RUNOFF CHARACTERISTICS OF THE COLUMBIA AND KOOTENAY RIVERS IN BRITISH COLUMBIA

by
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This paper, in general, describes the runoff in the Columbia River basin upstream from the gauging station at Birchbank, near Trail, B.C. (Fig. 1).

The drainage area at Birchbank is 34,000 square miles out of which 19,000 square miles, or 96 percent, are drained by the Kootenay River. Both the two main streams, the Columbia and Kootenay, above their junction are of nearly equal length - approximately 450 miles. At flood stage the river flow would travel this distance in about three to four days.

The elevations in the watershed range from 1,700 to over 12,000 feet in the northern part of the mountain ranges. A number of glaciers, with an aggregate area of approximately 300 square miles, occur in the northern half of the watershed. The watershed of the main stem of the Columbia is higher in elevation than that of the Kootenay, as illustrated in Table 1.

Table 1. Area - elevation relation

Stream	Station	Percent of area above indicated elevation		
		25%	50%	75%
Columbia	Nicholson	7,600	6,000	4,200
"	Revelstoke	7,500	5,950	4,200
"	Castlegar	7,200	5,600	3,800
Kootenay	Wardner	7,100	5,850	4,300
"	Porthill	6,300	5,100	3,800
"	at mouth	6,500	5,150	3,900
Columbia	Birchbank	6,800	5,300	3,850

At a number of gauging stations a 25-year (1929/30 - 1953/54) average annual and freshet (April - August) runoff has been computed or estimated. Runoff is highest in the north-central portion of the watershed, on the westerly slopes of the Selkirk Mountains. There, the average annual runoff is as high as 60 to 70 inches, and in a wet year nearly 100 inches.

Lowest runoff generally occurs in the south-eastern portion of the Kootenay watershed. The average annual runoff in that area is less than 10 inches. Areas of low runoff, 10 to 20 inches annually, also occur in the narrow north-south valleys in the Rocky Mountains and in the south-west portion of the main stem of the Columbia basin.

The average snow-melt runoff, considering a five-month period from April to August, varies from 70 to 90 percent of the average annual runoff. In the larger streams the average April - August runoff is 74 to 79 percent of the average annual runoff.

The foregoing generally excludes small streams draining areas of relatively low altitude. In such small watersheds runoff can be greatly modified by local features.

Some characteristical data on runoff of the two main streams, the Columbia and Kootenay, for the 25-year period are given in Table 2, and for the period of record in Figure 2. As it can be seen from Figure 2, we have experienced above average runoff in the recent past, particularly in the Kootenay River basin.

The average annual runoff for the 10-year period ending in 1955 in the Kootenay basin was 10 to 15 percent, and the average April - August runoff 10 to 20 percent above the 25-year normal. In that decade only the year 1949 and, in some areas, also 1952, or 1953, were below normal.

In the basin of the main stem of the Columbia, upstream from the Kootenay, the average runoff in the last decade was only slightly above the 25-year normal, about 2 to 3 percent.

Going further back, the above mentioned wet decade was preceded by a dry period, the length of which was from 5 to 10 years depending on the location of a stream. Both the average annual and April - August runoff were 10 to 20 percent below the 25-year normal.

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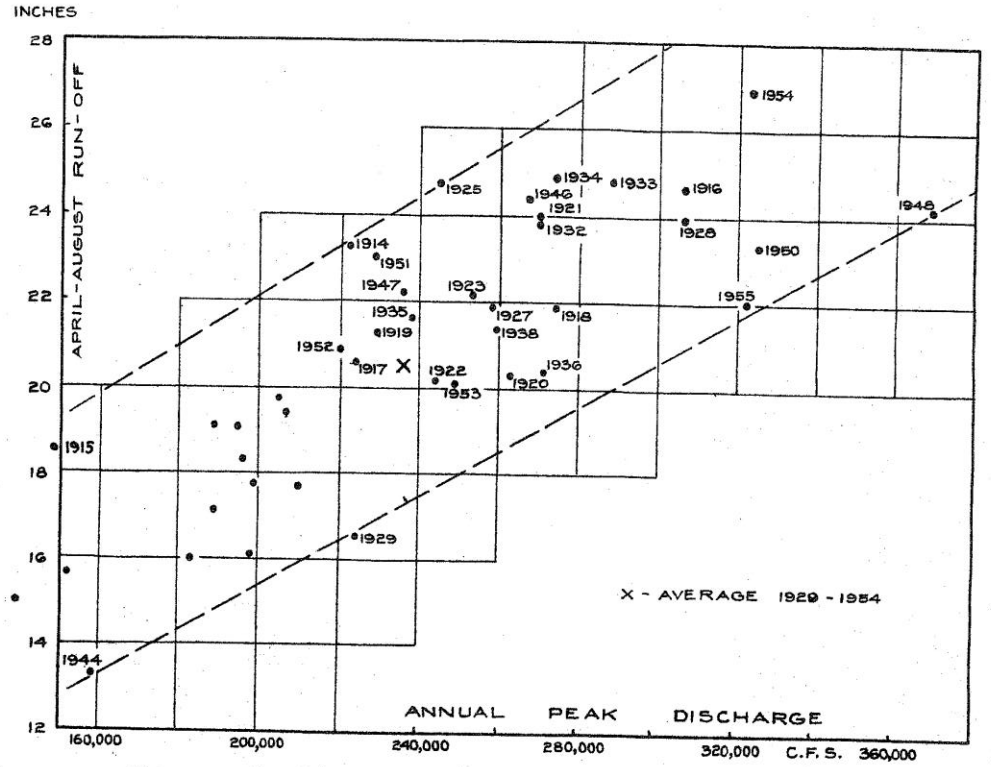
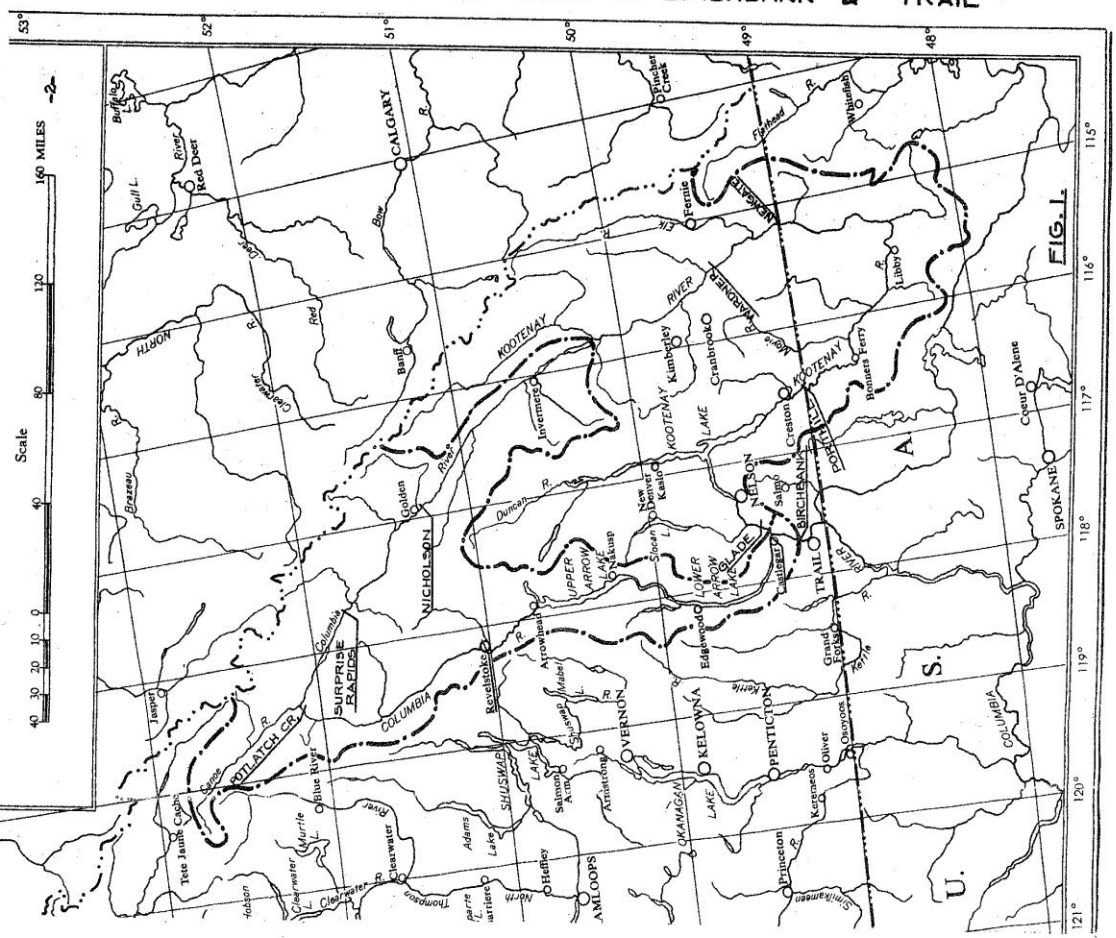


FIGURE 3. COLUMBIA RIVER AT BIRCHBANK & TRAIL



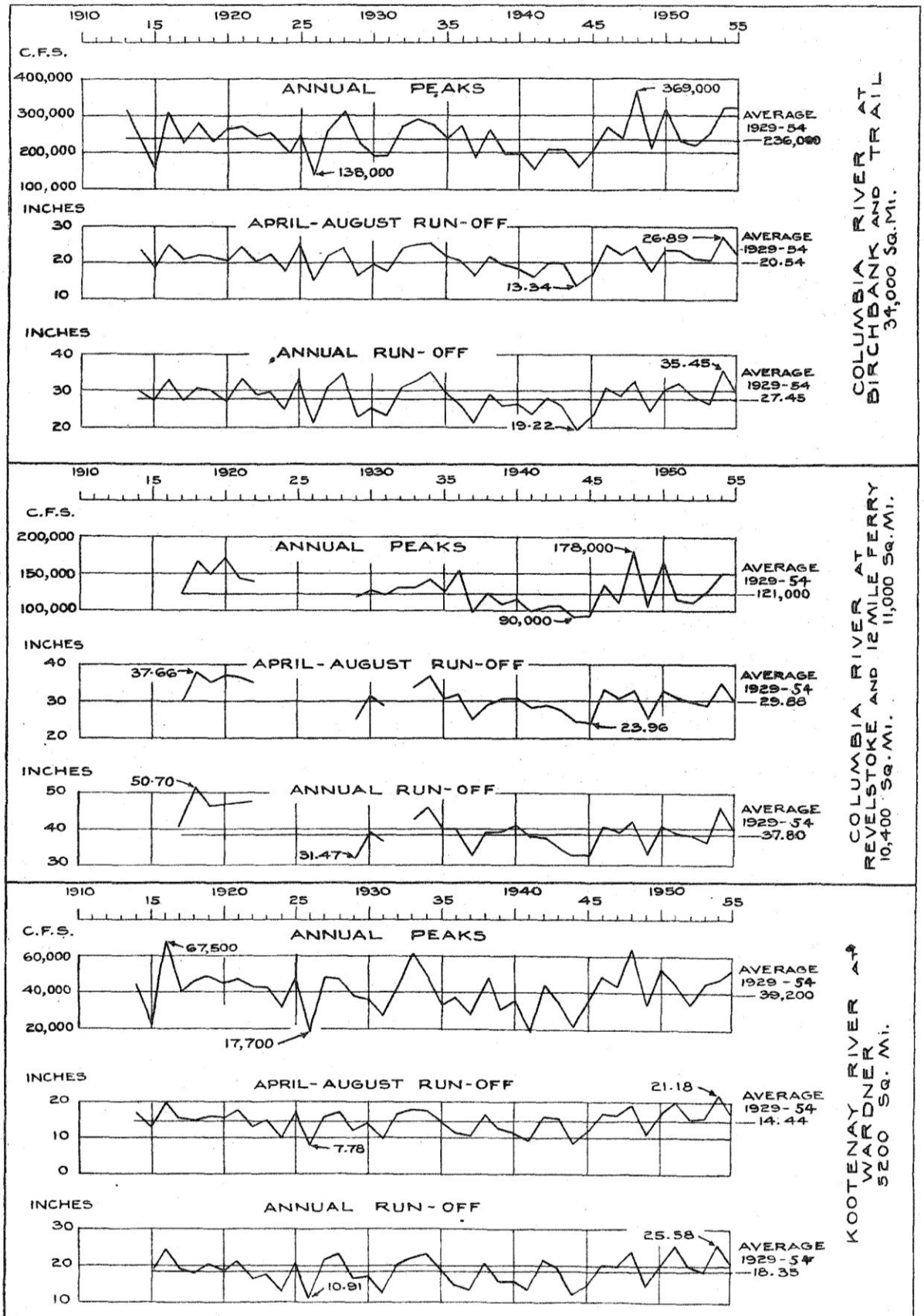


FIGURE 2. RECORDS OF PEAK DISCHARGE AND RUN-OFF

Table 2. Annual and Freshet Runoff, 1929/30 - 1953/54

Stream and Station	Annual Runoff					April - August Runoff			
	Drainage area, sq. mi.	Average c.f.s.	Average Inches	Max/Min % of average	% of Columbia @Birchbank	Aver. Inches	Max/Min % of average	% of Annual Runoff	% of Columbia @Birchbank
Columbia									
at Nicholson	2,570	3,650	19.4	136/74	5.3	14.9	139/69	77	5.4
at Surprise Rapids	5,420	10,800	27.2	-	15.7	-	-	-	-
at Potlach Creek	8,220	19,000	31.4	-	27.6	-	-	-	-
at Revelstoke	10,400	29,000	37.8	122/85	42.3	29.9	122/80	79	44.6
at Castlegar	14,300	37,400	35.5	-	54.4	26.4	-	74	54.0
Kootenay									
at Wardner	5,200	7,000	18.3	140/64	10.1	14.4	146/59	78	10.7
at Newgate	7,660	10,100	17.8	142/61	14.7	14.1	147/56	79	15.3
at Porthill	13,700	15,600	15.4	143/53	22.6	12.0	151/48	78	23.6
at Glade	19,100	30,400	21.6	-	44.2	16.2	-	75	44.4
Columbia									
at Birchbank	34,000	68,700	27.4	129/70	100.0	20.5	131/65	75	100.0

Table 3. Dating of Freshet Runoff

		Columbia River			Kootenay River	
		Nicholson	Revelstoke	Birchbank	Porthill	Wardner
Drainage area, sq. miles		2,570	10,400	34,000	13,700	5,200
25-year average discharge, c.f.s.		3,650	29,000	68,700	15,600	7,000
Period of record, years		38	31	41	25	38
Start of rise,	earliest	2/27	2/11	2/13	1/6	3/10
	average	3/25	3/22	3/20	3/5	4/3
	latest	4/30	4/21	4/21	4/7	4/27
Risen to 25-year average,	earliest	4/22	4/21	4/15	2/10	4/8
	average	5/14	5/7	5/5	4/12	4/29
	latest	5/28	5/23	5/21	5/6	5/15
Annual peak,	earliest	6/2	5/27	5/24	4/21	5/1
	average	6/29	6/21	6/18	5/24	6/5
	latest	8/7	7/18	7/20	6/23	7/4
Receded to 25-year average in fall,	earliest	8/24	8/29	8/19	6/30	7/10
	average	9/12	9/14	9/8	7/24	8/8
	latest	10/10	9/14	10/16	9/6	9/6
Average number of days above 25-year average discharge		121	129	124	103	104

Another above normal wet period of considerable length occurred some 33 years ago. In a period of 5 to 8 years, ending in 1922, the average runoff was 5 to 20 percent above the long - term normal. Some of the recorded maxima occurred at that time.

The progress in the annual snow-melt with respect to time in the two main streams, the Columbia and the Kootenay, is depicted in Table 3. The table shows the average and extreme dates of four characteristic points on the annual discharge hydrograph, (1) the first significant rise in discharge in spring, (2) discharge risen to the 25-year average, (3) annual peak, and (4) discharge receded to the 25-year average in fall. Of course, such a dating does not necessarily give a satisfactory description of a hydrograph because of the secondary peaks that can occur in any portion of the freshet runoff cycle. No attempt was made to separate the contribution of the rainfall from the snow-melt runoff.

Generally speaking, spring arrives from the south in this area, as would be expected, and moves on towards the north. As a rule, the active snow-melt in the Kootenay River basin is fairly well dispersed in time and the annual peaks in the middle and lower Kootenay River occur much earlier than in the Columbia River above their confluence. In the basin of the main stem of the Columbia nature's timing of active snow-melt, usually, is less dispersed in time.

There have been years in the past when the above description did not hold. Weather pattern can be such that after a cool spring warm air will blanket the whole area for a considerable time. These weather conditions will result in rapid snow-melt in the whole basin simultaneously or nearly so.

With respect to the magnitude of the annual peak discharges the water content of snow pack and the weather conditions during the snow-melt period appear to be the two dominant ones. On the Figures 3, 4 and 5 the annual peak discharges have been plotted against the April - August runoff. The latter closely correlates with the water content of the April 1st snow pack. A somewhat similar graph for the Columbia at The Dalles is published in the 1951 - Proceedings of the Western Snow Conference.

The extent to which the magnitude of peak discharges is governed by the weather conditions can be demonstrated by comparing the data for recent past on the above three graphs. The years of 1954 and 1951, both with high snow pack, produced peak discharges of only moderate magnitude. On the other hand, the years of 1955, 1950, and 1948, again with a high snow pack, exhibited rather high peaks which were 30 to 50 percent higher than those under the weather conditions of the first group, i.e. 1954 and 1951.

An examination of the dates of peak discharges, shown in Table 4, reveals that the high peaks were the result of weather conditions which caused nearly simultaneous peaking in the whole area, particularly in the Kootenay River basin.

The above appears to suggest that flood forecasting in the area under consideration could be successful only if the recurrence of such unfavourable weather patterns as in 1948, 1950, and 1955 can be predicted. To my knowledge advanced weather forecasting is limited to general patterns and does not provide the detailed information for predicting the magnitude of peak flows a month or two before occurrence.

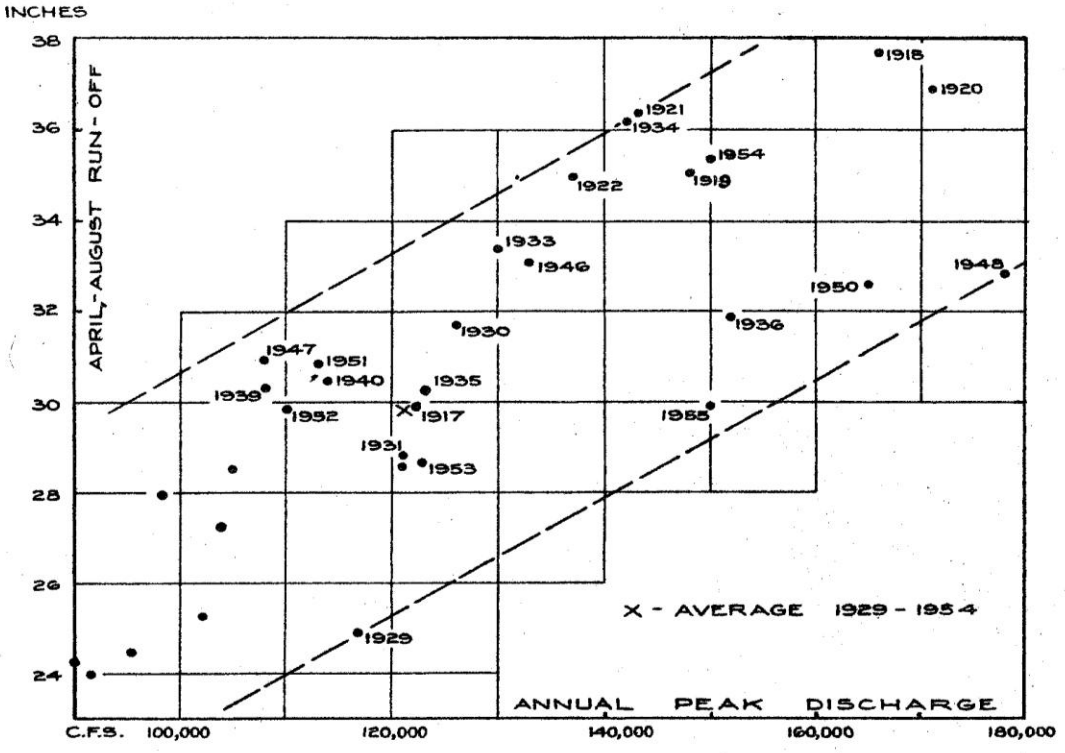


FIGURE 4. COLUMBIA RIVER AT REVELSTOKE & 12 MILE FERRY.

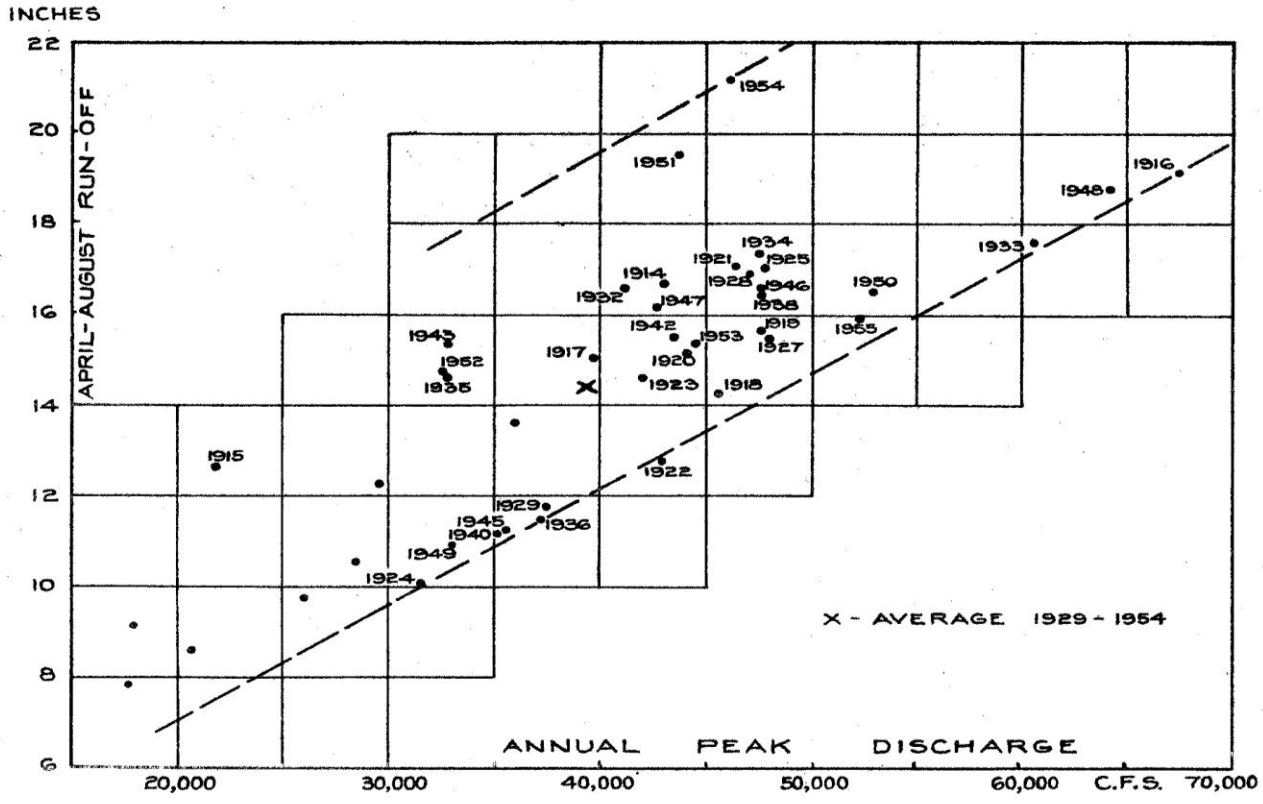


FIGURE 5 KOOTENAY RIVER AT WARDNER.

Table 4. Dates of Peak Discharges

		Heavy Snow Pack - High Peaks	
		1950	1948
Columbia	Nicholson	July 8, 9	June 11
"	Surprise Rapids	June 22	
"	Potlach Creek	June 21	June 9
"	Revelstoke	June 22	June 9
"	Castlegar	June 24	June 11
"	Birchbank	June 24	June 11
Kootenay	Glade	June 25	June 10
"	Porthill	June 23	June 1
"	Newgate	June 23	May 28
"	Wardner	June 22	May 27

		Heavy Snow Pack - Moderate Peaks	
		1954	1951
Columbia	Nicholson	July 10	July 20, 21
"	Surprise Rapids	July 9	July 18, 19
"	Potlach Creek	July 8, 9	July 15
"	Revelstoke	July 9, 10	June 16
"	Castlegar	July 12	May 27, July 10, July 21
"	Birchbank	July 11, 12	May 27
Kootenay	Glade	May 28 July 11	May 27
"	Porthill	May 22, 23	May 14
"	Newgate	May 21	June 17
"	Wardner	July 4	June 17