rock slide were used as a check on the marks on the canyon walls. It is very probably that the elevation of the crest of the flood of 1820 at this rock slide can be determined. River sand will doubtless be found up to crest of flood. Possibly pieces of cedar logs will be found driven in[3] the crevices between rocks. To obtain this flood crest, it will be necessary to descend this slide from the trail leading to Ruby Creek. The difference in elevation of the 1909, 1917 and 1820 floods should all be determined at this time; also their height above water surface at the time of visit. In order to transfer the height of the 1820 flood to the gage, it will be necessary to find the slope of the water surface between the rock slide and the gage, during the flood. This can be determined very closely by comparison with the slope of water surface at time of visit and for the floods of 1909 and 1917.

At Sedro-Woolley it may be of interest to examine some of the trees which have the flood marks on. The marks on the trees are made by the river and adhering in the crevices of the bark. The upper limit of this mud for the 1917 flood can be seen from a distance of about 100 feet, that of 1909 for about 30, feet while for the flood of 1820 it will probably be necessary to climb the tree and examine the deep crevices of the bark in order to determine

[3] HWN: Crossed out “on” and replaced with “in”.

this connection, however, that usually a time of drouth[4] in southern California will be a time of floods in Washington and vice versa. Floods seldom occur in both places during the same winter.

Flood marks on canyon walls above Reflector Bar gaging station.

It will probably be possible to determine the height of this great flood at Reflector Bar very closely. The picture shown above was taken from the cable about 100 feet downstream from the Reflector Bar automatic gage. This picture shows the marks of the 1909 and 1917 floods on the canyon wall about 700 or 800 feet upstream. Points to be noted are designated by numerals and arrows. No. 4 is the 1909 flood mark showing as a narrow horizontal line along fac of cliff above crest of 1917 flood.[5] Nos. 1, 2 and 3 are points on a rock slide a short distance downstream from the canyon wall on which the flood marks are. No. 1 is the point on

[4] Typist's note: Ibid.
[5] HWN (Handwritten Note): designated by No. 5
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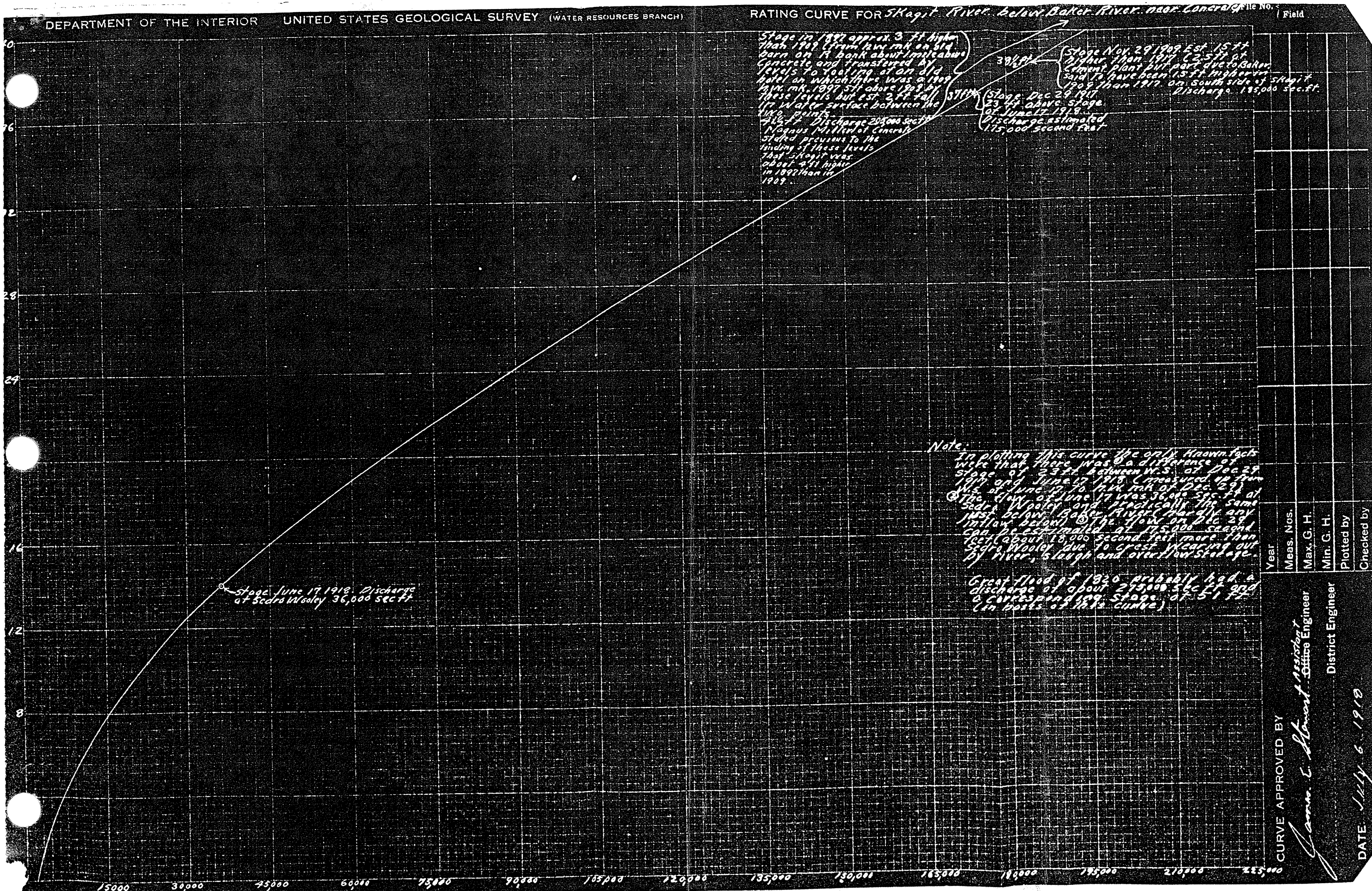
of 1820 and no doubt the flood crest could be traced throughout the valley by the river mud in the crevices of the bark of old cedar and fir trees. This should be done as soon as possible, for the old trees are dying and being cut down rapidly.

As soon as a station is installed on Suiattle River, the height of the 1917 flood in relation to the gage should be determined. Possibly from mud in fir and cedar trees or from drift and beach lines, the crest of the 1897 flood can also be determined. The estimates given in the report can then be checked up. It is probable that the estimates as given for Suiattle River are too large rather than too small, since the run-off per square mile is greater than Sauk River at Darrington except for 1909. With a larger drainage area, the tendency would be for a smaller run-off per square mile, other things being equal.

James E. Stewart,

Assistant Engineer

August 12, 1918.


DEPARTMENT OF THE INTERIOR UNITED STATES GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)
RATING CURVE FOR Skagit River below Baker River near Concrete
File No.
Field
40
36
32
28
24
16
12
8
15000
30000
45000
60000
75000
90000
105000
120000
135000
150000
165000
180000
195000
210000
225000
Stage in 1897 approx. 3 ft higher than 1909 (from h.w. mk on old barn on R bank about 1 mile above Concrete and transferred by levels to footing of an old hotel on which there was a 1909 h.w. mk. 1897 5 ft above 1909 by these levels but est. 2 ft fall in water surface between the two points.
41½ ft Discharge 205,000 sec ft
Magnus Miller of Concrete stated previous to the finding of these levels that Skagit was about 4 ft higher in 1897 than in 1909.
38½ ft
Stage Nov. 29 1909 Est. 1.5 ft higher than 1917 (2.5 ft at Cement Plant but part due to Baker. Said to have been 1.5 ft higher in 1909 than 1917 on south side of Skagit. Discharge 185,000 sec.ft.
37 ft
Stage Dec 29 1917 23 ft above stage of June 17 1918. Discharge estimated 175,000 second feet
Stage June 17 1918. Discharge at Sedro Wooley 36,000 sec ft
Note.
In plotting this curve the only known facts were that there was ① a difference of stage of 23 ft. between W.S. of Dec 29 1917 and June 17 1918 (measured up from W.S. of June 17 to h.w. mk of Dec. 29) ② The flow of June 17 was 36,000 sec.ft at Sedro Wooley and practically the same just below Baker River (hardly any inflow below) ③ The flow on Dec 29 can be estimated at 175,000 second feet (about 18,000 second feet more than Sedro Wooley due to crest wearing out by river, slough and overflow storage.
Great flood of 1820 probably had a discharge of about 275,000 sec ft and a corresponding stage of 51 ft (on basis of this curve)
Year
Meas. Nos.
Max. G. H.
Min. G. H.
Plotted by
Checked by
CURVE APPROVED BY
Assistant Office Engineer
District Engineer
DATE July 6 1918

DEPARTMENT OF THE INTERIOR UNITED STATES GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

RATING CURVE FOR Skagit River near Sedro Wooley Wash. File No. Field 913

56.5 ft peak of 1909 flood, discharge 182,000 sec ft.

56.0 ft peak of 1897 flood, discharge 171,000 sec. ft. (Mr Hart, an old settler, of 1870 measured up exactly 4.0 ft. from crest of 1897 flood to HW mark of 1820.)

Peak of the 1917 flood 54.9 ft.
discharge 157,000 sec ft.
Observer read 53.5 at 4 PM Dec. 30 1917 and estimated that the crest was about 54.0 ft at 6 AM. The flow at the HW mark of 1897 to be only 1.0 ft below that of 1909. This was about 4 miles down river and below effect of cut off at Sterling Bend.
Mr Hart, who lives on Rattlesnake Bar, between wagon and railroad bridge stated that the flood of 1917 was about 15 inches below the crest for 1909. The peak of Rattlesnake Bar occurred about Dec 29. This flood crest should travel the 80 mile to Sedro Wooley in 20 hrs or less one as it is the last of all tributaries to reach Sedro Wooley the river would drop rapidly after the crest from Rattlesnake Bar for a distance of about 12 miles. Below this point the fall would be retarded by the tide backwater for a distance of 8 or 10 miles. Below that of the mouth of the Baker River the fall would be rapid.

Year	Run off per sq mi
1820	50
1897	50
1909	58
1917	54

} 2,930 sq mi

Theoretical break in curves at 54 ft due to overflow of banks. Practically this probably does not occur because gradual increase in discharge through sloughs would smooth out this into a continuous curve.

7 (Computed using coef of 90% Lafr Studies indicate about 90)
7 (as originally computed Coef. 85%)

Nov 30 1909 – Nov 21 1910
Nov 22 1910 – Nov 19 1911
Dec. 20 1917

Note
In drawing up the curve for 1909 it was necessary to draw it so that it would have a greater discharge at 56.5 ft than the 1917 curve gave at 54 ft. This is practically certain for at that time there existed between the mouths of Sauk and Baker) many sloughs which at high stages carried a large portion of the total discharge of the river. Towards the end of 1917 these sloughs would carry much less water for the upper end of the reach was greatly obstructed by the cut off at Sterling Bend. The curve would therefore have to be drawn materially nearer the 1897 curve. Subsequent to 1917 the river began to cut back rapidly thus in 1917 it is assumed that the river below Sterling Bend was in same condition as in 1909 as in 1897.
The 1917 flood does not give a flow at Sedro Woolley that is as large proportionally as the sum of peaks at the different as does the 1909 and 1897 floods. This is probably due to the enormous flow of Sauk River which is separated from Skagit by a long island. Where the Sauk empties into the Skagit near Mouth of Baker River the Skagit has not resumed its former cold mud flat condition. The river has consequently the sluggish character of the upper reaches. The cut off at Sterling Bend was made in 1911 and the flood of 1917 was the first flood after the cut off. The condition of the river in 1897 is assumed to have been about the same as in 1917. It is possible that a curve drawn even a greater discharge would be justified as considerable filling was done after 1897 by the Northern Pacific Railway after the flood of 1897 and also by the Great Northern Railway after 1897. The effect of the cut off at Sterling Bend in 1911.

CURVE APPROVED BY
Office Engineer
District Engineer

Year	
Meas. Nos.	
Max. G. H.	
Min. G. H.	
Plotted by	
Checked by	

DATE July 6 1918

DEPARTMENT OF THE INTERIOR UNITED STATES GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

RATING CURVE FOR Skagit River at Reflector Bar near Marblemount Wash. Inclined gage

File No. Field 917

Break in curve due to overflow of bank

Flood crest Nov. 29, 1909. Gh. 15 ft. Discharge 58,300 sec. ft. Gh. obtained by three independent methods: Comparison of H.W. mks. of 1917 and 1897 at Davis Ranch one mile below; ② Levels to 1909 and 1917 H.W. mks on canyon walls 900 ft above gage; ③ Levels to drift log left by 1909 flood 100 ft below gage.

Flood crest Nov. 18, 1897 and Dec. 29 1917. Gh. 12.5 feet. Discharge 71,700 sec ft. Gh. obtained from H.W. mk at gage and from comparison of well and river on Dec. 30, 1917. 1897 Flood reached same height as 1917 (within 1 or 2) at Davis Ranch one mile below.

Partial meas by COB in 1916

Velocity curve drawn up only to see that a reasonable velocity was not exceeded for the peak flood

Vel in ft per sec

Discharge 1000's

Year
Meas. Nos.
Max. G. H.
Min. G. H.
Plotted by
Checked by

CURVE APPROVED BY
Jas. E. Stewart Assistant
Engineer
District Engineer

DATE July 6 1918

DEPARTMENT OF THE INTERIOR UNITED STATES GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

RATING CURVE FOR Skagit River near Marblemount, Wash. File No. Field 912

Lower Camp.

Flood crest of Dec. 29, 1917 gh 19.0 ft.
from drift of gage. Determined by
U.S. Rel. 2 1918 by means of hand
level. Discharge 47,400 sec ft
Est. flood of 1897 to be the same
discharge but probably 1.2 ft lower
gage height.

Quad to 1.5 miles S.E. of Marblemount
Lat 48°32'00" Long 121°26'00"
Approx. Elev. 650 ft. (Aneroid)

Flood crest of Dec. 29, 1917 gh 19.0 ft
from drift of gage. Determined by
U.S. Rel. 2 1918 by means of hand
level. Discharge 47,400 sec ft
Est. flood of 1897 to be the same
discharge but probably 1.2 ft lower
gage height.

Year	Run-off per sq mi	
1920	92	1090 sq mi
1897	43	
1909	58	
1917	43	

54
55
56
49
57
58
25
53
52
47
48
45
43
50 44
36
13 and 14

Note.
Only measurements by Survey engineers have been plotted. Those made by survey engineers have not been plotted as they probably in error. They may or may not be wrong. If data is revised a low water curve should be drawn up. This may shift to be above through "44" a little. Small at "50 and possibly "43". Probably a good many of Power Co measurements where made by 248 method can be used.

Shift may have been caused by drift jam at upstream gage. This should be examined at low water and measurement made.

Year	
Meas. Nos.	
Max. G. H.	
Min. G. H.	
Plotted by	
Checked by	

RATING CURVE APPROVED BY

James L. Stewart Assistant Office Engineer

District Engineer

DATE July 6. 1918

DEPARTMENT OF THE INTERIOR UNITED STATES GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

RATING CURVE FOR Skagit River at Marblemount. File No. / Field

Drawn up to find approximately how much discharge left in g.h. would mean at flood stage. Just estimated range of stage from what I remembered of river banks at this point. This represents combined flow of Skagit and Cascade.

Year
Meas. Nos.
Max. G. H.
Min. G. H.
Plotted by
Checked by

RATING CURVE APPROVED BY

Assistant Office Engineer

District Engineer

DATE July 6. 1918.

DEPARTMENT OF THE INTERIOR UNITED STATES GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

RATING CURVE FOR Cascade River near Marblemount Wash. File No. / Field

GAGE HEIGHT IN FEET

20
18
16
14
12
10
8
6
4
2

Estimate 20 feet crest of 1897 flood. Discharge 40,000 sec. ft. 1.60 sec. ft. per sq. mi. River said by settlers to have been much higher in 1897 than 1909

Est. 22 ft. crest of 1920 flood (approx.). Discharge 48,000 sec. ft. 2.07 sec. ft. per sq. mi. Cascade must have been very high from Indian Creek sediment that spread between Marblemount and Rockport

Est. 17 ft. crest of 1917 flood. Discharge 32,200 sec. ft. 1.44 sec. ft. per sq. mi. River said by settlers to have been much higher in 1917 than 1909

Crest of 1909 flood 15.0 ft. 5 P.M. Nov. 29.
Discharge 27,000 second feet.
1.17 sec. ft. per sq. mi.
Discharge for this gage height obtained as follows:
Area of cross section at 15.0 ft. gage
15 × 30 sq. ft. with 135 ft. top width
Steep angle not allowed for.
Bank at slope of 2 to 1
12 × 2 × 12 = 288
12 × 705 = 1260
total area 1548 (use 2000)
Est. velocity 13.5 per sec.
2000 × 13.5 = 27000 (assumed mean velocity)
= 27000 second feet

Note: 222 sq. mi. (published drainage area) used in obtaining run-off per sq. mi.

Note: [illegible] of the Cascade River emptied into the Skagit [illegible] Skagit bed at present [illegible] the Skagit above [illegible] Cascade [illegible] gage height in 1917 than 1909. [illegible] Skagit [illegible] Cascade [illegible] Skagit [illegible] comparatively [illegible] at this section [illegible] Skagit [illegible] Cascade [illegible] Skagit [illegible] observations [illegible] there was no [illegible] with a [illegible] additional backwater effect [illegible] was normal [illegible] shown [illegible] curve in the Cascade in 1897 [illegible] there is about 1.5000 [illegible] shown [illegible] curve above. [illegible] Skagit had been lower [illegible] it would still have been [illegible] 67,000 sec. ft. (2.400 per sq. mi.) the [illegible] would [illegible] 5000 [illegible] the additional [illegible] the Cascade curve would be corrected [illegible] being assumed that although [illegible] Cascade water [illegible] below [illegible] same effect as [illegible] coming [illegible]

22
18-21
17
25
24
27
8
6

22,000 27000 30,000 33,000 36,000 39,000 42,000 45,000

Year
Meas. Nos.
Mss. G. H.

CURVE APPROVED BY
[illegible] Assistant
Water Engineer

DEPARTMENT OF THE INTERIOR UNITED STATES GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

RATING CURVE FOR Sauk River at Darrington Wash. File No. Field 930

Stages from 2 to 3 ft higher than 1917 have occurred from time to time of river banks including bars left from old channels (see note) measured flood of 1897 approx was probably higher than 1897 probably not more than 1 ft higher giving a maximum discharge of 49,000 sec ft 764 sec ft per sq mi

Flood of 1897 higher than 1909 on Cascade and Stillaguamish Rivers have been higher on Sauk Estimate peak at 17.5 ft Discharge 44,900 sec ft. 750 sec ft per sq mi

16 ft Discharge 40,000 sec ft
Approx crest of 1909 flood
Affirm comparison by observation of backwater in his garden of 1909 and 1917 floods
Discharge 137 sec ft per sq mi

150 ft crest of 1917 flood
Discharge 36,000 second feet
123 second feet per sq mi
Discharge obtained as follows:
Water surface at crest of 1917 flood found to be 9.5 ft above water surface of measurement #23 ft cross sectional area 665 sq ft edge of water at station 161. Additional area station 20–200 is
95 x 16 = 1520 sq ft
Additional area to left of station 200 Channel overflowed & scour in sandy left portion of stream + piling up of water on left side estimated at 215 sq ft total area = 2460 sq ft
2400 x 15 = 36000 sec ft

GAGE HEIGHT IN FEET

18
16
14
12
10
8
6
4
2
0

36
33
34
35
29-30
28
32
31
27
4-5
9-10

36
23
35
25
39
30
29
28
32
27
23
4
9

Note 229 sq mi used in working up runoff per sq mi

"a" velocity

Velocity in feet per sec

Year	
Meas. Nos.	
Max. G. H.	
Min. G. H.	
Plotted by	
Checked by	

RATING CURVE APPROVED BY
Wm. E. Stewart Assistant
Office Engineer
District Engineer
DATE.

DEPARTMENT OF THE INTERIOR UNITED STATES GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

RATING CURVE FOR Baker River below Anderson Creek near Concrete Wash File No. Field 943

Great flood of 1820 (approx) probably reached a gage height of 16.0 ft with a discharge of 50,000 second feet 272 second feet per sq mi

Crest of 1909 flood gave 13.3 (obtained from drift rims on trees and from the high water reach line. Discharge 46,200 sec ft 251 sec ft per sq mi.

Flood of 1897 probably about same as 1917 or slightly less

Peak of 1917 flood 13.5 ft
Discharge 36,700 sec ft
199 sec ft per sq mi.
Discharge obtained by taking area of meas #19 (shows greatest scour) + 80 (probable additional scour) + 6.7 X 155 = 1040 (area above meas #12)
2160 sq ft V 17 ft per sec = 36,700 sec ft

Previous to Dec 29 1917 — Dec 30 1917 —

Measurement #18 made only 30 hrs after #18. Shows sudden falling off in velocity due to great scour that occurs when stage gets much above 7.0 ft

GAGE HEIGHT IN FEET

16.0
14.5
13.0
11.5
10.0
8.5
7.0
5.5
4.0
2.5
1.0

3,000 6,000 9,000 12,000 15,000 18,000 21,000 24,000 27,000 30,000 33,000 36,000 39,000 42,000 45,000

Vel in ft per sec 2 4 6 8 10 12 14 16 18

Year
Meas. Nos.
Max. G. H.
Min. G. H.
Plotted by
Checked by

CURVE APPROVED BY Sam. L. Stewart Assistant Office Engineer
District Engineer
DATE