WATER RESOURCES ANALYSIS
AND INFORMATION SECTION

Office Report No. 36

A CHECK POINT REPORT ON THE OKANOGAN BASIN INVESTIGATION

by

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(For Use by the Water Resources Management Division)

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PURPOSE

The purpose of this report is to present a summary of the information developed to date on the Okanogan Basin in order to allow an evaluation of the direction the present investigation is progressing. It is hoped that the use of "check point" reports will become a common occurrence in the Water Resources Management Division.

BACKGROUND

For the past three years a program to develop a water resources management program for the Okanogan/Methow Basin has been made under the direction of Kris Kauffman. On May 15, 1975, the Water Resources Analysis and Information Section was asked to make an analysis of the water resources of the Okanogan/Methow Basins.

The major issue in the Okanogan Basin is the allocation of the waters of the main stem of the Okanogan River in Washington. Of lesser importance is an analysis of water supply and water use in the smaller tributaries of the Okanogan Basin and the Methow Basin.

Subsequent to the request of May 15th, Greg Sorlie prepared a report on the water resources of the Okanogan/Methow Basins. This report was completed on June 30, 1975 (Office Report No. 28), and the information made available at that time. The report itself was not issued until July 15, 1975. On July 15, 1975, the Policy Development Section was asked to review the report for missing information--a review of the report was prepared by Kris Kauffman on August 21, 1975. Office Report No. 28 is titled, "A Brief Review of the Water Resources of the Okanogan-Methow Basins." The report presents considerable information on an annual basis. The principal annual elements are:

Irrigated acres
Irrigation water use
Land use
Estimates of all types of water use in the basins
Water rights
Water right claims
Historic trends in water rights and irrigated lands
Ground water availability
Surface and ground water interaction
An annual water budget which included annual runoff and a rough estimate of annual water use

Information on the probability distribution of historic monthly flows at eleven gaging stations was also included.

Certain deficiencies are obvious--the two principal ones are the fact the use of annual values for water use and water supply when water is not stored does little to compare the supply in the critical month (August or September to the use in the month); and also, the use of historic data for the analysis of those few streams with a gaging station does little to answer the question on the water supply available either under "natural" or present conditions in the basin.

In his memorandum of August 21st, Kris Kauffman pointed out certain deficiencies which had not been resolved. The principal ones are:

1. There are certain inconsistencies in the information presented which is related to the different sources of information.

2. The report did not include information on the users of water which do not have paper water rights issued by the state.

The report was also reviewed by Jim Thornton of the Policy Development Section. The memorandum was received on August 4, 1975. Jim specifically asked for frequency and water use data (monthly) for the following streams in the basins.

Methow River	Okanogan Basin
Chewack River	Antoine Creek
Twisp River	Bonaparte Creek
Gold Creek	Chewiliken Creek
Wolf Creek	Tunk Creek
	Johnson Creek
	Omak Creek
	Salmon Creek
	Loop Loop Creek

Jim asked for data on potential reservoir sites and capacities in both the Methow and Okanogan Basins. The information on reservoir sites was compiled by Greg Sorlie and a report written--Office Report No. 33 (Existing and Potential Reservoir Sites in the Methow-Okanogan and Chelan-Wenatchee-Entiat Basins). The report was completed in mid-August 1975.

Dick Thayer also reviewed the report. In a memorandum dated July 23, 1975, he suggested the following topics be considered:

1. Information on the availability of ground water in the Methow Basin should be developed.

2. Both the U. S. Bureau of Reclamation and Soil Conservation Service figures on potentially irrigable lands should be considered in the report.

3. The storage potential of Osoyoos Lake should be investigated.

4. A summary of water temperature in the Okanogan River should be given.

5. A list of presently adjudicated streams should be given.

6. Information on recreational subdivisions and their water requirements would be useful.

Some of the information requested by Messrs. Kauffman, Thornton, and Thayer would be reasonably easy to develop, but information on many items would be quite time consuming to develop. The most difficult is the development of monthly flow frequency on small basins without a gaging station. The development of this information would be a major expenditure of time and money.

Information on the "natural" flows of the Okanogan and Similkameen Rivers was not included in Office Report No. 28. In late June 1975, an attempt was made by R. T. Milhous to estimate the frequency distribution of natural flows of the Okanogan River near Tonasket (USGS gage 12-4450). The approach used "quick-and-dirty" techniques typically required in the low order of resolution work done in the

Department of Ecology. The results of this analysis was transmitted to Kris Kauffman on June 30, 1975. On August 21st, Kris requested similar information for the following stations:

12-4395	Okanogan River at Oroville
12-4435	Similkameen River near Oroville
12-4473	Okanogan River near Malott

When the initial data on the Okanogan near Tonasket was transmitted to Kris Kauffman, a report was in preparation which presented the results, as well as the methodology and assumptions, used in the analysis. Prior to completion of the report, information was received from the British Columbia Water Resources Service which completely invalidated the assumptions used in the initial analysis. Consequently, the planned report was not completed. On August 5th, a meeting was held with personnel of the British Columbia Water Resources Service which resulted in obtaining information on which to base a realistic analysis. The failure of the "quick-and-dirty" techniques has necessitated the use of analytical techniques and concepts which require considerable time, and analytical skill, in order to determine realistic answers to the question of water availability from the main stem of the Okanogan River in Washington.

The following sections present some of the information resulting from the analysis. This is followed by a discussion of a proposed approach to determining water availability, the possibility of developing information requested by Messrs. Thornton and Thayer, and the nature of reports planned at this time.

WATER BALANCE OF THE OKANOGAN RIVER

An annual water balance of the Okanogan River Basin is presented in Table 1. The location of the subbasins is given in Figure 1. The water balance for the Okanogan Lake Basin was taken directly from the reports of the British Columbia Water Resources Service, the other information was developed using the information in Office Report No. 28 (Sorlie, 1975), the British Columbia Water Resources Service (1974), Orsborn and Sood (1973), and Walters (1974).

HISTORIC USE OF WATER

The 1970 annual depletions of water from the Okanogan River Basin are estimated to be as follows:

Use	British Columbia	Washington	Total
Irrigation	97,000	77,500	174,500
Municipal and domestic	9,700	2,200	11,900
Industrial	4,600	100	4,700
T O T A L	111,300	79,800	191,100

(in acre-feet per year)

TABLE 1. Annual Water Balance for the Okanogan Basin

	Okanogan Lake Basin	Middle Okanogan Basin in British Columbia	Middle Okanogan Basin in Washington	Upper Similkameen in Washington	Similkameen Basin in British Columbia	Lower Similkameen Basin in Washington	Lower Okanogan Basin	Total Basin
Inflow								
Precipitation	2721	830	84	817	4585	436	1564	11037
Stream Flow	--	332	483	--	533	1500	2116	--
Diversions	--	--	8	--	--	--	50	--
TOTAL	2721	1162	575	817	5118	1936	3730	11037
Outflow								
Evapotranspiration								
non-irrigated land	2056	616	71	284	3608	241	1450	8341
irrigated land*	66	35	5	--	10	7	68	176
Major Lake Evaporation	267	28	7	--	--	6	12	320
Diversions	--	--	--	--	--	58	0	--
Stream Flow	332	483	492	533	1500	1624	2200	2200
TOTAL	2721	1162	575	817	5118	1936	3730	11037
Area (square miles)	2340	785	85	333	2880	367	1735	8525

Flows in 1,000 acre-feet per year.

*Includes municipal, domestic and industrial use which is about 10 percent of the total.

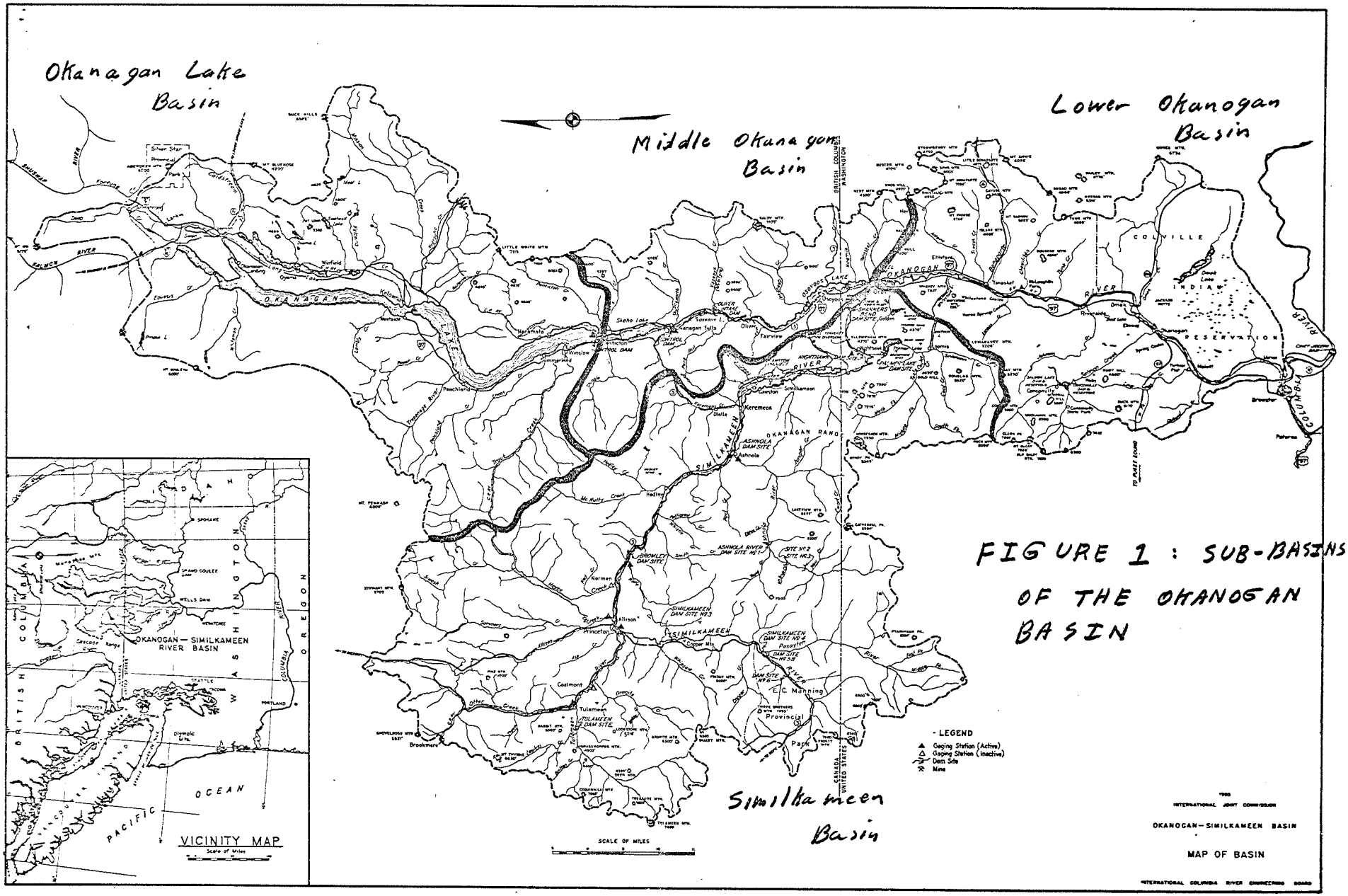

FIGURE 1 : SUB-BASINS OF THE OKANOGAN BASIN

The irrigation results in 91 percent of the total depletion resulting from water use in the Okanogan Basin. A fair amount of information has been developed on past irrigation use but little is available on the other uses.

The historic irrigation use of water is estimated to be as shown below:

Year	Okanogan Lake Basin	Middle Okanogan Basin	Similkameen Basin	Lower Okanogan Basin	Total
1920	18,000	6,700	7,500	15,200	47,400
1930	25,000	8,700	9,000	15,600	58,300
1940	32,000	10,800	9,000	14,900	66,700
1950	35,000	11,200	9,000	19,200	74,400
1960	35,000	12,200	9,000	25,900	85,100
1970	46,000	16,200	9,000	26,000	96,200

The results are interesting in that the growth rate in Washington is less than the growth in British Columbia. The potentially irrigated land not now irrigated is:

British Columbia	
Okanogan	100,000 acres
Similkameen	35,000 acres
Washington	85,400 acres
T O T A L	220,400 acres

NATURAL FLOWS

The natural flows in the Okanogan Basin have been estimated for the water year 1944 at most of the main stem gages in Washington and for 1945, 1969, and 1970 at Oroville. The results for Oroville are given in Table 2. The estimating of natural flows required the making of somewhat unrealistic assumptions on the impact of Okanogan Lake on the outlet from the lake under natural conditions. These assumptions will be discussed in a later report. Suffice it to say that uncertainty exists about the flows but that the general pattern is quite realistic. For instance, the very low September and October flows are realistic because the outflows under natural conditions from Okanogan Lake were probably often near zero, or zero, in many years. The cause of the zero outflow (as well as the uncertainty in the analysis) is the fact that the evaporation from the surface of the lake is large in relationship to the inflows. The outflow under natural conditions cannot be calculated because the relationship between lake stage and outflow under natural conditions is not known.

FIGURE 2. Historic Trends in Irrigated Land in the Okanogan Basin.

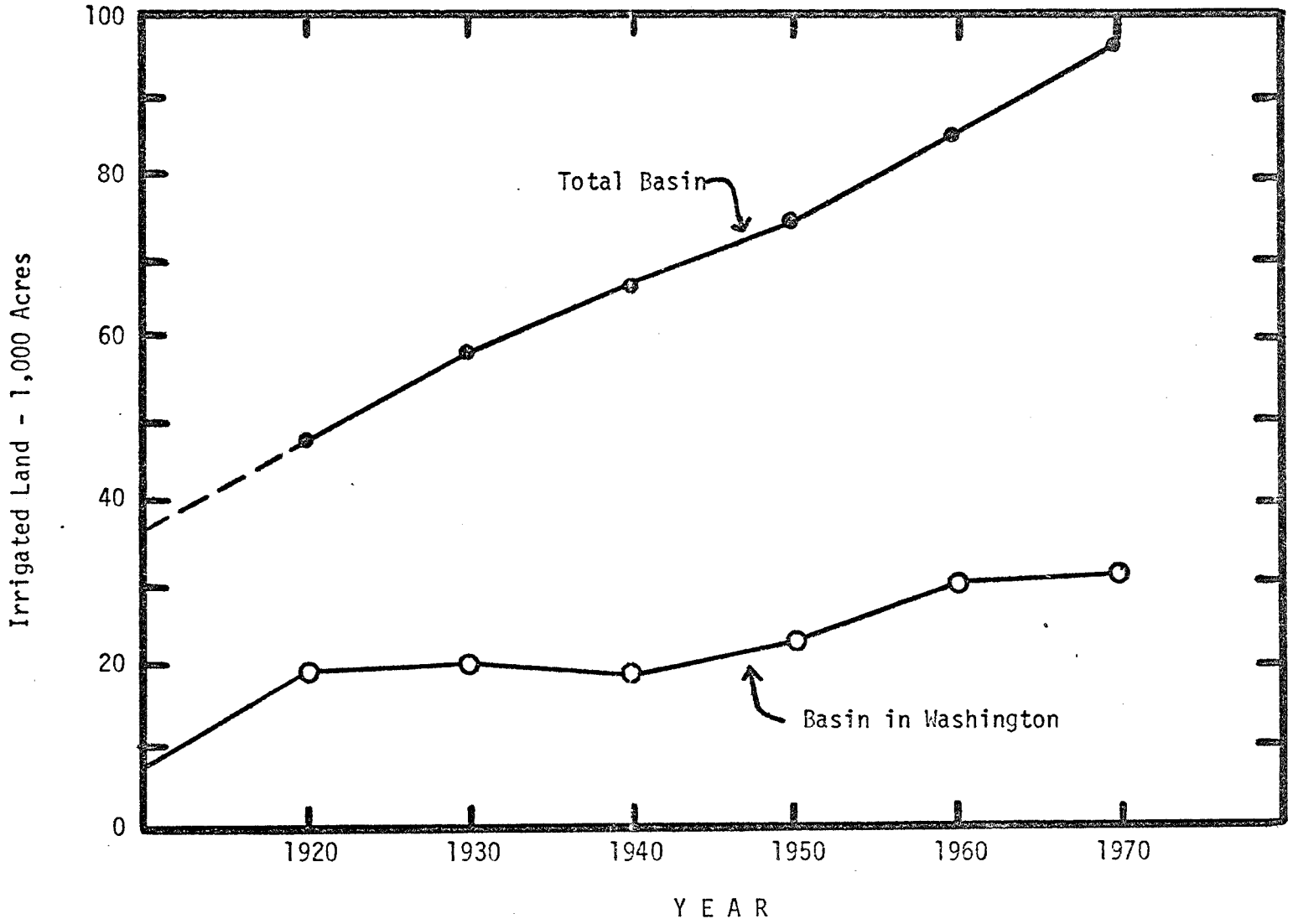

TABLE 2. Flows in the Okanogan River at Oroville, Washington under "Natural" Conditions and as Measured

Month	flow in cubic feet per second							
	1944		1945		1969		1970	
	Natural	Measured	Natural	Measured	Natural	Measured	Natural	Measured
October	0	201	20	188	0	583	30	614
November	50	224	210	258	270	645	100	453
December	30	193	0	436	170	361	320	424
January	40	184	300	530	50	793	290	417
February	240	229	290	500	260	781	140	262
March	0	130	110	543	320	933	240	349
April	590	185	130	660	1740	1040	190	380
May	2190	323	3030	1470	5210	1760	2030	746
June	2350	911	3460	1500	1690	824	1486	243
July	340	501	180	669	370	480	130	185
August	140	167	100	449	63	423	80	217
September	0	82	10	289	52	513	0	265

Flows in cubic feet per second.

The "natural flow" analysis for the Okanogan River stations in Washington and the Similkameen River has been done for the 1944 water year. The results are presented in Table 3.

FLOWS UNDER 1970 AND 2020 CONDITIONS OF DEVELOPMENT

An analysis of the flows during a 1944 water year was made for 1970 and 2020 conditions of development. The results are presented in Tables 4 and 7 through 9.

The outflows from Okanogan Lake under alternative operating criteria and alternative projections of growth are given in Table 4. The alternative operating criteria is principally related to the minimum flows required for fisheries and the flows required to supply diversions in the Okanogan River downstream of Okanogan Lake. The present requirements are for 300 c.f.s. at the gaging station near Oliver, B.C. The recommendation of the Canada-British Columbia Okanogan Basin Consultative Board is that the diversions in the Okanogan River be modified so that a 100 c.f.s. will be adequate to supply the divertors.

The alternative economic projections used in the analysis are given in Table 6. The projection recommended by the Consultative Board is number 3 (the low growth projection).

The alternative flows of the Okanogan River at Oroville is given in Table 7. As the table shows, the major impact on flows entering Washington is the alternative operating criteria with both alternative growth projections and growth itself being of lesser importance. Operating criteria 0 and 3 are the "critical" criteria from the viewpoint of a downstream user of the waters.

The flows in the Similkameen are given in Table 8. The projections were made by the writer. Considerable uncertainty exists as to present use of the river in British Columbia, to say nothing about future use.

The flows in the Okanogan River near Tonasket are given in Table 9. The U.S. projection was made by the writer, and is the average of the OBERS Level "C" and Level "E" projections.

ALTERNATIVE APPROACHES TO THE DETERMINATION OF WATER AVAILABLE

Three alternative approaches are possible in the determination of water available for future appropriation for the main stem of the Okanogan River in Washington. These alternatives are:

1. Estimate the "natural" flows and the existing uses, then allocate the remaining waters.

2. Estimate the flows in the Okanogan River under 1970 conditions of use, determine the required instream flows, then allocate the remaining waters.

3. Estimate the flows with 2020 conditions of development in British Columbia and no increase in development in Washington, determine the required instream flows, then allocate the remaining waters.

TABLE 3. Natural and Measured Flows in the Okanogan and Similkameen Rivers during the 1944 Water Year.

Month	12-4395 Okanogan at Oroville "Natural"	12-4395 Okanogan at Oroville Measured	12-4425 Similkameen near Nighthawk "Natural"	12-4425 Similkameen near Nighthawk Measured	12-4450 Okanogan near Tonasket "Natural"	12-4450 Okanogan near Tonasket Measured
October	0	201	440	473	580	655
November	50	224	450	470	520	731
December	30	193	380	393	390	594
January	40	184	310	327	320	492
February	240	229	300	319	630	656
March	0	130	360	373	380	539
April	590	185	910	922	1320	944
May	2190	323	4860	4786	6760	4747
June	2350	911	6800	6659	9650	7925
July	340	501	1950	1815	2120	2005
August	140	167	830	690	870	601
September	0	82	510	479	490	515

Flows in cubic feet per second.

TABLE 4. Flows of the Okanogan River during a 1944 Water Year at Penticton under Alternative Growth Projections and Operating Criteria.

		1970 Conditions					2020 Conditions													
Month	Historic	0	3	4	30	33	0	3	4	30	33	37(1)	37(3)	37(4)	38(1)	38(3)	38(4)	42(1)	42(3)	42(4)
October	157	89	100	239	239	100	114	120	264	264	114	100	100	100	337	336	330	100	100	100
November	152	83	100	273	347	100	98	358	214	287	100	100	100	100	156	156	152	185	261	106
December	144	90	412	273	347	100	107	358	214	287	107	100	100	100	164	163	160	185	261	106
January	131	81	412	273	347	100	97	358	214	287	100	100	100	100	155	154	152	185	261	106
February	126	82	412	152	152	100	95	100	165	165	100	100	100	100	155	155	152	100	100	100
March	118	92	100	162	162	100	106	108	176	176	106	100	100	100	166	166	164	100	100	100
April	79	300	100	170	300	300	300	100	170	300	300	261	261	258	136	135	133	261	260	258
May	202	300	100	100	300	300	300	100	100	300	300	300	300	300	100	100	100	300	300	300
June	602	300	100	100	300	300	300	100	100	300	300	300	300	300	100	100	100	300	300	300
July	392	400	200	200	400	400	368	168	168	368	368	390	386	417	190	186	217	390	386	417
August	190	391	191	191	391	391	380	180	180	380	380	403	399	430	403	398	430	403	398	430
September	169	330	130	280	330	330	338	138	288	338	338	332	331	338	357	356	363	332	331	338

Flows in cubic feet per second.

TABLE 5

SELECTED COMPUTER RUNS-MAINSTEM MODELLING

Run No.	Level of Development		Minimum Flow cfs	Minimum Fishery Flows All Times		Utilization of Design Channel Capacity	Import Shuswap River Water
	1970	2020		No	Yes		
0	Yes	Yes*	300	✓		80%	No
3	Yes	Yes*	100	✓		80%	No
4	Yes	Yes*	100		✓	80%	No
30	Yes	Yes*	300		✓	80%	Yes
33	Yes	Yes	300	✓		70%	No
37	2020 Projections 1, 3 and 4		300		✓	70%	No
38	2020 Projections 1, 3 and 4		100		✓	70%	No
42	2020 Projections 1, 3 and 4		300		** ✓	70%	No

*Runs 0, 3, 4 and 30 for 2020 level development were based on first economic growth projections prepared for study. These were subsequently modified under Projections 1, 3 and 4. Hence 2020 computer results for above mentioned 4 runs not exactly comparable to Projections 1, 3 and 4 under runs 37, 38 and 42 although differences are not considered significant because of lack of sensitivity of water demands to projects.

**Fishery demands not totally met.

TABLE 6

ECONOMIC PROJECTIONS FOR YEAR 2020

USED IN MAINSTEM OPERATING MODEL

Economic Projections	Population	Land Irrigated (Acres)	Remarks
First Economic Projection			
Region 1	242,550	17,000	Okanagan Lake
Region 2	73,200	3,800	Okanagan River
Region 3	6,750	1,200	Penticton-Okanagan Falls Okanagan Falls - Vaseux Lake Dam
Region 4	10,150	6,650	Vaseux Lake Dam - Oliver Gauging Station
Region 5	5,600*	5,980*	Oliver Gauging-Osoyoos Station
Total	338,250	34,630	
Second Economic Projection			
Projection 1			
Region 1	340,100	39,020	Medium Growth
Region 2	22,800	2,630	
Region 3	8,100	4,970	
Region 4	11,200	420	
Region 5	8,800	5,660	
Total	391,000	52,700	
Projection 3			
Region 1	252,600	39,020	Low Growth
Region 2	16,900	2,600	
Region 3	6,500	4,910	
Region 4	8,400	820	
Region 5	5,600	5,980	
Total	290,000	53,330	
Projection 4			
Region 1	340,100	47,420	Medium Growth and Indian Lands
Region 2	22,800	5,780	
Region 3	8,100	4,970	
Region 4	11,200	2,160	
Region 5	8,800	6,070	
Total	391,000	66,400	

* Estimated - First Projection did not include Osoyoos Lake area although allowance made for it in computer model by stipulating minimum flow at Oliver.

TABLE 7. Flow of the Okanogan River at Oroville, Washington, during a 1944 Water Year under Alternative Growth Projections and Operating Criteria.

Month	Historic	"Natural"	1970 Conditions					2020 Conditions							
			0	3	4	30	33	0	3	4	30	33	37(3)	38(3)	42(3)
October	201	0	140	151	290	290	151	166	172	316	316	166	145	181	145
November	224	50	163	180	353	427	180	178	438	294	467	180	175	231	336
December	193	30	147	469	330	404	157	158	409	265	338	158	151	214	312
January	184	40	142	473	334	408	161	156	417	273	346	159	157	211	318
February	229	240	196	526	266	266	214	206	211	376	276	211	209	264	209
March	130	0	105	113	175	175	113	134	136	204	204	134	109	175	109
April	185	590	415	215	285	415	415	405	205	275	405	405	368	243	368
May	323	2190	385	185	185	385	385	358	258	158	358	358	391	191	391
June	911	2350	543	343	343	543	543	505	305	305	505	505	564	364	564
July	501	340	444	244	244	444	444	376	176	176	376	376	450	240	450
August	167	140	297	97	97	297	297	261	61	61	261	261	335	334	334
September	82	0	227	27	177	227	227	224	24	274	224	224	233	258	234

Flows in cubic feet per second.

TABLE 8. Flow of the Similkameen River at Nighthawk with Various Levels of Depletion.

Month	Measured	"Natural"	1970 Conditions	2020 Conditions
October	473	440	473	484
November	470	451	470	476
December	393	375	393	399
January	327	312	327	332
February	319	303	319	324
March	373	362	373	377
April	922	907	922	927
May	4786	4856	4786	4763
June	6659	6795	6659	6614
July	1815	1947	1815	1771
August	690	826	690	645
September	479	508	479	469

Flows in cubic feet per second.

TABLE 9. Flow of the Okanogan River at Tonasket during a 1944 Water Year under Alternative Operating Conditions.

Month	Measured	"Natural"	1970 Conditions 0	1970 Conditions 3	2020 Conditions 0	2020 Conditions 3
October	655	584	801	812	846	852
November	731	517	674	691	699	959
December	594	393	552	874	573	824
January	492	317	453	784	475	736
February	656	633	627	957	645	650
March	539	383	513	521	549	551
April	944	1317	1177	977	1176	976
May	4747	6761	4794	4594	4212	4112
June	7925	9652	7527	7327	7513	7313
July	2005	2118	1920	1720	1779	1579
August	601	866	700	500	588	388
September	515	486	643	443	623	423

Flows in cubic feet per second.

The advantage of the first alternative is that it is the same as the approach being used in other basins. The disadvantage is that a determination of monthly water use in British Columbia would require a complete re-analysis of the British Columbia-Okanogan system.

The advantage of the second alternative is that it represents present conditions, the disadvantage is that Washington cannot control the future actions of British Columbia in allocating water.

The third alternative has the disadvantage of being a function of uncertain future events in British Columbia, and the advantage of taking into account some future use pattern in British Columbia. The Okanogan Lake operating criteria are a variable, and alternative criteria should be investigated in the process of doing any additional work.

POSSIBLE ADDITIONAL INFORMATION

In the various comments on Office Report No. 28, additional information was requested. The information which could be developed with relative ease is:

1. Comparison of potential SCS and USBR estimates of potential irrigated land.

2. The storage potential in Osoyoos Lake.

3. A list of adjudicated streams.

4. An estimate of water demand coefficients applicable to recreational subdivisions.

5. Review of water temperature in the Okanogan.

Some of these questions could be answered by the Policy Development Section.

A problem of some difficulty would be to improve the information on ground water. Any attempt to do so would require at least six man-weeks of effort and result in a low to medium order of resolution product.

The major problem is the need to determine the frequency of monthly flows in many of the smaller tributaries. The determination of a low order of resolution answer would require the commitment of approximately four man-months of effort.

R E C O M M E N D A T I O N S

The recommendations of the writer are:

1. The determination of water available from the Okanogan River be made by using 2020 British Columbia projections of use, and alternatives 0 and 3 for operating criteria. The U.S. use should be held to the 1970 level of use in the analysis.

2. Annual values be used in evaluating the availability of water in the smaller tributaries.

3. Some additional information be developed on the ground-water system, but this should be held to a minimum.

FUTURE REPORTS

A report on the preliminary analysis of the Okanogan system is nearing completion. A report will then be written presenting the results of a statistical analysis of monthly data for the main stem of the Okanogan River as recommended above.

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