THE GOVERNMENT OF
THE PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES

WATER RESOURCES SERVICE

KELOWNA CREEK WATER SUPPLY

FOR

GLENMORE AND ELLISON IRRIGATION DISTRICTS

DATE Apr. 1973
FILE 0242512-52
0256957

D. E. Reksten, P.Eng.
Hydraulic Engineer

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WATER INVESTIGATIONS BRANCH
BRITISH COLUMBIA WATER RESOURCES SERVICE
DEPARTMENT OF LANDS, FORESTS AND WATER RESOURCES
PARLIAMENT BUILDINGS
VICTORIA, BRITISH COLUMBIA

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SYNOPSIS

This study of Kelowna Creek hydrology for Glenmore and Ellison Irrigation Districts was done at the request of Mr. J. V. Eby, Chief, ARDA Division, Water Investigations Branch.

Water is stored in South Lake (500 acre-feet), Postill Lake (4000 acre-feet) and Bulman Lake (1000 acre-feet) and is shared on the basis of 75% to Glenmore I.D. and 25% to Ellison I.D. Glenmore I.D. also has an 800 acre-foot capacity balancing reservoir.

Glenmore I.D. wishes to increase its irrigated acreage by up to 1200 acres. Based on the estimates of mean and drought year (1929-31) runoff derived in this study, under present conditions of demand and storage capacity, the Irrigation Districts could be supplied with water until August of the third drought year (equivalent to 1929-31) after a mean runoff year.

If 400 acres of the possible 1200 were added to Glenmore I.D., the existing 5500 acre-feet of storage would be depleted during August of the second drought year (equivalent to 1929-30) after a mean runoff year.

Using the above information as a guide, further storage calculations can be made using the Hydrology Division computer program for various demands and number of consecutive drought years.

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KELOWNA CREEK WATER SUPPLY

FOR

GLENMORE AND ELLISON IRRIGATION DISTRICTS

1. INTRODUCTION

This study of Kelowna Creek hydrology was done at the request of Mr. J. V. Eby, Chief, ARDA Division, Water Investigations Branch.

Glenmore and Ellison Irrigation Districts have developed the Kelowna Creek watershed (Fig. 2) under an agreement in which they share the stored water and runoff at the Glenmore-Ellison intake on a 75% - 25% basis, the greater share going to Glenmore Irrigation District. Water is stored in South Lake (500 ac-ft.), Postill Lake (4000 ac-ft.) and Bulman Lake (1000 ac-ft.). Glenmore Irrigation District also has a balancing reservoir (McKinley reservoir) of 800 ac-ft.

Glenmore Irrigation District wishes to increase its irrigated acreage by up to 1200 acres. There is also a proposal to have Ellison I.D. supply the Scotty Creek I.D. with about 200 ac-ft. of water during a dry year such as 1970 when Scotty Creek I.D. was short of water.

This study estimates runoff in each of the reservoir sub-basins and unregulated runoff at the joint intake in mean and drought runoff years. Storage calculations are made for conditions similar to the 1929-31 drought recorded in the Okanagan basin. (A description of the procedure used to compute monthly storage conditions is given in the Appendix).

The results of the storage calculations indicate that with the present demand and storage capacity, storage would be depleted in August of the third drought year (1931). 1016 ac-ft. would be left at the end of the second drought year and 1737 ac-ft. left at the end of the first drought year.

If 400 acres of irrigable land were added to the system (additional demand of 800 ac-ft.) 346 ac-ft. of storage would be in place at the end of the first drought year and storage would be depleted by August of the second drought year (1930).

Glenmore I.D. holds a licence to store 560 ac-ft. in the Conroy Creek basin tributary to Kelowna Creek. At the most suitable damsite the mean annual runoff is estimated at 210 ac-ft. Developing storage in this basin would not appear to be worthwhile.

2. MEAN ANNUAL RUNOFF

2.1 RUNOFF FROM BASIN CHARACTERISTICS

Using multiple regression analysis, equations to estimate 1971 runoff using basin physiographic characteristics have been derived for the April-July period. Two equations used for this study are shown in Table 1 and 2. Not all the independent variables in these equations are significant at the 5% level. They are included in the equations as they reduced the percent estimating error for the Bulman Creek (BU) and Vernon Cr. (VE) sub-basins which are in the Kelowna Creek area. Both results for each sub-basin are averaged to yield 1971 April-July runoff. Based on the 1971 streamflow data used to derive these equations and median basin elevation the ratio of April-July to annual runoff was determined for 500 ft. elevation bands. For the 4 sub-basins in this study the ratio is 0.91 and yields the following estimates of 1971 annual runoff.

	Median Basin Elevation (ft.)	1971 Annual Runoff (in.)
Total basin	4620	10.06
South Lake	4830	12.46
Postill Lake	4860	12.53
Bulman Lake	4680	9.68

Based on an analysis of Okanagan Lake natural tributary inflow data (Reference 1) and 1967-71 natural streamflow data for 7 sub-basins, it is estimated that 1971 annual runoff in the Kelowna Creek basin is 25% above the long-term mean (1921-71). Reducing the above runoff estimates by 25% gives the following mean annual runoff estimates.

	Mean Annual Runoff (in.)
Total basin	8.04
South Lake	9.96
Postill Lake	10.03
Bulman Lake	7.74

2.2 UBC AVERAGE RUNOFF ESTIMATES

UBC's runoff-elevation relationship described in "Average Flows in the Tributary Basins" (Reference 2) gives the estimated mean annual runoff in 500-ft. elevation bands in the Kelowna Creek basin. The results using the UBC estimates are:

	Mean Annual Runoff (in.)
Total basin	6.66
South Lake	9.08
Postill Lake	9.07
Bulman Lake	7.53

2.3 GRID SQUARE METHOD

Mean annual runoff estimates for grid squares covering the Kelowna Creek basin (Reference 3) were weighted by area within the sub-basins to yield the following estimates. Mean basin elevation was calculated in the same way, based on the mean grid square elevations.

	Elevation	Mean Annual Runoff (in.)
Total basin	4320	8.1
South Lake	4890	11.0
Postill Lake	4820	10.9
Bulman Lake	4640	10.0

2.4 VERNON CREEK BASIN RUNOFF ESTIMATES

C. H. Coulson (Reference 4) has derived a runoff-elevation relationship for mean annual runoff using natural streamflow data for the 1969-71 period. The relationship is in the form of a curve described by squared and cubed values of elevation. On the basis of 500-ft. elevation bands mean annual runoff is estimated as:

	Mean Annual Runoff (in.)
Total basin	6.4
South Lake	9.4
Postill Lake	9.5
Bulman Lake	6.7

2.5 SUMMARY

The results of the four estimating methods are shown in Table 3. For the total basin above the intake, the estimate used in this study is the average of the 4 methods, or 7.3 in. For the South Lake, Postill Lake and Bulman Lake sub-basins, the results of 3 methods are averaged. The grid square estimate is not used as these sub-basins are much smaller than the area of the 5 km. grid squares for which data were compiled in the grid square report. The mean annual runoff for South Lake, Postill Lake and Bulman Lake sub-basins is 9.5 in., 9.5 in., and 7.3 in. respectively.

3. MINIMUM ANNUAL RUNOFF

Three estimating techniques are used to estimate minimum or drought condition runoff similar to the amounts which occurred in the Okanagan basin during the period 1929-31. The UBC estimates and Coulson's estimates for Vernon Creek basin are based on 1970 streamflow data; 1970 runoff was as low as that during the 1929-31 drought period. The third estimate is based on the ratio of 1929-31 runoff to mean runoff as determined in a previous study of Mission Creek hydrology.

3.1 UBC MINIMUM RUNOFF ESTIMATES

In the report "Flows in the Main Tributary Basins," (Reference 5) estimates of 1970 runoff for each 500 ft. elevation band are given. 1929-31 runoff is then given as 98%, 93% and 79% of 1970 runoff. Data in this report results in the following annual runoff estimates:

Annual Runoff (in.)

	Total Basin	South Lake	Postill Lake	Bulman Lake
1970	4.2	5.9	5.9	4.4
1929	4.1	5.8	5.8	4.3
1930	3.9	5.5	5.5	4.1
1931	3.3	4.7	4.7	3.5

3.2 VERNON CREEK BASIN RUNOFF ESTIMATES

C. H. Coulson's study (Reference 4) estimates 1970 annual runoff for 500 ft. elevation bands for the Vernon Creek watershed. To obtain 1929-31 data for this report, Okanagan Lake natural tributary inflow data (1921-71) were analyzed to obtain the relationship between 1970 runoff and that during the 1929-31 drought. These data show that 1929-31 runoff is 102%, 95% and 88% of 1970 runoff, resulting in the following estimates:

	Annual Runoff (in.)			
	Total Basin	South Lake	Postill Lake	Bulman Lake
1970	3.8	6.0	6.2	3.5
1929	3.9	6.1	6.3	3.6
1930	3.6	5.7	5.9	3.3
1931	3.3	5.3	5.5	3.1

3.3 MISSION CREEK HYDROLOGY ESTIMATES

In the report "Mission Creek Water Supply for Black Mountain Irrigation District" it was estimated that 1929, 1930 and 1931 were 57%, 53%, and 50% of the long-term mean. Using the mean runoff for each sub-basin estimated in Sec. 2.5, and assuming that the drought years have the same departure from the mean as the Mission Creek basin, the following estimates can be made:

	Annual Runoff (in.)			
	Total Basin	South Lake	Postill Lake	Bulman Lake
Mean	7.3	9.5	9.5	7.3
1929	4.2	5.4	5.4	4.2
1930	3.9	5.0	5.0	3.9
1931	3.6	4.8	4.8	3.6

3.4 SUMMARY

Estimates of the 1929-31 annual runoff are tabulated in Table 4. The average of the three estimating techniques is the estimate for each sub-basin used in this study. These values are shown in Table 4.

4. MONTHLY RUNOFF DISTRIBUTION

The monthly distribution of runoff is based on streamflow data collected in 1970 and 1971 in the Okanagan basin. The gauged sub-basins were assigned to 500 ft. elevation bands on the basis of median basin elevation. The monthly distribution is expressed as per cent of annual, and the average of the percentages for the sub-basins in each elevation band for each month computed.

The monthly distribution for 1970, a very low runoff year, is assumed to be valid for the 1929-31 drought years. The 1971 monthly distribution is used for mean runoff years as 1971, although an above average runoff year, is the only year fairly close to average with enough data available to establish the variation of monthly runoff distribution with elevation.

The 4 sub-basins in this study are in the 4500 to 5000 ft. median elevation range. The runoff distribution for these basins is as follows:

Monthly Runoff Distribution
(% of annual)

	Oct-Mar.	Apr.	May.	June.	July.	Aug.	Sept.
Mean Runoff Year .	12.0	4.0	49.5	26.0	4.5	2.0	2.0
Minimum Runoff Year	14.0	4.0	52.0	22.0	4.0	2.0	2.0

5. RESERVOIR EVAPORATION

To determine net inflow to the storage reservoirs for making storage calculations it is necessary to estimate lake evaporation losses.

The Atmospheric Environment Service, Can. Dept. of the Environment has estimated mean monthly lake evaporation on a grid square basis for the Okanagan basin. The estimates for each of the Glenmore-Ellison reservoirs are listed below in inches:

	South Lake	Postill Lake	Bulman Lake
Oct.-Mar.	0.9	0.9	1.0
April	1.6	1.6	1.7
May	3.3	3.3	3.4
June	3.8	3.8	3.9
July	4.9	4.9	5.0
August	4.3	4.3	4.4
September	2.4	2.4	2.5
Annual	21.2	21.2	21.9

In the Coulson report (Reference 4) mean annual and maximum annual lake evaporation for upland lakes (approximately 4400 ft. elev.) is given as 15.67 in. and 17.85 in. respectively. The figures tabulated above appear to be high on the conservative side and will be used for a mean and minimum runoff year.

To determine the amount of evaporation loss, the reservoir surface area at the spillway elevation is used in the storage calculations in Sec. 7.

6. DEMAND

Demand data used in this study was supplied by the ARDA Division and is given below for Glenmore and Ellison Irrigation Districts. 3.7% of the Glenmore I.D. demand is for domestic use while an even smaller proportion is required for domestic use for Ellison I.D.

	Demand (ac.-ft.)	
	Glenmore	Ellison
Oct.-Mar.	42	0
April	12	0
May	996	332
June	1,055	363
July	1,152	395
August	1,057	363
September	374	127
	4,648	1,580

7. STORAGE CALCULATIONS

A computer program has been devised by the Hydrology Division to perform calculations on runoff and demand to yield month-end storage in place. Because Glenmore I.D. has an 800 ac-ft. balancing reservoir (McKinley reservoir) below the joint Glenmore-Ellison intake, the computer program was used to obtain the monthly runoff available at the diversion and the rest was calculated by hand.

The following description of the operation of the Glenmore-Ellison system was provided by the ARDA Division. "Fall runoff from Kelowna Creek below the storage is diverted through the flume and Glenmore Syphon (maximum capacity 1500 ac-ft/month) to the Balancing Reservoir, until this fills, or cold weather necessitates the draining of the flume and syphon. Glenmore domestic water is supplied through the winter months by drawing on the storage in this Balancing (McKinley) Reservoir. In the Spring the flume/syphon is opened again to top up the Balancing Reservoir, to supply "flood-water" to the dry-farmed acreage and then to supply irrigation water when the season begins. The upper storage reservoirs are opened when the freshet can no longer meet demand, usually around mid-June. At this point "flood-water" is arbitrarily cut-off. In 1971, storage was not used till July 1, and "flood-water" was supplied to 50 acres all season."

"When the dams are opened, South Lake, Bulman Lake and Postill Lake are normally drawn down equally. Just downstream from the intake on Kelowna Creek the flow to Glenmore and Ellison is separated and recorded over weirs. In Ellison Irrigation District, irrigation water is "ordered" to eliminate fluctuations in demand as there is no balancing reservoir. Minor reductions in the demand cause the supply to overflow to the Glenmore system."

Two storage runs are made in this report. Storage calculations are made for a mean runoff year followed by three drought years (1929-31) first for the existing demand and secondly for a demand which assumes an additional 400 acres of irrigation. A detailed description of the calculating procedure is given in the Appendix. The results of the two storage runs are tabulated in Table 5 and 6 and can be summarized as follows.

Run 1

It is assumed that all reservoirs are empty at the beginning of the mean runoff year. By the end of June a total of 5161 ac-ft. are in place in upstream reservoirs and McKinley reservoir is full, the demand up to May 30 being supplied from unregulated runoff. Excess water is available during May and June totalling 967 ac-ft. at McKinley reservoir and 1296 ac-ft. at the joint intake where it flows into Kelowna Creek. The carry-over storage of 2439 is assumed to be distributed as 1952 ac-ft. in Postill Lake and 487 ac-ft. in Bulman Lake with South Lake being emptied due to its small capacity. It is assumed that 300 ac-ft. are retained in McKinley reservoir.

In the following drought years it is evident that little, if any, water would be available for "flood-water" irrigation. The 75% - 25% sharing of upstream storage can be met without difficulty during the drought period.

Under the assumed demand and operating conditions, the existing system would provide adequate water through two drought years and up to August of the third year. By the end of September, the system would be deficient by 743 ac-ft.

Run 2

For this run it is assumed that the demand is increased by 800 ac-ft. by the addition of 400 acres of irrigable land to the system. The total upstream storage reaches 5162 ac-ft. at the end of June and McKinley reservoir is full. During May and June excess water is available amounting to 1296 ac-ft. at the joint intake and 615 ac-ft. at McKinley reservoir. The carry-over storage of 1842 ac-ft. is distributed as 0 in South Lake, 1625 ac-ft. in Postill Lake and 217 ac-ft. in Bulman Lake. It is assumed that McKinley reservoir carries over 350 ac-ft.

In the following drought year Glenmore I.D. requires 4165 ac-ft. from upstream storage, more than its 75% share of 3471 ac-ft., although 300 ac-ft. are retained in McKinley reservoir. Ellison I.D. requires 788 ac-ft. which is less than its share of 1157 ac-ft. Only 346 ac-ft. are carried over to the next drought year (1930).

Due to the low carry-over storage, increased demand and transmission losses, storage is depleted during August of the second drought year. By September 30 the deficiency amounts to 1412 ac-ft.

These two runs indicate that some additional demand could be accommodated depending on the number of consecutive drought years one wishes to design for. If the design was based on one drought year, 400 acres of land could be added. It is obvious that the addition of 1200 acres of irrigable land could not be considered with the present amount of storage.

8. ADDITIONAL STORAGE

Glenmore I.D. holds a licence on Conroy Creek for 560 ac-ft. of storage. A damsite was proposed in 1962 at the point shown in Figure 2. The area of this basin is 0.66 sq. mi. with a median elevation of 4570 ft. In Figure 3, estimates of mean annual runoff for South, Postill, and Bulman Lake basins are plotted against their median elevations. Based on this simple relationship, the mean annual runoff for the Conroy Creek basin above the proposed damsite is estimated at 6.0 in. or 210 ac-ft. Although based on a different area (0.53 sq. mi.), 210 ac-ft. compares with 109 ac-ft. estimated in a report by Wannop and Hirtle Engineering Ltd. dated April 15, 1963. Their conclusion that "further consideration of the proposed Conroy Creek reservoir is not warranted at this time" would still appear to be valid. Considering evaporation losses, and transmission losses, the useable storage would be something less than 210 ac-ft.

9. CONCLUSIONS

The results of this study must be qualified by the following points:

1. Monthly evaporation losses for calculating reservoir net inflow are based on the reservoir area at the spillway elevation. This provides a conservative net inflow estimate on the low side.
2. The operation of the reservoirs, reflected in how the carry-over storage is distributed to each reservoir at the end of the year, could be varied as well as the operation of McKinley balancing reservoir.
3. The year of lowest runoff, 1931, has a return period of roughly 50 years. The return period for three consecutive drought years such as 1929-31 would be much greater.

The storage calculations indicate that:

(a) if the system is designed for a 1 year drought, 400 - 500 acres of irrigable land could be added to Glenmore I.D.

(b) if the system is designed for a 2 year drought, no additional acreage could be accommodated.

(c) there is not enough runoff available at the proposed Conroy Creek damsite to make further consideration worthwhile.

(d) ignoring transmission and distribution losses from Ellison I.D. to Scotty Creek I.D., it would be possible to supply 200 ac-ft. of water to Scotty Creek I.D. from Ellison I.D.'s share of the joint water supply for 1 drought year under present storage and demand conditions.

RECOMMENDATIONS

ARDA Division personnel should make any further storage runs they feel necessary to cover all alternatives of storage operation, demand, etc., through the Hydrology Division.

Monthly data should be obtained on South Lake, Postill Lake, Bulman Lake and McKinley reservoir to provide month-end lake levels. Facilities for measuring the outflow from these reservoirs should be established in order that the estimates made in this study can be verified.

TABLE 1

FORECAST EQUATIONS — OK SUB-BASIN 1971 RO FROM BASIN CHRTCS (NORTH) — STATION — RUN F

```
(Y 2) SURO2  = + 0.2626 PPN 1   (X 1)  SB = 0.1791   T = 1.47   PAR R =0.4602
               + 0.0653 AR45P   (X 7)  SB = 0.0156   T = 4.19   PAR R =0.8288
               + 0.7089 BRISE   (X12)  SB = 0.5667   T = 1.25   PAR R =0.4045
               - 2.6732         STAND. ERROR = 1.0379
     MULT R = 0.8930          R SQUARED = 0.7975          F( 3, 8) = 10.50
```

YEAR	FORECAST RUN-OFF	OBSERVED RUN-OFF	DIFF	PERCENT ERROR	12 YEARS
19ES	6.605	7.880	-1.275	-16.2	
19TE	6.552	7.070	-0.518	-7.3	
19LT	4.087	4.780	-0.693	-14.5	
19LB	3.769	4.040	-0.271	-6.7	
19WB	5.578	4.940	0.638	12.9	
19WM	5.262	4.420	0.842	19.1	
19PE	7.313	8.150	-0.837	-10.3	
19CL	3.088	2.580	0.508	19.7	
19CO	1.021	1.980	-0.959	-48.4	
19EW	5.897	4.510	1.387	30.8	
19VE	4.341	4.280	0.061	1.4	
19BU	4.267	3.150	1.117	35.4	

SURO2 = April-July runoff (ac.ft./sq.mi. x .01)
PPN1 = Jan.-Mar. precipitation (in.) (AES OKAGN5 model)
AR45P = Percent of sub-basin area above 4500 ft. (%)
BRISE = Basin rise (ft. x .001)

TABLE 2

FORECAST EQUATIONS — OK SUB-BASIN 1971 RO FROM BASIN CHRTCS (NORTH) — STATION — RUN F

```
(Y 2) SORC2   = +  0.1520 PPN 1     (X 1)    SB =  0.1739   T = 0.87   PAR R =0.2797
                +  3.8758 BELEV     (X11)    SB =  0.9820   T = 3.95   PAR R =0.7961
                - 14.5794           STAND. ERROR = 1.0903
      MULT R = 0.8652           R SQUARED = 0.7486          F( 2, 9) = 13.40
```

12 YEARS

YEAR	FORECAST RUN-OFF	OBSERVED RUN-OFF	DIFF	PERCENT ERROR
19ES	6.812	7.880	-1.068	-13.6
19TE	5.652	7.070	-1.418	-20.1
19LT	4.239	4.780	-0.541	-11.3
19LB	3.689	4.040	-0.351	-8.7
19WB	5.320	4.940	0.380	7.7
19WM	4.813	4.420	0.393	8.9
19PE	7.563	8.150	-0.587	-7.2
19CL	3.925	2.580	1.345	52.1
19CO	0.844	1.980	-1.136	-57.4
19EW	5.813	4.510	1.303	28.9
19VE	4.744	4.280	0.464	10.8
19BU	4.365	3.150	1.215	38.6

BELEV = Median basin elevation (ft. x .001)

TABLE 3 SUMMARY OF MEAN ANNUAL RUNOFF ESTIMATES

METHOD	BASIN RUNOFF (in.)			
	SOUTH	POSTILL	BULMAN	TOTAL
Basin Characteristics	10.0	10.0	7.7	8.0
U.B.C.	9.1	9.1	7.5	6.7
Grid Square	11.0	10.9	10.0	8.1
Vernon Creek	9.4	9.5	6.7	6.4
Average in.	9.5	* 9.5	* 7.3	* 7.3
Ac-ft.	1270	4200	1630	12,300

* Grid square estimate not included.

TABLE 4 SUMMARY OF MINIMUM ANNUAL RUNOFF ESTIMATES

METHOD	BASIN RUNOFF (in.)											
	SOUTH			POSTILL			BULMAN			TOTAL		
	1929	1930	1931	1929	1930	1931	1929	1930	1931	1929	1930	1931
U.B.C.	5.8	5.5	4.7	5.8	5.5	4.7	4.3	4.1	3.5	4.1	3.9	3.3
Vernon Cr.	6.1	5.7	5.3	6.3	5.9	5.5	3.6	3.3	3.1	3.9	3.6	3.3
Mission Cr.	5.4	5.0	4.8	5.4	5.0	4.8	4.2	3.9	3.6	4.2	3.9	3.6
Average (in.)	5.8	5.4	4.9	5.8	5.5	5.0	4.0	3.8	3.4	4.1	3.8	3.4
(ac-ft.)	773	719	653	2570	2430	2210	895	851	762	6900	6400	5720

GLENMORE-ELLISON I.D.(KELOWNA CR) STORAGE RUN [illegible] (DEMAND [illegible])

NUMBER OF RESERVOIRS = 3

RESERVOIR	AREA (ACRES)	STORAGE CAPACITY (ACRE-FT)	LAKE EVAPORATION IN INCHES OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	45.0	600.0	0.90	1.60	3.30	3.00	4.90	6.30	5.40
2	226.0	4000.0	0.90	1.60	3.30	3.00	4.90	4.30	5.00
3	60.0	1000.0	1.00	1.70	3.40	3.90	5.00	4.60	5.80

1 SOUTH LAKE RESERVOIR
2 POSTILL LAKE RESERVOIR
3 BULMAN LAKE RESERVOIR

YEAR: MEAN YEAR

	MONTHLY DISTRIBUTION (%) OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
ANNUAL NAT RUNOFF ABOVE INTAKE = 12300 ACRE-FT	12.0	4.0	40.5	24.4	4.5	2.0	2.0
TRANSMISSION LOSS	0.0	0.0	0.5	20.0	20.0	20.0	5.0

RESERVOIR	ANN NAT RUNOFF (ACRE-FT)	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1270	12.0	4.0	40.5	26.0	4.5	2.0	2.0
2	4200	12.0	4.0	49.5	26.0	4.5	2.0	2.0
3	1830	12.0	6.0	49.5	26.0	4.5	2.0	2.0

MONTH	BASIN RUNOFF ABOVE INTAKE	GROSS RESERVOIR INFLOW	UNREG RUNOFF	NET INFLOW RES 1 500	RES 2 4000	RES 3 1000	RES 4	RES 5	RES 6	RES 7	RES 8	TOTAL INFLOW STRD	SPILL	AVAIL FOR DIVERS
OCT-MAR	1474	852	624	109	487	191						828	0	584
APR	492	284	208	44	138	87						239	0	208
MAY	6088	3514	2574	615	2017	790						3076	346	2920
JUN	3152	1846	1352	315	1020	408						1020	719	2071
JUL	653	310	234	30	97	40						97	86	320
AUG	246	142	104	8	3	11						3	10	123
SEP	244	142	104	16	39	20						39	36	140
ANNUAL	12259	7059	5200	1185	3001	1521						5300	1206	6406
CARRY-OVER STORAGE				0	1952	487								

MONTH	DEMAND ELL.	SPILL MCKIN.	DEMAND GLEN.	STRGE. MCKIN.	SPILL LAKE	ELLISON REQUD. STRGE.	ELLISON TRANS. LOSS	ELLISON STOR. USED	GLENMORE REQUD. STRGE.	GLENMORE TRANS. LOSS	GLENMORE STOR. USED	TOTAL STOR. USED	STRGE. IN PLACE
OCT-MAR	0	614	41	682	0	0	0	0	0	0	0	0	826
APR	0	208	12	778	0	0	0	0	0	0	0	0	1066
MAY	331	*2588	356	800	*1610	0	0	0	0	0	0	0	4141
JUN	365	*1708	1035	800	*653	0	0	0	0	0	0	0	5161
JUL	395	0	1152	300	0	75	16	89	652	130	782	872	4386
AUG	365	0	1057	300	0	240	48	288	1037	211	1248	1556	2833
SEP	127	15	374	300	0	0	0	0	341	72	433	433	2435
ANNUAL	1980	5141	4648		2263	815	68	578	2070	413	1485	2861	

*MAX. CAPACITY OF SYPHON AND FLUME TO MCKINLEY IS 1500 AC.FT./MONTH

*SPILL LAKE CONSISTS OF 1088+208 AT JOINT INTAKE AND 522+445 AT MCKINLEY RESERVOIR

YEAR: 1929

	MONTHLY DISTRIBUTION (%) OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
ANNUAL NAT RUNOFF ABOVE INTAKE = 6900 ACRE-FT	14.0	4.0	52.0	22.0	4.0	2.0	2.0
TRANSMISSION LOSS	0.0	5.0	0.0	30.0	20.0	20.0	0.0

RESERVOIR	ANN NAT RUNOFF (ACRE-FT)	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	773	14.0	4.5	52.0	22.0	4.0	2.0	2.0
2	2570	14.0	4.0	52.0	22.0	4.0	2.0	2.0
3	895	14.0	4.0	52.0	22.0	4.0	2.0	2.0

MONTH	BASIN RUNOFF ABOVE INTAKE	GROSS RESERVOIR INFLOW	UNREG RUNOFF	NET INFLOW RES 1 500	RES 2 4000	RES 3 1000	RES 4	RES 5	RES 6	RES 7	RES 8	TOTAL INFLOW STRD	SPILL	AVAIL FOR DIVERS
OCT-MAR	564	893	373	105	343	120						568	0	378
APR	276	170	106	25	73	27						128	0	106
MAY	3588	2204	1384	349	1274	440						2025	100	1484
JUN	[illegible]	932	586	165	494	177						568	468	1054
JUL	276	170	106	11	11	11						0	35	155
AUG	130	78	63	-1	-29	-3						-31	0	55
SEP	138	85	63	6	6	8						17	0	58
ANNUAL	6900	4239	2661	690	2172	780						3064	601	3262
CARRY-OVER STORAGE				0	1481	256								

MONTH	DEMAND ELL.	SPILL MCKIN.	DEMAND GLEN.	STRGE. MCKIN.	SPILL LAKE	ELLISON REQUD. STRGE.	ELLISON TRANS. LOSS	ELLISON STOR. USED	GLENMORE REQUD. STRGE.	GLENMORE TRANS. LOSS	GLENMORE STOR. USED	TOTAL STOR. USED	STRGE. IN PLACE
OCT-MAR	0	378	42	451	0	0	0	5	0	0	0	0	3007
APR	0	106	12	725	0	0	0	0	0	0	0	0	3191
MAY	552	1152	956	800	121	0	0	0	0	0	0	0	6140
JUN	365	691	1055	800	0	0	0	0	364	78	487	457	5081
JUL	395	0	1152	500	0	266	51	307	852	170	1022	1573	3757
AUG	363	0	1057	500	0	810	62	872	1057	211	1268	1640	2077
SEP	127	0	374	360	0	74	14	88	224	48	268	357	1787
ANNUAL	1580	1327	4648		121	687	181	708	2010	561	5571	4158	

YEAR: 1930

MONTHLY DISTRIBUTION(%)

ANNUAL NAT RUNOFF ABOVE INTAKE = 6400 ACRE-FT	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
	14.0	4.0	52.0	22.0	4.0	2.0	2.0
TRANSMISSION LOSS	0.0	0.0	0.0	20.0	20.0	20.0	0.0

RESERVOIR	ANN NAT RUNOFF (ACRE-FT)	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	719	14.0	4.0	52.0	22.0	4.0	2.0	2.0
2	2430	14.0	4.0	52.0	22.0	4.0	2.0	2.0
3	881	14.0	4.0	52.0	22.0	4.0	2.0	2.0

MONTH	BASIN RUNOFF ABOVE INTAKE	GROSS RESERVOIR INFLOW	UNREG RUNOFF	NET INFLOW RES 1 800	RES 2 4000	RES 3 1000	RES 4	RES 5	RES 6	RES 7	RES 8	TOTAL INFLOW STRD	SPILL	AVAIL FOR DIVERS	DEMAND ELL.	SPILL MCKIN.	DEMAND GLEN.	STRGE. MCKIN.	SPILL LAKE	ELLISON REQUD. STRGE.	ELLISON TRANS. LOSS	ELLISON STOR. USED	GLENMORE REQUD. STRGE.	GLENMORE TRANS. LOSS	GLENMORE STOR. USED	TOTAL STOR. USED	STRGE. IN PLACE
OCT-MAR	858	560	338	97	323	114						836	0	336	0	556	41	644	0	0	0	0	0	0	0	0	2271
APR	216	160	94	22	87	26						115	5	96	0	36	12	728	0	0	0	0	0	0	0	0	2567
MAY	3312	3086	1348	361	1201	428						1988	0	1248	332	916	356	685	0	0	0	0	0	0	0	0	4574
JUN	1408	220	520	143	483	188						651	223	651	365	258	1055	0	0	0	0	0	78	0	78	78	4347
JUL	256	160	94	9	5	9						14	9	105	395	0	1152	0	0	230	88	848	1152	230	1382	1730	3131
AUG	128	80	48	-2	-31	-4						-39	9	48	363	0	1037	0	0	515	63	578	1057	211	1268	1646	1546
SEP	128	20	48	6	3	8						11	2	80	127	0	374	0	0	77	15	92	374	75	449	541	1016
ANNUAL	6408	4008	2400	838	2031	744						3874	134	2834	1960	1636	4648			682	156	818	2661	516	5177	5595	
CARRY-OVER STORAGE				8	762	254																					

YEAR: 1931

MONTHLY DISTRIBUTION(%)

ANNUAL NAT RUNOFF ABOVE INTAKE = 5720 ACRE-FT	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
	14.0	4.0	52.0	22.0	4.0	2.0	2.0
TRANSMISSION LOSS	0.0	0.0	0.0	20.0	20.0	20.0	0.0

RESERVOIR	ANN NAT RUNOFF (ACRE-FT)	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	683	14.0	4.0	52.0	22.0	4.0	2.0	2.0
2	2218	14.0	4.0	52.0	22.0	4.0	2.0	2.0
3	782	14.0	4.0	52.0	22.0	4.0	2.0	2.0

MONTH	BASIN RUNOFF ABOVE INTAKE	GROSS RESERVOIR INFLOW	UNREG RUNOFF	NET INFLOW RES 1 800	RES 2 4000	RES 3 1000	RES 4	RES 5	RES 6	RES 7	RES 8	TOTAL INFLOW STRD	SPILL	AVAIL FOR DIVERS	DEMAND ELL.	SPILL MCKIN.	DEMAND GLEN.	STRGE. MCKIN.	SPILL LAKE	ELLISON REQUD. STRGE.	ELLISON TRANS. LOSS	ELLISON STOR. USED	GLENMORE REQUD. STRGE.	GLENMORE TRANS. LOSS	GLENMORE STOR. USED	TOTAL STOR. USED	STRGE. IN PLACE
OCT-MAR	801	807	293	88	292	102						482	0	293	0	255	42	251	0	0	0	0	0	0	0	0	1436
APR	229	145	84	20	58	22						130	0	84	0	84	12	825	0	0	0	0	0	0	0	0	1538
MAY	2974	1865	1089	374	1087	379						1793	0	1089	332	757	956	124	0	0	0	0	0	0	0	0	3551
JUN	1222	797	461	128	415	148						829	61	323	365	160	1058	0	0	0	0	0	771	0	771	771	3249
JUL	229	148	84	7	-3	5						2	7	90	395	0	1152	0	0	305	61	366	1152	230	1382	1748	1603
AUG	114	72	42	-3	-36	-8						-47	0	42	363	0	1057	0	0	321	64	385	1057	211	1268	1653	-197
SEP	114	72	48	3	0	3						8	0	42	127	0	374	0	0	86	17	102	374	75	449	551	-748
ANNUAL	5718	3863	2598	669	1013	882						6964	68	2103	1880	1294	4648		0	711	142	883	3354	516	8870	4725	

GLENMORE-ELLISON I.D. [illegible] STORAGE RUN [illegible]

NUMBER OF RESERVOIRS = 3

RESERVOIR	AREA (ACRES)	STORAGE CAPACITY (ACRE-FT)	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
			LAKE EVAPORATION IN INCHES						
1	48.0	800.0	0.90	1.80	3.30	3.80	4.90	4.30	2.40
2	224.0	4000.0	0.90	1.80	3.30	3.80	4.90	4.30	2.40
3	80.0	1000.0	1.80	1.70	3.40	3.99	0.80	4.40	0.80

1 SOUTH LAKE RESERVOIR
2 POSTILL LAKE RESERVOIR
3 [illegible] LAKE RESERVOIR

YEAR: MEAN YEAR

ANNUAL NAT RUNOFF ABOVE INTAKE = 12300 ACRE-FT

	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
MONTHLY DISTRIBUTION(%)	12.0	4.0	49.5	24.0	4.5	2.3	2.0
TRANSMISSION LOSS	0.0	0.0	0.0	20.0	20.0	20.0	0.0

RESERVOIR	ANN NAT RUNOFF (ACRE-FT)	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1270	12.0	4.0	49.8	26.0	4.5	2.0	2.0
2	4200	12.0	4.0	49.5	26.0	4.5	2.0	2.0
3	1430	12.0	4.0	49.5	26.0	4.5	2.0	2.0

MONTH	BASIN RUNOFF ABOVE INTAKE	GROSS RESERVOIR INFLOW	UNREG RUNOFF	NET INFLOW RES 1 800	RES 2 4000	RES 3 1000	RES 4	RES 5	RES 6	RES 7	RES 8	TOTAL INFLOW STRD	SPILL	AVAIL FOR DIVERS
OCT-MAR	1478	852	626	149	487	191						826	0	826
APR	452	284	208	44	136	87						235	0	208
MAY	6368	3814	2574	815	2017	790						3076	346	2920
JUN	3152	1846	1352	315	1020	404						1020	119	2071
JUL	553	319	234	36	97	48						97	86	320
AUG	246	142	104	8	3	11						3	19	123
SEP	246	142	104	14	39	20						39	36	140
ANNUAL	12256	7050	5200	1188	3001	1821						6300	1206	8406
CARRY-OVER STORAGE				0	1678	217								

MONTH	DEMAND ELL	SPILL MCKIN	DEMAND GLEN	STRG MCKIN	SPILL LAKE	ELLISON REQ'D STRG	ELLISON TRANS LOSS	ELLISON STRG USED	GLENMORE REQ'D STRG	GLENMORE TRANS LOSS	GLENMORE STRG USED	TOTAL STRG USED	STRG IN PLACE
OCT-MAR	0	624	42	582	0	0	0	0	0	0	0	0	826
APR	0	368	12	778	0	0	0	0	0	0	0	0	1063
MAY	332	*2868	1124	600	*1442	0	0	0	0	0	0	0	4142
JUN	363	*1768	1239	600	* 468	0	0	0	0	0	0	0	5162
JUL	385	0	1352	350	0	75	18	80	902	180	1082	1172	4087
AUG	163	0	1241	350	0	240	48	288	1241	218	1489	1777	2513
SEP	127	13	436	350	0	0	0	0	425	86	510	510	1842
ANNUAL	1580	5141	5446		1911	815	63	378	2568	818	3081	3439	

* max. capacity of syphon and flume to McKinley is 1500 ac.ft./month

YEAR: 1929

ANNUAL NAT RUNOFF ABOVE INTAKE = 4900 ACRE-FT

	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
MONTHLY DISTRIBUTION(%)	14.0	4.0	52.0	22.0	4.0	2.0	2.0
TRANSMISSION LOSS	0.0	0.0	0.0	20.0	20.0	20.0	0.0

RESERVOIR	ANN NAT RUNOFF (ACRE-FT)	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	773	14.0	4.0	52.0	22.0	4.0	2.0	2.0
2	2570	14.0	4.0	52.0	22.0	4.0	2.0	2.0
3	888	14.0	4.0	52.0	22.0	4.0	2.0	2.0

MONTH	BASIN RUNOFF ABOVE INTAKE	GROSS RESERVOIR INFLOW	UNREG RUNOFF	NET INFLOW RES 1 800	RES 2 4000	RES 3 1000	RES 4	RES 5	RES 6	RES 7	RES 8	TOTAL INFLOW STRD	SPILL	AVAIL FOR DIVERS
OCT-MAR	566	193	373	109	343	120						568	0	373
APR	276	170	106	25	73	27						124	0	106
MAY	3588	2204	1384	389	1274	440						2094	18	1402
JUN	1518	932	586	185	494	177						671	115	741
JUL	276	170	106	11	11	11						21	11	118
AUG	138	85	53	-1	-29	-3						-34	0	53
SEP	138	85	53	0	0	0						13	4	87
ANNUAL	8908	4238	2661	808	2178	788						3487	188	2880
CARRY-OVER STORAGE				0	260	86								

MONTH	DEMAND ELL.	SPILL MCKIN.	DEMAND GLEN.	STRGE. MCKIN.	SPILL LAKE	ELLISON REQUD. STRGE.	ELLISON TRANS. LOSS	ELLISON STOR. USED	GLENMORE REQUD. STRGE.	GLENMORE TRANS. LOSS	GLENMORE STOR. USED	TOTAL STOR. USED	STRGE. IN PLACE
OCT-MAR	0	573	42	681	0	0	0	0	0	0	0	0	1410
APR	0	106	12	778	0	0	0	0	0	0	0	0	2534
MAY	332	1070	1124	721	0	0	0	0	0	0	0	0	4628
JUN	361	578	1258	600	0	0	0	0	0	0	0	0	4411
JUL	395	0	1552	400	0	0	0	0	740	148	888	888	2718
AUG	343	0	1241	300	0	277	85	332	1162	250	1362	1714	943
SEP	127	0	438	300	0	510	62	372	1141	238	1369	1741	346
					0	T0	14	84	436	88	526	610	
ANNUAL	1580	1927	5448		0	687	181	788	3471	694	4165	4963	

YEAR: 1939

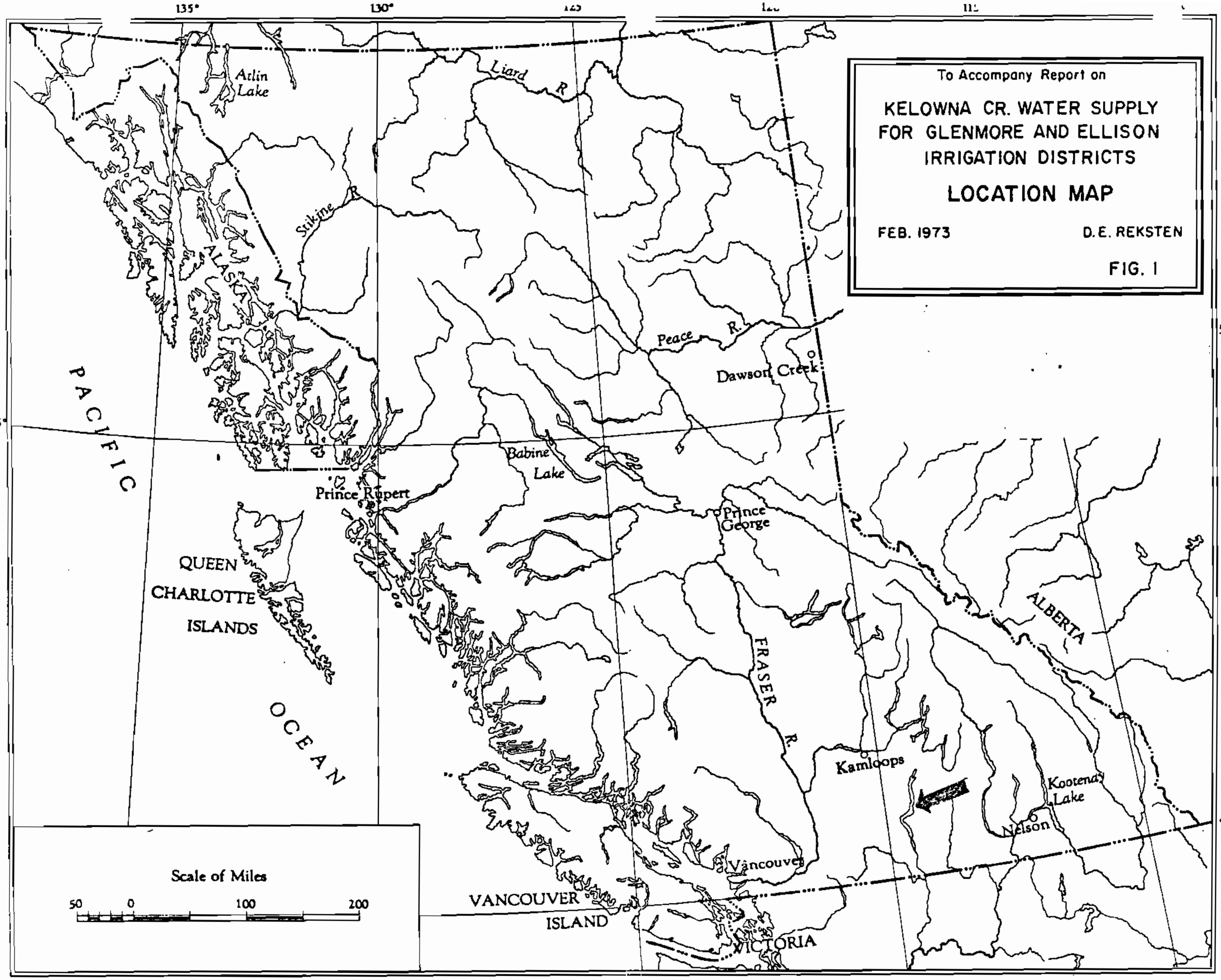
MONTHLY DISTRIBUTION

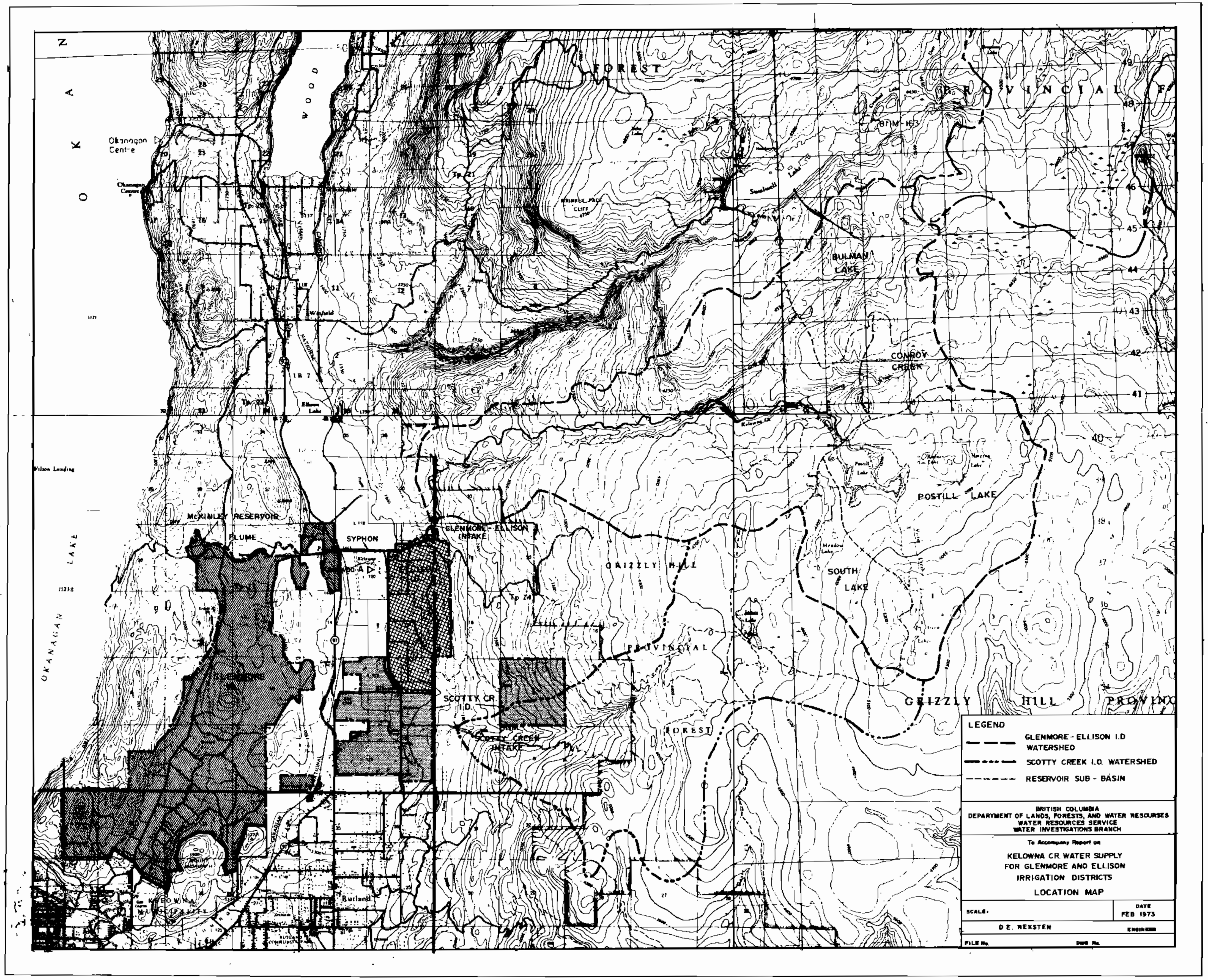
ANNUAL NET RUNOFF ABOVE INTAKE = 6400 ACRE-FT	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
	14.0	4.0	52.0	22.0	4.0	2.0	2.0
TRANSMISSION LOSS	0.0	0.0	0.0	20.0	20.0	20.0	0.0

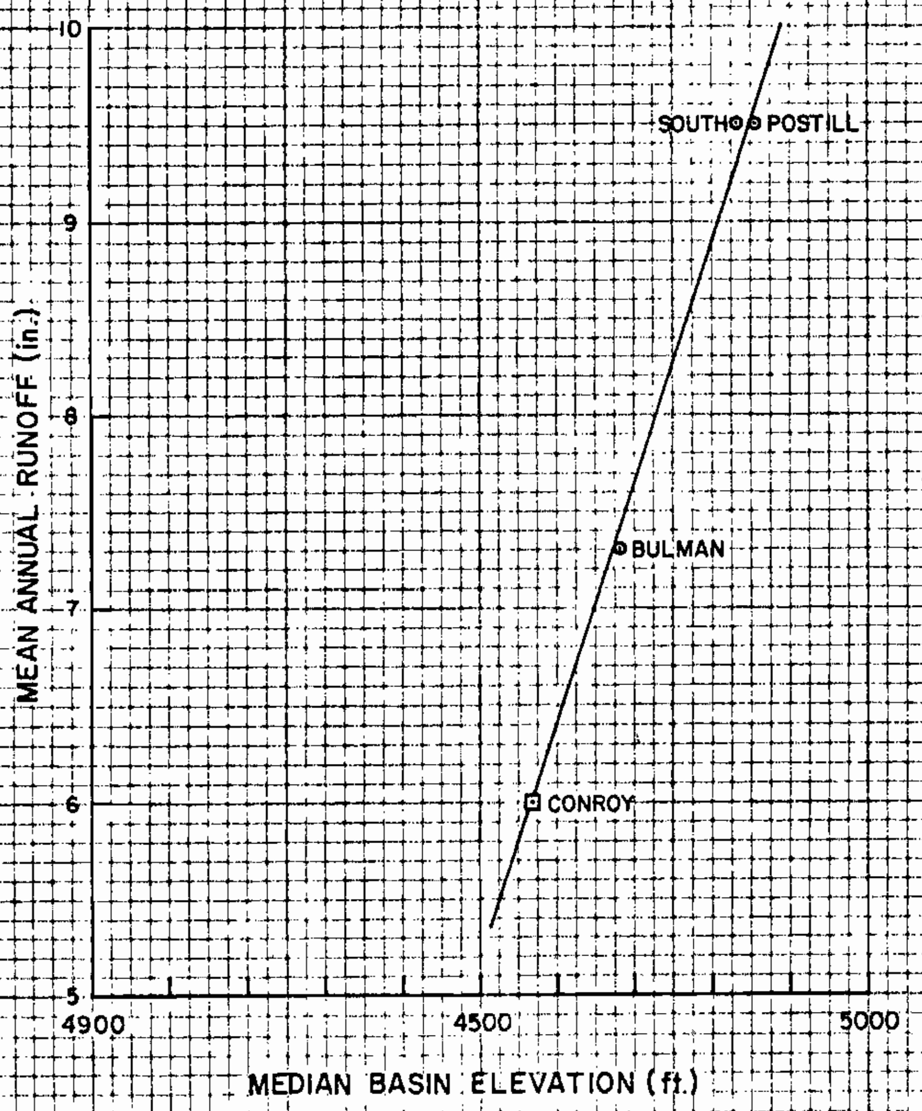
RESERVOIR	ANN NAT RUNOFF (ACRE-FT)	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	719	14.0	4.0	52.0	22.0	4.0	2.0	2.0
2	2430	14.0	4.0	52.0	22.0	4.0	2.0	2.0
3	851	14.0	4.0	52.0	22.0	4.0	2.0	2.0

MONTH	BASIN RUNOFF ABOVE INTAKE	GROSS RESER-VOIR INFLOW	UNREG RUNOFF	NET INFLOW RES 1 800	RES 2 4000	RES 3 1000	RES 4	RES 5	RES 6	RES 7	RES 8	TOTAL INFLOW STRO	SPILL	AVAIL FOR DIVERS
OCT-MAR	854	968	336	97	323	114						536	0	336
APR	224	160	96	22	67	76						115	0	96
MAY	3328	2020	1248	361	1201	426						1908	0	1248
JUN	1408	220	528	143	463	108						651	123	651
JUL	256	160	96	9	5	9						14	9	105
AUG	128	80	48	-2	-31	-4						-39	0	48
SEP	128	80	48	8	3	8						11	2	80
ANNUAL	8400	4000	0480	636	2031	764						3276	134	2834
CARRY-OVER STORAGE				8	0	0								

MONTH	DEMAND ELL.	SPILL MCKIN.	DEMAND GLEN.	STRGE. MCKIN.	SPILL LAKE	ELLISON REQUD. STRGE.	ELLISON TRANS. LOSS	ELLISON STOR. USED	GLENMORE REQUD. STRGE.	GLENMORE TRANS. LOSS	GLENMORE STOR. USED	TOTAL STOR. USED	STRGE. IN PLACE
OCT-MAR	0	156	42	534	0	0	0	0	0	0	0	0	880
APR	0	36	12	678	0	0	0	0	0	0	0	0	993
MAY	332	816	1114	470	0	0	0	0	0	0	0	0	2383
JUN	363	288	1239	0	0	0	0	0	481	96	577	577	3057
JUL	856	0	1351	0	0	290	58	348	1352	170	1622	1970	1101
AUG	563	0	1241	0	0	515	63	578	1241	248	1489	1867	-805
SEP	127	0	438	0	0	77	15	92	438	88	526	618	-1412
ANNUAL	1580	1656	5448		0	682	136	818	3812	702	4214	5032	


To Accompany Report on
KELOWNA CR. WATER SUPPLY
FOR GLENMORE AND ELLISON
IRRIGATION DISTRICTS
LOCATION MAP
FEB. 1973
D.E. REKSTEN
FIG. 1
Atlin Lake
Liard R.
Stikine R.
ALASKA
Peace R.
Dawson Creek
Babine Lake
Prince Rupert
Prince George
QUEEN CHARLOTTE ISLANDS
PACIFIC
OCEAN
FRASER R.
Kamloops
ALBERTA
Kootenay Lake
Nelson
Vancouver
VANCOUVER ISLAND
VICTORIA
Scale of Miles
50
0
100
200
135°
130°
125°
120°
115
55°
49


LEGEND
GLENMORE - ELLISON I.D WATERSHED
SCOTTY CREEK I.D. WATERSHED
RESERVOIR SUB - BASIN
BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURSES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH
To Accompany Report on
KELOWNA CR. WATER SUPPLY
FOR GLENMORE AND ELLISON
IRRIGATION DISTRICTS
LOCATION MAP
SCALE:
DATE
FEB 1973
D.E. REKSTEN
ENGINEER
FILE No.
DWG No.
OKANAGAN LAKE
WOOD
Okanagan Centre
McKINLEY RESERVOIR
FLUME
SYPHON
GLENMORE - ELLISON INTAKE
GRIZZLY HILL
PROVINCIAL FOREST
SCOTTY CR. I.D.
SCOTTY CREEK INTAKE
SOUTH LAKE
POSTILL LAKE
BULMAN LAKE
CONROY CREEK
Rutland
KELOWNA
Wilson Landing



BRITISH COLUMBIA DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES **WATER RESOURCES SERVICE** WATER INVESTIGATIONS BRANCH	To Accompany Report on KELOWNA CR. WATER SUPPLY FOR GLENMORE AND ELLISON IRRIGATION DISTRICTS D.E. REKSTEN	SCALE: VERT. HOR. DATE FEB. 1973 SURVEY BY: FILE No. DWG. No. FIG. 3

ADDENDUM

Further storage calculations were done at the request of the ARDA Division using revised demands and storage capacities to obtain data on possible changes to the system.

Run A1 incorporates the following changes (figures in brackets are those used in Run 1):

(a) Storage Capacities

South	560 acre-feet	(500)
Postill	4,065 acre-feet	(4,000)

(b) Demand (acre-feet) (Estimated 1973)

	Glenmore	Ellison
October-March	85	10
April	24	3
May	1,063	335
June	1,181	369
July	1,293	402
August	1,185	369
September	424	130
	5,255 (4,648)	1,618 (1,580)

(c) Initial Conditions

For the initial conditions in Run 1 and 2, it was assumed that the reservoirs were empty at the beginning (October 1) of the mean runoff year. For Run 1A it was assumed that the reservoirs were half full at the beginning of the first drought year (1929). In Run 1, the total storage in place at the beginning of the first drought year was 2,439 acre-feet. In Run 1A, the total storage in place is assumed to be 2,800 acre-feet, roughly half of the total storage capacity of 5,625 acre-feet.

Based on the above changes, the estimated 1973 demand could be satisfied until September of the second drought year (1930).

Run A2 was made to determine the additional storage required to satisfy the maximum projected demand. The storage capacities were increased arbitrarily by an amount estimated to satisfy the increased demand into the second drought year.

The following data were used (figures in brackets are those used in Run A1):

(a) Storage Capacities

South	1,060 acre-feet	(560)
Postill	5,565 acre-feet	(4,065)
Bulman	1,500 acre-feet	(1,000)

(b) Demand (acre-feet)

	Glenmore	Ellison
October-March	94	10
April	26	3
May	1,331	428
June	1,476	472
July	1,615	513
August	1,480	472
September	528	165
	6,550 (5,255)	2,063 (1,618)

(c) Initial Conditions

Same as Run 1A.

Under the above conditions a dependable water supply would be available until July of the second drought year. The feasibility of increasing the storage capacities of the three existing reservoirs was not considered. In any case, if one assumes that the optimum potential capacity of a reservoir is 80% of the mean annual inflow, Postill Lake and Bulman Lake would be over-developed with the assumed capacities and could not be used to their full potential. Based on present knowledge of the Kelowna Creek basin, it would appear that there is little possibility of increasing storage capacity to the degree necessary to satisfy the maximum projected demand during drought conditions.

Copies of the storage calculations are included in this addendum.

June 11, 1973

RUN A1

GLENMORE-ELLISON I.D.(KELOWNA CR) STORAGE RUN 123456789 (DEMAND A B.

NUMBER OF RESERVOIRS = 3

RESERVOIR	AREA (ACRES)	STORAGE CAPACITY (ACRE-FT)	L A K E E V A P O R A T I O N I N I N C H E S OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	48.0	560.0	0.90	1.60	3.30	3.80	4.90	4.30	2.40
2	276.0	4065.0	0.90	1.60	3.30	3.80	4.90	4.30	2.40
3	60.0	1000.0	1.00	1.70	3.40	3.90	5.00	4.40	2.50

YEAR: 1929

ANNUAL NAT RUNOFF ABOVE INTAKE = 6900 ACRE-FT

M O N T H L Y D I S T R I B U T I O N S	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
	14.0	4.0	52.0	22.0	4.0	2.0	2.0
TRANSMISSION LOSS	0.0	0.0	0.0	20.0	20.0	20.0	0.0

RESERVOIR	ANN NAT RUNOFF (ACRE-FT)							
1	773	14.0	4.0	52.0	22.0	4.0	2.0	2.0
2	2570	14.0	4.0	52.0	22.0	4.0	2.0	2.0
3	895	14.0	4.0	52.0	22.0	4.0	[illegible]	[illegible]

MONTH	BASIN RUNOFF ABOVE INTAKE	GROSS RESER-VOIR INFLOW	UNREG RUNOFF	NET INFLOW RES 1 560	RES 2 4065	RES 3 1000	RES 4	RES 5	RES 6	RES 7	RES 8	TOTAL INFLOW STRD	SPILL	AVAIL FOR DIVERS
	Assumed CARRYOVER			100	2200	500								
OCT-MAR	966	593	373	105	343	120						568	0	373
APR	276	170	106	25	73	27						124	0	106
MAY	3588	2204	1384	389	1274	448						1962	149	1533
JUN	1518	732	586	155	494	177						175	651	1237
JUL	276	170	106	11	11	11						0	33	139
AUG	138	85	53	-1	-29	-3						-34	0	53
SEP	138	85	53	6	6	5						17	0	53
ANNUAL	6900	4239	2661	690	2172	785						2812	833	3494
CARRY-OVER STORAGE				0	1385	165								

MONTH	DEMAND ELL.	SPILL MCKIN.	DEMAND GLEN.	STRGE. MCKIN.	SPILL LAKE	......ELLISON..... REQUD. STRGE.	TRANS. LOSS	STOR. USED	....GLENMORE.... REQUD. STRGE.	TRANS. LOSS	STOR. USED	TOTAL STOR. USED	STRGE. IN PLACE
				350									2800
OCT-MAR	10	363	85	628	0	0	0	0	0	0	0	0	3368
APR	3	103	24	707	0	0	0	0	0	0	0	0	3492
MAY	335	1159	1063	600	42	0	0	0	0	0	0	0	5454
JUN	369	666	1181	487	0	0	0	0	0	0	0	0	5629
JUL	402	0	1203	400	0	263	53	316	1206	241	1447	1763	3866
AUG	369	0	1185	300	0	316	63	379	1085	217	1302	1681	2151
SEP	130	0	424	300	0	77	15	92	424	85	509	601	1550
ANNUAL	1618	2532	5256		42	656	131	787	2716	548	3258	4046	

YEAR: 1930

ANNUAL NAT RUNOFF ABOVE INTAKE = 6400 ACRE-FT

M O N T H L Y D I S T R I B U T I O N S	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
	14.0	4.0	52.0	22.0	4.0	2.0	2.0
TRANSMISSION LOSS	0.0	0.0	0.0	20.0	20.0	20.0	0.0

RESERVOIR	ANN NAT RUNOFF (ACRE-FT)							
1	719	14.0	4.0	52.0	22.0	4.0	2.0	2.0
2	2430	14.0	4.0	52.0	22.0	4.0	2.0	2.0
3	851	14.0	4.0	52.0	22.0	4.0	2.0	2.0

MONTH	BASIN RUNOFF ABOVE INTAKE	GROSS RESER-VOIR INFLOW	UNREG RUNOFF	NET INFLOW RES 1 560	RES 2 4065	RES 3 1000	RES 4	RES 5	RES 6	RES 7	RES 8	TOTAL INFLOW STRD	SPILL	AVAIL FOR DIVERS
OCT-MAR	896	560	336	97	323	114						534	0	336
APR	256	160	96	22	67	26						115	0	96
MAY	3328	2080	1248	361	1201	426						1988	0	1248
JUN	1408	880	528	143	465	788						711	63	591
JUL	256	160	96	9	5	9						14	9	105
AUG	128	80	48	-2	-31	-4						-39	0	48
SEP	128	80	48	5	3	5						11	2	50
ANNUAL	6400	4000	2400	635	2031	744						3334	74	2474
CARRY-OVER STORAGE				0	0	0						0		

MONTH	DEMAND ELL.	SPILL MCKIN.	DEMAND GLEN.	STRGE. MCKIN.	SPILL LAKE	......ELLISON..... REQUD. STRGE.	TRANS. LOSS	STOR. USED	....GLENMORE.... REQUD. STRGE.	TRANS. LOSS	STOR. USED	TOTAL STOR. USED	STRGE. IN PLACE
				300									1550
OCT-MAR	10	326	85	541	0	0	0	0	0	0	0	0	2084
APR	3	93	24	610	0	0	0	0	0	0	0	0	2199
MAY	335	913	1063	460	0	0	0	0	0	0	0	0	4187
JUN	369	222	1181	0	0	0	0	0	493	100	593	593	4239
JUL	402	0	1253	0	0	297	59	356	1293	259	1652	1508	2405
AUG	369	0	1185	0	0	321	64	385	1185	237	1422	1807	563
SEP	120	0	424	0	0	80	16	96	424	85	509	606	-35
ANNUAL	1616	1554	5256		0	698	139	837	3401	681	4082	4919	

RUN A2

GLENMORE-ELLISON I.D. (KELOWNA CR) STORAGE RUN 123456789 (DEMAND A & B)

NUMBER OF RESERVOIRS = 3

RESERVOIR	AREA (ACRES)	STORAGE CAPACITY (ACRE-FT)	LAKE EVAPORATION IN INCHES: OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	45.0	1060.0	0.90	1.60	3.30	3.80	4.90	4.30	2.40
2	220.0	5565.0	0.90	1.60	3.30	3.80	4.90	4.30	2.40
3	60.0	1500.0	1.00	1.70	3.40	3.90	5.00	4.40	2.50

YEAR: 1929

ANNUAL NAT RUNOFF ABOVE INTAKE = 6900 ACRE-FT

	MONTHLY DISTRIBUTION (%): OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
	14.0	4.0	52.0	22.0	4.0	2.0	2.0
TRANSMISSION LOSS	0.0	0.0	0.0	20.0	20.0	20.0	0.0

RESERVOIR	ANN NAT RUNOFF (ACRE-FT)	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	773	14.0	4.0	52.0	22.0	4.0	2.0	2.0
2	2570	14.0	4.0	52.0	22.0	4.0	2.0	2.0
3	895	14.0	4.0	52.0	22.0	4.0	2.0	2.0

MONTH	BASIN RUNOFF ABOVE INTAKE	GROSS RESERVOIR INFLOW	UNREG RUNOFF	NET INFLOW RES 1 (1060)	RES 2 (5565)	RES 3 (1500)	RES 4	RES 5	RES 6	RES 7	RES 8	TOTAL INFLOW STRD	SPILL	AVAIL FOR DIVERS
Assumed carry-over				500	2500	700								
OCT-MAR	966	593	373	105	343	120						568	0	373
APR	276	170	106	25	73	27						124	0	106
MAY	3588	2236	1384	389	1274	448						2111	0	1384
JUN	1518	932	586	155	494	177						826	0	586
JUL	276	170	106	11	11	11						33	0	106
AUG	138	85	53	-1	-29	-3						-34	0	53
SEP	138	85	53	6	6	5						17	0	53
ANNUAL	6900	4239	2661	590	2172	785						3645	0	2661
CARRY-OVER STORAGE				0	300	237						0		

MONTH	DEMAND ELL.	SPILL MCKIN.	DEMAND GLEN.	STRGE. MCKIN.	SPILL LAKE	ELLISON REQUD. STRGE.	ELLISON TRANS. LOSS	ELLISON STOR. USED	GLENMORE REQUD. STRGE.	GLENMORE TRANS. LOSS	GLENMORE STOR. USED	TOTAL STOR. USED	STRGE. IN PLACE
				350									3700
OCT-MAR	10	273	94	525	0	0	0	0	0	0	0	0	4268
APR	3	103	26	606	0	0	0	0	0	0	0	0	4392
MAY	418	366	1431	300	0	0	0	0	63	14	83	83	6420
JUN	472	228	1476	0	0	0	0	0	948	190	1138	1138	5594
JUL	513	0	1615	0	0	407	81	488	1615	323	1938	2426	3601
AUG	472	0	1480	0	0	419	84	503	1480	296	1776	2279	1288
SEP	165	0	528	0	0	112	22	134	528	106	634	768	537
ANNUAL	2043	1560	6650		0	938	187	1125	4640	929	5569	6694	

YEAR: 1930

ANNUAL NAT RUNOFF ABOVE INTAKE = 6400 ACRE-FT

	MONTHLY DISTRIBUTION (%): OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
	14.0	4.0	52.0	22.0	4.0	2.0	2.0
TRANSMISSION LOSS	0.0	0.0	0.0	20.0	20.0	20.0	0.0

RESERVOIR	ANN NAT RUNOFF (ACRE-FT)	OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
1	719	14.0	4.0	52.0	22.0	4.0	2.0	2.0
2	2430	14.0	4.0	52.0	22.0	4.0	2.0	2.0
3	851	14.0	4.0	52.0	22.0	4.0	2.0	2.0

MONTH	BASIN RUNOFF ABOVE INTAKE	GROSS RESERVOIR INFLOW	UNREG RUNOFF	NET INFLOW RES 1 (1060)	RES 2 (5565)	RES 3 (1500)	RES 4	RES 5	RES 6	RES 7	RES 8	TOTAL INFLOW STRD	SPILL	AVAIL FOR DIVERS
OCT-MAR	896	560	336	97	323	114						534	0	336
APR	256	160	96	22	67	26						115	0	96
MAY	3328	2080	1248	361	1201	426						1988	0	1248
JUN	1408	880	528	143	463	168						774	0	528
JUL	256	160	96	9	5	9						23	0	96
AUG	128	80	48	-2	-31	-6						-39	0	48
SEP	128	80	48	5	3	5						13	0	48
ANNUAL	6400	4000	2400	635	2031	744						3408	0	2400
CARRY-OVER STORAGE				0	0	0						0		

MONTH	DEMAND ELL.	SPILL MCKIN.	DEMAND GLEN.	STRGE. MCKIN.	SPILL LAKE	ELLISON REQUD. STRGE.	ELLISON TRANS. LOSS	ELLISON STOR. USED	GLENMORE REQUD. STRGE.	GLENMORE TRANS. LOSS	GLENMORE STOR. USED	TOTAL STOR. USED	STRGE. IN PLACE
OCT-MAR	10	526	94	232	0	0	0	0	0	0	0	0	1071
APR	3	95	26	293	0	0	0	0	0	0	0	0	1166
MAY	414	620	1431	0	0	0	0	0	212	42	254	254	2320
JUN	472	56	1476	0	0	0	0	0	1420	284	1704	1704	1990
JUL	516	0	1615	0	0	417	83	500	1616	323	1938	2438	-425
AUG	472	0	1480	0	0	424	85	509	1480	296	1776	2285	-2710
SEP	165	0	528	0	0	117	23	140	628	106	634	774	-3484
ANNUAL	2043	1236	6660		0	958	191	1149	5255	1051	6306	7455	

APPENDIX

STORAGE CALCULATIONS

The method of calculating month-end storage for Glenmore - Ellison reservoirs is best explained with reference to Fig. A1 and Table A1. The computer program for these calculations was derived by R. Wyman of the Hydrology Division. Because McKinley reservoir is downstream of the joint intake, some of the calculations were done by hand. The numbers below refer to the columns in Table A1.

The natural runoff, for the whole basin above the intake is estimated (1). From this is subtracted the total natural runoff into each reservoir sub-basin (2) to obtain the unregulated runoff (3). From the natural reservoir basin runoff, lake evaporation is subtracted to yield net inflow for each reservoir (4, 5 and 6). The net inflow stored each month for each reservoir is totalled (7) until the reservoirs reach their capacity and net inflow must be spilled (8). What is available each month at the intake (9) is the sum of spill (8) and unregulated runoff (3).

At this point it is assumed that Ellison I.D. demand (10) is taken off first. What is left is spilled to the balancing reservoir (11) up to the flume and syphon capacity of 1500 ac-ft. per month. The amount that cannot be handled is assumed to be lost to Kelowna Creek and included in spill to lake (14). From spill to McKinley, Glenmore I.D. demand (12) is taken and the rest goes to filling McKinley reservoir (13). When McKinley is full (800 ac-ft.), water is spilled to Okanagan Lake (14).

The storage required for Ellison demand (15) is obtained by subtracting what is available at the intake (9) from the monthly demand(10). (If (9) is greater than (10), no storage is required.) A transmission loss of 20% of required storage during July - September (16) is added to the required storage (15) to obtain the storage used (17).

The storage required to satisfy the Glenmore I.D. demand (12) can be supplied either from upstream storage or the balancing (McKinley) reservoir. If Glenmore demand (12) is less than the spill to McKinley (11), no storage is required (18); in this case up to the end of June. In July, when storage is required, it is assumed that 450 ac-ft. are used from McKinley reservoir (13) and the balance is taken from upstream storage (18). The transmission loss (19) is added to this to obtain the storage used from upstream reservoirs (20). The storage used for Ellison I.D. (17) and Glenmore I.D. (20) are summed to yield the total upstream storage used (21). The storage in place (22) is the accumulated sum of the monthly total inflow stored (7) from which total storage used (21) is subtracted each month. This does not include the storage used from McKinley reservoir.

At the end of September in this example a total of 1842 ac-ft. is left in the 3 reservoirs. An assumed distribution of this carry-over storage to each reservoir must be made to begin calculations for the next year. This can be done on any basis as long as the 3 carry-over storages add up to 1842 ac-ft. In this example, reservoir 1 is assumed to be emptied because it has a high inflow in relation to its capacity (4). The other two are assumed to retain about 37% of their capacity in storage.

Calculations for the next year will take into account these carry-over storage amounts in each reservoir.

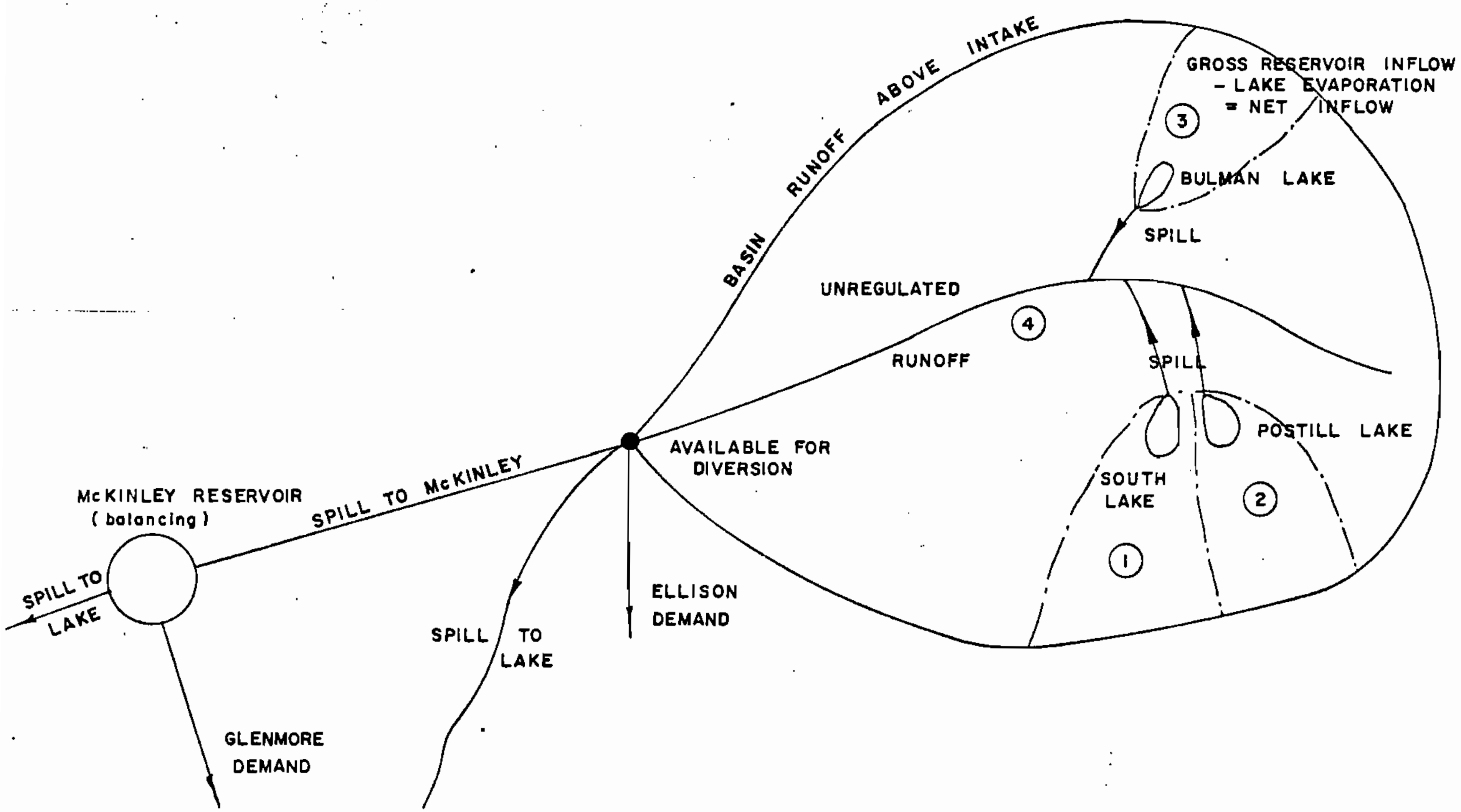
TABLE A1 Storage Calculation Example

YEAR: MEAN YEAR — MONTHLY DISTRIBUTION, %

		OCT-MAR	APR	MAY	JUN	JUL	AUG	SEP
ANNUAL NAT RUNOFF ABOVE INTAKE = 12300 ACRE-FT		12.0	6.0	49.8	26.0	4.5	2.0	2.0
TRANSMISSION LOSS		0.0	0.0	0.0	20.0	20.0	25.0	0.0
RESERVOIR	ANN NAT RUNOFF (ACRE-FT)							
1	1270	12.0	4.0	49.5	26.0	4.5	2.0	2.0
2	4200	12.0	4.0	49.5	26.7	4.5	2.9	2.0
3	1030	12.0	0.0	40.5	26.6	0.0	2.0	2.0

MONTH	1 BASIN RUNOFF ABOVE INTAKE	2 GROSS RESERVOIR INFLOW	3 UNREG RUNOFF	4 RES 1 800	5 RES 2 4000	6 RES 3 1000	NET INFLOW RES 4	RES 5	RES 6	RES 7	RES 8	7 TOTAL INFLOW STRG	8 SPILL	9 AVAIL FOR DIVERS	10 DEMAND ELL	11 SPILL MCKIN	12 DEMAND GLEN	13 STRG MCKIN	14 SPILL LAKE	15 ELLISON REC'D STRG	16 ELLISON TRANS LOSS	17 ELLISON STRG USED	18 GLENMORE REC'D STRG	19 GLENMORE TRANS LOSS	20 GLENMORE STRG USED	21 TOTAL STRG USED	22 STRG IN PLACE
OCT-MAR	1476	852	626	140	407	191						826	0	626	0	624	41	982	0	0	0	0	0	0	0	0	826
APR	452	304	208	46	130	57						239	0	208	0	210	13	778	0	0	0	0	0	0	0	0	1065
MAY	6076	3514	2574	615	2017	790						3076	340	2920	932	*2588	1124	800	*1442	0	0	0	0	0	0	0	4141
JUN	3155	1848	1352	315	1020	404						1920	714	2077	163	*1700	1237	800	*645	0	0	0	0	0	0	0	5162
JUL	513	319	234	28	97	48						97	80	379	195	0	1352	350	0	75	19	80	907	190	1051	1175	4087
AUG	246	147	106	8	3	11						3	10	123	363	0	1241	350	0	240	48	288	1241	248	1489	1777	1312
SEP	244	142	106	16	30	20						39	38	140	127	13	436	350	0	0	0	0	415	88	810	910	1848
ANNUAL	12250	7859	5200	1168	3901	1081						8300	1288	6406	1980	5141	6448		1911	315	68	378	2560	515	3351	5433	
CARRY-OVER STORAGE				0	1678	217																					

* max. capacity of syphon and flume to McKinley is 1300 ac.ft./month



BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH

TO ACCOMPANY REPORT ON
KELOWNA CR. WATER SUPPLY FOR GLENMORE AND ELLISON IRRIGATION DISTRICTS

WATERSHED MODEL FOR STORAGE CALCULATIONS

SCALE: VERT. .... HOR. .... DATE ....

D.E. REKSTEN ENGINEER

FILE No. .... DWG. No. FIG A.I

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