C. E. Thesis 1927

A STUDY OF THE HYDROLOGY

OF THE

KOOTENAY RIVER DRAINAGE BASIN

by

BARNETT SILVESTON

Submitted in Partial Fulfillment of the
Requirements for the Degree of
BACHELOR OF SCIENCE
from the
Massachusetts Institute of Technology
1927.

Signed ______________________

Certified by ....

Course I

Boston, Mass., May 23, 1927

Professor A. L. Merrill

Secretary of the Faculty

Massachusetts Institute of Technology

Dear Sir:

In accordance with the requirements for the degree of Bachelor of Science, I herewith submit a thesis entitled "A Study of the Hydrology of the Kootenay River Drainage Basin."

Respectfully submitted

Barnett Silveston

Barnett Silveston.

ACKNOWLEDGMENT

The author wishes to take this opportunity to express his appreciation for the many helpful suggestions rendered to him by Professor H. K. Barrows of the Massachusetts Institute of Technology, under whose direction this work was carried out.

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F O R E W O R D

There is perhaps no single substance entering into the structure of the earth, which has played, and is playing so important a part as water. It penetrates the soils, sands and rocks in large quantities and exists there till removed by evaporation and transpiration of plants and vegetation.

Water has the greatest direct influence on man, his health and industries. Its quality and especially its quantity directly affect his occupations. If there is too much, the ground is marshy, malarial and unfit for cultivation; if too little, the plants valuable for food do not thrive. There is a narrow range between excess and deficiency, and upon the nice adjustment of the balance between moisture and drought depends the existence of prosperous communities.

And at the present day, and especially in countries well advanced in the mechanical arts, water has attained to an even a greater significance because of the comparative ease with which power developed by it, can be sent to industrial communities further inland; without which power, those industrial centres could not have existed.

WATER SUPPLY OF BRITISH COLUMBIA

The primary source of water supply is rainfall, the chief source of which in British Columbia is evapöration from the Pacific Ocean. Brought from the Pacific by the westerly winds, warm and moist by the influence of the Japan current, the moisture in the air, is carried easterly across the country in quantities varying at different times of the year.

Now, all air holds a certain amount of moisture rainging from the amount suffieient to saturate it, to a very small proportion of that quantity. The point of saturation is much higher in warm air than in cold air, that is, warm air can hold a much larger quantity of moisture than can cold air. Whenever air is cooled below the point of saturation, rainfalls, and it can only fall when thus chilled. There are several ways in which air currents may be cooled; the current may be forced upward as when it climbs the slope of a mountain range; it may be cooled by intermingling with colder air currents; and again by coming in contact with cold lands. The sea recieves heat slowly and parts with it slowly; the land, on the contrary, is rapidly heated and parts with its heat as quickly. It results from these conditions that the ocean has a fairly uniform temperature all the year round, while the land is much colder in winter than in summer.

The west winds come off the Pacific laden with moisture, and having the temperature of the ocean, if they encounter land having a lower temperature, they are chilled below the point of saturation, and some of the moisture is deposited in the form of rain or snow. If, on the other hand, the land is warmer than the air, the air currents pass over it without any reductiom in temperature and with little or no loss of moisture.

During the autumn and winter, the Pacific cost is colder than the sea, and hence the copious precipitation which it enjoys at that season of the year. This is evidenced by the excessive run-off at Capilano Creek which averages about 160 inches per year. In the summer the conditions are reversed, and the air currents, although containing at least as much moisture as in cold weather, pass over the land with less loss by precipitation.

In the vicinity of Vancouver, there are local conditions affecting the quantity of precipitation, that is, certain fairly high mountains which cool the moist air currents and cause abnormal rainfall (140 inches at Conquitlan Lake.) This quantity diminishes advancing inland from Vancouver owing to the upward diversion of the moisture laden winds, and the lower elevation of the hills, till about 100 miles from the coast, the precipitation is so small that an arid district as resulted. This arid strip is nearly 100 miles wide and commonly called the " Dry Belt " of British Columbia. After passing over this belt, higher mountains are again met and they cool the air, consequently the precipitation in the vicimity of the Selkirk mountain is abnormanally large, averaging 60 inches at Glacier which is 4090 feet high.

In the upper Columbia Valley from Golden to Lake Windermere, there is another arid or semi-arid region lying between the Selkirks and the main range of the Rockies. The winds pass from one high range to another depositing only from 10 to 20 inches of precipitaion per annum in the valley (11 inches at Wilmer). The precipitation in the main range of the Rockies is large.

The following is an extract from the Monthly Weather Review of the Meteorological Service:-

' British Columbia is a territory with very pronounced geographic features, several lofty chains of mountains parralleling the coast from the extreme north to the most southerly boundary. Along the exposed western coast the precipitation is over a 100 inches, and eastward over Vancouver Island and the main-land, the western slopes of the various ranges each claim a much larger percentage of moisture from the Pacific winds than do the valleys and the interior plateaus. Near the eastern shores of Vancouver Island, the annual precipitation ranges between 35 and 50 inches, while in the valley of the Fraser, it is generally 50 to 60. Eastward of the coast ranges, the climate is drier, and annual precipitation is from 5 to 20 inches according to geographic situation. Approaching the Selkirk range, the precipitation increases, and at the higher altitudes is very great, chiefly owing to a heavy snowfall between October and April'.

Although British Columbia has such a wealth of potential water power, little has been done to harness that power. True it is that small hydro-electric plants do exist but these merely serve the timber mills and are not used much in other industries, due no doubt, to the cheapness of coal; hence, if hydro-electric plants are to exist the economies effected must be taken into account.

In all developments, the determination of available water supply and water losses at the site selected, has been one of the most difficult problems that confront the water power engineer; and this difficulty is paramount in British Columbia.

Rainfall records are few and those that do exist are, for the most part, located in valleys, and hence, are unsuitable for an accurate determination of the rainfall in the high mountain ranges where the greatest part of the water available for stream flow originates.

Run-off records although in the present case fairly accurate, are, always to a certain extent unreliable due to the short periods that the streams have been gauged, and also to the difficulty in maintaining run-off records at all stages and seasons.

In the study of hydrology of this or any other drainage area, it immediately becomes apparent that some relation must exist between precipitation and run-off; and it is as equally obvious that that relation instead of being simple, is complicated by a variety of factors which are themselves of a complex and varying nature.

It is the object, therefore, of this investigation to find the relation between precipitation and run-off of the Kootenay River Drainage Basin, and the effect of the other factors as far as possible.

Since a study of the hydrology of the whole of British Columbia was too herculean a task, the writer thought to devote his attention to the eastern part of the province, and to confine his study to that drainage area comprising the Columbia and Kootenay Rivers, but even that proved to be too large a task for the time allowed, and hence, he devoted his time to the consideration of the Kootenay River and its tributaries.

METHOD OF PROCEDURE

The investigation was carried out by obtaining the rainfall records for different stations in or about the drainage area over a period of ten years, from October 1914 to September 1924 inclusive. These records were obtained from the Annual Reports of the United States Weather Bureau for the stations in Idaho and Montana, and from the Water Resources Papers of the Dominion Water Power Service for the stations in British Columbia proper.

The mean precipitation, both seasonal and annual values, on the whole drainage area was determined for each year and also the run-off.

The altitudes of the stations used were then found by consulting the various maps of British Columbia and White's "Dictionary of Elevations of Canada".

The variation of precipitation and altitude were studied, in order to determine if any relation existed between them.

The mean precipitation on the whole drainage area, that had been previously determined, was then studied with respect to the run-off to see if any relation existed between them.

Graphs were plotted in order to bring out that relation more clearly.

DRAINAGE BASIN

The Kootenay River rises in the Beaverfoot range of the Rocky Mountains about 20 miles south of the Canadian Pacific Railroad main line at Palliser, British Columbia, and flows for 175 miles in a southerly direction, passing within 1 mile of Columbia Lake, and crossing the international boundary line at Gateway British Columbia. It flows through Montana and Idaho, reentering British Columbia 60 miles west of Gateway and 20 miles south of Kootenay Landing, at which point it loses itself in Kootenay Lake. From Kootenay Lake, the river flows in a southwesterly direction, discharging into Columbia River at Castlegar, about 20 miles north of the international boundary line.

The drainage area of Kootenay River comprises 13,100 square miles in British Columbia, and 6000 square miles in Montana and Idaho, making in all a drainage to mouth of 19,100 square miles.

AREA OF DRAINAGE BASIN

A map of the drainage basin was constructed by drawing ridge lines on the key map enclosed in the Water Resources Papers, as topographic maps of Eastern British Columbia were unavailable.

The area was then determined by planimeter, the scale of which had been previously found by planimetering the known area of a quadrilateral of the map. The area of the drainage basin so obtained, proved to be accurate, checking within 1% when compared with the value of 19,100 square miles as given in the Water Resources Papers.

WATER AREA

In the determination of the area of the water surface, no allowance was made for the area of streams and rivers, and the only bodies of water considered, are the lakes shown on the map.

In determining the size of these water surfaces, the outlines of the water area as shown by the map were traced through on a piece of tracing paper, in such a manner that the different area were made to fit together and present a harmonious whole, which could be easily and quickly planimetered. The area found was 224.6 square miles, about 1.1% of the total drainage area, and, hence can be neglected.

SUPPLYING MISSING DATA

The records for the precipitation stations in Montana and Idaho as given by the Annual Reports of the U. S. Weather Bureau were complete, but those records at the stations in British Columbia, as given in the Water Resources Papers of the Dominion Water Power Service, were incomplete having one or more months' record missing.

These missing values were supplied from adjacent records, using three stations forming a triangle which included the station for which the estimate was to be made, upon the assumption that the ratio of the record at the latter for the missing month, to the mean for that month, will be the same as a similar ratio for each of the surrounding stations. The mean of the three values so obtained from the surrounding stations , was then used as the probable precipitation for the missing month. Where three stations could not be obtained, two were used in a similar manner.

DETERMINATION OF MEAN PRECIPITATION

The mean precipitation on the drainage basin was obtained by giving to the records of the various stations in and about the area, various weights (vide table of Area Factors page 28.); that is multiplying the mean precipitation at a station by its corresponding factor, and obtaining the weighted mean precipitation for that portion of the area.

These Area Factors were obtained by dividing the drainage basin according to the Theissen method, which is, that the precipitation at any one station should be used for that portion of the drainage area nearest that station: that is, by erecting perpendiculars halfway between adjacent stations, the portion of the area nearest any particular station may readily be defined. The ratio of each area thus found, determined by planimeter, to the total area of the drainage basin (see Table of Area Factors page 28.), is then applied to the corresponding station records, and the sum of these amounts gives the weighted precipitation for the drainage area.

DISCUSSION

On comparing the run-off with the precipitation in the winter period from October to March inclusive (See Table of Seasonal Precipitation and Run-off), it was observed that the run-off was small and the resulting loses large. This is ofcourse perfectly natural in a country so far north as British Columbia, where the temperature is rather low in winter and most of the precipitation remains on the ground as snow. In the summer period, however, just the reverse takes place. The streams become raging torrents. The extreme high water or run-off is, during this period, in all probability, obtained through a combination of heavy snowfall during the preceding winter with a series of hot days and nights in May and June and the later months. Warm rain also increases the flow by melting the snow in the high altitudes. Considering the whole year, however, a great discrepancy in the results was discovered. The run-off was greater than the precipitation. This at first proved puzzling, but ofcourse, this can be accounted for in several ways, but the chief and most important of which being, that the precipitation records were insufficient, that is to say, too many stations were located in the valleys where precipitation was least, and too few on the ridges or high altitudes where the precipitation was greatest.

True it is, that the melting of the glacial ice sheet that still covers some parts of Canada, and which Geologists claim is receding, accentuated the run-off, but this could not be very great, probably about 5 to 7.5 per cent, the exact amount being at present unknown, and incidentally the determination of which should prove and interesting study (see Recommendations for further study).

On a further study of the area it became evident that the precipitation record at Wilmer with a mean annual value of 11.71 inches could not be used for a district which was composed almost entirely of high mountainous country.

In an effort to obtain some relation between altitude and precipitation which would off-set this error, graphs of precipitation and altitude (seasonal and yearly values) were constructed, and it became immediately evident, that no exact values could be obtained as, first of all, too few stations existed, and secondly, these were so scattered about the drainage area, as to make as exact mathematical determination impossible.

A curve could ofcourse, be approximated through the plotted points but on solving this curve it was found that the precipitation increased about 1.2 inches per 100 foot rise in altitude; this proved on testing to be entirely too high. Another plan adopted, was too take a horizontal section through the country, and plot values for the stations lying about that line. This was done; the stations used were Nelson, Cranbrook and Fernie, but the values for Cranbrook had to be discarded as it lay on the western slope of a ridge and its annual value for precipitation 14.82 inches was far too low.

The increase in precipitation per 100 foot rise in altitude, using the values for Nelson and Fernie, was determined as 0.78 inches. This seemed more reasonable a value, and compared favourably with the value of 0.58 inches as found by C. H. Lee in his study of Altitude Relations in California, Water Supply Paper 446, of the U. S. Geological Survey, although ofcourse the two countries have very little in common yet this tends to show that some similar relation does exist between precipitation and altitude.

To obtain the probable precipitation, the average altitude of the district had to be determined. This could not be done exactly as no topographic maps of that portion of British Columbia (Wilmer district) were available, but it was approximately taken as lying between 6000 and 7000 feet, a value which seemed perfectly feasable as there are some very high mountains in this district. A mean annual value of 48 inches was assumed for the probable precipitation over the district, which then meant that a value lying well below 0.78 inches was adopted for the variation factor. This is rather a conservative figure, and in all probability correct as the results finally bore out.

In order to compare the yearly values of precipitation and run-off, it was assumed that the ratio of yearly precipitation to the mean yearly precipitation over the total period, would be the same as a similar ratio for Fernie. This seemed reasonable as Fernie is on the eastern slope of the Rockies and in a mountainous district, although the final results would practically be the same no matter on what stations the yearly values were to be based.

Graphs were prepared of run-off and precipitation and average values were obtained. These were satisfactory and justified the assumptions made.

RECOMMENDATIONS FOR FURTHER STUDY

In reviewing the work performed in this thesis, the author wishes to state that he has not carried this investigation to that degree of completeness and exactness which he would deem desirable, due principally to lack of time and the incompleteness of the data available.

He would suggest for future study a determination of the Physiographical Constants of the drainage area, and also the probable amount that is contributed towards the run-off by the melting of the glacial ice sheet.

It is recommended then that the following be studied:-

(1) A contour map of the drainage area be constructed.

(2) Average elevation determined.

(3) Mean slope of the streams.

(4) Mean land slope.

(5) Effect of evaporation.

(6) Effect of the melting of the glacial ice sheet.

R E S U L T S

TABLE OF WATER LOSSES

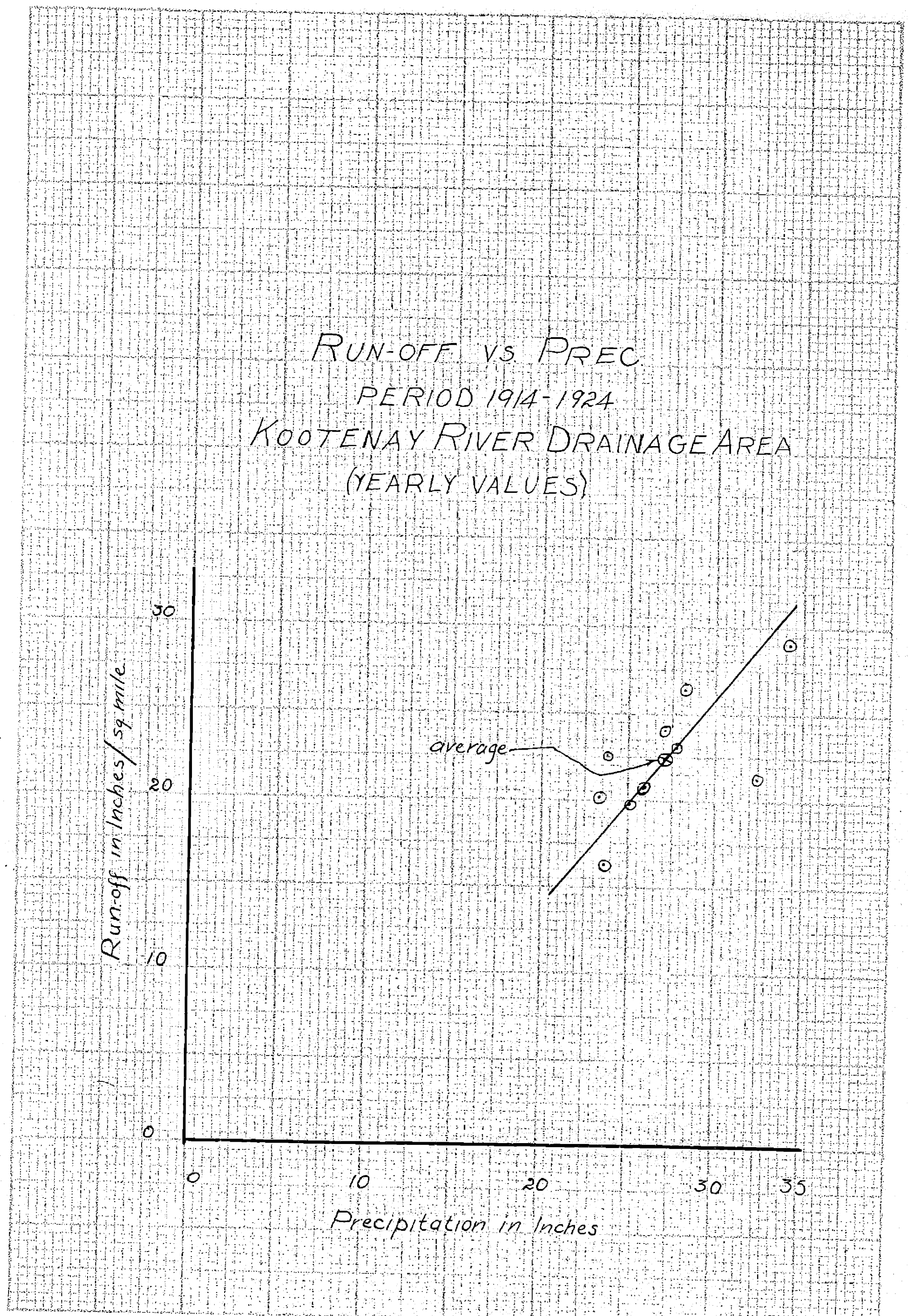
Total Year	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	Averag
Prec.	25.13	34.28	23.81	27.74	27.15	25.86	28.25	22.34	32.46	23.64	27.07
Run-Off	19.79	29.11	22.48	23.10	24.00	20.71	26.44	20.04	21.43	16.30	22.34
Losses	5.34	5.17	1.33	4.64	3.15	5.15	1.81	2.30	11.03	7.34	4.73
Ratio of R.O. to Prec.	.788	.849	.945	.834	.884	.800	.936	.897	.660	.690	.826

SEASONAL PRECIPITATION AND RUN-OFF ON DRAINAGE AREA

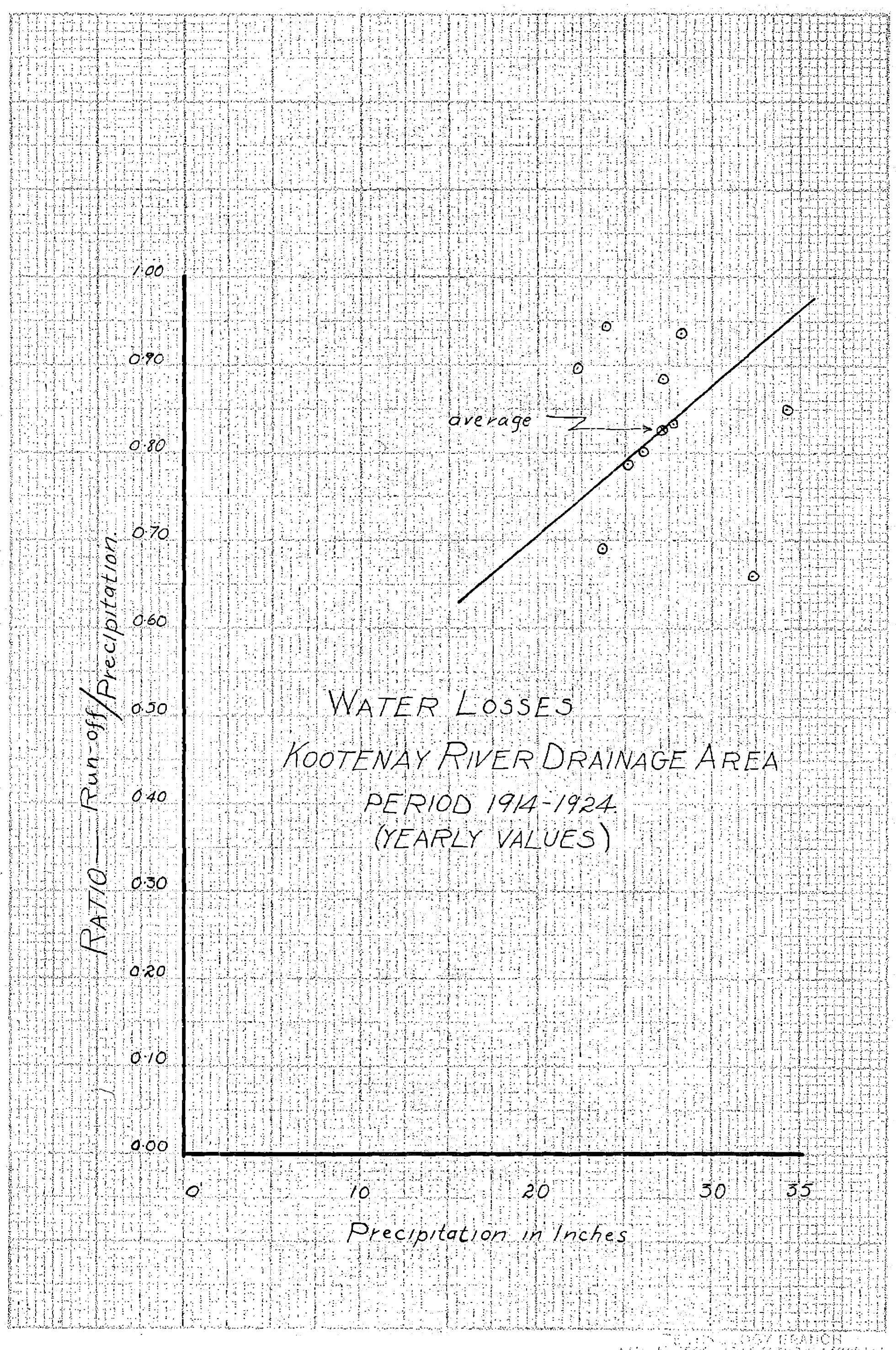
Oct.-March	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	Average
Prec.	12.45	21.87	12.56	18.34	19.34	13.54	18.62	14.22	20.18	14.52	16.56
Run-off	4.93	4.29	3.44	4.34	4.47	2.84	5.29	3.89	3.38	3.07	3.99
Losses	7.52	17.58	9.12	14.00	14.87	10.70	13.33	10.33	16.80	11.45	12.57

Apr.-Sept	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	Average
Prec.	12.68	12.41	11.25	10.40	7.81	12.32	9.63	8.12	12.28	9.11	10.70
Run-off	14.86	24.82	19.04	18.76	19.53	17.87	20.58	16.15	18.05	13.23	18.29
Losses	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

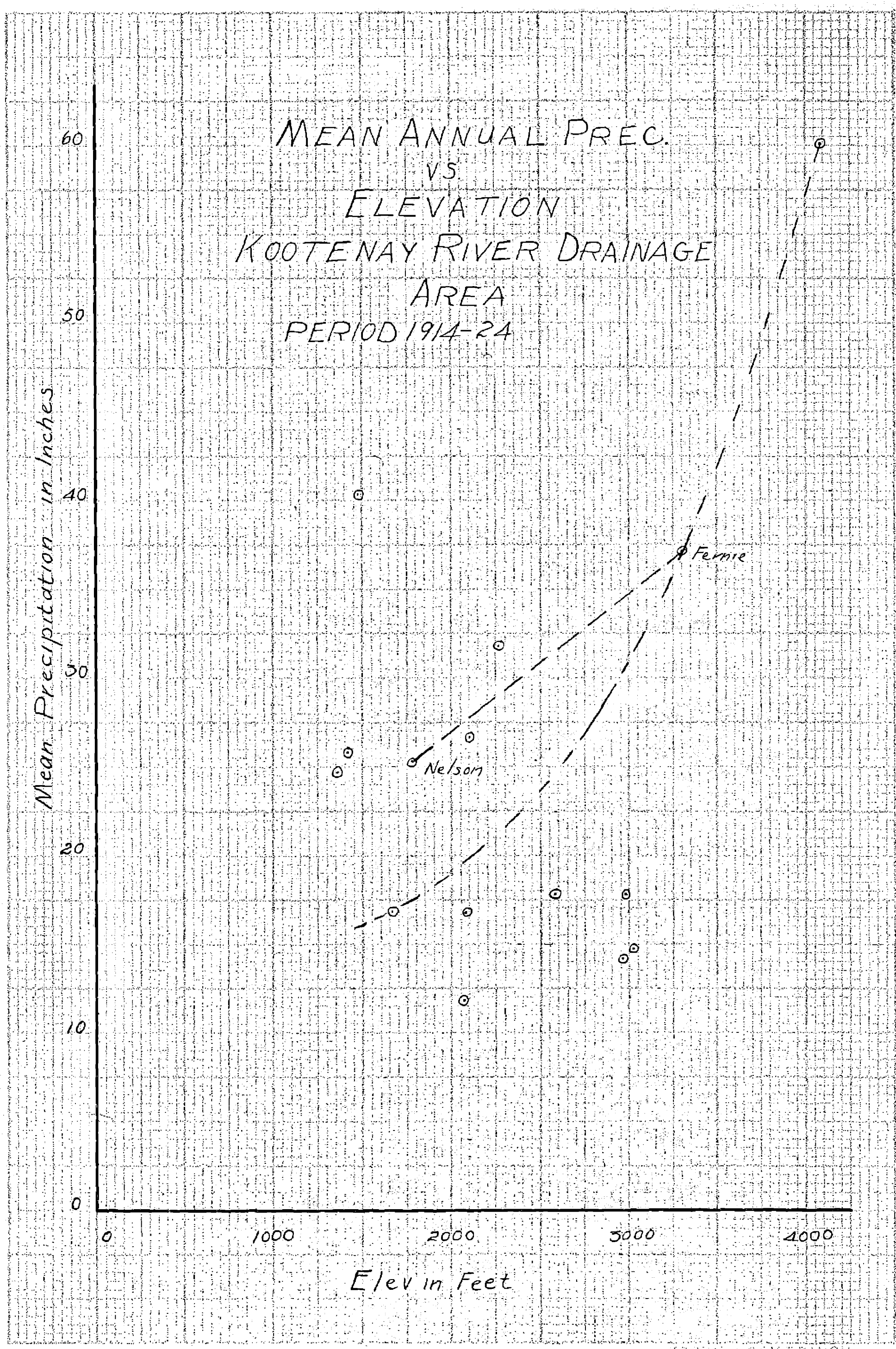
Total Year	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	Average
Prec.	25.13	34.28	23.81	27.74	27.15	25.86	28.25	22.34	32.46	23.64	27.07
Run-off	19.79	29.11	22.48	23.10	24.00	20.71	26.44	20.04	21.43	16.30	22.34
Losses	5.34	5.17	1.33	4.64	3.15	5.15	1.81	2.30	11.03	7.34	4.73

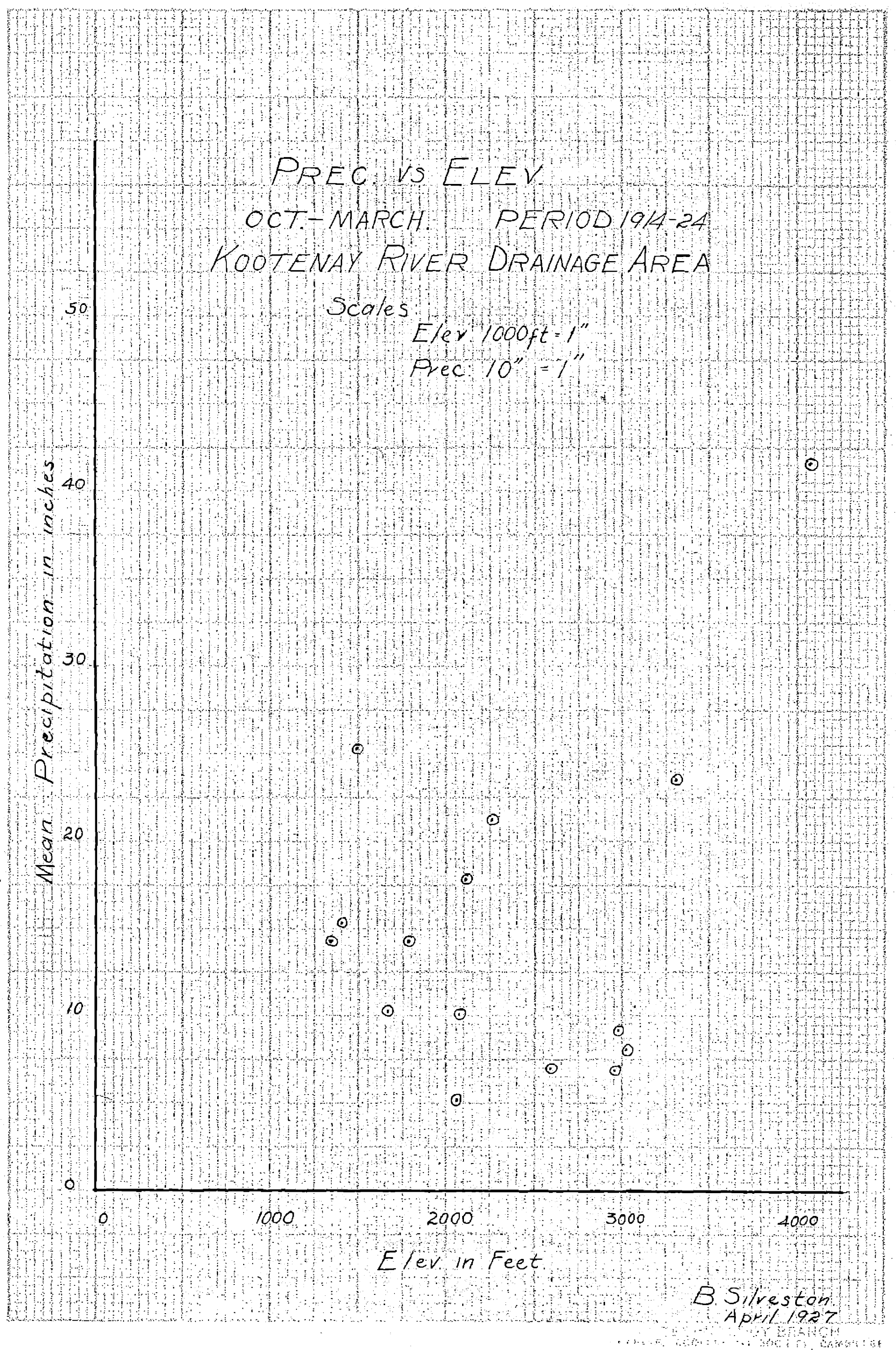


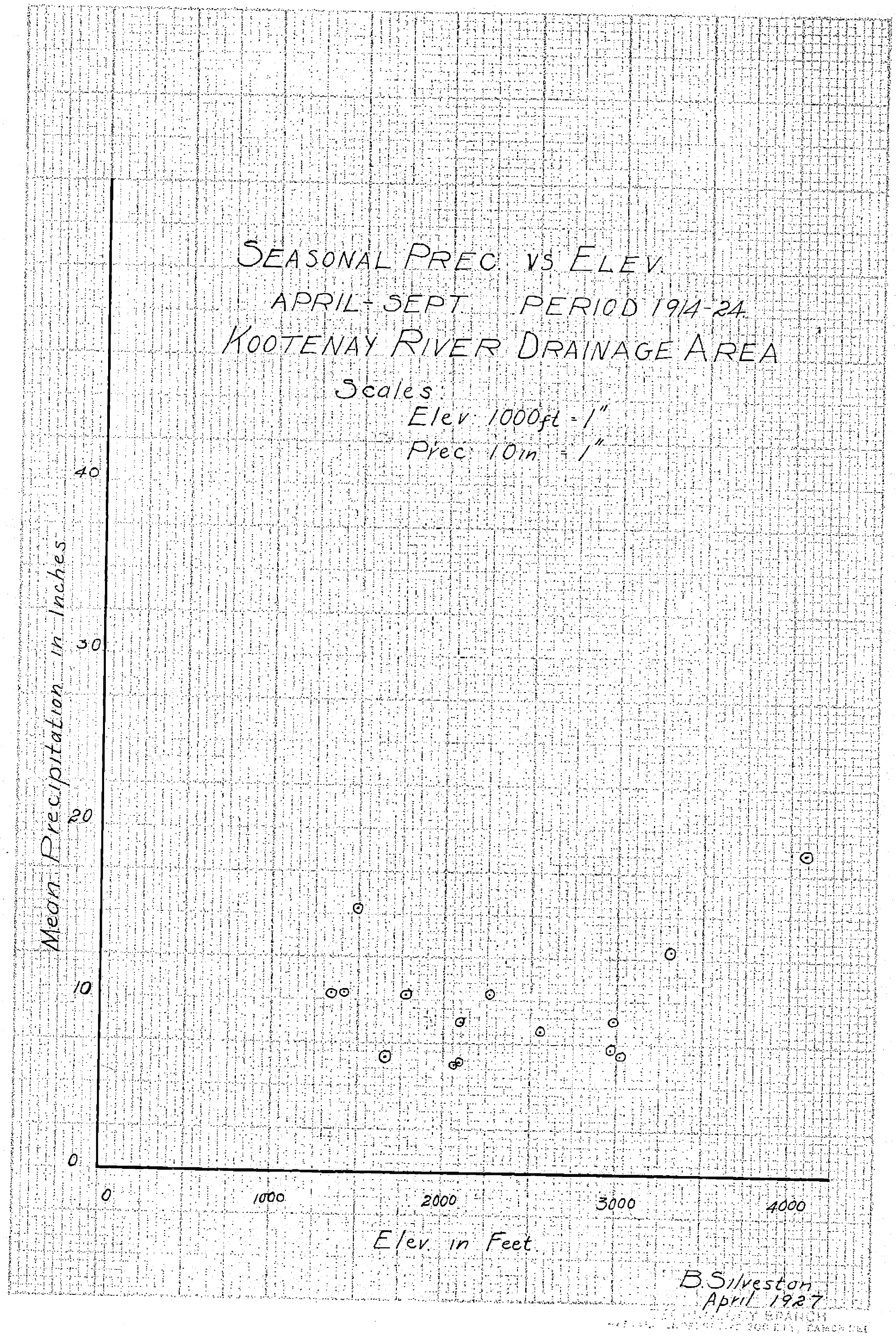
RUN-OFF VS PREC
PERIOD 1914-1924
KOOTENAY RIVER DRAINAGE AREA
(YEARLY VALUES)
average
Run-off in Inches/sq. mile
Precipitation in Inches
0
10
20
30
35



1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
average
RATIO — Run-off/Precipitation
WATER LOSSES
KOOTENAY RIVER DRAINAGE AREA
PERIOD 1914-1924
(YEARLY VALUES)
0
10
20
30
35
Precipitation in Inches


MEAN ANNUAL PREC.
VS
ELEVATION
KOOTENAY RIVER DRAINAGE
AREA
PERIOD 1914-24
Mean Precipitation in Inches
60
50
40
30
20
10
0
Fernie
Nelson
0
1000
2000
3000
4000
Elev in Feet


PREC. VS ELEV.
OCT.-MARCH. PERIOD 1914-24
KOOTENAY RIVER DRAINAGE AREA
Scales:
Elev. 1000ft = 1"
Prec. 10" = 1"
Mean Precipitation in inches
0
10
20
30
40
50
0
1000
2000
3000
4000
Elev. in Feet
B. Silveston
April 1927



SEASONAL PREC. VS ELEV.
APRIL-SEPT. PERIOD 1914-24
KOOTENAY RIVER DRAINAGE AREA
Scales:
Elev. 1000ft = 1"
Prec. 10in = 1"
Mean Precipitation in Inches
0
10
20
30
40
0
1000
2000
3000
4000
Elev. in Feet
B. Silveston
April 1927

A P P E N D I X

A

TABLE I

Station	Elevation in feet	Period	Yearly Mean	Oct.-March Mean	Apr.-Sept. Mean
Waneta	1358	1914-22	24.69	14.26	10.43
Nakusp	1414	1914-23	25.97	15.42	10.44
Revelstoke	1494	1914-20	40.44	25.21	15.23
Porthill	1665	1914-24	16.85	10.30	6.55
Nelson	1774	1914-24	25.09	14.73	10.36
Wilmer	2070	1914-24	11.71	5.35	6.36
Libby	2075	1914-24	16.53	10.10	6.43
Sandpoint	2086	1914-24	26.56	17.89	8.67
Heron	2261	1914-24	31.88	21.49	10.39
Golden	2583	1914-24	17.82	9.52	8.30
Kalispell	2965	1914-24	14.04	6.86	7.18
Fortine	2975	1914-24	17.90	9.04	8.86
Cranbrook	3020	1914-24	14.82	8.01	6.81
Fernie	3302	1914-24	37.01	23.58	13.44
Glacier	4094	1914-24	60.03	41.48	18.54

Area Factors by Theissen's Method

Station	Area by planimeter	Area in sq. mls.	Ratio to total area
Waneta	0.02	22.3	.001
Nakusp	1.26	1414.0	.074
Porthill	2.00	2230.0	.116
Nelson	2.15	2395.5	.125
Wilmer	3.05	3400.0	.178
Libby	1.79	1995.0	.104
Sandpoint	0.13	145.0	.008
Heron	0.10	111.5	.006
Golden	0.30	334.5	.018
Kalispell	0.15	167.0	.009
Fortine	1.45	1617.0	.085
Cranbrook	2.62	2920.0	.153
Fernie	1.82	2030.0	.106
Glacier	0.30	334.5	.018
		19116.3	1.001

Mean Annual Precipitation

Waneta	.00123	x 24.69	.03
Nakusp	.74	x 25.97	1.92
Porthill	.123	x 16.85	2.07
Nelson	.1253	x 25.09	3.14
Wilmer	.178	x 11.71	8.55
Libby	.1044	x 16.53	1.73
Sandpoint	.00758	x 26.56	.21
Heron	.00584	x 31.88	.19
Golden	.017	x 17.82	.31
Kalispell	.00874	x 14.04	.13
Fortine	.08460	x 17.90	1.52
Cranbrook	.153	x 14.82	2.27
Fernie	.1062	x 37.01	3.93
Glacier	.0175	x 60.03	1.05
Total			27.05

Seasonal Precipitation on Drainage Area

April-Sept. 1914-1924

	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
Waneta	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nakusp	1.25	0.91	0.74	0.36	0.67	0.94	0.73	0.52	0.84	0.77
Porthill	1.19	0.89	0.67	0.73	0.50	0.89	0.60	0.54	0.96	0.64
Nelson	1.75	1.28	1.41	1.44	1.09	1.27	0.93	1.07	1.85	0.89
Wilmer	2.92	3.27	3.85	3.64	2.49	3.93	3.36	2.48	3.13	2.98
Libby	0.86	0.84	0.62	0.69	0.41	0.81	0.51	0.60	0.96	0.42
Sandpoint	0.08	0.09	0.06	0.06	0.06	0.09	0.05	0.06	0.07	0.05
Heron	0.08	0.11	0.05	0.05	0.04	0.08	0.04	0.05	0.07	0.03
Golden	0.22	0.13	0.15	0.12	0.07	0.12	0.19	0.11	0.20	0.14
Kalispell	0.10	0.10	0.06	0.05	0.04	0.07	0.04	0.05	0.06	0.05
Fortine	1.01	1.29	0.77	0.74	0.45	0.81	0.55	0.41	0.92	0.57
Cranbrook	1.46	1.60	0.80	1.00	0.58	1.11	0.68	0.81	1.46	0.93
Fernie	1.35	1.50	1.76	1.22	1.15	1.81	1.54	1.15	1.44	1.37
Glacier	0.38	0.40	0.31	0.29	0.25	0.38	0.39	0.29	0.32	0.26
Total	12.68	12.41	11.25	10.40	7.81	12.32	9.63	8.12	12.28	9.11

Seasonal Precipitation on Drainage Area

Oct.-March 1914-1924

	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
Waneta	0.01	0.02	0.02	0.02	0.08	0.01	0.01	0.02	0.02	0.02
Nakusp	0.85	1.36	0.98	1.71	1.39	1.24	0.97	0.85	0.99	1.15
Porthill	0.96	1.60	0.91	1.33	1.56	0.97	1.34	0.93	1.26	1.10
Nelson	1.17	2.56	1.54	2.19	2.42	1.49	1.16	1.97	2.11	1.86
Wilmer	4.16	7.03	3.56	5.41	6.02	4.34	7.06	4.84	7.22	4.76
Libby	0.93	1.54	0.81	1.29	1.12	0.71	1.22	0.83	1.03	1.07
Sandpoint	0.09	0.15	0.10	0.16	0.18	0.09	0.16	0.12	0.16	0.14
Heron	0.08	0.16	0.09	0.15	0.15	0.08	0.15	0.14	0.14	0.11
Golden	0.11	0.16	0.11	0.30	0.21	0.18	0.22	0.11	0.17	0.11
Kalispell	0.07	0.08	0.06	0.08	0.04	0.05	0.06	0.06	0.05	0.05
Fortine	0.67	0.95	0.95	0.78	0.87	0.75	0.82	0.66	0.65	0.54
Cranbrook	0.96	2.28	0.96	1.28	1.77	0.83	1.47	0.89	1.04	0.80
Fernie	1.93	3.24	1.65	2.50	2.76	2.00	3.26	2.22	3.33	2.19
Glacier	0.45	0.75	0.82	1.15	0.78	0.80	0.73	0.60	0.57	0.61
Total	12.45	21.87	12.56	18.34	19.34	13.54	18.62	14.22	20.18	14.52

Yearly Discharge of Kootenay River at Glade

Drainage Area 19,100 sq. mls.

	Discharge in sec. ft.			Run-off		
	Maximum	Minimum	Mean	Per Sq. Mi.	Depth in inches on Drainage Area	Total in Acre Feet
1914-15	59000	8110	27800	1.46	19.79	20,185,000
1915-16	162000	7580	40700	2.13	29.11	29,649,000
1916-17	118000	5400	31500	1.65	22.48	22,931,000
1917-18	122000	8500	32400	1.70	23.10	23,524,000
1918-19	116000	7500	33700	1.76	24.00	24,496,000
1919-20	107000	5310	29000	1.52	20.71	21,098,000
1920-21	144000	8650	37100	1.94	26.44	26,926,000
1921-22	119000	5850	28100	1.47	20.04	20,394,000
1922-23	117000	5940	30100	1.57	21.43	21,836,000
1923-24	89000	5400	22900	1.20	16.30	16,630,000

Seasonal Discharge of Kootenay River at Glade

Oct.March Inclusive

Drainage Area 19,100 sq. mls.

	Drainage in sec. ft.		Run-off	
	Mean	Per Sq. Mi.	Depth in inches on Drainage Area	Total in Acre Feet
14-15	13900	0.73	4.93	5035000
15-16	12000	0.63	4.29	4369000
16-17	9700	0.51	3.44	3514000
17-18	12200	0.64	4.34	4404000
18-19	12600	0.66	4.47	4546000
19-20	7950	0.42	2.84	2891000
20-21	13800	0.78	5.29	4999000
21-22	10900	0.57	3.89	3954000
22-23	9500	0.50	3.38	3431000
23-24	8600	0.45	3.07	3105000

Seasonal Discharge of Kootenay River at Glade

Apr.-Sept. Inclusive

Drainage Area 19,100 Sq. Mls.

	Drainage in sec. ft.		Run-off	
	Mean	Per Sq. Ml.	Depth in inches on Drainage Area	Total in Acre Feet
14-15	41600	2.18	14.86	15,150,000
15-16	69400	3.64	24.82	25,280,000
16-17	53400	2.79	19.04	19,417,000
17-18	52600	2.75	18.76	19,120,000
18-19	54900	2.87	19.53	19,950,000
19-20	50000	2.62	17.87	18,207,000
20-21	53500	3.02	20.58	19,450,000
21-22	45400	2.38	16.15	16,440,000
22-23	50600	2.65	18.05	18,405,000
23-24	37200	1.95	13.23	13,525,000

APPENDIX

B

Supplying Missing Data

Monthly Prec. / Mean (missing station) = Monthly Prec. / Mean (known station)

Missing Data.

Golden	May June July 1918-19; Jan. Feb. 16-17; Nov. Dec. Feb. 15-16; Feb. Mar. Apr. 14-15	use	Galcier Wilmer
Wilmer	July 14-15	use	Golden Fernie
Revelstoke	May June July Aug. Sept. 19-20	use	Glacier Nakusp
Nakusp	June July Aug. Sept. 22-23	use	Nelson Glacier
Nelson	May June July Aug. Sept. 19-20; Jan. 15-16	use	Nakusp Waneta Cranbrook
Waneta	May June July Aug. Sept. 19-20; Feb. Apr. 14-15	use	Nelson
Cranbrook	March 23-24	use	Fernie Nelson
Fortine	Nov. Dec. Jan. Feb. 16-17; Nov. Dec. 17-18; Nov. Dec. Jan. Feb. Mar. 20-21	use	Kalispell Porthill Fernie
Heron	Nov. 20-21; July 22-23	use	Sandpoint Libby
Libby	Oct. 19-20	use	Kalispell Heron Porthill Fernie

Sample Computations

Supplying Missing Data for Nelson

$$\frac{x}{2.42} = \frac{7.08}{2.81}$$

$x = 6.1$ using Waneta.

$$\frac{x}{2.42} = \frac{1.95}{2.55}$$

$x = 1.85$ using Nakusp.

$$\frac{x}{2.42} = \frac{3.60}{2.10}$$

$x = 4.15$ using Cranbrook.

Mean $= 4.03$

DETERMINATION OF PLANIMETER SCALE

Area of Quad	(from U. S. Geol. Survey Bull.)			
Mid. lat.	49-15'	=	781.60	for 30' Quad
Mid lat.	49-45'	=	773.74	for 30' Quad
Area of degree Quad		=	2(773.74 + 781.60)	
(49-50)		=	3110.68	square miles
Area by Plan		=	2.77	
Value of 1 division		=	$\frac{3110.68}{2.79}$	= 1115.00
Area of Drainage Area		=	19100 square miles	
Area of Water Surface		=	224.6 square miles	

VALUES USED FOR WILMER DISTRICT

(Precipitation 1914-24)

	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
Oct.-March	4.16	7.03	3.56	5.41	6.02	4.34	7.06	4.84	7.22	4.76
Apr.-Sept.	2.92	3.27	3.85	3.64	2.49	3.93	3.36	2.48	3.13	2.98
Annual	7.08	10.30	7.41	9.05	8.51	8.27	10.42	7.32	10.35	7.74

A P P E N D I X

C

Waneta

Rainfall Record

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	1.33	2.99	1.43	1.20	0.91	2.07	2.95	4.85	3.03	4.26	0.10	0.80	25.92
15-16	2.38	3.25	3.55	7.08	2.65	1.99	1.08	3.58	4.01	2.10	1.12	0.97	33.76
16-17	0.76	3.97	4.55	2.80	4.15	2.40	3.92	2.33	1.54	0.05	0.10	1.10	27.67
17-18	0.45	0.95	4.53	2.55	3.47	3.30	0.46	1.54	2.30	2.54	3.31	0.71	26.11
18-19	3.60	2.27	1.60	3.75	2.89	2.08	1.94	1.93	0.40	0.65	3.07	2.05	26.29
19-20	1.49	1.22	1.42	1.48	0.83	1.52	1.00	1.56	0.87	1.84	0.72	1.61	15.56
20-21	1.41	1.88	1.65	4.10	2 46	0.88	0.87	0.82	1.88	1.17	2.04	4.16	23.32
21-22	1.74	4.01	2.71	1.68	1.01	1.68	2.06	0.95	0.68	0.29	0.99	1.05	18.85
22-23	----	----	----	----	----	----	----	----	----	----	----	----	----
23-24	----	----	----	----	----	----	----	----	----	----	----	----	----

Nakusp

Rainfall Record

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	1.98	3.31	1.58	2.00	1.62	1.02	3.85	4.57	3.70	3.11	0.63	1.05	28.42
15-16	2.84	2.01	3.53	1.95	3.69	4.36	1.68	2.55	1.84	2.09	2.26	1.80	30.60
16-17	0.58	2.18	2.33	3.29	3.44	1.45	3.01	1.44	2.54	0.94	0.46	1.55	23.21
17-18	2.95	1.31	7.24	5.19	4.46	2.00	0.53	1.32	0.92	1.39	0.58	0.13	28.02
18-19	3.67	2.44	3.31	3.21	2.79	3.40	1.76	2.05	0.81	0.76	1.23	2.45	27.91
19-20	1.54	3.74	3.59	4.42	0.97	2.46	0.55	2.69	1.89	1.82	1.23	4.57	29.47
20-21	2.51	0.29	2.83	3.32	1.92	2.27	1.43	0.46	3.14	0.10	1.90	2.83	23.00
21-22	2.11	1.07	3.03	2.83	1.63	0.77	1.95	2.07	0.30	0.03	1.65	0.97	18.41
22-23	3.12	0.20	3.91	4.04	1.70	0.40	1.02	2.83	2.93	2.33	1.05	1.20	24.73
23-24	----	----	----	----	----	----	-----	----	----	----	----	----	-----

Revelstoke

Rainfall Record

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	2.23	7.09	1.65	3.40	2.18	0.84	3.19	4.83	2.93	4.91	0.72	2.51	36.48
15-16	5.87	3.68	5.12	2.25	2.58	6.31	1.75	2.93	2.12	5.49	1.58	3.53	43.21
16-17	1.37	4.68	4.00	5.13	3.70	1.88	3.12	2.36	3.05	1.70	1.59	2.29	34.87
17-18	4.56	2.48	8.70	7.60	6.50	4.46	0.95	2.79	1.74	1.90	3.65	0.26	45.59
18-19	5.56	5.49	7.40	3.37	3.39	3.05	1.82	2.20	1.32	0.48	2.52	2.05	39.21
19-20	2.51	5.92	4.50	7.03	0.55	4.24	2.79	4.04	2.40	1.92	1.84	5.53	43.27
20-21	----	----	----	----	----	----	-----	----	----	----	----	----	-----
21-22	----	----	----	----	----	----	-----	----	----	----	----	----	-----
22-23	----	----	----	----	----	----	-----	----	----	----	----	----	-----
23-24	----	----	----	----	----	----	-----	----	----	----	----	----	-----

Porthill

Rainfall Record

Y E A R	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	1.85	3.24	0.73	0.30	1.59	0.56	1.96	2.20	1.60	2.49	0.23	1.77	18.52
15-16	1.14	2.99	2.95	1.91	1.73	3.05	0.82	1.69	2.86	0.99	0.35	0.92	21.40
16-17	0.66	1.62	1.39	1.00	1.42	1.74	1.70	1.78	1.25	0.20	0.51	0.37	13.64
17-18	0.51	0.83	4.46	1.37	2.17	2.13	0.31	0.95	0.82	1.63	1.19	1.37	17.74
18-19	2.81	1.54	1.29	3.61	2.55	1.64	1.50	0.73	0.30	0.17	1.04	0.53	17.71
19-20	0.83	1.88	1.66	2.00	0.54	1.44	1.45	1.73	1.11	0.61	0.98	1.83	16.06
20-21	0.84	2.19	2.15	2.45	2.16	1.76	0.87	1.87	1.04	0.29	0.34	0.80	16.76
21-22	0.85	2.37	1.60	0.96	1.02	1.21	1.29	0.83	0.38	0.59	0.33	1.20	12.63
22-23	1.98	0.36	3.54	3.60	0.79	0.56	0.71	2.23	2.07	1.74	1.24	0.25	19.07
23-24	1.79	1.54	2.11	1.64	1.75	0.64	0.08	0.28	1.63	0.26	2.61	0.67	15.00

Nelson

Rainfall Record

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	1.85	4.03	0.70	1.10	0.80	0.85	2.59	3.72	2.09	3.87	0.60	1.12	23.32
15-16	2.18	3.16	3.57	4.03	2.95	4.55	0.79	3.08	2.23	1.99	0.81	1.33	30.67
16-17	0.92	3.49	1.90	1.80	2.45	1.70	3.08	2.46	3.22	1.01	0.09	1.42	23.54
17-18	1.53	1.23	7.42	2.15	2.60	2.50	0.64	3.37	2.41	1.96	2.26	1.02	28.91
18-19	3.69	3.76	2.72	4.35	2.75	2.04	1.63	1.86	1.17	0.51	2.12	1.41	28.02
19-20	1.47	2.71	2.91	2.57	0.41	1.80	0.68	2.23	1.24	2.63	1.03	2.30	21.98
20-21	2.39	2.52	1.92	0.43	0.99	1.00	1.71	0.68	2.62	0.24	0.33	1.86	16.69
21-22	1.87	3.59	2.56	2.55	1.98	3.20	2.63	1.33	0.80	0.02	1.57	2.15	24.25
22-23	1.87	0.44	5.41	6.56	1.02	1.56	1.33	2.89	4.60	3.96	1.12	0.85	31.61
23-24	2.33	1.63	4.93	3.14	1.94	0.87	0.66	0.60	1.99	0.22	2.65	0.99	21.95

Wilmer

Rainfall Record

Y E A R	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	0.88	1.23	0.53	0.85	0.48	0.08	0.05	0.63	4.02	1.56	0.51	0.91	11.73
15-16	0.80	1.01	0.80	0.73	1.31	0.79	0.45	2.76	1.65	1.87	1.75	0.79	14.71
16-17	0.65	1.16	0.69	0.49	0.55	0.70	0.32	2.45	2.09	0.19	1.55	0.73	9.57
17-18	0.61	0.22	4.03	1.14	1.74	0.66	0.22	1.14	0.43	1.15	2.26	1.61	15.21
18-19	1.31	0.53	1.60	1.52	0.96	0.32	0.25	0.76	0.68	0.68	0.53	2.56	11.50
19-20	0.85	1.17	1.05	2.58	0.28	0.89	2.07	1.17	0.99	0.99	0.21	1.22	13.57
20-21	0.46	0.35	0.67	0.65	0.92	1.17	0.45	0.28	1.39	0.60	0.72	1.90	9.56
21-22	0.79	1.04	1.06	1.40	0.10	0.43	0.94	0.20	0.60	0.10	1.52	0.70	8.88
22-23	1.13	1.28	1.57	0.85	0.35	0.10	0.44	1.82	3.28	2.18	0.95	0.33	13.28
23-24	0.86	0.30	0.98	0.83	0.91	0.08	0.40	0.66	0.91	0.38	2.03	0.70	9.04

Libby

Rainfall Report

Y E A R	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	1.68	3.53	0.48	0.89	1.45	0.86	1.64	2.61	0.96	1.09	0.15	1.81	17.15
15-16	1.52	2.93	2.51	2.88	2.00	2.93	0.72	0.55	2.94	1.82	0.77	1.28	22.85
16-17	0.96	1.46	1.46	1.52	0.85	1.47	1.75	1.49	1.18	0.01	0.25	1.26	13.66
17-18	0.48	0.49	6.83	1.32	1.89	1.37	0.79	0.61	0.49	2.64	1.42	0.67	19.00
18-19	1.32	1.10	1.49	3.40	2.49	0.88	0.63	0.61	0.34	0.32	1.46	0.61	14.65
19-20	0.76	1.37	1.30	1.57	0.56	1.24	1.36	2.00	0.88	0.71	1.08	1.69	14.52
20-21	1.27	1.63	1.93	2.62	1.69	2.50	0.64	T	1.32	0.58	1.11	1.21	16.50
21-22	1.10	3.59	1.32	0.51	0.53	0.92	1.78	0.64	0.53	1.49	0.64	0.66	13.71
22-23	0.42	0.74	4.14	3.36	0.81	0.38	0.50	4.07	1.97	1.10	1.46	0.05	19.00
23-24	1.75	1.65	2.97	1.10	1.43	1.38	0.30	0.40	1.23	0.31	1.20	0.54	14.26

Sand Point

Rainfall Record

Y E A R	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	2.69	4.64	1.04	0.81	2.26	0.79	2.10	3.70	1.26	1.80	0.25	1.69	23.03
15-16	0.95	4.31	4.77	3.81	2.16	4.36	1.85	1.50	2.98	1.57	1.81	1.85	31.92
16-17	0.59	3.49	2.16	2.40	1.96	2.62	3.77	1.64	1.70	0.01	T	0.44	20.78
17-18	0.66	1.04	9.92	3.26	4.07	2.49	0.62	1.37	0.69	1.35	3.01	0.49	28.97
18-19	4.44	3.14	2.55	5.99	3.84	3.48	2.23	2.52	0.44	T	0.94	1.29	30.86
19-20	0.91	3.18	2.79	1.20	0.37	2.93	3.46	2.22	1.32	0.67	1.07	3.49	23.61
20-21	2.32	4.01	4.47	3.05	3.76	3.11	2.81	0.84	1.17	0.08	0.72	1.14	27.48
21-22	2.58	3.55	3.56	1.62	1.82	2.85	3.52	0.68	0.21	0.71	1.01	1.75	23.86
22-23	4.58	0.71	8.06	5.61	0.72	1.71	0.99	2.79	2.84	1.00	1.18	0.30	30.49
23-24	1.60	3.73	3.92	3.70	4.56	1.20	0.23	0.63	1.29	0.35	1.74	1.64	24.59

Heron

Rainfall Record

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	3.31	4.30	0.71	0.54	2.57	1.87	2.23	4.05	1.46	2.96	0.20	2.52	26.72
15-16	3.18	5.10	5.01	3.47	2.46	7.42	3.13	1.82	5.17	2.36	1.79	3.72	44.63
16-17	1.10	3.57	2.93	3.43	2.72	1.89	3.63	1.95	1.14	0.00	0.00	2.45	24.81
17-18	1.13	1.34	12.50	3.67	5.00	2.50	1.37	1.87	1.30	2.50	1.85	0.50	35.53
18-19	3.20	2.82	5.07	5.91	5.00	3.75	2.06	1.91	0.65	0.23	1.04	0.63	32.27
19-20	1.60	3.08	3.10	2.82	0.47	2.91	2.44	2.90	0.96	1.56	1.29	4.28	27.41
20-21	2.41	3.95	5.52	4.68	3.62	5.81	2.62	0.60	1.28	0.62	1.29	1.16	33.56
21-22	2.66	4.71	4.31	4.32	3.57	3.29	3.23	1.32	0.58	0.94	1.21	1.53	31.97
22-23	2.16	3.15	8.10	7.50	0.68	3.12	1.21	3.49	3.39	1.72	1.16	0.63	36.31
23-24	2.00	3.56	5.38	2.95	3.82	1.91	1.17	0.21	1.52	0.85	1.03	1.17	25.57

Golden

Rainfall Record

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	1.35	1.67	0.75	0.80	1.44	0.22	1.12	1.62	3.64	4.75	0.62	1.05	19.03
15-16	2.31	1.76	1.44	1.20	1.17	1.38	0.56	0.67	2.24	1.26	1.24	1.39	16.62
16-17	0.77	1.40	0.70	1.92	1.07	0.60	0.60	2.40	1.32	1.51	1.66	0.90	14.85
17-18	1.58	1.14	7.10	5.18	0.88	0.99	0.16	1.38	2.36	1.42	0.95	0.78	23.92
18-19	1.29	0.73	4.65	2.80	1.40	0.96	0.23	0.60	0.75	0.95	1.05	0.69	16.10
19-20	0.10	1.90	2.60	4.65	0.65	0.20	1.00	1.98	0.78	1.01	0.59	1.55	17.01
20-21	1.41	1.88	1.65	4.10	2.46	0.88	0.87	0.82	1.88	1.17	2.04	4.16	23.32
21-22	1.08	2.21	0.55	1.08	0.45	0.63	0.33	0.72	0.57	0.22	2.31	1.91	12.06
22-23	4.99	0.56	1.32	1.62	0.63	0.62	0.07	0.97	4.66	2.48	2.12	1.02	21.06
23-24	0.50	0.59	0.95	1.52	2.38	0.40	0.41	1.18	1.68	0.58	3.34	0.74	14.27

Kalispell

Rainfall Record

Y E A R	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	3.40	1.58	0.40	1.19	1.01	0.59	1.16	3.70	2.09	2.74	0.22	2.04	20.12
15-16	0.34	1.69	2.00	1.95	1.06	2.43	0.73	1.11	3.91	1.76	1.96	1.63	20.57
16-17	0.62	0.80	1.70	1.05	1.82	1.09	1.26	0.97	2.76	0.09	0.32	0.87	13.35
17-18	0.54	0.51	4.78	1.82	0.90	0.76	0.63	0.43	0.58	1.47	0.96	1.59	14.97
18-19	0.91	0.23	0.86	0.72	1.69	0.45	0.24	1.72	0.55	0.88	1.06	0.50	9.81
19-20	1.05	1.35	0.91	0.85	0.26	0.92	1.48	1.15	0.95	0.98	2.61	0.70	13.21
20-21	1.25	0.43	1.23	1.29	0.66	1.55	1.17	0.57	1.22	0.62	0.56	0.79	11.34
21-22	1.15	2.39	1.16	0.74	0.60	0.77	1.86	0.76	0.54	0.81	0.76	0.52	12.06
22-23	1.05	1.06	1.50	1.07	0.94	0.42	0.41	2.88	1.49	1.60	0.96	0.23	13.61
23-24	0.55	0.89	1.55	0.91	0.51	0.74	0.01	0.39	3.24	0.97	0.74	0.90	11.40

Fortine

Rainfall Record

Y E A R	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	2.90	1.57	0.48	0.61	1.57	0.83	1.07	2.38	2.59	2.33	0.87	2.70	19.90
15-16	1.63	2.37	1.70	1.49	2.06	1.96	1.33	1.19	4.04	2.58	3.42	2.63	26.40
16-17	0.58	1.91	1.99	1.36	1.93	3.49	1.83	1.36	3.24	0.11	0.44	2.05	20.29
17-18	0.39	0.56	4.33	2.10	1.03	0.83	0.69	0.87	0.46	2.44	1.80	2.50	18.00
18-19	1.56	1.82	1.60	1.87	2.70	0.67	0.61	1.72	0.71	0.44	1.19	0.60	15.49
19-20	0.22	1.13	2.15	1.74	0.98	2.67	1.62	0.99	1.37	2.51	2.49	0.62	18.49
20-21	1.81	1.28	1.60	1.85	1.38	1.77	1.17	1.19	2.00	1.08	0.74	0.28	16.15
21-22	0.83	2.42	1.80	1.06	1.18	0.48	1.22	0.74	0.66	0.34	0.91	0.91	12.55
22-23	1.00	1.13	1.98	2.04	1.06	0.48	0.57	3.81	2.98	1.33	2.03	0.11	18.52
23-24	1.02	0.55	1.75	1.70	0.86	0.54	0.27	0.74	2.84	0.71	1.04	1.16	13.18

Cranbrook

Rainfall Record

Y E A R	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	1.57	2.47	0.80	0.60	0.70	0.12	0.12	2.26	2.13	2.88	0.31	1.84	15.80
15-16	0.94	2.84	1.50	3.60	3.10	2.90	0.71	1.26	4.80	0.71	1.50	1.45	25.31
16-17	0.64	0.90	1.16	0.60	1.25	1.74	0.79	1.46	1.48	0.25	0.62	0.60	11.49
17-18	0.23	0.49	3.50	1.30	1.38	1.44	0.12	0.66	0.56	2.31	1.70	1.15	14.84
18-19	1.62	1.06	0.62	3.20	4.55	0.50	0.92	0.79	0.75	0.00	1.17	0.18	15.36
19-20	0.45	0.69	0.27	1.43	0.53	1.08	1.36	1.48	0.65	2.32	0.68	0.75	12.69
20-21	1.68	1.27	1.58	2.40	1.45	1.17	0.95	1.17	0.60	0.79	0.13	0.79	13.98
21-22	0.46	2.13	1.73	0.90	0.10	0.51	0.27	0.62	1.28	1.90	0.86	0.39	11.15
22-23	0.95	0.47	2.02	1.72	1.40	0.20	0.31	2.29	4.31	1.32	0.89	0.42	16.30
23-24	1.28	1.16	1.58	0.70	0.11	0.37	0.10	0.14	2.79	0.23	2.38	0.46	11.30

Fernie

Rainfall Record

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	4.47	7.09	0.81	1.84	2.86	0.95	1.05	2.83	4.47	1.84	0.26	2.19	30.71
15-16	3.45	6.84	5.91	3.50	4.08	6.66	2.18	2.60	3.57	1.89	1.97	1.94	44.59
16-17	1.19	3.60	2.36	2.75	1.72	3.88	5.20	2.84	4.16	0.64	2.46	1.29	32.09
17-18	2.04	0.91	8.94	4.09	3.61	3.84	0.88	3.39	1.34	2.24	2.53	1.06	34.87
18-19	4.62	4.98	3.90	6.97	2.61	2.93	3.30	2.54	0.85	0.45	1.11	2.54	36.80
19-20	0.71	3.33	3.07	6.69	1.26	3.75	3.19	2.16	2.14	0.74	1.85	7.03	35.82
20-21	4.26	4.72	4.65	6.02	4.99	6.05	3.29	1.38	3.42	2.89	0.62	2.90	45.19
21-22	2.52	5.00	6.47	2.83	2.15	1.97	2.42	3.27	1.52	1.20	0.72	1.65	31.72
22-23	7.95	2.27	8.61	8.89	1.16	2.79	2.26	4.95	3.60	1.35	0.39	0.99	44.85
23-24	2.28	3.82	4.79	2.70	6.29	0.75	1.83	0.97	3.87	0.57	3.91	1.71	33.49

Glacier,

Rainfall Record

YEAR	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Annual
14-15	2.55	9.10	3.55	5.60	4.30	0.63	2.76	2.90	5.42	6.29	1.82	2.41	47.33
15-16	8.09	9.60	7.95	3.60	3.40	9.96	3.04	3.28	2.36	5.89	2.78	5.34	65.29
16-17	3.92	11.00	6.60	14.05	6.00	5.25	1.90	2.51	5.45	3.86	2.24	1.85	64.63
17-18	8.20	5.61	18.63	12.73	14.23	6.50	0.93	3.74	2.88	1.46	5.83	1.24	81.98
18-19	5.89	6.60	12.61	9.83	5.10	4.65	1.89	3.61	1.42	2.73	2.44	2.30	59.07
19-20	5.61	8170	6.51	13.35	3.10	8.40	4.70	5.38	2.52	1.33	2.45	5.07	67.12
20-21	5.83	7.53	6.55	8.15	7.10	6.30	3.31	1.60	4.20	1.85	2.89	8.41	63.72
21-22	5.72	8.31	5.05	6.10	4.50	4.85	2.60	2.83	0.71	1.47	3.47	4.23	50.84
22-23	5.07	2.90	1.09	11.25	3.50	8.60	1.90	3.68	4.08	2.77	2.31	3.32	50.47
23-24	1.04	6.90	10.20	9.90	5.35	1.65	4.60	1.48	1.62	1.37	3.22	2.49	49.82

Monthly Discharge of Kootenay River at Glade 1914-15

Drainage Area 19,100 Sq. Mls.

	Discharge in sec. ft.				Run-off	
	Maximum	Minimum	Mean	Per Sq. Mi.	Depth in inches on Drainage Area	Total in Acre Feet
Oct.	20400	18100	19300	1.01	1.16	1190000
Nov.	25800	19200	22500	1.18	1.32	1340000
Dec.	19500	10500	14400	0.75	0.86	885000
Jan.	10900	8400	9940	0.52	0.60	611000
Feb.	8690	8110	8260	0.43	0.45	459000
Mar.	11300	8110	8940	0.47	0.54	550000
Apr.	40500	11700	24800	1.29	1.44	1480000
May	59000	41200	52300	2.74	3.16	3220000
June	58200	51800	55000	2.88	3.21	3270000
July	57800	48700	54100	2.83	3.26	3330000
Aug.	48700	32600	39900	2.09	2.41	2450000
Sept.	32200	17700	23600	1.24	1.38	1400000
Year	59000	8110	27800	1.46	19.79	20185000

Monthly Discharge of Kootenay River at Glade 1915-1916

Drainage Area 19,100 Sq. Mls.

	Discharge in Sec.Ft.				Run-off	
	Maximum	Minimum	Mean	Per Sq. Ml.	Depths in inches on Drainage Area	Total in Acre Feet
Oct.	17300	13900	15000	0.79	0.91	922000
Nov.	15600	12800	14400	0.75	0.84	857000
Dec.	12800	9940	11500	0.60	0.69	707000
Jan.	10900	7580	8520	0.45	0.52	523900
Feb.	9610	7830	8440	0.44	0.48	485500
Mar.	22000	9290	14200	0.74	0.85	873100
Apr.	39100	22000	29100	1.52	1.70	1732000
May	70500	39800	61900	3.24	3.73	3806000
June	162000	70500	110000	5.76	6.43	6545000
Jul	157000	87300	129000	6.77	7.80	7932000
Aug	83000	36400	56400	2.95	3.40	3468000
Sept	36100	23200	30200	1.58	1.76	1797000
Year	162000	7580	40700	2.13	29.11	29649000

Monthly Discharge of Kootenay River At Glade 1916-17

Drainage Area 19,100 Sq. Mls.

	Discharge in sec.ft.				Run-off	
	Maximum	Minimum	Mean	Per Sq. Ml.	Depth in inches on Drainage Area	Total in Acre Feet
Oct.	22800	13500	17000	0.89	1.03	1,040,000
Nov.	14100	10600	12500	0.65	0.72	744,000
Dec.	10900	7830	9470	0.49	0.56	582,000
Jan.	7500	6060	6920	0.36	0.42	425,000
Feb.	6900	6000	6660	0.35	0.36	370,000
Mar.	6150	5400	5740	0.30	0.35	353,000
Apr.	16400	5850	10200	0.53	0.59	607,000
May.	88000	16500	45700	2.39	2.76	2,810,000
June	118000	91200	105000	5.49	6.12	6,250,000
July	112000	64900	94600	4.95	5.71	5,820,000
Aug.	62800	30400	42100	2.20	2.54	2,590,000
Sept.	29600	18200	22500	1.18	1.32	1,340,000
Year	118000	5400	31500	1.65	22.48	2,293,100

Monthly Discharge of Kootenay River at Glade 1917-18

Drainage Area 19,100 Sq. Mls.

	Discharge in sec. ft.				Run-off	
	Maximum	Minimum	Mean	Per Sq. Mi.	Depth in inches on Drainage Area	Total in Acre Feet
Oct.	18600	12400	16000	0.84	0.97	984,000
Nov.	12200	9400	10800	0.57	0.64	643,000
Dec.	11900	9100	10100	0.53	0.61	621,000
Jan.	18100	12200	15200	0.80	0.92	935,000
Feb.	12100	9250	10800	0.57	0.59	600,000
Mar.	15800	8500	10100	0.53	0.61	621,000
Apr.	37400	16400	25100	1.31	1.46	1,490,000
May	71100	39400	61800	3.23	3.72	3,800,000
June	122000	60700	95200	4.98	5.56	5,660,000
July	104000	50000	73400	3.84	4.43	4,510,000
Aug.	49000	28400	37200	1.95	2.25	2,290,000
Sept.	29000	19500	23000	1.20	1.34	1,370,000
Year	122000	8500	32400	1.70	23.10	23,524,000

Monthly Discharge of Kootenay River at Glade 1918-19

Drainage Area 19,100 Sq. Mls.

	Discharge in sec. ft.				Run-off	
	Maximum	Minimum	Mean	Per Sq. Mi.	Depth in inches on Drainage Area	Total in Acre Feet
Oct.	19100	17500	18300	0.96	1.11	1,130,000
Nov.	17300	11700	14700	0.77	0.86	875,000
Dec.	11800	9400	10900	0.57	0.66	670,000
Jan.	15100	7500	9900	0.52	0.60	609,000
Feb.	15100	10200	12500	0.66	0.69	694,000
Mar.	10200	8650	9230	0.48	0.55	568,000
Apr.	44300	11000	22500	1.16	1.29	1,340,000
May	112000	46800	66300	3.47	4.00	4,030,000
June	116000	97000	106000	5.55	6.19	6,310,000
July	103000	49000	74000	3.88	4.47	4,550,000
Aug.	47700	28100	38000	1.99	2.29	2,340,000
Sept.	28100	16600	22300	1.16	1.29	1,330,000
Year	116000	7500	33700	1.76	24.00	24,496,000

Monthly Discharge of Kootenay River at Glade 1919-1920

Drainage Area 19,100 Sq. Mls.

	Discharge in Sec. Ft.				Run-off	
	Maximum	Minimum	Mean	Per Sq. Ml.	Depth in inches on Drainage Area	Total in Acre Feet
Oct.	16000	9250	12300	0.64	0.74	756000
Nov.	9400	8100	8740	0.46	0.51	520000
Dec.	8420	6000	6940	0.36	0.42	427000
Jan.	7650	6300	6850	0.36	0.42	421000
Feb.	6960	5700	6550	0.34	0.37	377000
Mar.	7500	5310	6340	0.33	0.38	390000
Apr.	16200	7350	10100	0.53	0.59	601000
May	57400	16600	40600	2.12	2.44	2496000
Jun	99000	51800	75000	3.93	4.38	4460000
Jul	107000	75600	98600	5.16	5.95	6060000
Aug	73800	30100	49000	2.57	2.96	3010000
Sept	29600	23900	26500	1.39	1.55	1580000
Year	107000	5310	29000	1.52	20.71	21098000

Monthly Discharge of Kootenay River at Glade 1920-21

Drainage Area 19,100 Sq. Mls.

	Discharge in sec. ft.				Run-Off	
Maximum		Minimum	Mean	Per Sq. Mi.	Depth in inches on Drainage Area	Total in Acre Feet
Oct.	32600	22800	27400	1.43	1.65	1,680,000
Nov.	22200	15800	17900	0.94	1.05	1,060,000
Dec.	16400	11200	13600	0.71	0.82	836,000
Jan.	12100	9400	11000	0.58	0.67	676,000
Feb.	13400	8650	11000	0.58	0.60	611,000
Mar.	15800	12800	14200	0.74	0.85	873,000
Apr.	33200	15800	23600	1.23	1.37	1,400,000
May	112000	32400	65100	3.41	3.93	4,000,000
June	144000	111000	126000	6.60	7.36	7,500,000
July	110000	53000	78800	4.13	4.76	4,850,000
Aug.	51400	26500	37200	1.95	2.25	2,290,000
Sept.	26000	14700	19300	1.01	1.13	1,150,000
Year	144000	8650	37100	1.94	26.44	26,926,000

Monthly Discharge of Kootenay River at Glade 1921-22

Drainage Area 19,100 Sq. Mls.

	Discharge in sec. ft.				Run-off	
	Maximum	Minimum	Mean	Per Sq. Mi.	Depth in inches on Drainage Area	Total in Acre Feet
Oct.	15700	13800	14500	0.76	0.88	892,000
Nov.	16400	12700	15000	0.78	0.87	892,000
Dec.	15100	10800	13100	0.69	0.80	806,000
Jan.	10800	7950	9380	0.49	0.56	577,000
Feb.	7650	6450	7190	0.38	0.40	399,000
Mar.	6750	5850	6320	0.33	0.38	388,000
Apr.	16400	6660	10400	0.55	0.61	619,000
May	79800	17500	42700	2.24	2.58	2,620,000
June	119000	83600	107000	5.60	6.25	6,370,000
July	89500	37700	60000	3.14	3.62	3,690,000
Aug.	37000	25800	30600	1.60	1.84	1,860,000
Sept.	26200	17300	21500	1.12	1.25	1,280,000
Year	119000	5850	28100	1.47	20.04	20,394,000

Monthly Discharge of Kootenay River at Glade 1922-23

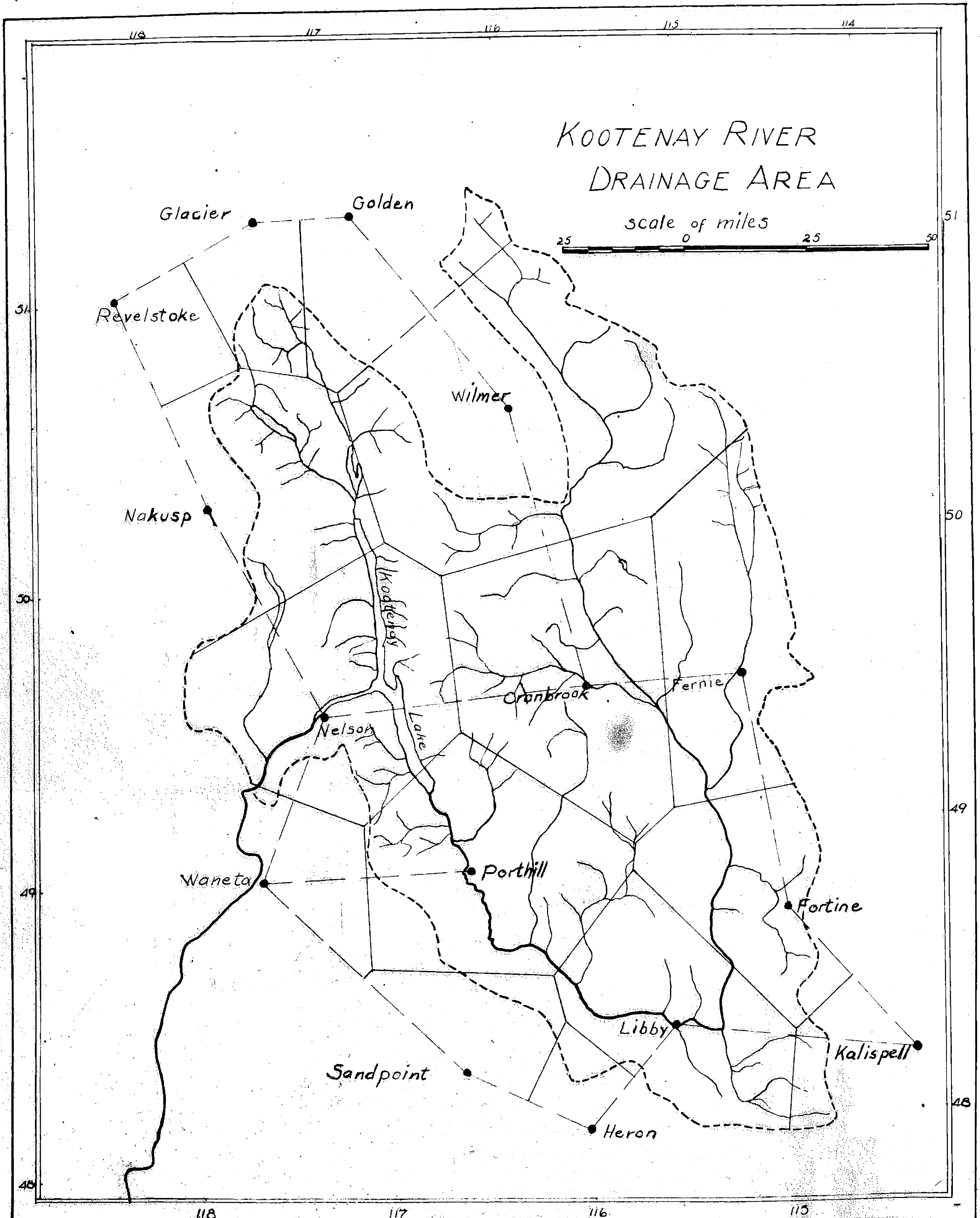
Drainage Area 19,100 Sq. Mls.

	Discharge in sec. ft.				Run-off	
	Maximum	Minimum	Mean	Per Sq. Ml.	Depth in inches On Drainage Area	Total in Acre Feet
Oct.	17100	12600	14500	0.76	0.88	891,000
Nov.	14000	9160	11600	0.61	0.68	690,000
Dec.	8950	6450	7550	0.40	0.46	464,000
Jan.	10300	8420	9610	0.50	0.58	591,000
Feb.	8650	6300	7340	0.38	0.40	401,000
Mar.	7260	5940	6310	0.33	0.38	388,000
Apr.	28800	7560	16500	0.86	0.96	982,000
May	80800	29500	54900	2.87	3.31	3,380,000
June	117000	81400	104000	5.45	6.08	6,190,000
July	102000	50600	74700	3.91	4.51	4,590,000
Aug.	49000	26100	33100	1.73	1.99	2,035,000
Sept.	25600	16400	20600	1.08	1.20	1,228,000
Year	117000	5940	30100	1.57	21.43	21,836,000

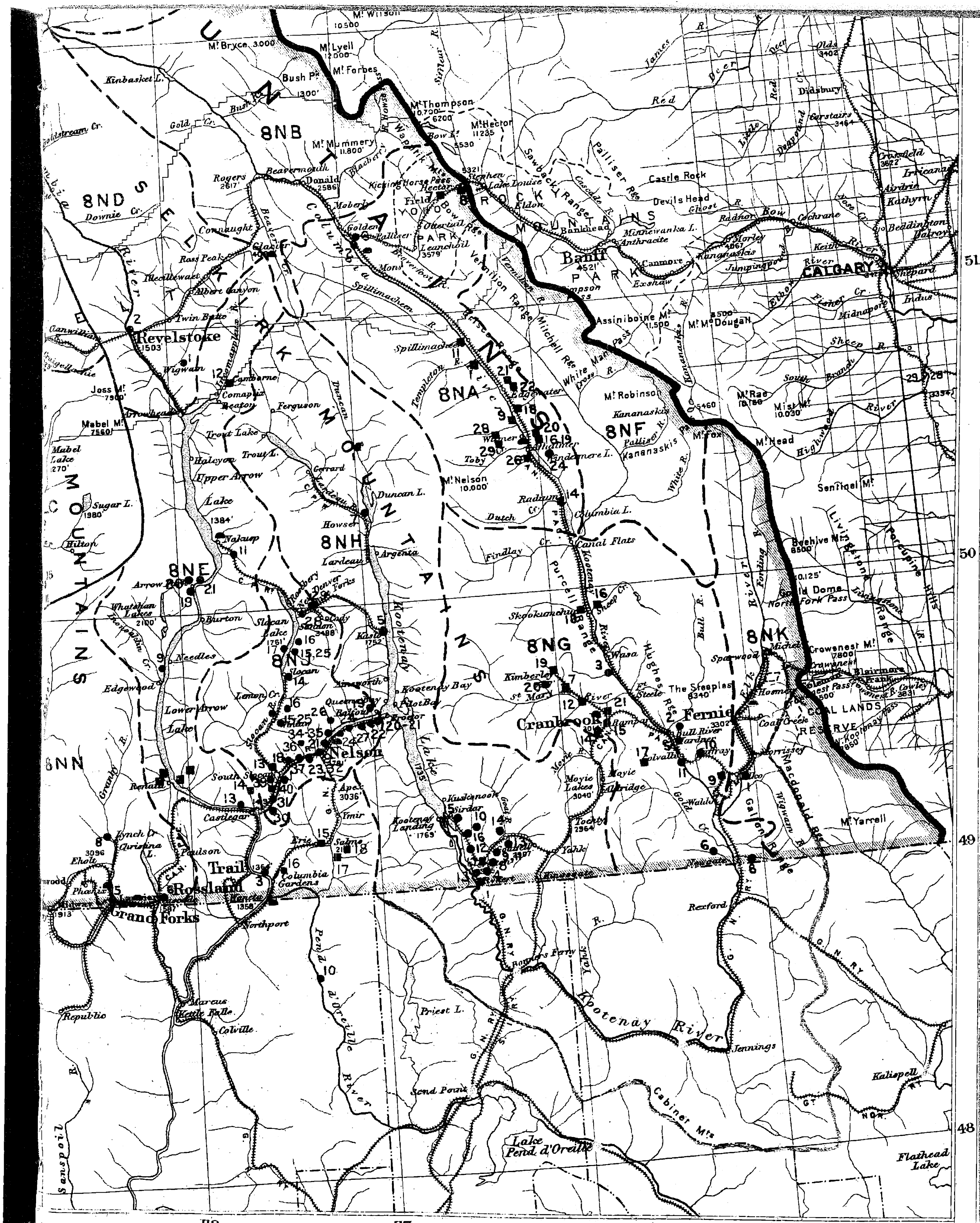
Monthly Discharge of Kootenay River at Glade 1923-1924

Drainage Area 19,100 Sq. Mls.

	Discharge in Sec.Ft.				Run-off	
	Maximum	Minimum	Mean	Per Sq. Mi.	Depth in inches on Drainage Area	Total in Acre Feet
Oct.	16200	9800	12300	0.64	0.74	756000
Nov.	9600	6900	7980	0.42	0.47	475000
Dec.	7800	6450	6990	0.37	0.43	430000
Jan.	6360	5400	5730	0.30	0.35	352000
Feb.	10700	6300	8850	0.46	0.50	509000
Mar.	10600	8300	9480	0.50	0.58	583000
Apr.	15700	7800	10500	0.55	0.61	625000
May	89000	16600	56700	2.97	3.42	3490000
Jun	80300	51400	64800	3.39	3.78	3860000
Jul	52000	30200	42300	2.21	2.55	2600000
Aug	30100	25000	28000	1.47	1.70	1720000
Sept	24500	16000	20700	1.08	1.20	1230000
Year	89000	5400	22900	1.20	16.30	16600000



KOOTENAY RIVER
DRAINAGE AREA
scale of miles
25
0
25
50
118
117
116
115
114
51
50
49
48
Glacier
Golden
Revelstoke
Wilmer
Nakusp
Kootenay
Lake
Cranbrook
Fernie
Nelson
Porthill
Waneta
Fortine
Libby
Kalispell
Sandpoint
Heron



Mt Wilson
Mt Bryce 3,000
Mt Lyell
Mt Forbes
Bush Pa.
Kinbasket L.
Mt Thompson
Mt Hector
8NB
Mt Mummery
Beavermouth
Donald
Rogers
Kicking Horse Pass
Hector
Stephen
Lake Louise
Field
YOHO PARK
Golden
Leanchoil
8ND
Downie Cr.
Connaught
Glacier
Ross Peak
Illecillewaet
Albert Canyon
Twin Butte
Revelstoke
Wigwam
Camborne
Comaplix
Beaton
Arrowhead
Joss Mt
Mabel Mt
Mabel Lake
Trout Lake
Halcyon
Upper Arrow Lake
Sugar L.
Hilton
Nakusp
Gerrard
Duncan L.
Howser
Ferguson
8NH
Argenta
Lardeau
8NE
Arrow Pk.
Whatshan Lakes
Burton
New Denver
Sandon
Slocan Lake
Kaslo
Needles
Edgewood
8NJ
Slocan
Ainsworth
Kootenay Bay
Pilot Bay
Lower Arrow Lake
Queens Bay
Balfour
Procter
Nelson
South Slocan
Renata
Castlegar
Apex
Ymir
8NN
Lynch Cr.
Christina L.
Paulson
Trail
Rossland
Erie
Salmo
Columbia Gardens
Phoenix
Grand Forks
Northport
Castle Rock
Devils Head
Banff
Bankhead
Minnewanka L.
Anthracite
Canmore
Exshaw
Kananaskis
Jumpingpound
Morley
Cochrane
CALGARY
Shepard
Midnapore
Airdrie
Crossfield
Carstairs
Didsbury
Olds
Beddington
Assiniboine Mt
Mt McDougall
Spillimacheen
8NA
Edgewater
Wilmer
Athalmer
Windermere L.
Toby
Mt Nelson 10,000'
Radium
Columbia L.
Canal Flats
Mt Robinson
8NF
Kananaskis Pass
Mt Fox
Mt Rae
Mist Mt
Mt Head
Sentinel Mt
Beehive Mt
Gould Dome
North Fork Pass
Livingstone Range
Porcupine Hills
Skookumchuck
Purcell Range
8NG
Wasa
Kimberley
Cranbrook
Fort Steele
The Steeples
Fernie
Bull River
Gardner
8NK
Michel
Crowsnest Mt
Crowsnest Pass
Blairmore
Frank
Cowley
Sparwood
Hosmer
Coal Creek
Morrissey
COAL LANDS RESERVE
Moyie Lakes
Moyie
Eldridge
Tochty
Yahk
Kitchener
Waldo
Mt Yarrell
Kuskanook
Sirdar
Kootenay Landing
Creston
Rexford
Newgate
Bonners Ferry
Priest L.
Kootenay River
Jennings
Kalispell
Sand Point
Cabinet Mts
Lake Pend d'Oreille
Flathead Lake
Marcus
Kettle Falls
Colville
Republic
Sanspoil
Pend d'Oreille River
SELKIRK MOUNTAINS
ROCKY MOUNTAINS
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117
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115
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50
49
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