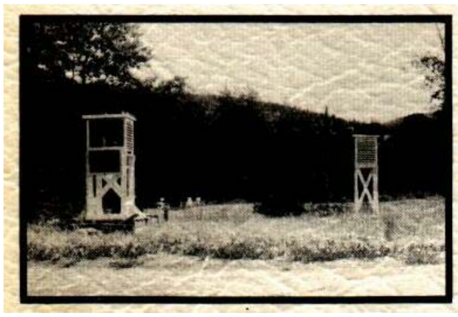
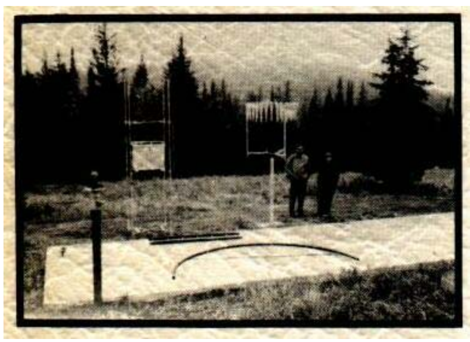
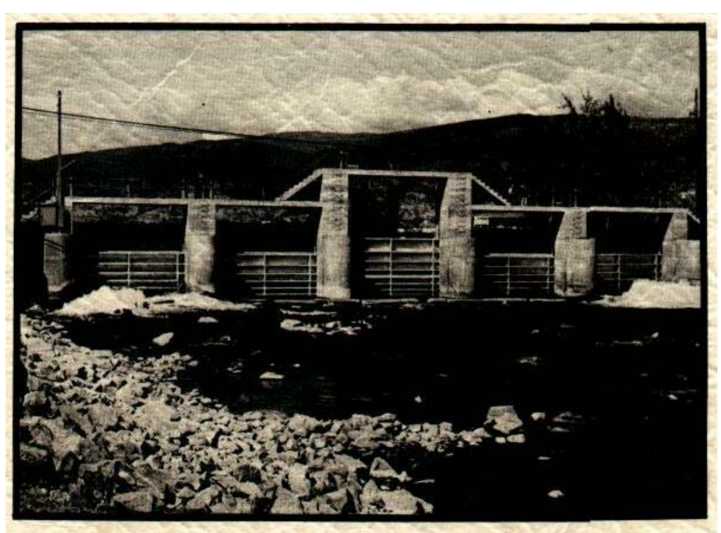
CANADA - BRITISH COLUMBIA
OKANAGAN BASIN AGREEMENT

TECHNICAL SUPPLEMENT





WATER QUANTITY
IN THE OKANAGAN BASIN



"To use water effectively you have to control it."

MARCH 1974

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CANADA - BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

TECHNICAL SUPPLEMENT I

TO THE

FINAL REPORT

WATER QUANTITY IN THE OKANAGAN BASIN

PUBLISHED BY

OFFICE OF THE STUDY DIRECTOR

Box 458, PENTICTON, B.C.

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THE CONSULTATIVE BOARD WISH TO ACKNOWLEDGE
THE CONTRIBUTION OF THE FOLLOWING PEOPLE IN
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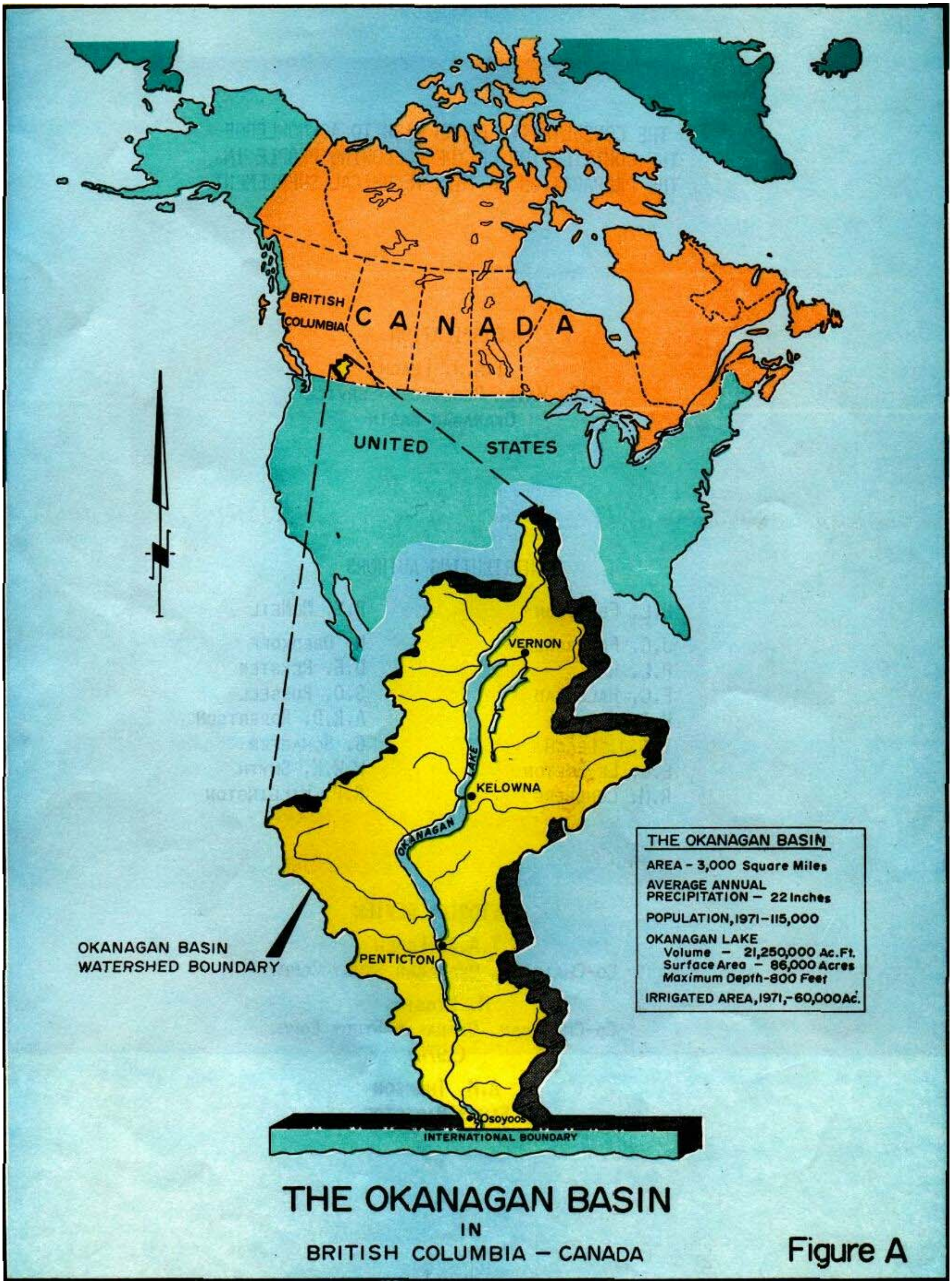
BRITISH COLUMBIA
CANADA
UNITED STATES
VERNON
KELOWNA
OKANAGAN LAKE
PENTICTON
Osoyoos
INTERNATIONAL BOUNDARY
OKANAGAN BASIN WATERSHED BOUNDARY
THE OKANAGAN BASIN
AREA - 3,000 Square Miles
AVERAGE ANNUAL PRECIPITATION - 22 Inches
POPULATION, 1971 - 115,000
OKANAGAN LAKE
Volume - 21,250,000 Ac. Ft.
Surface Area - 86,000 Acres
Maximum Depth - 800 Feet
IRRIGATED AREA, 1971, - 60,000 Ac.
THE OKANAGAN BASIN
IN
BRITISH COLUMBIA - CANADA
Figure A

FOREWORD

Technical Supplement I describes and presents the results of water quantity studies as carried out under the Okanagan Basin Agreement, including the synthesis of all historical water quantity resource data into a summarized form. The results of studies concerning water quantity computer models and water quantity alternatives are covered separately in Technical Supplements II and III respectively. Supporting water quantity data tables for all three supplements (I,II,and III) are included in Technical Supplement III. Other Study publications are listed on the Inside front cover of this report.

The material presented in this supplement supercedes that of all earlier preliminary reports or publications prepared under the Canada-British Columbia Okanagan Basin Agreement.

A. Murray Thomson
Study Director

SYNOPSIS

1. THE STUDY AREA

The Okanagan Basin including its major tributary the Similkameen River in its entirety drains an area of 6,000 square miles in south central British Columbia and 2,400 square miles in north central Washington upstream of its junction with the main Columbia River Valley near Brewster, Washington. The portion of the Basin referred to as "the study area" in this report includes the upper mainstem river and its tributaries above Zosel Dam located at the outlet to Osoyoos Lake at Oroville, Washington. Some additional reference is also made to the Similkameen River Basin which during high water can affect the discharge from Osoyoos Lake. It will be noted that the termination of the study area at Oroville rather than at the International Boundary (which cuts across Osoyoos Lake) was done in order that high and low water conditions on Osoyoos Lake could be evaluated.

About 68% of the land within the Canadian portion of the study area is forested while an additional 9% is classified as arable. The latter is located within the 1,000 foot elevation band of the valley bottom (up to elevation 2,000 feet). Only about one half of the arable land is cultivated and because of the semi-arid conditions a major portion of this is irrigated.

Major tributaries which discharge into Okanagan Lake and provide the main source of supply for the study area listed in order of decreasing annual discharge are: Mission, Vernon, Trout, Penticton, Equesis, Kelowna, Penticton and Powers Creeks.

These tributaries were the first to be developed for water supply primarily for agriculture and today about 70% of the total water consumed comes from this source. However, the major water requirements including non-consumptive in channel flow needs are met from the mainstem system extending from Okanagan Lake through to Osoyoos Lake.

The total population in the Basin in 1971 was some 115,000 people.

2. CLIMATE

The climate of the Okanagan Basin with its warm summers, fairly low humidity and mild winters provide an attractive environment for agriculture and recreation.

Annual precipitation in the valley bottom is 10 to 15 inches in the south increasing to 15 to 20 inches in the north while some mountainous areas to the northeast receive 35 to 40 inches mostly in the form of snow. Mean annual precipitation over the study area is estimated at 21.9 inches.

North and south winds are most common and these together with the south southeast and north northwest air flows occur during 70% of the hours when winds are recorded.

During the winter months when relative humidities linger in the high seventies or low eighties which are slightly below comparable coastal values; however, due to the lower air temperatures, the actual vapour content of the area is only about two-thirds of that measured at the coast. During summer months relative humidity drops to about 50%.

Outbreaks of very cold continental Arctic air occasionally reach the Okanagan Valley and minimum temperatures as low as -15°F to -25°F in the southern parts of the Valley and -30°F to -45°F in the north has been recorded.

In contrast, temperatures in excess of 1OO degrees Fahrenheit have been recorded at most Okanagan Valley locations.

3. HYDROLOGY

The Okanagan Basin hydrology is typical of the interior rivers of British Columbia where the major portion of the annual runoff occurs during April to July inclusive, due primarily to snow melt in the higher portions of the Basin. Thus, in the Okanagan Lake Basin (where about 80% of the inflow to the study area occurs) snow accumulates during the winter months in the 4,000 to 7,000 foot elevation band. Commencing in January, snow surveys are conducted at selected stations from which forecasts of inflow to Okanagan Lake are estimated for the upcoming freshet period.

A portion of the inflow to Okanagan Lake Basin is retained in the 50 headwater reservoirs of the major tributaries which in total amounts to about 113,000 acre-feet of active storage. The remaining inflow in its passage downstream to Okanagan Lake is partially depleted by diversions from the tributaries primarily for irrigation purposes. The residual water entering Okanagan Lake, either as surface or groundwater flow, is further reduced through evaporation "losses from the lake surface of some 200,000 to 300,000 acre-feet per year equivalent to 28.5 to 35.5 inches respectively over the lake surface. In summary, out of a total estimated average annual gross inflow to Okanagan Lake Basin of 664,000 acre-feet only about one half of this appears as net inflow to the lake after deducting natural losses and consumptive use.

In years of average or near average inflow, no major problem occurs in regulating Okanagan Lake within its normal four foot range which is equivalent to some 340,000 acre-feet and about equal to the average annual net inflow to the lake.

However, problems do arise in flood years when up to double the average inflow may occur because of the relatively limited discharge capacity of the Okanagan River downstream of Okanagan Lake Dam at Penticton which capacity may be further reduced by local inflow. Discharges may also be severely restricted at the outlet to Osoyoos Lake near Oroville, Washington due to high water from the Similkameen River.

A flood year for this study has been defined as one in which the total inflow is equal to or greater than 550,000 acre-feet. Its average re-occurrence interval is estimated to be about 1 year in 14.

In contrast to this are the drought years when the net inflow to Okanagan Lake may be less than 100,000 acre-feet.

The determination of a drought year has been based on water requirements along the mainstem which amount to some 244,000 acre-feet per year. Thus, net inflows to Okanagan Lake of less than 244,000 acre-feet have been classified as drought years and have an average re-occurrence interval of 1 year in 4.

4. MAINSTEM SYSTEM

The Okanagan Lake reservoir provides the major portion of the water for the mainstem and is controlled by a concrete dam at Penticton. The Okanagan Lake Dam along with other structures and improved river channels between Penticton and Osoyoos Lake make up the Okanagan Flood Control Works. Ancillary Works include the debris retaining basins at the mouths of Shattford (Shingle), Ellis and Shuttleworth Creeks. The operation of these works is under the direction of the British Columbia Water Resources Service, Department of Lands, Forests and Water Resources while maintenance costs are shared by this Department and the Federal Department of Public Works.

These works were constructed during 1950-58 by the Federal and Provincial Governments under the Okanagan Flood Control Act. While one of the main objectives of the project was to prevent flooding such as occurred in 1942 and 1948 it also provides storage regulation for salmon fisheries, water based recreation and aesthetics.

Discharges from Okanagan Lake Dam are limited by the channel capacity of the Okanagan River which varies from 2,100 cfs at Penticton to 3,400 cfs at the inlet to Osoyoos Lake. Only minor regulation (9,400 acre-feet) can be obtained in Skaha Lake (surface area 4,710 acres) which is maintained between elevation 1107.6 and 1109.6 by a concrete dam at Okanagan Falls.

In addition to the Okanagan Flood Control Works, a small concrete dam at the outlet of Vaseux Lake (surface area 690 acres), operated by the Southern Okanagan Land Improvement District (SOLID), maintains a water elevation on the lake of 975 feet and diverts a portion of the flow, up to 150 cfs through a canal to serve irrigation requirements in and around Oliver.

The maximum discharge at Oliver below Vaseux Lake Dam is currently held below 3,000 cfs because of channel capacity limitations, local inflow from tributaries which is not controllable, and high water levels in Osoyoos Lake when flows in the Similkameen are high.

The level of Osoyoos Lake is normally maintained between 910.0 and 912.0 feet GSC (910.3 and 912.3 USCGS) although the upper level may be exceeded in any flood year due to lack of control of flood waters on the Similkameen River. Normally, the lower level is maintained by the Zosel Dam near Oroville, Washington. However, at times the low level control may change to points upstream where bars have been formed by tributaries such as Tonasket Creek.

The Zosel Dam was originally constructed In 1927 by the Zosel Lumber Company to create a mill pond for log storage. During flood periods the structure is almost completely submerged while during low water periods there is considerable leakage through it which have to be compensated for by additional releases from Okanagan Lake in order to maintain Osoyoos Lake at its normal summer elevation of 911 feet (USCGS).

5. PRESENT DAY WATER REQUIREMENTS

Present day water requirements within the Okanagan Basin include consumptive use within, the tributaries and along the mainstem system as well as non-consumptive inflow channel requirements for the latter. This in total amounts to 312,000 acre-feet which can be met in a normal inflow year. It will be noted that about two-thirds of these water requirements are needed to maintain adequate lake levels and maintain in channel flows for fisheries, recreation, adequate intake, submergence and aesthetic purposes.

6. DROUGHTS AND FLOODS

Droughts have been defined as those years when the net inflow into Okanagan Lake is less than the water requirements along the mainstem system namely 244,000 acre-feet. A drought year does not necessarily mean a shortage of water providing there is sufficient to carry over storage in Okanagan Lake to make up the deficit or failing this Okanagan Lake is drawn down below its normal low water elevation. However, it is estimated that a re-occurrence of the 1929 to 1932 drought would result in Okanagan Lake being drawn down some 3.2 feet below its normal low water elevation assuming all water requirements are met at all times. Under these conditions, the lake would drop below its normal low water elevation in the middle of the second year of the drought and not refill to a level of 3 feet about normal low water until 3 years later. Such a prolonged drought has only occurred once in this century and was prevalent over much of North America.

At the other end of the spectrum are those years in which excessive inflows or flood occur. In general, a forecast seasonal inflow greater than 550,000 acre-feet is considered to indicate a potential flood and Okanagan Lake would have to be drawn down to its normal low water elevation or even lower prior to the freshet.

In the flood of 1972, Okanagan Lake exceeded its normal high water elevation by 0.9 feet in controlling the maximum April to July inflow to occur in this century. The estimate flood damage around Okanagan Lake amounted to $56,500, exclusive of flood damage at the mouths of Mission, Kelowna and Trout Creeks and other tributaries.

During this period Osoyoos Lake which has about *7% of* the area of Okanagan Lake and whole outflow was severely restricted by flood flows in the Similkameen, rose almost 5 feet to reach a maximum elevation of 917.1 GSC. It is estimated that some $212,000 worth of damage occurred within the Canadian portion of Osoyoos Lake through property damage or lost revenue to the tourist industry.

7. WATER SUPPLY IN EIGHT SELECTED TRIBUTARIES

Hydrometric data in selected tributaries which are being heavily utilized is much more limited than the 50 years continuous records available for the mainstem system. Within these limitation, it appears that with the exception of Vernon and Kelowna Creeks there are no consumptive use deficiencies under the present methods of operation.

With the exception of Penticton Creek (which is not considered a fishery stream) a modified regulation of upstream reservoirs have been carried out with the objective of meeting both consumptive use requirements throughout the sub-basins and minimum fishery flows at the mouths. While this should not be regarded as a recommended method of multi purpose operation, it does show that for a single year starting with a full reservoir, present methods of regulation can be modified to improve fishery flows significantly. However, such improvements result in practically complete depletion of headwater reservoir storage where up to 50% carry over storage is normally held in anticipation of the occurrence of a drought year. Further details of the operation of the selected tributary streams can be found in Technical Supplement III.

8. FOREST HYDROLOGY

It is estimated there exists approximately 1.2 million acres of merchantable forest land in the Okanagan Basin in Canada. Only about 300,000 acres are in the zone north of Penticton above 4,000 feet which is the area from which the major portion of the runoff occurs.

In 1971 some 10,000 acres of merchantable timber were harvested in the Basin while an additional 1,000 acres was lost to wild fires. This represents 1/120 year rotation for the Basin.

Water yield increases accrusing from forest harvesting within the 300,000 acres north of Penticton have been estimated at between 3.31% and 4.20%. These increases would only be realized within the area harvested and would likely be consumed in water deficits sites at lower elevations. This includes correction for sequential regrowth effects on increasing evapotranspiration. Additional increases for those areas lost to wild fires are estimated between 1.24% and 1.55% annually.

By adjusting the computed percentage water increases in the areas where forest harvesting and fires are taking place to the whole Basin water yield increases are only 0.50% to 0.64% for the former and 0.19% to 0.23% for the latter. These computed annual increases are not cumulative due to the effect of regrowth on evapotranspiration consumption.

In summary, it can be stated that:

a) Any increases are too small to be measured. Thus, yield increases would go undetected with the possible exception of very small tributaries where intensive forest harvesting is taking place.

b) Any increases occurring under (1) in the merchantable forest area above elevation 4,000 feet would be lost in the water deficit areas at the lower elevations.

9. GROUNDWATER

Evidence from seismic surveys, exploratory drilling and pump tests indicate that there is not nearly sufficient groundwater in the North Okanagan to meet water deficits within the Basin during drought years.

Well yields for aquifers in the study area are commonly expected to be less than 200 imperial gallons per minute (igpm) for pump settings of 200 feet. Locally, higher yields of up to 500 igpm or possibly 1,000 igpm may be obtained. Aquifers with well yields in the 200 to 500 igpm, are considered to occur in the O'Keefe Valley; and in the main valley in the locality just south of Armstrong and in parts of the fan deposits along the east valley wall, Well yields of up to 1,000 igpm may possibly be obtained near Enderby and also in the O'Keefe Valley, but more adequate testing is essential to verify these high yields.

The potential for groundwater development without depleting the resources is estimated to be from 3 1/3 to 6 c.f.s. It is unlikely that the total groundwater withdrawal is close to the lower value, so that there is limited scope for increasing the use of groundwater in this area.

Analysis of groundwater sampled in the study area show the chemical quality of the water is very good. The total dissolved solids content is in the range of 200 to 500 ppm and the water is primarily calcium and magnesium carbonate. The water is quite suitable for human consumption and for irrigation use and should reouire very little treatment for industrial purposes.

In addition to the intensive groundwater investigation in the North Okanagan which included depths of up to 2,000 feet, one test hole was drilled and seismic work was carried out near Okanagan Falls in the south end of the Valley.

Sub-basin Groundwater Reconnaissance studies were also carried out for Vaseux, Vernon, Penticton, Pearson, Lambly and Greata Creeks. In general, the groundwater contribution to the runoff is not considered significant when compared to the surface flow.

10. <u>WATER QUANTITY MONITORING</u>

The lack of adequate basic data in water quantity, climatology and particularly water quality at the start of this study has required that heavy reliance be placed on new station information collected during the past three or four years in the case of hydrology or about two years in the case of water quality. Fortunately, the last three years have provided a wide range of hydrological events varying from drought conditions in 1970 to a record flood year in 1972.

Future monitoring as outlined in this report are based on the following objectives:

a) To provide current data on water storages, diversions, discharges, precipitations, temperature, water quality and waste water treatment for day to day decision in water management.

b) To provide a check on water quantity models developed during the Okanagan Study as well as nutrient loadings and 1imnological changes that have been forecast for the next 10 to 15 years assuming tertiary or equivalent treatments is undertakenand recommendations.

c) To provide a basic data bank on hydrology, meteorology, limnology and water quality of sufficient length and detail for comprehensive statistical analysis.

11. TECHNOLOGICAL ADVANCES

The combined efforts of the hydrologist and meteorologist are required in hydrological studies with emphasis on the following:

a) Seasonal Volume Forecasts:
Through the development of water budgeting models, it is evident there Is a need for Improved weather forecasts together with better knowledge of soil moisture conditions.

b) Vegetation Management:
With better water quantity and quality modelling, it will be possible to assess the affect of alternative methods of forest harvesting and other types of vegetative management.

c) Weather Modifications;
At present, weather modification to increase precipitation is a technique having some potential but being primarily in the experimental stage.

12. CONCLUSIONS

The water quantity studies carried out in this Techinical Supplement and Technical Supplement III - Water Quantity Alternatives and Supporting Water Quantity Data, were carried out to meet the following objectives:

a) To evaluate the existing hydrologic regime of the Basin.
b) To evaluate means of regulating flows through storage and diversion.
c) To evaluate means augmenting and the surface water supply within the Okanagan Basin.

13. SUMMARY OF BASIC DATA

Okanagan-Simi1kameen Basin	
Drainage area, Total	8,400 sq.mi.
Drainage area, in BC	6,000 sq.mi.
Drainage area, in Washington	2,400 sq.mi.
Okanagan Basin	
Drainage area, Total	3,250 sq.mi.
Drainage area, in B.C.	3,165 sq.mi.
Drainage area, in Washington	85 sq.mi.
Irrigated Land (in B.C.)	60,070 ac.
Potentially Irrigable Land (in B.C.)	177,320 ac.
Morphology	
Maximum Elevation (Baldy Mtn)	7,558 ft.
Median Elevation (Okanagan Lk. Basin)	3,860 ft.

Minimum Elevation (Osoyoos Lk.)	910 ft.

Climate	Temperature in °F	Precipitation in Inches
Mean Annual		
Armstrong	45	17.6
Kelowna	47	12.0
Penticton	48	11.7
Oliver	48	11.8

Hydrology

Okanagan River

(i) Annual Discharge in cfs at Penticton

Mean, 52 years of continuous record. 1921-1972 Climatic (April-March) Year inclusive	499
Maximum, 1948 Climatic (April-March) Year	1,042
Maximum, 1972 Calendar (January-December) Year	1,070
Minimum, 1930 Climatic (April-March) Year	89

(ii) Annual Discharge in cfs near Oliver

Mean, 20 years of intermittent record, 1945-1972 Climatic (April-March) Year inclusive	605
Maximum, 1972 Climatic (April-March) Year	1,029
Maximum, 1972 Calendar (January-December) Year	1,240
Minimum, 1970 Climatic (April-March) Year	249

Okanagan lake

Surface Area	84,200 ac.
Maximum Depth	800 ft.
Mean Depth	250 ft.
Volume, Total	21,000,000 ac.ft.
Operation Range, Normal: 4 ft., between Elevation	1119.8 – 1123.8 ft.
Operation Range, Extreme: 5 ft., between Elevation	1118.8 – 1123.8 ft.
Usable Storage (Volume):	
at Normal Operation Range	336,800 ac.ft.
at Extreme Operational Range	421,000 ac.ft.

Skaha Lake

Surface Area	4,710 ac.
Maximum Depth	187 ft.

Skaha Lake con't

Mean Depth	85 ft.
Volume, Total	453,0000 ac.ft.
Operational Range: 2 ft., between Elevation	1107.6 – 1109.6 ft.
Usable Storage at Operational Range	9,420 ac.ft.

Osoyoos Lake

Surface Area, Total	5,660 ac.
Surface Area, in B.C.	3,660 ac.
Surface Area, in Washington	2,000 ac.
Maximum Depth	206 ft.
Mean Depth	49 ft.
Volume, Total	323,000 ac.ft.
Normal Range of Lake Level: 1.6 ft., between Elevation	910 - 912.0 ft.

Kalamalka Lake

Surface Area	6,340 ac.
Maximum Depth	465 ft.
Mean Depth	193 ft.
Volume, Total	1,233,000 ac.ft.
Operational Range: 1.4 ft., between Elevation	1282.6 – 1284.0 ft.
Usable Storage at Operational Range	8,876 ac.ft.

Woods Lake

Surface Area	2,260 ac.
Maximum Depth	112 ft.
Mean Depth	72 ft.
Volume, Total	162,200 ac.ft.
Operation Range: 1.4 ft., between Elevation	1282.6 – 1284.0 ft.
Usable Storage at Operational Range	3,164 ac.ft.

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