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April 11, 1995
File No. 42500-45/R 3-P
Study No. 418

HYDROLOGY SECTION REPORT

SEVEN PEAKS

INTRODUCTION

In response to the memorandum request of January 25, 1995 from the Southern Interior Water Manager, a brief hydrology study was done of a number of creeks in the Hedley area known as the Seven Peaks Environmental Study Area. This particular area, which includes the left bank tributaries of Similkameen River between Hedley and Keremeos and Shingle Creek, was defined as a result of an agreement signed on December 14, 1994 between the three Bands of the Okanagan Nation and the Province of British Columbia.

The requirements for this study were annual runoff and summer and annual low flow estimates for Hedley, Cahill, Winters, Bradshaw and upper Shatford creeks for assessment of future water license applications. Also required were annual hydrologic estimates for a preliminary water supply analysis for Nickel Plate Lake. There is a current application to transfer 160 acre-feet of storage from the lake to support diversion licenses at Apex, in the headwaters of Keremeos Creek. In conjunction with this application an assessment was required of the resulting potential downstream impacts, both on Keremeos Creek and Nickel Plate Creek.

STUDY REGION

The study region lies in the Okanagan Range of the northeastern fringe of the Cascade Mountains and borders the Thompson Plateau of the Interior Plateau. The study area is characterized by steep slopes that range in elevation from 500 m at the Similkameen River to

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2250 m at Apex Mountain, in a span of 11 km. This physiography distinguishes Cahill, Winters and Bradshaw creeks and the lower reach of Keremeos Creek. The upper reaches of Keremeos and Shatford creeks, above the runoff-producing elevation of 1200 m, are flatter and drain lower slopes, which comprise a majority if their drainage areas.

The study region lies in the moderate Southwest Interior climatic zone that covers a wide span from the western Skagit River to the eastern Columbia River. The Similkameen basin experiences predominant westerly frontal storms in the winter and convective storms in the summer. The winter storm activity divides the basin into two hydrologic zones, a western wet zone (caused by a carry-over of orographical precipitation from the windward side of the Cascade Range) and a semi-arid dry zone (caused by a rainshadow from the descending westerly air masses). The study basins all lie in the dry hydrologic zone where mean annual runoff varies from zero at 1000 m to 500 mm at 2000 m elevation. The approximate seasonal distribution of annual runoff varies from 100% for April-September at 1000 m elevation to 90% at 2000 m. A lower runoff zone or a rain shadow lies beyond the Similkameen-Okanagan divide in the Trout Creek region.

REGIONAL DATA

Hydrometric data for the study region were extracted from Water Survey of Canada (WSC) published sources and from a low flow monitoring program conducted in 1977 and 1993 by the Hydrology Branch (HB). Three WSC hydrometric and four HB low flow stations are listed in Table 1 with associated basin parameters, periods of record and summarised data used in the study procedure. (A more detailed work-up of these data is discussed below.) Long-term data compilations were based on historical WSC records up to 1993 but the short-term HB records were unpublished, preliminary data. Data were compiled as total discharge for annual water supply and as seven-day average low flows for summer and annual periods and are listed in Table 2.

TABLE 1 HYDROMETRIC STATIONS

HYDROMETRIC STATION			DRAINAGE	AREA	MEDIAN ELEVATION	
PLOT	NAME	NUMBER	AREA	> EZR	> STATION	> EZR
#			(km^2)	(km^2)	(m)	(m)
1	Hedley Creek near the Mouth	08NL050	390	374	1680	1685
2	Shatford Creek near Penticton	08NM037	98	77	1520	1630
3	Nickel Plate Reservoir Outflow	08NL068	7.95	7.95	1910	1910
4	Shingle Creek bl. Skulaow Creek	3BNM035	29.6	-	-	-
5	Cahill Creek near the Mouth	3BNL006	23.6	22.1	1690	1710
6	Winters Creek near the Mouth	3BNL009	52.8	47.4	1800	1820
7	Bradshaw Creek near the Mouth	3BNL004	19.8	17.4	1700	1770
8	Lower Nickel Plate Creek	-	25.8	-	-	-

All total discharge and low flow records were adjusted for upstream licensed diversions based on a procedure developed in earlier studies (referenced in the next section). The Water Licensing Information System VAX computer program was used to generate License Demand Reports showing the required information for all diversion points upstream of each hydrometric station. Direct diversions (e.g., domestic and waterworks withdrawals), which are licensed as rates rather than as total quantities, were quantified as required for the annual records of Shatford Creek (08NM037). There were no diversions occuring above Hedley Creek (08NL050), although upstream water licenses exist. The direct diversion licenses were added as rates to the observed seven-day average low flows, where necessary. Total licensed seasonal irrigation quantities were prorated for July-September seven-day average low flows using a factor derived in the Okanagan Tributaries study (0.000153 m^3/s per April-September total irrigation volume in acre-feet). Period average low flow licensed adjustments are listed in Table 2 in the "Ob LF" columns for each respective summarized record and low flow period.

TABLE 2 RUNOFF AND LOW FLOW

BASIN		PERIOD	MEAN ANNUAL		MEAN SEVEN-DAY LOW FLOW					
PLOT #	NAME	OF	RUNOFF		July-September			Annual		
		RECORD	> STA	> EZR	Ob LF	E Div	N LF	Ob LF	E Div	N LF
			(dam^3)	(mm)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
1	Hedley Creek	1974-93	76,200	204	0.632	0.000	0.632	0.190	0.000	0.190
2	Shatford Creek	1974-93	12,700	166	0.059	0.020	0.079	0.034	0.008	0.042
3	Nickel Plate Res.	A-S,1976	2,640$^{\alpha}$	331	-	-	0.005$^{\delta}$	-	-	0.000$^{\delta}$
4	Shingle Creek	J-S,1977	-	-	0.002	0.000	0.005$^{\beta}$	-	-	-
5	Cahill Creek	A-S,1992	4,900$^{\varepsilon}$	220$^{\delta}$	0.000	<0.098	<0.098	-	-	0.002$^{\delta}$
6	Winters Creek	A-S,1992	14,000$^{\varepsilon}$	300$^{\delta}$	0.038	0.012	0.061$^{\chi}$	-	-	0.007$^{\delta}$
7	Bradshaw Creek	J-S,1977 A-S,1992	4,500$^{\varepsilon}$	260$^{\delta}$	0.006 0.000	0.017 <0.017	0.052$^{\chi}$ <0.017	-	-	0.001$^{\delta}$
8	L. Nickel Plate C.	-	-	-	-	-	0.02$^{\delta}$	-	-	0.002$^{\delta}$

Ob LF, Observed Low Flow
E Div, Estimated Diversion
N LF, Natural Low Flow
$^{\alpha}$adjusted for net evaporation loss and to long-term mean-annual via 08NL050
$^{\beta}$adjusted to long-term mean-annual via 08NM037
$^{\chi}$adjusted to long-term mean-annual via 08NL050
$^{\delta}$estimated from regional curve
$^{\varepsilon}$runoff > EZR (mm) x drainage area > EZR (km^2)

Drought frequency analyses were carried out on the natural hydrometric record of Hedley Creek (08NL050), the reference station used in this study, for both total discharge and seven-day low flows. The best-fit distribution chosen was the Pearson Type III for both the annual discharges and the

seven-day average low flows. The best estimate regional frequency ratio of recurrence interval to mean-year for a five-year drought was 0.6 for annual discharges and for seven-day low flows for both summer and annual durations.

An important, and often limiting, hydrologic component in water supply analysis for potential storage is lake evaporation. The procedure generally used in storage evaluation is to apply an estimate of net evaporation loss (lake evaporation minus direct lake precipitation) to a water balance of the reservoir. For estimates of net evaporation loss at Nickel Plate Lake the results of a previous study were used directly (Study Number AQ-Similkameen Basin Hydrology). Also, the lake evaporation estimate was corroborated by an evaporation model used in a neighbouring study (Study Number 292-Campbell Creek). These estimates are given in the next section.

WATER SUPPLY ESTIMATES

The water supply estimates were based on a regional procedure developed in earlier studies (Study Number 282-Okanagan Tributaries, 1990, and 368 to 385-Southern Interior Region Low Flow, 1992). The 1974-93 record of Hedley Creek near the Mouth (08NL050), was used as the reference station in this study and the two other WSC hydrometric records for total discharge were adjusted to this period. The regional analysis of runoff consisted of plotting naturalized mean unit runoff (mm) for the selected stations against median basin elevation (m) on semi-logarithmic graph paper as shown in Figure 1. The procedure in Study AQ for defining the high tributary area contributing to runoff in a watershed (known as the area above the elevation of zero runoff (EZR), that elevation at which precipitation equals potential evapotranspiration with insignificant contribution to surface runoff on a mean annual basis, 1220 m in the study area) was used to define and plot unit runoff. The runoff-elevation (R-E) curve (straight line on a semi-log plot) was drawn though plot number point 1 with a slope common to those of the regional R-E curves derived in Study 385 and covered the area just north of this study. Point 2 (Shatford Creek) and 3 (Nickel Plate Lake) plot slightly below the curve. Shatford Creek represents the start of a lower runoff zone but point 3 is not reliable and should plot higher it is based on only a single seasons record of lake outflow data, unadjusted for storage change (adjustment was made for long-term runoff and net lake evaporation loss).

Estimates of mean annual volume runoffs for the problem sites using the above data and procedures are listed in Table 2. The runoff-elevation curve of Figure 1 was applied for the median elevations for the areas above EZR (1220 m) to give estimates of natural flow. Note that the graph is for mean-annual conditions and a factor of 0.6 can be applied to estimate five-year drought conditions. Note that for Nickel Plate Lake the estimate for runoff includes lake area; an adjustment for annual net evaporation loss would be 130 and 40 dam^3 for mean- and five-year drought conditions. If monthly estimates of runoff are required in water supply analyses a monthly distribution for the annual estimates can be based on that of Table A-4 of the Study AQ report (Dry Zone, Plot No. 20). A monthly distribution of annual lake precipitation and evaporation (potential evapotranspiration) can be derived from Table B-2 of the Study AQ report (Dry-Zone, 1900 m elevation band data).

LOW FLOW ESTIMATES

The low flow estimates in this study were based on a regional procedure developed in an earlier study (Similkameen Strategic Plan hydrology, 1983) and refined in more recent, nearby studies (e.g., Study 385). In this procedure low flow data are plotted against drainage area on log-log graph paper and regional curves are drawn to represent low flow zones. It was generally found that such zones are much larger, covering larger drainage areas, than runoff zones and were best represented by a series of asymptotic curves that converge from wide sections at small drainages to a narrow section in the graph at very large drainage areas.

In this study naturalized summer (July-September) and annual seven-day average low flow data for mean-year conditions were plotted as shown in Figure 2. A regional tributary summer low flow curve was drawn for the study area through the plot point 1 and made compatible (asymptotic) with those of Study 385. Shatford and Shingle creeks (points 2 and 4) plot lower than the curve to reflect a lower runoff zone across the Okanagan divide. An annual low flow curve was drawn, asymptotic to the former curve (to reflect convergence at large drainage sizes), through point 1 that represents natural flow. The two low flow curves are represented by straight-line segments. All the other Table 2 points were naturalized by adding upstream diversions and adjusted for long term using concurrent records of study reference station 08NL050 (long-term-to-short-term summer ratio was 2.08 for station 4 and 1.36 for station 6). Stations 5 and 7 were not adjusted or plotted since their observed low flows were zero or much lower than the estimated upstream diversions.

Estimates of mean seven-day low flow for the problem sites using the above data and procedures are listed in Table 2. The regional curves of Figure 2 were applied to give estimates of points 5 through 8. No estimate was provided for Shingle and Shatford creeks, other than the observed points (3BNM035 and 08NM037, respectively). Lower Shatford Creek and mid Shingle Creek drainage areas are affected by complex interdiversions and will be the subject of a later independent study.

APEX DIVERSION IMPACT

The application to transfer 160 acre-feet of storage from the Nickel Plate Lake to support diversion licenses at Apex, in the headwaters of Keremeos Creek, was assessed with respect to potential downstream impacts on Nickel Plate Creek and Keremeos Creek. Under the current application existing storage capacity would be used and would result in direct loss of water that would have been released to Nickel Plate Creek. Natural seven-day average low flows for the drainage area of Nickel Plate Creek between Nickel Plate Lake and its mouth were estimated to 0.02 and 0.002 m^3/s for the July-September and annual periods, respectively. A hypothetical distribution of 160 acre-feet over a six month period (the duration of lowest flow in an average annual hydrograph in this region) translates to 0.012 m^3/s. In this worst-case scenario the impact would be 100% at the lake outlet, assuming no release, to 80% at the mouth of Nickel Plate Creek. For Keremeos Creek there would be no impact on peak flows since any increase in snowpack due to snowmaking would tend to prolong snowmelt rather than increase its melt rate. The only effect on low flows would be to increase them locally, and only to a minor extent.

DEPENDABILITY OF ESTIMATES

The accuracy of the estimates cannot be defined in regional procedures for runoff and low flows. Total runoff depends on local precipitation regimes and basin retention characteristics; low flows depend on local geologic, groundwater and streambed conditions. None of these variables were considered in this study. The dependability of the regional estimates can be expressed in a confidence range (+/- 40%) that can be assumed to be the 95% confidence limits of the study reference station, Hedley Creek near the Mouth (08NL050).

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FIGURE 1 REGIONAL RUNOFF

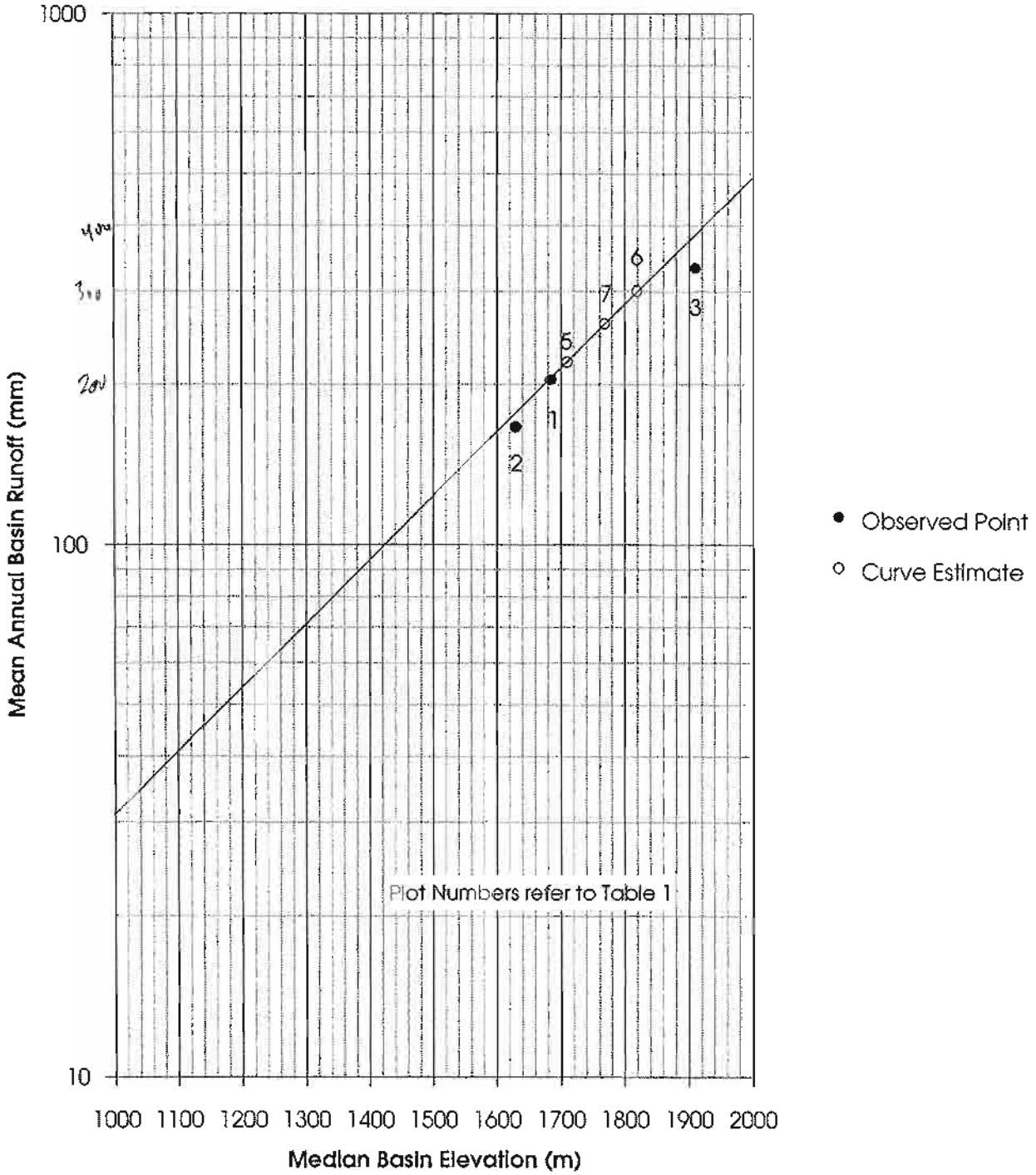
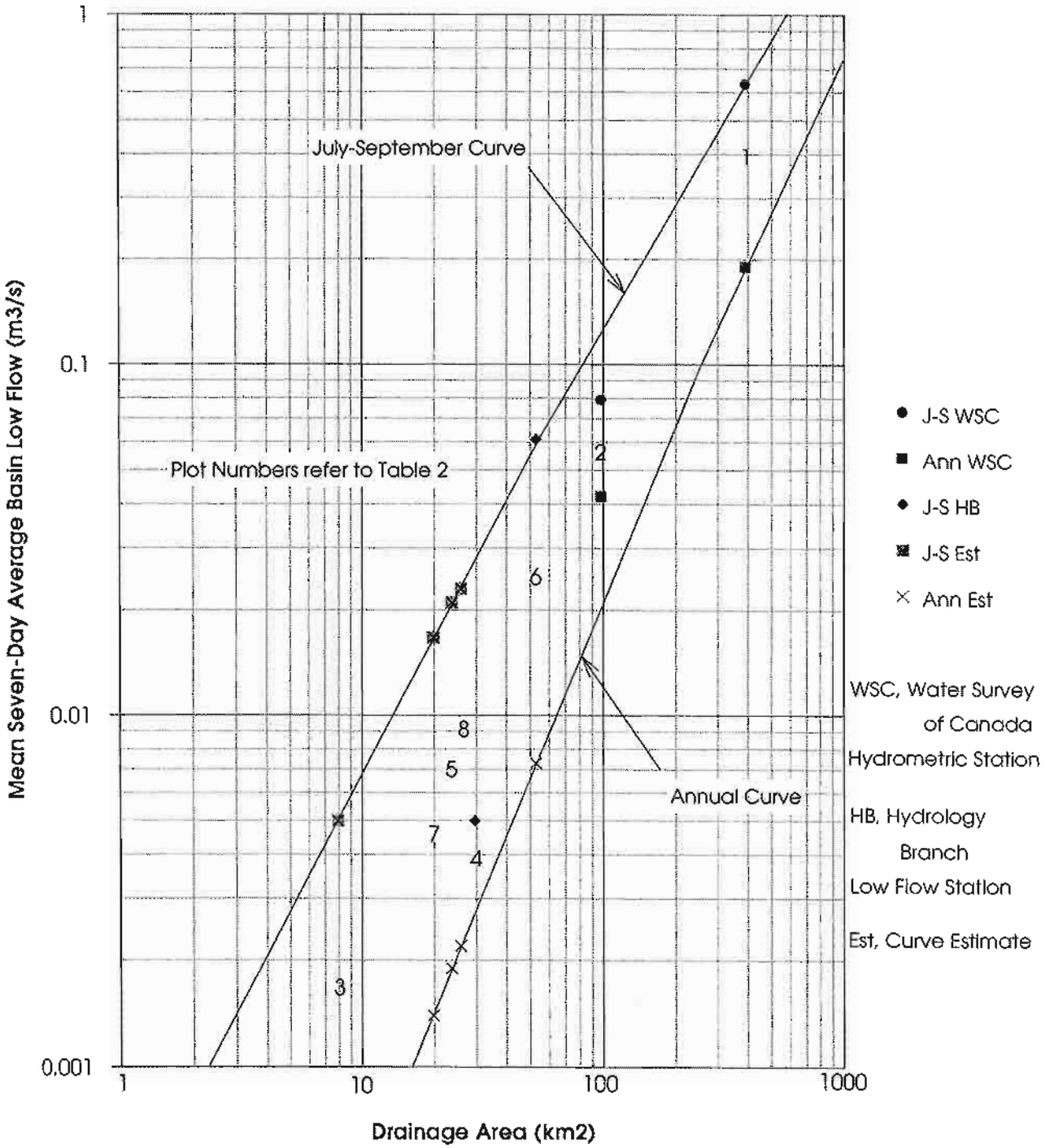


FIGURE 2 REGIONAL LOW FLOW



Province of British Columbia
MINISTRY OF ENVIRONMENT, LANDS AND PARKS
BC Environment
WATER MANAGEMENT DIVISION

MEMORANDUM

To: C.H. Coulson
Manager
Hydrology Section

Date: April 24, 1995
File No. 42500-45/R 3-P
Study No. 418

Re: Seven Peaks Study
Keremeos Creek
Water Supply and Low Flow Estimates

In response to the April 12, 1995 memorandum from Bill Franz, Southern Interior Water Utility Regulation Officer, the above study was extended to include Keremeos Creek. Water supply and low flow estimates were required to assess a water license application at two proposed Points of Diversion on Keremeos Creek in the headwaters at Apex Resort. Also, low flow estimates were required for Keremeos Creek at Olalla to assess fisheries values.

The procedure used in making the required water supply estimates for upper Keremeos Creek was based on that of the Hydrology Section Report, *Seven Peaks*, April 11, 1995. Drainage areas and median basin elevations were measured from a 1:50,000 scale map for the two proposed locations, Site 1, located 300 m upstream of the Lot 4062 boundary, and Site 2, located 1 km downstream of Site 1. Unit runoffs were extracted from Figure 1 of the above report and low flow estimates were extracted directly from Figure 2. The results are listed below in Table 1.

TABLE 1 KEREMEOS CREEK HEADWATER SITES RUNOFF AND LOW FLOW

SITE		1	2
Drainage Area$^{\alpha}$ (km^2)		2.74	6.45
Median Elevation$^{\alpha}$ (m)		1870	1860
Mean Annual Runoff	(mm)	350	340
	(dam^3)	960	2190
Mean 7-Day Low Flow (m^3/s)	July-September	0.001	0.004
	Annual	0.000	0.000

$^{\alpha}$basin drainage area above site and above EZR is the same since the site elevation is above EZR (1200 m)

Low flow estimates for Keremeos Creek at Olalla were based on Water Survey of Canada (WSC) published records for Keremeos Creek hydrometric stations, 08NL010 and 08NL045. The first station (08NL010) was located upstream of Olalla Creek with a record of 1919-27,

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1948-70. The second station (08NL045) was established downstream of Olalla Creek in 1971 and is still active. Table 2 lists seven-day low flow estimates for the two records. WSC records list drainage areas for both gauges as 183 km^2 but the lower gauge area should be larger by that of Olalla Creek (approximately 27 km^2).

TABLE 2 KEREMEOS CREEK AT OLALLA LOW FLOW

KEREMEOS CREEK		PERIOD	MEAN SEVEN-DAY LOW FLOW (m^3/s)					
Hydrometric Station		OF	July-September			Annual		
Location	Number	RECORD	Obs LF	E Div	Nat LF	Obs LF	E Div	Nat LF
near Olalla	08NL010	1921-70	0.216	0.062	0.278	0.166	0.000	0.166
bl.Willis Intake	08NL045	1971-93	0.212	0.086	0.298	0.129	0.007	0.136

Ob LF, Observed Low Flow
E Div, Estimated Diversion
Nat LF, Natural Low Flow

Drought frequency analyses on the above hydrometric records led to the same conclusions as in the reference report, except for one minor exception. The best-estimate regional frequency ratio of recurrence interval to mean-year for a five-year drought for seven-day low flows for annual durations was found to be 0.7 instead of 0.6.

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