THE FLUVIAL SETTING

2.0 ~~EXISTING CONDITIONS~~

2.1 Geology

2.1.1 Bedrock Geology

The upper reaches of Coldwater River and the major west bank tributaries, such as Juliet Creek, drain the eastern slopes of the Cascade Mountains. This is a region of high relief with summit elevations reaching 7,000 feet. As indicated on the bedrock geology map, shown in Figure 2.1.1, the Cascades are formed primarily of igneous rocks (granodiorite, quartz diorite, and granite) with volcanic intrusions (gabbro, tuff, and breccia). Sedimentary rocks (conglomerates, sandstones and shales) occur locally.

The main stem of Coldwater River is situated within the Thompson Plateau (as defined by Holland, 1976). This is a region of gently rolling upland separated by steep walled, flat floored valleys. Upland elevations generally range from 4,000 to 5,500 feet, with valley floor elevations being approximately 1,000 to 1,500 feet below the level of the adjacent upland. Bedrock geology consists principally of sedimentary rocks (argillite, slate, quartzite, limestone, greywacke, chlorite schist, greenstone, conglomerate, sandstone, and shale) with local volcanic intrusions of andesite, tuff and breccia. Small outcrops of the underlying igneous batholith occur locally.

A more detailed description of the bedrock geology, including mapping at a scale of 1:250,000, can be found in Rice (1947), Monger (1947), Cockfield (1948), and Duffel and McTaggart (1952). Roddick, Muller and Okulitch (1979) present a recent compilation of the available data at a scale of 1:1,000,000.

2.1.2 Surficial Geology

The surficial geology of the study region primarily reflects the effects of the most recent or Fraser Glaciation. At the glacial maximum, cordilleran ice extended throughout the Coldwater drainage, with surface elevations being roughly 6,000 to 7,000 feet (Prest, 1968; Fulton, 1975; and Holland, 1976). As a consequence, glacially rounded topography and deposits of till are found throughout the study area.

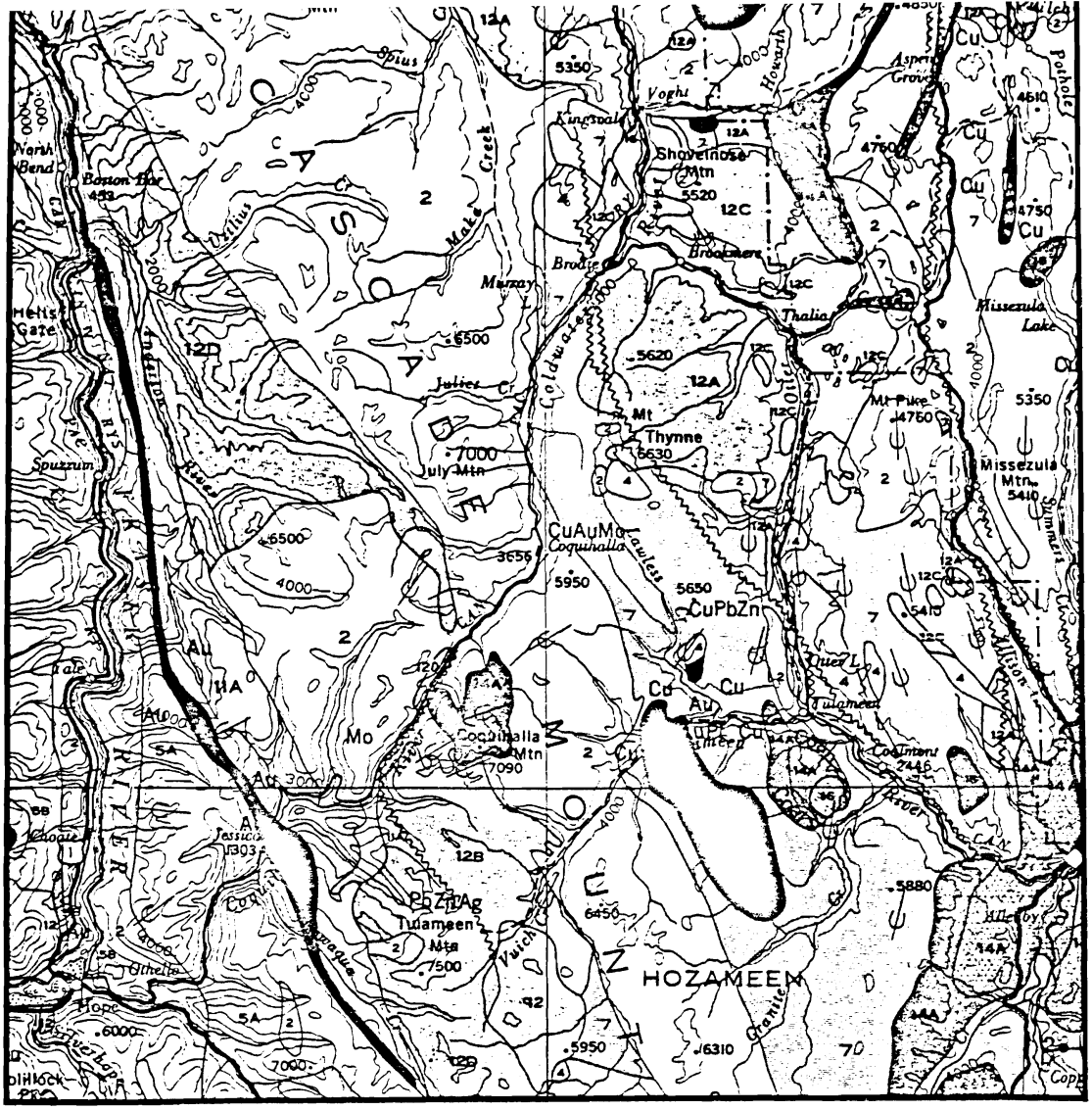
During the period of glacial recession, a series of glacially dammed lakes occurred in the vicinity of Merritt and the surrounding region, as illustrated on Figure 2.2.2. Of particular importance are Glacial Lakes Hamilton and Merritt which formed as a result of ice dams located in the lower Nicola Valley. Maximum elevations of lacustrine deposits associated with these lakes are 3,050 feet and 2,550 feet, respectively (Mathews, 1944 and Fulton, 1969; 1975).

The southward extent of the sediments within the Coldwater drainage has not yet been precisely mapped and extrapolations based on elevations are unreliable due to isostatic tilting. Measurements taken during the field studies indicate lacustrine sediments occur at elevations of at least 2,700 feet in the

area between the Brodie Diversion and the Bridge Crossing on the Coldwater River south of Kingsvale (station 802-878 m or 2,630-2,880 feet). Lacustrine sediments were also observed beneath fluvial materials in the vicinity of Juliet Creek (elevation 3,300 feet) and immediately downstream of the upper bridge crossing of Coldwater River (station 618 m or 2,028 feet; elevation 3,600 feet). Thus lacustrine sediments occur throughout the ~~id~~ immediate study area. ~~However, without more detailed investigations, it is not known whether these~~ These deposits likely resulted from sedimentation within local glacial lakes bordering an ice mass situated within the valley bottom, ~~or if~~ but they may represent the southward extension of major glacial lakes. This interpretation is of some importance to the present study as remnants of lacustrine sediments deposited within a major lake would be expected to have a greater likelihood of being present beneath the fluvial materials which now cover the valley bottom.

Following the period of lacustrine or proglacial sedimentation, extensive deposits of glacial outwash were laid down within the Coldwater Valley and later substantially eroded by fluvial reworking and downcutting. Remnants of these fluvial materials now form terraces (of either Kame or valley train origin) which occur intermittently along the valley walls. Fluvial fans occur at the base of the major tributaries to Coldwater River. In many cases the active portions of these features are now limited to a small section which is partially incised within a much larger relic surface.

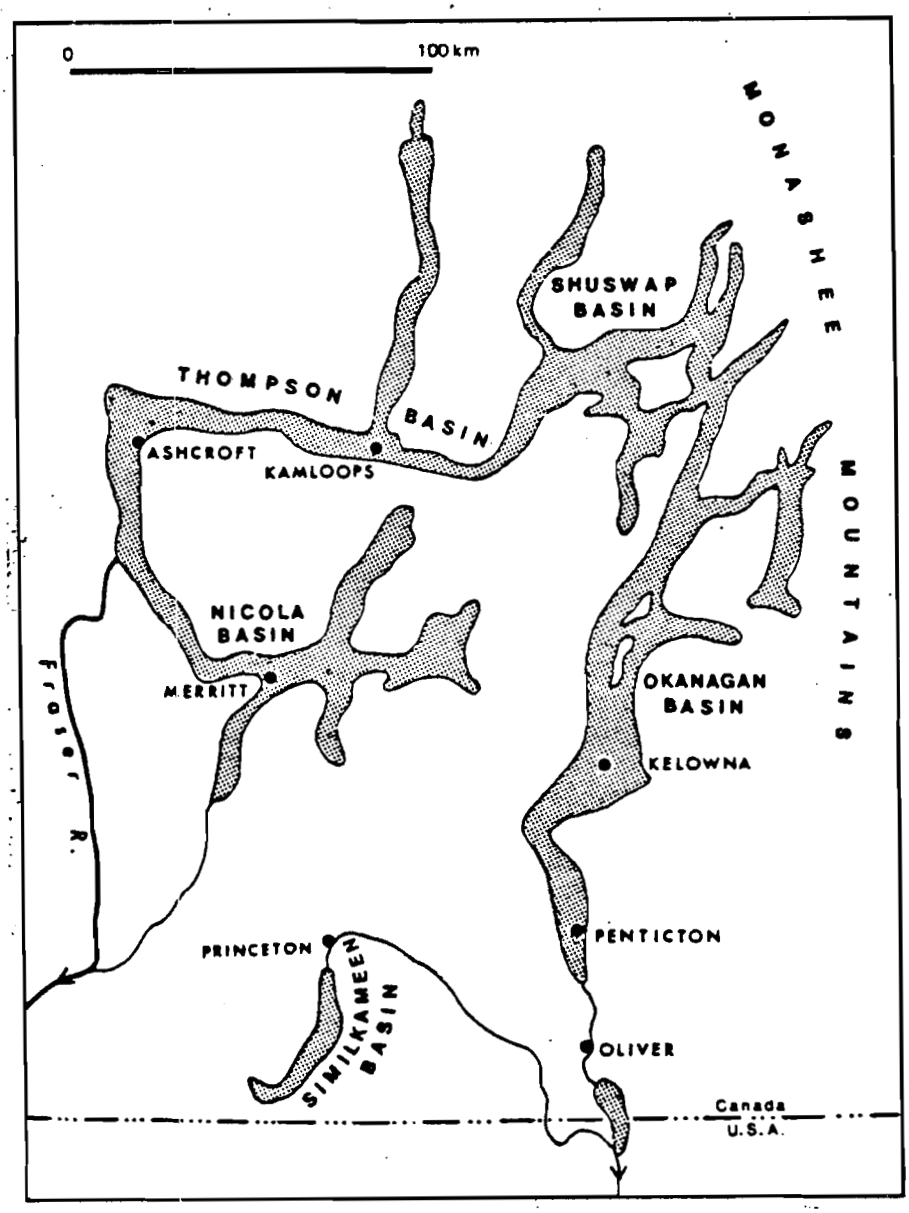
Additional information on the Quaternary history of the general study region can be found in Fulton (1965; 1967; 1969; 1975), Mathews (1944), Ostrem (1966) and Ryder (1971a; 1971b). The Geotechnical and Materials Branch of the Ministry of Transportation and Highways (Field, Egan, Hallam, and Woodburn, 1978) has prepared a reconnaissance level map of the surficial materials within the Highway Corridor. The Terrestrial Studies Branch of the Ministry of the Environment is currently preparing a series of folio maps for the headwaters of the Coldwater drainage and when available, this study will provide additional data on surficial materials (contact Ron Kowal, Kelowna). Soils mapping undertaken by Lowe and Green (1974) provide ~~some~~ information on the surficial geology for the region between Merritt and Kamloops, and agriculture capability



SEDIMENTARY & VOLCANIC ROCKS

14-16	16 Basalt 14 A Shale, sandstone, conglomerate, siltstone, coal, andesite, basalt, rhyolite, tuff, breccia	5	Cherts & slates, argillite, andesite, limestone, schist, gneiss
12	Conglomerate, sandstone, shale, tuff, breccia		INTRUSIVE ROCKS
11	Argillite, slate, arkose, greywacke, tuff, conglomerate, limestone, greenstone, chlorite schist	3,4	Granite, granodiorite, quartz & diorite
7	Andesite, argillite, slate, quartzite, limestone, greywacke, chlorite schist, greenstone	2	Granodiorite, quartz diorite, diorite, gabbro, granite
			Basic & ultra-basic rock

Figure 2.1.1: Generalized bedrock geology, Hope to Kingsvale (from GSC Map 1069A).



Note: The various basins were not necessarily filled contemporaneously.

Figure 2.1.2: Distribution of glacial lakes in southwestern British Columbia (from Bird, 1980).

2.2 Precipitation Regime

2.2.1 Regional Variation

The distribution of precipitation can be expected to vary substantially along the Hope to Merritt highway corridor. Figure 2.2.1 shows the seasonal composition of precipitation recorded at stations representative of the conditions occurring within different segments of this route. Station locations are shown on Figure 2.2.2.

Approximately 61 inches of precipitation occurs annually in the vicinity of Kawkawa Lake near Hope, with 12% of this total occurring as snow. The station at Allison Pass is representative of conditions further inland and shows a similar amount of precipitation but with a higher percentage of the total value (57%) being in the form of snow. The two Ministry of Transportation and Highways meteorology stations located within Boston Bar Creek only record total precipitation and thus do not discriminate between rain and snow. The station Boston Bar Creek Upper (or Box Canyon) is located in a tributary basin on the northwestern side of the central portion of the pass. Total average annual precipitation is 81 inches, which is significantly higher than near Hope and likely reflects orographic effects associated with its higher elevation. The station Boston Bar Creek Lower (or Summit) is located in the valley bottom near the eastern end of the pass and has a smaller annual precipitation of 62 inches, likely indicating the start of the rain shadow effects which would be expected to occur on the eastern side of the Cascades.

Long term snowfall records (1915-1959) collected by the CPR at Coquihalla Lakes have been converted into estimates of snow water equivalent by using the standard conversion factor of 10 inches of snow to one inch of water. These figures are open to some degree of uncertainty but indicate that total annual precipitation values in the vicinity of Coquihalla Lakes exceed 43 inches. From this point east, rainshadow effects become increasingly evident and result in substantially reduced precipitation totals. Thus in Merritt the total annual precipitation is only 10 inches, with 34% being in the form of snow.

This regional pattern of precipitation is reflected in the total snow accumulations recorded at the Ministry of Environment's snow course stations, as shown on Figure 2.2.3. The average maximum snow accumulation can be seen to decrease from a water equivalent of 51 inches at Boston Bar Creek Upper (or Box Canyon) to 31.5 inches at Boston Bar Lower (or Summitt) to 9.5 inches in the vicinity of Brookmere.

Interpolation of the precipitation gradient between these spot measurements is difficult due to the small number of recording stations and complex terrain. However a first approximation of the spatial variation in precipitation can be made on the basis of relationships which have been established between biogeoclimatic characteristics and annual precipitation. Figure 2.2.4 shows the distribution of biogeoclimatic zones defined for southwestern British Columbia by Krajina (1973)

along with the associated precipitation values given by Beil, Taylor and Guppy (1976). The precipitation ranges given by Biel et al. correspond reasonably well to the available spot measurements and thus the values predicted for ungauged sites do not appear to be unreasonable.

2.2.2 Seasonal Distribution and Frequency

The precipitation data from Boston Bar Creek and Coquihalla Lake, shown in Figure 2.2.1, indicate that within the Cascade region, the period of October through March is characterized by high rates of precipitation, ranging from 8 to 12 inches per month. This water may either be stored as snow or runoff immediately if the precipittation is in the form of rain. Average monthly precipitation during the remaining portion of the year shows relatively little between month variation (except for a minor peak in May) with total monthly values generally being less than 3 inches. A similar pattern occurs within the Thompson Plateau, with the exception that peak monthly precipitation occurs in the shorter period of December through January, with a subsiduary peak in May and June. Short term climate data collected by the Air Management Branch in the vicinity of the Coldwater and Otter Creek drainages (shown on Table 2.2.1) further illustrate this pattern and indicates that mid-summer precipitation totals appear to be relatively consistent throughout this region.

Is it necessary

The seasonal variation in 24-hour precipitation at Merritt is shown on Figure 2.2.5. Maximum values occur in September and October and during the period of snow melt runoff in May and June.

Figures 2.2.5 and 2.2.6 show the frequency distribution of 24-hour precipitation and rainfall for stations representative of the Hope to Merritt corridor. Rates of 24-hour precipitation can be seen to increase from Hope inland to Boston Bar Creek, and then to substantially decrease on the eastern side of the Cascades. ~~Thisxdata~~ These data show that 10 year recurrence interval 24 hour precipitation is in the order of 5 inches in Boston Bar Creek and 1.5 inches in Merritt. Figure 2.2.6 indicates that the frequency of 24-hour rainfall . . is similar to that for total precipitation.[1] Rates of rainfall in Boston Bar Creek are unknown as thermograph records at the Ministry of Highways ~~and~~ Transportation gauging sites do not provide a sufficiently complete record to allow the separation of rain and snow events. However it is expected that rates of 24-hour rain will be less than that of total precipitation, as is the case for Allison. It is interesting to note, however, that the Allison Pass data indicate that the predicted magnitude of 24-hour rainfall and total precipitation events converge at high recurrence intervals.

Rates of rainfall and precipitation at Merritt for periods of one, two, five and ten days are shown on Figures 2.2.7 and 2.2.8.[2] These data indicate that the total rainfall and

---

[1] The Atmospheric Environment Service has not abstracted 24-hour rainfall data for Merritt STP.

[2] These figures are based on data up to 1966 and thus 24-hour values are not equivalent to those shown on Figures 2.2.5 and 2.2.6, which include data up to 1980.

precipitation which can be expected to occur over a ten day period is roughly double that predicted on a 24-hour basis.

The precipitation gauges at Merritt and Boston Bar Creek do not provide data for periods of less than 24 hours and thus shorter duration frequency analyses are unavailable.

2.2.3 Significance

The preceding discussion indicates that there is a dramatic decrease in precipitation between Boston Bar Creek and Merritt. Thus streams which drain the eastern slopes of the Cascades, such as the upper Coldwater River and Juliet Creek, can be expected to have significantly larger discharges than those whose drainages lie entirely within the Thompson Plateau.

The available data do not allow the prediction of peak rainfall rates in those regions immediately adjacent to the Cascades. However analysis of the Ministry of Transportation and Highways' climate data from Boston Bar Creek during the period surrounding the December 27, 1980, flood discharges on the Coquihalla and Coldwater Rivers indicate that

Analysis of snow pillow data from the Ottomite gauging station shows a net decrease in snow water equivalent over this period and thus much or all of this precipitation must have been in the form of rain. Therefore, while the frequency analyses

for 24-hour precipitation in Boston Bar Creek may over-predict values of 24-hour rainfall, for low recurrence interval events, the extreme values predicted by the graph are likely representative of rainfall intensities which could be reasonably expected. Thus rates of rainfall of over 5 inches in 24 hours must be expected in the headwater areas of the streams draining the eastern slopes of the Cascades. This precipitation intensity is sufficiently high to result in severe flood discharges, particularly if combined with snow melt. Slope erosion and rotational failure in susceptible materials must also be expected to occur as a result. Such processes were well illustrated by the documented results of the December 27 flood on Coldwater River, described in Section 2.4.

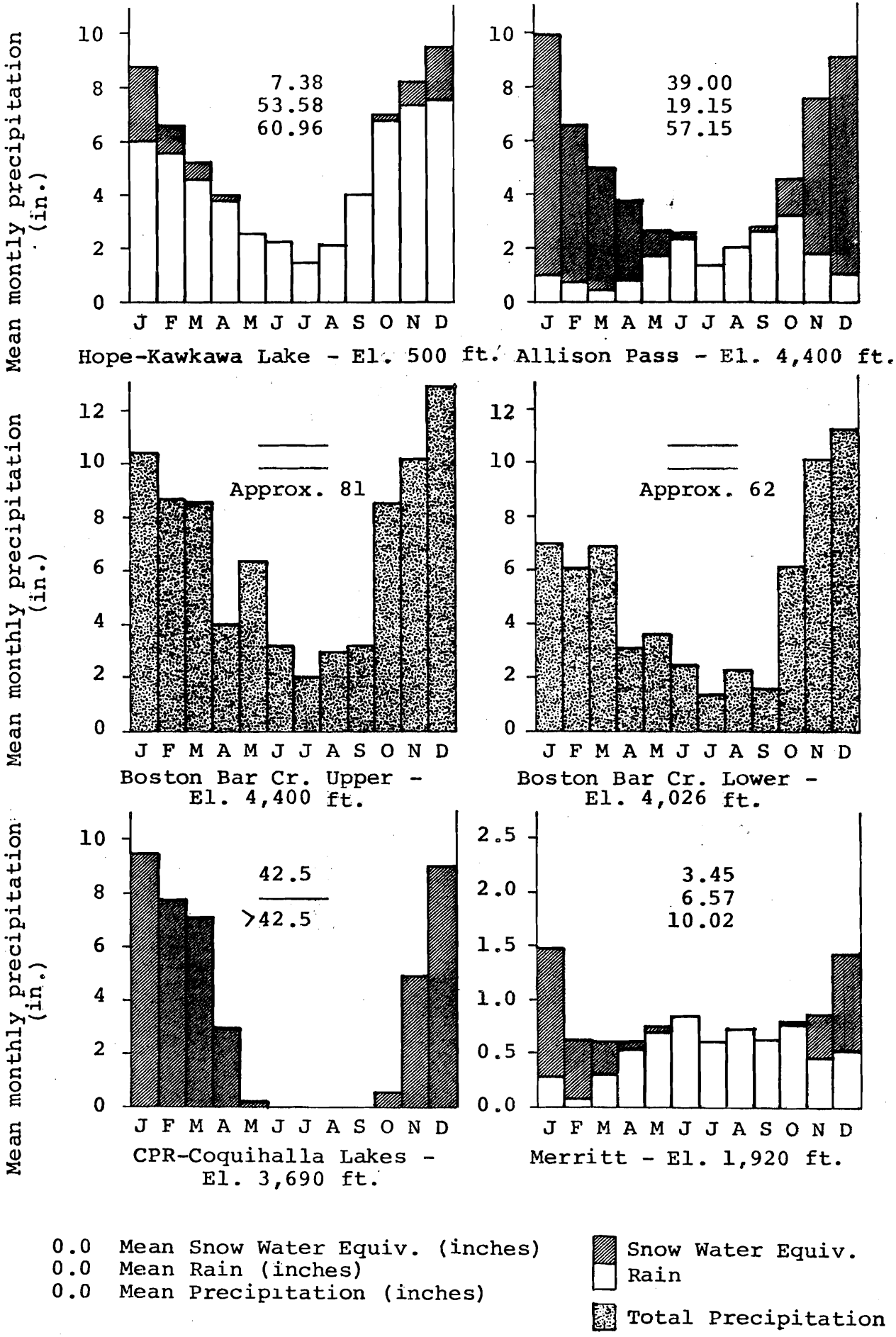


Figure 2.2.1: Seasonal distribution and composition of mean monthly precipitation.

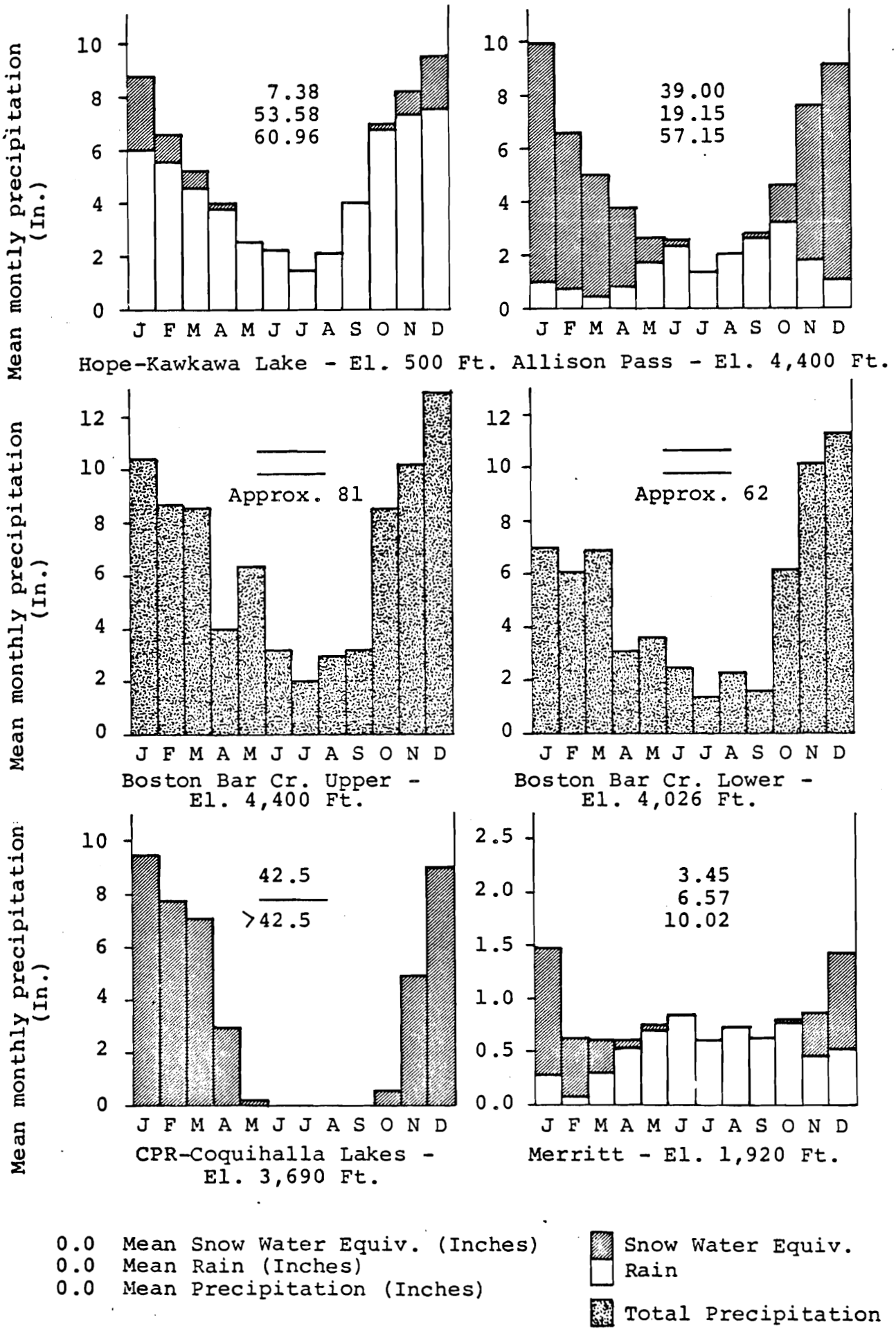
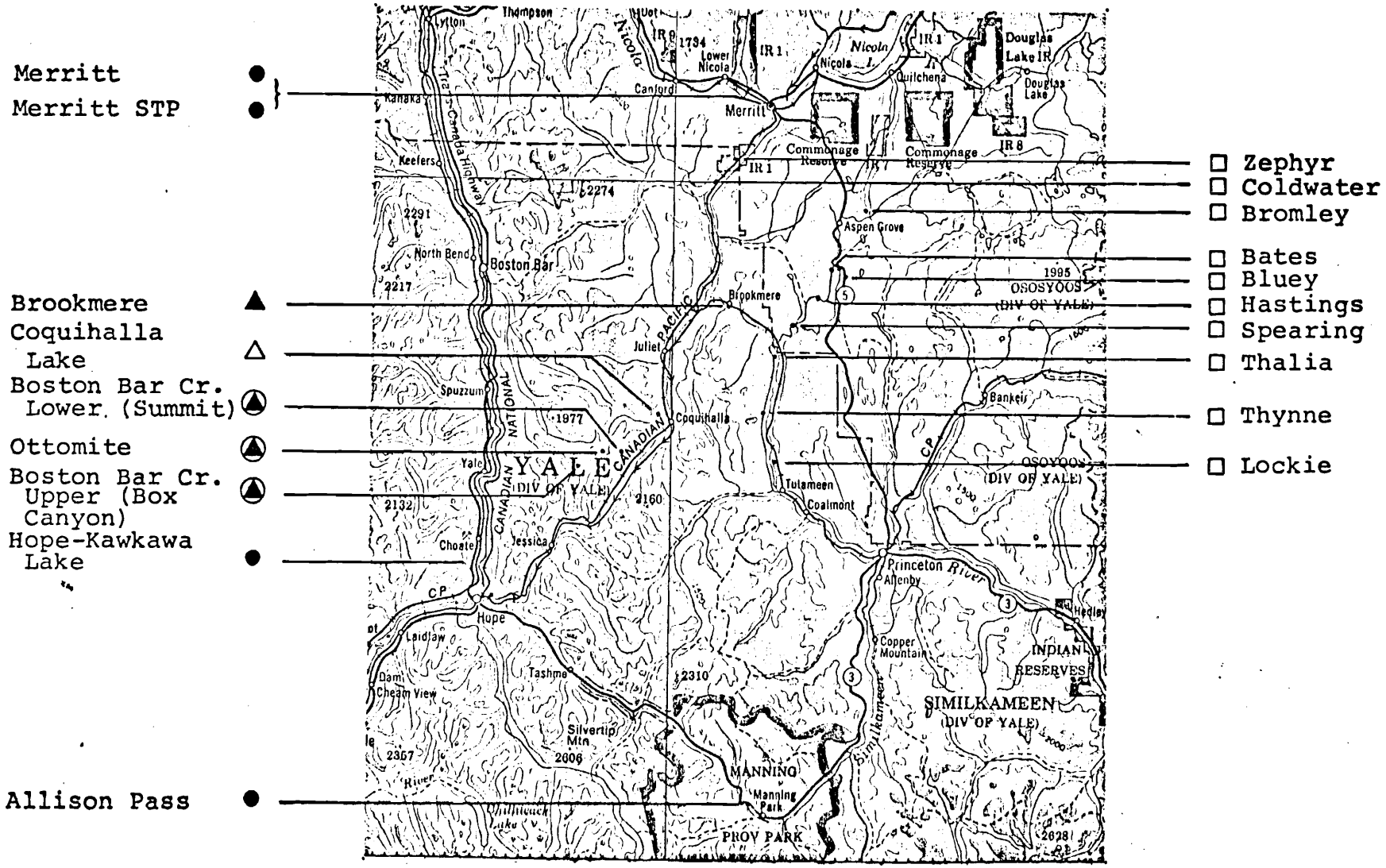


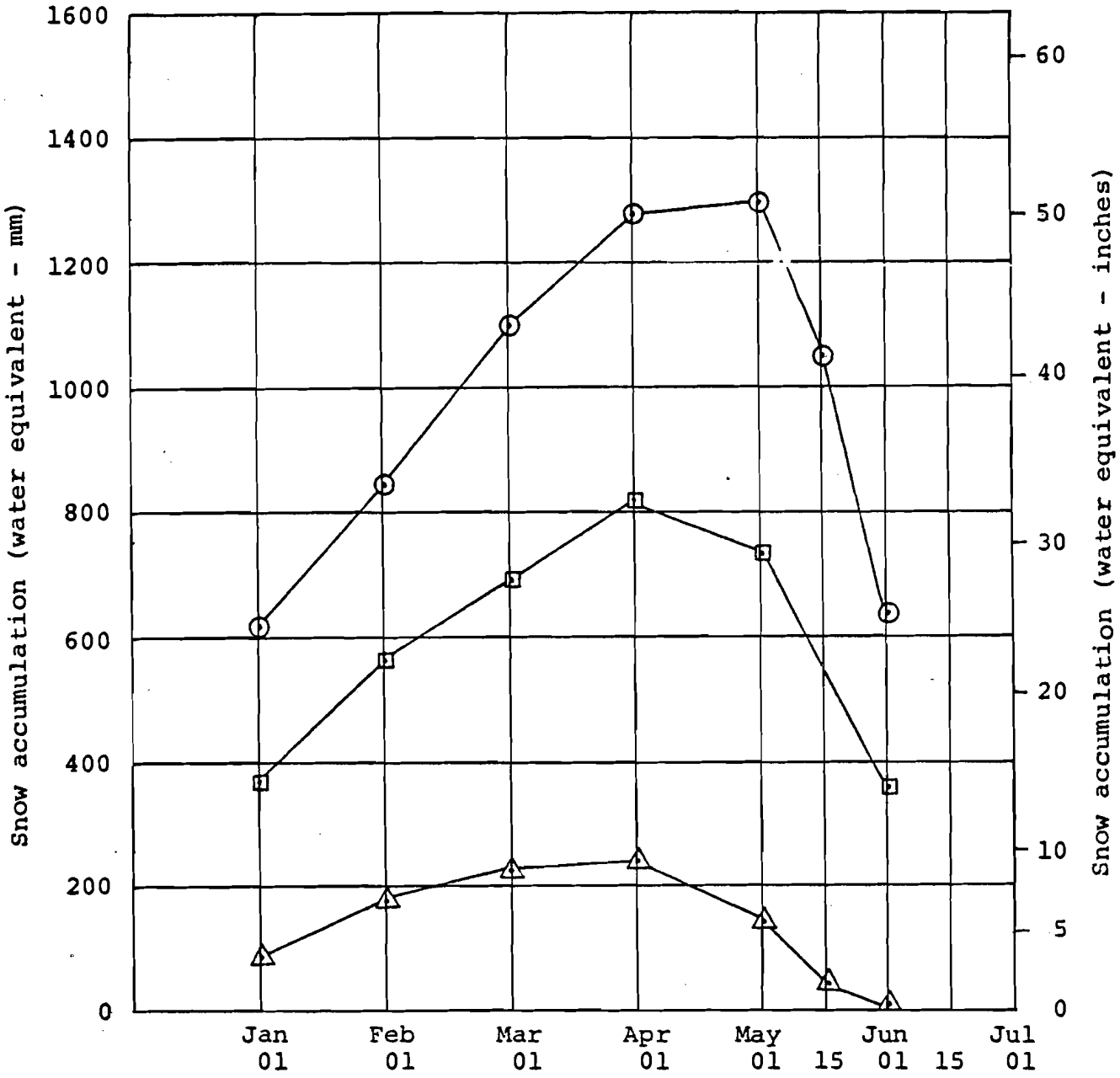
Figure 2.2.1: Seasonal distribution and composition of mean monthly precipitation.



KEY

- ● A.E.S., climate stn.
- ○ B.C. Ministry of Highways, climate stn.
- △ C.P.R., snow survey site
- ▲ B.C. Ministry of Environment, snow course
- □ B.C. Ministry of Environment, seasonal climate stn.

Figure 2.2.2: Meteorologic and snow course stations located in the vicinity of the study area.

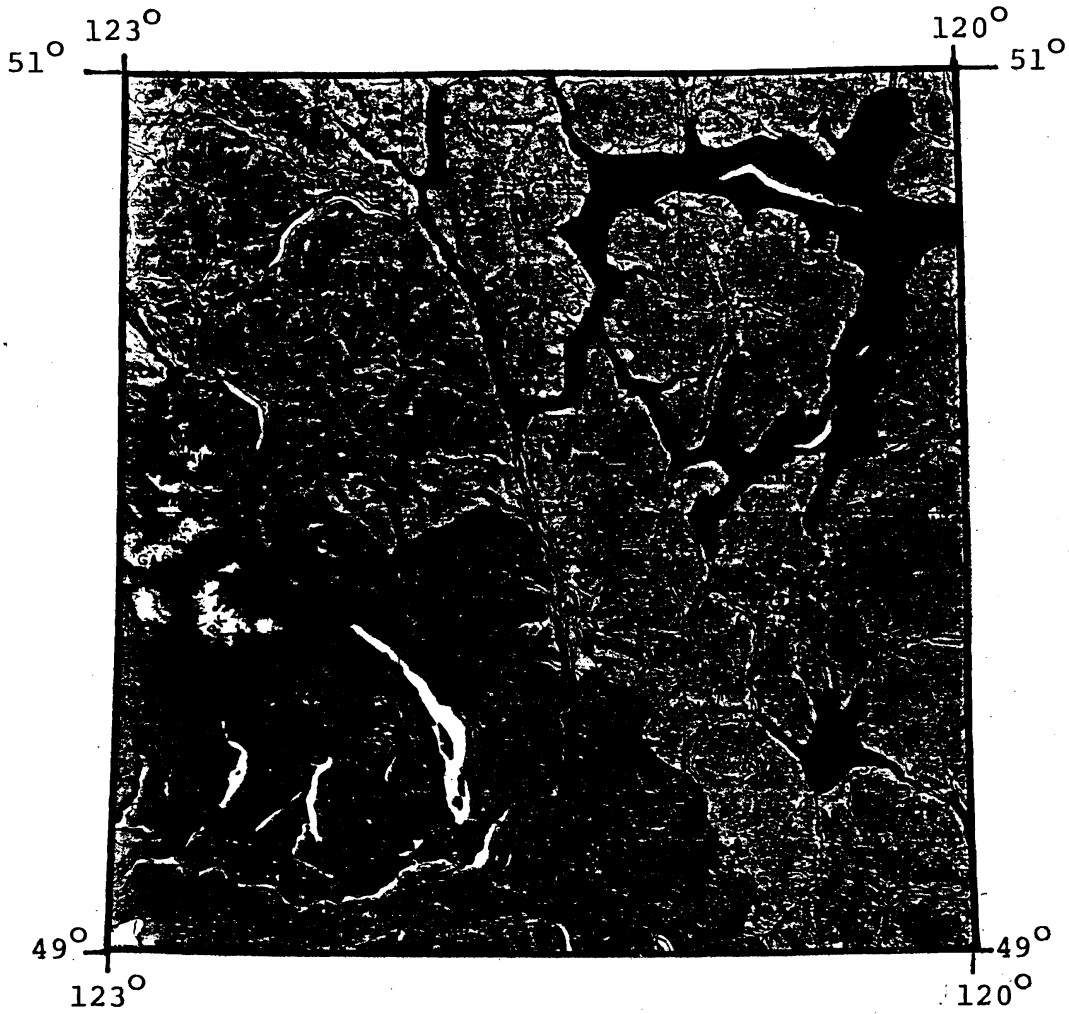


○ Boston Bar Creek (Upper), elev. 4,400 feet (1974-1980)

□ Boston Bar Creek (Lower), elev. 4,026 feet (1974-1980)

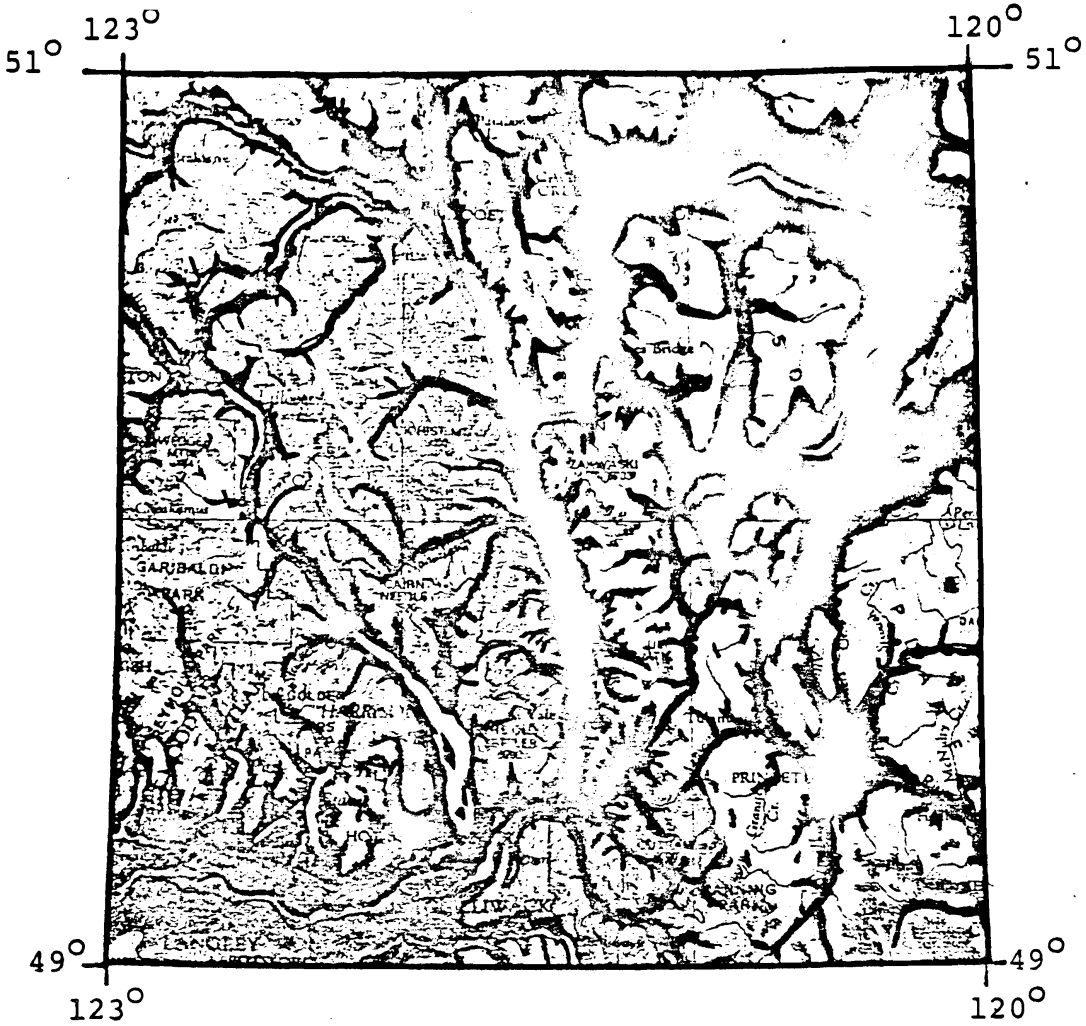
△ Brookmere, elev. 3,210 feet (1945-1980)

Figure 2.2.3: Average snow accumulation in the vicinity of the the study area.



Biogeoclimatic Zone	Annual Precip. mm	(in)	% as Snow
Coastal Douglas Fir	657-1524	(26- 60)	2- 9
Coastal Western Hemlock	1550-4400	(61-173)	7-14
Subalpine Mountain Hemlock	1780-4320	(70-170)	20-70
Alpine Tundra	700-2800	(28-110)	72-74
Subalpine Engelmann Spruce-Subalpine Fir	410-1830	(16- 72)	43
Interior Douglas Fir	359- 565	(14- 22)	24-51
Ponderosa Pine-Bunch Grass	213- 352	(8- 14)	16-29

Figure 2.2.4: Biogeoclimatic zones and associated precipitation in southwestern British Columbia (after Krajina, 1973 and Beil et al, 1976).



Biogeoclimatic Zone	Annual Precip. mm	(in)	% as Snow
Coastal Douglas Fir	657-1524	(26- 60)	2- 9
Coastal Western Hemlock	1550-4400	(61-173)	7-14
Subalpine Mountain Hemlock	1780-4320	(70-170)	20-70
Alpine Tundra	700-2800	(28-110)	72-74
Subalpine Engelmann Spruce-Subalpine Fir	410-1830	(16- 72)	43
Interior Douglas Fir	359- 565	(14- 22)	24-51
Ponderosa Pine-Bunch Grass	213- 352	(8- 14)	16-29

Figure 2.2.4: Biogeoclimatic zones and associated precipitation in southwestern British Columbia.

STATION NAME	REFERENCE NUMBER	ELEVATION (FEET)	PERIOD OF RECORD	TOTAL MONTHLY PRECIPITATION - INCHES						
				APR	MAY	JUN	JUL	AUG	SEP	OCT
ZEPHYR	116258	2240	71, 72, 73	—	.48	1.75	.41	.51	.91	.58
COLDWATER	116259	2432	71, 72, 73	—	.37	1.31	.22	.69	.92	1.07
BROMELY	112010	2420	71, 72	.42	.64	2.00	.17	.97	.80	1.90
LOCKIE	112013	2560	71, 72	.20	.56	1.57	.52	.67	1.20	3.16
THYNNE	112014	2730	71, 72	.06	.48	1.75	.55	.74	.90	3.88
THALIA	112015	2855	71, 72	.06	.53	1.76	.41	.59	.97	2.66
SPEARING	112016	3180	71, 72	.05	.57	1.85	.35	.50	.89	2.17
HASTINGS	112017	3630	71, 72	.18	.65	2.39	.60	—	.97	1.21
BATES	112018	3455	71, 72	.05	.77	2.48	.45	.70	.93	1.60
BLUEY	112027	3380	71, 72	.11	.61	2.50	.45	.62	.88	1.64
AVERAGE				.14	.57	1.94	.41	.67	.82	1.99

TABLE 2.2.1: Monthly precipitation totals recorded at Air Management Branch Climate Stations.

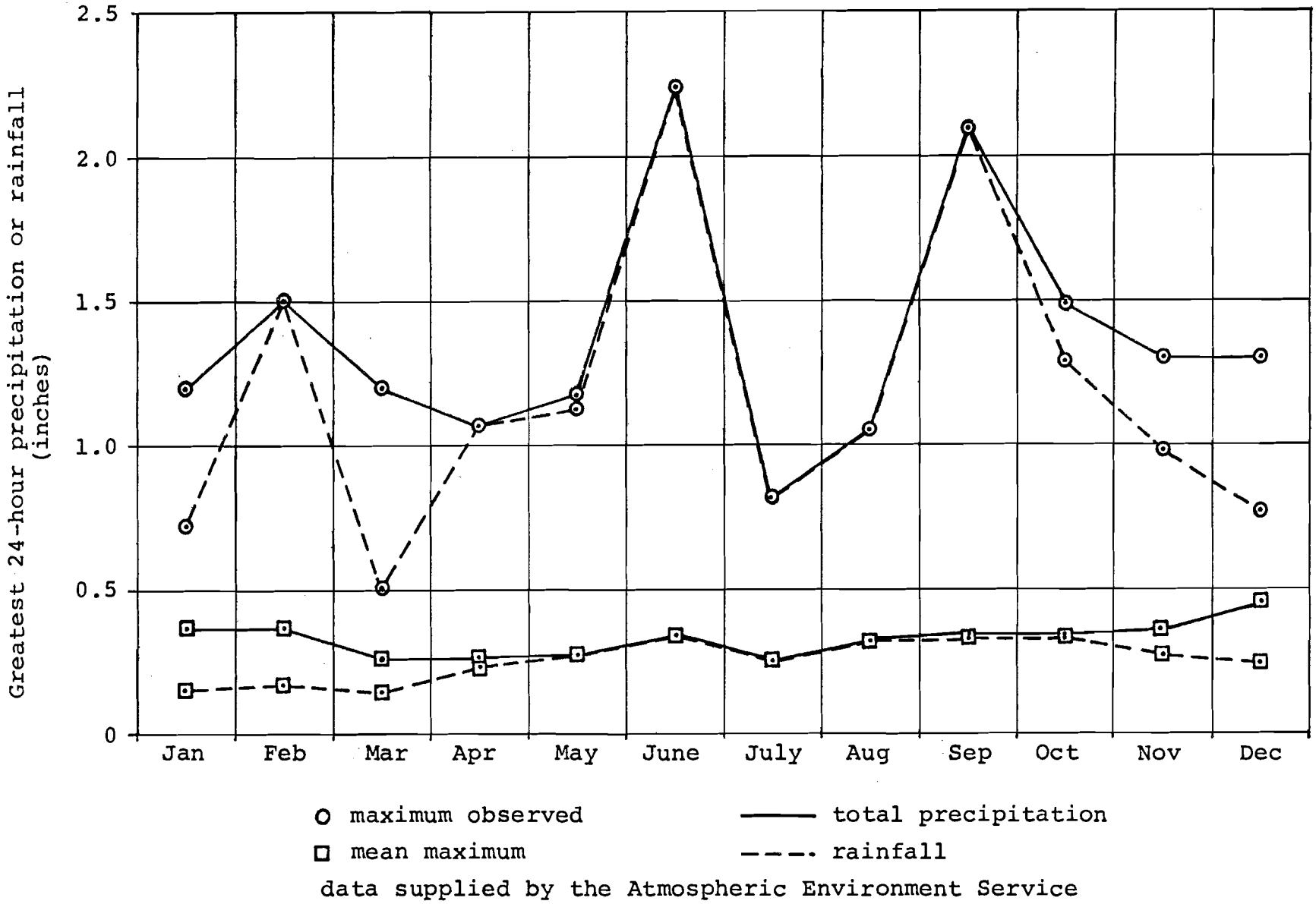
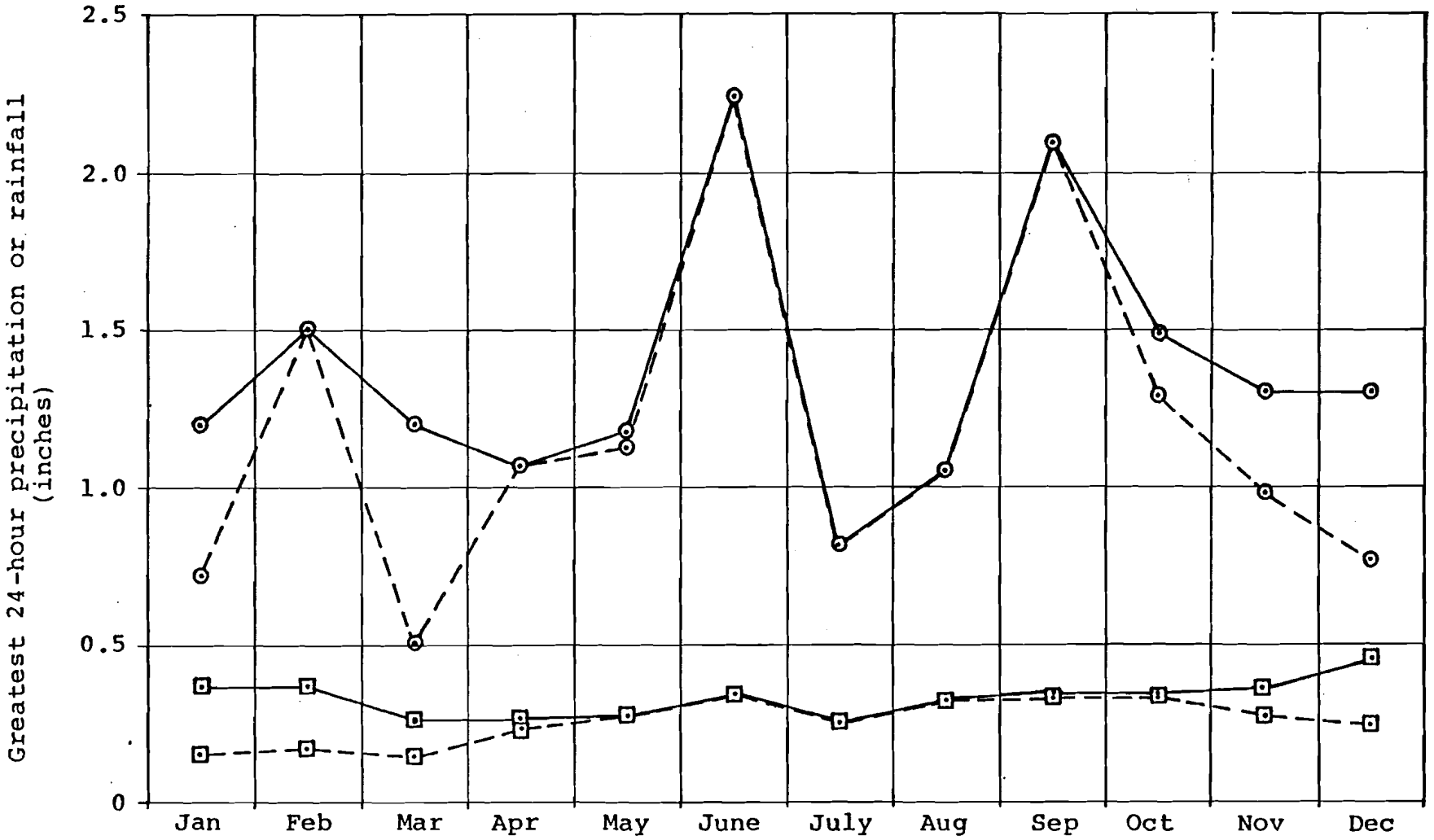


Figure 22.5: Seasonal variation in maximum 24-hour precipitation and rainfall at Merritt, B.C. (1918-1952; 1962-1966)

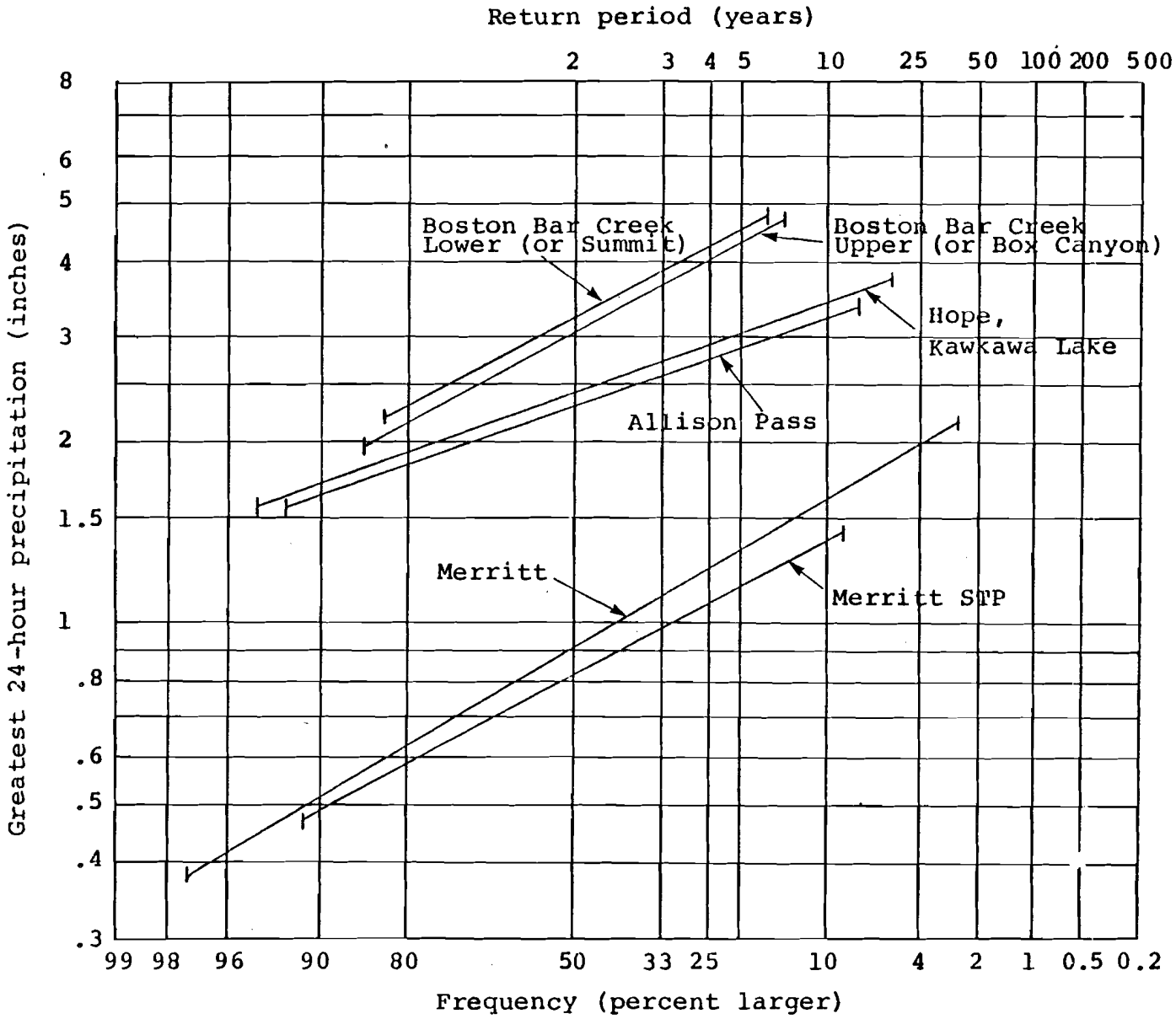


maximum observed ——— total precipitation

mean maximum - - - - rainfall

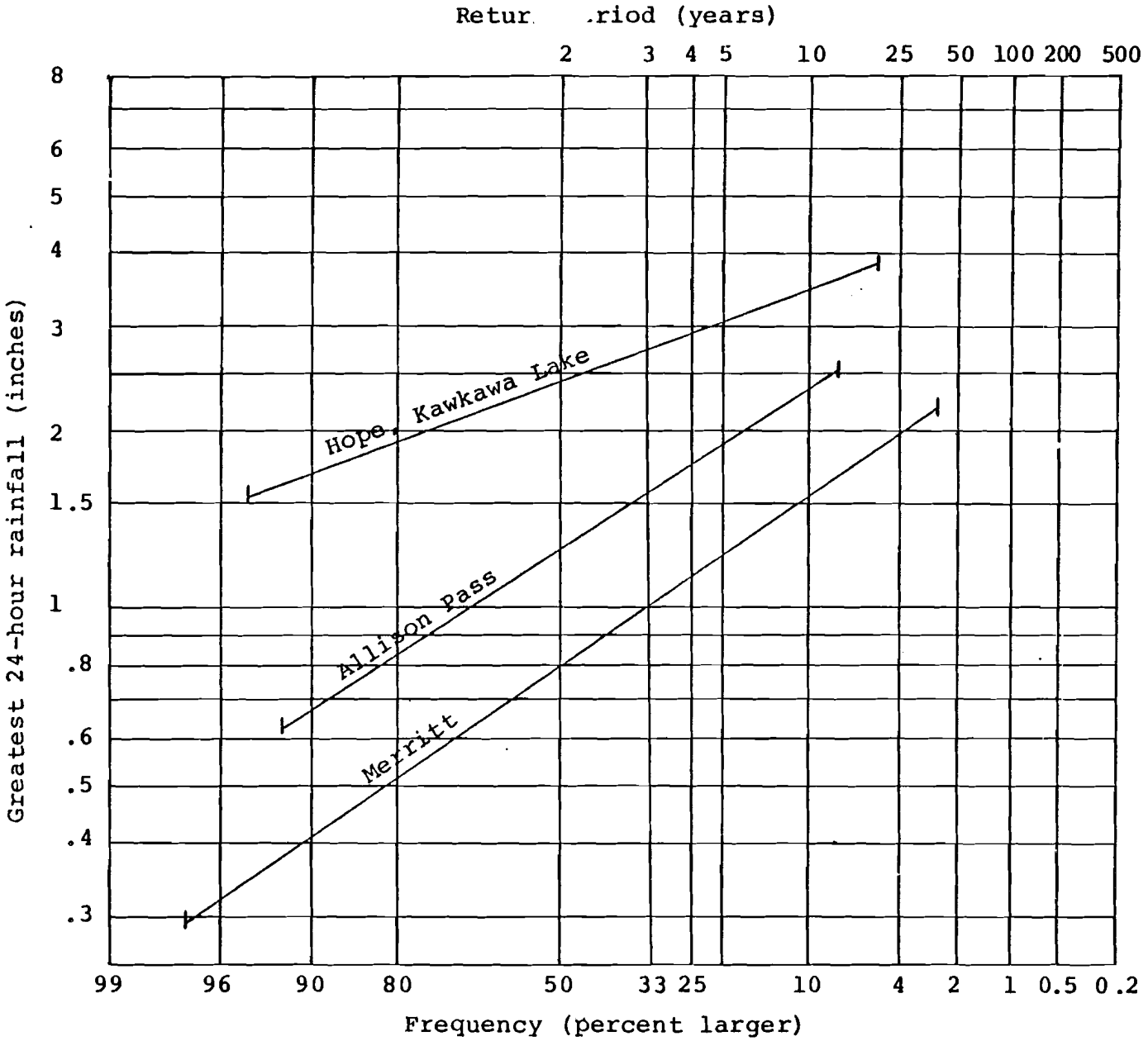
data supplied by the Atmospheric Environment Service

Figure 2.2.5 : Seasonal variation in maximum 24-hour precipitation and rainfall at Merritt, B.C. (1918-1952; 1962-1966)



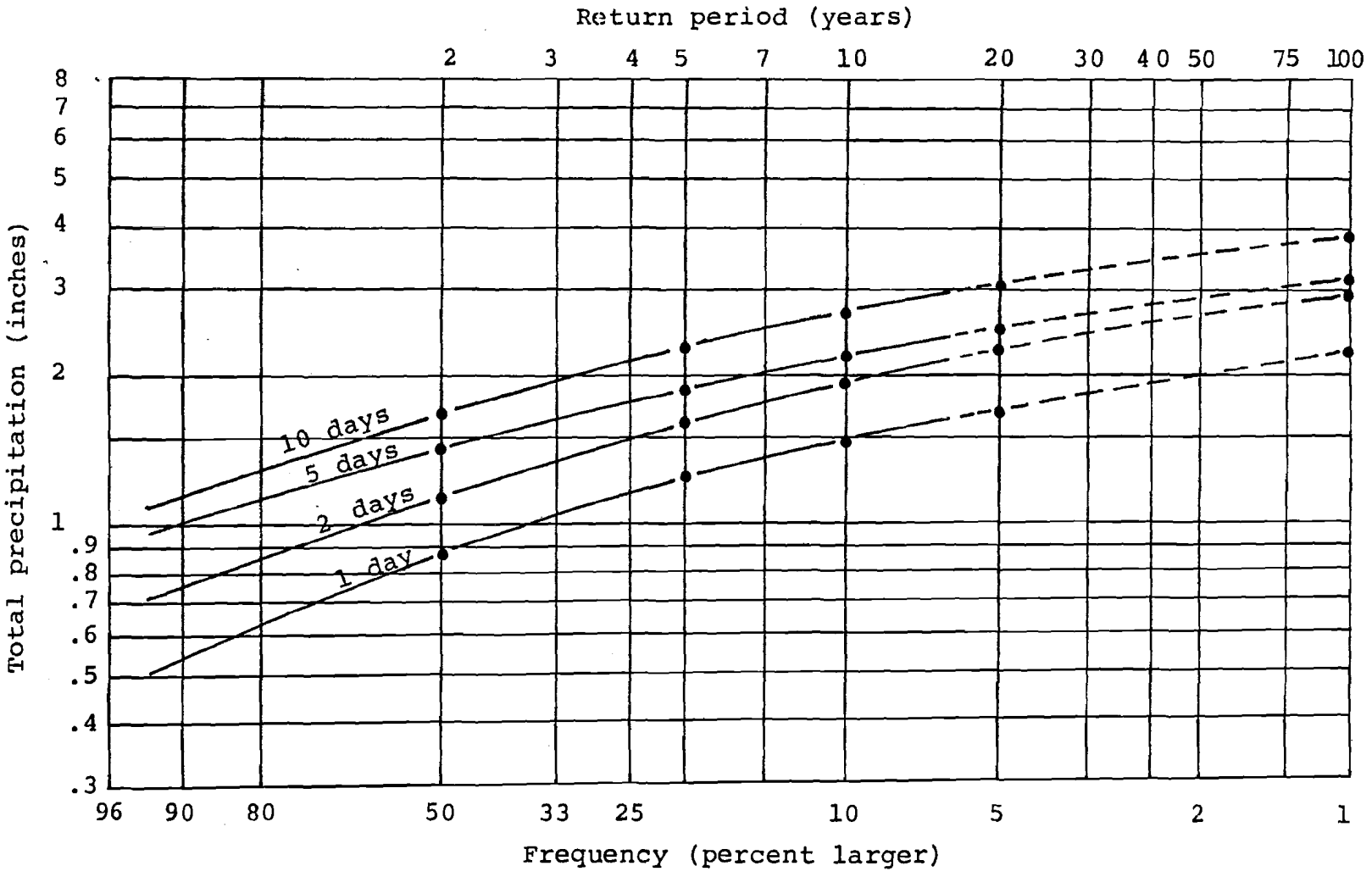
Note: Straight lines fitted by eye. The length of the lines corresponds exactly to the extent of data coverage.

Figure 2.2.6 : Frequency distribution of greatest annual 24-hour precipitation.



Note: Straight lines fitted by eye. The length of the solid lines corresponds exactly to the extent of data coverage.

Figure 2.2.7 Frequency distribution of greatest annual 24-hour rainfall.

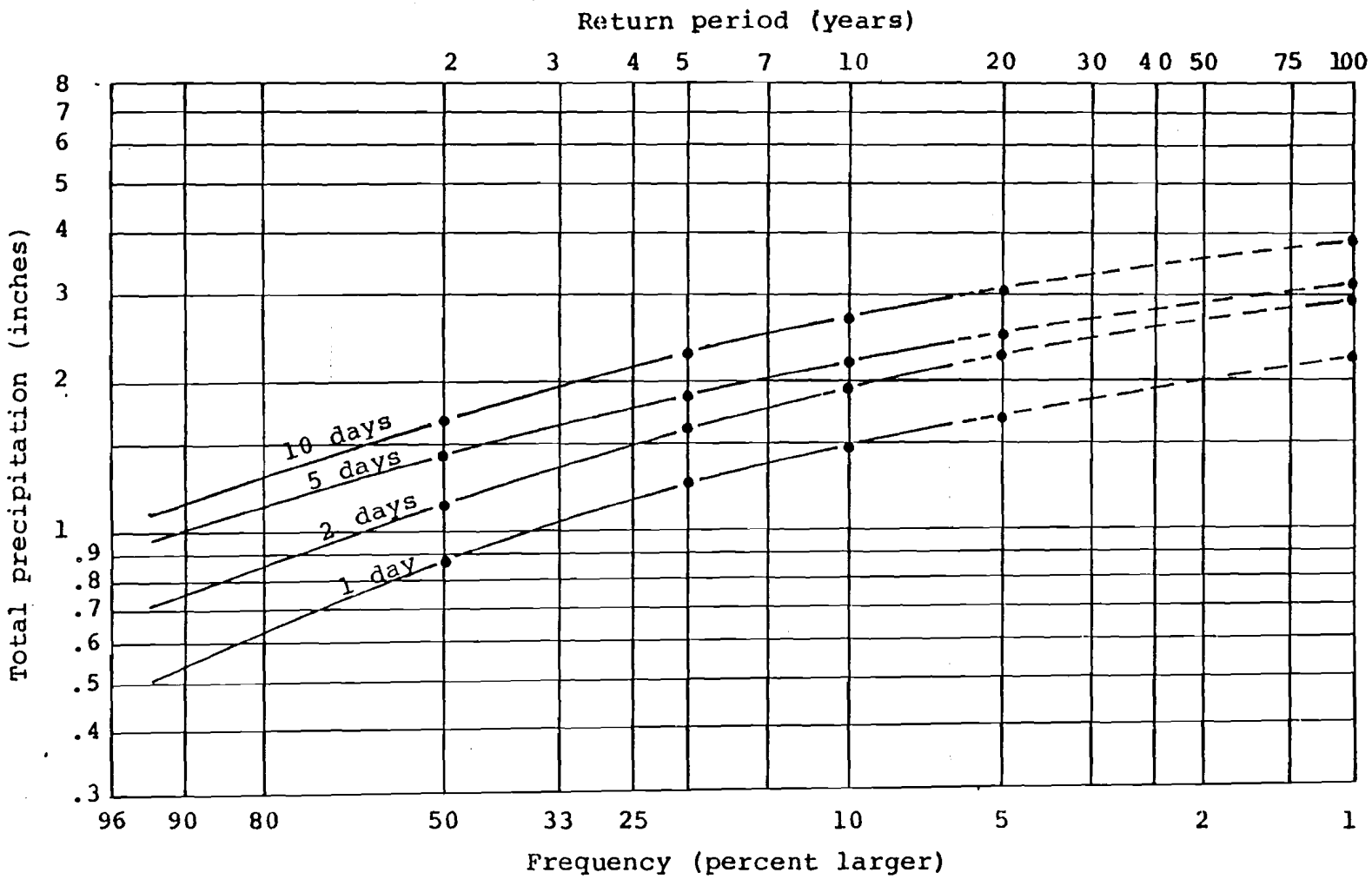


Notes: Data provided by the Air Management Branch, B.C. Ministry of the Environment.

Analysis undertaken using the Gumbel Type 1 distribution fitted by the method of moments.

The length of the solid line corresponds exactly with the extent of data coverage.

Fig 7.2.8 Frequency distribution of 1, 2, 5 and 10 day total precipitation at Merritt.

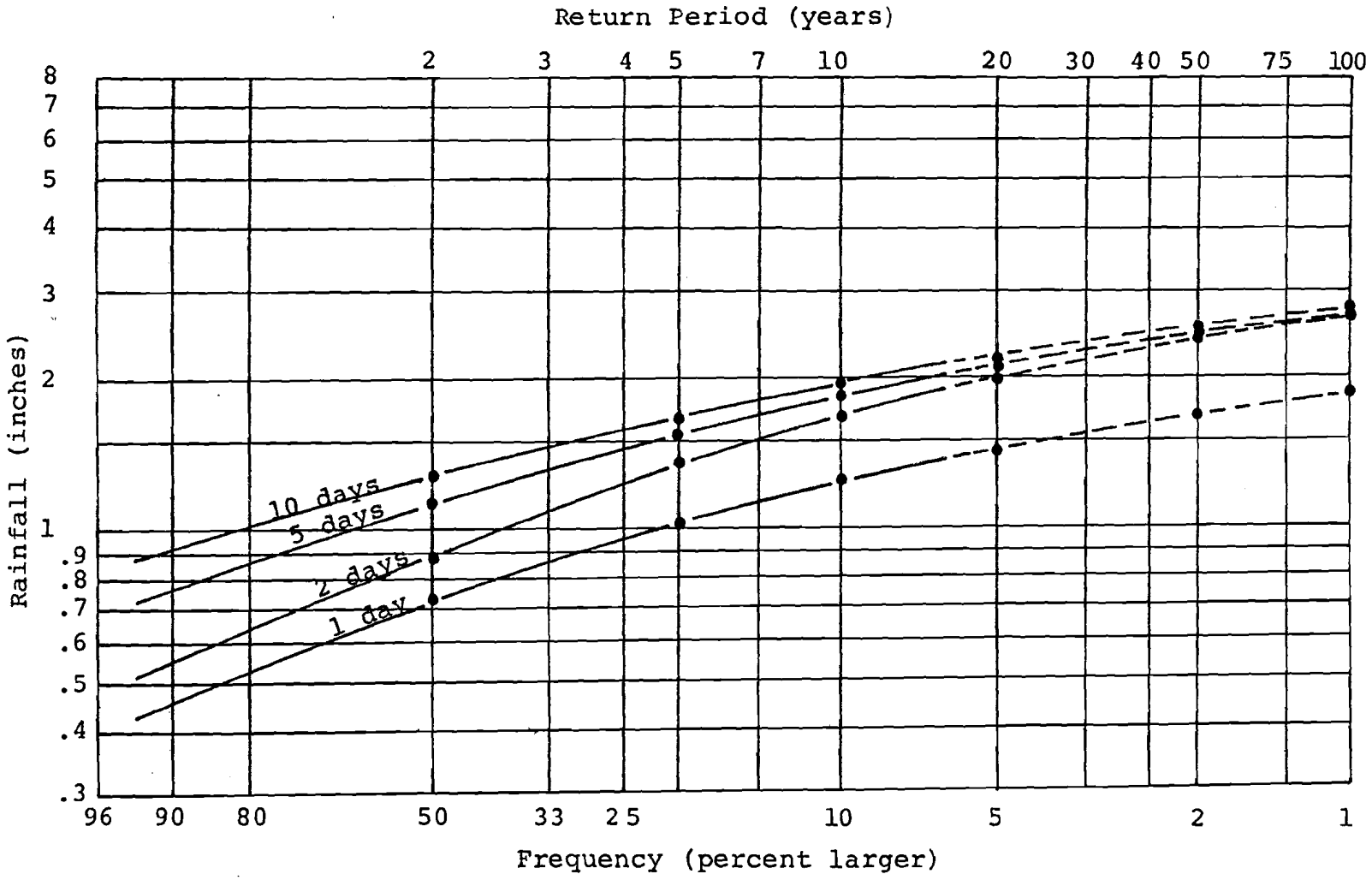


Notes: Data provided by the Air Management Branch, B.C. Ministry of the Environment.

Analysis undertaken using the Gumbel Type 1 distribution fitted by the method of moments.

The length of the solid line corresponds exactly with the extent of the data coverage.

Figure 7.2.8 Frequency distribution of 1, 2, 5 and 10 day total precipitation at Merritt.

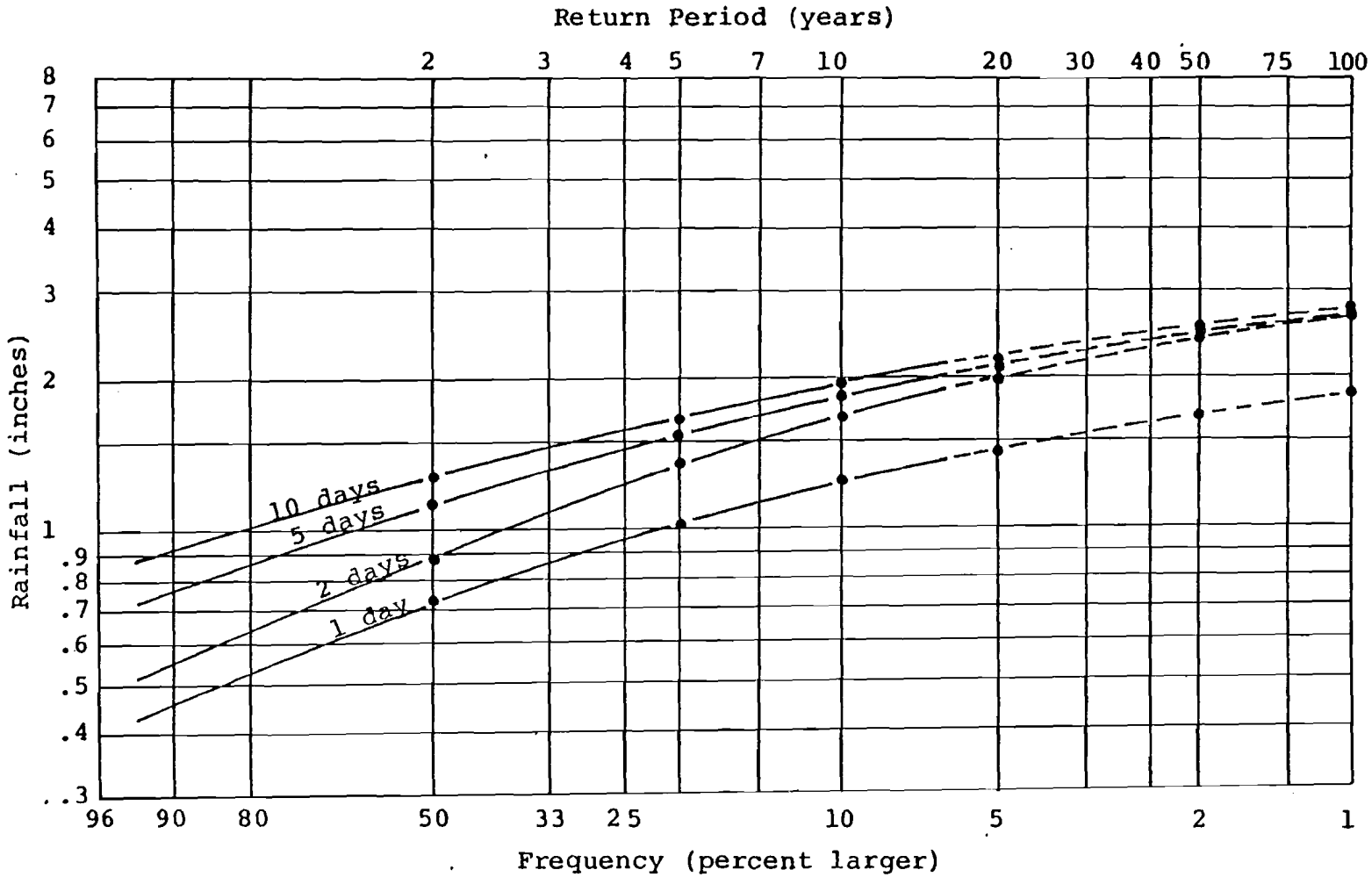


Notes: Data provided by the Air Management Branch, B.C. Ministry of the Environment.

Analysis undertaken using the Gumbel Type 1 distribution fitted by the method of moments.

The length of the solid line corresponds exactly with the extent of data coverage.

Fig 2.2.9 Frequency distribution of 1, 2, 5 and 10 day rainfall at Merritt.



Notes: Data provided by the Air Management Branch, B.C. Ministry of the Environment.

Analysis undertaken using the Gumbel Type 1 distribution fitted by the method of moments.

The length of the solid line corresponds exactly with the extent of the data coverage.

Figure 2.2.9 3 Frequency distribution of 1, 2, 5 and 10 day rainfall at Merritt.

2.3 Runoff Regime

2.3.1 Annual Runoff

Table 2.3.1 presents a summary of hydrologic data from the Water Survey of Canada gauging stations located in the vicinity of Coldwater River. Gauging station locations are shown on Figure 2.3.1.

The tabulated values indicate that the mean annual runoff is approximately 47 inches in the Central region of the Cascade Range (as represented by the station Coquihalla River below Needle Creek). Runoff values recorded on Coldwater River range from 28 inches at Brookmere to 12 inches at Merritt and reflect the increasing percentages of the upstream basin which are located in the drier region of the Thompson Plateau. Gauging stations on Spius Creek and on Tulameen River have runoff values ranging from 18 to 35 inches, reflecting the large percentage of their upstream drainages which are located within the Cascades. Runoff values for the Thompson Plateau north of Merritt (not tabulated) decrease to the order of one inch. This variation in runoff supports the regional pattern in precipitation developed in Section 2.2 and further indicates that the gauging stations on Coldwater River at Brookmere, on Tulameen River upstream of Coalmont, on Spius Creek, and on Coquihalla River below Needle Creek all have a relatively similar range in runoff values. Thus data from these stations can be used as a basis for describing the

hydrologic conditions occurring within the central and eastern region of the Cascades.

Figure 2.3.2 shows the maximum, average, and minimum mean monthly discharge for Coldwater River near Brookmere. Maximum monthly discharges occur in May and June, with 15 to 20 percent of the total annual runoff generally occurring at this time. Minor peaks in discharge also occur in November, December, and January. This seasonal pattern of runoff reflects the dominant spring snow melt as well as peaks in precipitation which occur in both the spring and fall as previously shown on Figure 2.2.5.

Maximum, average, and minimum daily discharge values recorded in each month of the year on Coldwater River near Brookmere are shown in Figure 2.3.3. The maximum annual discharge has occurred in the spring 13 times in the 15 years of record. The maximum observed daily flow of 3238 cfs occurred on Dec. 27, 1980 and is slightly higher than the maximum observed spring discharge of 3220 cfs which occurred on May 10, 1972. Minimum daily flows can be seen to occur in the mid-winter period of December, January and February, and again in the late summer period of August and September. This seasonal pattern consisting of two periods of both maximum and minimum discharge indicates that frequency analyses must consider both populations of events, rather than just analyzing the extreme annual values.

2.3.2 Maximum Daily Discharge

Figure 2.3.4 shows the relationship between the geometric mean of the annual peak daily discharges and basin area for the stations tabulated on Table 2.3.1. Within a hydrologically homogeneous area, unit discharge can be expected to increase with decreasing basin area, as indicated by the plotted envelope curves. The anomalously low annual discharge values for stations 2 through 7 likely reflect their location within ~~regions of~~ portions of the Thompson Plateau and the short period of record over which they were operational (1 to 3 years). Similarly, stations 12 and 14 are located entirely within the Thompson Plateau and thus can also be expected to have smaller than average discharges. The remaining stations show a relatively good fit to the envelope curve recommended by Creager et al. (1961), with the slightly lower value associated with the Coldwater River at Merritt (station 10) being not unexpected. Thus the values predicted by the envelope curve provide a rough guide to the average annual peak daily discharges which can be expected in the headwaters of the Coldwater drainage. As this estimate is based on the geometric mean of the maximum annual values, the predicted discharges theoretically have a recurrence interval of approximately 2 years.

The maximum observed daily discharge values (on a unit area basis) are plotted on Figure 2.3.5 and show a similar regional variation as described above. The envelope curve again

shows a reasonably good fit to the recorded data and provides a rough estimate of the size of discharge which could be expected to occur in the headwater region of the Coldwater drainage on the basis of values observed in the surrounding region. No recurrence interval can be attached to these estimates.

A magnitude and frequency analysis of peak discharges was undertaken for the stations on Table 2.3.1 which have 10 or more years of data. Frequency analyses were conducted on the maximum annual discharges and on the maximum discharges recorded in the periods of September to February and March to August. The analysis based on recorded discharges in the fall-winter and spring-summer periods is based on a technique developed by Stoddart and Watt (1970) and allows the separat~~ion~~e analysis of rain and snowmelt peaks. As discussed by Church and Kellerhals (1979), this procedure is a statistically valid method of analysing data which is composed of two populations of events, and frequently yields a more conservative (i.e., larger) estimate of the magnitude of high recurrence interval discharges than would result if the two populations were not differentiated. An example of the use of this technique is shown in Figure 2.3.6.

Analysis of each data set was undertaken using the computer program developed by the Inventory and Engineering Branch of the B.C. Ministry of the Environment. This program produces discharge estimates based on four different frequency distributions. A summary of results ~~for the station Coquihalla River below~~

shown in Tables 2.3.2 to 2.3.7. Best estimates of specific recurrence interval discharge were chosen from the range of computed values on the basis of data skew, size of the standard error of the estimate and results of the Kolmogorov-Smirnov goodness of fit test.

The wide range in discharge estimates for Coldwater River, shown in Tables 2.3.3 and 2.3.4, deserve comment. Maximum annual discharges occur in both the September to February and March to August periods, with the majority of maximum annual flows occurring in the spring. In some years, no significant flow occurred during the fall and winter, and thus frequency analysis based on the largest annual flow in this period includes numerous values of mid-winter minimum flow values. Thus the analysis ~~was~~ were conducted on flows of widely varying magnitude and the resulting ~~analysis is~~ are therefore frequently unreliable, as indicated by the Kolmogorov-Smirnov goodness of fit test. The best estimates of potential discharge are thus primarily based on the analysis of the annual and spring discharges. However in the case of Coldwater River at Merritt, the predicted fall and winter discharges are not entirely unreasonable and thus the best estimate value is slightly larger than those predicted on the basis of the spring discharges. The values arrived at in this manner appear to be consistent with the discharges predicted on the basis of other stations in the region.

TP

Values of the 2, 10, 50, 100, and 200 year recurrence interval discharges as are plotted against basin area in Figures 2.3.7 to 2.3.11.

The best fit line through the plotted data is representative of conditions occurring within and along the east slope of the Cascade Range, and is thus applicable to the Coldwater drainage upstream of Kingsvale. Data from Coldwater River at Merritt plots below the best fit line reflecting the percentage of the upstream basin which drains the Thompson Plateau. Similarly, discharge estimates for Otter Creek at Tulameen, which is both regulated and situated within the Thompson Plateau, are less than those predicted by the remaining stations. The best fit line on these graphs can be used as a basis for predicting specific recurrence interval discharges for drainage basins larger than 20 mi^2 in area along the Coquihalla Lakes to Kingsvale section of the Hope-Merritt Highway. (Basin areas for this section of Coldwater River are presented in Section 4.2.)

Discharges for basin areas of less than 20 miles^2 in area are difficult to estimate as there are no relevant gauging stations in this size range. A rough estimate of the average annual mean daily discharge can be made on the basis of the envelope curves shown in Figure 2.3.4. In order to estimate the potential size of peak flows, the 200 year recurrence interval discharges calculated previously have been converted into unit discharges and plotted against basin area in Figure 2.3.12. The unit runoff values can be seen to increase with decreasing basin area, and correspond relatively well to the envelope curve proposed by Creager et al, (1961). This curve, with a coefficient C equal to 4, provides an approximation of the 200 year mean daily discharge for small basin areas.

2.3.3 Maximum Instantaneous Discharge

The discharges predicted in the preceding section are

estimates of the "mean daily discharge". Within this 24 hour period, the "maximum instantaneous" or peak flow can be significantly higher, and is frequently the major cause of flood damage. For this reason the Guide to Bridge Hydraulics, by Neill (1973) recommends that design flows should be calculated on the basis of instantaneous discharge.

Figure 2.3.13 presents a compilation of the average ratios of instantaneous to corresponding mean daily discharges for the reporting stations. This statistic is only available for the maximum discharge recorded each year. Stations on the Coquihalla River below Needle Creek, and on the Coldwater River (reference numbers 1, 8, and 9) have average ratios of approximately 1.2. Figure 2.3.14 presents a similar plot showing the maximum observed ratios. Values from Coquihalla and Coldwater Rivers can be seen to range from 1.6 to 1.75. This ratio normally increases as basin area decreases and thus a tentative envelope curve has been drawn through the data.

The significant difference in values predicted by these two figures reflect the dominance of ratios associated with snowmelt floods which comprise the majority of the recorded events. This is illustrated by Figure 2.3.15 which shows all of the ratios of instantaneous to mean daily discharge observed on Coldwater River near Brookmere. The snowmelt events can be generally seen to have ratios in the range of 1.05 to 1.2, while the fall rainstorm associated events have ratios of

1.24 to 1.73. It is significant that the ratio of instantaneous to mean daily discharge associated with the fall storms increases with size of the mean daily flow. It is thus recommended that the envelope curve about the maximum observed ratios of instantaneous to mean daily discharge (Figure 2.3.13) be used as the basis for calculating instantaneous discharges associated with high recurrence interval events.

2.3.4 Minimum Discharge

The minimum observed discharges for the stations listed on Table 2.3.1 are plotted on Figure 2.3.16. Stations whose upstream drainages are located principally within the Thompson Plateau (reference numbers 2, 3, 7, 10, 12, and 14) can be seen to have minimum flows of or near 0 cfs. Stations principally draining the east slope of the Cascades have larger minimum flows of 0.04 to 0.1 cfs/mile^2, while within the Cascades, minimum discharges are slightly higher at 0.3 cfs/mile^2. These discharges are all sufficiently small that low flows, particularly during periods of either very warm or very cold weather may comprise a significant threat to the fisheries resource.

Frequency analyses of low flows recorded on the two stations on Coldwater River are shown on Figures 2.3.17 and 2.3.18. At recurrence intervals less than 1.25 years, minimum flows near Brookmere are more severe in the summer than in the winter.

Above this recurrence interval, winter minimums are smaller than the corresponding summer discharge. These analyses indicate that once every 10 years, mid-winter minimum flows can be expected to decrease to 10 cfs, with the corresponding recurrence interval mid-summer minimums being 16 to 17 cfs.

The frequency analysis of minimum discharges on Coldwater River at Merritt indicate that the summer minimum flows are more severe for all recurrence intervals. Thus once every 10 years summer minimum discharges can be expected to decrease to 6 cfs, while the corresponding winter minimum is 15 cfs. It is interesting to note that the summer minimum discharges at Merritt are smaller than at Brookmere, possibly reflecting evapotranspiration losses and water withdrawal for agricultural and domestic purposes.

2.3.5 Water Temperature and Ice Cover

Water temperatures observed at the two gauging stations on Coldwater River are shown on Figure 2.3.~~18~~19 and 2.3.~~19~~20. Near Brookmere, peak mid-summer temperatures can be seen to occur in the period of July, August, and September and reach values of 15°C to 18°C. At Merritt, maximum water temperatures occur in roughly the same time period, with larger percentages of the extreme values occurring in the July-August period. Maximum observed values are slightly warmer than at Brookmere and commonly reach 15°C to 22°C. These temperatures are sufficiently cool not to pose problems to the fisheries resource, as discussed in Section

Mid-winter temperatures of $0^{\circ}C$ have been recorded at both stations over the period of late November through early March. The longer term observations of ice conditions[1] compiled by the Water Survey of Canada indicate that at the Brookmere Station, ice has been present in the river as early as October 28. The latest recorded initiation of ice conditions is December 14, with a median date of November 27. The cessation of ice conditions has occurred as early as January 22 and as late as April 2, with a median date of March 11. The longest recorded period of continuous ice conditions was 132 days, when ice was present between November 21, 1972 and April 2, 1973.

Discharges recorded during periods of ice conditions are generally small, with maximum values ~~generally~~ frequently being in the range of 100 to 500 cfs. However in the spring of 1968, the period of recorded ice conditions was immediately followed by a discharge of 1,200 cfs. Thus, while most discharges associated with ice conditions are of relatively small size, occasionally moderately large discharges will occur and can be expected to result in ice jamming and ice pressure against structures such as bridges.

---

[1]The Water Survey of Canada records indicate those days on which the stage-discharge relationship has been affected by the presence of ice. Ice conditions do not necessarily mean that a complete cover of ice is present.

2.3.6 Water Licences

In the region between Coquihalla Lakes and Shouz Creek (located just south of Kingsvale), there ~~were~~ are no outstanding water licences located in the vicinity of the mainstem of Coldwater River.*1 There is one application on file from Leafar Lands Ltd. of Kamloops, B.C., for 6,000 gallons of domestic water per day for a site located on the fan of Bottletop Creek. This application is apparently related to a proposed subdivision development. Information supplied by Mr. Kent of the Ministry of Transportation and Highways indicates that this project has now been abandoned.

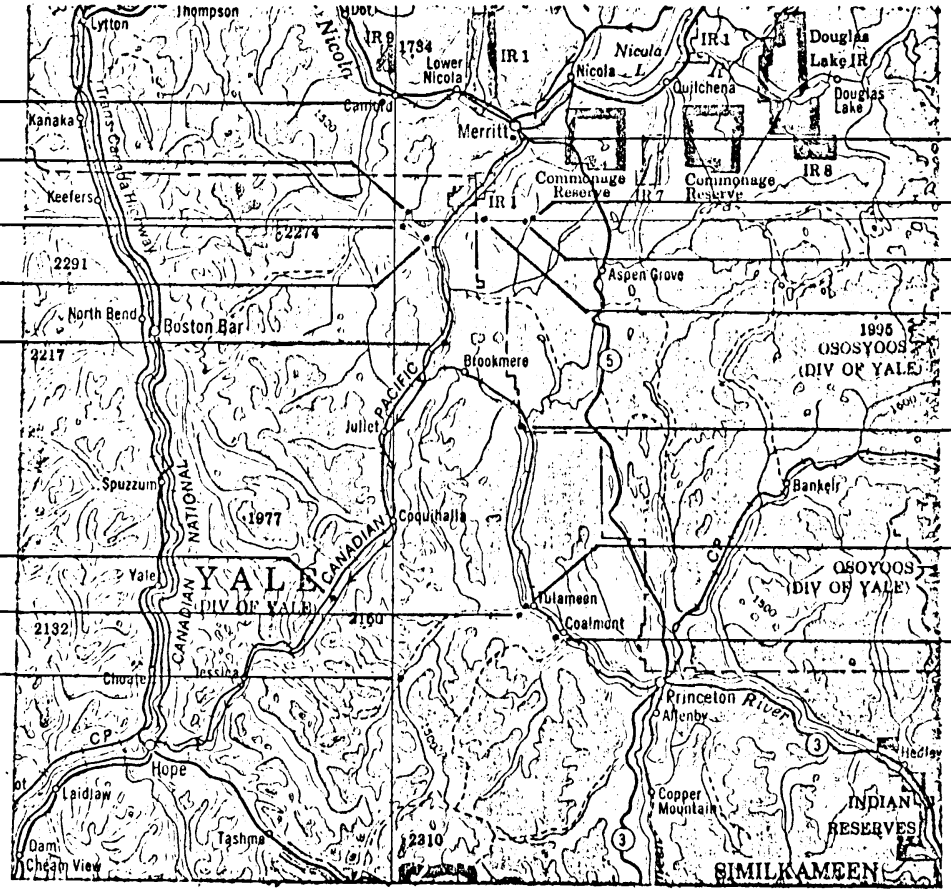
Water licences issued for sites adjacent to Coldwater River north of Shouz Creek are summarized on Tables 2.3. to 2.3. . Water licences on the lower reaches of Voght Creek, near Kingsvale and its tributaries have also been included in this summary. The approximate location of intake facilities are shown on Figures 2.3.21 to 2.3.23. The majority of water licences are for irrigation purposes only. In the region near Kingsvale (shown on Figure 2.3.21), domestic water consumers who may be affected by the proposed highway alignment are limited to Trans Mountain Pipeline Ltd. which is allowed to draw 1,000 gallons per day from Coldwater River, and I.E. Busby who is

---

*1 as of October 27, 1980.

licenced to use a similar quantity of water from Voght Creek.

Water licences on Coldwater River in the vicinity of Midday Creek, shown on Figure 2.3.22, are again mostly for irrigation purposes. Two exceptions occur at the southern boundary of this region where a total domestic use of 500 gallons/day has been authorized. In the region north to Nicola River, there is only one licenced user of domestic water, which is the Town of Merritt.



Note: Reference numbers refer to Table 2.3.1.

Station locations:

- △ Coquihalla drainage
- O Nicola drainage
- □ Similkameen drainage

Figure 2.3.1: Water Survey of Canada gauging station locations.

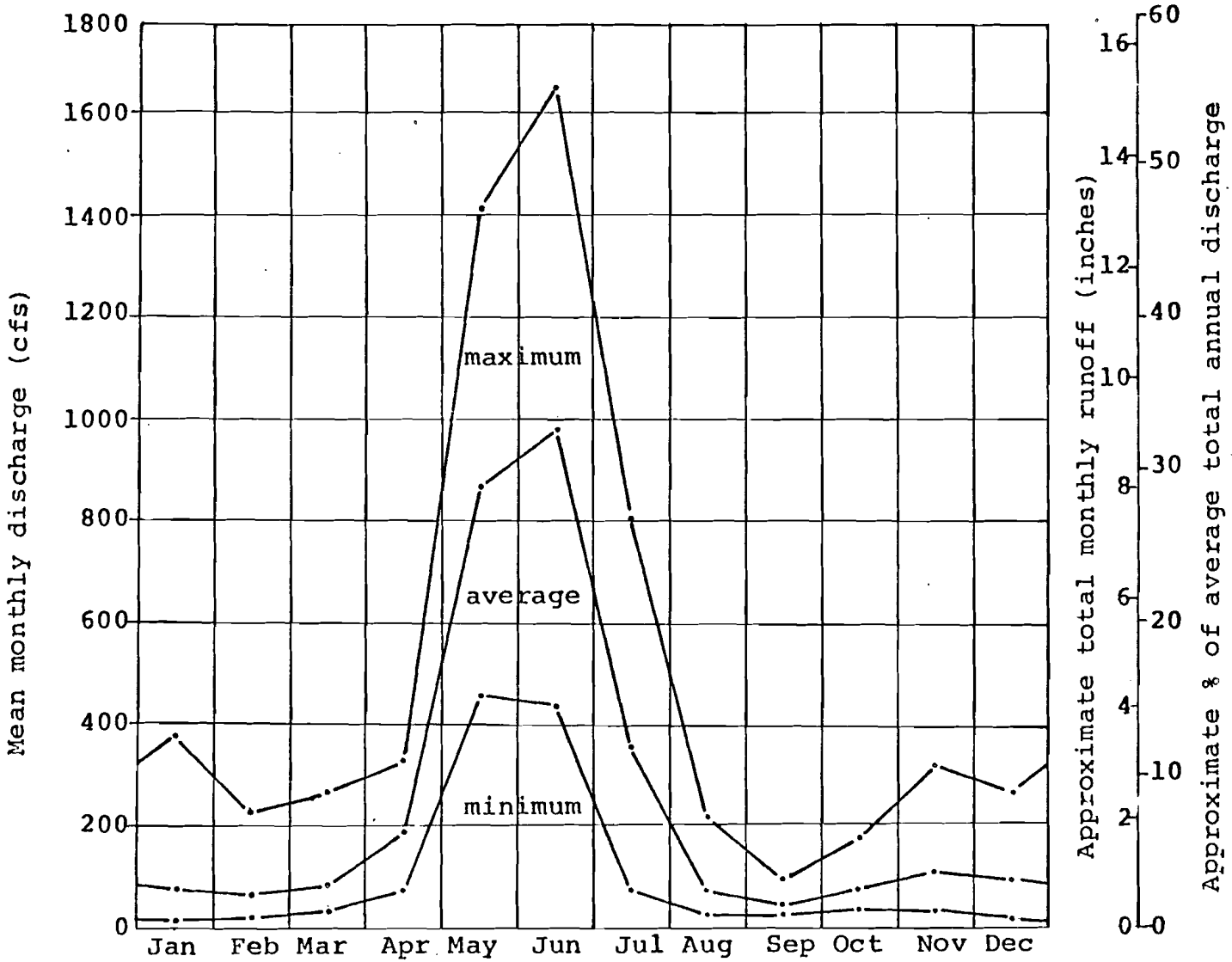


Figure 2.3.7: Maximum, average and minimum "mean monthly discharge" for the Coldwater River, near Brookmere (1965-1979).

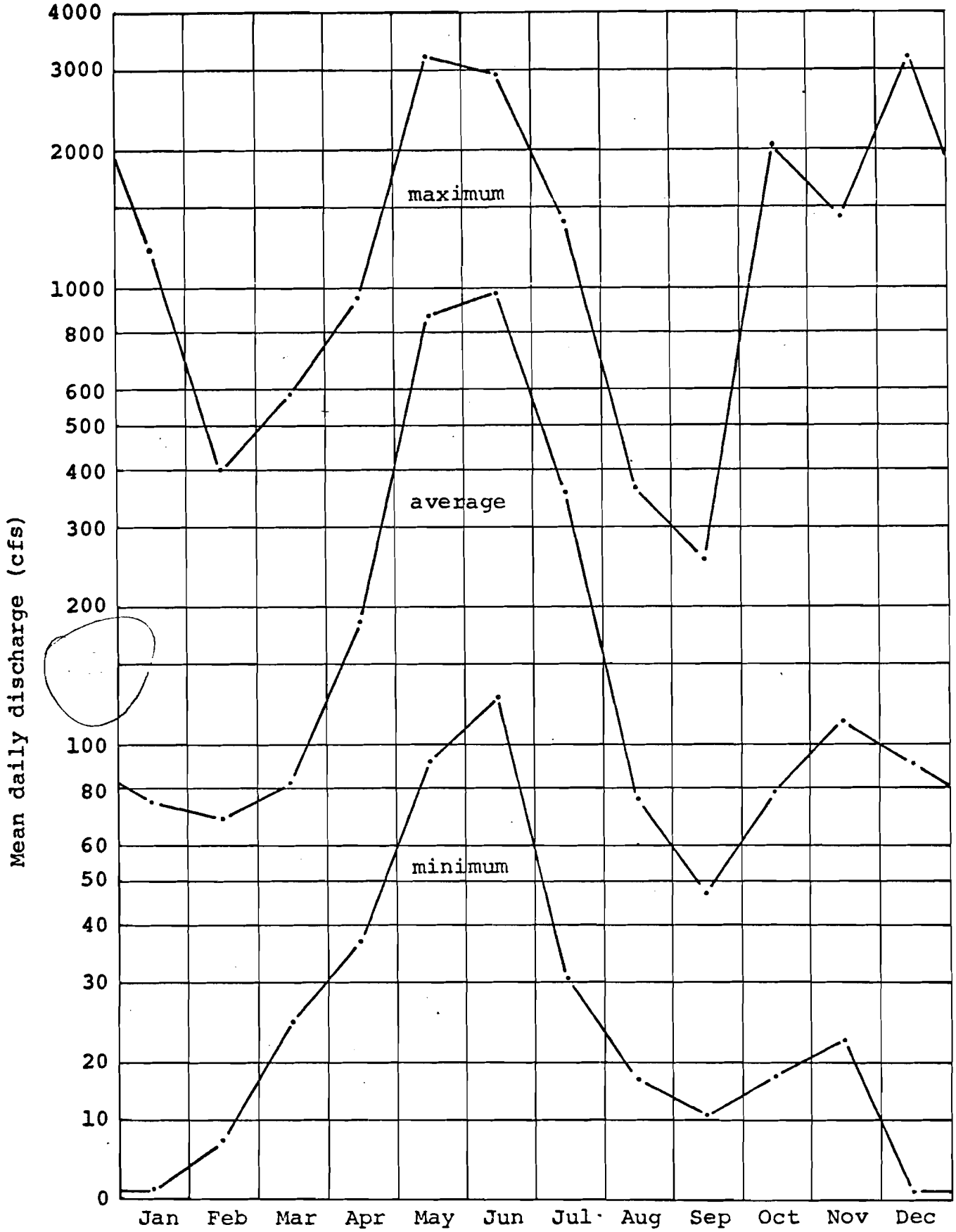
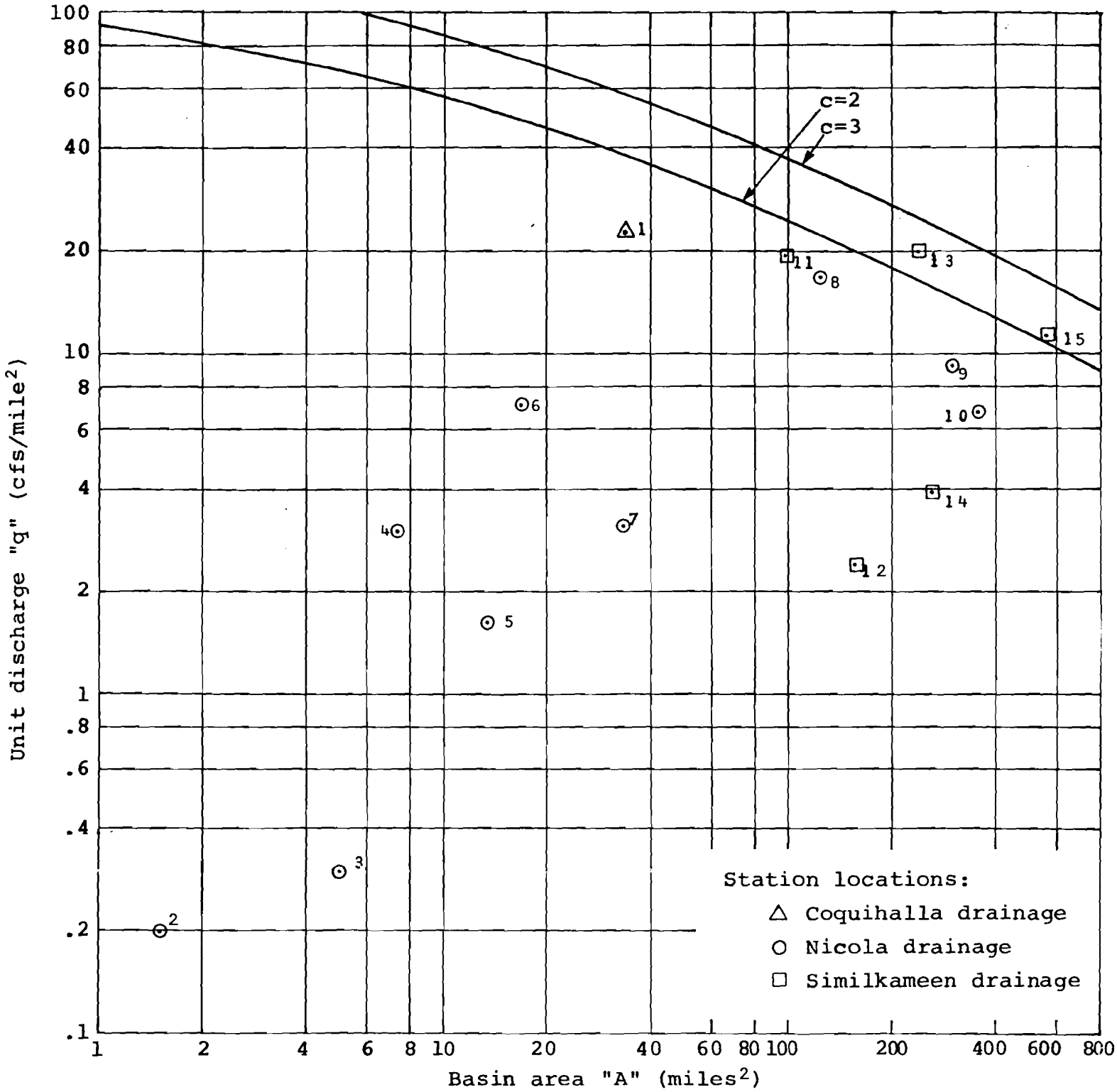


Figure 2.3.3: Maximum, average and minimum daily discharge for each month of the year, Coldwater River, near Brookmere (1965-1980).

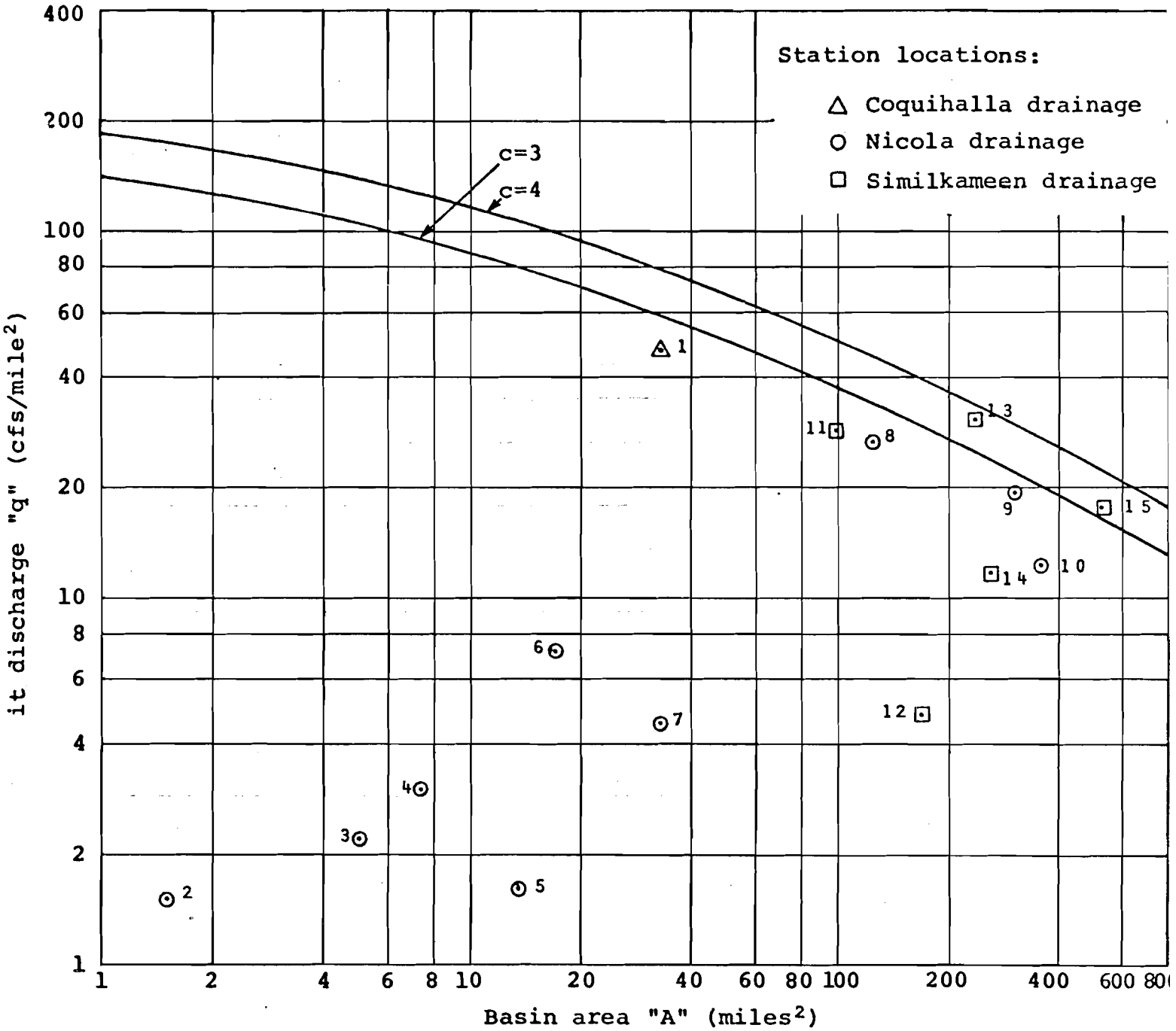


Note: Envelope curve is from Creager's Equation:

$$q = 46\ CA^{(0.894A^{-0.048})-1}$$

Reference numbers refer to Table 2.3.1.

Figure 2.3.4 Geometric mean of annual peak daily discharges (per unit area) plotted against basin area.

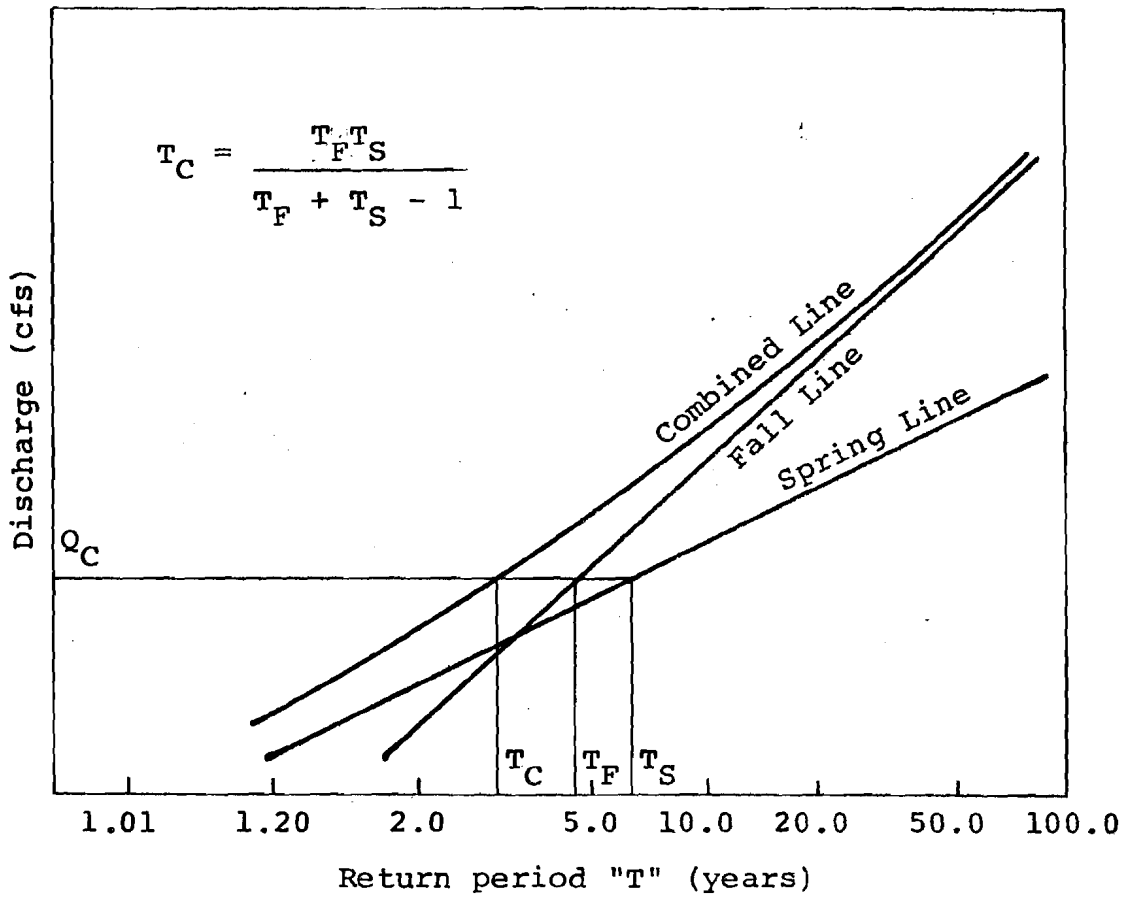


Note: Envelope curve is from Creager's Equation:

$$q = 46\ CA^{(0.894A^{-0.048})-1}$$

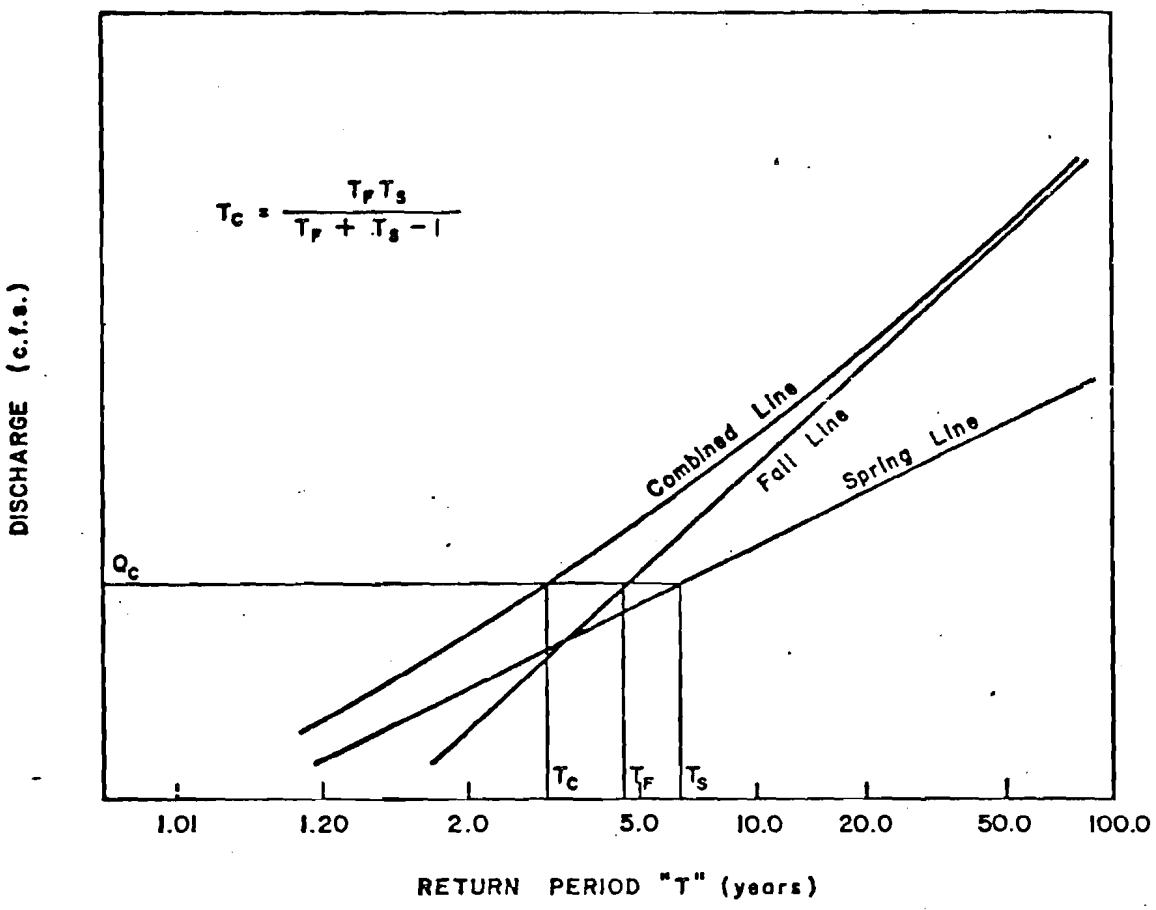
Reference numbers refer to Table 2.3.1.

Figure 2.3.5 Maximum observed mean daily discharge (per unit area) plotted against basin area.



Note: For a specific discharge Q_C, T_S is the associated recurrence interval for spring snowmelt events, T_F is the associated recurrence interval for fall rainstorm events and T_C is the recurrence interval for the combined population of events.

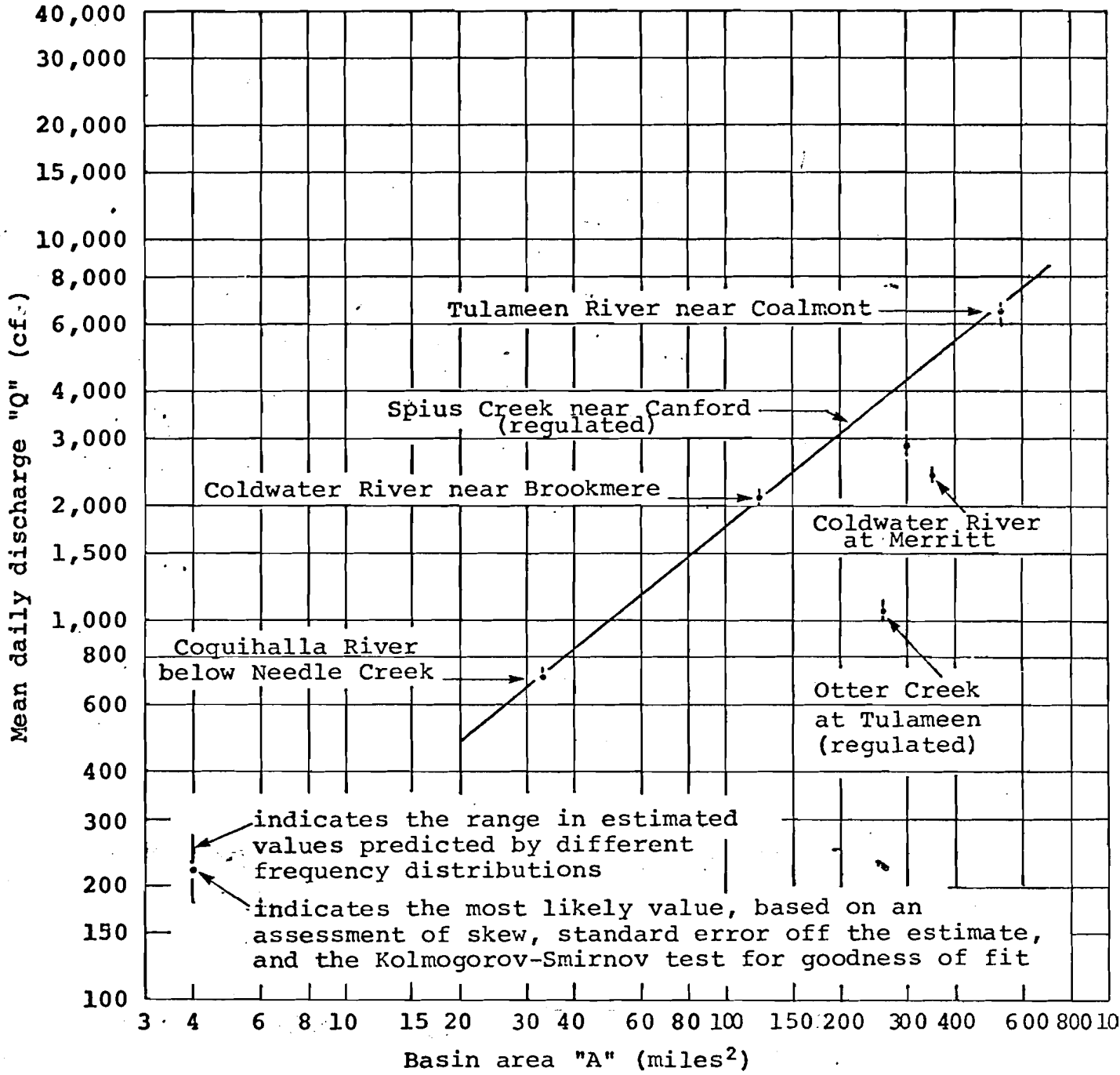
Fig 2.3.6 An illustration of the procedure for flood frequency analysis using a combination of both spring and fall discharges.



NOTES : For a specific discharge Qc, Ts is the associated recurrence interval for spring snowmelt events, T_F is the associated recurrence interval for fall rainstorm events and Tc is the recurrence interval for the combined population of events.

2.3.6

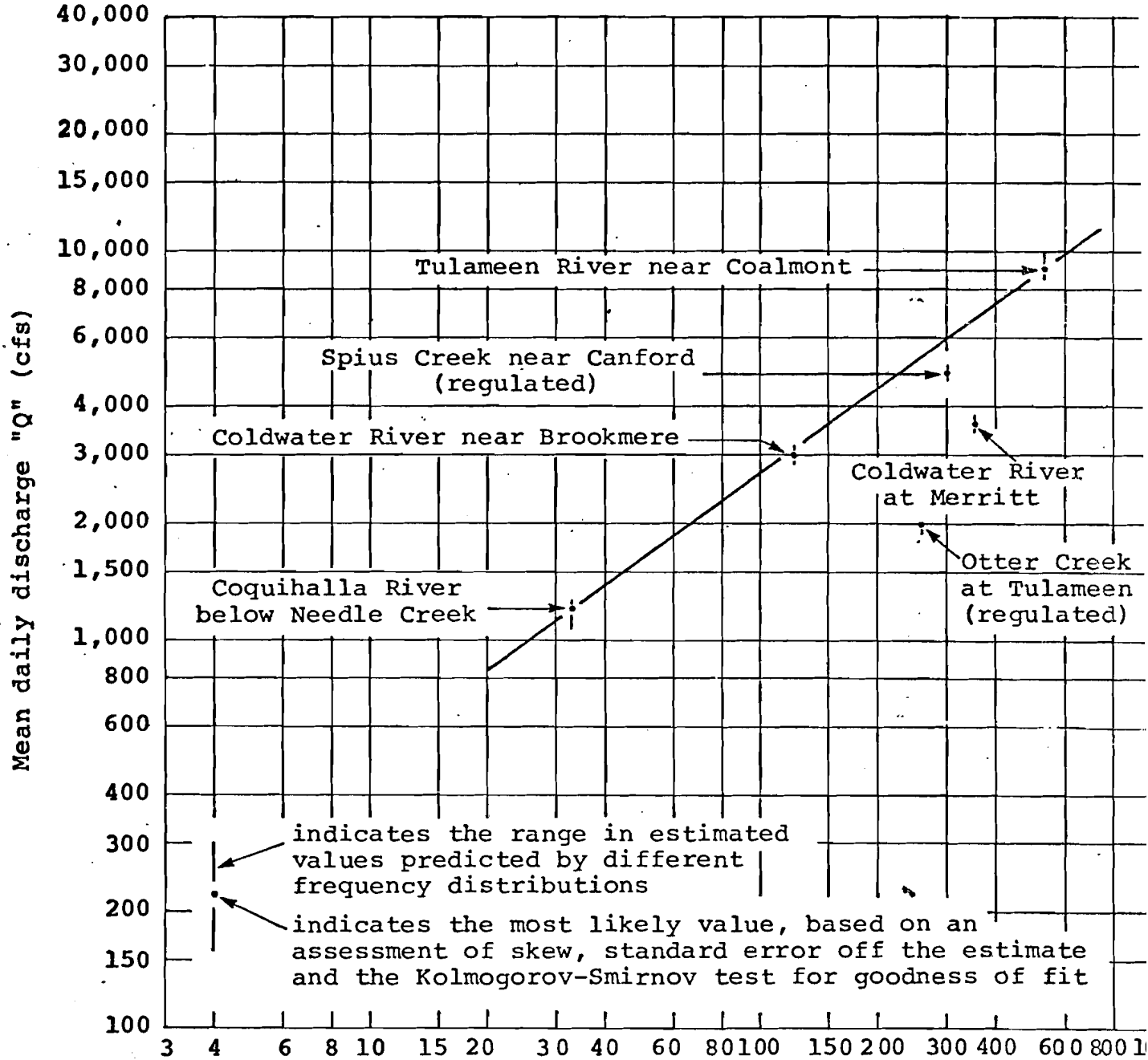
Fig. ~~2.3.11B~~ – An illustration of the procedure for flood frequency analysis using a combination of both spring and fall discharges.



Note: The plotted line has the equation:

$$\ln (Q) = 0.81 \ln (A) + \ln 42.92$$

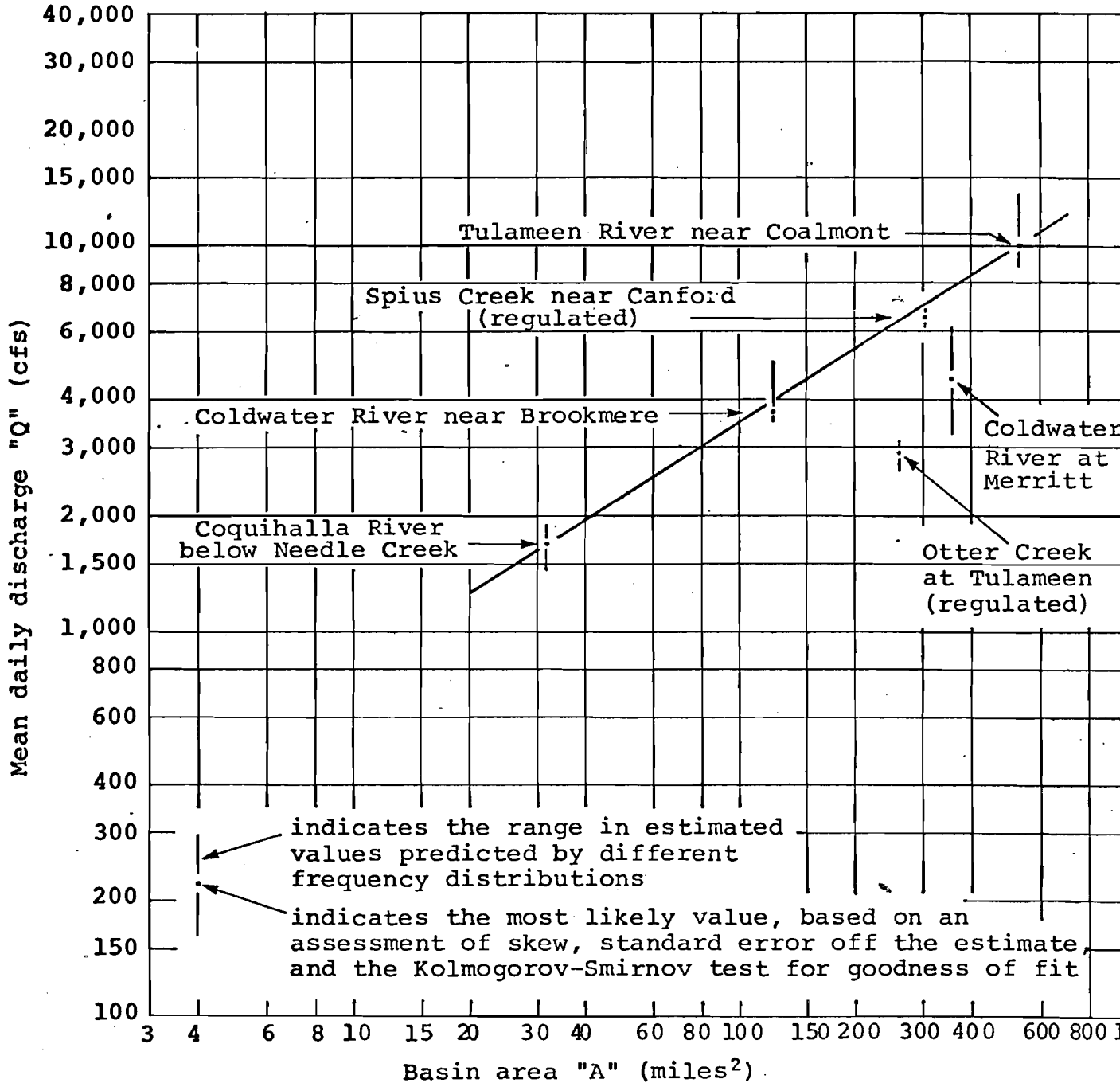
Figure 2.3.7 Predicted two year recurrence interval discharge plotted against basin area.



Note: The plotted line has the equation:

$$\ln(Q) = 0.72 \ln(A) + \ln 95.03$$

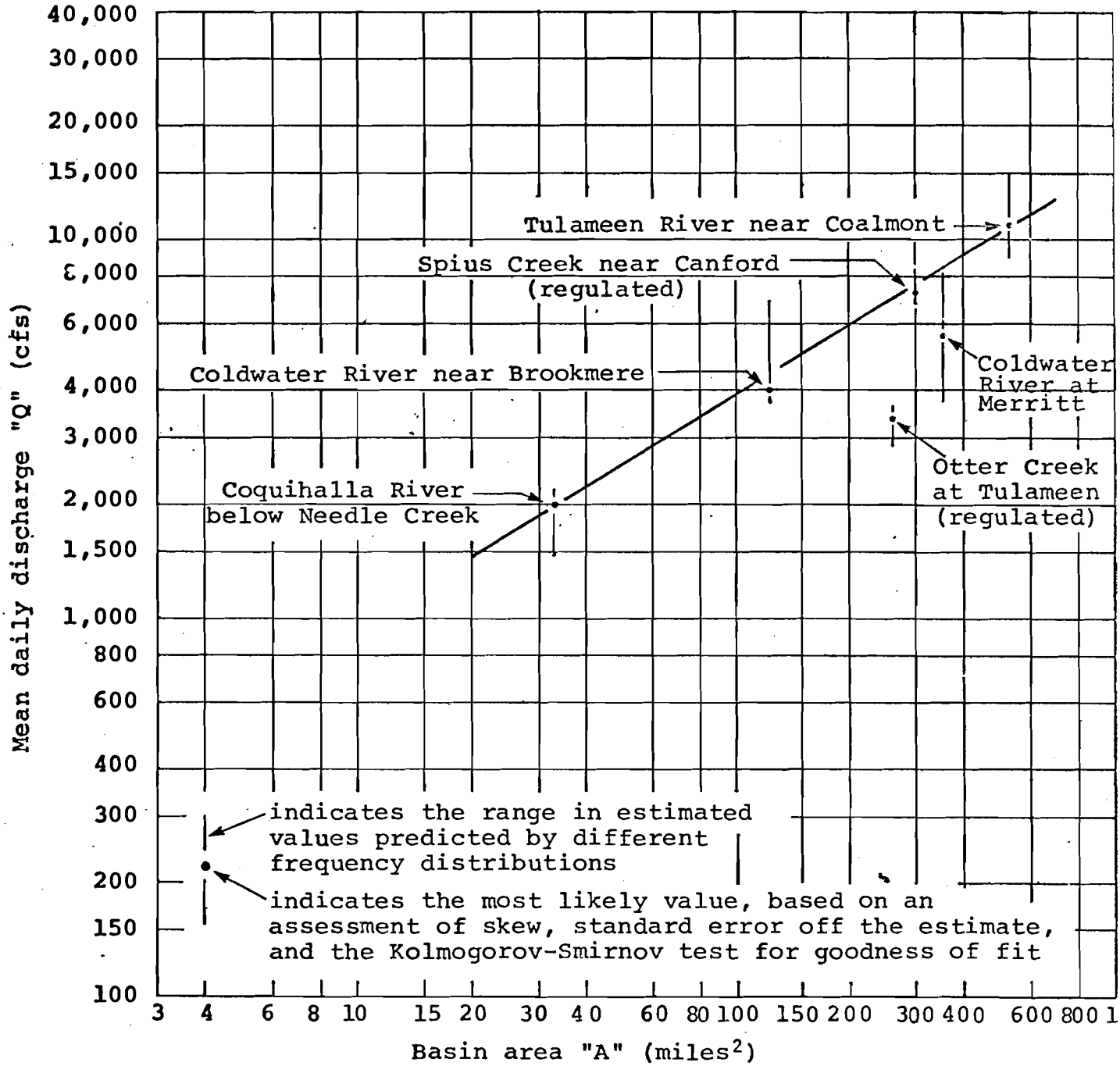
Figure 2.3.8 Predicted ten year recurrence interval discharge plotted against basin area.



Note: The plotted line has the equation:

$$\ln (Q) = 0.64 \ln (A) + \ln 186.33$$

Figure 2.3.9 Predicted 50 year recurrence interval discharge plotted against basin area.

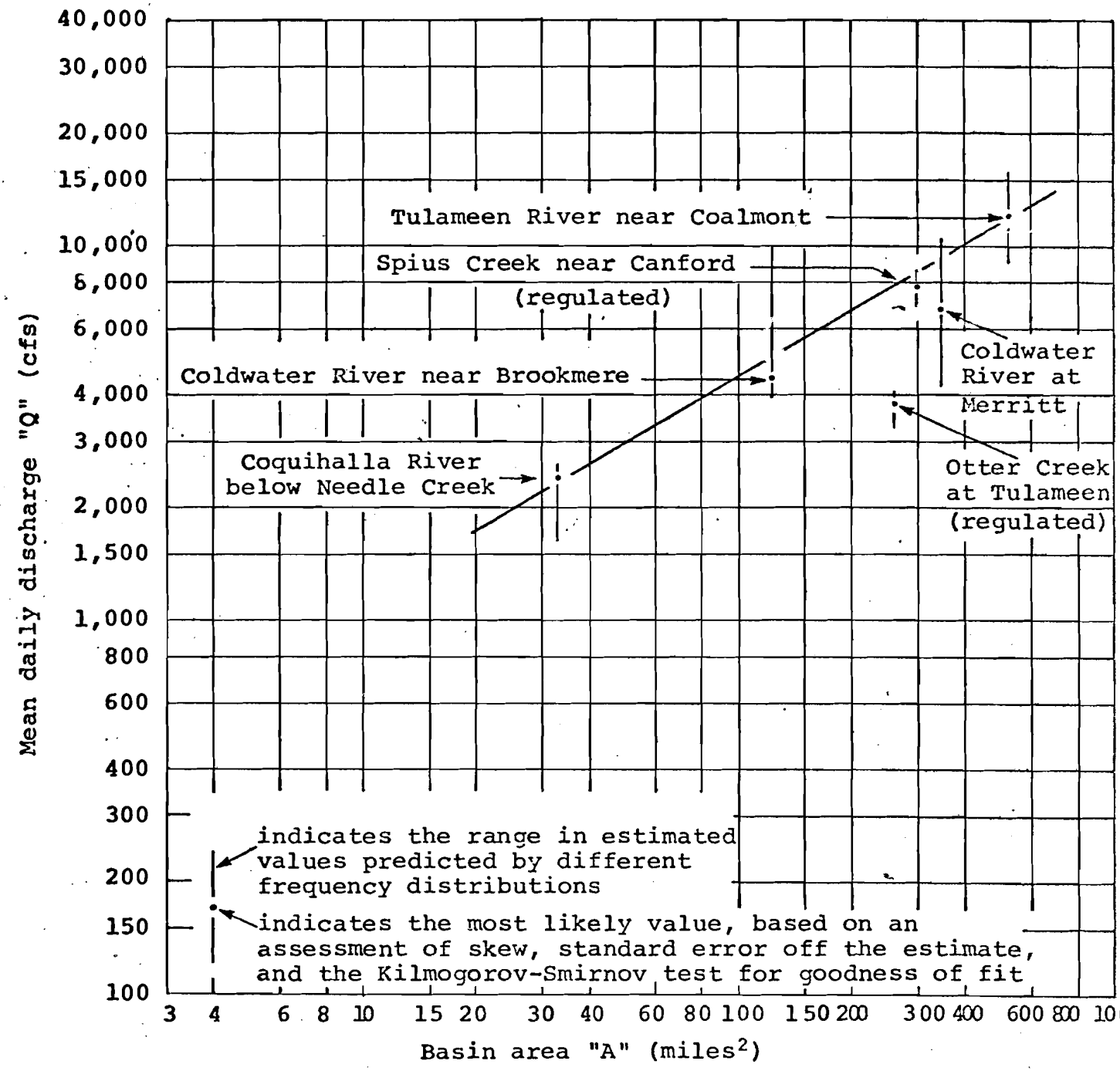


Note: The plotted line has the equation:

$$\ln (Q) = 0.61 \ln (A) + \ln 228.93$$

Figure 2.3.10

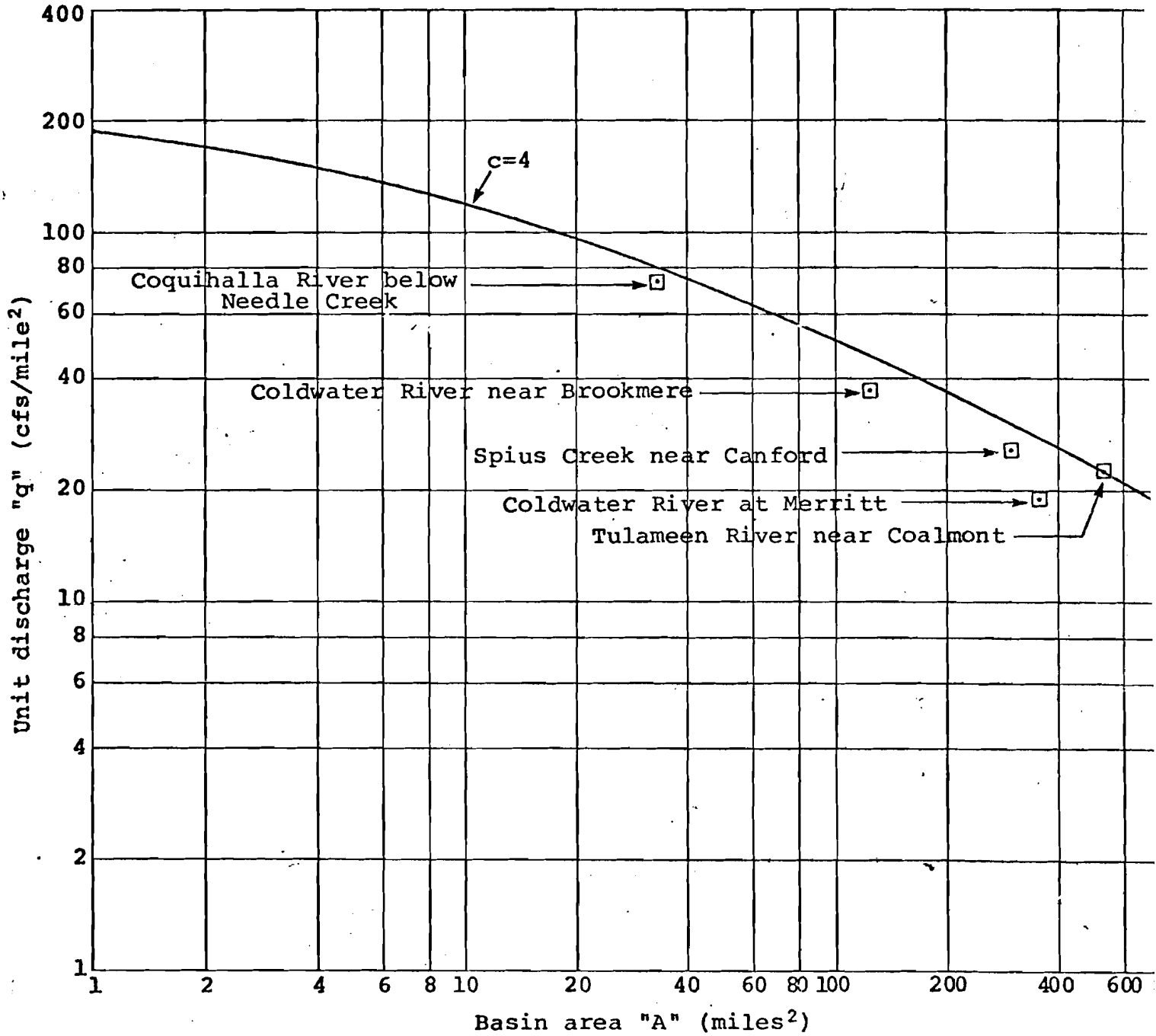
Predicted 100 year recurrence interval discharge plotted against basin area.



Note: The plotted line has the equation:

$$\ln (Q) = 0.58 \ln (A) + \ln 302.47$$

Figure 2.3.11 Predicted 200 year recurrence interval discharge plotted against basin area.

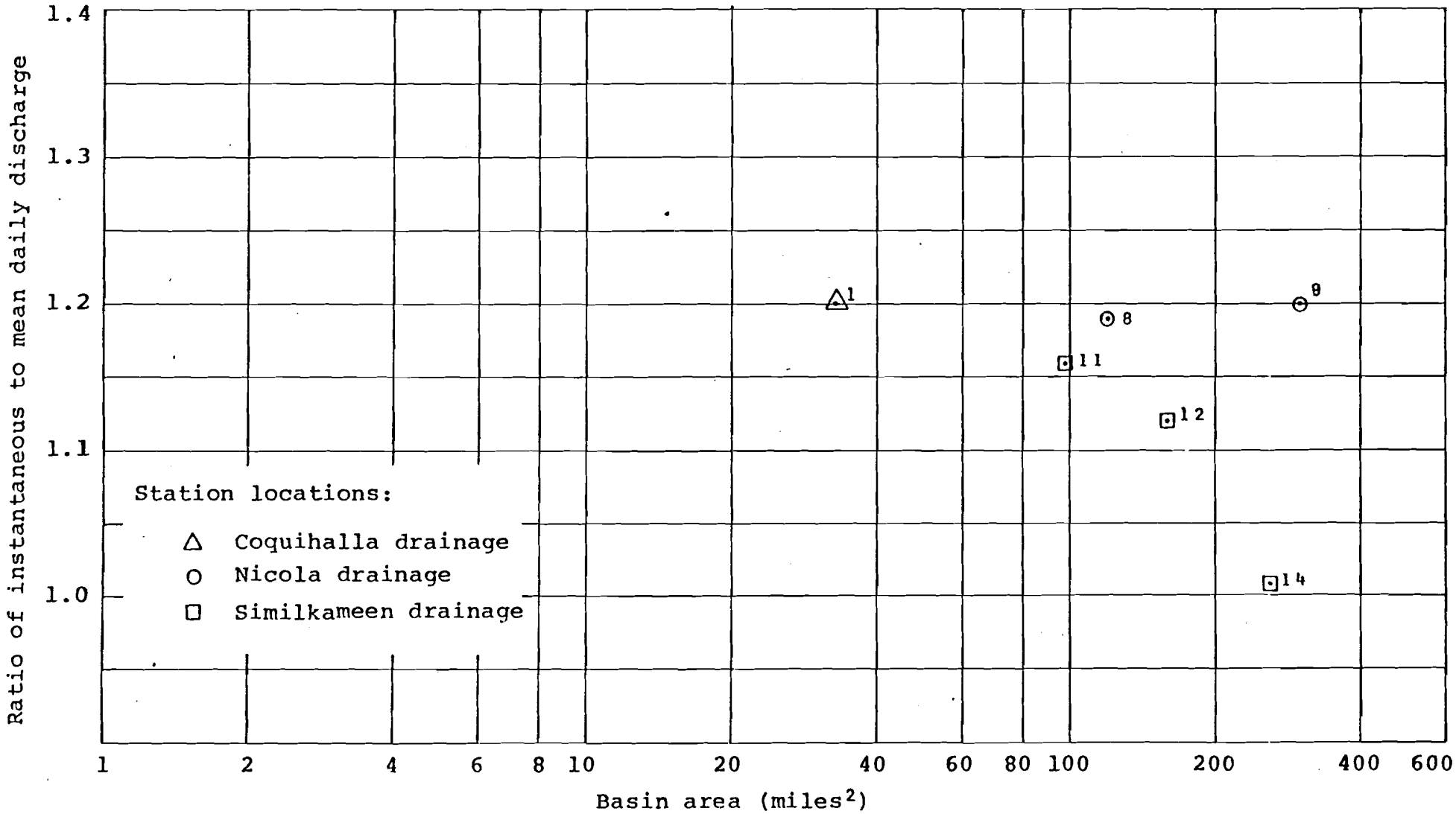


Note: Envelope curve is from Creager's Equation:

$$q = 46\ CA^{(0.894A^{-0.048})-1}$$

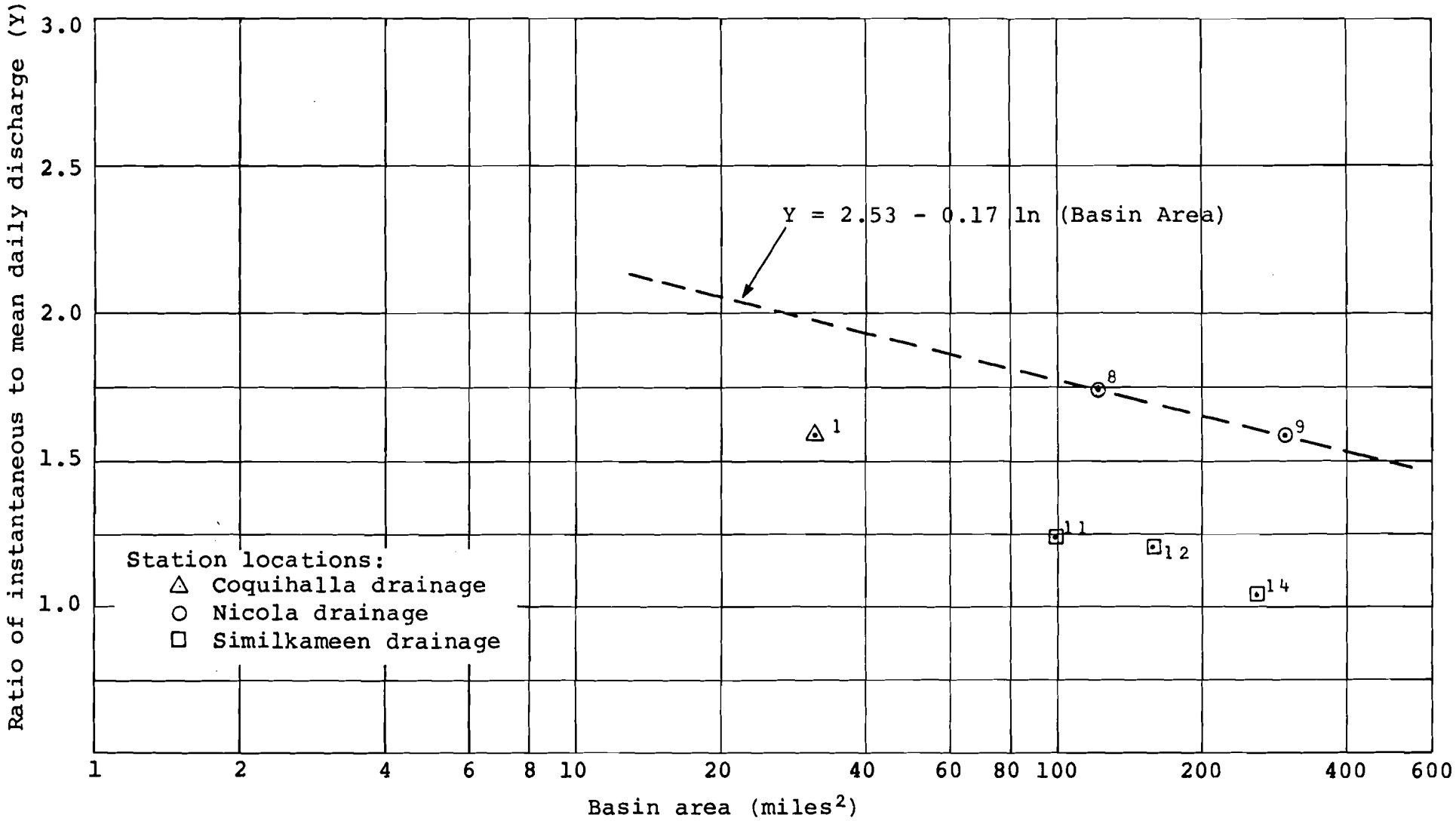
Fig 2.3.12

Predicted 200 year recurrence interval unit discharges plotted against basin area.



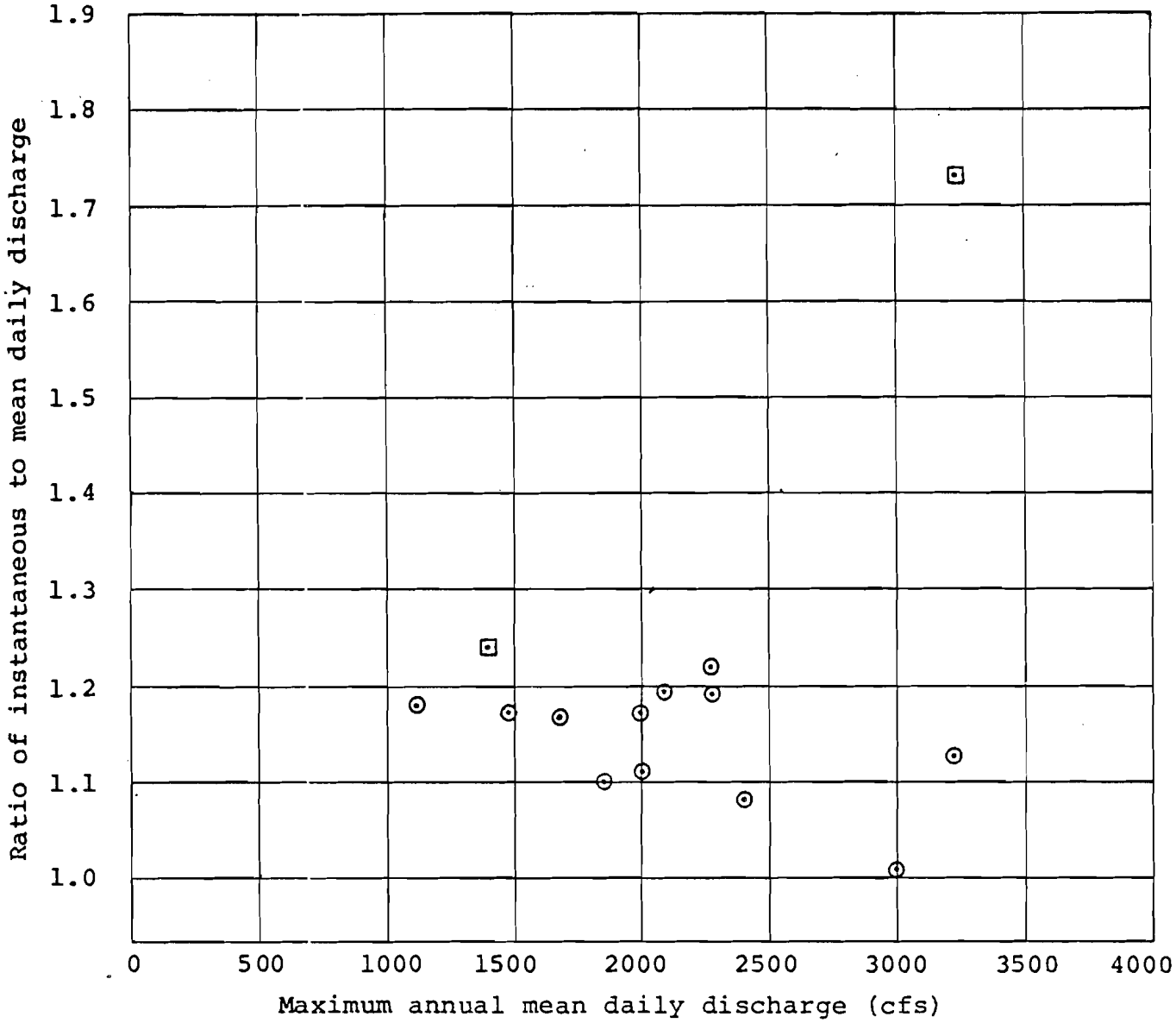
Note: Reference numbers refer to Table 2.3.1.

Figure 2.3.13: Average ratio of instantaneous to mean daily discharge plotted against basin area.



Note: Reference numbers refer to Table 2.3.1.

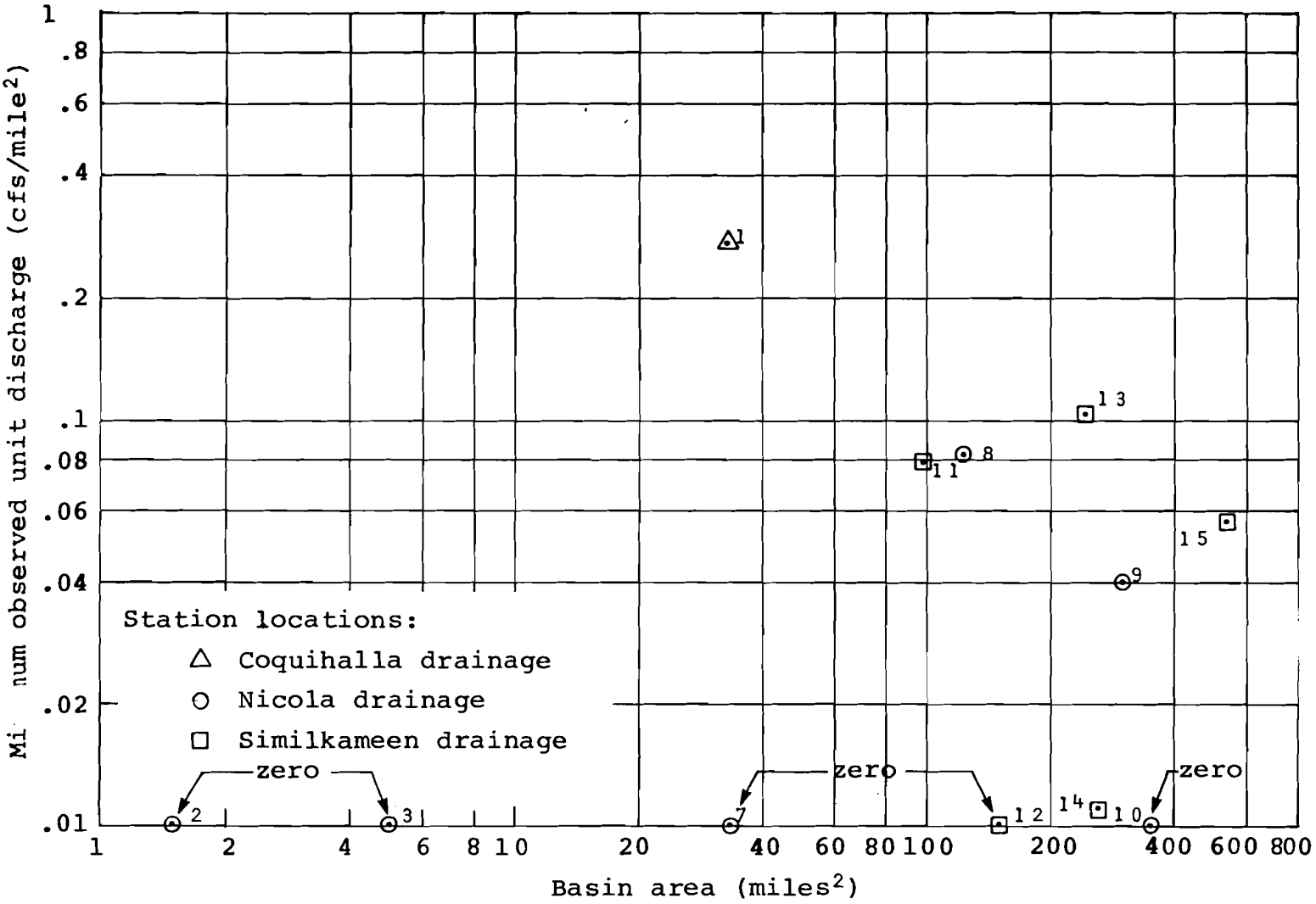
Figure 2.3.14 Maximum observed ratio of instantaneous to mean daily discharge plotted against basin area.



Note: O represents a discharge occurring in May and June

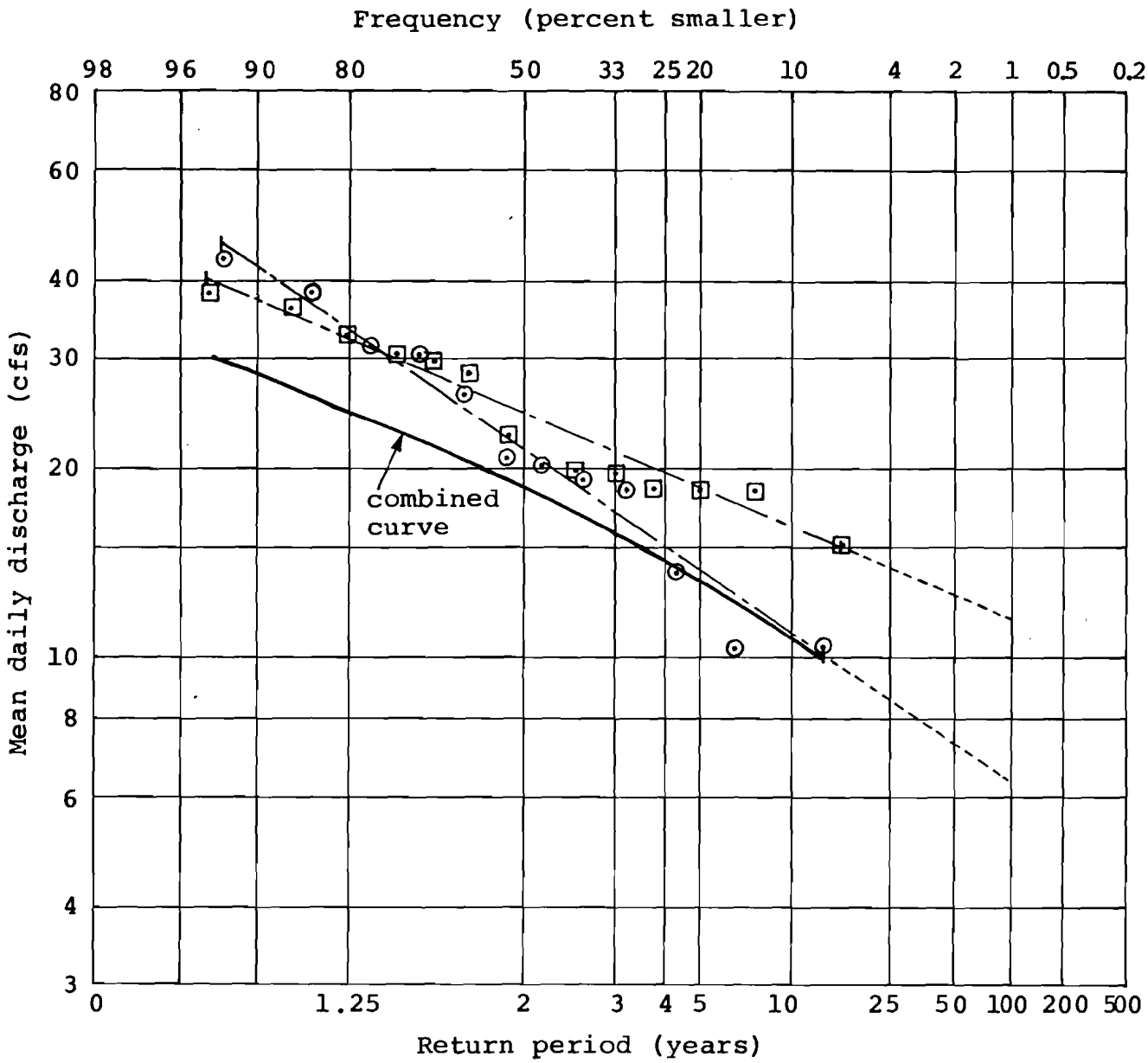
□ represents a discharge occurring in December

Figure 2.3.15: Observed ratios of instantaneous to mean daily discharge for the Coldwater River, near Brookmere.



Note: Reference numbers refer to Table 2.3.1.

Figure 2.3.16: Minimum observed daily discharge plotted against basin area.

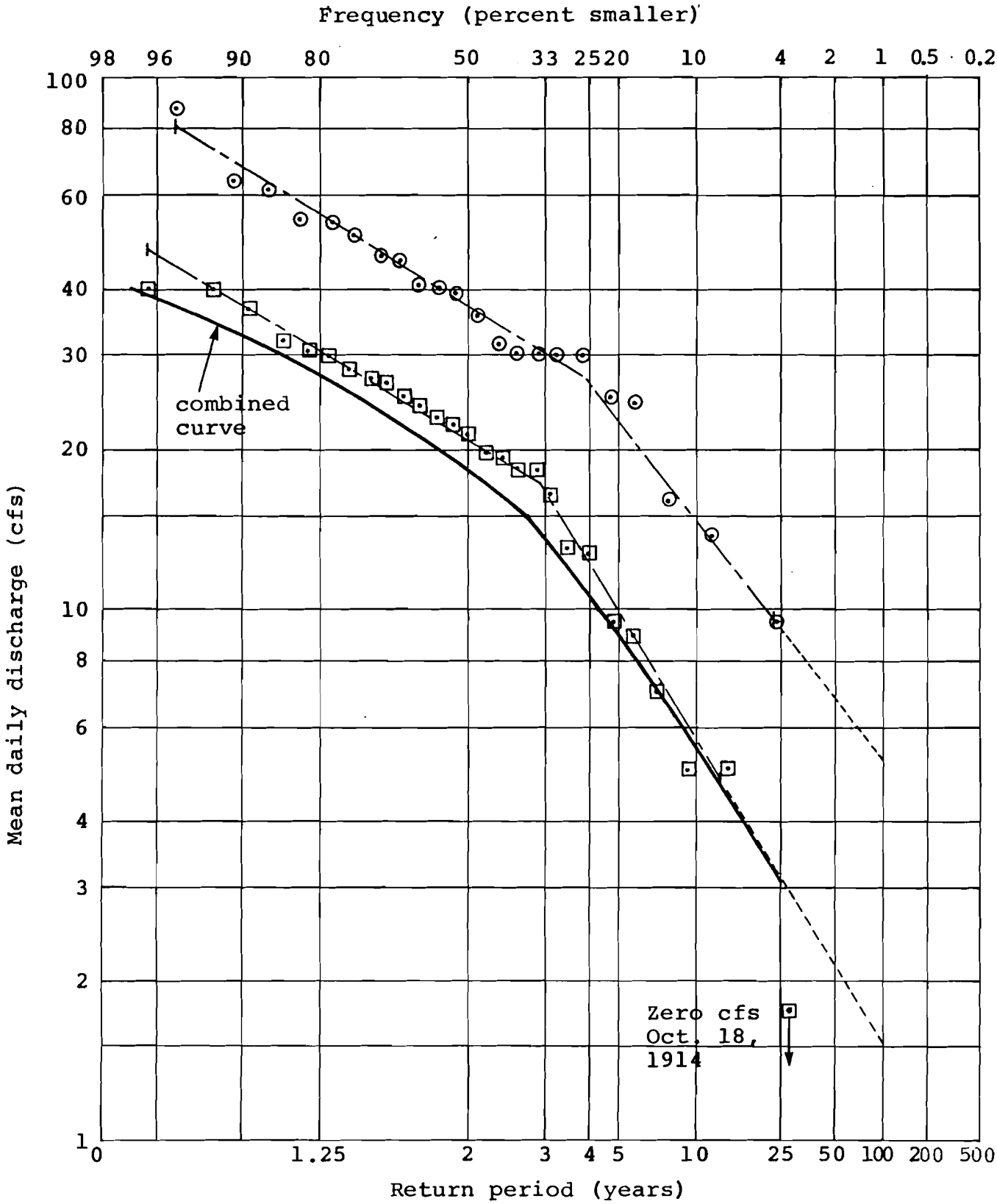


Note: Frequency analyses are based on:

○ minimum discharge between December and May

□ minimum discharge between June and November

Figure [illegible]: Frequency analyses of minimum flows on Coldwater River, near Brookmere.



Note: Frequency analyses are based on:

○ minimum discharge between December and May

□ minimum discharge between June and November

Figure 2.3.18 Frequency analyses of minimum flows on Coldwater River, at Merritt.

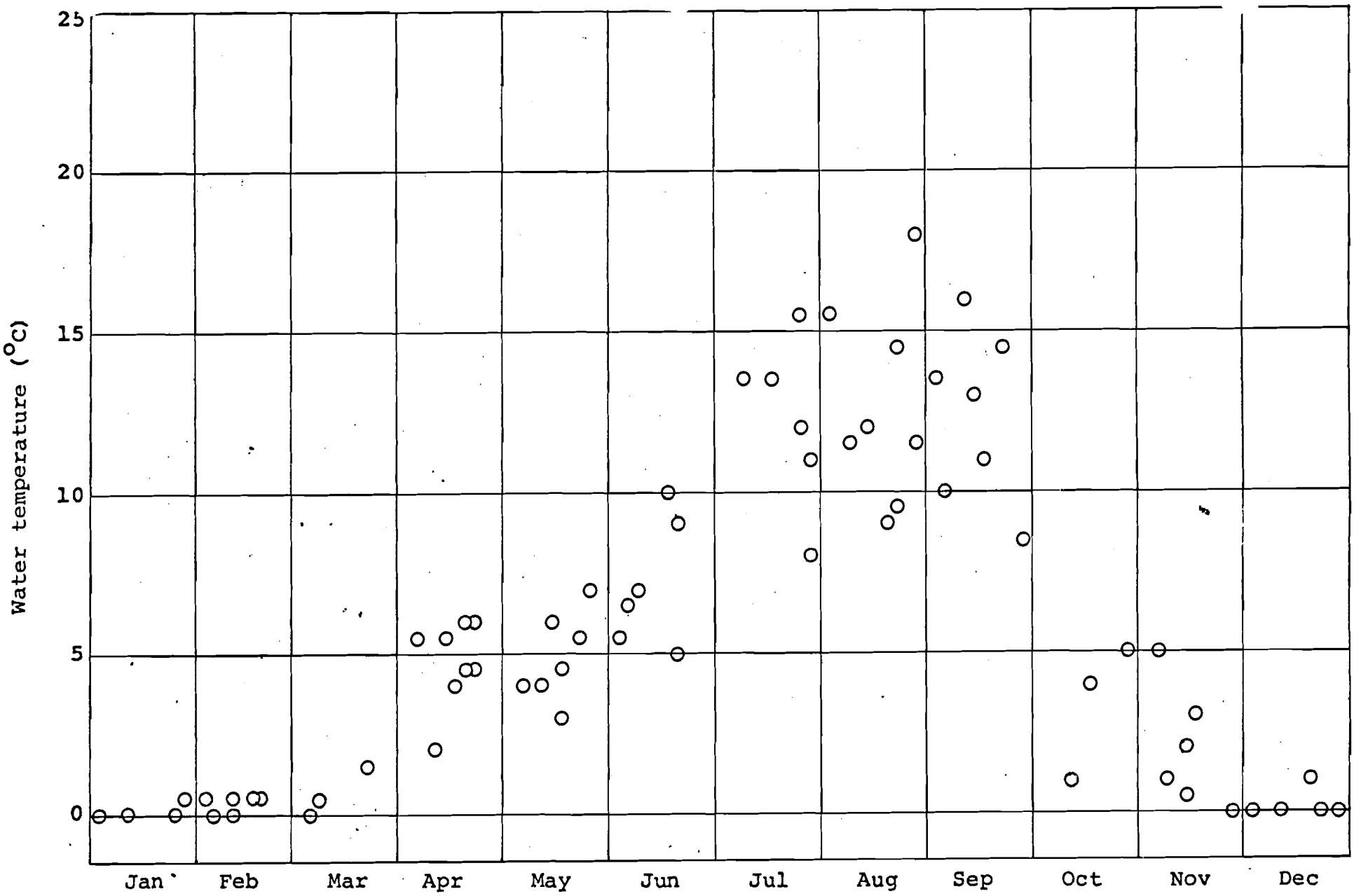


Figure 2.3.19: Water temperatures, Coldwater River near Brookmere.

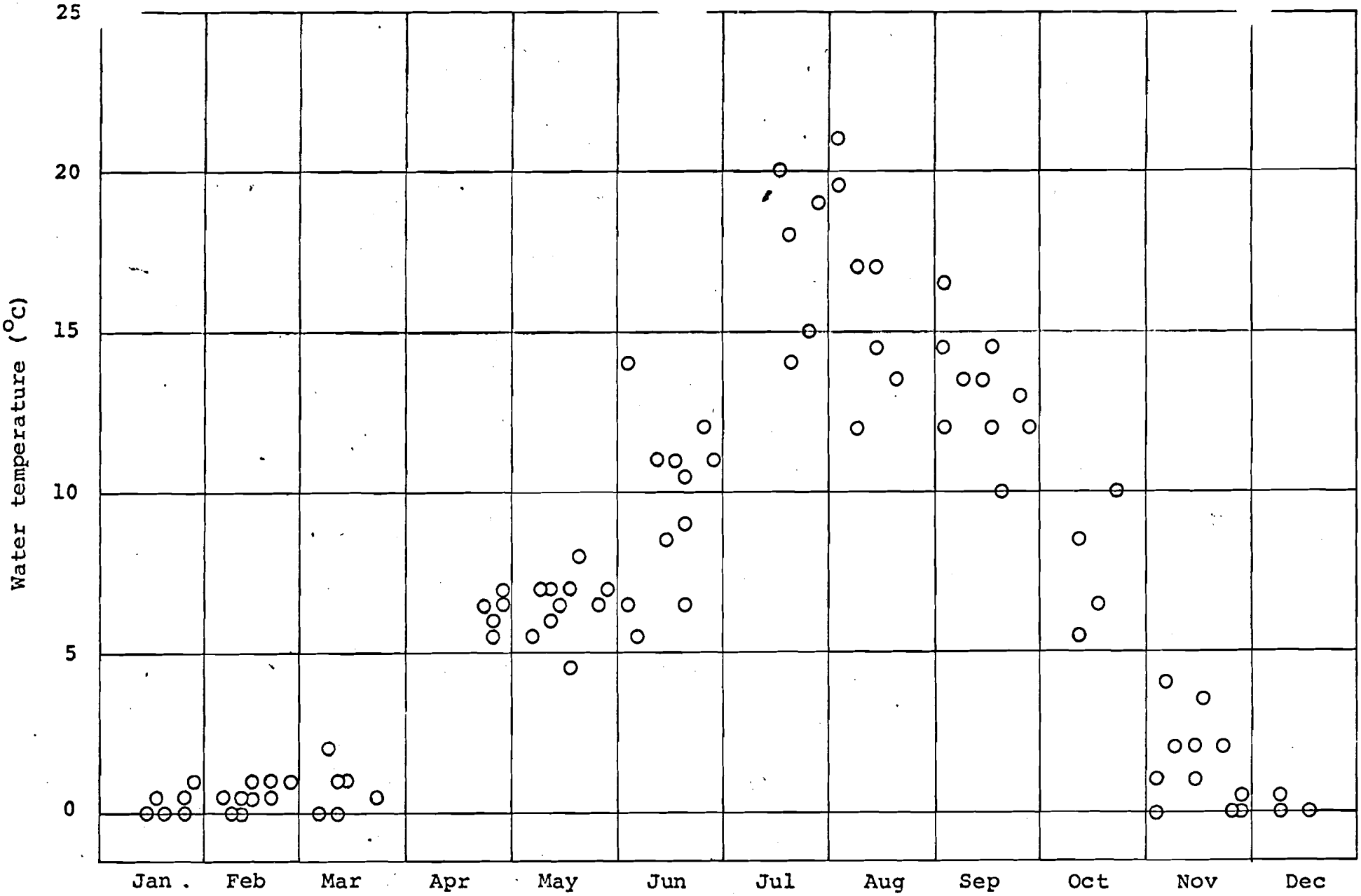


Fig 2.3.20 Water temperatures, Coldwater River at Merritt.

Boundary	Intake Reference	Water Source	Licence #	Licencee	Use	Amount	
6061	A	Nilsson Cr.	5717 F	F.D. & L.A. Miller	domestic	500	GD[1]
					irrigation	73.5	AF[2]
	A[A]	Coldwater R.	20032 F	Trans Mountain Pipeline	domestic	1,000	GD
	B[B]	Nilsson Cr.	11780 F	Balco Industries Ltd.	irrigation	150	AF
	E[E]	Coldwater R.	15575 F	J.M. Anderson	irrigation	20	AF
	J[J]	Coldwater R.	53595 C	C.R. & J. McLeod	irrigation	0.350	AF
			53596 C	D. Harrison	irrigation	0.400	AF
			53597 C	J.M. Anderson	irrigation	19.250	AF
	M	Nilsson Cr.	As per Intake Reference A.				
	M[M]	Kingsvale Cr.	53598 C	J.M. Anderson	irrigation	37.5	AF
	N	Nilsson Cr.	As per Intake Reference A.				
	N[N]	Voght Cr.	29788 C	I.E. Busby	domestic	1,000	GD
					irrigation	15	AF
	Q	Coldwater R.	9269 F	C.A. Beatton	irrigation	22	AF
	S[S]	Coldwater R.	53597 C	J.M. Anderson	irrigation	19.250	AF
	T[T]	Coldwater R.	53596 C	D. Harrison	irrigation	0.400	AF
	U[U]	Coldwater R.	53595 C	C.R. & J. McLeod	irrigation	0.350	AF
	V[V]	Voght Cr.	366048 A	W.H. Grayson F.H. Harwood K. Moyes	domestic	8,500	GD
	W[W]	Unnamed (Devil's) Cr.	367132 A	J.M. Anderson	irrigation	100	AF

[1]GD - gallons/day
[2]AF - acre-feet

Re: Licence #'s: F indicates a finalized licence.
C indicates a conditional licence.
A indicates an application only.

Water licence data in the vicinity of Kingsvale.

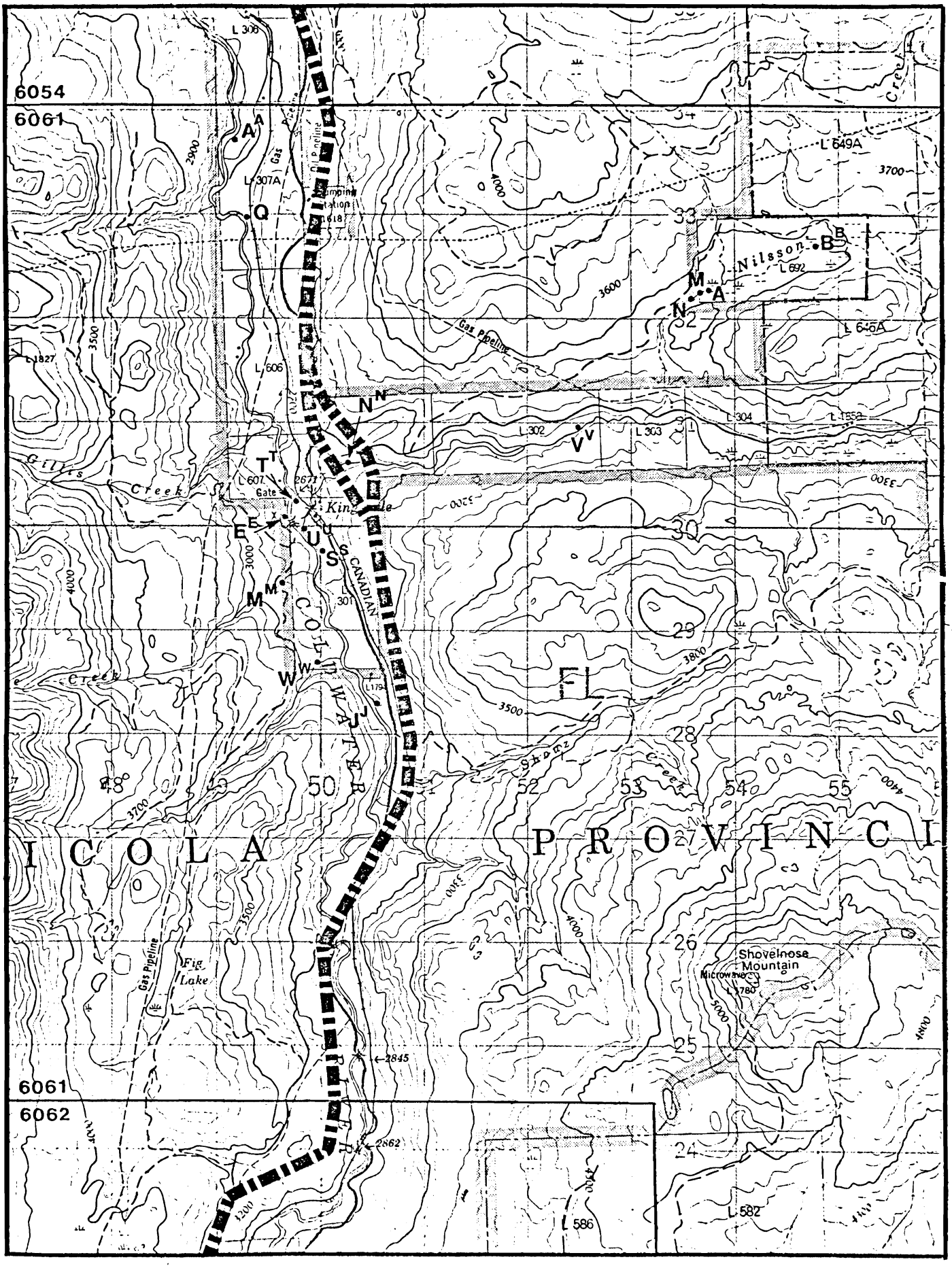

6054
6061
6062
L 300
L 307A
L 649A
L 692
L 606
L 607
L 302
L 303
L 304
L 552
L 301
L 179
L 586
L 582
L 780
L 1827
Nilsson
Gas Pipeline
Oil Pipeline
Pumping Station
Gate
Kingvale
Gillis Creek
Shovelnose Mountain
Microwave
Fig Lake
CANADIAN
COLDWATER
ICOLA PROVINCI
2845
2862
2671
3900
3700
3600
3500
3300
3200
3000
2900
2700
4000
4400
5000
3800
1200

Figure 7.3.21

Boundary	Intake Reference	Water Source	Licence #	Licencee	Use	Amount	
6053	A, B, W, X	Coldwater R.	11230 F	Indian Affairs	irrigation	205	AF[1]
6054	E	Coldwater R.	11229 F	Indian Affairs	irrigation	10.0	AF
	E	Coldwater R.	47351 F	H.S. Strande	irrigation	50.4	AF
	E[E], F[F]	Coldwater R.	33227 F	A.E. & R.M. Powell	domestic	500	GD[2]
				E.D. & D.M. Mackie	irrigation	120	AF
	G[G]	Coldwater R.	50392 F	D. & A. Belcham	irrigation	115	AF
	G[G]	Coldwater R.	50393 F	W.C. Strande	irrigation	45	AF
	Q[Q]	Coldwater R.	As per Intake Refence G[G] (50392 F).				

[1]AF - acre-feet
[2]GD - gallons/day

Re: Licence #'s: F indicates a finalized licence.
C indicates a conditional licence.
A indicates an application only.

Water licence data in the vicinity of Midday Creek.

Boundary	Intake Reference	Water Source	Licence #	Licencee	Use	Amount	
6052 B	D[3]	Coldwater R.	14629 F	Collett Ranch Ltd.	irrigation	335	AF[1]
6052 C	U	Coldwater R.	25311 F	Town of Merritt	waterworks	1,000,000	GD[2]
			26589 F	Town of Merritt	waterworks	15,000	GD
			30750 F	Town of Merritt	waterworks	463,100	GD
			30751 F	Town of Merritt	waterworks	463,100	GD
6053	C	Coldwater R.	11230 F	Indian Affairs	irrigation	205	AF
	Q[Q]	Coldwater R.	32353 F	G.E. & B.L. Ewalt	irrigation	400	AF

Re: Licence #'s: F indicates a finalized licence.
C indicates a conditional licence.
A indicates an application only.

[1] AF - acre-feet
[2] GD - gallons/day

Water licence data for the region immediately south of Merritt.

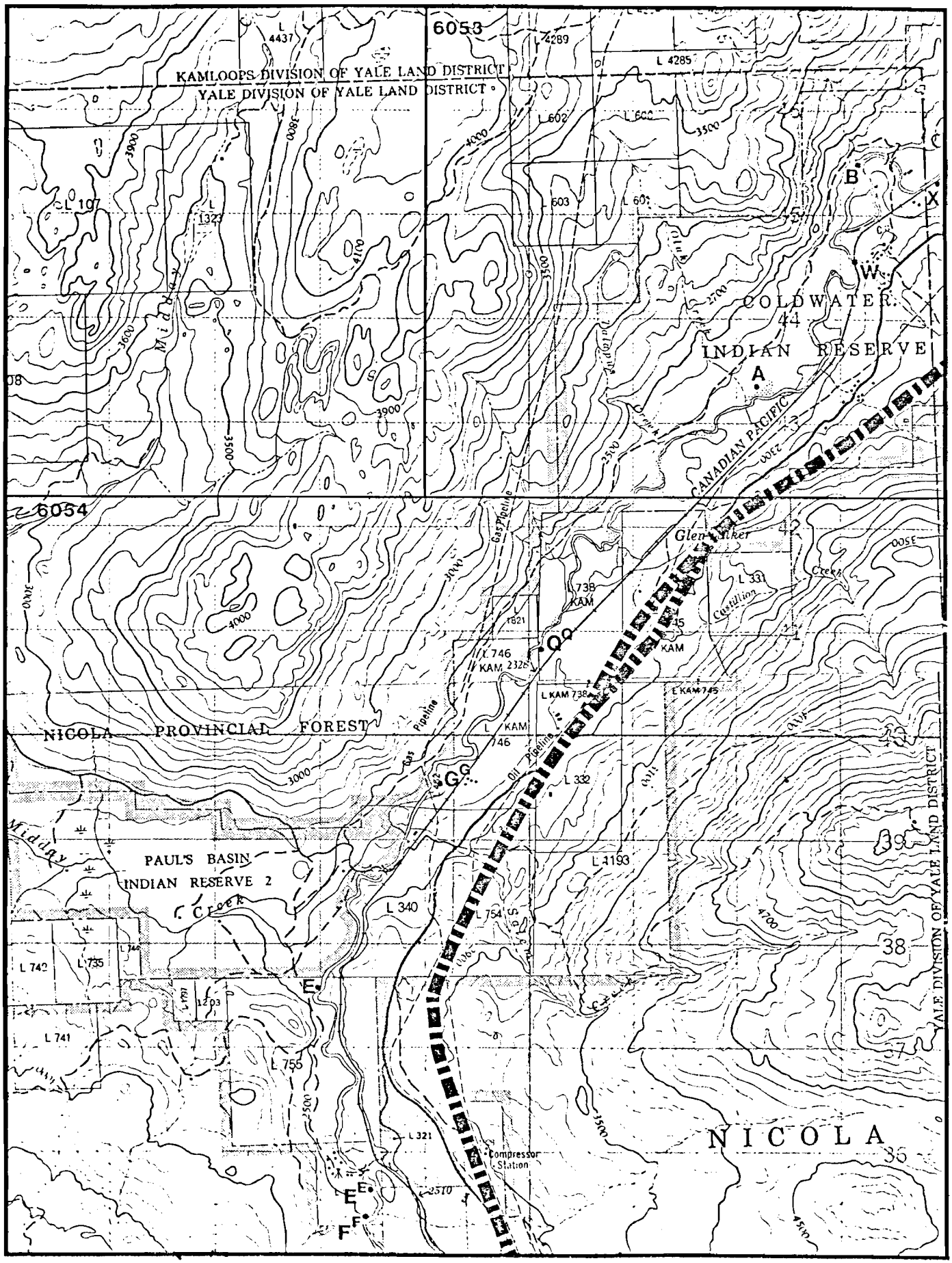

6053
6054
KAMLOOPS DIVISION OF YALE LAND DISTRICT
YALE DIVISION OF YALE LAND DISTRICT
COLDWATER
INDIAN RESERVE
CANADIAN PACIFIC
Glen Tinker
Creek
Castillon
NICOLA PROVINCIAL FOREST
Gas Pipeline
Oil Pipeline
PAUL'S BASIN
INDIAN RESERVE 2
Creek
Midday
Compressor Station
NICOLA
YALE DIVISION OF YALE LAND DISTRICT
L 4437
L 4289
L 4285
L 602
L 603
L 107
L 1323
L 738 KAM
L 331
L 746 KAM 2326
L KAM 738
L KAM 745
L KAM 746
L 332
L 4193
L 340
L 754
L 742
L 735
L 741
L 755
L 321
44
42
39
38
37
36
A
B
W
X
E
F
G
Q

Fig 23-22

Boundary	Intake Reference	Water Source	Licence #	Licencee	Use	Amount	
6052 B	D[3]	Coldwater R.	14629 F	Collett Ranch Ltd.	irrigation	335	AF[1]
6052 C	U	Coldwater R.	25311 F	Town of Merritt	waterworks	1,000,000	GD[2]
			26589 F	Town of Merritt	waterworks	15,000	GD
			30750 F	Town of Merritt	waterworks	463,100	GD
			30751 F	Town of Merritt	waterworks	463,100	GD
6053	C	Coldwater R.	11230 F	Indian Affairs	irrigation	205	AF
	Q[Q]	Coldwater R.	32353 F	G.E. & B.L. Ewalt	irrigation	400	AF

[1] AF - acre-feet
[2] GD - gallons/day

Water licence data

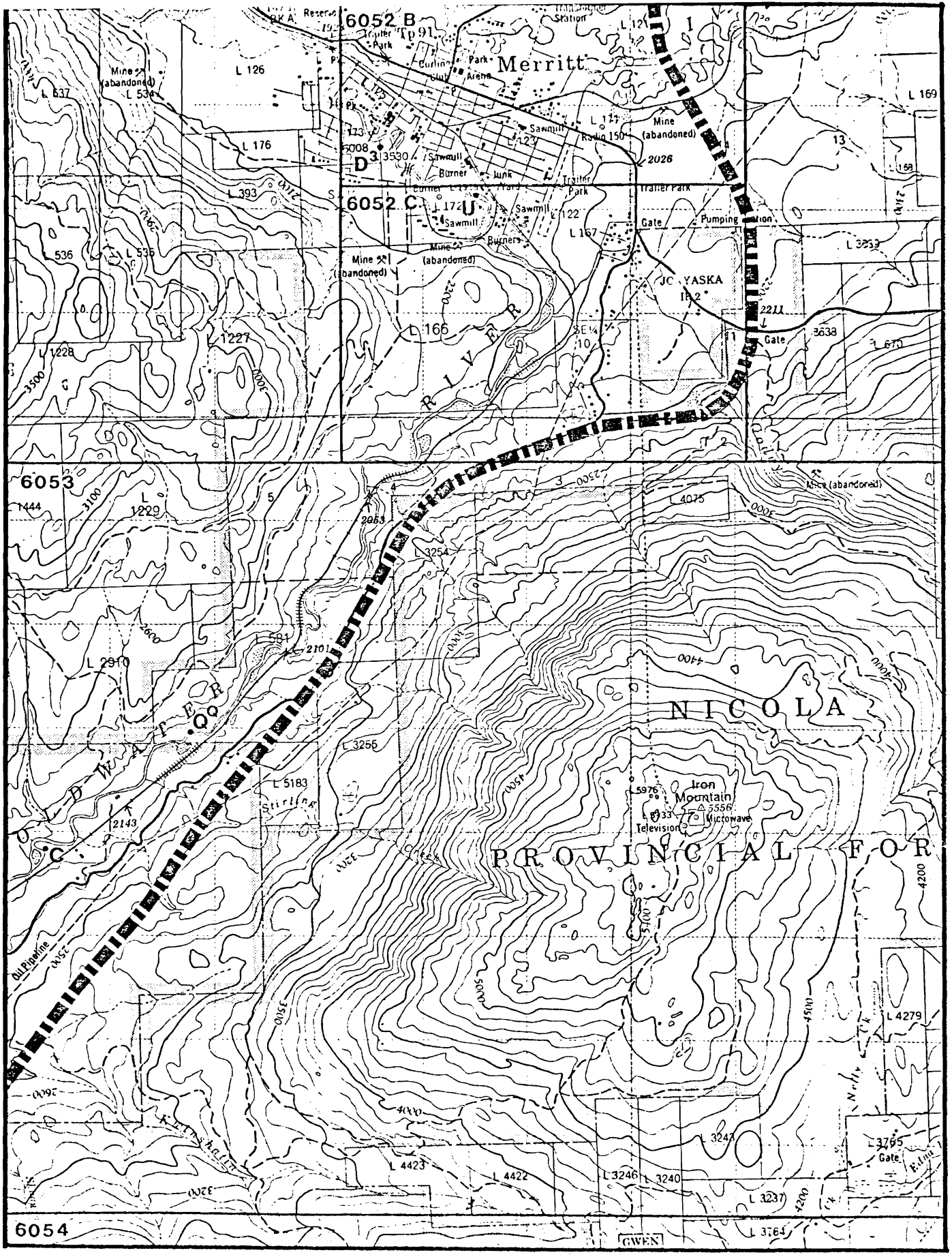

6052 B
Merritt
Trailer Park
Curling Club
Park
Arena
Sawmill
Burner
Junk Yard
Trailer Park
Mine (abandoned)
Gate
Pumping Station
JOCKASKA
6052 C
6053
6054
NICOLA
PROVINCIAL FOR
Iron Mountain
Microwave
Television
Stirling
Old Pipeline
GWEN

Fig 2.3.23

2.4 Fluvial Processes

2.4.1 The Fluvial Setting

Coldwater River can be described as a degrading, gravel to cobble bedded, irregularly meandering channel. The river is laterally mobile, with meander progression and occasional cut-offs resulting in the formation of a moderately wide valley flat. Lowlying areas of wetland occur commonly, and are generally formed by abandoned river channels or groundwater ponded behind beaver dams and other obstructions.

The river is occasionally confined by either the valley walls or terraces of varying height. The valley walls are primarily formed of till overlying bedrock and are thus resistent to erosion. In these areas, rates of channel migration may be comparatively slow and large scour holes frequently develop. The relic outwash and lacustrine terraces are also relatively resistent, except during major floods when fluvial undercutting can result in significant quantities of sediment production. The valley flat and associated low terraces are less resistent to erosion and undercut banks and partially eroded vegetation are commonly found along the outside edges of meander bends.

Numerous small tributaries drain into the Coldwater River valley, and the associated fans frequently displace the main

channel to the opposing valley wall. Of the four major tributaries in the region between the upper bridge crossing near Coquihalla Lakes and Kingsvale, three are of particular relevance to the proposed Highway. Loss or Mine Creek, Juliet Creek and Bottletop Creek are all partly incised within their fans, but still remain laterally unstable. Juliet Creek has an upstream basin area of 34.5 miles^2 and thus is slightly larger in size than the main stem of Coldwater River at this point. The remaining stream, Brook Creek (near Brookmere), is partially regulated by an upstream lake and poses no concerns for this project as the highway alignment is located on the opposing valley wall.

An inventory of valley flat characteristics along the relevant sections of Coldwater River is presented in Figure 2.4.1. The mapping indicates areas of active channel, fans, wetland, and regions appearing to be subject to flooding at varying frequencies. The exposed bedrock outcrops within the valley flat and existing revetments are also indicated. The criteria upon which flooding evaluations were made are shown on in Table 2.3.1, the valley flat mapping legend.

One of the items which should be noted on this mapping is the existing distribution of training works. Rough calculations indicate that 3.5 miles of revetments have been placed between the upper existing bridge crossing near Coquihalla Lakes and Brodie. The total thalweg length in this reach is 12.7 miles. In the region between the existing bridge near Kingsvale and the ~~proposed final~~ existing encroachment (Station 1+400 / 3+75m opposite) approximately

1.1 miles of training works have already been installed. The total thalweg length in this reach is approximately 2.3 miles. Thus bridge sites and encroachments associated with the original CPR railway alignment, the Trans-Mountain Oil Pipeline and the Westcoast Transmission Gas Pipeline have already resulted in a significant restriction of the lateral mobility of Coldwater River.

2.4.2 Channel Geomoetry

In order to define the channel geometry of Coldwater River, 21 cross-sections were surveyed for the present study by the Ministry of Transportation and Highways. Twelve sites and associated long profiles were established at the proposed diversion site between Stations 2155 to 2176 feet (657-663 m). Five sections were surveyed in the region of the Brodie Diversion at Stations 2600-2620 feet (792-799 m) and six sections were established in the vicinity of the Kingsvale Diversion at Stations 2914 to 2922 feet (888-891 m). Cross-section locations are indicated on Figure 2.4.1.

The hydraulic properties of the surveyed cross-sections are summarized in Tables 2.4.2 to 2.4.4.[1] These data show the channel geometry based on the water level at the date of survey, on the basis of the elevation of lowest rooted vegetation and the ~~two~~ lowest channel bank. In order to compute discharge, the roughness factor n in Manning's formula has been estimated from the Strickler formula:

$$n = 0.0395\ D_{50}^{1/6}$$

with D_{50} based on the grid samples discussed in Section 2.4.3. Slope estimates were based on averages between the upstream

---

[1]The original survey results have been filed with the Design and Surveys Branch of the Ministry of Transportation and Highways in Victoria.

and downstream water surface elevations at the date of survey, and on highwater surface slopes estimates based on the elevation of rooted vegetation.

2.4.3 Bed and Bank Materials

In the reach between the upper bridge crossing near Coquihalla Lakes and Kingsvale, Coldwater River is primarily gravel to cobble bedded. Sand sized materials are generally limited to small deposits in sheltered locations, such as along the inside of meander bends, adjacent to small side channels, or in the lee of boulders, log jams and islands. Log deposits of large boulders occur infrequently, and primarily result from the reworking of outwash materials. These large boulders are frequently associated with major scour holes.

In order to quantify bed material sizes, nine samples were collected from the region of the three proposed diversion channels. Samples were collected by stretching a survey tape across a typical exposed area of river bed or bar as shown in Plate 2.4.1. The intermediate axis of 50 stones located directly beneath a regularly spaced interval was then measured and constitutes the sample. The method is described in detail in Kellerhals and Bray, 1971. The resulting grain size distribution is equivalent to a seive curve. The nine size distributions are plotted on Figure 2.4.2 and the main results are tabulated in Table 2.4.5. The textures of the sampled materials are relatively similar and no significant change was observed between the diversion sites. The average textural composition shown by these data therefore represents the size of material required in order to prevent the river from degrading.

Like all degrading gravel bed rivers, almost the entire river bed is armoured in the sense that the exposed surface layer is deficient in fines with respect to the material immediately below that layer. The above grid samples characterize only the surface armour and the underlying sediments will be finer in size. Volumetric samples encompassing many cubic yards of material would be required to accurately sample the underlying sediments and this level of effort is not warranted in the present study.

The composition of the river banks vary with the origin of the material. Where the river impinges on the valley wall, bedrock, lacustrine, glacial and glacio-fluvial sediments may be exposed. Adjacent to major tributaries, exposures in fluvial fan materials range in texture from silt and clay to sands and gravels. At sites where the river impinges on fluvial terrace materials, the sedimentary sequence is generally composed of up to 1 m of sands or gravelly sands overlying gravels or gravelly cobbles and boulders. Low lying terraces and the active flood plain are formed by a similar sedimentary structure except that the sandy fluvial veneer is usually better developed, as shown on Plate 2.4.2.

Sub-bed materials were not sampled, but can generally be expected to be composed of sandy gravels and gravelly cobbles and boulders. However, as discussed in the Geology Section, fine textured glacial or glacio-lacustrine sediments may occur

beneath the present river bed. The depth to bedrock is generally not known. However in the vicinity of the bedrock outcrops indicated on Figure 2.4.1, bedrock may be found at or immediately below the river bed. In ~~some~~ isolated locations.

2.4.4 Channel Stability

On a geological time scale, Coldwater River is lowering its bed and widening its valley and thus the river is both vertically and laterally unstable.

The long term trend of channel degradation will likely only be noticeable on a time scale of centuries. However, significant short term variations in bed elevation can be expected as a result of the shifting of gravel bars, the passage of a particularly heavy slug of sediment, the formation and destruction of debris jams or due to channel migration and cut-offs. Such processes can be expected to result in changes in water level for a specific discharge of up to 3 or 4 meters.

Lateral stability is a much more noticeable process. In the undisturbed state, Coldwater River could be expected to freely migrate from valley wall to valley wall. Existing revetments have, however, curtailed this process, and the proposed highway alignment will add additional restrictions. In order to document potential rates of erosion, the net channel displacement between May 5, 1978 and January 13, 1981 ~~have~~ has been determined on the basis of aerial photography for a number of sites relevant to the proposed alignment. The results are tabulated in Appendix III, with the measurement site locations being indicated in Figure 2.4.1.

Annual maximum mean daily discharges measured at Coldwater River near Brookmere were 1970 cfs in 1978, 1395 cfs in 1979 and 3238 cfs[1] in 1980. The 1980 flow was associated with an instantaneous discharge of 5332 cfs.[1] On the basis of the flood frequency analyses presented in Section 2.3.2, the 1980 mean daily flow has a recurrence interval of approximately 20 to 25 years. Observations prior to the December 27 flood event, and subsequent field and photogrammetric investigations, indicate most or all of the channel displacements tabulated in Appendix III are related to the peak discharge of December 27, 1980. It is interesting to note that there was a noticeable increase in channel instability downstream of Juliet Creek indicating this drainage area produced significant quantities of runoff. what about bed material?

Areas of river channel located adjacent to wetland areas or lowlying areas subject to frequently flooding (units W and 2 on the valley flat mapping shown in Figure 2.4.1) were observed to be highly mobile, with complete channel relocations of up to 50 m being recorded. Channel relocations or avulsions appeared to be particularly prevalent in areas of debris jams or beaver dams and in the vicinity of poor quality rip-rap designed to keep the river out of a former channel.

Channel instability in higher elevation areas of the

---

[1]Preliminary estimates.

valley flat (units 2 + 3, 2/3, 3/2 and 3) was also widespread, with meander progression of up to 20 m being common. Channel displacements adjacent to low terraces (units 3/4, 4/3 and 4) were much smaller, with values of less than 2 to 3 meters being representative.

Areas of channel protected by rip-rap were also observed to be subject to erosion, though net displacements were generally less than 5 m. May of the presently installed training works are composed of cobble to boulder sized, fluvially derived materials and thus its failure was not unexpected. However relatively high quality shot rock (such as that adjacent to the proposed third Coldwater Bridge at Station 2552 feet/778 m) was also observed to fail, likely due to scour and undercutting of non-keyed in material.

Rates of erosion at sites where the river was confined by either the valley wall or thick deposits of road fill material were generally small, being in the neighbourhood of less than 2 m. Exceptions occurred just north of the first Coldwater Bridge (Station 2095 feet/639 m) and again near the existing bridge at Kingsvale ~~2~~ (station 2877 feet/877 m). At both sites undercutting resulted in the collapse of the road and significant erosion of the associated terrace.

The stability of the fluvial fans tributary to Coldwater River also deserve comment. The apex of Loss or Mine Creek

has obviously been realigned by Westcoast Transmission in the period between 1978 and 1981 and it is likely that without this continuing maintenance the channel would have long since abandoned its present convoluted course. As a result of the December 27 flood, Juliet Creek substantially aggraded in the reach downstream of the proposed bridge crossing, as illustrated on Plate 2.4.3. In the undisturbed state, such aggradation is typically followed by a shift in the lateral position of the channel. Thus both vertical and lateral instability will prove to be a problem in the vicinity of the proposed access ramps.

The small right bank tributary located in the middle of the proposed Brodie diversion (Station 2600 feet/792 m) was not visited after the December 27 storm. However, historically, this creek has produced significant quantities of silt and clay sized materials from a variety of distributary channels. Continuing sediment production can be expected and given the shape of the fan, sediment aggradation will not be localized within any single distributary channel. Most of the other small creeks draining into Coldwater River were observed to produce sufficient quantities of runoff to result in localized flooding, the infilling of culverts, and minor channel realignments.

2.4.5 Sediment Transport

Sediment transport may be in the form of dissolved sediment, suspended sediment or bed load. Specific measurements of these parameters have not been made for Coldwater River, however the water quality data obtained by the provincial Pollution Control Board provides a rough estimate of representative dissolved and suspended sediment transport values. These measurements are based on estimates of filterable and non-filterable residues which approximately correspond to dissolved sediment and suspended sediment, respectively. The major uncertainties in these values are due to the possible presence of organic material which may cause an overestimate of suspended sediment, and to the sampling technique, whereby if the samples were taken in shallow water near the shore, the reported values would underestimate the higher values of suspended sediment which frequently occur in mid-channel.

On the basis of the Pollution Control Board data, the seasonal variation in dissolved sediment concentration on Coldwater River is shown in Figure 2.4.3. Peak values can be seen to occur during the spring freshet in March and April, and again during the fall. Minimum values occur in both mid-winter and mid-summer. The seasonal variation in dissolved sediment transport (based on Water Survey of Canada discharge measurements at Merritt), indicate a similar seasonal variability with maximum rates of transport occurring in the April, May and June period.

The plot of dissolved sediment concentration versus discharge, shown on Figure 2.4.5, indicates a general decrease in concentration occurs with increasing flow. Figure 2.4.6 shows dissolved sediment transport as a function of discharge and indicates a relatively good relationship exists between these variables. The dissolved sediment values observed between September and February are similar to those recorded during equivalent discharges in March through August and thus there is no evidence for a seasonal shift in the rating curve.

The seasonal variation in suspended sediment concentration is shown on Figure 2.4.7. Maximum concentrations again occur during the spring and fall and have been observed to reach values of over 700 mg/l. As discussed in ~~Section~~ Log Report, concentration continually ~~of~~ over 80 mg/l are thought to be harmful to fish and the plotted data indicate that it is not uncommon to exceed this threshold. for short periods. The seasonal variation in suspended sediment transport is shown on Figure 2.4.8, again based on Water Survey of Canada discharge data. Maximum recorded transport rates can be seen to occur in the spring, with minor peaks occurring in the fall. The maximum recorded value corresponds to a transport rate of 4×10^6 kg/day. Figure ~~2x~~ 2.4.9 shows suspended sediment concentration as a function of discharge and indicates that a general increase in concentration occurs with increasing flow. The variability about this trend likely reflects the effects of variations in sediment supply.

Figure 2.4.10 ~~xhax~~ shows the relationship between discharge and suspended sediment transport. These data indicate that there is no significant difference in transport rates for equivalent discharges occurring in the periods of September to February and March to August. This graph allows a rough estimation of the amount of suspended sediment which Coldwater River is able to transport at various discharge levels.

The availability of suspended sediment during periods of high flow was well illustrated by the December 27, 1980 flood on Coldwater River. The maximum daily discharge recorded at Brookmere was over 3,000 cfs which from Figure 2.4.10 roughly corresponds to a transport rate of 5 , 10^6 kg/day. Surveys of flooded areas undertaken after this event indicated that it was not uncommon to find deposits of sand of 1 to 2 feet in depth overlying the pre-existing vegetated surface, as illustrated on Plate .

Measurements of bed load transport are not available for Coldwater River. In order to gain a rough quantitative idea of the approximate size of material mobile under a range of flow conditions, the average cross-section parameters measured in the vicinity of the Brodie diversion, Station 2600-2620 feet (792-799 m) shown on Tables 2.4.2 to 2.4.4, have been used to compute maximum mobile grain sizes on the basis of the shields tractive force criterion.

No bedload transport measurements are available for the Coldwater River but the morphology of the channel offers ample evidence of frequent, extensive bed material movement. In order to gain some idea of the size of material that the river is capable of moving, the channel geometry data for the three surveyed river reaches have been used to estimate bed material sizes that would be just mobile under three flow conditions. The computations are based on the Shields tractive force criterion and a mean flow formula similar to the Manning formula. The exact equations are given in Appendix 5 of the Guide to Bridge Hydraulics (Neill, 1973).

The results are shown in Table 2.4.2. They indicate that even at the lowest flow conditions considered (approximately 50% of two-year flood) bed material sizes become mobile that are well represented in the channel bed (see Figure 2.4.3 and Table 2.4.5), suggesting that the channel bed is frequently mobile.

1st page Section 2.4.5

SYMBOL	TERRAIN UNIT	REPRESENTATIVE TEXTURE	SOILS	VEGETATION	FLOODING FREQUENCY	FISHERIES VALUE
Q	active channel of the main river or tributary	gravels to cobbles	regosols	absent	much or all of this unit will be subject to annual flooding	holding, rearing and spawning habitat
F	fluvial fans	variable-ranging from fines to cobbles	variable-generally regosols	variable-ranging from primary colonizing species to mature secondary colonizing species	not assessed; will depend on the lateral stability of the tributary channel	may provide fisheries habitat; site specific details given in text
W	wetland areas (in which no juvenile salmonids were observed)	variable-ranging from fines to cobbles	regosols gleysols	hygric species	annually	potentially important rearing habitat for juvenile coho and chinook; may also have some holding and spawning areas
(W)	wetland areas (in which juvenile salmonids were observed)	variable-ranging from fines to cobbles	regosols gleysols	hygric species	annually	important rearing habitat for juvenile coho and chinook; may also have some holding and spawning value
~~W~~	wetland areas isolated from the fluvial system	variable-ranging from fines to cobbles	regosols gleysols	hygric species	annually	none
2	low-lying areas of flood plain composed of recent fluvial deposits and abandoned river channels	sands to gravels overlying gravelly cobbles	regosols generally having a fluvially deposited surface litter, F and H horizons thin or absent	primary colonizing species	frequent	potential holding habitat during flood discharges; areas in which channel migration can easily occur and thus form new fisheries habitat
3	low-lying fluvial terraces	medium sand overlying gravelly cobbles	regosols (including cumulic regosols)	mature vegetation including secondary colonizers	rare (portions or all of the unit will be subject to flooding at high stage)	potential future fish habitat due to channel migration
4	high fluvial terraces	medium sands overlying gravelly cobbles	generally regosols but may include brunisols, podsols and luvisols	mature vegetation, consisting of secondary colonizers preferring dryer site conditions	unlikely to be flooded under the present hydrologic and channel conditions	none at the present time; channel migration will eventually erode this unit over a long time period and thus provide future fisheries habitat

Mapping Conventions and Notes

A / indicates a unit is intermediate in character between two defined types. For example a unit coded 2/3 has characteristics of both units 2 and 3, but more closely resembles unit 2; while a unit coded 3/2 more closely resembles unit 3.

A + indicates a composite unit composed of two defined types which are too small in area to be shown separately at the scale of mapping (e.g., 2 + 3)

location of bedrock exposure along riverbank

XXXX location of existing dyke, rip rap or bridge abutment

Mapping of the entire valley flat has been undertaken for the areas of interest. The outside boundary of the valley flat is shown by a heavy line and areas outside of this boundary are not of recent fluvial origin. Flooding frequency, as indicated by field characteristics, is difficult to determine in areas which have been burned, logged, or subject to disturbance due to farming or the construction of roads and pipelines. In these circumstances the flooding potential has been given a conservative bias. Extensive flooding or channel relocation on tributary fans, log jams, landslides, channelization of water along roads or pipeline right of ways and extensive channel migration are all factors which can result in flood waters reaching areas which do not show any signs of recent flooding.

TABLE 2.4.1: Valley flat mapping legend.

Table

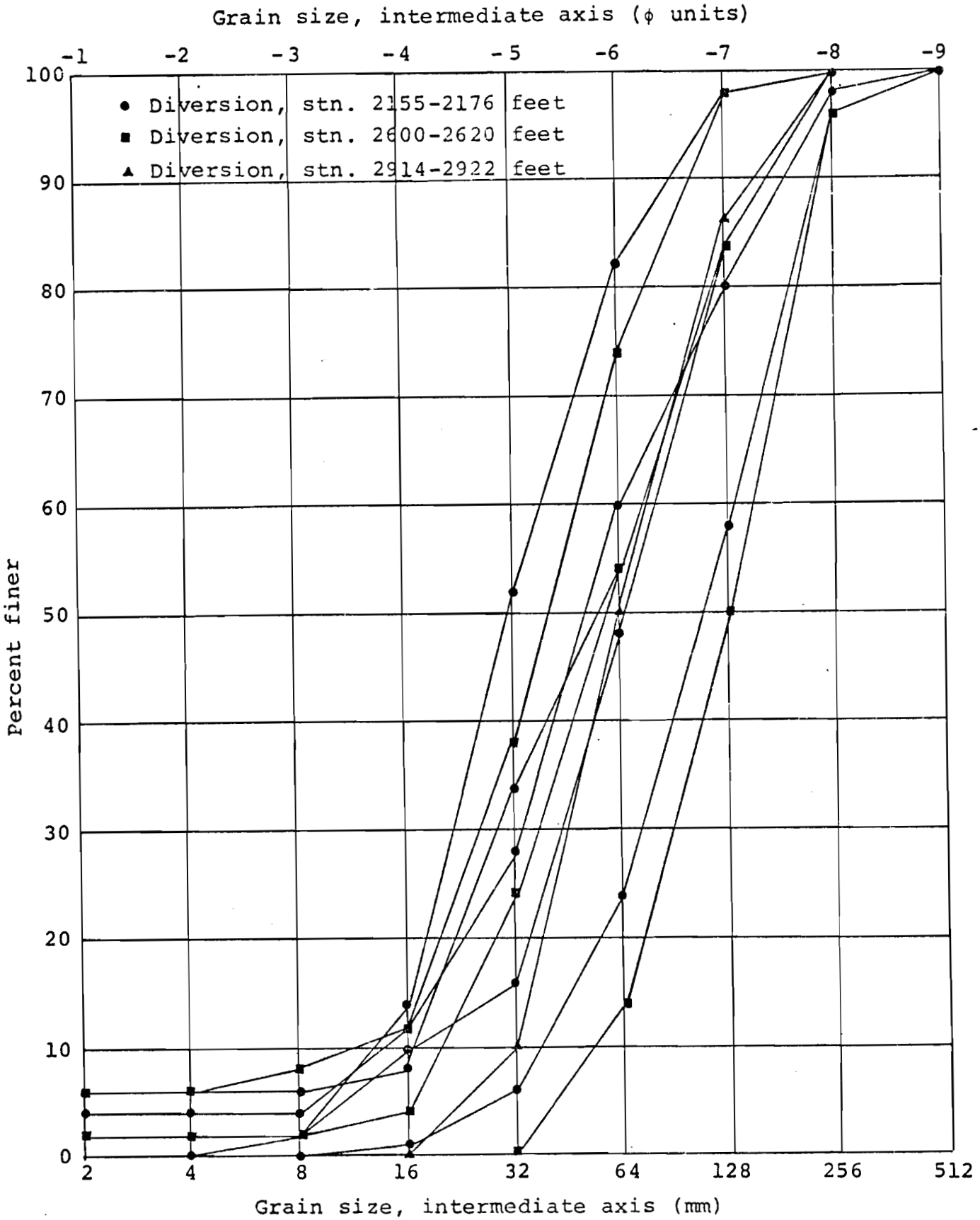
2.4.1

Legend Valley flat Mappins

Table

2.4.2
2.4.3
2.4.4

hydraulic geometry



Note: Materal smaller than 2 mm is sand sized or finer.

FIGURE 2A.2 Bed materal texture, Coldwater River.

SAMPLE #	LOCATION	X_s #	BED MATERIAL SIZE (mm) D_{max}	D_{90}	D_{84}	D_{65}	D_{50}	D_{35}	D_{16}	D_{10}	D_{min}	Size in comparison to bed material in thalweg
1	diversion, stn. 2155-2176 feet 657- 663 m	A- 6	170	94	74	44	31	23	18	13	sand	finer
2		A- 7	350	223	208	147	108	79	47	38	12	similar
3		A- 8	198	169	128	84	56	34	20	17	sand	
4		A- 9	284	194	152	79	54	38	20	14	sand	
5		A-11	170	169	128	91	69	47	32	16	6	slightly finer
		$\bar{x}$	234	170	138	89	64	44	27	20	-	
		σ	80	48	48	37	28	21	12	10	-	
6	diversion, stn. 2600-2620 feet 792- 799 m	B-14	190	169	119	74	60	41	24	20	sand	
7		B-15	140	104	84	56	39	28	18	11	sand	
8		B-16	285	231	208	158	128	104	66	52	34	similar
		$\bar{x}$	205	168	137	96	76	58	36	28	-	
		σ	74	64	64	54	47	41	26	22	-	
9	diversion, stn. 2914-2922 feet 888- 891 m	C-21A	193	158	121	86	64	50	36	32	24	
All Samples		$\bar{x}$	220	168	136	91	68	49	31	24	-	
		σ	70	47	47	38	31	26	16	14	-	

Note: $\bar{x}$ - mean; σ- standard deviation about the mean

Table 24.5 Bed material texture, Coldwater River

Plate 2A.1

bed material

Ted + Tape

Plate 80-08-07
YS-C21

Plate 2.4.2

Typical Sedimentary structure of lowlying fluvial materials

photo 80-08-06

Xs C-22

Plate 2.4.3

Plate 81 10 - 10A

Joliet Gr Bridge
Post Flood

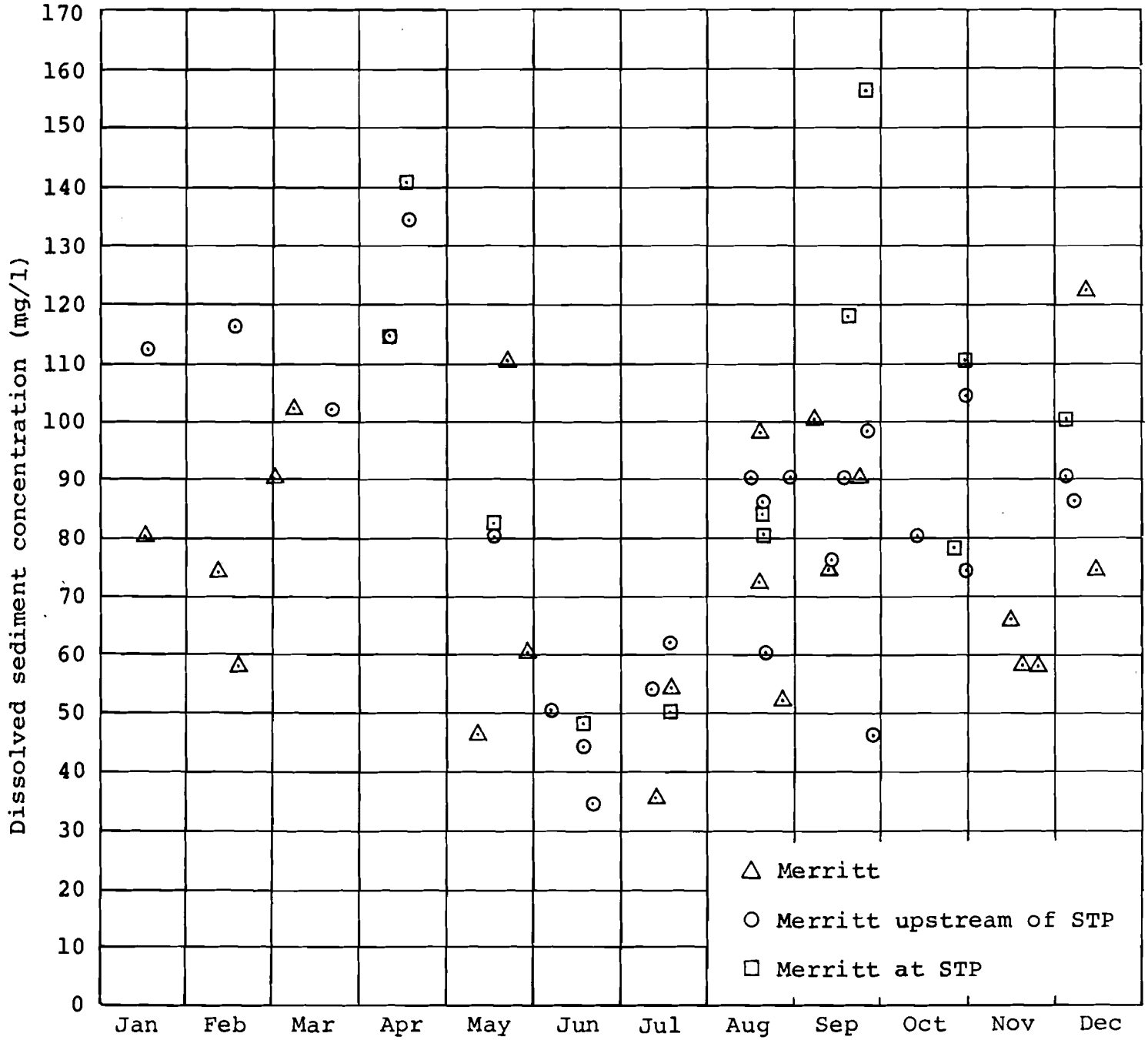


Figure 2.4.3: Seasonal variation in dissolved sediment concentrations, Coldwater River, near Merritt.

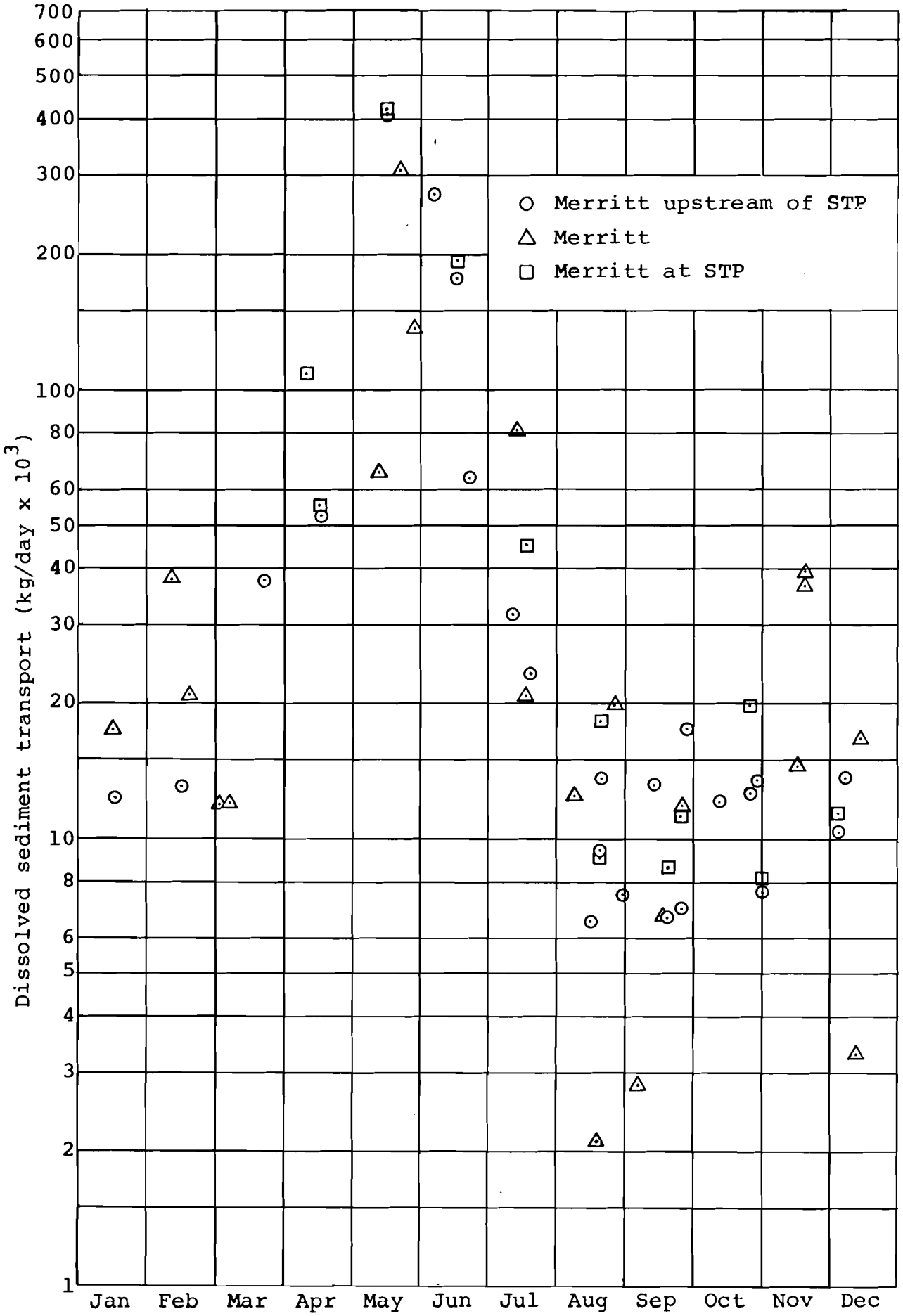
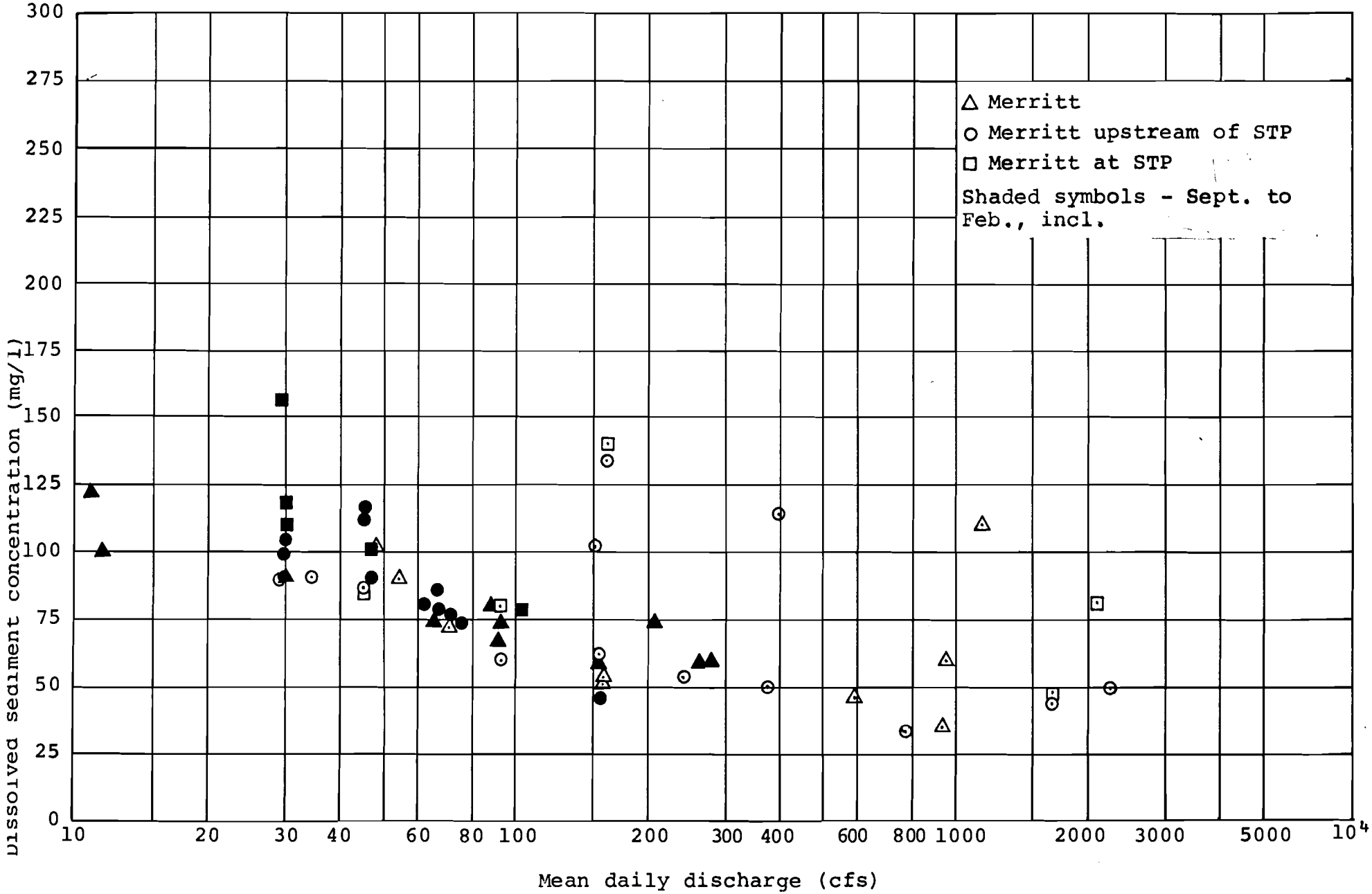


FIGURE 24.4: Seasonal variation in dissolved sediment transport, Coldwater River, near Merritt.



2.4.5 Dissolved sediment concentration plotted against discharge for the Coldwater River.

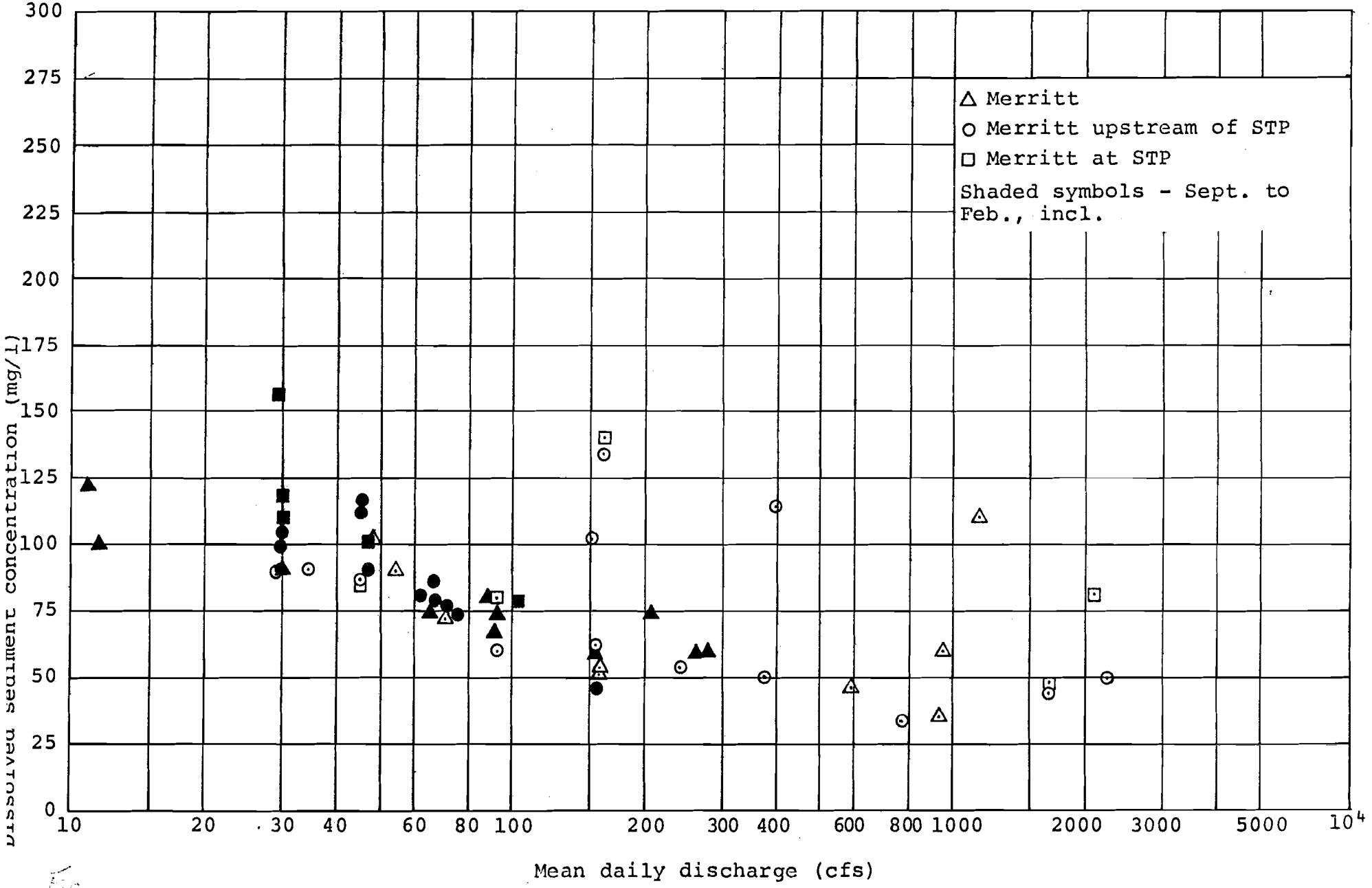
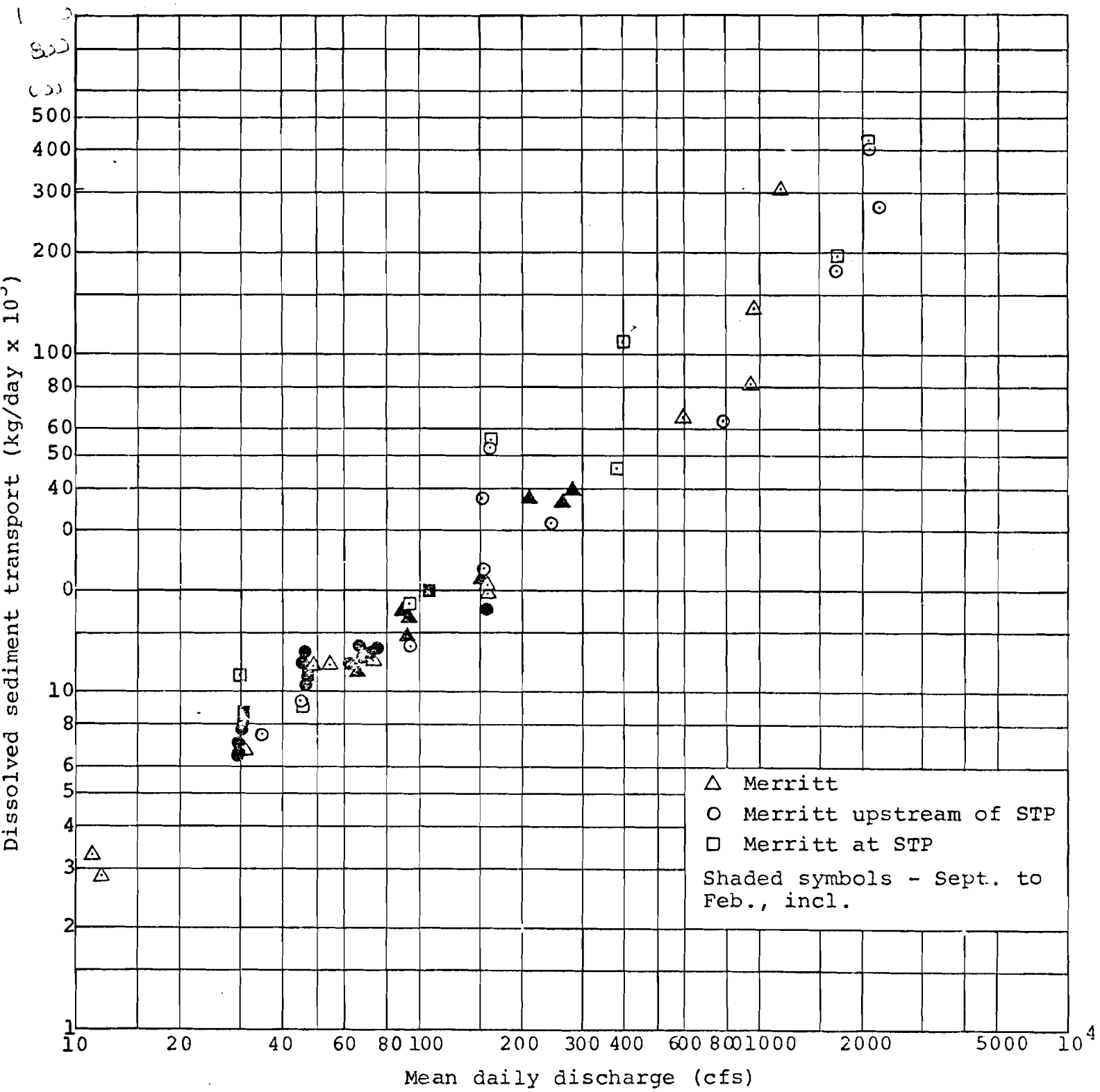


Fig 4.6 Dissolved sediment concentration plotted against discharge for Coldwater River near Merritt.



7.4.6. Dissolved sediment transport as a function of discharge, Coldwater River, near Merritt.

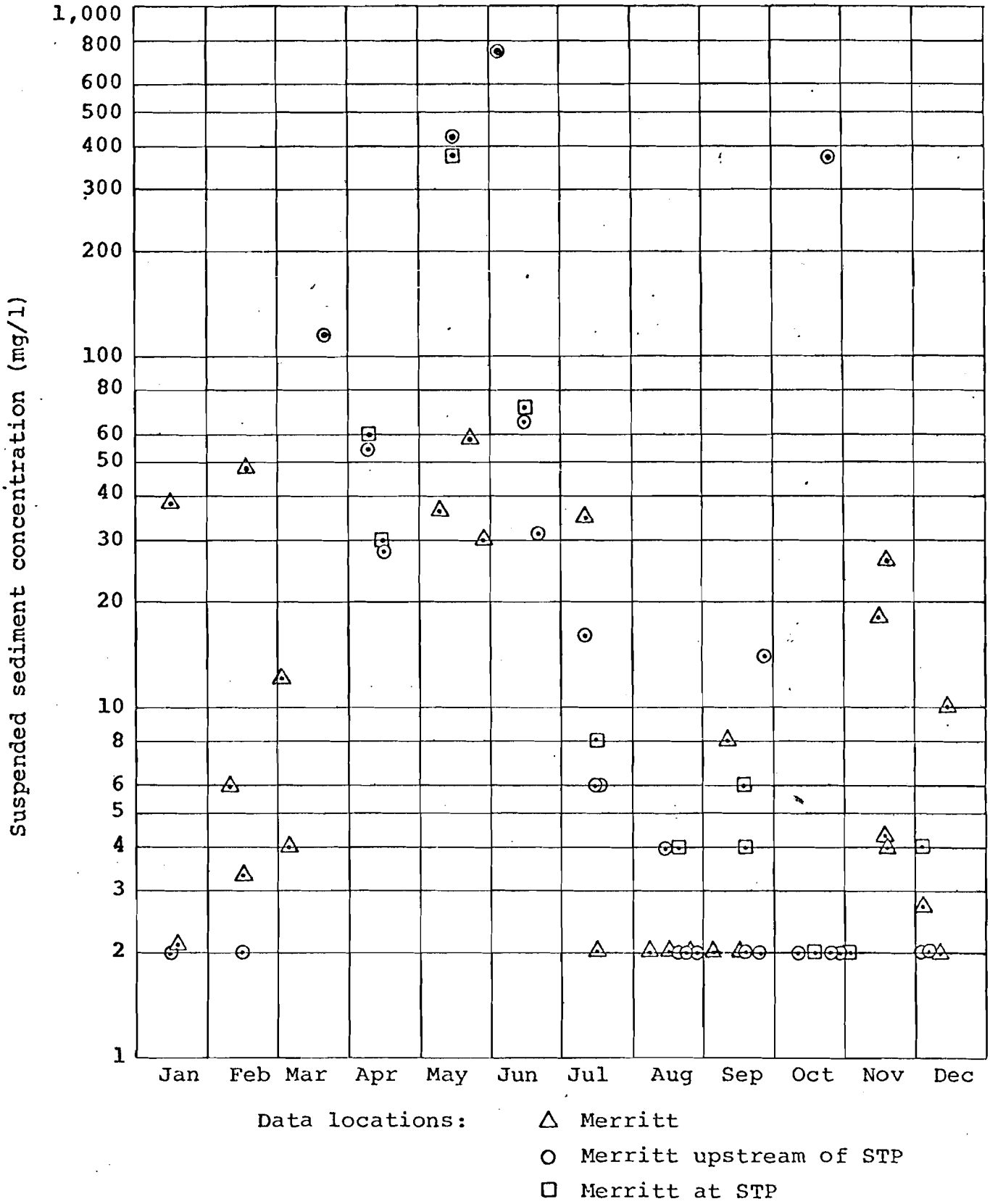


Fig. 2.4.7

Seasonal variation in suspended sediment concentration, Coldwater River near Merritt.

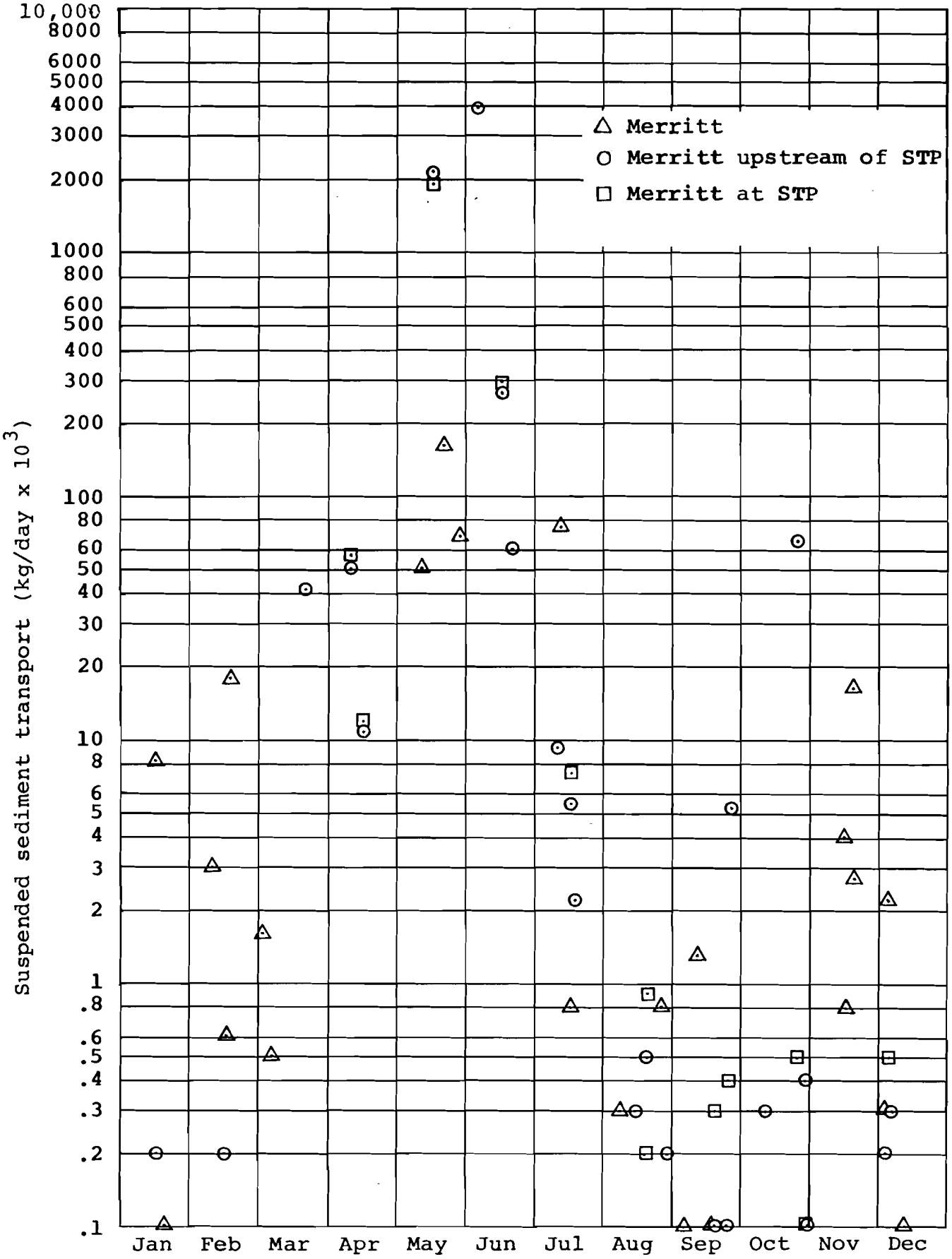
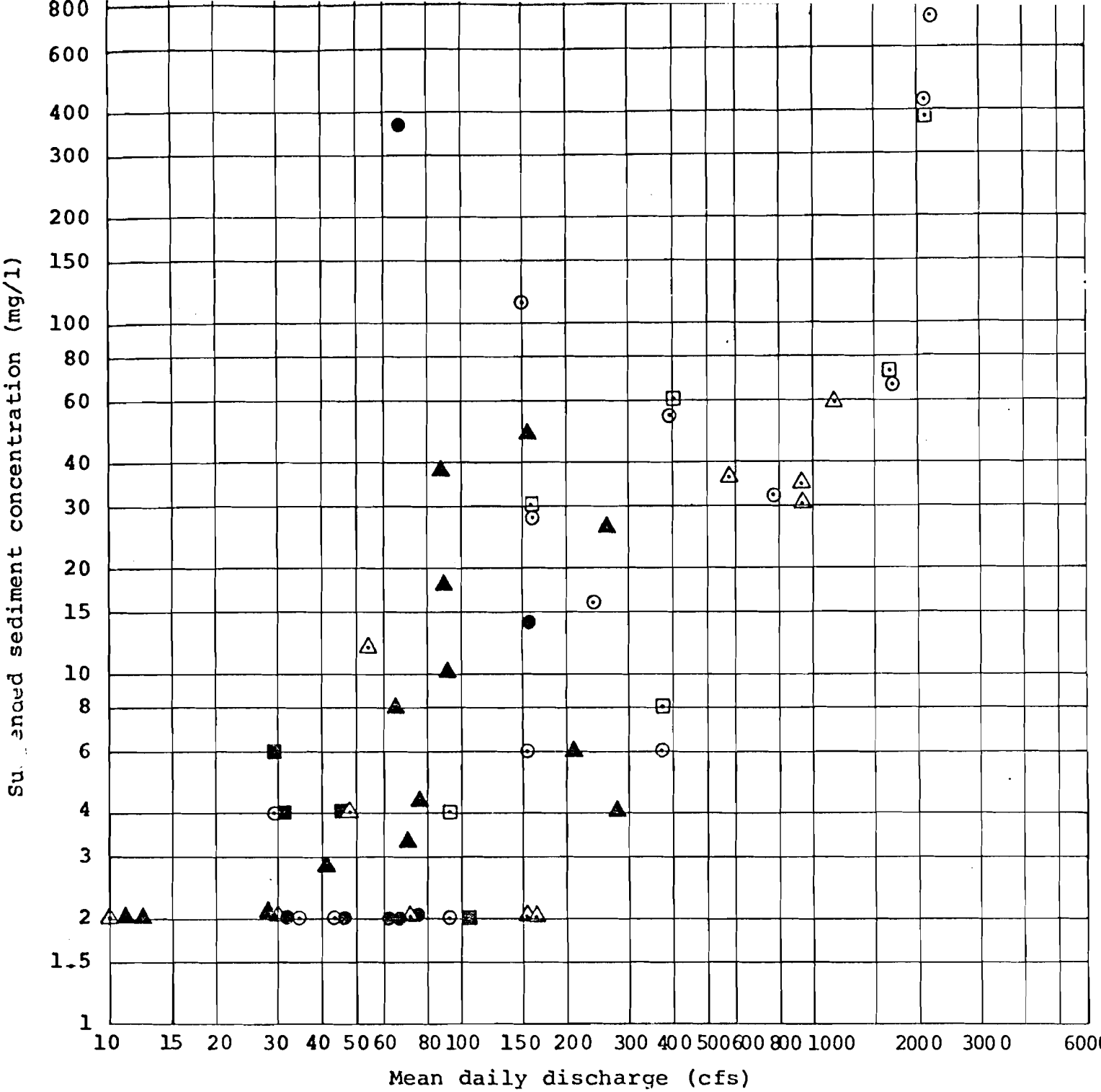


Figure 2.4.8: Seasonal variation in suspended sediment transport, Coldwater River, near Merritt.



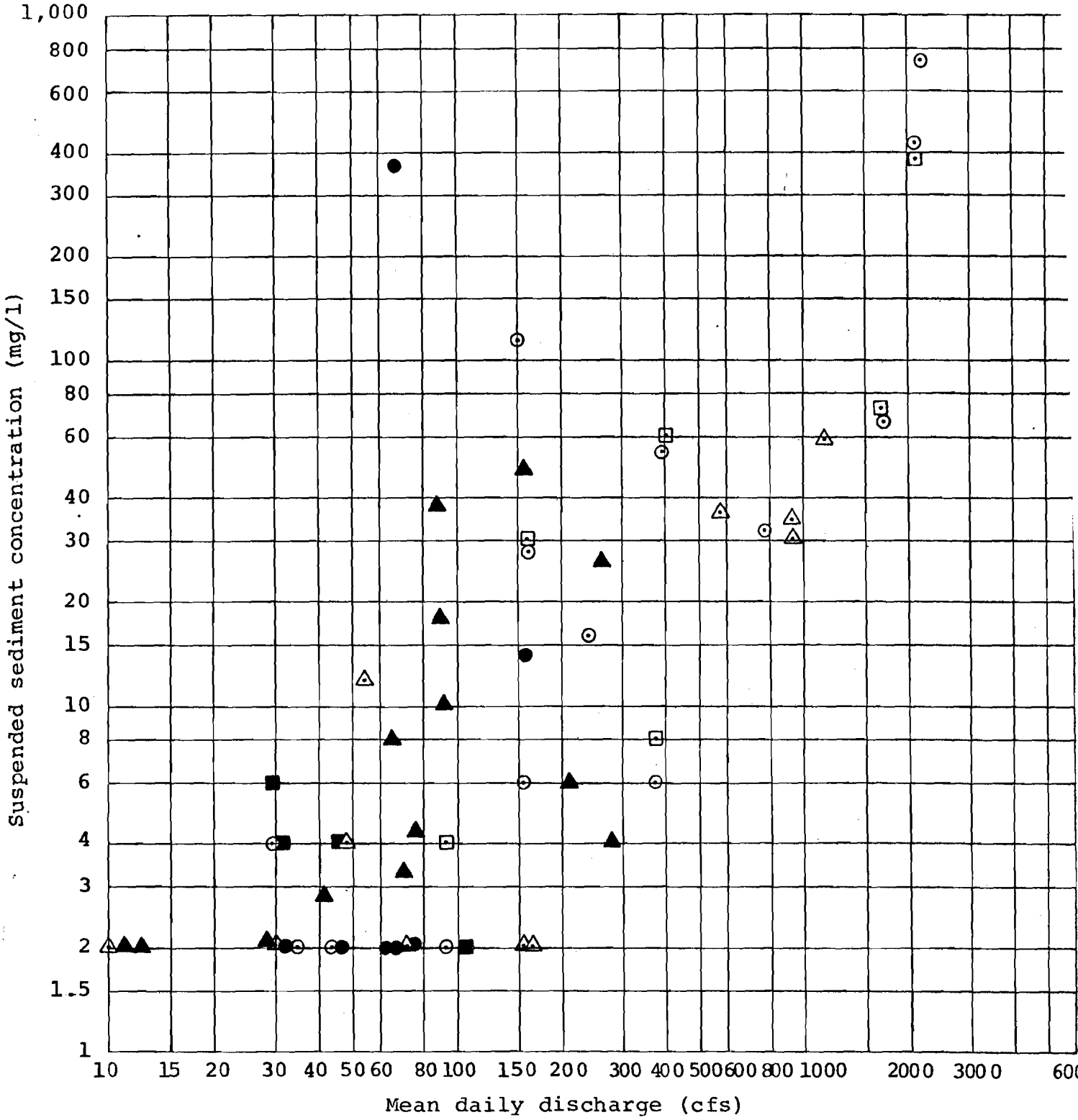
Data locations: △ Merritt

○ Merritt upstream of STP

□ Merritt at STP

Shaded symbols - Sept. to Feb., incl.

2.4.9 Suspended sediment concentration plotted against discharge for Coldwater River.



Data locations: △ Merritt

○ Merritt upstream of STP

□ Merritt at STP

Shaded symbols - Sept. to Feb., incl.

Fig 2.4.10 Suspended sediment concentration plotted against discharge for Coldwater River near Merritt.

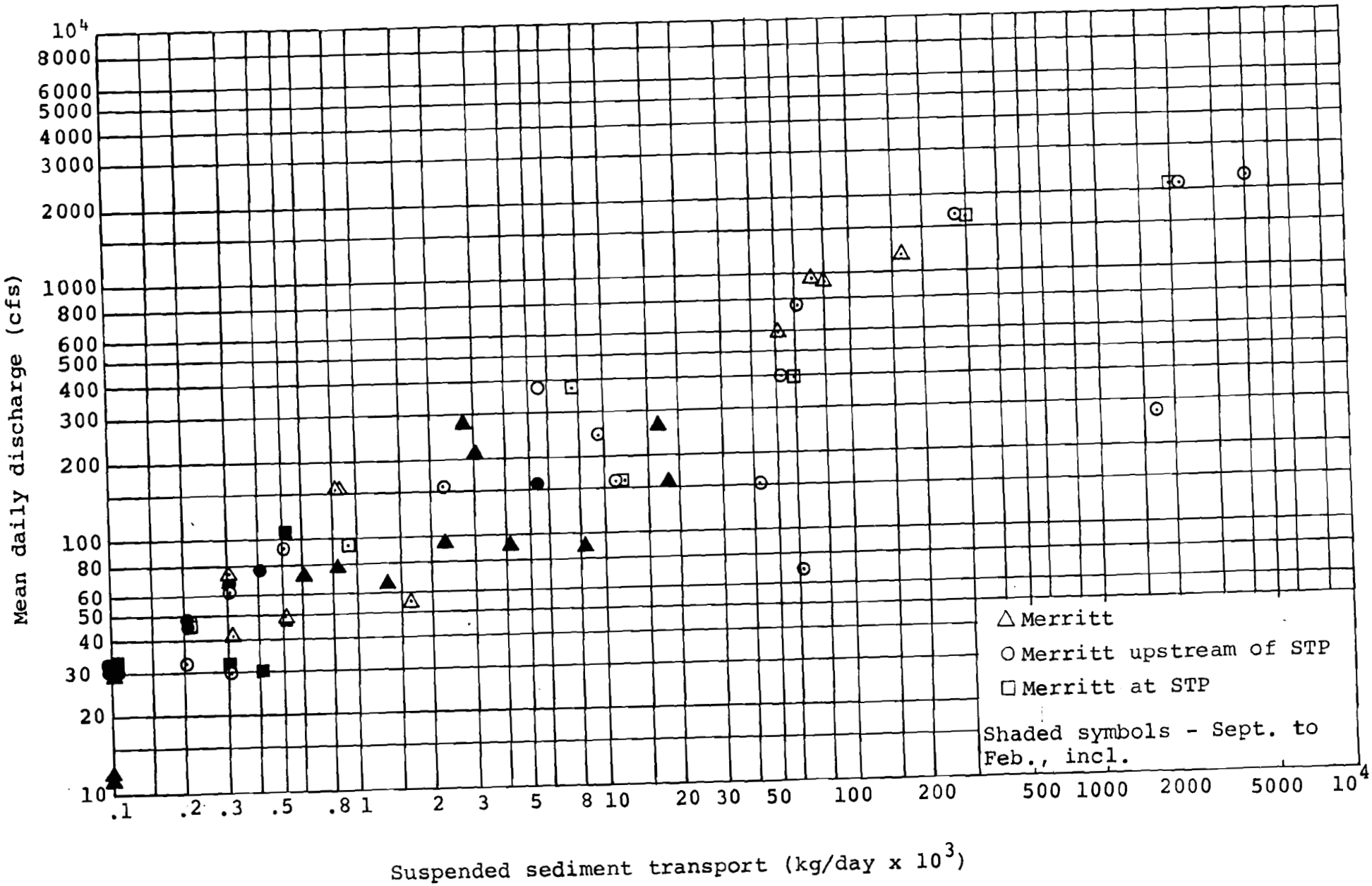


Figure 2.4.10 Suspended sediment transport as a function of discharge, Coldwater River, near Merritt.

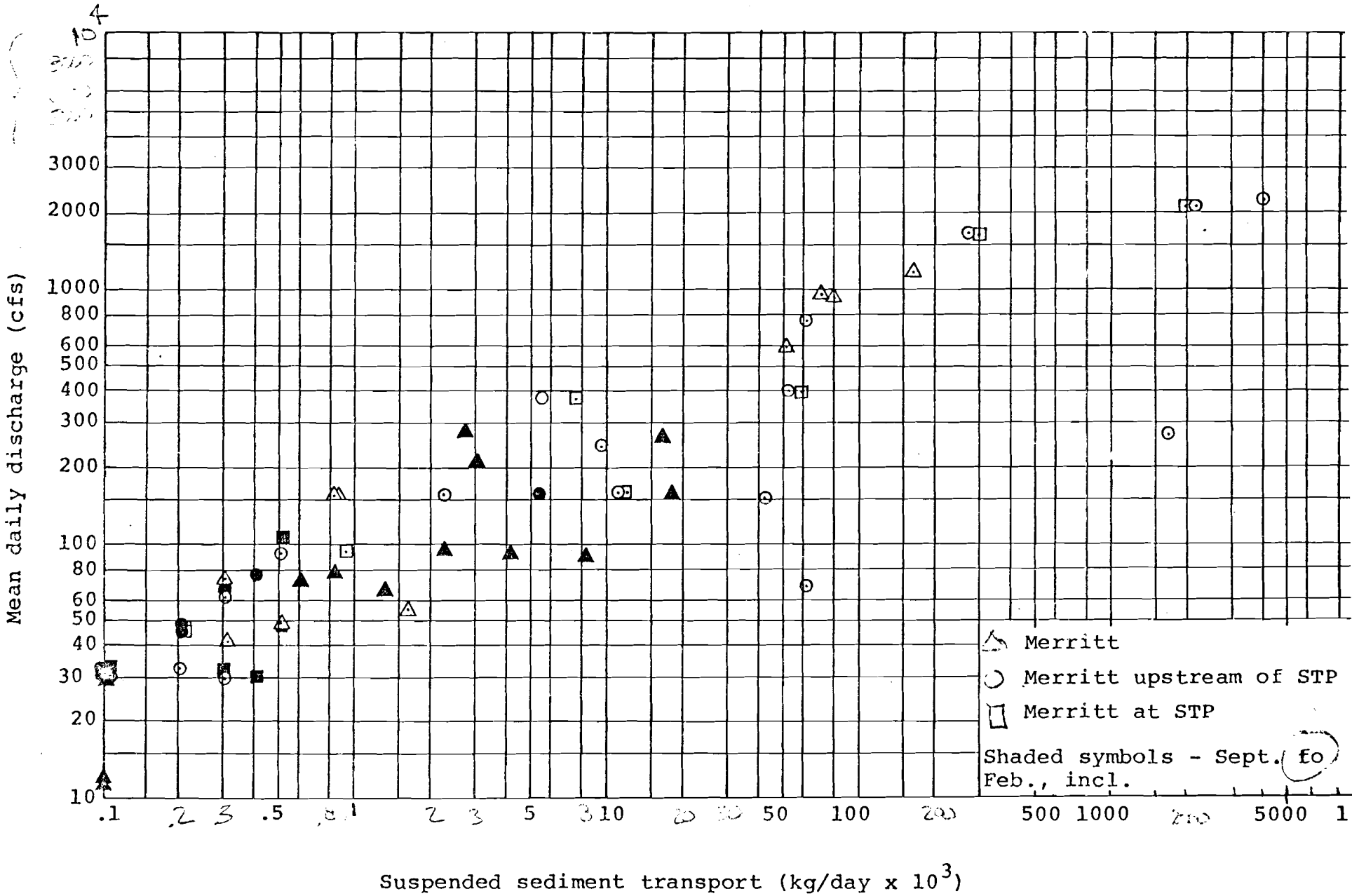


Figure 24.6: Suspended sediment transport as a function of discharge, Coldwater River, near Merritt.