DRAFT

PRELIMINARY REPORT
ON
OPERATION OF OKANAGAN LAKE

1. SCOPE

Further to a memorandum from T.A.J. Leach to H.I. Hunter, the author was asked to investigate the possible operation of Okanagan Lake - particularly with respect to years of higher than average inflow. The possibility of changing the rule curves such that Okanagan Lake could be drawn down below its normal lower limit in anticipation of a flood is examined.

2. ASSUMPTION AND DATA

2.1 Maximum Channel Capacity

While Okanagan River immediately south of the Okanagan Lake Dam has a nominal capacity of 2,100 cfs, experience has shown that it is not possible to utilize more than 70% of this over sustained periods. It has therefore been assumed that maximum discharges on a mean monthly basis from Okanagan Lake are 70% of 2,100 or 1,470 cfs. In fact, during the 1972 operation, in the period March through July, releases totalling 72.5% of channel capacity were achieved. In some of these months, however, it was not found possible to release as much as 70% with other months achieving more than 70% - e.g., only 63% was released in May while 94% was released in July. For ease of computation, however, it is assumed that 70% of channel capacity could be achieved in any month. Some calculations are made which assume 80% channel capacity utilization (1,680 cfs) as this could probably be achieved if some relatively minor improvements were made in the river channel and other problem areas such as Tugulnuit Lake.

2.2 Minimum Releases

As the period discussed in the report is part or all of the period February through June, it was originally assumed that lateral inflows downstream of Penticton would be sufficient to provide for the withdrawals and residual flows. A steady release of 100 cfs was assumed from Penticton. However, examination of the 1973 operation shows that the lateral flows were not sufficient to operate the system with only 100 cfs released at Penticton and that higher discharges were necessary during the whole runoff period. Accordingly, in the following calculations minimum releases at Penticton are assumed to be:

Month	Avg. Min. Flow (cfs)	
February	100	57,000 ac.-ft.
March	100	
April	250	
May	250	
June	250	

2.3 Flood and Drought Probabilities

Where likely return periods of various magnitudes of floods or droughts are quoted, the figures are taken from frequency curves of April-July net inflows prepared by J.G. Zalanfy dated October 10, 1973. These curves are for both "exceedence" and "non-exceedence" return periods.

2.4 Lake Elevations

Okanagan Lake elevations in this report are referred to on a scale with a "normal maximum" elevation of 4.0 feet and a "normal minimum" of 0.0 feet. This normal minimum corresponds to elevation 1119.8 on the C.G.S. datum.

3. THE PROBLEM

It is not the purpose of this report to examine the operation of Okanagan Lake during "normal" years nor during the period April-June of any year. Rather, this report examines some possible operating procedures for the period up to the beginning of April, particularly with respect to very high inflow years.

While a few snow courses are sampled at the beginning of January, the majority are not measured prior to the beginning of February. This means that, unless there were a phenomenally large snowpack indicated by the January snow survey, it has to be assumed that every year in an average year until the beginning of February. Thus, when there is an excess of water at the end of an irrigation season, it is necessary to look ahead to the following February and select a target elevation for the lake. If the lake is below this target elevation, then the discharges would obviously be kept to a minimum throughout the winter to conserve as much water as possible in an attempt to keep the lake as close to the target elevation as possible.

Obviously, the target elevation has to be the elevation which, in the operator's opinion, best balances the risks of flooding and shortages. Once forecasts of the coming year's inflow are available, the lake can be drawn down if required to accommodate a flood or kept as high as possible to conserve water for use later in the year. The selection of this target elevation is discussed in the following paragraphs.

4. HISTORIC OPERATION

Since the completion of the existing dams and river channel in about 1956, the lake level on February 1 has averaged +0.94 feet and in the ten-year period 1963-72 has averaged +1.03 feet. During this time only once, in 1972, has the lake level gone out of the normal four-foot range. During this period inflows have, in general, been remarkably normal with only single year droughts (such as 1970 and 1973) and the one major flood in 1972. The operating policy has been to keep the lake at close to the +1.0-foot level through February (~~or~~ average March 1 elevation +0.81) with, on average, a slight reduction in lake level during March to an average April 1 elevation of +0.63 feet. When major floods have been anticipated, such as in 1967 and 1972, the reservoir has been drawn down to about its normal lower limit by the beginning of May, but this has been considered the lowest "allowable" level, although there appears to be no legal constraint to this effect.

As stated above, the first major snow survey of the year is undertaken at the beginning of February, but since, an average, the water equivalent of the snowpack at that time is only about two-thirds of its maximum, it is not meaningful to make a quantitative forecast of the likely inflow to the lake for that year. Obviously, if the snowpack is either very light compared with previous February surveys or is very heavy compared with either previous February surveys or with, say, normal April 1 snowpacks, it is possible to make qualitative predictions as to the coming inflow. This is, in practice, done as can be shown by the following quotations from the February Snow Survey Bulletins for 1972 and 1973:

1972: "At this early date......(inflow) is expected to be above average. ......Okanagan Lake will be lowered......to accommodate the expected inflow."

1973: "The early indication is for below normal......runoff. ......Minimum daily discharge from the lake is being maintained in order to conserve water."

Thus, in extreme flood and drought years such as 1972 and 1973, it is possible to act on the indications given by the February snow survey and either draw down the lake to provide storage for high inflows or cut back on releases to conserve as much water as possible.

The March 1 snow survey allows the first quantitative forecast of volume inflow to be made. If the expected inflow is not exceptional, the operation of the lake is based on experience with the object of getting the lake as close to full as possible without causing flooding. This has, in general, been successfully achieved for the last 15 years or so and, while more formalised methods of decision-making (such as that proposed by S.O. Russell in Chapter XI of Technical Supplement No. II of the Okanagan Basin Study) are available, it will take some time to gain confidence in them and for their viability in the Okanagan to be proven. In exceptionally wet or dry years the operation at this stage becomes obvious with the release of either the maximum or the minimum possible volume of water respectively.

5. FEBRUARY 1 TARGET ELEVATION

5.1 Maximum Runoffs

If Okanagan Lake were at elevation +1.5 feet on February 1, the maximum volume of runoff that could be accommodated to the end of June would be 652,000 acre-feet. This assumes a steady release of 1,470 cfs from the lake. With 80% channel capacity utilized, this figure rises to 713,000 acre-feet. If it is assumed that February-March inflows are average (a total of 29,000 cfs), the adjusted April-June inflow volumes have return periods of about 45 and 70 years respectively. Lowering the target elevation for February 1 by six inches to +1.0 feet and making the same assumptions would mean that floods with return periods of about 50 and 100 years could be accommodated for 70% and 80% channel capacities respectively. The following table summarizes these figures and shows the levels to which Okanagan Lake would be drawn down by April 1.

DATE	CHANNEL CAPACITY					
	70% (1,470 cfs)			80% (1,680 cfs)		
	LEVEL	VOLUME	RETURN PERIOD	LEVEL	VOLUME	RETURN PERIOD
1 February	1.50	652,000	45 years	1.50	713,000	70 years
1 March	0.65			0.50		
1 April	-0.22			-0.52		
1 February	1.00	665,000	50 years	1.00	726,000	100 years
1 March	0.15			0.00		
1 April	-0.72			-1.02		

5.2 Minimum Runoffs

With a February 1 starting elevation of +1.5 feet the minimum volume required to fill the lake, assuming minimum releases, would be 267,000 acre-feet. Alternatively, to fill the lake to the +3-foot level (which provides

252,000 acre-feet of stored water) would require an inflow of 187,000 acre-feet. Assuming average February-March inflows, it appears that insufficient flows would occur one year in 3.4 to fill the lake to +4 and one year in nine to reach the +3 level.

Similarly, with a February 1 starting elevation of +1.0, flows of 310,000 and 226,000 acre-feet would be required to fill the lake to +4 and +3 respectively. These volumes are associated with "failure rates" of one in two and one in 4.5 years respectively. It is of interest to note that the average maximum lake elevation for the ten-year period 1962-71 was only +2.9 feet with an average February 1 elevation of 1.03 feet.

6. 1972 OPERATION

The above quotation from the February, 1972 Snow Survey Bulletin shows that the abnormal nature of the snowpack was recognized at an early date. However, as a result of the accepted operating rule at the time that the lake should not be drawn down below elevation 0.0 in anticipation of the flood, releases during February, March and April were set such that the lake was very close to its normal lower limit on May 1. The following table compares the actual operation with what might have been achieved if the restriction on drawdown had been ignored. Also, for interest, the effects of increasing the channel capacity from 70% to 80% of its design capacity and of starting at a higher elevation (+1.50 feet) on February 1 are illustrated.

DATE	ACTUAL INFLOW (kaf)	OUTFLOW (kaf)			LAKE LEVEL				
		ACTUAL 1972	CHANNEL CAPACITY %		ACTUAL 1972	CHANNEL CAPACITY %			
			70	80		70	80	70	80
February 1					1.18	1.18	1.18	1.50	1.50
	16.6	48.6	82.4	94.0					
March 1					0.77	0.40	0.26	0.72	0.68
	47.0	80.7	91.2	104.0					
April 1					0.32	-0.12	-0.42	0.20	0.00
	51.2	83.2	88.3	101.0					
May 1					-0.05	-0.56	-1.01	-0.24	-0.59
	320.5	82.2	91.2	104.0					
June 1					3.04	2.16	1.55	2.48	1.97
	266.2	97.0	88.3	101.0					
July 1					4.84	4.27	3.51	4.64	3.93

The advantages to be gained by increasing the capacity of the river channel to 80% of its design flow for a sustained period are clear from the above figures as the examples in which this increased capacity is assumed are the only ones in which flooding does not occur. The fact that the lake could have been as high as 1.50 and still contained the 1972 runoff within the normal upper limit, assuming the increased capacity is of interest as the 1972 flood, is believed to have a return period of about 75 years.

7. CONCLUSIONS

There does not appear to be any reason why Okanagan Lake should not be drawn down below its present normal lower limit in anticipation of a major flood. Indications of an extremely heavy snowpack from the snow surveys of either the beginning of February or March should be acted on by releasing as much water as possible from Okanagan Lake. Should subsequent precipitation be below normal resulting in the "normalization" of the snowpack, no real harm would have been done as it is improbable that the final runoff would be below normal and there would, therefore, be enough runoff to fill the lake. In theory, this means that with no channel improvements all floods, except 1 in 45 years, could be contained. In practice, of course, there is little defence against a flood of the type that occurred in 1948 where a "normal" snowpack until April was followed by a late melt and abnormally high late spring and early summer precipitation. A rare event like this, which cannot be predicted, would almost certainly result in flooding using any normal set of operating rules and is a risk that has to be accepted.

If the Okanagan River channel were improved to allow 80% of the channel capacity to be utilized, the lake could be drawn down by as much as one foot below its normal lower limit prior to the start of the freshet if a very heavy inflow were expected. The 1972 runoff could have been contained with the maximum lake level not exceeding the normal top elevation (+4.0) if this extra channel capacity had been available.

It would appear that the February 1 target elevation for the lake - which has to be selected assuming an average inflow year - should be somewhat higher than has been used in the past. The exact elevation chosen - which cannot, of course, always be achieved following a year of below average runoff - depends on the value judgement of the relative "desirability" of floods and shortages. This "value judgement" can be formalized by using Baysian decision theory and a model such as that proposed in Technical Supplement No. II to the Okanagan Basin Study. At present this model is not set up to operate at as early a stage in the year as the beginning of February, but work is in hand to enable this model to be used to determine the optimum target elevation for February 1. This will use the utility curve developed for the Okanagan Study with a "forecast" of the historic average February-June inflow and historic standard deviation.

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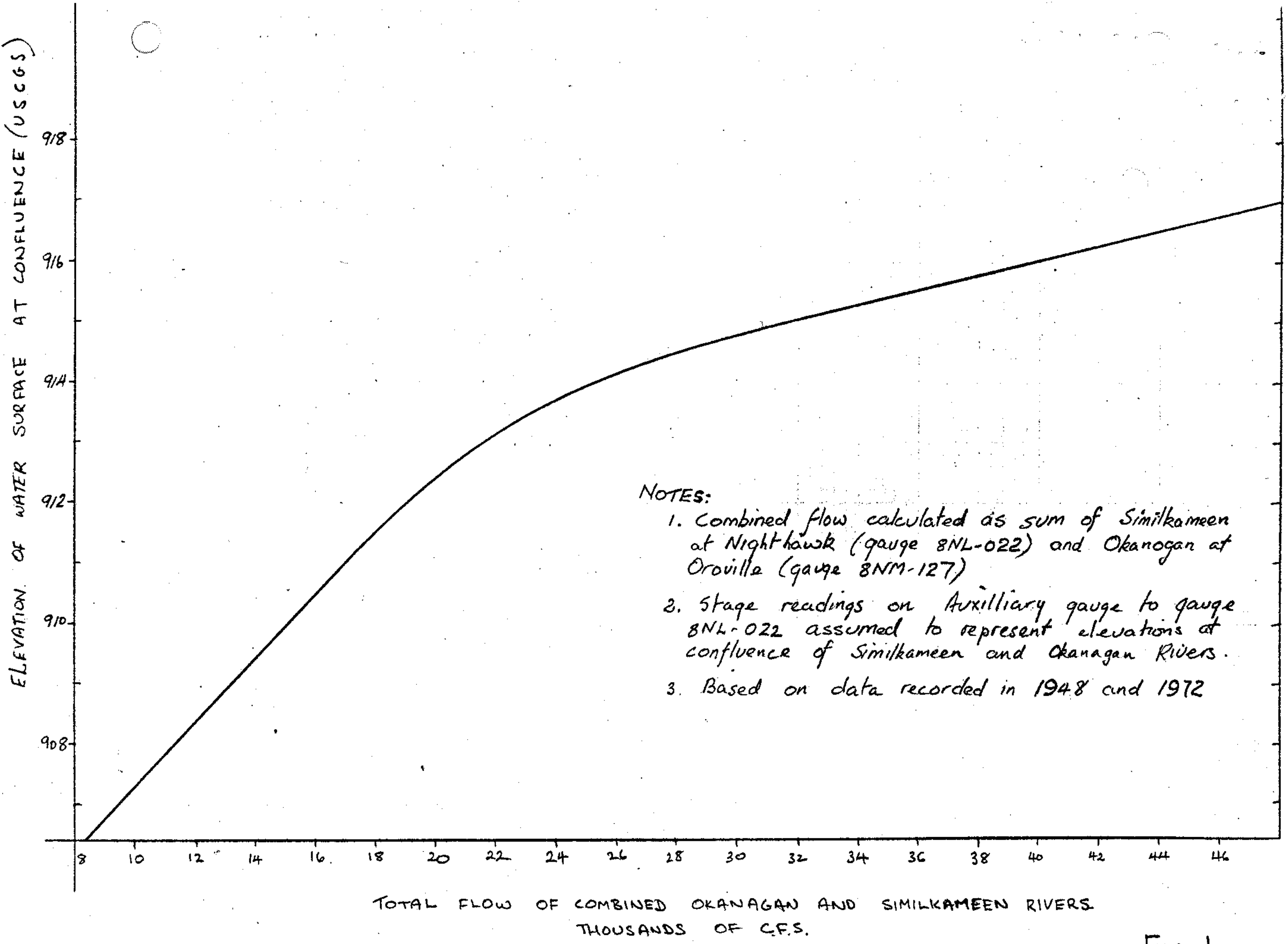
RYMcN/js

November, 1973



NOTES:

1. Combined flow calculated as sum of Similkameen at Nighthawk (gauge 8NL-022) and Okanogan at Oroville (gauge 8NM-127)
2. Stage readings on Auxilliary gauge to gauge 8NL-022 assumed to represent elevations at confluence of Similkameen and Okanagan Rivers.
3. Based on data recorded in 1948 and 1972

FIG 1.

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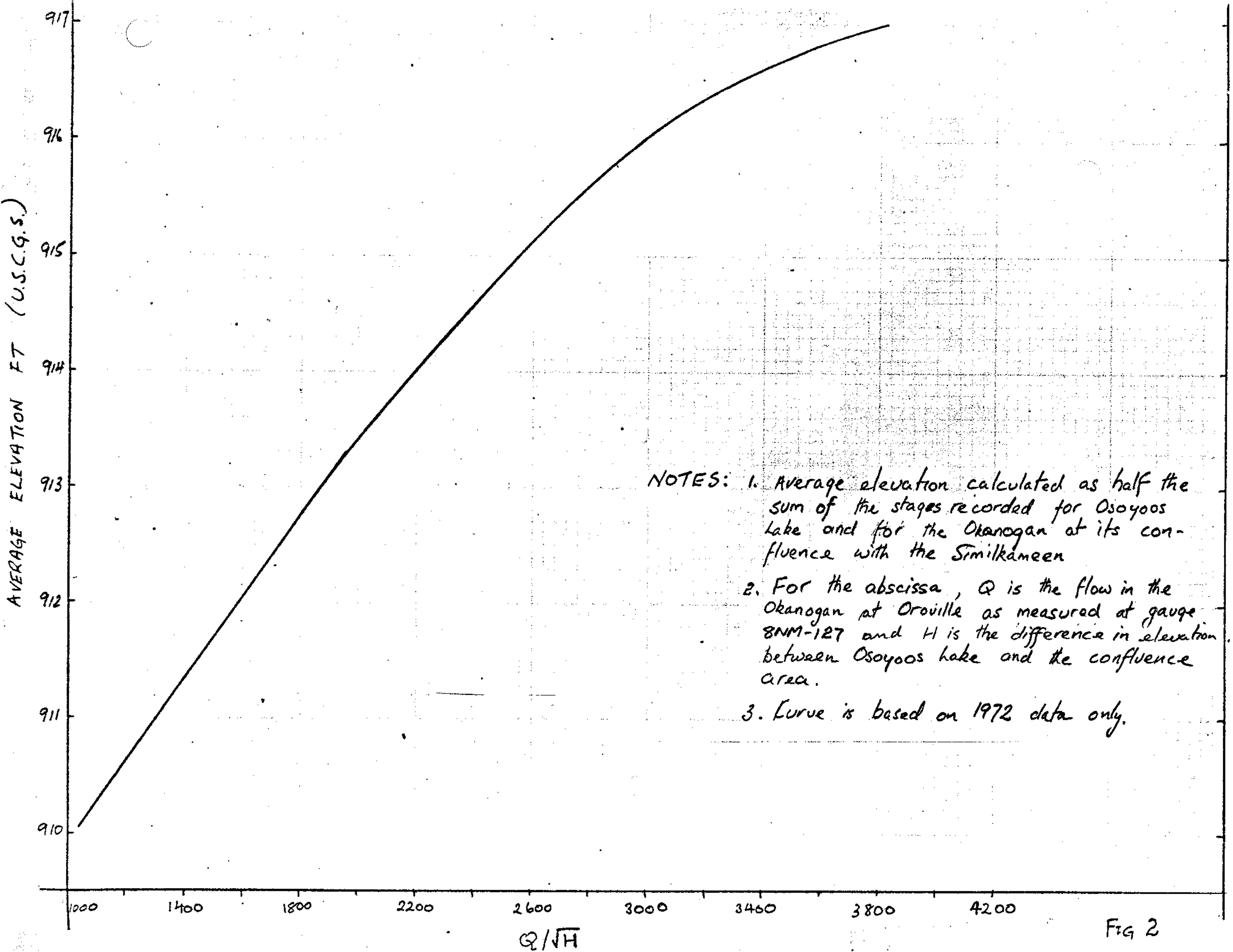

NOTES:
1. Average elevation calculated as half the sum of the stages recorded for Osoyoos Lake and for the Okanogan at its confluence with the Similkameen
2. For the abscissa, Q is the flow in the Okanogan at Oroville as measured at gauge 8NM-127 and H is the difference in elevation between Osoyoos Lake and the confluence area.
3. Curve is based on 1972 data only.

FIG 2

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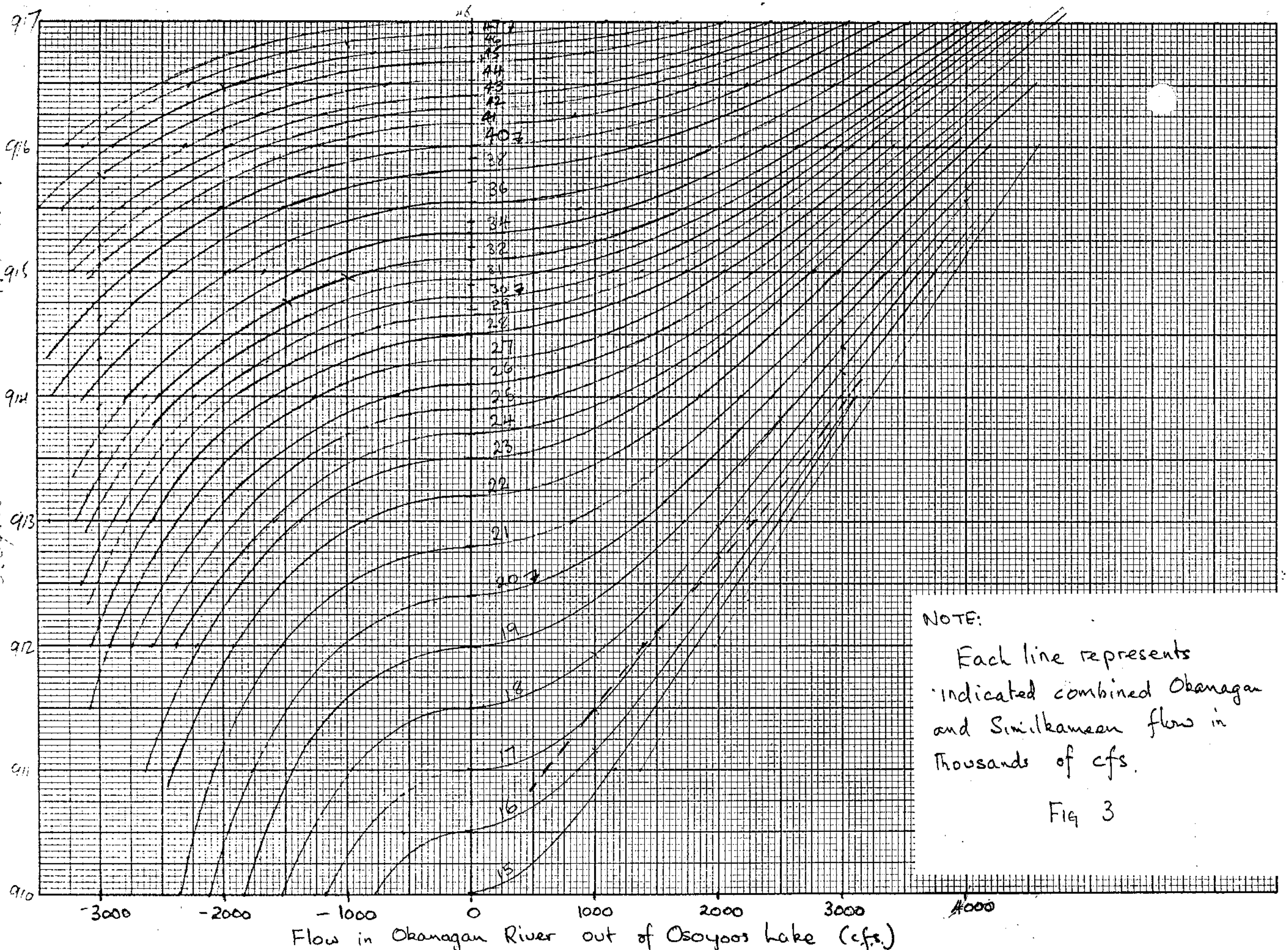
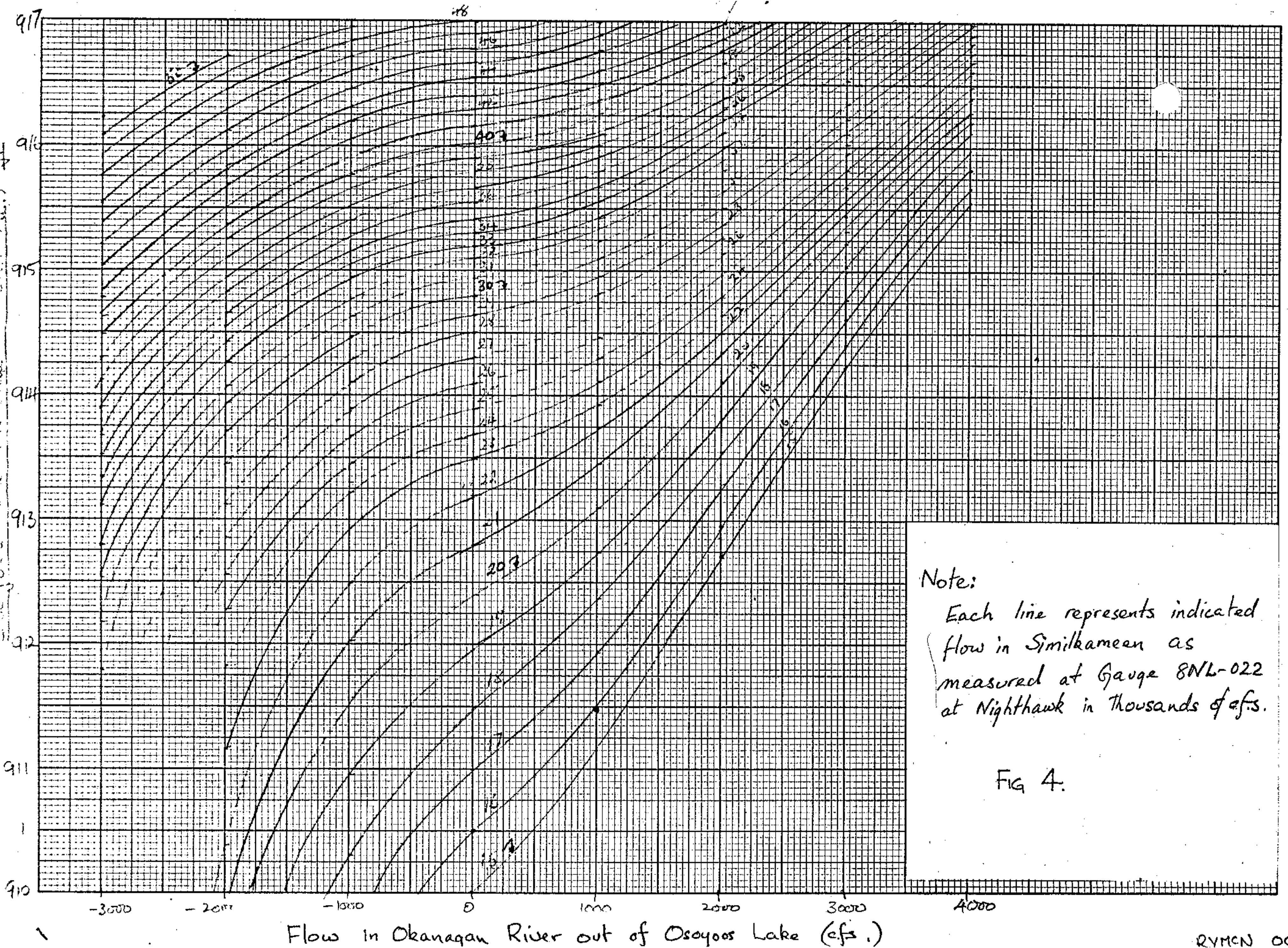
Fig 3



NOTE:
Each line represents indicated combined Okanagan and Similkameen flow in Thousands of cfs.

Fig 3

Fig 4



Note:
Each line represents indicated flow in Similkameen as measured at Gauge 8NL-022 at Nighthawk in Thousands of c.f.s.

FIG 4.

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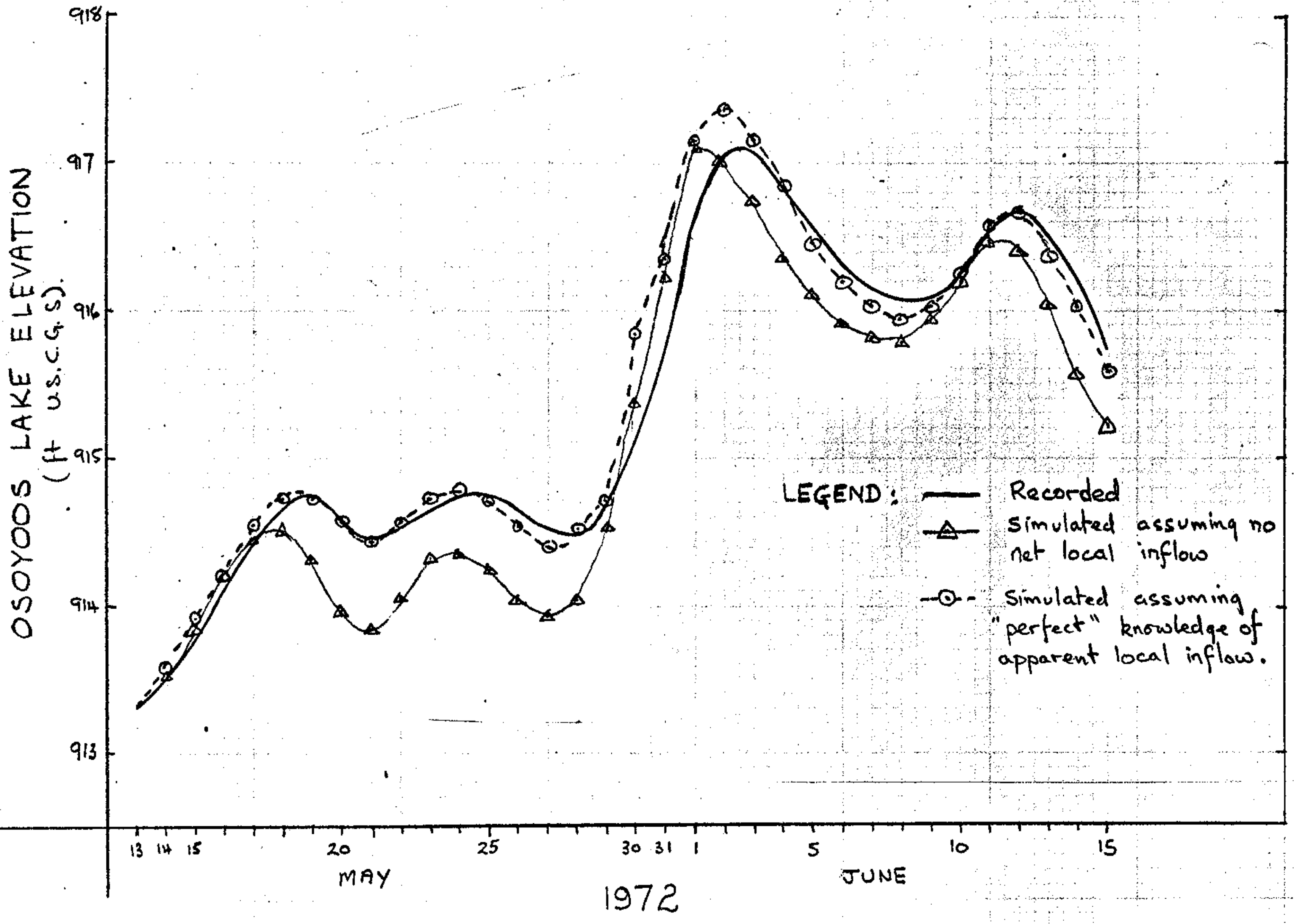

Reconstitutions of 1972 Osoyoos Lake fluctuations

FIG 5

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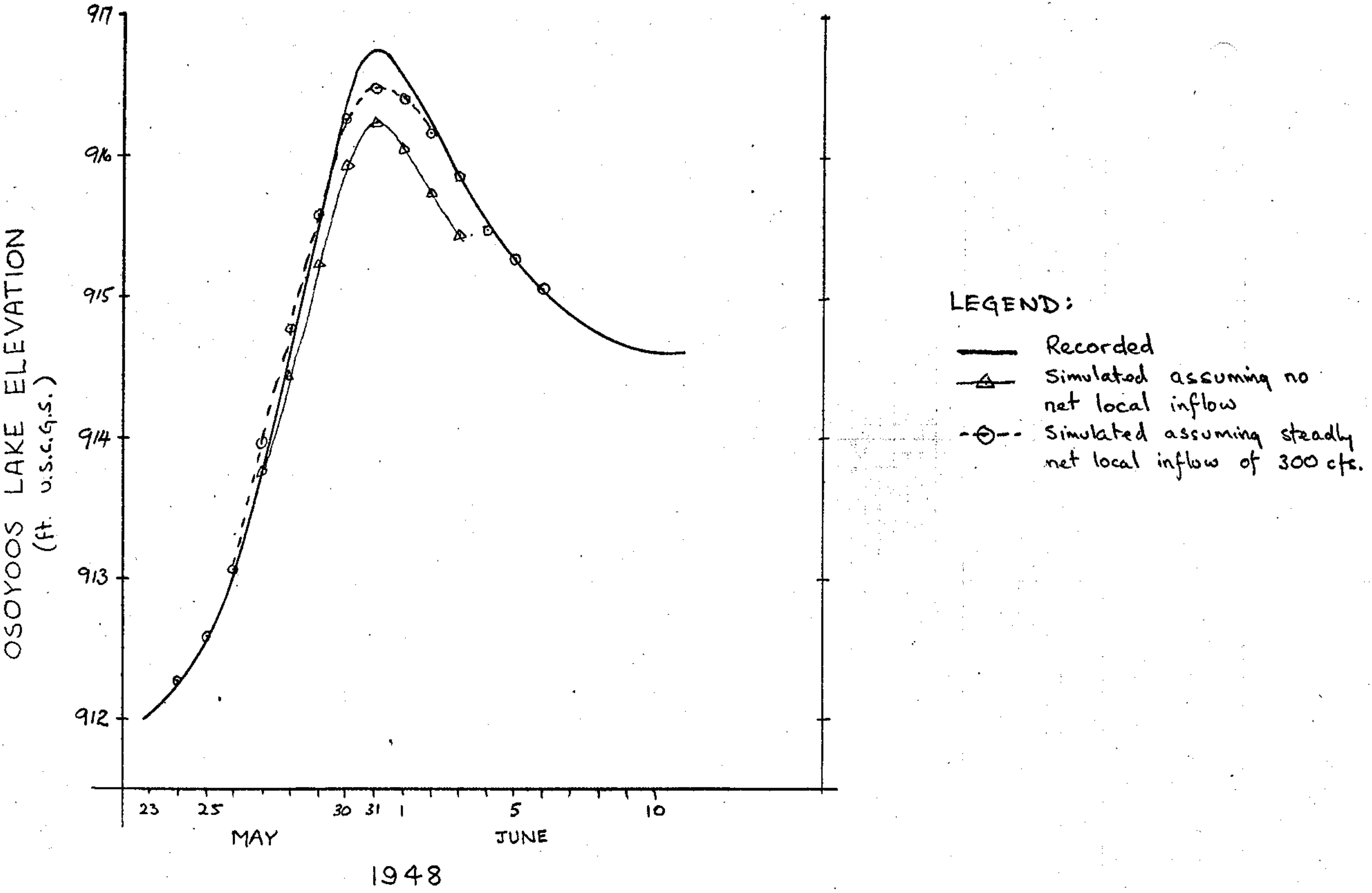

Reconstitution of 1948 Osoyoos Lake fluctuations

FIG. 6

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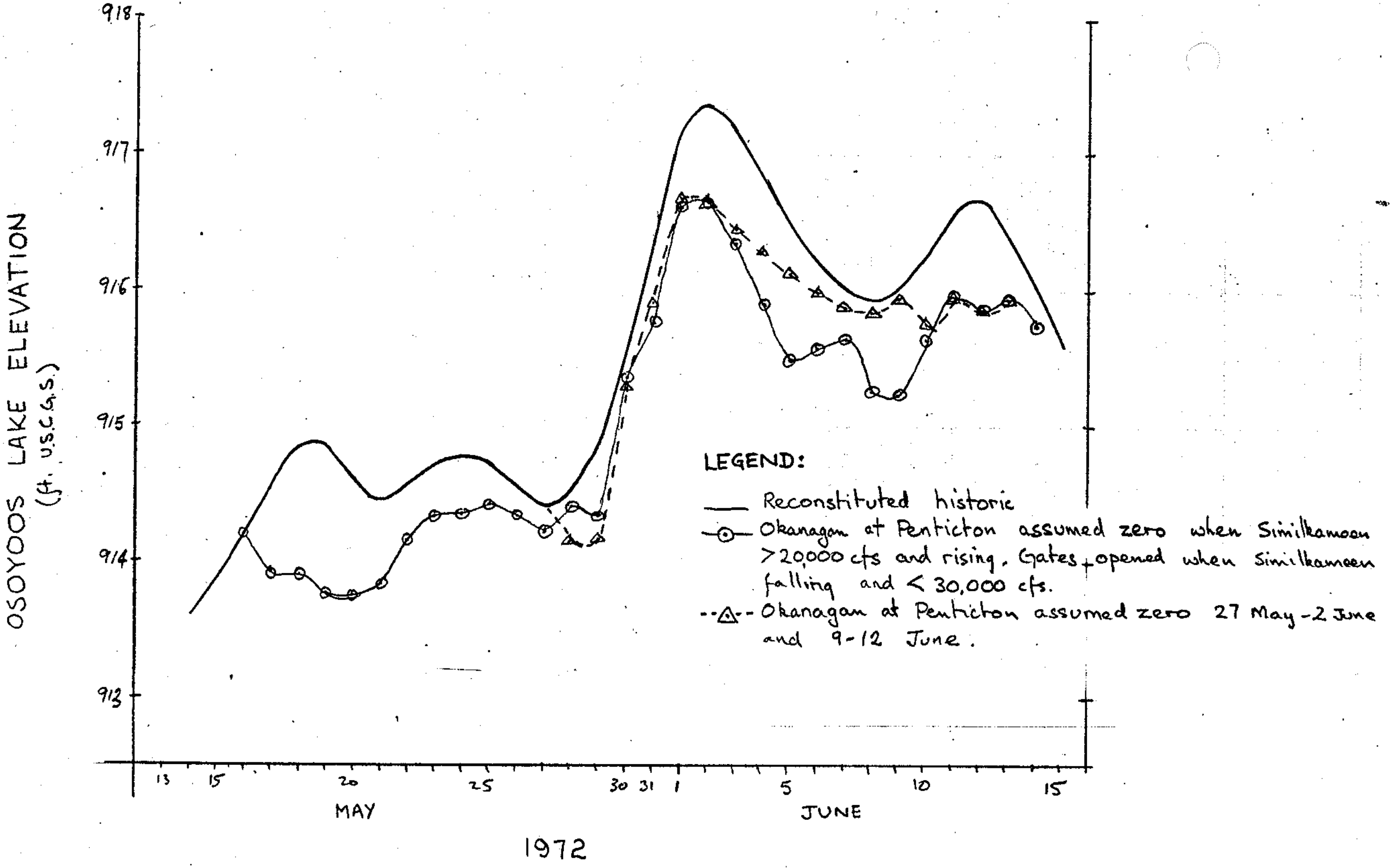

Osoyoos Lake fluctuations assuming adjusted Okanagan River flows.

FIG. 7

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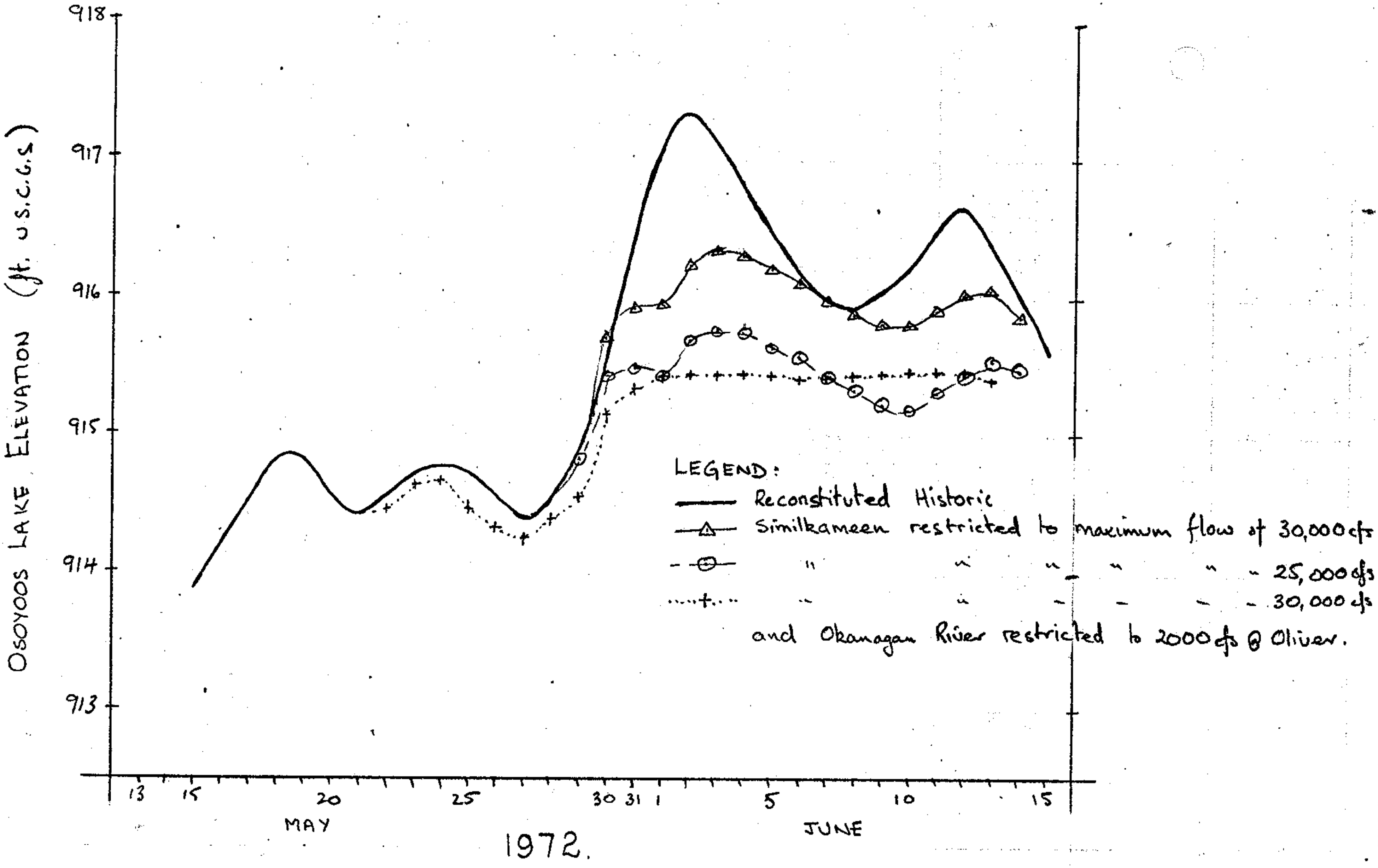

Osoyoos Lake fluctuations assuming adjusted Similkameen River flows.

FIG 8

D.V. MCN OCT '72