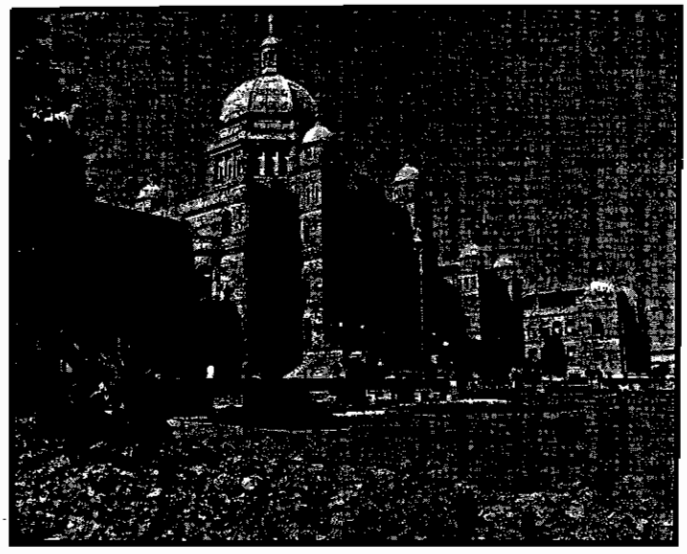
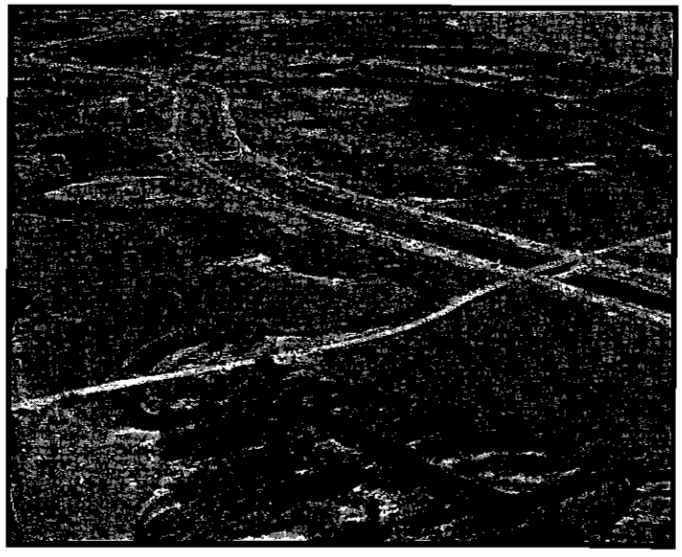
CANADA-BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT



PLANNING, ADMINISTRATION AND INSTITUTIONAL CONSIDERATIONS



JUNE 1975

TECHNICAL SUPPLEMENT XII

CANADA-BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

TECHNICAL SUPPLEMENT XII

TO THE

FINAL REPORT

PLANNING AND ADMINISTRATION

MAY 1975

THE CONSULTATIVE BOARD WISH TO ACKNOWLEDGE
THE CONTRIBUTION OF THE FOLLOWING PEOPLE IN
THE PREPARATION OF THIS TECHNICAL SUPPLEMENT

COMPILATION

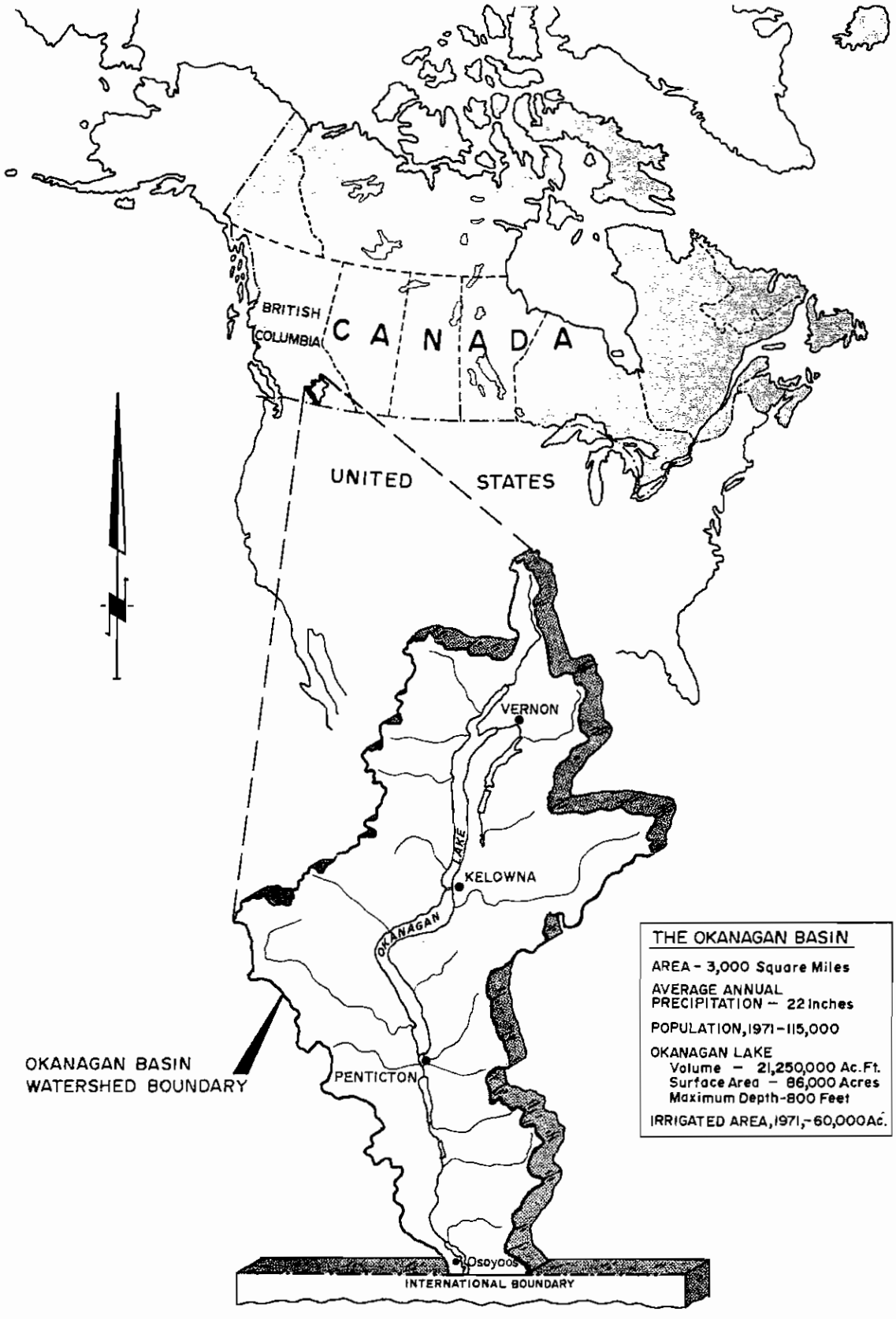
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THE OKANAGAN BASIN
IN
BRITISH COLUMBIA – CANADA

Figure A

FOREWORD

This Technical Supplement describes the planning concepts and arrangements used in the study of the water resources of the Okanagan Basin and the evolvement of a plan for the development and management of this resource. It also outlines the administrative arrangements for carrying out the Study and presents a breakdown of costs for various study components. The results of the detailed studies themselves may be found in other publications as listed on the inside front cover of this report.

The material presented in this supplement supercedes that of all earlier preliminary reports prepared under the terms of reference of this Agreement.

A. Murray Thomson
Study Director

SYNOPSIS

The objective of the Canada-British Columbia Okanagan Basin Agreement was "to develop a comprehensive framework plan for the development and management of water resources for the social betterment and economic growth in the Okanagan Basin". Implicit in the terms of reference of the Agreement was also the maintenance or enhancement of the natural environment. Planning as carried out in the Okanagan Basin Study to meet this objective, is described in this supplement under the headings:

1. the development of an initial program of studies;
2. changes and additions to this initial program of studies to provide the information needed to develop a comprehensive plan;
3. the development and evaluation of alternatives, and the evolvement of a comprehensive plan through the reiteration of the evaluation process.

Because the Okanagan Basin Study represented a new approach to water resource planning, the knowledge gained from this planning experience has also been set out, and an improved model for future basin studies is proposed.

1. Development of Initial Program of Studies

The initial program of studies (Study Plan) was based on: (1) program proposals as set out by five Federal-Provincial Task Forces in the fields of hydrology, limnology, water quality, waste treatment, and socio-economics; (2) a review of these task force proposals at a seminar held in Victoria early in 1970; and (3) the work of a special sub-committee established to prepare a comprehensive Study Plan from the task force proposals and seminar discussions. This initial study plan provided a schedule and preliminary budget for each proposed task assignment to be carried out, recognizing the time and financial limitations of the Agreement. The plan, including a detailed program and budget for the first year of the Study, was approved by the Consultative Board in June, 1970.

2. Changes and Additions to Study Plan

A continuing review of the progress and results of various task assignments at Committee and Board meetings, and at Study seminars, resulted in a

number of changes and additions to the initial program of studies to provide the information base needed for the development of the comprehensive plan. Study programs concerning fisheries, land use and public involvement, for example, were greatly expanded, while others such as groundwater exploration were curtailed. Extreme variations in runoff during the Study period also permitted the collection of additional flood damage and hydrometric data which would not otherwise have been available.

One of the major changes in this program involved that of economic growth studies. Initial results of these studies indicated that existing growth patterns resulting from previous government programs and incentives would not change significantly before 1980. However, because of the uncertainty in predicting future economic development beyond 1980 in a small region such as the Okanagan Basin, these studies were expanded to provide a range of future growth rates. This concept permitted a sensitivity analysis of the capability of the basin's water resource to meet a wide range of future demands, and also of placing a different emphasis on the three major goals of economic growth, environmental quality, and social betterment.

3. The Evaluation Process and Development of the Comprehensive Plan

The development and evaluation of alternatives, to meet the planning objectives of the Study was accomplished through a six step evaluation process as outlined below:.

(i) Define planning objectives for management component being evaluated;
(ii) Assemble information base to assess present conditions (resource capability versus present demands);
(iii) Determine the future demands for water use to the year 2020;
(iv) Compare resource capability with future demands and formulate alternative ways of managing the resource to meet these demands;
(v) Evaluate alternatives and express results in evaluation matrices;
(vi) Select most suitable alternatives or plan.

To facilitate this evaluation process and to specify how each of the major uses of water in the basin can contribute to the multiple goals of the Study, the complex water resource system was broken down into four management components:

(a) Water Quantity Management

- to supply water for all consumptive water requirements for agricultural, residential, commercial and industrial purposes;
- to supply water for all non-consumptive water requirements for fisheries, wildlife, recreation and aesthetic resources;
- to minimize economic and social consequences of floods and droughts in lakes

and tributary streams;
- to minimize conflicts between existing and potential uses of water

(b) Water Quality Management

- to protect the health of Okanagan residents;
- to provide water quality compatible with agriculture, municipal, domestic and industrial uses;
- to provide the highest possible water quality for water-based recreation, sport fisheries and other non-consumptive uses of water.

(c) Fishery Management

- to preserve, enhance and manage environments suitable for sport fishery development;
- to maintain and protect the environment for sockeye salmon stocks in the Okanagan River

(d) Water-Based Recreation Management

- to provide opportunities for a full range of water-based recreational activities;
- to protect and enhance the aesthetic qualities of the Okanagan Valley.

The evolvement of a comprehensive framework plan for the development and management of water resources in the Okanagan Basin was achieved through a number of reiterations of this evaluation process, accompanied by feedback from the public as the results of these reiterations were made available to the public involvement task forces and the residents of the Okanagan Basin.

4. An Improved Model for Future Basin Studies

Based on the planning experience gained from the Okanagan Basin Study, an improved model for carrying out future basin studies is proposed. The model includes three distinct phases: a preliminary assessment of a basin; detailed field studies, and an evaluation phase. One of the major differences between this model and the plan used for the Okanagan Basin Study is that a preliminary assessment stage has been added. This preliminary assessment phase is considered important for the proper identification of detailed study requirements, and in relating the priorities of water use in a basin with those of the Province as a whole, which in turn may affect the planning objectives and the value of water for a particular use in a basin.

It should also be emphasized that planning represents only one phase of water management. Past study agreements have tended to isolate such planning, rather than considering it as only a component of long term resource management. This shortcoming should be recognized in any future water management arrangements if the benefits to be derived from comprehensive planning, which often involve expensive and time consuming studies, are to be fulfilled.

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PART I
INTRODUCTION

CHAPTER 1
Background

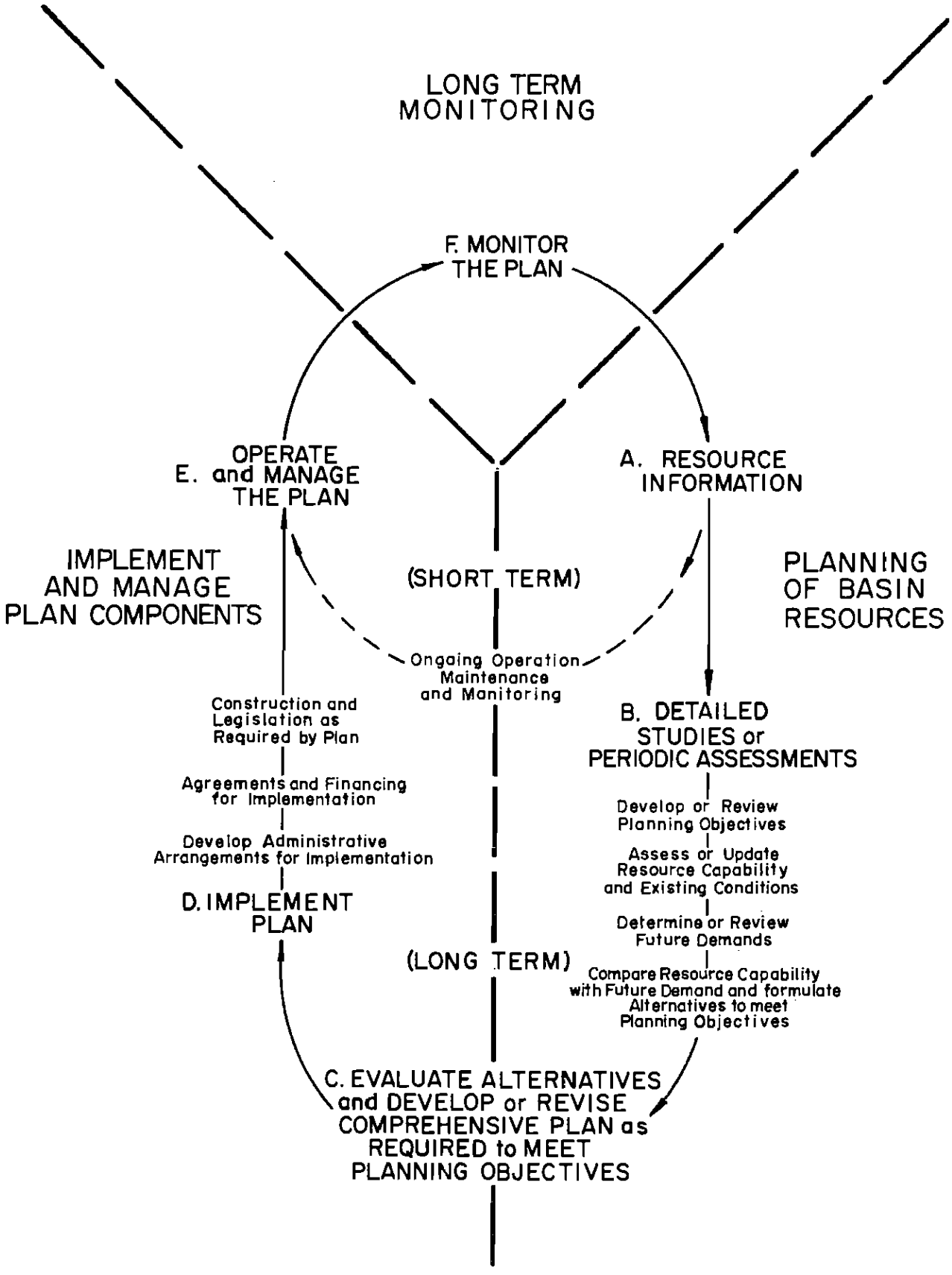
1.1 OBJECTIVES

The Okanagan Basin Study represented a new approach to water management, bringing together the combined skills of many experts in such fields as water quantity, water quality, waste treatment, socio economics, limnology and fisheries. Being in part a pilot project in basin planning, many new approaches were developed, and many new problems encountered during the evolvement of a plan for the development and management of the basin's water resource. The objectives and results of each of the major fields of study have been set out in Technical Supplements I to XI. The purpose of this particular supplement is to (1) set out the manner in which the plan of study incorporating these various disciplines was developed; (2) describe the evaluation process used in the development of the comprehensive plan; and (3) outline how the experience gained from this study may be used to provide an improved model for future basin studies of a similar nature.

1.2 PRE-AGREEMENT PLANNING

Historically, most planning in the water resource field has been of a short term - single purpose nature. If water was required for such uses as irrigation or domestic consumption, it was primarily a matter of ensuring there was a reasonably adequate quantity and quality of water available in a stream to meet the needs of the proposed development, and that storage and conveyance of the water to the point of use was both feasible and economical. Little attention was given to the effect of such a project on the region's water resource as a whole, or on other water dependent resources or activities such as fisheries and recreation.

As long as an abundant supply of water exists in comparison to total demands, this method of planning has generally been adequate, and local water managers have been able to cope with this type of planning based on experience and a minimum of information. When the amount of water withdrawn or consumed in a sub-basin or region approaches the amount of the available supply however, conflicts of use begin to occur, particularly in low runoff years. At this point in time, a more detailed assessment of the water resources of a basin may become necessary to provide water managers with the knowledge and tools required to properly manage this resource under these more critical supply - demand conditions (Figure 1.1). It should also be recognized that evolving scientific knowledge of the complex role of water in a regions' environment currently allows



THE PLANNING COMPONENT IN
WATER RESOURCE MANAGEMENT

Figure 1.1

for much more comprehensive studies on this aspect than has been possible in the past.

In the Okanagan Basin, the capability of the available water supply to meet the various demands of the region probably reached this critical stage sometime between 1960 and 1970. Certainly shortages, particularly for irrigation, began to occur in a number of tributaries while many other streams became fully licensed, resulting in new demands having to be met from more distant sources. Flows in the lower reaches of many streams also became very low or non-existant in the summer and fall months, due to upstream storage and diversion, greatly reducing the area of historical spawning grounds for the main valley lake fisheries, particularly trout and kokanee. The impact of an increasing population and expanding economy also caused a noticable decline in the quality of water in the main valley lakes, which provide the main attraction for recreational and aesthetic pursuits in the Okanagan Valley.

Such changes did not occur suddenly, but rather were the culmination of many events occurring over a period of years. Monitoring of the resource itself and activities dependent on water, provided some awareness of these changes, but because most uses were single-purpose in scope, the cumulative effect of these changes was not recognized until major conflicts of use began to occur.

The Agreement on which the Okanagan Basin Study was based resulted from a growing public concern about these changes, and also recognizition by the senior governments that better planning and management of the Basin's water resource were necessary if future demands on this resource were to be met, and the natural environment maintained for recreational and aesthetic pursuits. These factors led to the initiation of discussions between Federal and Provincial authorities during the latter part of 1968, concerning water resource studies within the Okanagan Basin.

Following the initial discussions, the Regional Districts of Central Okanagan and Okanagan-Similkameen were empowered by the Province to establish the Okanagan Basin Water Board. The objectives of the Board were to:

(1) Organize and receive proposals on water resource utilization and management within the Okanagan Basin;

(2) Define problems, determine priorities and support legislation or required action;

(3) Provide for communication on water resource utilization between various governments;

(4) Participate financially or otherwise in surveys and investigations.

This Board was subsequently enlarged to include the Regional District of North Okanagan.

By the spring of 1969 discussions by the senior governments on the proposed Okanagan Basin Study were sufficiently advanced to indicate the need for an expanded water quantity monitoring network, and the introduction of a water quality monitoring program. As a result of these discussions, these monitoring programs were initiated in June 1969.

1.3 THE AGREEMENT

The Canada-British Columbia Okanagan Basin Agreement (Appendix A) was signed in October 1969.

The study area covered by the Agreement, and referred to in this report as the Okanagan River Basin, included some 3000 square miles in the semi-arid south central interior of the Province of British Columbia. The main valley is comprised of a series of deep glacial lakes interconnected by Okanagan River, which exits through the State of Washington to join the Columbia River near the town of Brewster (Figure 1.2). That portion of the Okanagan Basin lying in the United States is the subject of a separate study being carried out by U.S.A. authorities. Although Okanagan River is a tributary of the Columbia, it has always been considered as a separate basin by Canada because of its location in respect to the International Boundary, and differing climatic conditions.

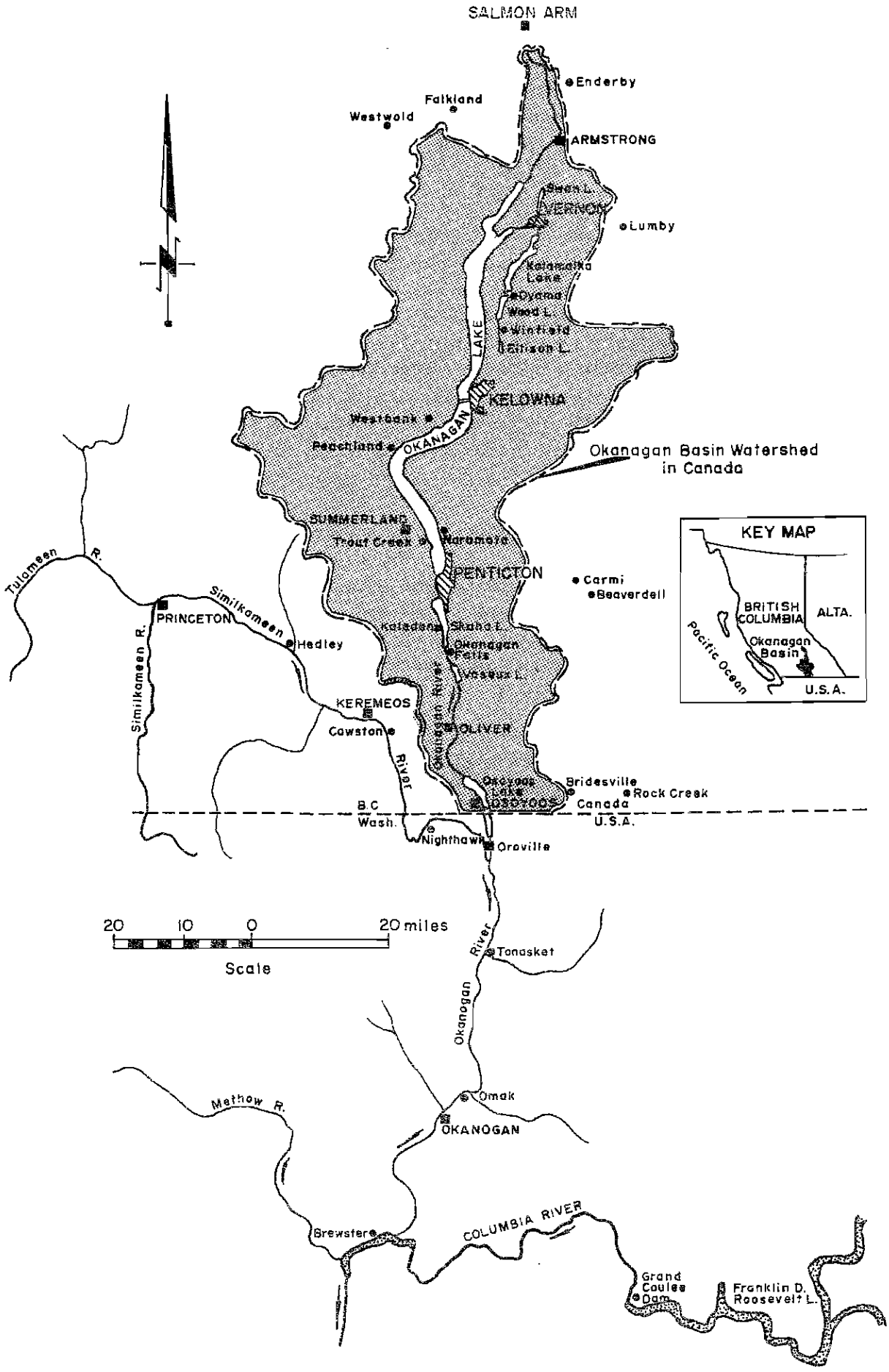
The objective of the Study as stated in the Agreement was:

> "to develop a comprehensive framework plan for the development and management of water resources for the social betterment and economic growth in the Okanagan Basin."

The scope of the Study as outlined in the Agreement was:

> "Due to the increasing demands likely to be placed on the water resources of the basin for municipal, industrial, agricultural and recreational uses and for fish and wildlife management, and in view of the deterioration of water quality, disturbance of ecological balances, and diminution of water quantity in the Basin, the Study will focus on identification and analysis of these problems, and the evaluation of economic, engineering, ecological, financial and organizational alternatives for water resource utilization in the solution to these problems. The planning horizon of the Study will be to the year 2020 A.D."

The Agreement also provided for: inclusion in the study of areas outside of the basin likely to be affected by the adoption of various alternatives; experimental waste treatment programs associated with the removal of nutrients



OKANAGAN DRAINAGE BASIN IN CANADA ------- Figure 1.2

from waste effluents; and public involvement as required, to ensure the plan evolved would represent the wishes of the people for whom it was designed.

1.4 ADMINISTRATIVE ARRANGEMENTS

The administrative framework required to facilitate joint Federal-Provincial participation in the planning process was set out in the Agreement (Appendix A). The Governments of Canada and British Columbia each appointed three members from senior levels in the Public Service to form the Canada-British Columbia Consultative Board (Figure 1.3 and Table 1.1). This Board was made responsible to the Ministers for the undertaking and overall supervision of the Study program. The Board met at least once a year for the purpose of approving the various studies and their budgets, and also attended all major seminars organized for the presentation and discussion of the findings of these studies.

A six member Okanagan Study Committee was also appointed with equal representation from both governments (Figure 1.3 and Table 1.1), to carry out the joint planning studies and pilot projects under the direction of the Consultative Board and in accordance with the Terms of Reference of the Agreement. To fulfill their responsibilities the Study Committee met at least once a month between the time of appointment and March 1974. Some of the main management activities of the Committee included:

(a) The establishment of the task forces for preparing terms of reference and costs of studies in the fields of water quantity, water quality, limnology, waste treatment and socio-economics, and the development of a study plan from the programs submitted by these task forces;

(b) the appointment of a Study Director to manage, coordinate and develop the overall planning program under the direction of the Committee;

(c) the review of task assignments and incorporation of new tasks in the Study Plan as needed to meet the requirements of the terms of reference;

(d) the development of planning and evaluation methods throughout the Study;

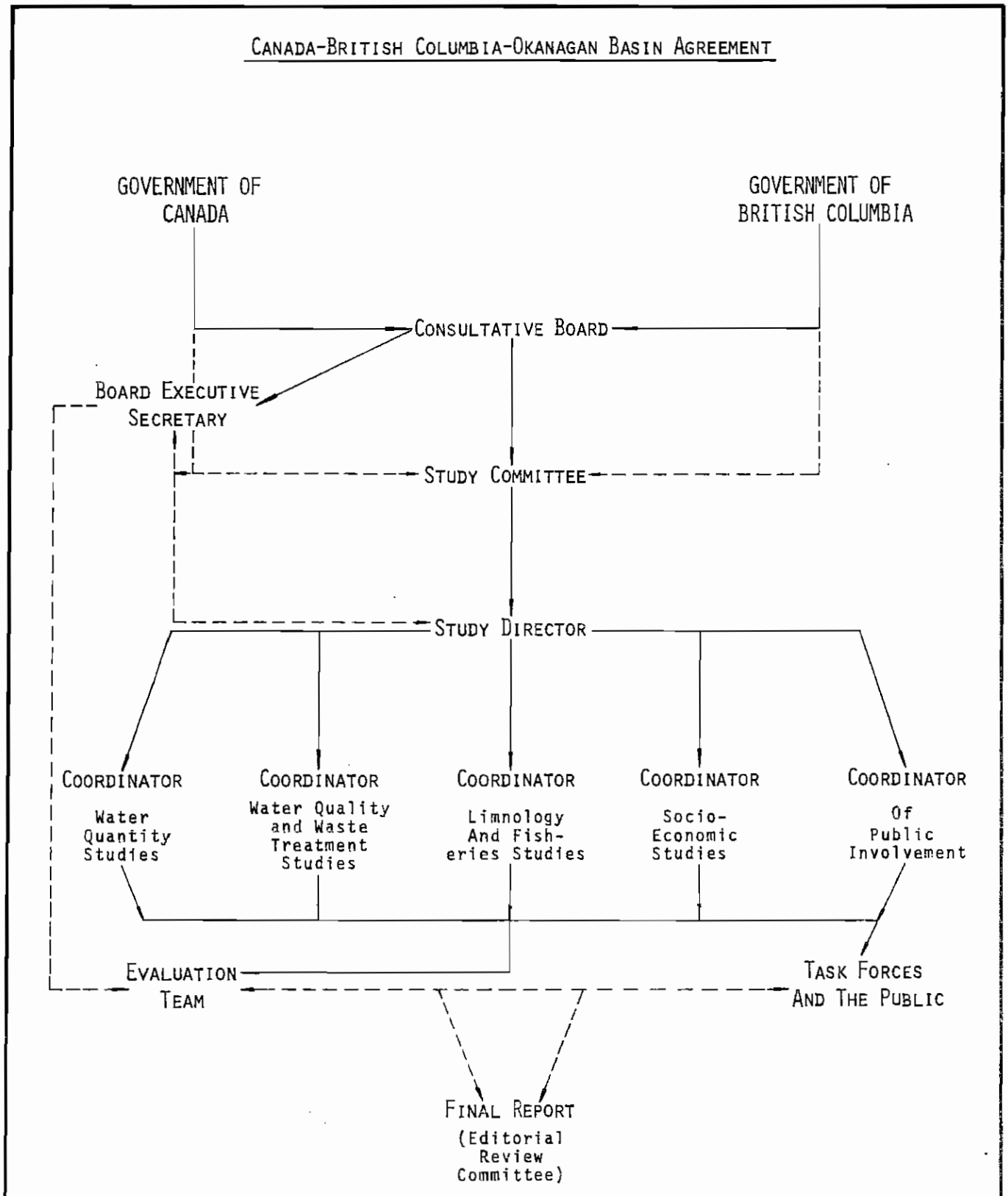
(e) the promotion of and participation in various seminars on the Okanagan Basin Study;

(f) the preparation, review and publication of information bulletins and other materials on the Okanagan Basin Study

(g) the preparation of annual and other reports made to the Consultative Board

(h) the preparation of annual budgets to the Consultative Board

The administrative center for the Study was established in Penticton following the appointment of the Study Director in June 1970. This office was also used as a base for many of the studies carried out under the Okanagan Basin Study,



ORGANIZATION STRUCTURE

Figure 1.3

TABLE 1.1

MEMBERS OF THE OKANAGAN BASIN STUDY

Shown in Figure 1, Organizational Structure

NAME	POSITION	AFFILIATION AT TIME OF APPOINTMENT TO STUDY
1. CONSULTATIVE BOARD		
(a) FEDERAL		
1. Dr. A.T. Prince	Co-Chairman	Director, Inland Waters Branch, Energy, Mines and Resources Canada
2. Dr. E.R. Tinney	Member	Director, Policy and Planning Branch, Energy, Mines and Resources Canada
3. Mr. K. Lucas	Member 1970-72	Director, Resource Development Service, Fisheries and Forestry Canada
(i) Replaced by Mr. R.L. McLaren	Member 1972-74	Regional Director, Environmental Protection Service, Environment Canada
(b) PROVINCIAL		
4. Mr. B.E. Marr	Co-Chairman	Chief Engineer, B.C.W.I.B. W.R.S. Dept. of Lands, Forests, and Water Resources
5. Mr. W.H. Venables	Member	Director B.C.P.C.B. W.R.S. Dept of Lands, Forests and Water Resources
6. Mr. H.D. Debeck	Member	Comptroller Water Rights Branch W.R.S. Dept. of Lands, Forests and Water Resources
Mr. J.C. Bunge	Board Secretary 1970-71	B.C.W.I.B. W.R.S. Dept. of Lands, Forests and Water Resources
(i) Replaced by Mr. J.G.A. Kidd	Board Secretary and Consultant 1971-73	Underwood, McLellan and Associates, Vancouver British Columbia
2. STUDY COMMITTEE		
(a) FEDERAL		
1. Mr. R.C. Hogdes	Co-Chairman 1970-71	Chief, Planning Divison, Energy, Mines and Resources
(i) Replaced by Dr. J. O'Riordon	Co-Chairman 1971-73	Policy and Planning Branch, Energy, Mines and Resources
2. Mr. L. Edgeworth	Member 1970-71	Chief Resource Development Branch, Fisheries Service, Pacific Region
(i) Replaced by Mr. F.C. Boyd	Member 1971-74	Chief Environmental Quality Unit, Fisheries Service, Pacific Region
3. Dr. C.C. Strachan	Member 1970-71	Director, Summerland Research Station, Department of Agriculture, Canada
(i) Replaced by Dr. J.L. Mason	Member 1971-74	Head, Soil Service Section, Summerland Research Station Department of Agriculture,Can
(b) PROVINCIAL		
1. Mr. T.A.J. Leach	Co-Chairman	Asst. Chief Engineer B.C.W.I.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
2. Mr. E.H. Vernon	Member	Chief, Fisheries Management, Fish and Wildlife Branch Dept. of Recreation and Conservation, Victoria, B.C.
3. Mr. M.W. Slezak	Member	Chief, Projects and Research Division, B.C. P.C.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
Dr. R.J. Buchanan	Interim Coordinator 1969-70	Water Resources Service Dept. of Lands, Forests and Water Resources, Victoria, B.C.
Mr. A.M. Thomson	Study Director 1970-74	Canada-British Columbia Okenagan Basin Agreement
3. COORDINATORS	FIELD OF STUDY	
1. Mr. T.A.J. Leach	Water Quantity	Asst. Chief Engineer B.C.W.I.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
2. Mr. M.W. Slezak	Water Quantity and Waste Treatment 1970-72	Chief, Projects and Research Division, B.C. P.C.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
(i) Replaced by Mr D. Currigan	Water Quantity and Waste Treatment 1972	B.C.P.C.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
(ii) Replaced by Mr. E. Haughton	Water Quantity and Waste Treatment 1973-74	B.C.P.C.B. W.R.S. Dept of Lands, Forests and Water Resources, Victoria, B.C.
3. Dr J.G. Stockner	Limnology-Fisheries 1970-72	Freshwater Institute, Fisheries Research Board Environment Canada
(i) Replaced by Mr. G.D. Koshinsky	Limnology- Fisheries 1973	Freshwater Institute, Fisheries Research Board Environment Canada
(ii) Replaced by M. Pinsent	Limnology-Fisheries 1973-74	Fish and Wildlife Service, Dept of Recreation and Conservation, Victoria, B.C.
4. Dr. J. O'Riordon	Socio-Economics (Federal)	Policy and Planning Branch., Energy, Mines and Resources
5. Mr. C.H. Thomas	Socio Economics (Provincial)	Water Resources Service, Department of Lands, Forests and Water Resources, Victoria, B.C.
6. Mr. G.W. Sinclair	Public Involvement 1972-74	G.W. Sinclair and Associates, Penticton,B.C.
4. EDITORIAL REVIEW COMMITTEE		
1. A.M. Thomson	Study Director	As Shown Above
2. Mr. T.A.J. Leach	Co-Chairman Study Committee	As Shown Above
3. Dr. J. O'Riordon	Co-Chairman Study Committee	As Shown Above
5. SPECIAL AFFILIATIONS		
1. Mr. H.B. Rosenburg	Federal Coordinator Ottawa	Policy and Planning Division Environment Can
2. Dr. S.O. Russell	Water Quantity Consultant	University of British Columbia
3. Dr. W. Oldham	Waste Treatmant Consultant	University of British Columbia

for the preparation of the many reports resulting from the Study, and as a center for the public involvement program.

To facilitate study arrangements, Coordinators were designated for each of the major fields of study (Figure 1.3 and Table 1.1). These Coordinators were made responsible for all tasks being carried out by their agency (see also Section 3.3) and simplified the coordination of the Study program as directed by the Study Committee through the Study Director.

Due to the pilot nature of the Study, numerous changes in planning strategies were made by the Board in the overall development of the Comprehensive Plan. These changes were generally the result of new information obtained during the Study, or experience gained in the planning process. The Board also undertook the preparation of findings and recommendations resulting from the Study, following the completion of the draft final reports by the Study Committee. The organizational structure shown in Figure 1.3 portrays the administrative framework as developed during the tenure of the Study. While this structure is linear in form, it is important to recognize the high level of cooperative effort achieved by Study members throughout the planning process.

1.5 FINANCIAL ARRANGEMENTS

The Agreement placed financial control of the Study in the hands of the Consultative Board, with the provision that total Study costs would not exceed $2 million and that these costs would be shared equally by both governments. Through mutual agreement by the two governments, the Study was extended to March 31, 1974 although no additional funds were allocated.

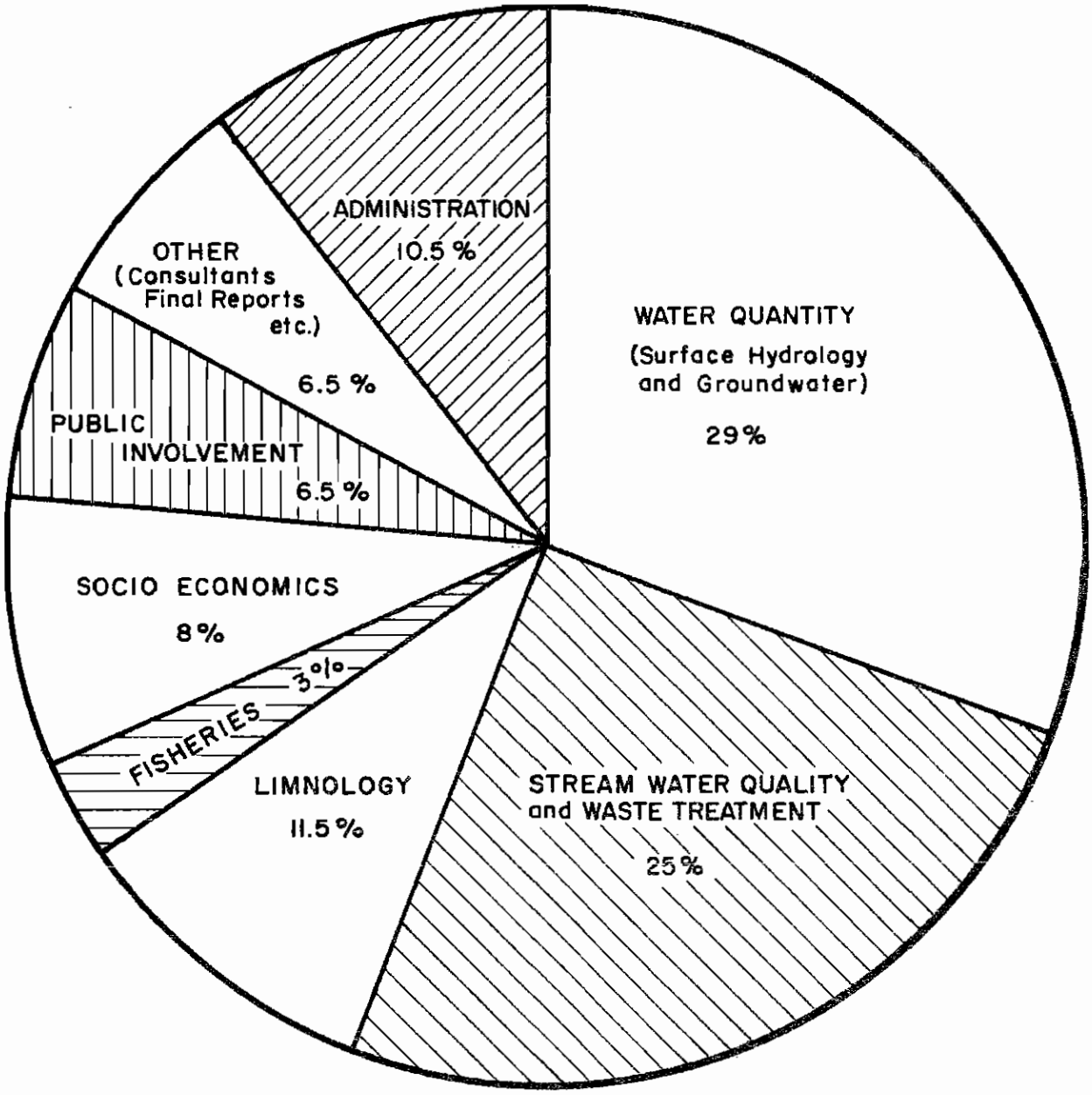
Funding for specific task assignments and for management of the Study was allocated and reviewed by the Committee and Board on an annual basis. The control of funding for work carried out under the Study was handled through the Comptroller, Land and Water Resources Service, Department of Lands, Forests and Water Resources, Province of British Columbia. A statement of expenditures for the period October 1969 to March 1974 is shown in Table 1.2, and portrayed graphically in Figure 1.4. These figures do not include any costs incurred prior to October 1969, or costs incurred by Committee and Board members in the supervision of this Study.

TABLE 1.2

CANADA - BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

STATEMENT OF EXPENDITURES, OCT 1969 TO MARCH 1974

TASK	DESCRIPTION	Oct, 1969 to Mar 31, 1971	1971-72	1972-73	1973-74	TOTAL TASK COST	TOTALS	PERCENTAGE OF TOTAL
	STUDY DIRECTOR'S OFFICE							
	- Management of Study	22,721	34,067	44,209	39,221	140,218		
	- Office Accomodation and Supplies for Administrative Staff; Limnology, Fisheries, Socio Economic and Public Involvement Programs.	9,940	17,836	18,036	12,754	58,566	209,170	10.5%
	- Publications - Brochures, Annual Reports and Data Bulletins etc.	-	1,550	8,303	533	11,386		
	PUBLIC INVOLVEMENT PROGRAM							
	- Administrative and Consulting Services	-	17,329	51,062	33,629	102,020	131,424	6.5%
	- Media, Publications, and Public Meetings	-	12,384	8,048	8,972	29,404		
	PLANNING CONSULTANTS - BOARD & COMMITTEE		17,421	54,591	10,101	82,113	82,113	4.1%
	FINAL REPORT AND TECHNICAL SUPPLEMENTS				44,453	44,453	44,453	2.2%
	WATER QUANTITY							
	(a) Surface Hydrology							
35	- Matching of Supply and Demand	-	137	28,979	-	29,116		
180	- Forest Hydrology	-	5,000	-	-	5,000		
53	- Regionalization of Sub-basin Hydrology	6,543	17,508	-	-	24,051		
43	- Surface Gauging Network	85,521	-	-	-	85,521		
44	- Meteorological Network	20,997	3,471	-	-	24,468		
36	- Water Supply Studies	2,583	8,209	-	-	10,792	374,854	19.0%
38	- Hydrogeological Investigations	7,200	-	-	-	7,200		
52	- Operation of Gauging Stations	27,429	39,251	7,430	-	74,276		
21	- Shoreline Survey	-	7,612	-	-	7,612		
34	- Computer Models (Including Task 29)	14,001	32,251	28,144	6,976	81,372		
22	- Engineering Investigations	-	-	25,446	-	25,446		
	(b) Groundwater							
40	- Deep Valley Test Holes	151,916	-	-	-	151,916		
41	- Deep Well Instrumentation	-	18,446	-	-	18,446	201,876	10.1%
39	- Seismic Exploration	29,581	-	-	-	29,581		
47	- Groundwater Evaluations	-	16	-	-	1,933		
	WATER QUANTITY - SUBTOTAL	345,771	132,067	91,916	6,976	576,730		
	WATER QUALITY							
130	- Outfall Discharge Study	-	17,858	-	-	17,858		
131	- 32 Streams Quality Study	61,026	25,510	-	-	86,536		
128	- Design Data Bank	6,000	-	-	-	6,000		
139	- Groundwater Nutrient Inputs	904	6,531	45,000	-	52,435		
133	- Storm Discharge Study	-	471	9,010	-	9,481		
134	- Dustfall and Precipitation	87	140	6,961	-	7,188	243,948	12.2%
135	- Bacteriological Study	136	2,563	-	-	2,699		
105	- Present and Future Waste Loadings	5,054	9,244	28,134	-	42,432		
102	- Stream Ecology	-	-	18,823	-	18,823		
126	- Inventory Pesticide Use	-	-	496	-	496		
	WATER QUALITY - SUBTOTAL	73,207	62,317	108,424	-	243,948		
	LIMNOLOGY							
118	- Lake Monitor Study	1,000	26,416	-	-	27,416		
119	- Nutrient Bioassay	16,717	9,545	-	-	26,262		
120	- Physical Limnology Study	4,184	23,020	-	-	27,204		
124	- Chemical Limnology Study (Tasks 150,117 &124)	17,243	40,887	1,578	-	59,708		
121	- Geological Study	-	14,205	-	-	14,205	231,777	11.5%
122	- Benthic Studies	-	14,456	-	-	14,456		
123	- Zooplankton Study	-	2,401	-	-	2,401		
115	- Fish Population and Analysis	-	25,946	3,161	-	29,107		
104	- Lake Ecology Evaluations	-	3,636	27,382	-	31,018		
	FISHERIES							
66	- Fisheries Studies	-	25,829	8,900	7,077	41,806		
163	- Salmonid Enhancement	-	-	6,800	-	6,800	69,372	3.0%
161	- Sport Fisheries and Water Management	-	9,559	-	-	9,559		
162	- Pacific Salmon Population-Habitat	-	1,207	-	-	1,207		
	LIMNOLOGY-FISHERIES - SUBTOTAL	39,144	197,107	47,821	7,077	291,149		
	WASTE TREATMENT							
142	- Review Nutrient Removal Methods	9,545	569	1,940	-	12,054		
147	- Applied PilTot Research Projects		23,200	168,508	-	191,708	252,038	12.6%
113	- Waste Treatment Evaluations	-	450	47,826	-	48,276		
	WASTE TREATMENT - SUBTOTAL	9,545	24,219	218,274	-	252,038		
	SOCIO-ECONOMICS							
	(a) Economic and Land Use							
201	- Economic Base Study	7,603	-	-	-	7,603		
205	- Economic Growth Study	2,160	29,079	-	-	31,239		
11	- Inventory Irrigable Land	894	2,498	-	-	3,392		
15	- Present-Future Water Use	2,451	1,769	-	-	4,220		
54	- Water Demand Studies	-	6,896	-	-	6,896	88,179	4.4%
202	- Existing Land Use	7,637	-	-	-	7,637		
206	- Alternate Economic Growth Plans	-	-	18,265	-	18,265		
209	- Future Land Use Studies	-	-	4,745	1,348	6,103		
20	- Flood Damage Studies	-	2,824	-	-	2,824		
	(b) Evaluation Studies							
207	- Principles of Evaluation	3,688	2,566	-	-	6,254		
10	- Methodology for Evaluations	-	10,329	14,649	-	10,329	31,232	1.5%
111	- Alternative Evaluations	-	-	-	-	14,649		
	(c) Financial and Institutional Studies							
203	- Financial and Institutional Studies	720	5,080	5,031	-	10,831	11,457	0.5%
204	- Water Management Opportunities	-	-	626	-	626		
	(d) Water Based Recreation							
208	- Recreation and Aesthetic Resources	-	-	13,833	-	13,833	33,512	1.6%
112	- Tourist and Resident Recreation Surveys	-	19,679	-	-	19,679		
	(e) Wildlife and Water Management							
160	- Wildlife and Water Management	-	4,595	-	-	4,595	4,595	0.2%
	SOCIO-ECONOMIC - SUBTOTAL	25,153	85,315	57,149	1,358	168,975		
	TOTAL EXPENDITURES PER YEAR	525,481	601,612	707,833	165,415	2,000,000	2,000,000	100.0%



DISTRIBUTION OF EXPENDITURES FOR THE OKANAGAN BASIN STUDY

Figure 1.4

PART II
THE STUDY

CHAPTER 2
Development of Initial Program of Studies

Following the signing of the Agreement, a preliminary Study Plan was developed which set out the relationship, timing, and budget for individual studies or tasks necessary to achieve the Study objective within the time limitations and funding stipulated in the Agreement. This chapter outlines the development of this initial study plan.

2.1 STUDIES PROPOSED BY FEDERAL-PROVINCIAL TASK FORCES

At the first meeting of the Study Committee held on February 17, 1970, it was agreed that five Federal-Provincial task forces be established to set out those studies required to assess the water resource capability and to determine future demands on this resource, based on the terms of reference of the Agreement. The five fields of study reviewed included hydrology, limnology, water quality, waste treatment and socio-economics. The members of these task forces and their 1970 affiliation are listed in Figure 2.1. The study proposals of these task forces were presented and discussed at a Board-Committee Seminar held in Victoria on May 14 - 15, 1970. A description of these proposals is included in Appendix B of this report and summarized below:

1. HYDROLOGY

Twenty-three separate tasks were proposed in the field of water quantity. These tasks consisted of studies to estimate the firm water supply and consumptive use demands for present and proposed developments under varying constraints; water quantity models to aid in the evaluation and selection of alternative water management and development schemes; the development of management techniques in the continuing long term operation of the Okanagan system; and groundwater resource studies to assess the magnitude and sources of this component. The studies on surface hydrology in particular were designed to determine the contribution of each of the major streams in the basin to the total annual runoff, and the part that groundwater plays in this balance.

2. LIMNOLOGY

The limnology studies proposed were designed to determine the distribution and circulation of nutrients - plant and animal food - and other chemical substances in the major lakes of the Okanagan Basin, in order to understand the process involved in lake eutrophication (aging) and the measures needed for its control. The program outlined was considered basic for assessing the present and future

FIGURE 2.1

TASK FORCE MEMBERSHIP

PROVINCIAL	FEDERAL
HYDROLOGY TASK FORCE	
Mr. H.I. Hunter, Chief Hydrology Division, B.C.W.I.B. Water Resources Service	Mr. H.T. Ramsden, Dist. Engineer Water Survey of Canada, I.W.B. Energy, Mines and Resources
Dr. J.C. Fowerаker, Chief Groundwater Division, B.C.W.I.B. Water Resources Service	Mr. E. C. Halstead Hydrologic Science Div., I.W.B. Energy, Mines and Resources
LIMNOLOGY TASK FORCE	
Dr. T.G. Northcote Fish and Wildlife Branch (U.B.C.) Recreation and Conservation	Dr. J.R. Vallentyne Eutrophication Section Freshwater Institute, F.R.B.,
Mr. C.L. Neilson Provincial Entomologist Department of Agriculture	Dr. R.K. Lane, Head Physical Limnology Section, C.C.I.W., Energy, Mines and Resources
SOCIO-ECONOMIC TASK FORCE	
Mr. M.H.A. Glover Exec. Director, Economic Research Ind. Development, Trade & Commerce	Dr. J. O'Riordan Policy and Planning Branch Energy, Mines and Resources
Mr. C.H. Thomas Research Officer Water Resources Service	Dr. G. Gartner Planning Branch Regional Economic Expansion
WATER QUALITY TASK FORCE	
Mr. A.J. Lynch Chief Public Health, Chemist Dept. of Health Services	Mr. S.W. Reeder Water Quality Division, I.W.B., Energy, Mines and Resources
Mr. A.J. Chmelauskas, Chief Industrial Division, B.C.P.C.B. Water Resources Service	Mr. K.J. Jackson Resource Development Branch Fisheries and Forestry
WASTE TREATMENT TASK FORCE	
Mr. J.E. Dew-Jones Chief, Municipal Div., B.C.P.C.B. Water Resources Service	Dr. D.S. Stevenson Summerland Research Station Canada Dept. of Agriculture
Mr. C.H. Brownlee Soils Branch Department of Agriculture	Mr. A.R. Townshend Water Quality Division, C.C.I.W., Energy, Mines and Resources

1. Affiliations shown are for period of Task Force involvement in 1970

2. Abbreviations:

B.C.W.I.B. - British Columbia Water Investigations Branch
B.C.P.C.B. - British Columbia Pollution Control Branch
I.W.B. - Inland Waters Branch
F.R.B. - Fisheries Research Board of Canada
C.C.I.W. - Canada Centre for Inland Waters
U.B.C. - University of British Columbia

Figure 2.1

ability of the lakes to use or assimilate waste materials without adversely affecting potential uses of the water. Nine tasks covering limnogeological, physical, chemical and biological studies were set out by the limnology task force. Some previous limnology studies had been carried out on the main valley lakes, principally those of Clemins, Rawson, and McHugh in 1935, and the results of these studies were to be used for comparison purposes to indicate the changes that had occurred over the past 35 years.

3. WATER QUALITY

The water quality program recommended by the water quality task force involved 12 separate studies and was designed to determine present sources and levels of pollution, and to devise models that would express nutrient balances and pollution effects. A subsequent program, not detailed at this stage, was also proposed which would assess the extent and range of possible future levels of pollution. The water quality program was also to provide for the chemical analysis of water quality samples collected under the other fields of study - i.e. limnology, groundwater, etc.

4. WASTE TREATMENT

Study proposals presented by the waste treatment task force included a review and examination of existing nutrient removal processes in North America, the selection of nutrient removal experimental programs, an examination of the feasibility and cost of removing effluent from the basin, and the examination and relocation, if necessary, of waste discharges to surface waters or to the ground. The results of the nutrient removal experimental programs, in conjunction with data from other research programs and plant operations, were to be used to make recommendations for future wastewater management in the Okanagan Basin.

5. SOCIO-ECONOMIC

The proposals of this task force were considered by the Study Committee to be the key to the development of a unified comprehensive plan. Studies proposed included: an examination of the existing relationship between water resources, economic activity and aesthetic values; forecasting the nature of the main economic activities in the Okanagan Basin to the year 2020 to make possible an estimate of future water requirements; the evaluation of the effect of alternative plans for water resource development and management on the environment; alternative ways of managing and financing the use of water resource in the basin; and public involvement to ensure the framework plan developed met the needs of the people for which it was designed.

2.2. PREPARATION OF INITIAL STUDY PLAN

Following the preparation of program proposals by the task forces and their review at the Victoria Seminar of May 14-15, 1970, the Study Committee established a special sub-committee to prepare a comprehensive study plan in consultation with the task forces and the Study Committee. The terms of reference were not precisely defined, but were to include identification and scheduling of tasks, budgets, and terms of reference for executing agencies. Representatives on this sub-committee included one member from each of the senior governments, the secretary for the Consultation Board, and a planning consultant.

Initially it was agreed that the whole study needed to be laid out in an interrelated plan in order to appraise the first years' activities. It would not have been in the spirit of the Agreement if the basin were studied scientifically, economically and socially without all parts fitting into a planned strategy in a pre-determined manner.

The studies proposed by the task forces were therefore identified by a name and a number and assembled into a comprehensive study plan. Both the timing and the inter-dependencies of various tasks were considered in preparing this program of studies. Several tasks not listed by task force members, but considered essential in the overall plan, were also identified and scheduled. These included studies on wildlife, ecology, transportation, land use and the evaluation of the feasibility and costs of a number of alternative management schemes. The special sub-committee also recommended that all tasks not considered absolutely essential to the program, be postponed.

This proposed program of studies was presented to the Consultative Board on June 18, 1970. The Board subsequently approved this program and the budget for the first year of the Study. This Study Plan is outlined in Figure 2.2 and illustrates the components of the original plan along with those tasks added over the course of the Study. Detailed descriptions of each of the tasks shown in the Plan are included in Appendix C.

2.3 ASSIGNMENT OF TASKS

The two main options considered with respect to the delegation and carrying out of task assignments were:

1) To make one government agency responsible for a group of related tasks, which in turn could sub-contract components of the work to others.

2) To give the responsibility to the task forces who prepared the preliminary proposals for the various programs.

1970 | 1971 | 1972 | 1973 | 1974

Penticton Seminar Feb. 9-11 '71 — Vancouver Seminar Feb. 22-24 '72 — Naramata Seminar Mar. 24-25 '72 — Duncan Seminar June 5-9

VICTORIA SEMINAR MAY 12-13, 1970

INITIAL SELECTION OF STUDIES

DOCUMENT EXISTING CONDITIONS

WATER QUANTITY

TASK 43 - Construction of Hydrometric Stations - (June 70 to May 71)
44 - Installation of Meteralogical Network - (Aug. 70 to Aug. 71)
52 - Operation of Hydrametric and Meteralogical Stations - (Oct 70-Oct 73)
180 - Forest Hydrology Studies - (Sept. 71 to March 72)
34 - Water Quantity Computer Models - (Apr. 71 to Dec. 72)
29 - Development of Forecasting Models - (Nov. 71 to March 73)
36 - Tributary Water Supply Studies - (Nov. 71 to Feb. 73)
38 - Hydro Geologic Surface Investigations - (June 70 to May 71)
39 - Seismic Exploration of Groundwater Resources - (June 70 to Sept. 70)
40 - Graundwater Resource Exploration (Aug. 70 to May 71)
41 - Instrumentation and Testing of Deep Wells - (Jan. 71 to Nov. 72)
53 - Mainstem and Sub-Basin Hydrology Studies - (Jan. 71 to March 73)

SOCIO ECONOMICS

TASK 21 - Shoreline Survey and Flood Damage Studies - (Apr. 71 to Sept. 72)
11 - Definition of Irrigable Land by Location and Elevation - (Sept 70 to June 71)
202 - Land Use Studies (Present) - (June 70 to Apr. 71)
15 - Preliminary Estimate of Present and Future Demands - (Dec. 70 to Apr. 71)
201 - Economic Base Study - (Aug. 70 to April 71)
54 - Detailed Water Demand Studies - (July 71 to Sept. 72)

TASK 207 - Principles of Evaluation - (Oct. 70 to April 71)
203 - Institutional and Financial Studies - (Sept. 71 to May 72)
170 - Identification of Social Systems - (April 71 to Aug. 71)

TASK 160 - Wildlife and Water Management - (May 71 to March 72)
161 - Sport Fisheries and Water Management - (May 71 to March 72)
162 - Pacific Salmon Population and Habitat - (May 71 to Oct. 71)
66A - Stream Habitat Survey - (June 70 to Sept. 71)
66B - Limnology of Headwater Lakes - (April 71 to Sept. 72)
66C - Creel Census - (April 71 to Oct. 72)

TASK 128 - Design Water Quality, Data Storage and Retrieval Systems - (April 70 to Sept. 70)
129 - Analyse Output from Data Bank - (May 70 to Sept. 70)
130 - Outfall Discharge Study - (July 69 to March 72)
131 - Stream Quality Study - (Aug. 71 to Dec. 72)
133 - Storm Sewer Discharge Study (Aug. 71 to Dec. 72)
134 - Dustfall and Precipitation Study - (Nov. 71 to Dec. 72)
135 - Bacteriological Study - (May 71 to Dec. 72)
139 - Groundwater Nutrient Input Study - (June 70 to June 73)
126 - Pesticide Use Study - (May 71 to May 72)

LIMNOLOGY

TASK 115 - Fish Population Survey Main Valley Lakes - (April 70 to May 72)
117 - Chemical Limnology and Nutrient Mass Study - (May 70 to June 72)
118 - Lake Monitor Study - (Sept. 70 to July 72)
119 - Nutrient Bioassay - (March 70 to March 72)
120 - Physical Limnology - (Aug 71 to May 72)
121 - Limnogeological Study - (March 71 to July 72)
122 - Benthic Studies - (Sept. 69 to Dec. 72)
123 - Zooplankton Studies - (Sept. 69 to March 72)

WASTE TREATMENT

TASK 142 - Review and Evaluation of Nutrient Removal Methods - (June 70 to Jan. 73)
147 - Applied Research and Advanced Waste Treatment - (March 71 to May 73)

ASSESS RESOURCE CAPABILITIES through Preliminary Evaluations and Project Future Demands

TASK 23 - PRELIMINARY EVALUATION OF MAINSTEM WATER QUANTITY ALTERNATIVES (APRIL 71 TO JAN. 72)

TASK 47 - Groundwater Evaluations (Sept. 71 to Aug. 72)

TASK 205 - Economic Growth Studies (July 71 to June 73)

TASK 10 - Methorology and Studies for Evaluating Water Resource Benefits - (Sept. 71 to May 73)

TROUT CREEK PILOT STUDY (Sept. 71 to - Not Completed)

All Tasks → TASK 171 - Public Involvement and Development of Alternatives

TASK 105 - Estimate Present Loadings for Nutrients and Other Parameters to the Okanagan Lake System

TASK 104A - Limnology of the Okanagan Lakes (Their Present Status)

ELLISON - WOOD - KALAMALKA LAKES SUB BASIN EVALUATION - (Aug. 71 TO Nov. 72)

(Kalamalka-Wood Lake Study Undertaken by Province of B.C. (Completed Dec. 1974)

COMPARE RESOURCE CAPABILITIES WITH FUTURE DEMANDS AND CARRY OUT COST-FEASIBILITY STUDIES

TASK 22 - Engineering Cost Feasibility Studies
35 - Matching of Supply and Demand in Selected Tributaries under Present and Future Development Conditions
209 - Land Use Study (Future)

TASK 21 - Evaluation of 1972 Flood Damage - (May 72 to July 72)

TASK 206 - Development of Alternative Economic Growth Plans

TASK 200 - Identify Factors and Values Associated with Water Based Recreation and Aesthetic Resources - (June 72 to May 73)

TASK 66E - Kokanee Shore Spawning Studies - (July 72 to April 73)
163 - Salmonid Enhancement Feasibility Study (July 72 to Dec. 72)
66D - Fishery Potentials in the Okanagan - (July 72 to Dec. 72)

TASK 103 - Estimates of Future Nutrient Loadings to the Okanagan Lake System

TASK 102 - Evaluate Present and Probable Future Water Quality in Basin

TASK 104B - Limnology of the Okanagan Lakes (Their Future Status)

TASK 141 - Assess and Optimize Waste Discharge Locations

TASK 113 - Evaluate Waste Water Management Alternatives

DEVELOP ALTERNATIVES

TASK 5 - Final Selection of Water Quality Alternatives to Meet Planning Objectives

TASK 17 - Future Demand for Recreational and Aesthetic Resources

TASK 204 - Define Water Management Opportunities and Alternatives

TASK 18 - Implications for Fishery Potentials and Fishery Opportunities of Selected Water Management Opportunities

TASK 172 - Public Response to the Alternatives in the Development of the Comprehensive Plan

TASK 6 - Develop Water Quality Alternatives to Meet Study Objectives

EVALUATE ALTERNATIVES

TASK 11 - Evaluate Alternatives (March 73 to Aug. 73)

TASK 1 & 101 - Prepare Draft of Final Report and Comprehensive Plan for Public Comment - (June 73 to Nov. 73)

PREPARE COMPREHENSIVE FRAMEWORK PLAN AND FINAL REPORT

EDIT FINAL REPORT AND TECHNICAL SUPPLEMENTS TO FINAL REPORT (Nov. '73 to Apr. '74)

_ Specific Task Assignments Added to initial Study Plan Over Period of Agreement

STUDY PLAN FOR CANADA-BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

1970 | 1971 | 1972 | 1973 | 1974

Figure 2:2

The special sub-committee recommended that appropriate government agencies should be made responsible for all task assignments in each of the major fields of study. This decision was based in part on previous problems encountered in other studies, where the responsibility for task assignments was divided. Moreover, the expertise to carry out such studies and the authority to expend funds were already established for government agencies, particularly for monitoring programs in the field of water quantity and water quality. The task forces were retained to act in an advisory capacity to the Study Committee.

This method of delegating the tasks was approved in June 1970, with the five areas of study assigned as follows:

1)	Water Quantity Studies	-	B.C. Water Investigations Branch Water Resources Service, Province of British Columbia
2)	Water Quality Studies	-	B.C. Pollution Control Branch Water Resources Service, Province of British Columbia
3)	Waste Treatment Studies	-	B.C. Pollution Control Branch, Water Resources Service, Province of British Columbia
4)	Limnology Studies	-	Freshwater Institute, Fisheries Research Board of Canada Department of Fisheries and Forestry, Canada
5)	Socio-Economic Studies	-	Special Work Group, consisting of one Federal and one Provincial Coordinator

Because there was no specific government agency operating in the field of socio-economics at that time, a special work group was established consisting of one Federal and one Provincial Coordinator, with funds for this program to be administered through the B.C. Water Resources Service. The Board also approved the appointment of a representative from the Okanagan Basin Water Board to this work group because of its anticipated participation, particularly in public involvement.

The above arrangements did not preclude the responsible agencies from contracting task assignments to other government agencies or private enterprise and Figure 2.3 lists the various government departments, private consultants, and contractors who were engaged in Study tasks during the period of the Agreement.

FIGURE 2.3

OKANAGAN BASIN STUDY PARTICIPANTS

FIELD OF STUDY	RESPONSIBLE AGENCY, SUB AGENCIES, CONSULTANTS AND CONTRACTORS	TASK INVOLVEMENT
Water Quantity	B.C. Water Investigations Branch, Water Resources Service, Dept. of Lands, Forests & Water Resources, B. C.	All Water Quantity Tasks
	1. Water Survey of Canada, Water Management Service, Environment Canada	52, 43
	2. Meteorological Branch, Department of Transport	44, 52
	3. Civil Engineering Department, U.B.C.	34, 29, 31, 33
	4. Air Survey, Survey and Mapping Branch, Victoria, B.C.	21
	5. Faculty of Forestry, U.B.C.	180
	6. Dr. M. Danard, University of Waterloo	53
	7. Osoyoos Water Well Drilling	41
	8. Hydrologic Sciences Division, Environment Canada	41
	9. E. Livingston, Consulting Geologist, Vancouver, B.C.	40
	10. Big Indian Drilling Company Ltd., Calgary, Alta	40
	11. P.M. Lundberg, P. Eng.	39
	12. Dr. M. Danard, University of Waterloo	
	13. Forestry Department, U.B.C.	180
Water Quality & Waste Treatment	B.C. Pollution Control Branch, Water Resources Service, Dept. of Lands, Forests and Water Resources, Victoria, B.C.	All Water Quality Tasks and Waste Treatment Tasks
	1. Water Quality Laboratory, I.W.B., Calgary, Alta	131
	2. B.C. Dept. of Health Laboratory, Vancouver, B.C.	133, 134, 135, 130, 131, 139
	3. B.C. Research Council, Vancouver, B.C.	128
	4. Soils Branch, B.C. Dept. of Agriculture	142, 139, 147
	5. Summerland Research Station, Canada Dept. of Agriculture	142, 139
	6. Consortium of Waste Treatment Consultants (Associated Engineering, Stanley Associates, Dayton & Knight)	142, 147
	7. Civil Engineering Department, U.B.C.	133, 139, 147
Limnology	Fisheries Research Board of Canada, Freshwater Institute Environment Canada, Winnipeg, Manitoba	All Limnology Tasks
	1. Canada Centre for Inland Waters, Burlington, Ontario	118, 120, 124, 121
	2. Water Quality Laboratory, Water Management Service Calgary, Alberta	124
	3. B.C. Fish and Wildlife Branch, Victoria, B.C.	115, 66
Socio-Economics	B.C. Water Resources Service and Water Planning and Management Branch, Environment Canada	All Socio-Economic Tasks
	1. Pearse, Bowden & Associates, Economic Consultants, Vancouver, B.C.	151, 207
	2. Ward & Associates, Economic Consultants, Vancouver	205
	3. Howard Paish & Associates, Vancouver	170
	4. B.C. Fish and Wildlife Branch, Penticton, B.C.	160, 161
	5. A.C. Brooks, Biologist Consultant	160
	6. Fisheries Service, Environment Canada, Vancouver	162
	7. H.D.C. Hunter, Barrister & Solicitor, Vancouver	203
	8. A.R.D.A. Regional Development & Economic Expansion	11, 54
	9. Canada Land Inventory, B.C. Dept. of Agriculture	
	10. Dept. of Industrial Development, Trade & Commerce	201
	11. Dr. D. Conner, Consulting Sociologist, Ottawa, Ont.	170, 171, 172
	12. B.C. Research Council	201
	Okanagan Study Committee	All Tasks
	1. Harry Hill Limited, Waterloo, Ontario	23
	2. Orchard City Press, Kelowna, B.C.	Annual Report
	3. Stuart Graphics, Penticton, B.C.	170
	4. Fleming Review Printing Limited, Victoria, B.C.	208
	5. Finlay Printing, Kelowna, B.C.	171
	6. G.W. Sinclair & Associates, Penticton, B.C.	171, 172
	Consultative Board	
	1. Underwood, McLellan & Associates, Vancouver, B.C. (G.J.A. Kidd, P. Eng.)	

Figure 2.3

CHAPTER 3
Changes and Additions to the Study Plan

A continuing review of the progress and results of various task assignments at Committee and Board meetings, and at Study Seminars, resulted in a number of changes and additions to the Study Plan throughout the first 2½ years of the Study to meet changing priorities and to improve weak areas in the information base. These changes and additions to the Study Plan are summarized on a chronological basis in this chapter.

Those tasks dealing with the evaluation process and development of the comprehensive plan are described in following chapters.

3.1 WASTE TREATMENT (NUTRIENT REMOVAL) PILOT PROJECTS

Following the preparation of the preliminary report on "Review and Evaluation of Nutrient Removal Methods" in October 1970, an arrangement was reached whereby the waste treatment consultants retained by the cities of Vernon, Kelowna and Penticton would form a consortium to review existing waste treatment study proposals and advance a recommendation for the types of projects that would be most desirable for the Okanagan within the terms of reference of the Agreement. The consortium's recommendations were subsequently reviewed by the B.C. Pollution Control Branch and presented to the Committee in March, 1971.

The three pilot waste treatment projects recommended for implementation were as follows (See also Technical Supplement VI):

1. Lysimeter Study at Penticton
2. Groundwater Monitoring of the spray irrigation system at Vernon
3. Lime treatment, utilizing a pilot plant for phosphate removal and full scale incineration facilities for sludge disposal at Kelowna.

A fourth proposal, which was not implemented, concerned the testing of a carbon column dentrification unit. This was deleted, based on preliminary findings of the limnology program in 1970, and because an extensive research program on nitrogen removal was already underway at the Canada Centre for Inland Waters in Burlington, Ontario - the results of which would be made available to the Okanagan Basin Study if required.

3.2 PUBLIC INVOLVEMENT

Two different seminars in late 1970 and early 1971 focussed on public involvement and the development of a more formal program in this field than originally set out.

The first of these seminars involved a review of Study proposals for public involvement by a panel of experts in the field of economics and sociology.

The second was a Study Seminar held in Penticton in February 1971, at which both Study members and valley residents were in attendance. This was the first real opportunity that residents of the Okanagan had to express their views on the Study. The theme of the major part of the seminar was on organization and communication and a consultant was retained as chairman for this part of the program.

Both seminars, and subsequent meetings of the Committee and Board, resulted in the development of a more formal public involvement program to be carried out by a full time field worker and supporting staff. The three tasks describing this initial program were as follows (Appendix C):

Task 170 - Study of Social Systems and Power Structure in the Okanagan Valley

Task 171 - Public Involvement and Development of Alternatives

Task 172 - Public Response to the Comprehensive Plan

While the consultants retained to carry out this program and the structure for attaining public involvement changed dramatically throughout the term of the Study, the objectives outlined in these task descriptions have remained essentially the same.

3.3 FOREST HYDROLOGY

Based on questions raised at the Penticton Seminar of February 9 - 11, 1971, the Study Committee agreed that studies on the effect of deforestation on the watershed should be included. Three preliminary assessments were therefore proposed as follows:

1. A request for the Provincial Forest Service to supply estimates of present and probable future changes in cover on the watershed;
2. A preliminary appraisal, by the Forestry Hydrology Department of the University of British Columbia as to what effect deforestation and cutting rates have on the flow regimen and water quality;
3. A field survey of streams to document aquatic environs and stream quality in existing denuded areas.

The first assessment was covered in a letter in August 1971 from the B.C. Forest Service, including an outline of other more detailed information and plans available to the Study on request. This information was subsequently made available to the Forest Hydrology Department at U.B.C. as part of Task 180

The second item was developed into a specific task assignment based on Study proposals by the U.B.C. Forest Hydrology Department as follows (Appendix C):

Task 180 - Evaluation of Watershed Deforestation and Harvesting Practices.

This task assignment was intended to provide only a preliminary appraisal with any further studies dependent on the results of this first assessment.

The third study was subsequently included as part of more detailed studies on stream ecology and water quality, (Section 3.5.2).

3.4 GROUNDWATER REVIEW

Under the initial plan of study, the Groundwater Division of the B.C.W.I.B. Water Resources Services had completed a large part of the groundwater exploration program in the main Okanagan Valley by late 1970. Due in part to the cost of this program, and also a growing difference of opinion as to the extent of investigation required to make a preliminary assessment of the role of groundwater in the hydrologic cycle of the basin, it was agreed by the Study Committee that an overall review should be carried out, based on the information obtained to date. While no further exploration was to be undertaken until this preliminary evaluation was completed, wells that were already drilled were to be tested as soon as possible to provide additional information on the groundwater potential in the North Okanagan. This review of groundwater studies was carried out jointly by Federal and Provincial groundwater personnel.

The findings of this review subsequently confirmed that groundwater inflow did not represent a significant source of water to the basin and therefore, no further groundwater exploration was undertaken.

3.5 FISHERIES (AND WILDLIFE) MANAGEMENT

Probably the most significant change in the scope of the Study occurred in the area of fishery management. The inclusion of a number of studies on this aspect occurred over a period of two years as the result of three different events: a review of the Study plan in November 1970 when concern was expressed by Fish and Wildlife managers that the effect of water management

on fish and wildlife in the Okanagan had not been included in the Study; the emerging importance of sport fishing in the valley as revealed by the preliminary results of Task 161 - "Sport Fisheries and Water Managament" and Task 115 - "Fisheries Survey of Okanagan Mainstem Lakes"; and the need for cost benefit data on fishery alternatives as revealed at the Duncan seminar in June 1972.

3.5.1 Effect of Water Management Alternatives on Fish and Wildlife

A review of the Study Plan in November 1970, involving thorough discussions with each agency, resulted in the addition of three new task assignments which were concerned with the effect of water management on fish and wildlife in the Okanagan Valley. It was argued that while some aspects of fish and wildlife were being studied by the Socio-economic and Fisheries Research Board groups, there was no direct input into the Study Plan respecting the effect of water management alternatives on fish and wildlife from local fish and wildlife management agencies. Examples cited were the consequence of diversions, excessive fluctuations of reservoirs, and obstructions - such as dams or weirs - on fisheries.

The Study Committee agreed that this type of input to the Study was lacking and that three new tasks should be set up as follows;

Task 160 - Wildlife Problems ssociated with Water Management

Task 161 - Sport Fisheries and Water Management

Task 162 - Pacific Salmon Population and Habitat

While the responsibility for these tasks was assigned to the socio-economic group the actual field studies were to be carried out by the agencies concerned with the management of these resources.

3.5.2 Stream Ecology Studies

The initial studies proposed on stream ecology (See Section 3.3 - Forest Hydrology) were expanded during the planning stage to provide a much broader appraisal of stream and headwater ecology than initially envisaged. This was due in part to the growing need for more information on the tributaries and headwater lakes, and the increasing importance that fisheries were assuming in the overall study plan. It was also recognized that there was an inherent relationship between the three major components of the Okanagan system; headwater lakes, tributaries and main valley lakes; and that any meaningful biological study must involve all three components, particularly in respect to sport fishery potential.

This program on stream and headwater ecology was initially divided into three studies: an evaluation of the habitat potential of tributary streams, particularly in respect to reproductive opportunities for the salmonid fish

species from the mainstem lakes; an examination of several headwater lakes with proven fish producing capacities including the documentation of their limnological characteristics; and a creel census to quantify the sports-fish harvest from the various components of the Okanagan system. The task numbers and headings assigned to these tasks were as follows:

Task 66 A - Stream Habitat Survey

Task 66 B - Limnology of Selected Headwater Lakes

Task 66 C - Creel Census

3.5.3 Kokanee Reproduction and Age-Growth Analysis

The results of studies on Task 115, "Fisheries Survey of Okanagan Main Valley Lakes" indicated the importance of shore-spawning to the productivity of kokanee, and a difference in the comparative growth rates of certain other species in different lakes. More information on shore spawning kokanee was desirable in view of the effect water quantity alternatives might have on lake level fluctuations and spawning habitat. A more detailed analysis of comparative growth rates was also considered essential to obtain a meaningful assessment of future fish productivity. One additional study, and additional analyses of data obtained under Task 115, were therefore approved as follows:

Task 66 E - Kokanee Shore Spawning Studies

Task 115 - Fisheries Survey - Extension of data analysis program to determine growth rates of fish in each of the mainstem lakes.

3.5.4 Salmonid Enhancement Studies

As a result of a review of Study needs in respect to evaluating alternatives (Duncan Seminar, June 1972), two new tasks were proposed, the first to determine the costs and feasibility of maintaining or improving salmonid stream spawning areas, and the second to investigate the cost of maintaining the Okanagan River Sockeye salmon run by means of an artificial spawning channel. Both studies were required for the evaluation of fishery alternatives in the basin. These investigations were subsequently approved under the following task heading:

Task 163 - Salmonid Rehabilitation, Maintenance and Enhancement Feasibility Studies.

3.5.5 Fishery Evaluations

Two evaluation tasks were also added to the Study Plan in 1972 to combine the results of individual fishery studies into a comprehensive overview. The first of these concerned the evaluation of the existing resources and the second the evaluation of future fishery potentials and opportunities, as follows:

Task 66 D - Fishery Potentials in the Okanagan

Task 18 - Implications for Fishery Potentials and Fishery Opportunities of Selected Water Management Alternatives

One other evaluation study that should be mentioned in respect to fisheries is that of the "Trout Creek Pilot Study"[1/] This sub-basin was used for a pilot study to evaluate the inter-relationship of various tributary water resource management alternatives. The fisheries segment of this study included the testing of various flow rates to determine desirable minimum flows for salmonids during spawning and incubation periods, and this information was combined along with other reconnaissance studies to establish the desirable minimum flow conditions for fisheries in streams tributary to Okanagan Lake.

3.6 IMPACT OF LAND USE ON WATER QUALITY

One of the studies originally proposed by the water quality task force was the monitoring of surface runoff in representative land use areas such as mixed farming, orchards and virgin lands to determine the effect of various land use practices on water quality. It was hoped that the resulting data would provide mathematical relationships between land use and water quality that could be used for predicting future water quality in the basin. This study was subsequently deleted in 1970-71 because of the probable costs that would be involved.

As a result of the Trout Creek Pilot Study[1/] and the Committee's request to evaluate the effect of deforestation on water quality, a much less ambitious program on the effect of land use was initiated in 1972. This involved a short term study of the water quality at specific points along Kelowna and Lambly Creeks. This study was carried out as part of Task 102 "Water Quality Evaluations, Present and Future."

3.7 INDIAN LANDS

Undeveloped lands in the basin, particularly those on Indian reserves, posed problems in respect to future development and the impact of such development on water resources. Approaches were made to the Department of Indian Affairs during the Study to obtain plans for the probable future development, but none were made available. The Study Committee therefore made its own assessment of this aspect for planning purposes. While not a specific task assignment, this particular aspect of planning is noted as having been reviewed, and also points out the uncertainty of some aspects of the comprehensive plan, particularly beyond the year 1980.

[1/] For description of Trout Creek Pilot Study, see Chapter 5, Section 2

3.8 TRIBUTARY WATER QUANTITY MONITORING PROGRAM (1972)

One of the original assignments proposed by the water quantity task force was the selection and instrumentation of five suitably spaced tributary streams in the basin to determine the runoff from the various parts of the basin. Based on preliminary information from this study, procedures were developed for estimating tributary flows in drought and average runoff years. Similar studies were initiated for flood years, but never completed. Certain anomalies appeared in the data obtained however, warranting more detailed field information, particularly on the smaller branches of the tributaries. In anticipation of a major runoff in 1972 as indicated from snow survey data, a program to provide additional monitoring of selected streams during the freshet was approved. The program was specifically designed to monitor flows at specific elevation bands on a weekly basis, by using portable measuring equipment, to tie into the procedures being developed for estimating runoff in low, average and flood years for all tributary streams. This work was carried out under Task 52 - "Operation of Stream Gauging and Meteorological Network".

3.9 FLOOD DAMAGE STUDIES FOLLOWING 1972 FLOOD

Shoreline surveys and flood damage studies as proposed in the initial Study Plan were carried out in 1971 based on terms of reference established by the Study Committee. For Okanagan Lake this included the assessment of damage resulting from lake levels up to two feet above the existing high water operating level (1123.8) and down to three feet below the normal low operating level (1119.8). For Osoyoos Lake, only the consequences of lake levels two feet above the existing high operating level were examined as minimum lake levels were controlled by natural topography.

Three factors were responsible for additional studies, particularly in respect to flood damage on Osoyoos Lake. First, the 1972 flood was one of the highest on record and flood levels and damage around Osoyoos Lake greatly exceeded the elevation for which flood damage data were available. Second, flooding on both Osoyoos and Okanagan Lakes provided an opportunity to assess actual damage and compare this with potential damage as estimated under the flood damage studies. Third, a preliminary review of water quantity alternatives on the mainstem system indicated that it was not possible to maintain the levels of Okanagan Lake within the normal operating range as set out in the operating terms of reference for the Okanagan Flood Control Works under extreme flood (or drought) conditions. Moreover, it was evident that the main factor affecting Osoyoos Lake levels during extreme floods was the backwater effect of the Similkameen River. For these reasons additional studies were carried out on the frequency and extent of flood damage on Okanagan and Osoyoos Lakes, and on on the effect of extended drought periods on the drawdown of Okanagan Lake.

Both of these studies were carried out under Task 21 "Shoreline Survey and Flood Damage Studies".

3.10 SOCIO-ECONOMIC IMPACTS OF WATER QUALITY PROBLEMS

While the studies on the value of water to various users included recreational aspects, no specific studies on the effect of poor water quality on recreation could be planned until such conditions actually occurred. A major algae bloom on Wood Lake in 1971 provided the opportunity for such a study, and in the late summer of 1972 an interview and cost-benefit survey was conducted among resort owners around Wood Lake and a control group around Kalamalka Lake to discover whether water quality problems and the resulting publicity had negatively influenced the operation of Wood Lake resorts. This study was carried out as part of Task 200 - "Evaluation of Factors Associated with Water Based Recreation and Aesthetic Resources".

3.11 ECONOMIC GROWTH STUDIES

Following a review of the economic growth studies at the Duncan Seminar in June 1972, new guidelines for preparing economic growth projections were developed. Based on studies to that date, it was recognized that current growth patterns, developed as a result of previous government programs and incentives, would not change significantly until 1980 or afterwards. However, because of the uncertainty in predicting future economic development beyond 1980 in a small region such as the Okanagan Basin, the Board decided that a range of projections of future growth should be prepared as follows, and evaluations carried out for each projection:

Projection I
- Maintaining the present rate of economic growth, assuming existing economic policies in the Okanagan are continued.

Projection II
- Greater economic growth through tourism, irrigation, industry, etc.
- Water levels, quality and utilization to match such growth
- Health protected

Projection III
- Greater emphasis on quality of life - e.g. recreation, parks, aesthetics, high quality, etc.
- Emphasis on slowing down the rate of economic growth.

This approach had the advantage of placing a different emphasis on each of the three major goals: economic growth, environmental quality and social betterment. It also permitted a wide range of future demands for water and

related resource use to be considered in relation to the capability of the resource to satisfy these demands; and it provided residents of the Okanagan the opportunity to consider a wider range of life styles available to them.

This change in study guidelines did not involve any new task assignments, but greatly extended the time required to complete the growth projection tasks and subsequent evaluations.

3.12 LAND USE STUDIES

Land use studies initially included in the Study Plan were limited to an inventory of present and potential agricultural lands in order to assess existing and probable demands for irrigation water as compared to available supplies. During the preliminary stages of the evaluation phase of the Study, it was recognized that a more detailed identification of the probable future use of lands was required, if a rational assessment of future water requirements by tributary and lake basins was to be made.

Based on the above, a new task was outlined which would distribute regional projections of population, industrial and agricultural development (as obtained from the economic growth studies) within the various sub-basins. Moreover, the capability of various land areas to support different forms of land use (agricultural, residential, industrial, etc.) was to be considered in this distribution. The information obtained from this study would then be considered in relation to available water supplies: tributaries where present and future shortages might occur could be identified, and alternatives developed and evaluated.

This study was approved and carried out during 1972-73 under the heading:

Task 209 - Land Use Study (Future)

3.13 SUMMARY

Changes and additions to the initial plan of study have been outlined in this Chapter. These amendments were based on an ongoing review of the progress and results of various task assignments, and the modification of the Study Plan as required to meet changing priorities and improve weak areas of the information base. The most significant changes in the plan occurred in the areas of sport fisheries, studies on tributary sub-basins and public involvement. Seventeen new tasks were added in these three fields of study alone. Additional studies were also included on such aspects as forest hydrology, land use and 1972 flood damage, while others were curtailed such as in the field of groundwater hydrology. This phase of the Study was initiated in June 1970 and continued through to April 1973 although most of the assignments were actually completed in the fall of 1972.

CHAPTER 4
The Evaluation Process

4.1 INTRODUCTION

The evaluation phase of the Okanagan Basin Study consisted of the development and evaluation of alternatives to meet the planning objectives of the major water resource components - water quantity, water quality, fisheries, and water based recreation. The process involved six steps, as shown in Figure 4.1.

THE EVALUATION PROCESS

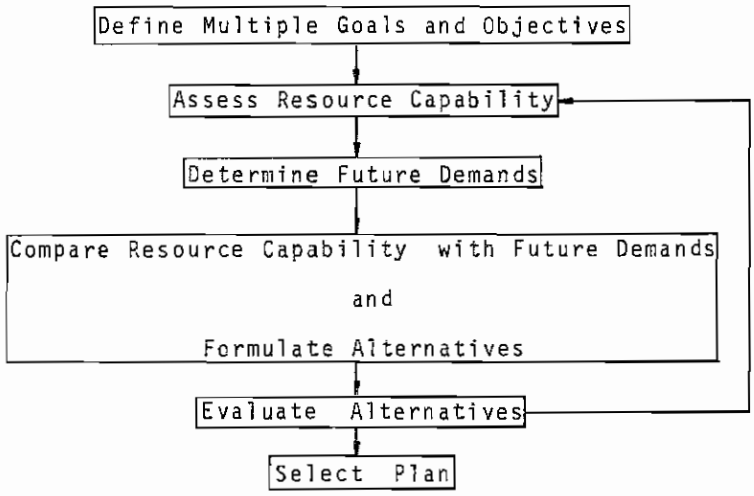


Figure 4.1

The process is re-iterative as indicated by the feed back loop. Each of these steps as applied to the Okanagan Basin Study is described in this Chapter. The development of the Comprehensive plan using this process is outlined in Chapter 5.

4.2 DEFINE MULTIPLE GOALS AND OBJECTIVES (STEP 1)

4.2.1 Planning Philosophies

Most water resource planning studies to date (1970) have been primarily concerned with contributing to the single goal of economic growth and consequently, most of the benefits and costs associated with water development plans have been evaluated in monetary terms only. Comprehensive basin planning

provides a new approach to water management, in that it includes an examination of uses not normally considered in the past - fisheries, water based recreation, aesthetics, etc. - and because it includes environmental and social values as well as economic values in the assessment of water resource management alternatives. Because of the newness of this type of planning, some explanation of the basic philosophy used to develop the goals and planning objectives of the Okanagan Basin Study has been included as Appendix D.

4.2.2 Study Goals

The purpose of the Okanagan Basin Study as set out in the Agreement was:

> " to develop a comprehensive framework plan for the development and management of the water resources for the social betterment and economic growth in the Okanagan Basin"

The Agreement also made several references to environmental quality such as:

> "provision for an adequate quality of water in the basin" and "to determine the effects of water resources development and utilization on the aesthetic values of the basin."

These three major goals - economic development, social betterment and maintenance or enhancement of environmental quality, were therefore defined as follows for this particular study:

1. Economic Development - to increase economic development in the Okanagan Basin and adjacent regions as measured by net regional income; that is, the economic value of income, goods and services accruing to the residents of the Okanagan Basin and surrounding areas. The geographic boundaries of the Valley should be drawn wide enough to encompass all significant economic impacts of water resource development plans.

2. Environmental Quality - to maintain and enhance environmental quality through management, preservation and improvement of certain natural resources and ecological systems. Generally, all benefits and costs associated with the environmental quality goal must be expressed in quantitative units (biological, physical) and/or in qualitative terms rather than dollar values.

3. Social Betterment - to enhance social betterment by providing the opportunity for a more equitable distribution of income, employment, recreational opportunities and environmental quality that will contribute to the security of life and health.

It should be emphasized that planning cannot maximize the achievement of each of these goals simultaneously, but rather it should attempt to achieve a desirable balance - as dictated by public preference - between these three sets of values. In theory, achieving a desirable balance between these multiple

goals involves a broad study of a wide range of social and economic plans for the management of natural and human resources. Within the context of the Okanagan Basin Agreement, water and water related resources and activities such as fisheries, wildlife, water-based recreation and shoreline land use were the primary areas of study. However it was recognized that a broader set of criteria associated with these multiple goals should be considered in the development of a framework plan. Examples of these general criteria and their relationship to the major study goals are shown in Table 4.1.

TABLE 4.1

GENERAL FEATURES ASSOCIATED WITH MULTIPLE GOALS

ECONOMIC DEVELOPMENT	Regional Income Total Employment Per Capita Income
ENVIRONMENTAL QUALITY	Air, water and land quality Fisheries production Aesthetics Wildlife and other ecological systems Quietness Wilderness areas Recreation opportunities
SOCIAL BETTERMENT	Population density Job security Health Education Cultural amenities Urban conditions Communications Income distribution

4.2.3 Planning Objectives

It should now be understood that within the context of the Okanagan Basin Study, the social, environmental and economic goals outlined above can be partially achieved by developing plans to allocate water and related resources among existing and future uses. These water uses include consumptive demands for agriculture, municipal and industrial purposes, as well as non-consumptive requirements for recreation, aesthetics, fish and wildlife resources. Both social and economic values are associated with each of these uses of water, and it is through the analysis of these values that the achievement of the goals of the Study can be realized.

To facilitate the planning process and to specify how each of the major uses of water in the basin can contribute to the multiple goals of the Study, the complex water resource system was broken down into four management components, as follows:

(a) Water Quantity Management
(b) Water Quality Management
(c) Fishery Management
(d) Water Based Recreation Management

Within each of these management components a number of general planning objectives were established to serve as guidelines for developing a framework plan. These planning objectives were defined in more detail than the broadly conceived study goals and thus act as intermediary steps to relate the uses of water to the set of social and economic values contained in the major goals. Examples of such planning objectives are outlined below:

(a) Water Quantity Management - to supply water for all consumptive water requirements for agricultural, residential, commercial and industrial purposes.

- to supply water for all non-consumptive water requirements for fisheries, wildlife, recreation and aesthetic resources.

- to minimize economic and social consequences of floods and droughts in lakes and tributary streams.

- to minimize conflicts between existing and potential uses of water.

(b) Water Quality Management - to protect the health of Okanagan residents.

- to provide water quality compatible with agricultural, municipal, domestic and industrial uses.

- to provide the highest possible water quality for water-based recreation, sport fisheries and other non-consumptive uses of water.

(c) Fishery Management - to preserve, enhance and manage environments suitable for sport fishery development.

- to maintain and protect the environment for sockeye salmon stocks in the Okanagan River.

(d) Water-Based Recreation Management - to provide opportunities for a full range of water-based recreational activities.

- to protect and enhance the aesthetic qualities of the Okanagan Valley.

Not all of the requirements of these planning objectives can be achieved for each of the three assumed types of future described earlier (Section 3:11). Because of physical and biological limitations, the quantity and quality of water interact, with some of these interactions being complementary and some in conflict. Over the planning horizon of the next 50 years, as values associated with the achievement of these objectives change, new interactions will also become evident. By evaluating a range of future growth conditions however, a better understanding of the capability of the water resource to meet a wide range of potential demands is obtained, and different weighting systems can be developed to assess the different balances between economic, environmental and social values.

4.2.4 The Role of Public Involvement in the Evaluation Process

Because the development of the framework plan involves such critical questions as the type of lifestyle sought by the majority of Okanagan residents, the involvement of the public in the evaluation process was considered to be one of the key ingredients in comprehensive planning. This involvement was achieved in the Okanagan Basin Study through: (1) a public education program (information out) which sought to provide to the public the range of water management alternatives available to them, and the consequences of implementing or not implementing specific options: (2) public response (information in) involving ideas, proposals and criticisms from valley residents concerning the water management options available to them; and (3) the development of a plan of preferred options by the public involvement (P.I.P.) task forces (See Technical Supplement XI) based on information supplied by the Study at meetings involving study and task force personnel. The public therefore participated in all stages of the evaluation process, the final stage being the integration of the preferred life style of the Okanagan community, as expressed through the P.I.P. task forces, with the technical aspects of the water management alternatives.

4.3 ASSESS RESOURCE CAPABILITY (Step 2)

Once the planning objectives for each management component had been set out, the existing situation with respect to water supply-demand conditions and water quality was evaluated. The majority of field investigations outlined in the Study Plan (Figure 2.2) were carried out to provide the information necessary for these evaluations. This assessment of existing conditions (denoted as zero or null alternative in this study) then became the basis for comparing the impacts of various alternatives to, for all planning objectives, in both economic and non-economic units. The zero alternative is defined as existing water management (1970) procedures and assumes that nothing will be done to change the situation, i.e., the status quo will be retained into the future.

4.4 DETERMINE FUTURE DEMANDS (Step 3)

The third step in the evaluation process involved the development of future water demands and/or quality conditions for each of the components being evaluated, based on the economic growth projections prepared under the Study. As noted in section 3.11 these economic projections provided for a range of alternative future developments because of the uncertainties in projecting growth conditions beyond 1980 in such a small area as the Okanagan Basin. Forecasts of water needs and/or quality conditions were made for each of these future development conditions to provide a measure of the sensitivity of various levels of demand (or pollution effects) on each of the components being

evaluated. These in turn aided in the formulation of suitable alternatives for each of these development possibilities.

4.5 COMPARE RESOURCE CAPABILITY WITH FUTURE DEMANDS AND FORMULATE ALTERNATIVES (Step 4)

The fourth step in the evaluation process was to assess the capability of the water and related land and biological resource base to meet the projected demands for each of the alternative development futures. Where conflicts existed, alternative ways of developing and managing the resource system to achieve the planning objectives of each management component were devised, recognizing the constraints of the resource base itself.

4.6 EVALUATE ALTERNATIVES (Step 5)

The alternatives developed for water resource management were then assessed in terms of the social, environmental and economic values associated with the major goals of the Study. The benefits of achieving certain planning objectives were weighted against the costs required to meet them and the costs of foregoing the full achievement of other planning objectives because of conflicts in resource use. While it was recognized that any single alternative may not accommodate all competing uses equally, the development of an evaluation matrix provided an information system which allows the decision maker to fully assess the implication of implementing any chosen alternative. The main principles that affect the process of evaluation and indicate in theory how an evaluation matrix can be established to choose between alternative plans, were developed under Task 207 of the Okanagan Basin Study and are reproduced in this report as Appendix E.

In summary, the development of an evaluation matrix involved three steps:

1. Impact Analysis - the consequences or impacts of each alternative upon all planning objectives were stated in annual terms. Those impacts that contributed positively or negatively to the economic growth objectives were measured in dollar terms. Impacts which contributed positively or negatively to the social and environmental objectives were measured in appropriate physical or biological units.

2. Comparison with Zero Alternative - the annual impacts for each alternative, stated in both economic and non-economic units for all planning objectives were compared with the zero alternative. The difference (positive or negative) in the annual impact is referred to as the incremental impact. The zero alternative is defined as present day operating procedures and assumes that nothing will be done to change the situation - i.e. the status quo will be retained into the future.

3. Weighting Schemes - weights may also be placed on the non-economic planning objectives to reflect the relative value of these gains or losses to society.

(Note - This weighting procedure was not used in the Okanagan Basin Study).

One of the main reasons for using an evaluation matrix to express the consequences of implementing a specific alternative is that we cannot yet compare all values (social, environmental, and economic) on a single commensurate value scale. For each alternative being considered, for example, there are a number of benefits and costs associated with each of the major Study goals. Benefits are defined as positive contribution to the attainment of objectives and costs are defined as negative contributions to specified objectives. There can be economic benefits and costs, environmental benefits and costs and social well-being benefits and costs, which may be expressed in one of the following forms:

1. Benefits and costs that are ordinarily valued on the market and can be expressed in monetary terms.
2. Benefits and costs that are not valued on the market, but can be expressed in quantitative units, e.g. physical units (number of fish) or social units (employment opportunities).
3. Benefits and costs that cannot easily be quantified and are expressed by qualitative description or a social preference index.

To fully analyse the consequences of any water resource management alternative therefore, some basis must be established for evaluating and communicating to the decision maker both the monetary and non-monetary consequences of various alternatives. In the Okanagan Basin Study this has been done through the use of evaluation matrices. Examples of the type of matrix prepared for the water quality and fishery management components are included in this section as Tables 4.2 to 4.8. It will be noted from these examples that a number of matrices may be required to fully set out the options available and their benefits and costs. An example of the first evaluation matrix prepared for water quantity alternatives (mainstem system) is also included in Chapter 5 (Table 5.2).

4.7 SELECT PLAN

The development of the evaluation matrices described above completes the process of evaluation. The final step in the planning process then requires the selection of those alternatives that best achieve the study goals of economic growth, social well-being, and maintenance or enhancement of environmental quality. In the Okanagan Basin Study, the development of a comprehensive plan was a gradual one which involved the reiteration of the evaluation process a number of times, each reiteration resulting in an improved understanding of the capability of the resource to meet various future water needs, and the elimination of those alternatives which were no longer viable to the plan. The evolvement of this plan is described in more detail in Chapter 5.

TABLE 4.2

ASSUMED RELATIONSHIP BETWEEN WATER QUALITY AND WATER-BASED RECREATION FOR ESTABLISHING BENEFITS FOR WASTE TREATMENT ALTERNATIVES

YEAR	LAKE	WATER QUALITY CONDITIONS	IMPACTS ON WATER-BASED RECREATION DEMANDS
1980	Wood Lake	Annual algae blooms, extensive weed growth around shorelines.	Additional costs involved in harvesting weeds. Annual decline of 10% in tourism to 1975 rising to 25% by 1980
2000	Wood Lake	Annual algae blooms and extensive weed growth around shorelines.	Continued decline in tourism estimated at 50% per annum after 1985
1980	Kalamlka Lake	Localized weed growth at Coldstream Creek spreading towards Kalamalka Beach	Additional costs of weed harvesting. Little impact on recreation due to availability of clean water at Cozen's Bay and at Kalamalka Beach
2000	Kalamalka Lake	Increased weed growth at north end of lake. Uncertainty about occurrence of algae blooms due to the unusual phosphorus ppt. cycle in lake discharge of Wood Lake water will affect resorts at south end of lake	Increased costs of weed harvesting. Estimated 10% decline in recreation after 1980 rising to 50% after 1990 due to adverse publicity from Wood Lake experience.
1980	Okanagan Lake	Continued weed growth in Vernon Arm and around Kelowna shoreline. Infrequent algae blooms in both locations. Weed growth at other local areas such as Westbank outfall and around Summerland.	Additional costs of weed harvesting At least 10% of Vernon area recreation would be reduced each year to 1980; reduction of 10% in Kelowna area after 1975 rising to 20% after
2000	Okanagan Lake	Continued weed growth and frequent algae blooms in Vernon Arm and around Kelowna area. Weed growth will continue to extend around Summerland and Westbank	50% loss of recreation opportunity in Vernon Arm after 1985. Estimated 50% reduction in Kelowna tourism by 1990 - similar reduction in resident beach-days; 10% reduction in recreation demand in south basin
1980	Skaha Lake	Occasional algae blooms in late summer, weed growth increase in south basin	Little reduction in recreation demand forecast provided Penticton attains 80% removal of phosphorus
2000		Frequent algae blooms and extending weed growth.	A 10% reduction in annual recreation demands after 1980 rising to 30% in 1985 and 50% by 1990.
1980	Osoyoos Lake	Occasional algae blooms, increase in weed growth	A 10% reduction in recreation demand after 1975
2000	Osoyoos Lake	Frequent algae blooms and increased weed growth	A 20% reduction in annual recreation demands after 1980 rising to 30% in 1985 and 50% in 1990.

TABLE 4.3

EXAMPLE OF EFFECT OF VARYING LEVELS OF WASTE TREATMENT ON PHOSPHORUS LOADINGS TO SKAHA LAKE

YEAR	PROJECTION	TYPE OF WASTE TREATMENT *1	TOTAL PHOSPHORUS LOADINGS (POUNDS)	AESTHETIC EFFECTS	QUALITATIVE RANKING	IMPROVED OR DETERIORATED RELATIVE TO 1972
Recommended Criteria			30,000 - 40,000		+10 to -10	
Present			48,460	Frequent Algal Blooms, and Weed Problems	-7	0
1980		Present	57,840	Annual Algal Blooms, and Weed Problems	-8	-1
		Tertiary (80% P Removal)	34,720	Infrequent Algal Blooms - Weeds not serious	0	+7
2000	II	Present	82,080	Annual Algal Blooms and Weed Problems		
	High Economic Growth	Tertiary (80% P Removal)	45,340	Frequent Algal Blooms and Weed Problems	-6	+1
	III	Present	71,520	Frequent Algal Blooms and Weed Problems		
	Low Economic Growth	Tertiary (80% P Removal)	40,840	Infrequent Algal Blooms and Weeds not serious	-2	+5
2020	II	Present	106,600	Annual Algal Blooms and Weed Problems		
	High Economic Growth	Tertiary (80% P Removal)	56,560	Annual Algal Blooms and Weed Problems	-9	-2
		(90% P Removal	41,380	Infrequent Algal Blooms, Weeds not serious	0	+7
	III	Present	77,380	Annual Algal Blooms and Weed Problems		
	Low Economic Growth	Tertiary (80% P Removal)	43,580	Frequent Algal Blooms and Weed Problems	-6	+1
		(90% P Removal)	33,320	Infrequent Algal Blooms Weeds not Serious	0	+7

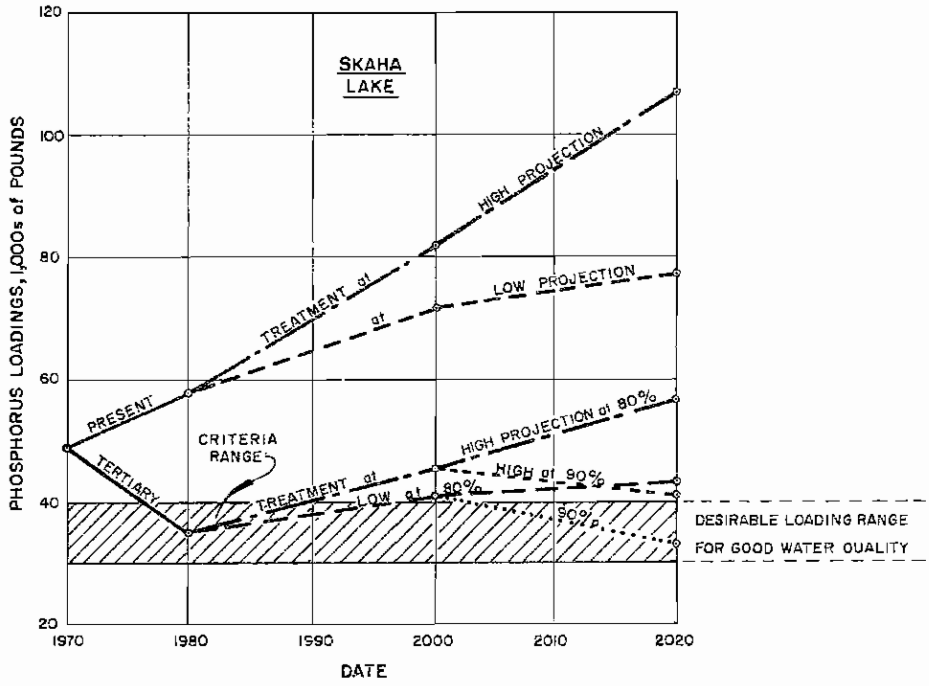


TABLE 4.4

ESTIMATED COSTS OF WASTE TREATMENT TO 1985 FOR MAJOR URBAN CENTERS IN THE OKANAGAN

AREA	1971 POPULATION	EXISTING TREATMENT: CURRENT TREATMENT TYPE	1985 POPULATION	POPULATION AT MIDDLE OF DESIGN PERIOD (1971-1985)	TREATMENT OPTIONS WITH DESIGN CAPACITY ADEQUATE TO AT LEAST 1985	ESTIMATED CAPITAL COST5(to 1985) THOUSANDS OF DOLLARS: SANITARY SEWERS	TREATMENT PLANT COSTS (Secondary)	PHOSPHORUS REMOVAL FACILITIES	ANNUAL COSTS-PHOSPHORUS REMOVAL: TOTAL ANNUAL 80% PHOSPHORUS REMOVAL $000's	TOTAL ANNUAL 90% PHOSPHORUS REMOVAL $000's	TOTAL POPULATION SERVICED	AVERAGE ANNUAL COST PER HOUSEHOLD 80% PHOSPHORUS REMOVAL $	AVERAGE ANNUAL COST PER HOUSEHOLD 90% PHOSPHORUS REMOVAL $
Vernon including Coldstream	18,200	Trickling Filter	32,500	32,500	Spray Irrigation (excluding land cost)		1,800	330	- 51.0 -		32,500	- 5.40 -	
				32,500	Activated Sludge Plant (All new)	2,100	1,800	440	110.0	134.0	32,500	11.60	14.10
				32,500	Renovation of Existing Plant and Construction of New Activated Sl.		1,100	410	103	134	32,500	10.80	14.00
Okanagan Landing	700	Septic Tanks	1,000	900	Batch Lagoon	135	90	3	-	2.5	900	-	9.25
				900	Trunk Mains to Vernon Plant		230	25	10	13.5	900	39.80	51.00
Armstrong	1,600	Aerated Lagoon	2,350	2,180	Batch Lagoon		270	6	-	6.5	2,180	-	9.90
				2,170	Activated Sludge	110	240	50	10	13.5	2,170	16.40	21.20
					Trunk Main to Vernon Plant		Not Economical until 1985						
Kelowna & Rutland	19,500 K.only	Activated Sludge	63,000	35,200	Activated Sludge	6,400	2,300	880	203	258	55,400	12.40	15.80
Winfield	2,200	Septic Tanks	3,600	3,100	Batch Lagoon		220	6	-	11	3,100	-	12.10
				3,100	Activated Sludge	530	270	80	15	19	3,100	16.80	21.10
				3,100	Trunk Main to Kelowna Plant		520	80	11	14.5	3,100	12.70	15.90
Westbank	1,600	Facultative Lagoon	3,500	2,700	Activated Sludge	220	280	70	15	18	2,700	18.30	22.20
Peachland	1,500	Septic Tanks	3,100	2,500	Activated Sludge	450	270	55	20	23.5	2,500	26.60	32.00
Summerland		Septic Tanks	7,900	7,200	Activated Sludge		490	120	28	36	7,200	13.20	16.90
				7,500	Trunk Main to Penticton Plant	1,150	1,600	130	38	41	7,500	17.30	18.60
Penticton	19,000	Activated Sludge & tertiary	27,000	3,600	Activated Sludge	1,200	230	320	84	99	28,400	10.05	11.85
Naramata	460	Septic Tanks	700	600	Batch Lagoon		60	3	-	2	600	-	10.30
				600	Trunk Main to Penticton Plant	100	980	11	3	3.5	600	19.00	20.40
Okanagan Falls	620	Septic Tanks	1,200	1,000	Batch Lagoon		100	3	-	3	1,000	-	9.40
					Trunk Main to Penticton Plant	180	Not Economical to 1985						
Oliver	1,600	Package Act'd. Sl.	1,800		Present Facilities - Sun-Rype removed	30	Facilities Adequate to 1985	70	9	14	1,700	18.20	27.60
Osoyoos	1,300	Facultative Lagoon	1,800	880	Spray Irrigation	75	90	120	16.0		1,600	35.00	

TABLE 4.5

ANNUAL COSTS OF PHOSPHORUS REMOVAL AND BENEFITS TO WATER BASED RECREATION TO 1985

LAKE	ANNUAL PHOSPHORUS REMOVAL COSTS RANGE DEPENDING ON TYPE OF TREATMENT	ANNUAL BENEFITS ECONOMIC	SOCIAL
Wood	$ 10,000 to 20,000	$ 36,000	$ 69,000
Kalamalka	5,000 to 13,000	12,000	60,000
Okanagan*	305,000 to 385,000	136,000	710,000
Skaha	84,000 to 99,000	48,000	135,000
Osoyoos	25,000 to 30,000	33,000	95,000
TOTALS	$429,000 to 547,000	$265,000	$1,069,000

*Includes Phosphorus Removal at centers of Vernon, Kelowna and Okanagan Center only. Additional cost of including Armstrong, Westbank, Peachland, Summerland and Naramata would be approximately $75,000 annually.

TABLE 4.6

ESTIMATED BENEFITS AND COSTS OF STOCKING PROGRAM IN HEADWATER LAKES TO MEET PROJECTED ANGLING DEMANDS, 1970-2020

	PROJECTED DEMAND (ANGLING DAYS)		TROUT HARVEST REQUIRED (NO. X 1000)		TROUT INTRODUCTIONS REQUIRED AT 2500 FRY PER POUND (No. X 1000)		TOTAL COSTS (1970 DOLLARS) INCREMENTAL ($1000)		TOTAL BENEFITS ($1000)			
									ECONOMIC		SOCIAL	
YEAR	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW
1970	65,900	65,900	125.5	125.5	1728.4	1728.4	0	0	0	0	0	0
1980	114,300	100,000	217.2	190.0	2382.9	2085.7	31.4	21.0	22.5	19.7	56.5	49.6
2000	187.700	150,000	256.6	285.0	3629.3	2900.4	1110.0	772.0	768.6	655.6	1209.5	1252.4
2020	246,800	191,000	469.9	362.9	4678.3	3619.9	2160.0	1362.0	1559.2	1256.5	2676.6	2130.6

TABLE 4.7

SPORT FISHERY MANAGEMENT PROGRAM FOR KOKANEE AND RAINBOW TROUT IN OKANAGAN LAKE, 1970-2020

	IMPROVEMENT	INCREASED HARVEST (NO. X 1000)			ANNUAL COSTS	ANNUAL COST PER
		DATE	KOKANEE	TROUT	($1000)	HARVESTABLE FISH
1.	Implement Okanagan Lake operation improvements	1974	47.2	0	nil	nil
2.	Initiate modified operations on Mission Creek	1975	0	6.9	nil	nil
3.	Development of storage on Mission Creek	1976	78.7	28.1	99.0	D.93
4.	Pumping and streambed improvement on Trepanier Creek	1980	83.5	1.0	65.0	0.77
5.	Incubation channel in Trout Creek	1980	25.4	4.8	17.2	0.57
6.	Rehabilitate Mission Creek spawning area	1990	120.8	89.0	44.4	0.21
7.	Rehabilitation and Storage on Equesis Creek	1990	43.0	6.0	20.5	0.42
8.	Enhancement of shore-spawning kokanee habitats	2000+		To be determined		
9.	Establishment of incubation boxes as required	2000+		To be determined		

TABLE 4.8

OKANAGAN SPORT FISHERY MANAGEMENT EVALUATION MATRIX
IN MISSION, TREPANIER AND EQUESIS CREEKS

ALTERNATIVE	POTENTIAL KOKANEE HARVEST		POTENTIAL TROUT HARVEST		COSTS		CAPITALIZED BENEFITS	
	INCREMENTAL HARVEST	TOTAL HARVEST	INCREMENTAL HARVEST	TOTAL HARVEST	CAPITAL $1000	ANNUAL $1000	ECONOMIC $1000	SOCIAL $1000
	NO. X 1000		NO. X 1000					
Mission Creek								
1. modified discharge	-	1212.7	6.9	24.8	-	-		
2. increased storage	78.7	1291.4	28.1	52.9	$ 900.0	$ 99.0		
3. streambed improvement	120.8	1412.2	89.0	141.0	440.0	44.4		
TOTAL	199.5		114.0		$1,340.0	$143.4	$1191.9	$1991.7
Equesis Creek								
1. increased storage	43.0	1418.1	6.0	141.5	$ 175.0	$ 18.0		
2. streambed improvement					28.5	2.5		
TOTAL	43.0		6.0		$ 202.5	$ 20.5	$ 254.0	$ 423.8
Trepanier Creek								
1. pumping	83.5	1499.6	4.7	145.2	$ 173.0	$ 55.0		
2. streambed improvement					100.0	10.5		
TOTAL	83.5		4.7		$ 273.0	$ 65.5	$ 508.2	$ 850.1
TOTALS	326.0		131.7		$1,816.5	$240.5	$1,954.1	$3,265.6

4.8 SUMMARY OF PLANNING PRINCIPLES

The main planning principles used in the Okanagan Study are reviewed here in summary form:

(1) The Okanagan Study was concerned with developing a framework plan for the development and management of water and directly related resources and activities such as sport fisheries, water-based recreation and shoreline land use over the next 50 years. This plan was designed to contribute to the multiple goals of economic growth, social betterment, and maintenance or enhancement of environmental quality in the Okanagan Basin.

(2) It was recognized that future development in the Okananagan to the year 2020 cannot be foreseen with any degree of certainty. This problem was compounded by the fact that society's set of values associated with the three goals of the study will change through time. Consequently, the framework plan developed had to consider a wide range of paths to cover the breadth of probable public preferences in water resource management. In keeping with this principle, a range of growth patterns for the basin was considered, involving differing rates of economic growth and expected levels of environmental quality.

(3) For these future projections for the basin, a complete range of demands for water and related resources was assessed and plans developed to meet these demands. To provide some basis for evaluation, a third planning principle was established, namely that all future water management alternatives should be compared with the consequences of doing nothing, i.e. maintaining the *status quo*.

(4) In recognition of the multiple goals of the Study, it was considered unsatisfactory to evaluate the consequences of water management alternatives in economic terms alone. Thus, a fourth planning principle was developed requiring assessments be made to evaluate intangible factors associated with environmental quality and social well-being goals and weigh these against economic values.

(5) Planning in a vacuum, insulated from the residents of the Okanagan Basin is unacceptable under the planning process described above, because social values and desires must be taken into account in the decision-making process. Consequently, a fifth principle states that involvement of the public is an essential ingredient in the planning process and during the implementation of the desired framework plan.

(6) The sixth planning principle requires that a range of water resource development and management alternatives be considered in developing framework plans. This principle is in keeping with the intent of the Agreement, which states that "the Study will focus on . . . the evaluation of economic, engineering, ecological, financial and organizational alternatives for water resource utilization". Both structural proposals and non-structural or management

alternatives to improve the efficiency of water resource utilization are therefore included in the development of framework plans.

(7) In view of the constraints of time and resources imposed on the Study, not all water management alternatives could be examined in depth. Thus, the seventh and final planning principle embodies the concept that framework plans are really a "bag of tools" to indicate procedures and methods for evaluating water management alternatives and to provide a broad information base. It is anticipated these evaluation procedures and the information base can be applied periodically to determine the course to be followed as conditions and desires change in the future. It is also anticipated that these procedures and the information base may be expanded and improved throughout the next 50 years.

CHAPTER 5
Development of Comprehensive Plan

5.1 INTRODUCTION

The evolvement of a comprehensive framework plan for the development and management of water resources in the Okanagan Basin was achieved through several reiterations of the evaluation process, accompanied by feedback from the public involvement program after the results of these reiterations were made available to the P.I.P. task forces and the residents of the Okanagan Valley. The major phases in the evolvement of this plan are shown in Figure 5.1

It should be re-emphasized that the purpose of this framework plan was to provide a suitable mix of water quantity, water quality, sport fishing, and shoreline management measures which together would ensure good water management in the basin and resolve most of the major conflicts in water use at a minimum cost. Because of the uncertainty concerning water resource management beyond 1980, the plan must also remain flexible. In the Okanagan Basin the plan evolved was also based on:

1. the finding that the same basic plan applied to all growth projections examined, and that the same mix of water management decisions will be required regardless of the economic future the Okanagan pursues, and
2. the designation of the future lifestyle and water management measures preferred by the residents as enunciated through the public involvement task forces.

The development of this plan is outlined in the following sub-sections.

5.2 PRELIMINARY EVALUATIONS (PHASE 1)

Three preliminary evaluations were carried out, one of which was a specific task assignment included in the study plan, and the other two of which were added as a result of specific events during the Study period. These three preliminary evaluations were as follows, each of which is summarized in this section.

1. Task 23 - Preliminary Water Quantity Evaluations - Mainstem System
2. Preliminary appraisal of Kalamalka-Wood Lake Sub-basin
3. Trout Creek Pilot Study

FIGURE 5.1

PHASES IN DEVELOPMENT OF COMPREHENSIVE FRAMEWORK PLAN

(Based on Reiteration of Evaluation Process, Figure 4.1)

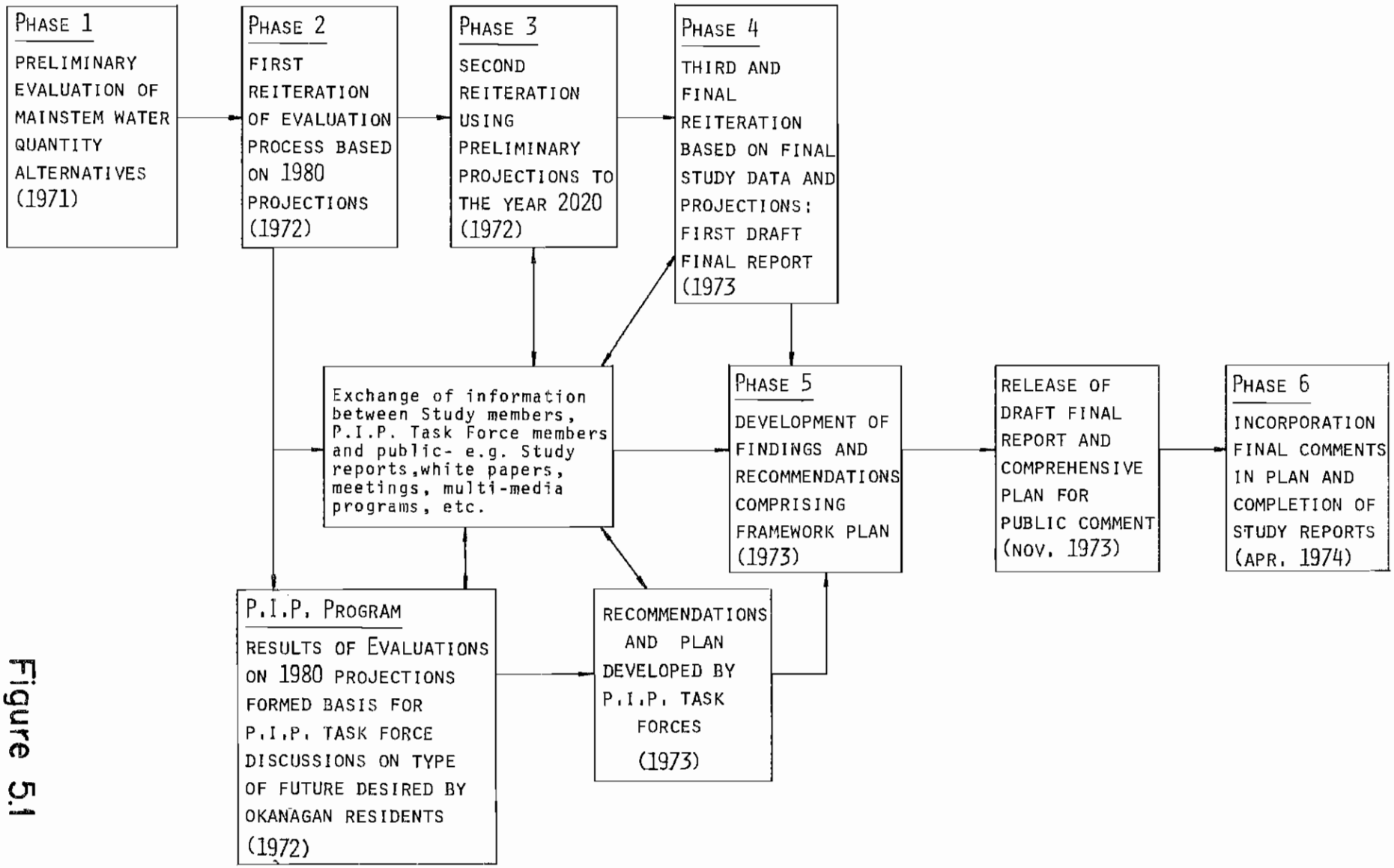


Figure 5.1

5.2.1 Preliminary Evaluation of Water Quantity Alternatives, Mainstem System (Task 23)

The first run-through of the evaluation process was undertaken early in the Study (June 1971) to:

1) determine if there was a potential shortage of water in the system and if so to develop alternative schemes to alleviate this shortage (e.g. importation of water) and
2) allow the completion of feasibility and costing studies on selected alternatives within the time limits of the Agreement. This preliminary evaluation also provided the opportunity to test and become familiar with this relatively new process which was to be used a number of times in the development of a framework plan.

The main finding of this first evaluation was that under good water management there is enough water in the basin to supply all projected withdrawals and meet proposed fishery and recreation requirements in the main valley, assuming the withdrawal of larger volumes of water from Okanagan Lake during prolonged drought periods than has occurred in the past, and resulting lower lake levels. This findings resulted in the elimination of those alternatives dealing with the large scale importation of water from outside the basin, and allowed a more detailed examination of management alternatives within the basin itself.

The flow chart for this preliminary evaluation is shown in Figure 5.2, examples of planning objectives for mainstem management in Table 5.1, and the evaluation matrix resulting from this assessment is included as Table 5.2. Because the procedures developed in this initial evaluation were recorded in some detail, as compared to later evaluations, the preliminary report on this task has been included in this supplement as Appendix F, and the methods of evaluating the impact of various water quantity alternatives on fisheries, wildlife and recreation as Appendix G.

5.2.2. Preliminary Appraisal of Kalamalka-Wood Lake Sub-Basin

During the summer of 1971, the continuous occurrence of surface algae blooms in Wood Lake and on one occasion their intrusion into Kalamalka Lake - aroused public concern over the future quality of water in this sub-basin. A preliminary assessment of these waters was therefore initiated to report on the movement of the discolored Wood Lake waters into Kalamalka Lake, and to review the extent of study data available to answer some of the particular problems unique to these lakes.

This evaluation was carried out during August of 1971 and resulted in the following findings:

1. that there has not been any major change in the trophic state of these lakes since 1935. However, such factors as the scarcity of kokanee in Wood Lake

FLOW CHART - PRELIMINARY EVALUATION OF WATER QUANTITY ALTERNATIVES - MAINSTEM SYSTEM (Task 23)

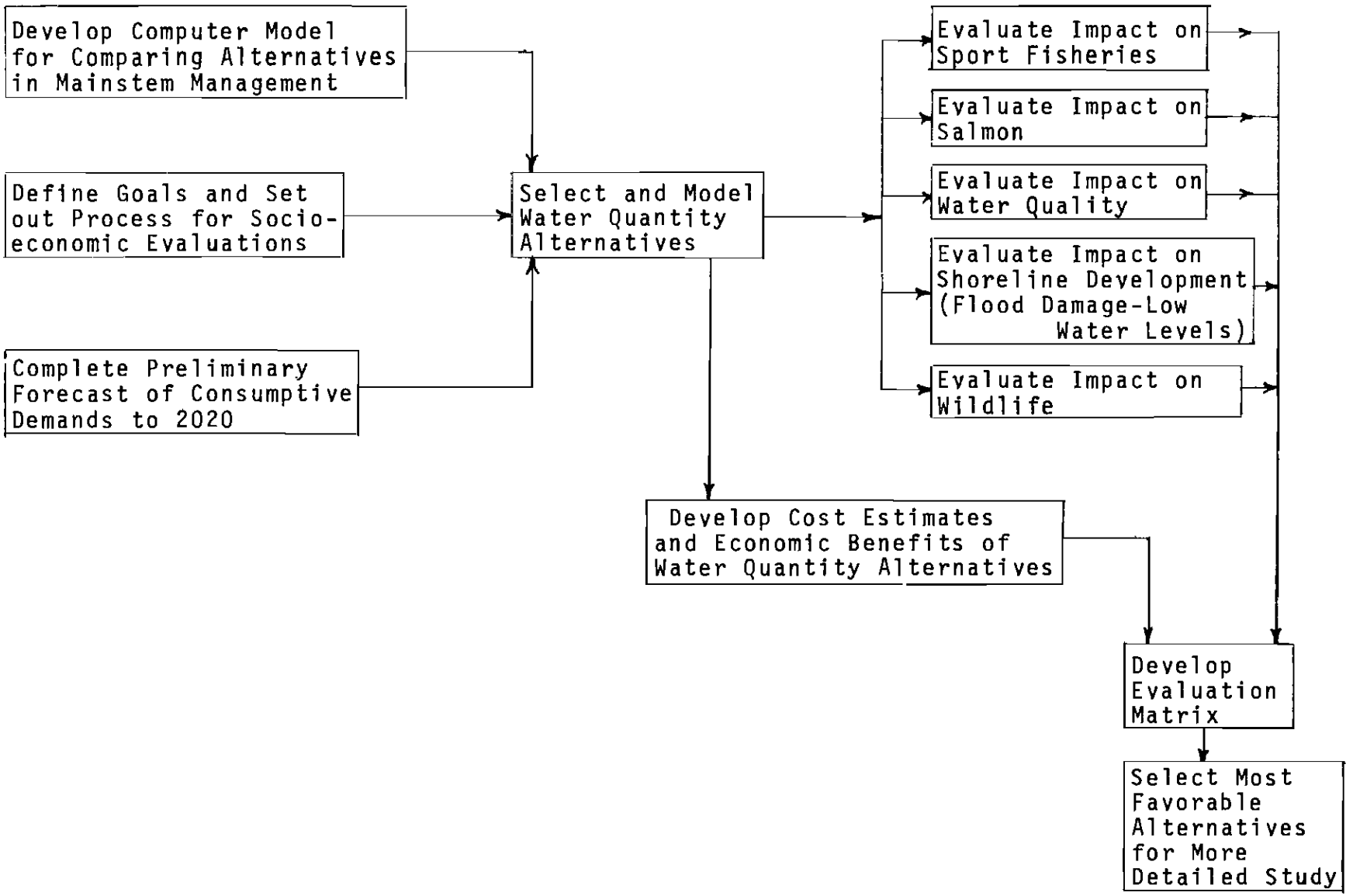


FIGURE 5.2

TABLE 5.1

EXAMPLES OF PLANNING OBJECTIVES FOR USER AREAS IN MAINSTEM OKANAGAN

PLANNING OBJECTIVES	WHERE	WHEN	HOW MUCH*[1]	WHO OR WHAT
A - Agricultural Use				
1. Maintain water supplies to existing and projected irrigated land to 2020.	Okanagan Lake Region	April to September inclusive	37,000 ac.ft. 1970 25,000 ac.ft. 2020	
	Okanagan River Region	April to October	31,000 ac.ft. 1970 23,400 ac.ft. 2020	
2. Expand agricultural acreage and provide adequate water supplies	North Okanagan (Vernon-Enderby)	Projected to 2020	19,740 acres 35,500 ac.ft.	
	Shuswap Area	Projected to 2020	9,510 acres 17,118 ac.ft.	
3. Improve efficiency of water use	Okanagan River Region	April to September inclusive	Reduce minimum flows from 300 cfs to 100 cfs at Penticton, in emergencies Apr.-July	
4. Expand agricultural production.	North Okanagan Shuswap Area	Projected to 2020	Unknown	Hay, pasture Vegetables
B - Industrial Use				
1. Maintain water supplies to existing and projected industrial development to 2020.	Okanagan Lake Region	All year	1970: 4,410 ac.ft. 2020: 36,050 ac.ft.	
	Okanagan River Region	All year	1970: 236 ac.ft. 2020: 650 ac.ft.	
2. Avoid flood damage to industrial land.	Okanagan Lake Shoreline	May - July	Levels 1,123.8'	Simpson Mill at Kelowna
C - Municipal and Domestic Use				
1. Maintain water supplies to existing and projected municipal and domestic needs to 2020.	Okanagan Lake Region	All year	1970: 8,270 ac.ft. 2020: 31,200 ac.ft.	
	Okanagan River Region	All year	1970: 808 ac.ft. 2020: 800 ac.ft.	
2. Maintain lake levels and flows to enable intakes to operate efficiently.	Okanagan Lake	All year	1,125.0'-1,116.8'	City of Oliver, various individual domestic intakes
	Okanagan River	All year	100 cfs anywhere in Okanagan.	
3. Avoid flood damage to municipal and domestic use.	Okanagan Lake shoreline	May - July	OK. Lake 1,123.8'	
	Osoyoos Lake	May - July	Os. Lake 913.0'	
D - Transportation Use				
1. Maintain water levels to facilitate barge traffic	Okanagan Lake	All year	1,119.8 feet 1,123.8 feet	CNR Railway CPR Railway, Wharfs
2. Maintain water levels to protect Kelowna Floating Bridge.	Okanagan Lake	All year	1,118.8 feet 1,123.8 feet	
3. Protect bridges from high river flows.	Okanagan River	All year	2,100 cfs to 3,400 cfs depending on location	McAlpine Bridge
E - Recreation Use				
1. Avoid inundation of recreational sites.	Okanagan Lake Shoreline	May to September	1,123.8 feet	Recreation, Beaches Campgrounds
2. Avoid loss of boating opportunities by maintaining lake levels.	Okanagan Lake	February to November	1,119.8 feet 1,123.8 feet	Public boat access, Private boat docks, Private marin
F - Fish and Wildlife Use				
1. Maintain river flows to protect anadromous salmon spawning, incubation and migration opportunities.	Okanagan River	Aug. 1-Sept. 15 Sept. 16 - Oct. 30 Nov. 1 - April 30	300 - 450 cfs 300 - 500 cfs 1,000 cfs 170 cfs	Sockeye Salmon
2. Protect salmon run for Indian population	Okanagan River	Aug. - Oct.	1,000 salmon per year	Indian population
3. Provide flows to support sports fishery requirements	Okanagan River	Aug-Nov. Dec.-Mar. Mar.-July	250 cfs 170 cfs. 100 cfs	Kokanee Rainbow trout Whitefish
4. Maintain lake levels to protect game bird habitats.	Okanagan Lake	All year	1,119.8 ft. 1,123.8 ft.	Wildfowl
G - Aesthetic Use				
1. Maintain lake levels to avoid unsightly exposure of shoreline.	Okanagan Lake	All year	1,119.8 feet	Private properties, Public areas
2. Maintain lake levels and flows to protect important ecological systems.	Okanagan Lake Skaha Lake Vaseux Lake Lake Osoyoos	All year	1,119.8'-1,123.8' (Okanagan Lake) (Okanagan River)	Wildlife habitats aquatic eco-system habitats
	Okanagan River	All year	100 cfs.	
3. Maintain water quality standards to protect important ecological systems and aesthetics.	Okanagan River Skaha Lake Vaseux Lake Osoyoos Lake	All year	100 cfs. (Ok. R.)	

TABLE 5.2

PRELIMINARY EVALUATION MATRIX - TASK 23 - WATER QUANTITY ALTERNATIVES

ALTERNATIVE		ECONOMIC CONSIDERATIONS												ENVIRONMENTAL CONSIDERATIONS								BENEFITS MINUS COSTS	OVERALL RANKING	
		ANNUAL COSTS (X $1000)							ECONOMIC BENEFITS (ANNUAL)					QUALITATIVE RANKINGS										
Number	Set	Diversion Canal and Pumping Plan	Storage Costs	Down-Stream Canal	Pumping	Operating Costs	Other	Total	Lake Levels	Upstream Irrigation	Salmon Benefits	Other	Total	Salmon	Other Fish	Wild-Life	Lake Levels High	Lake Levels Low	Water Quality	Other	Composite Ranking	ANNUAL (X $1000)	Within Set	Overall
2	A	0	0	0	0	0	134	0		0				0	0	0	0	0	0		0		4	4
3	B	0	0	35	0	-30	134	5	147	0	35.0		-34.8	-6	-6	5	-2	4	-1		-6	- 39.8	8	14
4	B	0	0	35	0	-30	134	5	392	0	0		392	+4	2	2	0	4	-1		+11	- 4.6	1	1
5	B	0	0	35	0	-30	134	5	384	0	29.0		384	-5	-4	3	1	4	0		-1	- 33.6	7	13
6	B	0	0	35	0	-30	134	5	678	0	0		678	3	1	2	0	2	0		+8	- 4.3	2	2
7	B	0	0	35	0	-30	134	5	570	0	0		570	3	1	1	-1	0	0		+4	- 4.4	3	3
8	B	0	0	35	0	-30	134	5	-393	0	0		-393	3	2	-2	-2	-6	2		-3	- 5.4	5	7
9	B	0	0	35	0	-30	134	5	-401	0	0		-401	3	2	-1	-5	-6	2		-5	- 5.4	6	10
10	C	0	0	0	0	Not	134	0	36	0	0		36	3	2	0	0	-3	1		+1	36	1	5
11	C	0	0	0	0	Estimated	134	0	563	0	-11.4		-10.8	-2	-2	0	4	+3	-1		+2	- 10.8	3	8
12	C	0	0	0	0	But	134	0	684	0	-29.0		-28.3	-5	-4	+3	5	5	-1		+3	- 28.3	5	11
13	C	0	0	0	0	Positive	134	0	-124	0	0		-124.0	3	2	-1	1	-4	+1		+2	- 124	2	6
14	C	0	0	0	0	"	134	0	150	0	-11.4		-11.3	-2	-2	0	2	1	0		-1	- 11.3	4	9
15	C	0	0	0	0	"	134	0	490	0	-29.0		-28.5	-5	-4	2	4	3	0		0	- 28.5	6	12
20	D	836	Not	0	+	0	134	836	500	0	0		500	3	2	3	5	6	2		+21	- 835.5		
21	D	866	Estimated	0	+	0	134	866	500	0	0		500	3	2	3	5	6	2		+21	- 865.5		
22	D	836	"	0	+	0	134	836	500	0	0		500	3	2	3	5	6	2		+21	- 835.5		
23	D	866	"	0	+	0	134	866	500	0	0		500	3	2	3	5	6	2		+21	- 865.5		
24	D	896	"	0	+	0	134	896	500	0	0		500	3	2	3	5	6	2		+21	- 895.5		
25	D	926	"	0	+	0	134	926	500	0	0		500	3	2	3	5	6	2		+21	- 925.5		
26B	E	866	0	0	231	Included	134	1097	507	0	0		506	3	2	2	4	4	2		+17	-1096.5	2	
27B	E	969	0	0	279	In	134	1248	732	0	0		732	3	2	3	6	7	2		+23	-1247.3	1	
28B	E	1053	0	0	318	Pumping	134	1371	491	0	0		491	3	2	4	2	6	2		+19	-1370.5	3	
29	E	866	0	0	315	0	134	1181	568	0	0		568	3	2	2	5	5	2		+19	-1180.4		
30	E	969	0	0	378	0	134	1347	1089	0	0		1089	3	2	4	7	8	2		+26	-1345.9		
31	E	1053	0	0	350	0	134	1403	571	0	0		571	3	2	5	3	6	2		+21	-1402.4		
$26B_1$	E	899	0	0	250	0	134	1149	506	-	0		506	3	2	2	4	4	2		+19	-1148.5		
$27B_1$	E	993	0	0	294	0	134	1297	732	-	0		732	3	2	3	6	7	2		+23	-1296.3		
$28B_1$	E	1072	0	0	331	0	134	1403	491	-	0		491	3	2	4	2	6	2		+19	-1402.5		
$26B_2$	E	912	0	0	262	0	134	1174	506	-	0		506	3	2	2	4	4	2		+19	-1173.5		
$27B_2$	E	1014	0	0	307	0	134	1321	732	-	0		732	3	2	3	6	7	2		+23	-1320.3		
$28B_2$	E	1091	0	0	344	0	134	1435	491	-	0		491	3	2	4	2	6	2		+19	-1434.5		
$26B_3$	E	939	0	0	274	0	134	1213	506	-	0		506	3	2	2	4	4	2		+19	-1213.5		
$27B_3$	E	1027	0	0	315	0	134	1342	732	-	0		732	3	2	3	6	7	2		+23	-1341.3		
$28B_3$	E	1103	0	0	352	0	134	1455	491	-	0		491	3	2	4	2	6	2		+19	-1454.5		

in 1971 compared to 1935, did indicate some further deterioration in water quality;

2. that the main cause of the intrusion of surface algae blooms into Kalamalka Lake in July of 1971 was due to a heavy surface bloom of blue-green algae in Wood Lake which was transported to Kalamalka Lake by an unusually late and above average runoff. Normally there is little or no runoff into or out of these lakes after the end of June. While this combination of circumstances was not expected to re-occur in the immediate future, the probable future condition of these lakes could not be predicted until ongoing studies had been completed; and

3. that based on the assessment of available data, it was recognized there was a scarcity of information, particularly on the sources and amount of nutrient loadings to these lakes, and their relation to the surface and groundwater regime.

Using the results of this assessment, the Province of British Columbia initiated a much more detailed study of water quantity and water quality aspects in this sub-basin. This study was considered necessary by the Province in order to discharge their responsibilities under the B.C. Water Act and the Pollution Control Act on a continuing basis. (This Study was completed in December 1974). The information obtained under this separate study was made available to the Okanagan Basin Study for use in the final evaluation phase.

The findings of this preliminary assessment also promoted some additional limnological studies, particularly in Wood and Ellison Lakes, over the fall of 1971, and provided the opportunity to evaluate the effect of poor water quality on recreational behaviour and to determine visitors' perceptions and attitudes towards the different levels of quality in Wood and Kalamalka Lakes.

The final results of these and other studies on the Vernon Creek sub-basin have been recorded in the Main Report and Technical Supplements I to XI, and will not be repeated here. While this particular assessment did not involve the identification or evaluation of water management alternatives, it did indicate the form and extent of the data base which would be necessary for the evaluation of quality management alternatives for the main valley lakes in the latter stages of the Study.

5.2.3 Trout Creek Pilot Study

The Trout Creek Pilot Study was initiated by the Okanagan Study Committee in September 1971, with the objectives of (1) assessing the capability of the information base being developed under the Study to meet the planning requirements for individual tributary sub-basins, and (2) testing analytical procedures for evaluating tributary management alternatives. While the Committee recognized

that it would not be possible to complete evaluations for all tributary sub-basins within the time and financial limitations of the Agreement, it was felt that a detailed evaluation of one sub-basin would provide a model for the subsequent assessment of other major tributaries in the basin. Such an assessment would also provide an indication of the adequacy of the existing information base being developed under the Study for tributary evaluations as compared to information needs for developing a comprehensive plan for the Okanagan Basin.

The selection of the Trout Creek Sub-basin was made for the following reasons:

1. It represented one of the major tributaries to Okanagan Lake, both with respect to watershed size and runoff.
2. The water in Trout Creek is used to meet a wide range of consumptive and non-consumptive demands, including irrigation, municipal needs, industry, fisheries and wildlife.
3. Demands for water from this sub-basin were approaching the limits of the dependable supply, and emerging conflicts between various water uses were therefore more obvious than in most other sub-basins.
4. Good access to the watershed and proximity to the Study Office facilitated study arrangements.

The first stage of this study, which involved a compilation of all relevant background data for this sub-basin, immediately indicated the sparcity of data for specific sub-basins, particularly in the water quantity and quality areas, and subsequently led to more detailed studies of these aspects. While these studies could not be completed in time to finalize the pilot study initially envisaged, they did greatly improve the information base for the evaluation of tributary water management alternatives in the final phase of the Study.

The pilot study, as far as it was completed, also indicated that it was not necessarily advantageous to evaluate multiple water use-water management alternatives for one tributary in isolation from other tributary streams. For example, it is quite possible that spawning habitat for Okanagan Lake sport fish should be managed only in those watersheds which harbor the greatest potential rather than in every tributary watershed. In some water use areas therefore, it appears to be more efficient to examine all major tributaries as a group, rather than singly, and to allocate uses to individual streams according to social, economic and environmental criteria.

5.3 FIRST REITERATION - 1980 PROJECTION (PHASE 2)

Following the Duncan Seminar in June 1972, it was agreed that the first comprehensive evaluation (first reiteration of evaluation process) would be for the 1980 time horizon since alternative projections would not be involved. This was expected to simplify the development of evaluation techniques and procedures. It was also agreed that the economic growth projections developed would be reasonably reliable to that date and would allow an analysis of various supply-demand factors. An arrangement was also approved, based on experience with the preliminary mainstem quantity alternative assessment and the Trout Creek Pilot Study, whereby a team of evaluators would be formed to work together on all future evaluations. Evaluators were to be available as required by the Study Committee on a priority basis. It was recognized that the diverse locations of the various evaluators would involve some disadvantages in communication, but the team concept was considered the best solution at that time. The direction and coordination of this team of evaluators was to be provided by the Executive Secretary to the Consultative Board. The members of this team and their field of evaluation responsibility is shown in Figure 5.3.

Evaluations for the 1980 projections were carried out over the period of June 1972 to October 1972. The basic procedure was to establish component evaluation requirements in relation to the principles and processes outlined in Chapter 4; to designate to each evaluator responsibility in completing evaluation segments; and to review the results of these assignments at a subsequent meeting and determine the next step or additional work required to complete these 1980 evaluations. Several such meetings were held prior to a meeting with the Board and Committee in October 1972, when the results obtained were presented and discussed. While these results provided a much better perspective of the trends that could be expected in selected resource components than was available from Task 23, there was still no significant integration between the differing resource components required for a comprehensive plan, and no overall view of the range of demands or quality impairment that might be expected over the next 50 years.

The results of this first reiteration of the evaluation process for the 1980 projections formed the basis for the public involvement task force discussions and the eventual preparation of their own plan and recommendations concerning the future of the Okanagan Basin (See Technical Supplement XI).

5.4 SECOND REITERATION - PRELIMINARY 2020 PROJECTIONS (PHASE 3)

The main purpose of the second reiteration of the evaluation process - based on the results and shortcomings of the first reiteration - was to determine the sensitivity of possible future consumptive demands to economic growth. This second reiteration was based on very preliminary growth projection data,

LIST OF EVALUATORS AND COORDINATORS

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CORRIGAN, D.	B.C. Pollution Control Branch Parliament Buildings Victoria	Water Quality and Waste Treatment
HALL, D.	Water Investigations Branch B.C. Water Resources Service Parliament Buildings, Victoria	Socio-Economics, Land and Water Use
KOSHINSKY, G.D.	Fisheries Research Board Freshwater Institute 501 University Crescent Winnipeg	Fisheries Coordinator
LEACH, T.A.J.	Water Investigations Branch B.C. Water Resources Service Victoria	Co-Chairman, Okanagan Study Committee
McNEIL, Robin	Dept. Civil Engineering U.B.C., Vancouver	Water Quantity
MOOIJ, H.	Projects & Research Division Pollution Control Branch Victoria	Water Quality
O'RIORDAN, Dr. J.	Planning Division Environment Canada 404 - 1001 West Pender Street Vancouver	Chairman - Study Committee Socio-Economic Coordinator
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SINCLAIR, G.	Okanagan Basin Study P.O. Box 458, Penticton	Public Involvement
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THOMAS, C.	Water Resources Service Dept. Lands, Forests and Water Resources, Parliament Buildings Victoria	Socio-Economics Coordinator

NOTE: Affiliation shown is that at time of participation in the Okanagan Basin Study.

Figure 5.3

and resulting demands for water to the year 2020, including a broad range of possible demands for irrigated agriculture which represented the major user of water in the basin.

The results of this evaluation indicated that there were no large differences in the total water requirements for the range of growth projections examined for the year 2020 (310,000 to 340,000 acre feet), and also that the increase in demands from 1970 to 2020 would not be a significant factor in future water management (300,000 to 340,000 acre feet).

This second reiteration provided the first good overview of the range of demands that might be expected for the growth projections examined and the type of alternative required to meet various quality standards and levels of growth, although good cost and benefit data were lacking at this stage. It also pointed out areas where more specific planning was required - e.g. fisheries - before a comprehensive plan could be finalized. The results of this second reiteration were assembled in the form of a mini-final report, as an example of the form the comprehensive plan might be expected to take, and was presented to the Board in March 1973.

5.5 THIRD AND FINAL REITERATION - FINAL 2020 PROJECTIONS (PHASE 4)

The final reiteration of the evaluation process involved the development and/or refinement of data concerning various water management alternatives, using the final projection figures for 2020 development conditions. Because this phase also included the preparation of the first draft of the final report, all aspects of the plan had to be drawn together in a coordinated presentation, and the reasons for the selection of various alternatives set out in accordance with the evaluation principles and processes previously described.

Moreover, while a continuous association with the public involvement task forces had influenced to some extent the development of the plan to date, it was in this phase and subsequently in the fifth phase, that the actual recommendations of the task forces were considered in detail in the development of the comprehensive plan.

5.6 DEVELOPMENT OF RECOMMENDATIONS (PHASE 5)

This phase in the development of the comprehensive plan involved the development of findings and recommendations based on the results of the Study, and consistent with the future lifestyle preferred by the residents of the Okanagan Basin as expressed through the Study's public involvement program. The actual plan developed consisted of a series of recommendations representing an integration of the best alternatives, selected through the evaluation process, for

managing water quantity, water quality, fisheries and shoreline recreation. These findings and recommendations, constituting the framework plan, were then put together in the form of a draft summary report.

The Consultative Board were the key participants in the development of this plan, and met several times during its preparation, including one meeting with the public involvement task forces.

This draft summary report containing the comprehensive plan, along with a draft of the main report, was released for public comment in November 1973.

5.7 FINAL PUBLIC RESPONSE TO DRAFT PLAN (PHASE 6)

The fifth and final phase of the development of the comprehensive plan involved a review of the public response to the draft findings and recommendations, and the incorporation of comments received where such were required to ensure the plan reflected the concensus of valley opinion. This final phase was carried out between December 1973 and April 1974, when the final report and recommendations were completed for presentation by the Board to their respective ministers.

PART III

REVIEW OF PLANNING PROCESS

CHAPTER 6
Review of Okanagan Basin Study Planning and Problems

6.1 INTRODUCTION

The Okanagan Basin Study represented a new and dynamic approach in water resource planning in that it considered not only the needs and value of various uses of water in the basin including agriculture, municipalities and industry, but also the impact of these uses on environmental quality, water based recreation, fisheries and wildlife, etc. It compared the water resource capability of the basin to both existing and a range of future demands, and evaluated the consequences of implementing or not implementing various water management alternatives to meet these demands in terms of economic, social and environmental criteria. Finally, it provided a comprehensive plan for the development and management of the basin's water resource over the next 50 years, based on these evaluations and public preference as expressed through the Study's public involvement program.

As a planning exercise this Study must be considered as an extremely successful venture, and the knowledge gained and plan developed for water management in the basin of great value to water users. The question still arrises however, as to what has been learned from this particular study that could be useful in future basin studies of a similar nature. This chapter therefore reviews this aspect of the Study. An improved model for future basin planning based on this experience is set out in Chapter 7.

6.2 PLANNING AS A COMPONENT OF WATER RESOURCE MANAGEMENT

The Agreement on which this study was based evolved largely from public pressures due to a noticable decline in water quality in the basin, and the need to resolve a number of emerging water use conflicts. While the terms of the Agreement provided for studies to resolve these problems and for the development of a plan for developing and managing this resource over the next 50 years, it did not provide for the implementation or monitoring of the plan evolved, which should be also key components of any water management program. Rather, the Study had a beginning and an ending, the primary result being a set of technical reports which may or may not be used by water managers to improve water management in the Okanagan Basin. The absence of any implementation phase in the Agreement was one of the primary concerns stated by the public from the outset of the Study, and it was based on this concern that a recommendation on implementation was eventually included in the comprehensive plan.

The first improvement suggested therefore, is to make any similar future studies a planned component of a long term management program. Or, stated in another way, basin planning should not consist merely of special studies of selected basins as the need arises; rather, such studies should be an integral part of long term basin planning. Such arrangements would not obviate the need or advantages of joint study undertakings, especially where jurisdictions may be divided (e.g. international streams), but could certainly alter the responsibilities of the parties to such agreements.

6.3 SCOPE OF STUDY

The scope of the Study as outlined in the Agreement, stated that the framework plan should be specifically concerned with the management and development of the basin's water resource. It has also been noted in previous sections of this supplement that the objective of the Study as stated in the Agreement could only be achieved through an understanding and management of all resources and activities in the basin including agriculture, forestry, receration, tourism, mining, industrial development, land use, etc. It has therefore been argued that the scope of the Study was too limited.

Experience in comprehensive planning, as gained through the Okanagan Basin Study, indicates that total resource planning in one stage may not be realistic for some time to come because of the lack of adequate planning tools and communication processes which would be necessary to undertake such a large scale study. Even within the limited scope of the Okanagan Basin Study, the coordination and assimilation of material on only water and water-related resources was in itself a major accomplishment.

It is recognized however, that land use planning should have been included and studied in more detail. While some land use studies were carried out to determine existing demands for water, the absence of any plan for future land use in the basin severely limited the development of quantity and quality alternatives, particularly for future tributary water management. For example, the distribution of future population increases, and the location of new industries or agricultural acreages will affect the supply-demand balance of the sub-basin from which water is drawn to meet the demands of these potential water users, and the waste products from these developments will affect the water quality of the tributary or lake to which waste effluents are discharged.

The second improvement proposed for future basin studies therefore, is the inclusion of land use planning to the extent that such planning may affect future water management in the basin.

6.4 TIME AND FINANCIAL CONSTRAINTS

Any planning exercise which is based on an agreement between two governments, normally includes time and monetary limitations. While such constraints do not necessarily hinder the successful conclusion of any joint undertaking, in the case of the Okanagan Basin Study they were found to be particularly limiting because of the pilot nature of the Study. A good deal of Study time, for example, involved the development of study techniques, planning objectives, and evaluation procedures, which greatly reduced the actual time that could be spent on the Study itself. Any future studies involving new concepts should therefore make appropriate time allowances for the development of such concepts, over and above that required for the study proper.

A second point in respect to the time limitation aspect, is that detailed studies had to be initiated immediately in order to complete the Study within the period stipulated in the Agreement. This meant that detailed studies were being carried out before the need for such studies - as based on a preliminary assessment of existing data - could be examined. A preliminary assessment might indicate for example, that a long term monitoring program was required to properly evaluate the availability of a resource before any detailed studies were undertaken, or conversely, that sufficient data already existed in specific fields to evaluate these without any further study.

In the Okanagan Basin Study, the initiation of detailed studies without going through the process of a preliminary evaluation, resulted in an imbalance of data on the various aspects being studied and in some cases the unnecessary expenditure of funds. While this imbalance was to some extent resolved as the Study progressed, the time lost and funds initially expended could not be recovered.

To rectify this situation in future basin studies, it is recommended that a preliminary assessment of a basin or sub-basin should be made, and planning objectives more fully developed before detailed studies are initiated. Moreover, such assessments should be a prelude to, rather than a part of, any detailed study or agreement. Since preliminary assessments are essentially in-house reviews of existing data, they should not be costly and could be completed in a relatively short period of time. Such assessments would also allow some initial interaction with the public and provide them the opportunity to express their views and preferences prior to the formulation of any detailed study proposal.

6.5 MONITORING

Certain aspects of water resource management require data records over a period of years before the data can be used with any reliability to indicate

the resource capability. This is particularly true for water quantity data where continuous records of up to 50 years are often required to assess the available water resource within a basin.

Because the value of this type of monitoring as obtained under the tenure of any study agreement is limited, it is felt that monitoring requirements of a long term nature should not be initiated as part of special basin studies. Rather these should be considered separately as part of the long term management programs of government. The elimination of such monitoring from special studies would then limit investigations to those which could be carried out in one to two years, and greatly increase the time and funds available for the assessment of such data and the evaluation of management alternatives. This step should not preclude the identification of long term monitoring needs in a basin during a preliminary assessment phase, or of considering these needs in relation to other basins in the Province. Moreover, all data obtained from separate long term monitoring programs, both prior to and during a study, should be readily available for use in any detailed basin studies.

The separation of long term monitoring needs and programs from special basin studies also applies to other disciplines (e.g. water quality, limnology, etc.) even though such programs have not yet been developed to the same extent as water quantity monitoring.

6.6 DEVELOPMENT OF EVALUATION TECHNIQUES

In the Okanagan Basin Study, many new concepts were explored to express the effect of various water management alternatives on future conditions within the basin. For example, phosphorus loading criteria were developed for each of the main valley lakes to assess the effect of various future waste loadings (phosphorus) on lake water quality. Because such standards are new, they must be considered at best, to be very approximate until tested over a period of years.

A second example involves water quantity modelling of the mainstem system (Okanagan Lake to Osoyoos Lake) where 50 years of past data (1921 to 1970) were used to provide monthly lake water levels and discharges under varying operating conditions. While the month as a unit of time was sufficiently accurate for some evaluations, it could not be applied to Osoyoos Lake because of the rapid fluctuations in its level during freshet periods, or to the simulation of tributary flows due to rapid changes in discharge. Time did not permit the introduction of a shorter time interval during the Study, or the use of synthetic hydrology, although considerable research was done on the latter.

One of the major needs for future basin studies therefore, is to improve evaluation techniques through the continuing development of these concepts.

6.7 PUBLIC INVOLVEMENT IN COMPREHENSIVE BASIN PLANNING

As experienced in the Okanagan Basin Study, public-minded citizens will demand a certain amount of involvement in the planning of a basin's resource, either through vigorous criticism or planned involvement. Either approach can be very time consuming for the key personnel involved in basin studies. The following points concerning this study are instructive to future public involvement in planning.

(a) While the Okanagan Basin Agreement provided for public involvement - "as required, to enable a comprehensive plan to be truly responsive to the wishes of the people for which it is designed, while reflecting the characteristics of the Okanagan Valley and surrounding regions" - the absence of any involvement prior to and during the preparation of the Agreement, the delay in initiating a formal program of public involvement, and the lack of experience and proven techniques in conducting such a program once one had been initiated, all led to thebuild-up of public distrust or animosity toward the Study Group which lasted throughout much of the four year study period.

(b) The time required of key study personnel first to offset adverse criticism, and following this to provide technical input to the more formal public involvement program, was much more than anticipated and occurred during a period when study personnel were already deeply involved in providing an assessment of the existing resource base and evaluating alternatives.

(c) Public involvement is essential in the development of detailed planning objectives if the resulting comprehensive plan is to represent the wishes of the people for whome it is designed.

(d) The final recommendations of the Okanagan public, as expressed through the public involvement task forces did not differ appreciably from those of the Study group, once a knowledge of the resource base and the alternatives available were made understandable to them.

Based on this experience in the Okanagan Basin Study, it would seem desirable in future basin studies to have a planned public involvement program in harmony with the various phases and needs of these studies. Such a program should ensure that the input of local knowledge and public preferences occurs when it is most needed - i.e. in the initial planning stages and during the development of the comprehensive plan (evaluation phase). This would also best utilize the time of key Study personnel who may only be able to devote a limited amount of time to public involvement while detailed field studies are in progress.

CHAPTER 7
An Improved Model for Future Basin Planning

7.1 INTRODUCTION

The Okanagan Basin Study represented a new approach to basin planning, with many problems being encountered and many new techniques developed. Based on the experience gained in this study, one would be remiss of this knowledge was not incorporated into an improved plan for future water basin studies. Such a plan or model is outlined in Figure 7.1, with each of the major phases discussed in more detail below.

7.2 PRELIMINARY ASSESSMENT OF BASIN

A certain amount of data exists for most river basins in Canada, as collected by federal, provincial and local authorities. In fact, if it were not for such data, particularly that of long term stream flow records, detailed water management planning would not be possible. It is therefore suggested that the first phase of any future basin study should be a preliminary assessment of such data. Such an assessment would provide an overview of the supply-demand conditions within a basin and the identification of major constraints in respect to the optimum development of a basins' water resource. This in turn would allow the development of more detailed planning objectives, and the detailed studies required to set out and evaluate alternatives to meet these planning objectives. The steps involved in such a preliminary assessment are presented in some detail to illustrate the planning that should be completed before any costly detailed studies are undertaken.

7.2.1 Document Existing Data

The first step in any preliminary assessment of a basin should involve the compilation of existing data in a form that can be readily used to compare water availability with use and water quality levels with health or other quality standards. For example, basin runoff should be documented in terms of annual availability 50, 70, 90 percent of the time (or in other appropriate units) at a specific location in the watershed. The consumptive use of water (irrigation, municipal supply, etc) should be documented in terms of location and annual withdrawals, and include any information on available storage if applicable. Non-consumptive uses of water should be set out in terms of installed capacity (hydropower), angling days (sport fisheries), or recreation days (water based recreation). Waste loadings to a system should be shown as weight per chemical constituent per year, and existing wastewater treatment

Model for Water Resource Basin Planning

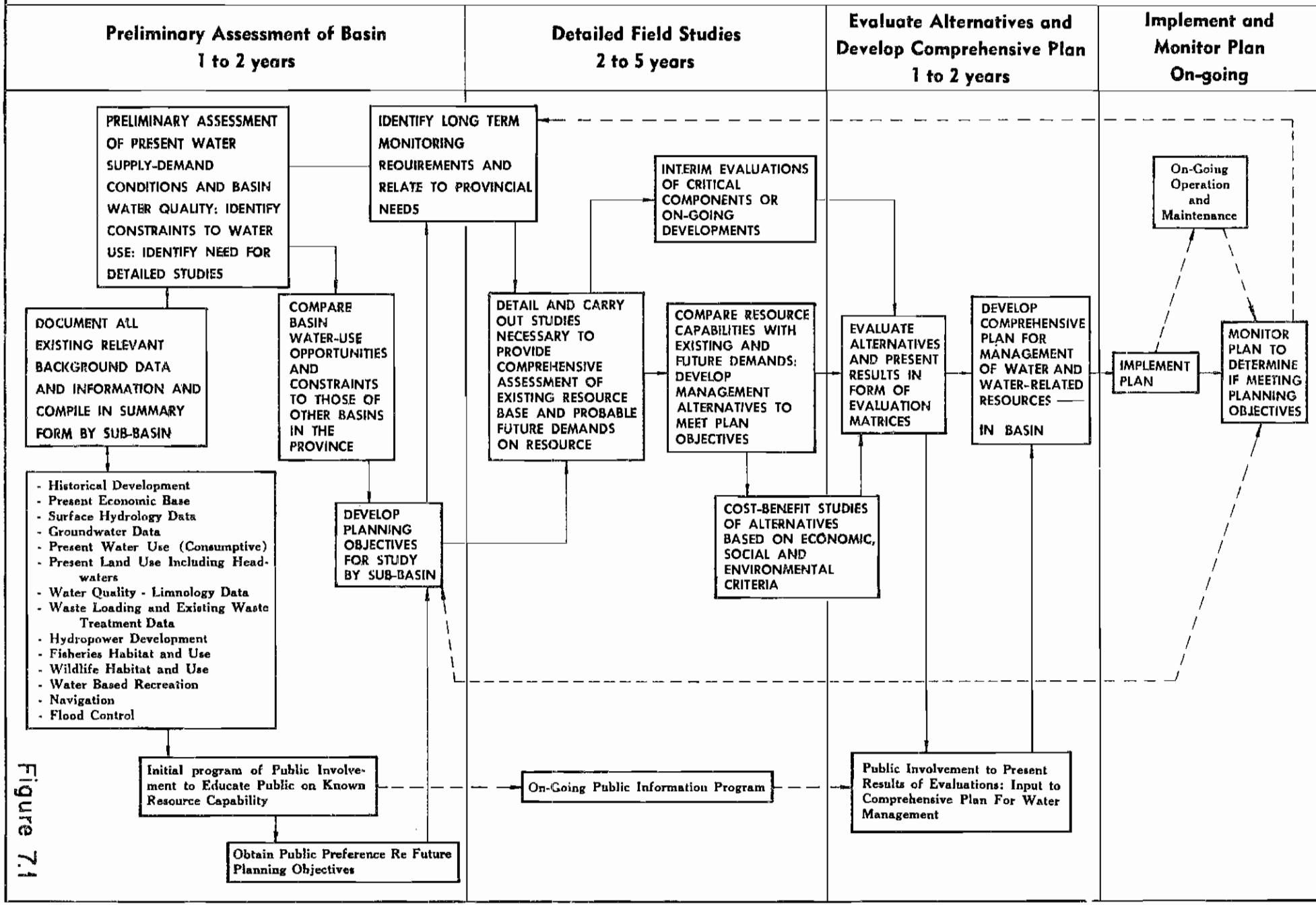


Figure 7.1

processes identified. In all cases the units used for availability should be comparable to those of demand. Where there are insufficient data to provide such figures, this should be noted for future planning and study purposes.

7.2.2 Compare Supply - Demand Conditions and Assess Water Quality

A comparison of the supply-demand conditions as developed above should identify the major users of water in a basin, emerging conflicts of use and constraints to water use. It may be found for example, that water use in a basin or sub-basin is very limited and that no major problems exist. In such cases, no detailed studies should be required at this point in time. Certain long-term monitoring stations in such basins may be desirable, however, to provide a suitable base for future evaluations should future development appear likely. The preferred locations and type of data desired from such monitoring should be clearly set out for these basins.

In other cases it may be found that there is more than sufficient water available on an annual basis, but that lack of storage or poor water quality is limiting to the optimum use of the basin's water resources. In these circumstances, the studies necessary to develop and evaluate alternatives to make the best use of the available resources should be clearly set out. It will be noted that no evaluations are proposed at this stage, but rather only an assessment of existing conditions and the identification of constraints which are limiting to the optimum use of a basin's waters.

7.2.3 Comparison of Basin Assets and Limitations to those of Other Basin within Province

The third step in the preliminary assessment of a basin is concerned with determining the roles that a particular basin plays in meeting water demands that are province-wide in scope as compared to local demands. For example, although water availability for developing hydropower is based on the capability of a specific basin, the demands for such power may be based on provincial rather than local needs. It will also be recognized that some basins in the Province are more attractive than others for certain uses of water. The Columbia and Peace Rivers, for example, are being highly developed to meet future electric power needs in British Columbia; the Okanagan Basin is particularly attractive to tourists for its water based recreation; the Fraser River supports one of the major commercial fisheries in Canada. It would therefore seem desirable to be able to indicate just what share of the Province-wide demands for water each basin provides for each of the major uses of water. This would not only identify the level of importance of a particular use of water in a basin to the Province as a whole, but would also provide an improved basis for evaluating (weighting) social and environmental values for a particular use of water in each basin.

7.2.4 Public Involvement

Following the completion of the preliminary assessment of present water supply-demand conditions, the first stage of public involvement should be initiated. This initial program would:

(a) Inform the public of the results of the preliminary assessment.
(b) Obtain from the public any local knowledge concerning problems or conflicts in the management of their particular basin;
(c) Obtain from the public some expression concerning their preferences with respect to future water resource planning objectives for that basin.

In carrying out such a program the public should be made fully cognizant of the fact that this represents a preliminary assessment only, and if and when a basin study is initiated, a more detailed program of public involvement would be included.

7.2.5 Develop Planning Objectives

The final step in this preliminary assessment would be the development of detailed planning objectives based on: the preliminary assessment of supply-demand conditions; the role the basin's waters play in meeting provincial demands; and the preference of the public in respect to the type of desired future lifestyle, as expressed through a public involvement program.

Examples of planning objectives have been detailed in other parts of this report and will not be repeated here. It should be re-emphasized however, that these must be in sufficient detail to allow the development of a study program which will provide the information necessary to develop and evaluate alternatives that will meet these planning objectives.

7.2.6 Long Term Monitoring Requirements

Coincident with the latter steps of this preliminary assessment, any long term monitoring stations required to properly assess water quantity or water quality conditions should be identified, their need evaluation in relation to stations in the province as a whole, and a composite (provincial) program of monitoring selected. Such monitoring should also recognize the need of comprehensive water management plans already implemented, and of special monitoring programs designed to improve the accuracy of information, or knowledge of the water resource regime in general.

7.2.7 Summary

The desirable steps in the preliminary assessment of a basin, have been outlined in this section. These steps are considered a prerequisite to any comprehensive basin planning studies to ensure that the data resulting from

such studies will provide the necessary base for the development and evaluation of alternatives required to meet the planning objectives of the study area.

Moreover it would be desirable to complete this preliminary assessment phase for all major basins in the province, prior to the initiation of any comprehensive basin studies, because a number of water uses are managed on a provincial rather than a local basis (e.g. hydropower, commercial fisheries, tourism, etc.). Such planning (province-wide) could in turn have a significant effect on the planning objectives of individual basins.

A second reason for completing preliminary assessments for all basins prior to any detailed studies, is the advantage of considering long term monitoring requirements for all basins in the province collectively, rather than individually, because of the limited funds and associated needs for this form of data collection.

At this point in the planning process, more detailed studies may then be considered, particularly for basins where the supply-demand situation appears critical and water use conflicts are evident. Such studies may be of a joint venture, or by individual governments, so long as they remain part of the long term management process.

7.3 DETAILED FIELD STUDIES

The second major phase in comprehensive water resource planning for a particular basin involves the detailing and carrying out of the studies necessary to provide a comprehensive assessment of the resource base, and probable future demands on this resource. The studies programmed should be based primarily on the planning objectives and study needs as outlined in the Preliminary Assessment. The value of setting up task forces to detail the study requirements for the various fields of investigation (as was done in the Okanagan Basin Study) is somewhat diminished assuming the preliminary assessments have been carried out properly, however, such task forces could still provide a valuable check at this stage to ensure that the studies proposed are reasonable and that no significant features have been omitted.

One of the major advantages of the preliminary assessment is that this second phase can be carried out as time and personnel resources permit, unless joint studies are agreed on to examine a particular basin. Should an evaluation of new developments or conflicting uses in a basin become necessary prior to the completion of the detailed study phase, interim evaluations could be carried out based on data from the preliminary assessment and any new information available at the time of the evaluation. The results of these interim evaluations would be incorporated into the main evaluation phase later in the study. Similarly,

interim evaluations could be made of the effect of new development or construction in the basin as necessary to provide for ongoing economic development.

It is important to recognize, that during this detailed study phase, key personnel will only be able to devote a limited amount of time to public involvement. Public involvement during this phase should therefore be primarily one of providing information on the progress of studies rather than the evaluation of results.

7.4 EVALUATION PHASE AND DEVELOPMENT OF COMPREHENSIVE PLAN

The third major phase of the planning process involves evaluations similar to those detailed in Chapter 4 and including: a documentation of the capability of the existing resource base; a comparison of resource capability with present and future demands; the development of alternative ways of meeting the planning objectives for the various water and water-related resources involved; estimates of the costs and benefits of such alternatives in terms of social, environmental and economic criteria; and the presentation of this material in the form of evaluation matrices.

The second major part of the public involvement program should also be initiated during this phase of the study. This program would first present the results of the detailed studies, the alternatives available to meet the stated planning objectives, and the consequences of implementing or not implementing the various alternatives available. The second objective of the public involvement program would be to obtain from the public their preferences with respect to the alternatives available and to use these in the development of a comprehensive plan for water management in the basin.

7.5 IMPLEMENTATION AND MONITORING OF PLAN

The development of a comprehensive plan for water management in a basin completes the planning phase of the water management cycle. However, under good water management practices this plan should then be implemented, and an ongoing monitoring program developed to ensure that the plan implemented is effective in meeting the stated planning objectives.

Such monitoring should include not only the evaluation of data from long term water quantity and water quality stations in the basin, but also study reviews at appropriate intervals throughout the planning horizon of such factors as economic growth, changes in the trophic state of major lakes, participation and catch-rates in sport fisheries, and changing demands on water based recreation

facilities. The frequency of such monitor reviews will depend to a great extent on the rate of economic growth, but it would seem desirable whenever possible to tie these reviews to such long term government assessments as the population census which is carried out every 10 years.

7.6 SUMMARY

This chapter has reviewed the planning process used in the Okanagan Basin Study, and based on this experience, a proposed model for future water resource planning has been developed. The model includes three distinct phases: a preliminary assessment of a basin; detailed field studies; and an evaluation phase. One of the major differences between this model and the plan used for the Okanagan Basin Study, is that a preliminary assessment stage has been added. This preliminary assessment phase is considered important for the proper identification of detailed study requirements, and in relating the priorities of water use in a basin with those of the Province as a whole, which in turn may affect the planning objectives and the value of water for a particular use in a basin.

It should also be re-emphasized at this time that planning represents only one phase of water management. Past study agreements have tended to isolate such planning, rather than considering it as only a component of long term resource management. This shortcoming should be recognized in any future water management arrangements if the benefits to be derived from comprehensive planning, which often involve expensive and time consuming studies, are to be fulfilled.

APPENDICES

APPENDIX A

THE CANADA - BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

APPENDIX A

CANADA-BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

THIS AGREEMENT made as of the 29th day of October, 1969

BETWEEN: THE GOVERNMENT OF CANADA
represented herein by the Minister of Energy, Mines and Resources (hereinafter called "Canada")

OF THE FIRST PART

AND THE GOVERNMENT OF THE PROVINCE OF BRITISH COLUMBIA
represented herein by the Minister of Lands, Forests and Water Resources (hereinafter called "British Columbia")

OF THE SECOND PART

WHEREAS the Governments of Canada and British Columbia recognize the growing need to plan water resources development on a comprehensive basis; and

WHEREAS the economy of the Okanagan Basin is heavily dependent on the quantity and quality of its limited water resource for agricultural production, recreation and tourism, as well as for domestic, municipal and industrial water supply and for the assimilation of wastes; and

WHEREAS the water supply problems in the Basin may involve the re-use of municipal waste water in irrigation systems, increased efficiencies in the use of water for irrigation, and the augmentation of water supply from groundwater and from diversion; and

WHEREAS the Shuswap-Thompson Rivers and the Okanagan River are important habitats for valuable stocks of Pacific Salmon; and

WHEREAS the Shuswap-Thompson system is a potential diversion source for the Okanagan Basin; and

WHEREAS these problems and possible solutions may have not only municipal, regional, provincial, and national significance, but potential implications outside Canada; and

WHEREAS His Excellency, the Governor-in-Council by Order-in-Council, P.C. 1969-7/2051 has authorized the Minister of Energy, Mines and Resources to execute this Agreement on behalf of Canada; and

WHEREAS His Honour, the Lieutenant Governor-in-Council by Order-in-Council No. 2423/1969 has authorized the Minister of Lands, Forests and Water Resources to execute this Agreement on behalf of British Columbia.

NOW THEREFORE THIS AGREEMENT WITNESSETH THAT in consideration of the premises, covenants and agreements herein contained the parties covenant and agree with each other as follows:

1. OBJECTIVE

The purpose of this Agreement is to develop a comprehensive framework plan for the development and management of water resources for the social betterment and economic growth in the Okanagan Basin.

2. SCOPE

The Okanagan Basin is of major significance to the Province of British Columbia. Due to increasing demands likely to be placed on the water resources of this Basin for municipal, industrial, agricultural and recreational uses and for fish and wildlife management and in view of the deterioration of water quality, disturbance of ecological balances, and diminution of water quantity in the Basin, the study will focus on identification and analysis of these problems and the evaluation of economic, engineering, ecological, financial and organizational alternatives for water resource utilization in the solutions to these problems. The planning horizon of the study will be to the year 2020 A.D.

The study will also embrace any areas likely to be affected by the adoption of various alternative solutions including, but not limited to, the possibility of diverting water from the Shuswap-Thompson Basin.

The study may also include the expansion of the present hydrologic and water quality data collection systems and an implementation phase in the form of pilot advance treatment plants and an experimental program of effluent disposal including spray irrigation and other techniques.

3. TERMS OF REFERENCE

The studies leading to the formulation of a comprehensive framework plan for the Okanagan Basin are to be sufficiently broad in scope as to examine possible alternatives for the efficient utilization and provision of an adequate quantity and quality of water in the Basin and in those areas likely to be affected by a diversion. Consequently, the program will include:

(a) ECONOMIC GROWTH STUDIES - as required, to provide a regional, national and internationl market perspective in which to view the emerging patterns of water demand for the Basin. The studies will focus on the regional resource base and on the economic viability of new and existing kinds of industry and agriculture, including tourism and water-based recreations, upon which water demand predictions can be based.

(b) WATER DEMAND STUDIES - as required, to provide an estimate of current demands and a forecast of future water demands by sector - municipal, industrial, agricultural, transportation, fisheries, recreational - to the year 2020 A.D.

(c) WATER SUPPLY STUDIES

(i) Water Quality Studies - as required, to determine present sources and levels of pollution, the relationships between inputs and outputs of nutrients and other chemical parameters in the waters of the Basin; to devise mathematical models to express the nutrient balances and pollution effects; and to determine the extent and range of possible future sources and levels of pollution.

(ii) Water Quantity Studies - As required, to evaluate the existing hydrologic regime of the Basin, including studies of runoff, lake levels, flows, groundwater and geological structure; climatology and meteorology; to evaluate means of regulating flows through storage and diversion; and to evaluate means of augmenting water supplies within the Okanagan Basin.

(d) ECOLOGICAL AND AESTHETIC STUDIES - as required, to determine the effects of water resources development and utilization on the fish and wildlife, and on the aesthetic values of the Basin.

(e) WATER RE-USE AND PILOT PROJECTS FOR ADVANCED TREATMENT OF WASTE WATER - as part of the water quality studies to determine practicability of augmenting water required for irrigation with the waste waters and to develop pilot plants for the control of nutrient discharges through the treatment of municipal and industrial wastes.

(f) STUDIES OF FINANCIAL AND ORGANIZATIONAL STRUCTURES - as required, to broaden the scope of the planning process to include all practical alternatives for the subsequent efficient utilization of the water resources of the Okanagan Basin.

(g) PUBLIC INVOLVEMENT - as required, to enable a comprehensive plan to be truly responsive to the wishes of the people for which it is designed while reflecting the characteristics of the people in the Okanagan Valley and surrounding regions.

4. FINANCING

(a) Canada and British Columbia shall equally share the entire cost of the study, including, but not limited to, the cost of collection of data, field surveys and the cost of consultants engaged as part of the program as well as an equitable share of the items described in (d) hereunder. Salaries of federal and provincial civil servants engaged in the program shall not be paid from funds approved under this Agreement excepting staff specifically assigned to and engaged in studies under this Agreement.

(b) Subject to the terms and conditions of this Agreement and subject to the funds being voted by Parliament, the aggregate sum to which Canada shall be liable in respect of the Agreement is not to exceed $1,000,000 of which not more than $250,000 will be available for financial assistance provided by Canada for the items described under (d) below.

(c) Subject to the terms and conditions of this Agreement and subject to the funds being voted by the Legislative Assembly, the aggregate sum to which British Columbia shall be liable in respect of the Agreement is not to exceed $1,000,000 of which not more than $250,000 will be available for the items described under (d) below.

(d) From time to time during the life of this Agreement, and as part of the Program, Canada and British Columbia may approve and provide financial assistance to local communities and organizations for:

(i) an experimental program of waste water reclamation by irrigation; and

(ii) a pilot advanced treatment installation.

Any project thus approved and constructed shall be operated and maintained by the municipality or local authority. Access shall be provided at all times for personnel authorized to work on the Program.

(e) This Agreement shall take effect on the date that the parties have executed this Agreement. No costs incurred prior to March 25, 1969 shall

be eligible or considered for payment under this Agreement. This Agreement shall terminate four years from the date of signing.

(f) Canada and British Columbia shall keep complete records of all expenditures made severally pursuant to the Agreement and shall support such expenditures with proper documentation. Canada and British Columbia upon request shall make these records and documents available to auditors appointed by the other.

(g) British Columbia shall keep complete financial records of all costs incurred under this Agreement. Upon request, British Columbia will make these records available to auditors appointed by Canada.

(h) Subject to the cost-sharing provisions of this Agreement, Canada shall pay to British Columbia, Canada's share of expenditures made by British Columbia pursuant to this Agreement upon the submission of a claim in a mutually agreed manner and form by British Columbia, certified by a senior official of British Columbia, and bearing a British Columbia audit certificate.

(i) Subject to the cost-sharing provisions of this Agreement, British Columbia shall credit Canada for expenditures made directly by Canada pursuant to this Agreement, upon the submission by Canada of a claim in a mutually agreed manner and form.

(j) Each party shall provide the staff including any field staff and administrative facilities necessary to implement any portion of the program assigned to the respective parties.

5. LEGAL IMPLICATIONS

Any studies undertaken under the provisions of this Agreement shall take into account in an appropriate fashion any legal implications necessarily incidental thereto.

6. ADMINISTRATIVE FRAMEWORK OF THE STUDY

Canada and British Columbia shall participate in a process of joint planning. To facilitate this, the following shall be established.

(a) A CANADA-BRITISH COLUMBIA CONSULTATIVE BOARD consisting of six members at a senior level in the public service, three of whom will be appointed by Canada and three by British Columbia. This Board shall be responsible for undertaking the program described herein; shall supervise the Okanagan Study Committee; shall meet at least once each year; and shall report to the Minister of Energy, Mines and Resources of Canada and to the Minister of Lands, Forests and Water Resources of British Columbia on progress of the Program and on the results of the investigation.

(b) AN OKANAGAN STUDY COMMITTEE, reporting to the Canada-British Columbia Consultative Board, will consist of three members appointed by Canada and three members appointed by British Columbia. With the approval of the Board, the Committee may appoint a study director, various sub-committees and other staff to carry out specific portions of the Program. All staff appointments shall be through the Provincial Civil Service Commission on the advice and consent of the Consultative Board. A party hereto may, upon the recommendation of the Board, employ the services of private consulting individuals and firms as required for data collection, planning and implementation.

(c) The Okanagan Study Committee under the supervision of the Board, shall carry out the joint planning studies and pilot projects in accordance with the terms of reference. In addition, the Committee shall involve the public in the planning process.

7. FINAL REPORT

The comprehensive plan resulting from this Agreement shall be accompanied by a final report including a full benefit-cost analysis of the alternative solutions and recommendations for further courses of actions.

8. GENERAL

(a) British Columbia and Canada shall exchange copies of all reports and related available information from prior and current studies for use in the Program.

(b) This Agreement shall not be construed as to vest in Canada any proprietary interest in projects constructed hereunder.

(c) The Agreement may from time to time be reviewed by the parties hereto and with the approval of the Governor-in-Council and the Lieutenant Governor-in-Council, may be revised.

(d) No Member of the Parliament of Canada or Member of the Legislative Assembly of British Columbia shall hold, enjoy or be admitted to any share or part of any contract, agreement, commission or benefit arising out of this agreement.

(e) The Okanagan Study Committee will submit annual reports to the Consultative Board on its findings as well as a final report on or before the expiration date of this Agreement, and other reports as required by the Board.

(f) The Board may make recommendations to both parties regarding further participation in detailed studies beyond the terms of this Agreement and regarding the implementation of the comprehensive plan.

IN WITNESS WHEREOF the Honourable J.J. Greene, Minister of Energy, Mines and Resources, has hereunto set his hand on behalf of Canada and the Honourable Ray Williston, Minister of Lands, Forests and Water Resources, for the Province of British Columbia.

In the Presence of	Signed on behalf of the Government of Canada
"A.T. Davidson"	"J.J. GREENE" Oct. 29, 1969
In the Presence of	Signed on behalf of the Province of British Columbia
"V. Raudsepp"	"Ray Williston" Oct. 29, 1969

APPENDIX B

FEDERAL-PROVINCIAL TASK FORCE STUDY PROPOSALS (1970)

B.1 Water Quantity Studies

B.2 Limnology Studies

B.3 Water Quality Studies

B.4 Waste Treatment Studies

B.5 Socio-Economic Studies

APPENDIX B

FEDERAL-PROVINCIAL TASK FORCE STUDY PROPOSALS (1970)

INTRODUCTION

At the first meeting of the Study Committee held on February 17, 1970, it was agreed that five Federal-Provincial task forces be established to set out those studies required to assess the resource capability and to determine future demands on this resource, based on the terms of reference of the Agreement. The five fields of study to be considered included hydrology, limnology, water quality, waste treatment, and socio-economics. The members of these task forces are listed in Figure 2.1 of this Supplement. The initial studies proposed by these task forces, and the reasons for their inclusion are presented in sub-sections B.1 to B.5 of this Appendix.

B.1 WATER QUANTITY STUDIES (WATER QUANTITY TASK FORCE)

The studies of water quantity were designed to determine the contribution of each of the major streams to the total annual runoff and the part that groundwater plays in this balance. Moreover, by comparing water supply with water demands, it would also be possible to determine the most efficient management of the water resources under present and future developments.

The Hydrology Task Force identified twenty-three separate tasks in this field of study; six on groundwater and seventeen on surface hydrology. These included: studies on estimating the firm water supply and both consumptive and non-consumptive uses in the lakes, river and streams for present and projected future developments under various constraints; hydrologic computer models to aid in the evaluation and selection of alternative water management and development schemes; the development of management techniques for the operation of the Okanagan mainstem system; and groundwater studies to assess the magnitude and availability of such resources.

B.1.1 Tasks Involving Water Supply and Demand

The majority of the continuous long-term hydrometric data within the Okanagan Basin were confined to the mainstem system. Records in the tributaries were, in general, scattered and incomplete. Since the majority of irrigated lands in the Okanagan are served from systems utilizing tributary streams, one of the main objectives of the Study was to compare the available supply of water in any area with present and projected future water demands in that area. Thus, a number of water quantity tasks were designed to provide firm estimates of water available from the more heavily utilized tributaries. This required a

detailed inventory both of the water management system including all storages, diversions and licences and of the location of the irrigable land served from the tributaries. A similar inventory was to be undertaken for the mainstem system. To achieve these inventories, it was proposed that use be made of the Canada Land Inventory soil classification, soil survey information of the British Columbia Department of Agriculture, and aerial photography and reconnaissance surveys. The resulting areas were to be transferred onto 1:50,000 topographical maps with current water licencing data included. This particular task was subsequently undertaken by the Socio-Economic group along with other consumptive use and land use studies.

An enhanced hydrometric network had been initiated in the summer of 1969 in anticipation of the signing of the Study Agreement. This network was subsequently incorporated into the Hydrology Task Force's recommended monitoring program of eight tributary streams. Factors considered in the selection of these sub-basins included geographic location, hydrological representation, existing hydrometric stations, accessibility, storages, diversions and instrumentation and installation costs. The eight sub-basins were considered to be a representative sample, with the hydrologic information collected to be extrapolated by regionalizing techniques to neighbouring sparsely gauged or ungauged sub-basins. It was felt that the quantitative runoff estimates thus derived would provide an inventory of available water supply in the Okanagan Basin and that the enhanced hydrometric network would result in better water management in the future.

The Hydrology Task Force in their presentation, stated that it had not yet assessed the exact terms of reference for analysis of hydrologic data. As a preliminary step, all data that had been collected and work that had been done in the Okanagan Basin prior to the Study was to be reviewed and assessed. The next step was to consist of reviewing all relevant regionalizing techniques with a view to their applicability in the Okanagan. The next step would involve adapting techniques such as the Grid Square Method and those involving regional frequency curves and then modifying or developing them further if they proved inadequate.

In addition to these hydrometric installations, meteorological installations were considered necessary to provide representative data for precipitation, free water evaporation and evapotranspiration estimates needed for regionalization techniques. These stations were not to be confined to the lower valley sites, but were to provide a cross-section of the elevation range of the Okanagan Basin, with emphasis on those five sub-basins selected for detailed hydrometric coverage.

B.1.2 Water Quantity Models

In assessing the hydrologic regime of a basin, it is often considered adequate to estimate the hydrometeorological and physiographic parameters for major sub-basins or for the area as a whole. These estimates provide figures for such parameters as precipitation, evaporation and runoff. However, where knowledge of the hydrologic regime is required for operational and management planning, additional knowledge of the spatial and temporal abnormalities are required. Therefore, the approach recommended by the Task Force was a form of systems modelling in which both time and space effects of hydrologic distributions are estimated by routing and runoff simulation techniques. In the Okanagan Basin Study such an approach involving many interrelated variables was desirable since the objective was to develop a working plan for the development and management of water resources in the area. The basic mechanism of the model was to be a mathematical simulation of the flow regime which would be defined by flow routing and runoff simulation utilizing optimizing techniques. This approach would be developed on a flexible basis with the basic variable inputs of the model to be of a physical nature. Historical flows would be used to analyze past performance while variable structural controls and different levels of economic development would be fed in, to observe their effects on the system. Present and future operational schemes for flood control and irrigation storage might also be incorporated in the model in a later phase of the Study.

It was envisaged that the final output of the model would consist of regional water yield estimates distributed both in time and space, and hopefully, a model capable of improving inflow forecasting. Initially however, only the first phase of the model concerning water quantity in the mainstem system was to be developed. Outputs were to be in the form of Okanagan Lake levels and discharges in the Okanagan River, to provide a first estimate of firm water supply in the matching of supply and demand for the basin as a whole. Details of the second and third phases of the model were not included at this stage.

B.1.3 Tasks Concerning Groundwater Studies

There was essentially no information on groundwater in the Okanagan Basin at the start of the Study. To provide an understanding of all facets of the hydrologic cycle in the Okanagan Basin, the Hydrology Task Force considered it essential to ascertain the contribution which groundwater made to the total inflow to the Basin and the potential of groundwater aquifers. Previous studies by the British Columbia Water Investigations Branch on the Okanagan-Shuswap Basins included the possibility of a diversion from the Shuswap River near Enderby to the north end of Okanagan Lake for irrigation and domestic purposes. Another initial objective of these groundwater studies, therefore, was to determine if groundwater represented a feasible alternative to surface diversion

should the supply of surface water within the Okanagan Basin be inadequate to meet present and future demands.

The program proposed by the task forces was divided into three main components: a study of groundwater in representative sub-basins; groundwater in the main Okanagan Valley, and groundwater studies initiated prior to the Agreement.

The study of groundwater in selected sub-basins was initially to be limited to surface hydrological reconnaissance investigations, and the interpretation of surface characteristics with regard to groundwater flow. More detailed studies including drilling and well instrumentation would depend on the results of these preliminary investigations.

The study of groundwater in the main valley was to be undertaken in three phases: seismic and geophysical surveys to discover the extent and nature of possible water bearing strata in the main Okanagan Valley; a deep test hole drilling program to obtain logs of the strata in the valley with the location of these test holes to be based on the findings of the seismic program; and instrumentation and testing of both deep and shallow wells to aid in the evaluation of groundwater storage and flow estimates at selected cross sections in the valley.

The purpose of a groundwater program initiated by the British Columbia Water Investigations Branch in 1969, prior to the signing of the Study Agreement, was to study land and agricultural aspects as they affected groundwater quality and water table levels. The third proposal by the task force was for a continuation of data collections from the observation well network set up under this program, and at a later stage of the Study to construct additional observation wells to obtain more detailed information on subsurface geology in these study areas.

B.2 LIMNOLOGY STUDIES (LIMNOLOGY TASK FORCE)

The objective of the program of studies proposed by the Limnology Task Force was to determine the distribution and circulation of nutrients - plant and animal food - and other chemical substances in the major lakes of the Okanagan Basin, in order to understand the process involved in "Lake Eutrophication" or aging, and the measures needed for its control. The program proposed was considered basic in the determination of the present and future ability of the lakes to use or assimilate waste materials without adversely affecting potential uses of the water.

Nine tasks were initially set out which included only those studies considered essential for a minimal understanding of the physical, chemical and

biological processes within the lakes required to effect control of eutrophication and to assist in the development of resource planning and water use in the Basin. These task proposals are summarized under the headings of limnogeological, physical, chemical and biological studies. Some previous limnology studies had been carried out on the main valley lakes, principally those of Clemins, Rawson and McHugh in 1935, and the results of these studies were to be used for comparison purposes to indicate the changes that have occurred over the past 35 years.

B.2.1 Limnogeological

A detailed mapping and sampling program of the bottom sediments of the main valley lakes was proposed by the Limnology Task Force to provide detailed information on the distribution and properties of the lake bottom sediments, and the contribution of nutrients from this source to the lake nutrient budget. Cores would also be taken for diatom analysis to assess major changes in the trophic state during the lakes' histories.

B.2.2 Physical Limnology

Information on the movement of water in the lakes was considered necessary to assess residence times, and the diffusion and circulation of nutrients in the lakes. Because of the cost of this type of program, detailed circulation studies were to be limited to Skaha Lake. Analysis of thermal and conductivity data however, was to be carried out on all the main valley lakes to determine watermass boundaries and to infer gross circulation features and other events such as upwelling, which are significant in the supply of nutrients to algae.

B.2.3 Chemical Limnology

Proposed tasks in this field of study included the determination of the concentrations of the primary nutrients nitrogen and phosphorus, in each of the main valley lakes during spring turnover, and the spatial and temporal distribution of major chemical characteristics significant to the evaluation of the present state of eutrophication.

The first task was to provide a measure of the potential of a lake to produce algae under a variety of growth conditions, and as part of the basic data for the appraisal of past, present and future ecological conditions. These nutrient mass determinations were to be initiated in the spring of 1970 and repeated in the spring of 1971 and 1972.

The second task proposed for 1970 was to obtain a preliminary assessment of the chemical distribution of various elements for the planning of a more comprehensive sampling program in 1971. The results of this and future sampling programs were to be used along with other limnology results to evaluate the present trophic state of each lake.

B.2.4 Biological

The types of dominance of various plant and animal populations and communities living within the lakes as determined from biological studies, provide a good indication of the present trophic state of a lake. Changes that have occurred due to nutrient enrichment may also be determined by comparing the results of such studies with previous biological records. Five of the nine limnology studies proposed by the task force were biological assessments, including algal abundance, nutrient bioassays, benthic, zooplankton and fisheries studies.

Estimates of the abundance and distribution of planktonic algae, and the effect of temperature, conductivity, and light on this abundance and distribution, were required for biological evaluation and to provide an estimate of the magnitude and location of major nutrient sources to each lake. The nutrient bioassay task was designed to identify those nutrients or elements that limit phytoplankton populations to each lake. These studies were also to be used as a basis for estimating algal growth potential given certain projected loadings or concentrations of nutrients in the lakes.

The benthic, zooplankton, and fisheries studies were designed to provide estimates of the species composition and relative abundance of plant and animal populations in each lake. Apparent changes in species composition resulting from eutrophication were also to be evaluated by comparing these data with those of Clemins *et al* obtained in 1935. The inclusion of fisheries as an indices of eutrophication was a relatively new concept. That fish respond to changes in the trophic nature of their environment has long been known, but their position near the top of the food chain often makes them the last and least affected species in the lakes. Characteristics of fish which reflect changes in their environment include the relative abundance of species, their length-frequency distribution, their length-weight relationship, and their growth rate.

Because of public concern over pesticides and heavy metals, particularly mercury, in sport fishes and other sectors of the environment, samples of more important of the sport fish were to be analysed for these constituents. These analyses would provide a measure of the extent of such trace metals and pesticide pollution which would not be detectable by other forms of analysis because of the ability of fish to accumulate such natural and foreign materials from their surrounding environment.

B.3 WATER QUALITY STUDIES (WATER QUALITY TASK FORCE)

The water quality program recommended by the water quality task force was designed to determine present sources and levels of pollution in the Basin,

and devise models that would express nutrient balances and pollution effects. A subsequent program, not detailed at this stage, would assess the extent and range of possible future levels of pollution. This program was also to provide for the chemical analysis of water quality samples collected under other partsof the study plan - i.e. limnology, groundwater, etc.

B.3.1 Sources of Nutrients and Other Pollutants

Six tasks were proposed to determine the input of nutrients and other pollutants to the waters of the basin. These included the monitoring of: thirty-two tributary streams; major industrial and municipal outfalls; municipal storm waters; dust all and precipitation; and groundwater sources. This information was to be used as a measure of the existing level of water quality in the basin, and in conjunction with limnology studies and economic forecasts, to determine probable future levels of pollution. A preliminary assessment of the nutrient loading data from this monitoring program was proposed for early in 1971. This assessment, it was felt, would reveal information useful in the design of detailed studies in the limnology program, and for determining any desirable changes in the water quality data collection program over the remaining monitoring period.

Two associated tasks were concerned with the collection of water samples for bacteriological analysis, and a survey and documentation of pesticide use within the Basin. The main objective of the bacteriological study was to develop meaningful criteria for expressing the coliform count and to determine the relative coliform level at which beaches should be closed to swimming for public health reasons. The inventory of past and present uses of pesticides in the Basin was proposed to assist in evaluating the sources and levels of this type of pollutant

B.3.2 Water Quality Data Bank

Models proposed for the water quality program by the task force included the design of a computer storage and retrieval system for water quality data, the analysis of this data to update the sampling program, and the ongoing operation of this data bank. The correlation of water quantity data to provide estimates of loadings to the main valley lakes from specific sources was also included. While more complex models, which would express the nutrient balances and pollution effects were envisaged, they were not included at this stage of the planning process.

B.3.3 Representative Land Use

To supplement the information on source loadings, the Task Force also recommended that surface waters be monitored to determine the effects on surface water quality of such land uses as general farming, orchards, feed

lots, and forested areas. Specific studies were also recommended for land fill operations, for representative settlements serviced by septic tanks and for irrigation return flows, in order to assess the effect of these on the water quality of the main valley lakes.

B.4 WASTE TREATMENT STUDIES (WASTE TREATMENT TASK FORCE)

Studies recommended by the waste treatment task force included a review and examination of existing waste treatment facilities in North America, the selection of waste treatment experimental programs, an examination of the feasibility and cost of removing effluent from the Basin, and the examination and relocation - if necessary - of waste discharge points to surface waters or to the ground. The results of the experimental plants, in conjunction with data from other research programs and plant operations were to be used to make recommendations for future waste water management in the Okanagan Basin.

B.4.1 Review of Existing Waste Treatment Facilities

This proposal included the documentation and review of existing nutrient removal methods in Canada and the United States for the purpose of comparing the relative performance and cost of selected treatment plants, and of selected ground disposal schemes, in reducing the amount of nutrients being discharged to surface waters. The results of this study were to be used as a basis for the selection of the various waste treatment experimental programs.

It was anticipated that an adequate assessment of existing tertiary treatment and ground disposal facilities on this continent would initially require tours of a number of projects at various locations in Canada and the United States, and might also include follow-up visits during the term of the Agreement. Information gained from these visits along with other reference material was then to be compiled and assessed in summary form for evaluation-selection purposes.

B.4.2 Pilot Studies and Experimental Programs

The Task Force in their submission recognized that two of the three major centers in the Valley had already sought and obtained amendments to the pollution control permits to initiate a nutrient removal program. Therefore, the task force recommended that if these schemes proceeded, it would be more beneficial to carry out research on the effectiveness and methods of operation of these full scale plants rather than setting up pilot plants. A final proposal for this task was deferred pending a report on the review of existing waste treatment facilities, and consultation between Study officials and local authorities.

B.4.3 Removing Waste Waters from the Okanagan Basin

The task force recommended that only a preliminary feasibility study be made on this waste export concept as it appeared unlikely even at this stage of the Study, that this proposal would be adopted.

B.4.4 Location of Discharge Points

The task force felt that terms of reference for this field of study could not proceed until a certain amount of other information had been assembled and evaluated. They did note that some of the problems that have arisen in the past are closely related to the question of connecting industrial discharges to municipal sewer systems, with or without some degree of pre-treatment.

B.5 SOCIO-ECONOMIC STUDIES (SOCIO-ECONOMIC TASK FORCE

These study proposals were designed to: examine the existing relationship between water resources, economic activity and aesthetic values; provide a forecast of the nature of the main economic activities in the Okanagan Basin to the year 2020 to make possible an estimate of future water requirements and waste loadings, as well as of other water related demands such as fisheries and recreation; and evaluate the effects of alternative plans for water resource development and management on the environment of the Basin. These studies would also examine alternative ways of managing and financing the use of water resources in the basin to provide for the future needs of the people.

The proposals of this Task Force were considered by the Study Committee to be the key to the development of a unified comprehensive plan. Goals established by the task force to meet their objectives were as follows:

1. to identify and examine the present economic structure and water use patterns in the basin and to project regional economic growth patterns to the year 2020;
2. to project future patterns of water demand in the basin for various sectors of the economy on the basis of water use trends and projected population and economic growth;
3. to estimate the value of water in alternative uses both now and in the future;
4. to evaluate the social and economic benefits of alternative comprehensive plans for water resource management in the basin;
5. to involve the public in the planning process; and
6. to assess financial and institutional alternatives for more efficient water utilization in the basin.

Seven tasks were subsequently set out by the Socio-Economic Task Force in the areas of economic and social evaluation principles, economics, land use, water use, institutional and financial structures, and public involvement.

B.5.1 Evaluation Principles and Value of Water and Related Resources

The objective of these tasks was to prepare guidelines which would identify criteria and establish procedures required to evaluate the various components of the Study Plan. The first task would outline the principles and procedures of existing evaluation techniques, based on a review of the available literature. The remainder of the tasks would use some of these techniques to calculate the value of water in various uses, for the present and for the future. Both economic and social (intangible) values were to be used in determining the costs and benefits of water for irrigation, domestic and industrial use and for recreational and other activities. The results of this study were to be coordinated with the study of water management opportunities, to enable a number of feasible managerial alternatives to be identified and integrated into a comprehensive plan.

B.5.2 Economic Studies

The Task Force recommended both an economic base study and more detailed economic growth studies for the Basin. The purpose of the economic base study was to provide the foundation from which to make projections of economic and population growth, and in turn to determine future water demands by various users in the Basin. Because the growth of the Okanagan economy is closely interrelated with the economy of the Province as a whole, the Study was also to describe this relationship with the economic relationships among the various sectors within the regional economy.

The economic growth studies were required to project, as accurately as possible, changes in the economic and population characteristics of the basin to the year 2020. Detailed analysis and growth projections were to be conducted for several key sectors of the Study - agriculture, manufacturing, recreation and tourism - because the level of future activity in these sectors would be particularly sensitive to future water quantity and quality conditions. Economic trends in the mining, forestry and recreational industries were also to be assessed, along with population forecasts for a range of economic growth projections. The use of economic models to explain various growth patterns, and to allocate resources among the various sectors of the economy was also envisaged by the Task Force.

B.5.3 Land Use Studies

While the Socio-Economic Task Force did not detail any land use studies in their submission, these were added to provide a base for estimating future

water use in the basin. These added land use surveys were to present a description and catalogue of the total area, relative location, proportion and other significant characteristics of such activities as agriculture, forestry, or any other category of water-utilizing endeavour. This description was also to take into account present land use, indicate areas of apparent change, and relate data to the capability analyses prepared under the Canada Land Inventory. This information would thus permit judgements to be made regarding resource utilization in the Basin.

B.5.4 Water Use Studies

The scope of this task encompassed the determination of present water use patterns in agriculture, industry, municipalities, transportation, fisheries and wildlife and water-oriented recreation; the analysis of past trends and probable future trends in the efficiency of water use; and - using the results of the economic growth studies - to forecast water demands in each of the above water use sectors to the year 2020. These estimated were to be provided on a tributary basis as well as for the Basin as a whole. It was considered essential that these demand data be compatible with hydrologic supply data so that regions which have current or emerging water quantity and quality problems could be identified.

B.5.5 Shoreline Survey and Flood Damage Studies

The purpose of these studies was to evaluate present and future damage that might be caused by extreme fluctuations in Okanagan and Osoyoos Lakes. Potential damage to developed shoreline, including recreational, residential, transportation and commercial uses, would be assessed along with the cost of adjustments to existing structures and intakes to accommodate the anticipated fluctuations in the level of these lakes. This information was required for the evaluation of various water quantity alternatives.

B.5.6 Institutional and Financial Studies

Traditionally, only structural alternatives such as dams, canals, pipelines, etc., have been included in the planning process, but the Okanagan Basin Agreement stated the need to enlarge the range of alternatives to include managerial opportunities for subsequent efficient utilization of water resources. To meet this commitment, the Socio-Economic Task Force recommended a study of the present institutional arrangements involved in water resource management in the Basin.

The Study was to describe the historical development of current legislation and administrative organizations affecting water resource management in the Okanagan; to outline existing organizations having an impact on the use of water; to disclose their powers, duties and financial resources; and

to describe and evaluate the relationships between the different organizations and between them and individuals.

A second phase of this study was to involve the identification of opportunities for modifying existing institutional arrangements to ensure efficient utilization of the water resource in the Basin in the light of emerging water demands.

8.5.7 Public Involvement

At the start of the Study it was agreed that the public involvement program would form an integral part of the socio-economic program. The socio-economic Task Force recognized that public cooperation and support for the Okanagan Basin Study were essential if the comprehensive framework plan was to reflect the wishes of the people in the Okanagan Basin. Unless citizens were informed and understood the Study process, they could not effectively contribute to the development of a comprehensive plan for water resource development and management.

It was therefore envisaged that the first aspect of Public Involvement would be to inform the public of the concepts and principles of the project plan. Public meetings would be held in several centers in the Basin and cooperation of the Okanagan Basin Water Board was considered to be essential to encourage public participation and feedback.

The second aspect of Public Involvement would relate to evaluation studies. The public would be requested to indicate the values they placed on certain intangible benefits such as recreational experience, aesthetic satisfaction and water quality. The yardsticks of evaluation might include willingness to pay, the cost of experiencing a similar level of satisfaction by alternative means, and the cost of tangible opportunities foregone elsewhere in the economy - for example, reduced school or hospital development - in order to pay for enhanced environmental quality.

Public meetings would also be held for the purpose of outlining the present and potential water resource problems that were identified as a result of the first stage of study. The public could be invited to respond to these problems and to engage in a dialogue on the opportunities available for water resource management and development to solve these problems.

APPENDIX C

TASK DESCRIPTIONS

Reprint of description of task assignments as revised and consolidated in preliminary publication dated July 1972, Office of the Study Director, Penticton, B. C., Canada-British Columbia Okanagan Basin Agreement.

C-1 Water Quantity Tasks

C-2 Water Quality Tasks

C-3 Limnology Tasks

C-4 Waste Treatment Studies

C-5 Socio-Economic Studies

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APPENDIX C-1

WATER QUANTITY STUDIES

TASK 21 - SHORELINE SURVEY AND FLOOD DAMAGE STUDIES
(Joint study B.C.W.I.B. and Socio-Economics - Includes former Task 20 - Flood Damage Studies)

OBJECTIVE: To evaluate present and future damage that may be caused by extreme fluctuations in Okanagan and Osoyoos Lakes.

SCOPE: The survey will assess potential damage to several categories of developed shoreline land use including recreational, residential, transportation and commercial uses. For Okanagan Lake the scope of the study will assess damage resulting from lake levels up to two feet above the existing high water operating level (1123.8) and down to three feet below the minimum operating level (1119.8). For Osoyoos Lake, only the consequences of lake levels two feet above the existing high water operating level of 912 feet will be examined as low water levels are controlled by natural topography. Other lakes will not be surveyed as it is not expected that any of the proposed alternatives will affect existing operating levels.

Engineering aspects will include the cost of adjustments to the floating bridge at Kelowna, commercial wharves, and the effect of extreme low water on the intakes around Okanagan Lake.

LINKS: Principles of Evaluation (207) and Water Quantity Alternatives Tasks 23 and 5.

REPORT DATE/S: This task is to be undertaken jointly by the Socio-Economic and Water Quantity Study Groups and the following separate reports will be compiled:

21(a) - Socio-Economic Group - Social and Economic Aspects of the Shoreline Survey. March 31, 1972.

21(b) - Water Quantity Group - Engineering Aspects of the Shoreline Survey. June 30, 1972.

(EDITORS' NOTE: This task was subsequently expanded to assess flood damages on Okanagan and Osoyoos Lakes resulting from the major runoff which occurred in 1972.)

TASK 22 - ENGINEERING INVESTIGATIONS

(Includes Former Tasks - 22: Cost specific alternatives
- 8: Irrigation cost function
- 24: Cost proposed alternatives)

OBJECTIVE and SCOPE: Preliminary results from Evaluation Task 23 have indicated what alternatives require cost estimates. At present, the Water Investigations Branch has completed the first estimates on the cost of improving the Okanagan River to carry sustained flood flows as well as the cost of improvements to the river intakes in order that water may be used more efficiently.

At the same time, the cost of several different diversion schemes from Shuswap River at Enderby has been estimated. These costs were prepared for Task 23 which evaluation was carried out in 1971.

Because of the favourable benefit-cost ratio of all schemes with respect to improvements to the Okanagan River system, it is evident that the final design of this should be completed as soon as possible.

REPORT/S:
(1) General Irrigation Cost - B.C.W.I.B. - 1 March 1972.
(2) Final Report on Costs of Okanagan River Diversions - Consultant - 30 August 1972.
(3) Final Report on Cost of Diversion - Consultant - 30 August 1972.

TASK 29 - DEVELOPMENT OF FORECASTING MODEL

(Includes Former Tasks: 26 - Completion Phase III of Computer Model
29 - Phase III Model Parameters)

OBJECTIVE: To develop and model hydrologic parameters such as precipitation (including snow accumulation) and temperature which can be used as a basis for forecasting runoff into Okanagan Lake.

SCOPE: The development of a good forecast procedure for Okanagan Lake has been part of a continuing study carried out by the Water Investigations Branch over the last 20 years.

The development of a Water Quantity model under Task 23 deals with the use of 50 years of historic data and the manipulation of these flows to meet the needs of the present and future developments.

However, this model in itself is of no use in forecasting freshet inflow which is needed if improved operations are to be effected. Some preliminary work has been done in the development of this model by the University of British Columbia using such parameters as snow survey data, temperature, precipitation, etc. It is hoped that the model will provide weekly forecasts of inflow from various tributaries.

REPORT/S:

(1) Interim Report on Forecasting Water Quantity Model, Department of Civil Engineering, University of British Columbia - 30 October 1972.

(2) Final Report on Forecasting Water Quantity Model, Department of Civil Engineering, University of British Columbia - 31 March 1973.

TASK 34 - WATER QUANTITY COMPUTER MODEL - MAIN STEM

(Includes Former Tasks: 31 - Phase II Parameters
28 - Develop Model Capability
34 - Phase II Computer Model
6 - Model Operation
33 - Development of Phase I Computer Model)

OBJECTIVES: To develop a water quantity model of the main lake and river system and operate this using records from the study period 1920-1971, under varying conditions.

SCOPE:

(a) Main stem model for operational purposes developed by the Water Investigations Branch and expanded by the Department of Civil Engineering, University of British Columbia, under present and future development.

(b) Parallel study to (a) to include new (1971) Department of Fishery proposed flows on Okanagan River and additional Department of Indian Affairs future water requirements.

Due to the number of alternatives introduced under Task 23 and time limitations, University of British Columbia took over the main stem model planning development while Water Investigations Branch retained the development of the best operation plan for the main lake system.

REPORT/S: Initial report on main stem under present growth projection and 1969 fishery flows - completed as assignment to Task 23 by University of British Columbia.

Final Report on main stem under alternative growth projections (includes Indian Lands) and 1971 fishery flows - August 31, 1972, by University of British Columbia.

TASK 35 - MATCHING OF SUPPLY AND DEMAND IN SELECTED TRIBUTARIES UNDER PRESENT AND FUTURE DEVELOPMENTS

(Includes former Task 45 - Sub-basin Runoff and Consumptive Use)

OBJECTIVE: To compare the firm water supply available in selected tributaries with present and future requirements in order to define "water surplus" and "water deficit" areas.

SCOPE: This task will involve analysis of shortages of available water in various tributaries within the basin in light of present and projected water demands. A number of suggested alternatives to meet these shortages should result from this study.

Matching of supply and demand will be undertaken by the Water Investigations Branch, while Socio-Economic studies will provide projections of future population and irrigated land according to enumeration areas. These areas will have to be combined or split according to the particular drainage basin under study.

In order to limit work to critical areas and critical periods, it is proposed that only those streams where heavy water use is occurring be studied for drought, average, and flood years as follows:

(1) Mission Creek
(2) Vernon Creek (including Coldstream)
(3) Trout Creek
(4) Peachland Creek
(5) Kelowna Creek
(6) Penticton Creek
(7) Powers Creek
(8) Equesis Creek
(9) Deep Creek
(10) BX Creek

LINKS: This task requires input from Task 54 and Task 36 and will require Committee considerations before proceeding to Task 5.

REPORTS: (1) Matching of Present Demands in Selected Tributaries with Supplies - Water Investigations Branch - July 31, 1972.

(2) Matching Future Demands in Selected Tributaries with Supplies - Water Investigations Branch - December 31, 1972.

TASK 36 - TRIBUTARY WATER SUPPLY STUDIES FOR PERIOD 1920 to 1971

(Includes Former Tasks: 60 - Virgin Flows by Tributaries
36 - Estimates to Firm Water Supply
12 - Evaluation and Supply)

OBJECTIVE: To develop a set of hydrometric records of the natural flows of all Okanagan Basin tributaries for the period 1920 to 1971 at a number of points in each stream.

To determine the firm water supply available in selected tributaries.

SCOPE: To develop the natural flows for a drought, average and wet year at key locations on all tributaries for the study period 1920-1971.

Such data would provide a breakdown of the natural inflow into Okanagan Lake and River and tabulate the information for future reference.

If time permitted, it would be desirable to carry out a statistical analysis of "Supply and Demand" for the whole study period, although such work is not anticipated in this Task.

REPORTS: Estimated Tributary Discharges in the Okanagan Basin for the period 1920 - 1971 -- Water Investigations Branch - February 28, 1973.

TASK 38 - SELECTED SUB-BASIN HYDRO-GEOLOGIC SURFACE INVESTIGATION

OBJECTIVE: To determine as much as possible about selected sub-basin groundwater flows on the basis of a surface hydro-geology study.

SCOPE: A hydro-geologic crew will map significant surface characteristics of selected sub-basins (springs, soils, geologic outcrops and formation, etc.) and will interpret these characteristics with regard to groundwater flow.

REPORT: 31 March, 1971.

TASK 39 - SEISMIC EXPLORATION OF GROUNDWATER RESOURCES

OBJECTIVE: To discover the extent and nature of possible water-bearing strata in the main Okanagan Valley.

SCOPE: Initially seismic data will be gathered across the Valley where well logs exist. Depending on the significance of the seismic data, several other cross-sections may be explored. Rights-of-way will be negotiated.

LINKS: An exploratory drilling program will commence depending on the seismic data obtained.

REPORT: 31 December 1970.

TASK 40 - GROUNDWATER RESOURCE EXPLORATION; MAIN VALLEY DEEP ROTARY TEST HOLES

OBJECTIVE: To obtain logs of the strata in the Okanagan Valley.

SCOPE: Several holes will be drilled, cored and logged under the direction of B.C. Water Investigations Branch personnel.

LINKS: Based on this information, piezometer wells will be installed and pump tests undertaken in the progressive exploration of groundwater resources.

REPORT: October 31, 1972.

TASK 41 - INSTRUMENTATION AND TESTING OF DEEP WELLS

OBJECTIVE: To obtain a preliminary evaluation of the transmissibility, well yields, and recharge rates of the aquifers in the region of the deep wells drilled in 1971.

SCOPE: The task consists of cleaning, development, test pumping and instrumentation of test holes drilled under Task 40. Basic data will also be collected on water temperature and the quality of the well water. The completed test wells will be retained for long term observation purposes.

REPORT: April 30, 1972.

TASK 43 - INSTALLATION OF SUB-BASIN SURFACE HYDROLOGY GAUGING NETWORK

OBJECTIVE: To instrument several characteristic sub-basins in order to reconstruct virgin flow parameters.

SCOPE: Gauging stations will be installed in several selected sub-basins.

LINKS: The resulting interpretation of the virgin sub-basin inflows are required to develop the water quantity computer models.

REPORT: October, 1971.

(Editors Note: This task was not carried out based on review of groundwater studies in early 1972.)

TASK 44 - INSTALLATION OF HIGH-ELEVATION METEOROLOGICAL NETWORK

OBJECTIVE: To install a regional meteorological network in order to correlate virgin stream discharges with meteorological data.

SCOPE: Several meteorological stations are to be installed.

LINKS: The resulting interpretation of the virgin sub-basin inflows are required to develop the water quantity computer models.

REPORTS: October 1, 1971

TASK 47 - GROUNDWATER EVALUATION

OBJECTIVE: To determine order of magnitude figures of the extent, yield, and recharge rates of groundwater aquifers, and the source of the recharge water to these aquifers, particularly in the North Okanagan.

SCOPE: The evaluation will, as far as basic data permits, include order of magnitude figures for the following items:

1. Location and size of aquifers in study area.
2. Geographic sources and destinations of groundwater.
3. Annual yields, recharge rates and depth in relation to mean sea level.
4. Quality of groundwater.
5. Cost of groundwater at surface per acre foot per 100 feet of lift.

6. Limits of accuracy.

REPORTS: 1. Groundwater Review Board Report - September, 1971.
2. Final Report - August 31, 1972.

TASK 52 - OPERATION OF STREAM-GAUGING AND METEOROLOGICAL NETWORK

OBJECTIVE: To collect and process data from meteorological and stream-gauging stations.

SCOPE: A field staff will collect pertinent stage-flow measurement data from the installed stream gauges and pertinent data from the meteorological stations. Office staff will estimate flows and meteorological parameters.

LINKS: The resulting interpretation of the virgin sub-basin inflows are required to develop the water quantity computer models.

REPORTS: The first of continuing reports is due by 1 February 1971.

TASK 53 - MAIN STEM AND SUB-BASIN HYDROLOGY

OBJECTIVE AND SCOPE: Task 48, entitled "Preliminary Analysis of Hydro Regime of All Sub-Basins" covers the determination of the significant hydrological and meteorological parameters over the various sub-basins required to arrive at virgin runoff.

Task 53, dealing with the regionalization of all sub-basin hydrology, will attempt to integrate the information from Task 48 through multiple regression studies. Next year, it is planned to refine these studies through the regionalization of selected sub-basins, under Task 49.

In addition to installation of additional hydrometric stations in the Okanagan, the Atmospheric Environment Service has undertaken to carry out some basic studies including the following:

1. Monthly evaporation estimates for the main valley lakes, including Wood, Kalamalka, Okanagan, Skaha and Osoyoos.
2. Monthly precipitation, free water evaporation and evapotranspiration for the years 1971 and 1972 on a grid-square basis.

From the above, it is hoped to establish potential evapotranspiration versus elevation for the northern, central and southern portions of the valley.

These tasks are those undertaken jointly by the Water Investigations Branch, assisted by Dr. Danard, Consulting Hydrologist, and the Atmospheric Environment Service.

REPORTS:

1. Preliminary Report on Grid Square (Task 48) - B.C.W.I.B. - 31 December 1971.
2. Preliminary Report on Potential Evaporation versus Elevation (Task 48) - A.E.S. (Ferguson) - 31 December 1971.
3. Preliminary Report on Regionalization of All Sub-Basins (Task 53) - B.C.W.I.B. (Obedkoff) - 28 February, 1972.
4. Preliminary Report on Lake Evaporation (Task 48) - A.E.S. (Ferguson) - 31 December 1971.
5. Preliminary Report on Distribution of Monthly Precipitation, Free Water Evaporation and Evapotranspiration - A.E.S. (Ferguson) - 31 March, 1972.
6. Final Report on Grid Square (Task 48)- B.C.W.I.B. (Obedkoff) 30 September 1972.
7. Final Report on Lake Evaporation - A.E.S. (Ferguson) 31 December 1972.
8. Final Report on Distribution of Monthly Precipitation, Free Water Evaporation and Evapotranspiration - A.E.S. (Ferguson) - 31 December 1972.
9. Composite Report - T.A.J. Leach - 31 March, 1973.

TASK 180 - EVALUATION OF WATERSHED DEFORESTATION AND HARVESTING PRACTICES

OBJECTIVE: To provide a preliminary appraisal of the Okanagan Basin Watershed in terms of cover and characteristics by major biophysical zones; and to outline the effects of timber harvesting on water quantity and water quality within these zones.

SCOPE:

(i) Using existing data supplemented by some field reconnaissance, characterize selected watersheds into major biophysical zones and tabulate, by zone, the present and future harvesting rates. Also tabulated would be present and future cover changes in forested range.

(ii) To provide a preliminary evaluation of the effects of timber harvesting on water quantity and quality by zone. Limitations to harvesting rates imposed by sustained yield will necessarily be incorporated insofar as assigning significant effects (10%) water quantity and quality to the various zones.

(iii) To indicate zones in which forest harvesting might incite major problems of erosion and nutrient leaching as a consequence of roads and/or harvesting technique. Also, the recommendation of special harvesting practices for certain zones.

REPORTS: March 31, 1972.

APPENDIX C-2

WATER QUALITY STUDIES

TASK 102 - EVALUATE OKANAGAN BASIN WATER QUALITY - PRESENT AND FUTURE

OBJECTIVE: To provide an assessment of the water quality of individual streams and lakes under present conditions, and to evaluate the probable condition under future loadings as determined from Task 103.

SCOPE:

(a) Evaluate present stream and lake water quality and assess if this quality is compatable with existing water use -- i.e. irrigation, fisheries, domestic, recreation, etc. The following streams will be given priority over other streams for this task:

1. Trout Creek
2. Mission Creek
3. Peachland Creek
4. Kelowna (Mill) Creek
5. Penticton Creek
6. Powers Creek
7. Equesis Creek
8. Deep Creek
9. BX Creek
10. Shorts Creek
11. Vaseux Creek
12. Ellis Creek
13. Brandts Creek
14. Lambly Creek
15. Inkaneep Creek

(b) Evaluate present effects of specific land use activities in the Okanagan Basin on stream water quality.

(c) Given future loadings as determined under Task 103, evaluate future stream and lake quality and assess if this will be compatable with proposed future water use.

(d) Identify water quality problems existing in specific streams under both present and future loading conditions, and present alternatives that may be implemented to improve the quality of any such streams.

(EDITOR'S NOTE: Due to limitations in ability to predict the location of future economic development in the basin, particularly in such small areas as tributaries, it was not possible to evaluate future tributary water quality, as described in 'Scope, Parts c and d.)

LINKS: Input to Task 18, Fish Production Under Varying Conditions, and Task 101, Comprehensive Plan.

REPORTS:
(1) Preliminary Report - Present Okanagan Basin Water Quality - May 31, 1972.
(2) Final Report - Present Okanagan Basin Water Quality - September 15, 1972.
(3) Preliminary Report - Future Okanagan Basin Water Quality - September 30, 1972.
(4) Final Report - Future Okanagan Basin Water Quality - December 31, 1972.

TASK 103 - ESTIMATE FUTURE LOADINGS FOR NUTRIENTS AND OTHER PARAMETERS TO THE OKANAGAN LAKE SYSTEM

OBJECTIVE: To obtain an estimate of future loadings for nutrients and other parameters to each of the main valley Okanagan lakes.

SCOPE: From economic and land use studies, and based on predetermined population growth and commercial and/or industrial growth to the year 2020, estimate the total amount of nutrients and other parameters of interest to be generated to each of the main valley Okanagan lakes.

LINK: Task 141 (1971); 113 (1971)

REPORTS:
(1) Preliminary Report - August 31, 1972.
(2) Final Report - November 30, 1972.

TASK 105 - ESTIMATE PRESENT LOADINGS FOR NUTRIENTS AND OTHER PARAMETERS TO THE OKANAGAN LAKE SYSTEM

OBJECTIVE: To provide an estimate of total present loadings for nutrients and other parameters to each of the main valley Okanagan lakes.

SCOPE: This task will combine the outputs of the following tasks with water quantity data, to provide loading levels of nutrients and other measured parameters, to each of the main valley Okanagan lakes.

1. Task 130 - Outfall Discharge Study
2. Task 131 - Stream Quality Study
3. Task 133 - Storm Sewer Discharge Study
4. Task 134 - Dustfall and Precipitation Study
5. Task 139 - Groundwater Nutrient Inputs

The resulting estimates will be presented in tabular form for each of the major lakes: namely, Wood, Kalamalka, Okanagan, Skaha, Vaseux and Osoyoos. Where data is scarce, library research may be used to provide order of magnitude figures, particularly for the preliminary reports.

REPORTS: (1) Preliminary Report, Total Loadings of Nutrients from All Sources to Main Lakes - (i.e. Null or Present Loading Levels) - May 15, 1972.

(2) Final Report, Total Loading of Nutrients and Other Measured Parameters from all Sources to Main Valley lakes - November 30, 1972.

TASK 126 - PESTICIDE USE STUDY

OBJECTIVE: To make a survey and documentation of pesticide use within the Okanagan Basin.

SCOPE: All private and governmental agencies will be canvassed to obtain qualitative and quantitative information on the pesticides used (past and present). The literature will be searched and historical data (detrimental effects, etc.) will be documented and presented in a report.

LINKS: This study will furnish useful information in evaluating stream and lake ecology.

REPORTS: Final report May 31, 1972.

TASK 128 - DESIGN WATER QUALITY DATA STORAGE AND RETRIEVAL SYSTEM

OBJECTIVE: To design a computer storage and retrieval system for the water quality program.

SCOPE: British Columbia Research Council has submitted a brief to British Columbia Pollution Control Branch to meet the above objective. This agency would punch cards, store data on tape and carry out elementary statistical analysis (means and standard deviations).

LINKS: Following this analysis B.C.P.C.B. will make decisions on the updating of the sampling network.

REPORT: July 15, 1970.

TASK 129 - ANALYSE OUTPUT FROM TASK 128

OBJECTIVE: To develop an updated sampling program based on preliminary analysis of data collected during the pre-agreement period.

SCOPE: The means, standard deviations and raw data from sampling points will be reviewed and decisions taken on each sampling point in the current program.

LINKS: These decisions depend upon the systematic documentation of existing data (Task 128). The outcome of data analysis will affect design of the program for Primary Nutrient Mass (117b) Algal Abundance (118a) and Present Loadings (105).

REPORT: August 15, 1970.

TASK 130 - OUTFALL DISCHARGE STUDY

OBJECTIVE: To determine the input of nutrients and other parameters to receiving waters from positive waste discharges.

SCOPE: This task involves collection and analysis of water samples from all significant positive discharges from municipal, sanitary and industrial sources.

LINKS: This information will contribute to the estimation of total nutrient inputs (Task 105) for use in limnological evaluations.

REPORT: Final Report - July 30, 1972.

TASK 131 - STREAM QUALITY STUDY

OBJECTIVE: To determine input of nutrients and other parameters to the lake system from tributary streams.

SCOPE: This task involves collection and analysis of water samples from tributary streams.

LINKS: This information will contribute to the estimation of total nutrient inputs (Task 105) for use in limnological evaluations.

REPORTS: Final Report - June 30, 1972.

TASK 133 - STORM SEWER DISCHARGE STUDY

OBJECTIVE: To determine the input of nutrients and other parameters to receiving waters derived from storm water sources.

SCOPE: This task involves the collection and analysis of storm water samples, with estimation of quantity inputs to receiving waters from representative residential and commercial acres within the three major municipalities.

LINKS: This information will be extrapolated to estimate nutrient and chemical inputs from stormwater sources throughout the Basin.

REPORT: Final Report - August 31, 1972.

TASK 134 - DUSTFALL AND PRECIPITATION STUDY

OBJECTIVE: To determine the contribution of the nutrients and chemicals to the main valley lakes due to dustfall and precipitation.

SCOPE: Dustfall and precipitation measurements will be taken at key stations located adjacent to the main valley lakes. The first year will involve consultation with meteorological officials and establishment of the station network.

LINKS: Information from this task will provide input to the estimation of total nutrient loadings to each of the main valley lakes (Task 105).

REPORTS: Final Report - August 31, 1972.

TASK 135 - BACTERIOLOGICAL STUDY

OBJECTIVE: To develop meaningful criteria for expressing the coliform count.

SCOPE: Data collected previously will be evaluated in order to update the ongoing program of the B.C. Health Branch. In addition to determining the best sampling techniques, minimum number of samples required, and the frequency of sampling for coliforms, an evaluation of the significance of the fecal vs. total coliform tests and their relation to pathogenic organisms is to be undertaken.

LINKS: This study will provide input to the selection of water quality alternatives and subsequent evaluation of water quality effects on water-based recreation.

REPORT: Final Report - May 15, 1972.

TASK 139 - GROUNDWATER NUTRIENT INPUT STUDY

OBJECTIVE: To estimate groundwater contribution of agriculture return flow, septic tanks and sanitary landfills, to nutrient gain in receiving waters.

SCOPE: Pilot plant studies, complemented by literature research and some field work will be carried out for septic tanks and sanitary landfills to provide an estimate of nutrient contributions from these sources. A more general approach will be taken for estimating nutrient contributions from agriculture based land use concepts. The source systems will be defined and modelled.

LINKS: Information from this task will provide input to the estimation of total nutrient loadings to each of the main valley lakes (Task 105).

REPORTS: Preliminary Report - April 30, 1972.
Final Report - August 31, 1972.

APPENDIX C-3

LIMNOLOGY

(Including freshwater Fisheries)

TASK 18 - IMPLICATIONS FOR FISHERY POTENTIALS AND FISHERY OPPORTUNITIES OF SELECTED WATER-MANAGEMENT ALTERNATIVES

(Abbreviated title: Fishery implications of water management alternatives)

OBJECTIVE: To predict, in both qualitative and quantitative terms, future potentials and opportunities for fisheries on the basis of specific selected water management (quality and/or quantity) alternatives.

DETAIL: This assessment will encompass the main valley lakes, the headwater lakes, selected tributary streams and the Okanagan River.

Attention will be given to all available fish species which appear to manifest fishery potential, either now or in the future. Both sport and commercial fishing opportunities will be evaluated.

To accomplish these objectives, present fishery utilization will first be compared with existing fish stocks, and with existing factors contributing to the limitation or enhancement of these stocks and/or their present utilization. Future fishery potentials and opportunities will be predicted on the basis of the present situation, in conjunction with such new environmental constraints as may be expected under selected water-management alternatives. The impact of such imposed constraints on fish populations will be estimated mainly by internal comparison of present situations within the Okanagan and by reference to exploited lakes of known characteristics in other locations.

It will generally be possible to assess fishery potentials only in rather broad terms and with rather wide limits.

INPUTS:

1. All main valley limnology tasks:
2. Task 66:
   - A. Stream survey
   - B. Headwaters limnology
   - C. Creel census
   - D. Fishery potentials

3. Task 161: Lake utilization census.

4. Task 115, with all its extensions:

   (a) Fish age and growth analysis
   (b) Kokanee reproduction

REPORTS:

1. Evaluation of mainstem operating alternatives -

   Preliminary: completed
   Final: 31 October, 1972.

2. Preliminary Report, Task 18 - 31 October, 1972.

3. Final Report, Task 18 - 31 December, 1972.

TASK 66

This is a composite of five discrete tasks for which no meaningful overall title or description is possible. These five task components are accordingly outlined separately as follows:

TASK 66A - STREAM HABITAT SURVEY

OBJECTIVE: To assess, in qualitative and quantitative terms, the habitat potential of Okanagan tributary streams, particularly as regards reproductive opportunities for salmonid fish species from the main valley lakes.

DETAIL: Over 30 streams with sufficient virgin flows to support spawning runs of Rainbow trout and/or kokanee are tributary to the Okanagan main valley lakes. Fish habitats in these streams will be/have been examined. Natural constraints regarding reproductive opportunities will be identified and assessed.

Impacts of human activities on these stream habitats will be/have been identified, quantified and assessed.

Opportunities for maintaining or enhancing fish habitat potentials will be identified. Where practicable, structural works which may be desirable will be subjected to preliminary costing.

INPUTS:

1. Stream habitat survey: B.C. Fish and Wildlife Report.
2. Task 66B: Headwaters limnology.

3. Task 66C: Creel census.
4. Task 115b: Survey of stream-spawning kokanee

REPORTS:
1. Abstract of stream habitat survey: Completed.
2. Trout Creek Pilot Study: fishery implications: Completed.
3. Water and structural requirements for fisheries in selected tributaries: September 30, 1972.

TASK 66B - LIMNOLOGY OF HEADWATER LAKES

OBJECTIVE: To obtain an appreciation and understanding of the major factors involved in the productivity and utilization of the headwater lakes for sport fishing.

DETAIL: Over 100 headwater lakes in the Okanagan Basin support game fish stocks. These lakes lie in a broad range of altitudes, are of varying dimensions, and have a wide range of dissolved nutrient contents. Many of them serve as storage reservoirs. Several of these lakes, displaying a broad range of characteristics, will be selected for detailed examination of the contribution and operation of the various factors in fish production.

This study will provide a basis for estimating the present potential of these lakes to produce fish. It will also permit, by means of internal comparison, some prediction of impacts on fisheries of possible water management alternatives in these lakes or in new reservoirs which may be developed (Task 18).

INPUTS: Task 66C: Creel census.

REPORT: 30 April, 1972 (Final).

TASK 66C - CREEL CENSUS

OBJECTIVE: To quantify the sport-fish harvest from the various components of the Okanagan system in terms of:

(a) Total catch
(b) Catch per unit effort
(c) Species Composition
(d) Seasonal characteristics
(e) Size and/or age composition

DETAIL: All the main valley lakes, over 100 headwater lakes, the Okanagan River and certain tributary streams provide sport fishing. The angling catch in these waters (or in representative components) will be determined over a 1-year period.

The sport-fish harvest will be related to standing stock indices and to other parameters of limnological productivity. This will allow an assessment of present fishery potentials and also (by internal comparisons) predictions of future potentials and opportunities.

INPUTS:
1. Task 161: Lake utilization census
2. Task 66B: Headwater limnology
3. All main valley limnology tasks, especially Task 115.

REPORT: September 30, 1972.

TASK 66D - FISHERY POTENTIALS IN THE OKANAGAN

OBJECTIVE: To prepare a statement of the fishery resource and fishery potentials under present conditions of water quantity and water quality, with a broad assessment of the implications of certain general water-management alternatives.

DETAIL: This task will amalgamate data on fish stocks, limnological characteristics, factors controlling fish production, and fishery utilization in all components of the Okanagan system.

The general effects of broad water management alternatives will be predicted from this basis.

The final task report will be essentially a draft of Appendix IX to the Main Report.

INPUTS:
1. Task 66:
   - A. Stream survey
   - B. Headwaters limnology
   - C. Creel census
2. All mainstem limnology tasks.
3. Task 115, with all its extensions:
   - (a) Fish age and growth analysis
   - (b) Kokanee reproduction

REPORTS: 1. Task 66D, Final: September 30, 1972.

2. Appendix IX: December 31, 1972.

TASK 66E - KOKANEE SHORE-SPAWNING STUDIES

OBJECTIVE: To determine the effect of lake level fluctuations on the reproductive success of shore-spawning kokanee.

SCOPE:

(1) Locate kokanee shore spawning sites.
   (a) in Okanagan Lake
   (b) in other mainstem lakes if practical

(2) Categorize shore-spawning sites according to
   (a) substrate, gradient
   (b) exposure
   (c) location, etc.

(3) Estimate the depth distribution of deposited eggs, at representative sites via transects.

(4) Sample deposited eggs during incubation for survival.

(5) Evaluate the depth distribution of kokanee eggs, terms of anticipated lake level fluctuations for particular mainstem operating alternatives.

REPORTS: Interim - 15 December, 1972.
Final - 30 April, 1973.

TASK 104A - LIMNOLOGY OF THE OKANAGAN LAKES-THEIR PRESENT STATUS

OBJECTIVE: Synthesis of all available inputs for an overall statement of the current ecology and trophic state of the five major lakes.

SCOPE:

(1) Evaluate present ecological state of each lake on the basis of tasks 115 to 123. Review historical material pertaining to earlier ecological condition with a view to deducing the mechanisms of any changes observed.

(2) Identify critical and limiting factors in the ecology and productivity of the lakes, etc.

- physical, geological, climatic, etc.
- nutrients
- pollutants
- other cultural disturbances
- food chains

(3) Estimate the capacities of the lakes to assimilate wastes under present conditions.

REPORTS: No preliminary report.
Final Report - August 1, 1972.

TASK 104B - LIMNOLOGY OF THE OKANAGAN LAKES - THEIR FUTURE STATE

OBJECTIVE: Synthesis of present information on the ecology of each lake (Task 104A)with a view to deducing future conditions given a variety of projected industrial developments and population densities.

SCOPE: Evaluate the impact of future industrial and municipal waste loadings on the ecology of the lakes. Specifically, the effects on fisheries, water quality and the occurrence of algal blooms. Estimate the capacity of each lake to absorb (assimilate) future waste loadings.

Identify future critical and limiting factors that will affect the future ecology and productivity of the lakes.

REPORTS: No Preliminary Report
Final Report - December 31, 1972.

TASK 115 - FISHERIES SURVEY OF OKANAGAN MAIN VALLEY LAKES - RESIDUE AND METAL ANALYSES - OKANAGAN FISHERIES

OBJECTIVE AND SCOPE: To determine the growth rate and relative abundance of all major sport fish in the five major lakes, with data to be related to the trophic state of each lake. To analyze the concentration of chlorinated hydro carbons, heavy metals and, where appropriate, fungicides and herbicides in fish muscle. Samples will be taken from a spectrum of age and size classes.

LINKS: Results to be used in overall assessment of eutrophication and pollution in the Okanagan main valley lakes.

REPORTS: June 30, 1972.

TASK 117 - CHEMICAL LIMNOLOGY AND NUTRIENT LOADING STUDY

(Includes former Tasks 117 and 124)

OBJECTIVE: To estimate the total nutrient mass intake in Okanagan main valley lakes and to determine the spatial and temporal distribution of major chemical constituents.

SCOPE: Nutrient mass data is required to appraise the potential of lakes to produce algae under a variety of growth conditions. It serves also as part of the basic data for the appraisal of past, present and future lake ecological conditions. The distribution of the major chemical constituents is also required for the evaluation of the lake's present trophic state.

REPORTS: Interim - March 31, 1972.
Final - June 15, 1972.

TASK 118 - LAKE MONITOR STUDY

OBJECTIVE AND SCOPE: To estimate the annual variation of temperature, conductivity and light penetration in the lake, from which a determination of the biological, chemical and physical characteristics of the lakes can be made. This description of the present state of the lakes will serve as a baseline from which judgements can be made about the effects of man's activities.

LINKS: Nutrient input estimation; clues as to the discharge of nutrients may become evident from this task. Also the design of the sample collection phase of this task may be enhanced by some estimates of the magnitude and location of major inputs. The chemical limnology task report may also enhance the data collection design.

REPORTS: Equipment will be tested in the first year. A report on this and initial design of the data collection program for 1971-72 will be made by 15 November, 1970 (complete).

Final Report - March 31, 1972.

TASK 119 - NUTRIENT BIOASSAY

OBJECTIVE AND SCOPE: To identify, if possible, what specific nutrients or trace elements are limiting phytoplankton populations in all lakes. These studies will be used as a basis for estimating algae growth given certain projected concentrations of nutrients in the lakes.

LINKS: Estimates of nutrient input to the lakes (water quality) would enhance the data collection phase; also the nutrient bio assay results may be used to update the nutrient input data collection program. The waste treatment nutrient removal studies will be enhanced by knowing the fate of nutrients; also the optimum waste discharge location study will require this information. The algal abundance and primary nutrient mass studies require information from the nutrient bioassay, and continuing nutrient bioassay studies require information from both the algal abundance and primary nutrient mass studies.

REPORT: Final Report - March 31, 1972 (complete).

TASK 120 - PHYSICAL LIMNOLOGY STUDY

OBJECTIVE AND SCOPE: To assess the diffusion and circulation of nutrients which are of direct importance to the biological communities within the lakes. The studies will comprise:

(a) an analysis of all temperature and conductivity measurements in order to interpret the diffusion and circulation within all lakes, and

(b) drogue tracking and dye diffusion measurements within Skaha Lake to ascertain the fate of nutrient input via the Okanagan River.

LINKS: Results of this task will be assessed for the interpretation of algal abundance distribution.

It will also assist in the selection of optimum waste discharge locations.

REPORTS: A report on the design of the 1971-72 data collection program will be available by 15 November, 1970 (complete).

Final Report - May 31, 1972.

TASK 121 - GEOLOGICAL STUDIES

OBJECTIVE AND SCOPE: To determine the characteristics of sediments in all main valley lakes. Studies to include organic and inorganic chemical analyses, particle-size fractionation and other pertinent physical and chemical features. Sediment cores from selected lakes will be examined for microfossils to deduce lake history or rate of change of water quality. Bathymetric mapping and broad consideration of superficial geology will be included.

LINKS: This study will contribute knowledge regarding the fate of nutrients in the lakes and will also assist in providing valuable background information on the rate of lake aging.

REPORTS: Paleolimnology Report - March 31, 1972 (complete).

Main Geological Report - April 30, 1972.

TASK 122 - BENTHIC STUDIES

OBJECTIVE: To determine the distribution and abundance of phytobenthos (bottom living plants) and zoobenthos (bottom living animals) in the main valley lakes.

SCOPE: The phytobenthos studies will include an estimate of periphyton growth rates in the five main valley lakes. A detailed copy of the distribution and relative abundance of aquatic plants in the littoral zone will be included.

Zoobenthos studies will include an enumeration of species and a tabulation of their relative abundance in both clean and polluted stations. Inter-lake comparisons will be drawn on the basis of abundance and species composition. Both the studies will permit variation of the present trophic state of each lake.

LINKS: Results will be used in the assessment of lake eutrophication and will provide important supportive data for the compilation of Task 104A.

REPORTS: Zoobenthos Studies - Final - April 15, 1972 (complete).

Phytobenthos Studies - Final - March 31, 1972 (complete).

TASK 123 - ZOOPLANKTON

OBJECTIVE AND SCOPE: To determine the species composition and relative abundance of Zooplankton in the main valley lakes. These data will be used to assess the present trophic state of each lake.

LINKS: Results to be used in compilation of Task 104A and in Task 66.

REPORT: Final Report - April 30, 1972.

APPENDIX C-4

WASTE TREATMENT STUDIES

TASK 112 EVALUATE WASTE WATER MANAGEMENT ALTERNATIVES

OBJECTIVE: To assess the feasibility and costs of alternative means or concepts for treating and disposing of municipal and industrial wastewater discharges within specific areas of the Okanagan Basin.

SCOPE: This study will include a critical assessment of waste management for the entire basin. It is intended to outline the degree of treatment required to meet environmental requirements for disposal of all wastes to the land or water within the Okanagan Basin and will include an evaluation of the concept of exporting wastewaters from the Okanagan Basin.

LINKS: Input to this task will be provided by Tasks 11, 15, 105, 135, 142 (a) and 142 (b), 138, 139, 106, 147, 202.

REPORTS: Preliminary Report - August 15, 1972.

Final Report - December 31, 1972.

TASK 141 ASSESS AND OPTIMIZE WASTE DISCHARGE LOCATIONS

(Formerly Tasks 148 and 141)

OBJECTIVE: To assess and determine those areas within the Okanagan Basin which have sufficient assimilative capacity to accept existing and future treated wastewaters from municipal and industrial sources.

SCOPE: This study involves a review of existing discharges (Quality and Quantity) and receiving water capacities to determine the suitability of such discharges and to investigate the feasibility of relocating any unsuitable discharges to optimum locations. The locations of future discharge points to land and water will also be assessed under this task.

LINKS: The results of Tasks 130, 131, 105, 124, 117, 119, 202, 206 and 205 will provide background information and data to this study.

REPORTS: Preliminary Report - August 15, 1972.

Final Report - December 31, 1972.

TASK 142 - REVIEW AND EVALUATION OF NUTRIENT REMOVAL METHODS

OBJECTIVE: To review and evaluate known physical, chemical and biological waste treatment methods and processes to remove nutrients, including an evaluation of techniques in use in the Okanagan. Design criteria, costs and operating efficiencies will be estimated for all feasible methods.

SCOPE: Examination of existing treatment facilities for nutrient removal on the North American Continent, preliminary review of all pertinent publications and preliminary evaluation of available data from other applied research programs will be undertaken in the first year. In the forthcoming year the study will encompass a continuing review and evaluation of the present status in advanced waste water treatment.

LINKS: Preliminary evaluation of nutrient removal methods will aid in the determination of waste treatment program applied research projects. The outcome of this study will provide input to the evaluation of waste water management alternatives.

REPORTS: Preliminary - October 1, 1970.

Final Report - September 30, 1972.

TASK 147 - APPLIED RESEARCH - WASTE TREATMENT
(Formerly Tasks 144, 145, 147 and 149).

OBJECTIVE: To evaluate the practicability of utilizing advanced waste treatment and irrigation methods in the Okanagan Basin to remove nutrients from industrial and municipal waste waters.

SCOPE: The nutrient removal studies will consist of:

(a) A pilot scale lysimeter study at Penticton to determine the feasibility of utilizing Okanagan Basin soils for waste water treatment and reclamation.

(b) Groundwater monitoring of a spray irrigation system at Vernon to compliment the study outlined under (a) above.

(c) Lime treatment of raw sewage (pilot plant) for phosphorus removal with subsequent incineration of sludge produced in the City of Kelowna's incineration facilities.

LINKS: Task 142

REPORTS: Preliminary Report - August 31, 1972.

Final Report - December 15, 1972.

APPENDIX C-5

SOCIO-ECONOMIC STUDIES

TASK 10 - METHODOLOGY AND STUDIES FOR EVALUATING WATER RESOURCE BENEFITS

(Includes Tasks 10, 14, 19, 112 and 151. These task numbers will be retained as well as revisions).

OBJECTIVE: To develop a methodology and undertake studies for evaluating the following water resource benefits:

10-A Supplying water for irrigated agriculture (Task 10).

10-B Supplying water for domestic municipal and industrial uses. (Task 14).

10-C Aesthetic, intangible and environmental quality factors associated with water and related resources in the basin (Task 19).

10-D Tourist and Recreational Benefits (Task 112).

10-E Ecological benefits, including sport fishing (Task 151).

SCOPE: Each of the above represents a specific study and the scope of each of those studies is outlined separately below:

10-A Irrigated Agriculture (Task 10)

(1) Describe methods for evaluating primary benefits by use of farm budget analysis to determine net marginal value product to water use.

(2) Describe methods for evaluating secondary benefits to meet income distribution objectives.

(3) Scale of studies will be restricted to the development of irrigated agricultural potential in the North Okanagan and in selected tributary watersheds.

10-B Domestic, Municipal and Industrial Uses (Task 14)

(1) Describe methods for evaluating primary benefits in industrial and municipal uses.

(2) Describe methods for evaluating secondary benefits to meet income distribution objectives.

(3) Describe methods for evaluating aesthetic values and social well-being values for lawn sprinkling and in-house domestic uses.

10-C Aesthetic and Intangible Values (Task 19)

Studies will examine several aspects such as water levels in lakes; stream flow discharges; balanced rural-urban landscapes; lawn sprinkling and the

relationship between the economic demands made on the environment and non-quantifiable demands on the environment. Testing of methodology will be undertaken for selected water management alternatives.

10-D Tourist and Recreation (Task 112)

(1) Describe methods for evaluating primary (consumer surplus) benefits to recreation to meet social well-being and environmental quality objectives.

(2) To undertake a survey of present resident and non-resident (tourist) water-based recreational behaviour and preferences in the Okanagan Basin.

(3) Describe methods for evaluating net economic returns to the economy from tourist expenditures in the basin.

10-E Fish and Wildlife Benefits (Task 151)

Studies will initially concentrate on sport fishing opportunities and will describe and test methods for:

(1) Determining the value of direct use of sports fishing opportunities in the Okanagan.

(2) Assessing net gains to the Okanagan economy from expenditures by non-resident sports fishermen.

(3) Assessing the environmental and social benefits associated with sports fishery to resident fishermen.

LINKS: Principles of Evaluation - Task 207 (a); Economic Growth Studies - Task 205; Recreational and Aesthetic Considerations - Task 200; and Sport Fishery Survey - Task 161.

REPORTS:

10-A Methodology for Evaluating Irrigation Benefits (Task 10) - June 30, 1972.

10-B Methodology for Evaluating Domestic, Municipal and Commercial Water Use Benefits (Task 14) - June 30, 1972.

10-C Methodology for Evaluating Aesthetic Factors (Task 19) - April 30, 1972.

10-D Methodology for Evaluating Tourist and Recreation Benefits (Task 112) - April 30, 1972.

10-E Methodology for Evaluating Ecological and Sport Fishing Benefits and Costs (Task 112) - April 30, 1972.

(NOTE: Completion dates for 10-A, 10-B and 10-C may be extended to August 31, 1972, in order to include field results from 1972 spring surveys. May 6, 1972.).

TASK 11 DEFINITION OF IRRIGABLE LAND BY LOCATION AND ELEVATION

OBJECTIVE: To determine the present irrigated and potentially irrigable land by location and elevation and by land classification under the following designations:

(a) Land irrigated at present.

(b) Irrigable land not irrigated but within the service area of present supply distributions.

(c) Other irrigable land.

SCOPE: The task includes the reconciliation of three information sources:

(a) Water Resources of Columbia River Basin, Appendix IV, 1955 (I.J.C. Report);

(b) Soil Survey of Okanagan and Similkameen Valleys (1949);

(c) Canada Land Inventory of agricultural capability and other reports.

The resulting areas so defined will be projected to 1:50,000 topographical maps which will also include current water licensing data.

LINKS: Present water use studies (15a); Preliminary water demand forecasts (15b); Definition of crop production (9); Land use studies (202).

REPORTS: Preliminary - October, 1971.

Final - May 31, 1972.

TASK 15 - PRELIMINARY ESTIMATES OF PRESENT AND FUTURE WATER DEMAND

OBJECTIVE: (a) To estimate present water use patterns in agriculture, industry, and municipalities, for the entire Okanagan Basin.

(b) To make a forecast of water demand for agriculture, industry, residential purposes for the entire Okanagan Basin to 2020.

SCOPE: (a) Present Water Demand

(1) The study will complete an inventory of all available water use and licence data.

(2) The study will analyse past trends in the efficiency of water use in agricultural, municipal, industrial.

(3) The study will augment the existing data on water use where necessary to be compatible with data requirements for future water demand studies.

(b) Future Demands

Based on information obtained in Task 15(a) and Task 201, preliminary estimates of future water demands will be made. Trends in water use coefficients will be considered.

LINKS: Irrigated Land Use - Task 11; Economic Base Study - Task 201.

REPORTS: Preliminary Estimates of Present Water Use (15a) - April 30, 1971.

Preliminary Estimates of Future Water Demands - April 30, 1971.

TASK 17 - FUTURE DEMAND FOR RECREATIONAL AND AESTHETIC RESOURCES UNDER VARIOUS WATER MANAGEMENT ALTERNATIVES

OBJECTIVES: To assess present and potential water and related land resource capability to support water-based recreation demands to 2020, under varying water management alternatives.

SCOPE: (1) The study will examine C.L.I. maps to assess the physical capability of water and related land resources in the Okanagan Valley to support water-based recreation.

(2) The study will undertake beach counts and interview surveys to determine public preferences for water-based recreational experience, and specifically assess the impact of water quantity and water quality management alternatives on recreational resources.

(3) Based on projected demands for water-based recreation contained in Economic Growth Studies (Task 205), the study will examine options for the future management of water-based recreation and aesthetic resources.

LINKS: Recreation and Tourist Surveys (Task 112); Economic Growth Study (Task 205); Shoreline Survey (Task 21).

REPORT: February 28, 1973.

TASK 21 - SHORELINE SURVEY AND FLOOD DAMAGE STUDIES

(Joint study B.C.W.I.B. & Socio-Economics. Includes former Task 20 - Flood Damage Studies)

OBJECTIVE: To evaluate present and future damage that may be caused by extreme fluctuations in Okanagan and Osoyoos Lakes.

SCOPE: The survey will assess potential damage to several categories of developed shoreline land use including recreational, residential, transportation and commercial uses. For Okanagan Lake the scope of the study will assess damage resulting from lake levels up to two feet above the existing high water operating level (1123.8), and down to three feet below the minimum operating level (1119.8). For Osoyoos Lake, only the consequences of lake levels two feet above the existing high water operating level of 912 feet will be examined as low water levels are controlled by natural topography. Other lakes will not be surveyed as it is not expected that any of the proposed alternatives will affect existing operating levels.

Engineering aspects will include the cost of adjustments to the floating bridge at Kelowna, commercial wharves, and the effect of extreme low water on the intakes around Okanagan Lake.

LINKS: Principles of Evaluation (207); Water Quantity Alternatives (23 and 5).

REPORTS: This task is to be undertaken jointly by the Socio-Economic and Water Quantity Study Groups and the following separate reports will be compiled.

(a) 21(a) - Socio-Economic Group - Social and Economic Aspects of the Shoreline Survey - March 31, 1972.

(b) 21(b) - Water Quantity Group - Engineering Aspects of the Shoreline Survey - June 30, 1972.

(EDITOR'S NOTE: Same as Task Description shown in Water Quantity Section: This task was subsequently expanded to assess flood damages on Okanagan and Osoyoos Lakes resulting from the major runoff which occurred in 1972.)

TASK 54 DETAILED WATER DEMAND STUDIES

OBJECTIVE: To make a detailed inventory of water demands and requirements for agricultural, industrial and domestic use.

To make detailed forecasts of future water demands to the year 2020 for agricultural, domestic and industrial purposes, as well as for recreation, fish and wildlife, and transportation.

SCOPE: Inventory of Water Demands - 54 (a)

1. Supply a detailed listing of water demand by location and source of water.
2. Depict water use by tributary and by region.
3. Augment, where necessary, data of water diversion, consumptive use and return flows to provide an overview of actual water use in the basin.

Forecast of Future Demands - 54 (b)

1. The development of alternate economic development phases for the basin will be used to project future water requirements.
2. Discuss pricing and present water metering practices.
3. Supply detailed forecasts of future trends in water use with and without management policies.
4. Include projections of water use by tributary sub-basin.

LINKS: Task 15 - Preliminary Estimates of Present and Future Water Demand; Task 205 - Economic Growth Studies; all evaluation tasks.

REPORTS: Detailed Water Demand - Present Use Studies, Task 54(a):

Preliminary - October, 1971
Final - August, 1972.

Forecast of Water Demands, Task 54(b):

Preliminary - August 1, 1972.
Final - September 15, 1972.

TASK 160 - WILDLIFE PROBLEMS ASSOCIATED WITH WATER MANAGEMENT IN MAINSTEM OKANAGAN

OBJECTIVE: Describe wildlife populations associated with water and define impact of selected water management alternatives for the mainstem Okanagan system on these populations.

SCOPE: List and briefly describe wildlife populations associated with or dependent on water within the mainstem Okanagan. The study will assess the impact of selected water quantity management

alternatives on wildlife resources in the mainstem system. In addition, studies will examine the consequences of water quantity alternatives in the Trout Creek tributary on wildlife populations. These studies will be limited to Okanagan Lake, Okanagan River and Trout Creek sub-basin.

LINKS: Tasks 23, 6 (Trout Creek Pilot Study).

REPORTS: 30 April, 1972.

TASK 161 - SPORT FISHERIES AND WATER MANAGEMENT

OBJECTIVE: Determine total angler use and other types of recreational boating on all major lakes in the Okanagan Basin and its tributaries.

SCOPE: List and briefly describe present and potential sport fisheries in waters of the Okanagan Basin. Estimate present and other forms of recreational boating. Total numbers of boating days for each major lake in the valley will be provided.

LINKS: Information is required to determine the value of sport fishing in the Okanagan Basin as a water-dependent resource and to determine benefits and disbenefits associated with water management alternatives. Task 10, Task 66 (including census) and Task 205.

REPORTS: Final Report March 31, 1972.

TASK 162 - PACIFIC SALMON POPULATION AND HABITAT

OBJECTIVE: To describe the salmon population and habitat requirements. Document population characteristics, discharge - spawning area relationships and water quality parameters, and identify present and potential limiting factors associated with water management practices.

SCOPE: Summarize sockeye salmon escapement data; review and upgrade spawning distribution records, spawning substrate quality and rearing habitat information; establish acceptable discharge - spawning area relationships and discuss factors limiting production.

LINKS: Water quantity (availability), Tasks 35 and 36. Water quality (temperature, chemistry, nutrient load), Tasks 105 and 131, and Limnology Tasks 118 and 120, incl. Socio-Economic Tasks 15a, 15b, 54a, and Task 23.

REPORT: Final Report - 31 March, 1972.

TASK 163 - SALMONID REHABILITATION, MAINTENANCE, AND ENHANCEMENT FEASIBILITY STUDIES

OBJECTIVES: A. To determine the feasibility and cost of maintaining the peak present run of spawning trout and kokanee in Mission Creek and of restoring the indicated historic productive potential in Trout Creek.

B. To investigate the feasibility and cost of maintaining the Okanagan River sockeye run under reduced flow conditions by means of an artificial spawning channel and/or alternative flow control methods.

SCOPE: A. Maintenance and Enhancement of Kokanee and Rainbow Trout stocks.

(1) Assess obstructions to migration, and detail necessary modifications including costs.

(2) Assess actual potential spawning areas in these streams, and estimate productive capabilities.

(3) Calculate required flows for spawning and incubation.

(4) Consider stream bed modifications, including costs.

(5) Preliminary design and costing of spawning channels where the need for such is indicated.

(6) Compare costs under (5) with hatchery costs.

(7) Preparation of drawings for any engineering work recommended.

(8) To assess applicability of these results to other tributaries.

B. Maintenance of Sockeye Salmon Run

(1) Site selection and Topographical mapping.

(2) Preliminary design of a proposed spawning channel including -

(a) Drawings and Costs.
(b) Flow requirements.
(c) Evaluate sockeye run with and without artificial habitat and/or flow control.

REPORT DATES: 163A and 163B - Interim - September 15, 1972.
- Final - November 30, 1972.

TASK 200 - EVALUATION OF FACTORS ASSOCIATED WITH WATER-BASED RECREATION AND AESTHETIC RESOURCES

OBJECTIVES: To identify and evaluate factors that presently contribute to aesthetic, recreational and environmental values of valley residents.

SCOPE: The study will follow up on the results of the water-based recreation surveys (Task 112) and determine through an interview questionnaire the relationship between resident and tourist values towards aesthetic and recreational resources and water resource management. Specifically, the study will attempt to determine how much time, money and effort recreationists spend on participating in recreational activities and assess the impact of water quantity and water quality criteria or the value of such opportunities.

LINKS: This study will complement Task 112 and Task 151 (Sports Fishery Survey) to provide comprehensive data on present values of water-based recreation and aesthetic resources in the Okanagan.

REPORT: September 30, 1972.

TASK 201 - ECONOMIC BASE STUDIES

OBJECTIVE: To analyse the present economic structure of the Okanagan Basin in terms of sources of income and employment, with emphasis placed upon the inter-relationships among various sectors of the economy both in and outside the region.

SCOPE:

(1) Identify and delineate the economic area that encompasses the Okanagan Basin and contiguous basins which may be affected by water management decisions.

(2) Describe the economic linkages between the study area and the province.

(3) Assess, in general terms, the anticipated economic growth trends in the province to 2020 and relate these to the study area.

(4) Describe the present structure and inter-relationships among the various sectors of the study area's economy.

(5) Develop a complete inventory of current and potential resource use (physical, human, economic) and in the study area.

(6) Identify and assess the various factors that presently limit the rate of economic growth and development.

LINKS: This study provides essential information for economic growth studies, water demand studies and evaluation of water use studies.

REPORTS: Final report to be completed by 31 March, 1971. Preliminary report completed by 1 December 1970.

TASK 202 - LAND USE STUDIES

OBJECTIVE: To determine the location and area of various economic activities. The survey should present a description and catalogue of the total area, relative location, proportion and other significant characteristics of such activities as agriculture, forestry or any other category of water-utilizing endeavour. This description must take account of present land use and indicate areas of apparent change, as well as to relate the data to surveys of potential as prepared by C.L.I.; permitting judgments to be made regarding resource utilization of the area.

SCOPE: The land use study must encompass the entire Okanagan Basin and those significant contiguous areas which are included in other phases of the Socio-Economic study.

LINKS: This study will provide input to water demand studies, economic base study and estimates of present use.

REPORTS: A series of maps together with a catalogue presenting quantitative data on different categories of land use will be due by April 1971.

TASK 203 - INSTITUTIONAL AND FINANCIAL STUDIES

OBJECTIVE: To describe the historical development of current legislation and administrative organizations affecting water resource management in the Okanagan. To outline existing organizations having an impact on the use of water, to disclose their powers and duties as well as financial resources. To describe and evaluate the relationships between the different organizations and between them and individuals.

SCOPE: The task will review the functional framework of various water management and associated organizations at the federal, provincial and municipal levels. It will examine the operation of administrative organizations, the jurisdiction of different levels of government and the rights of individuals.

LINKS: All evaluation tasks and the Public Involvement program.

REPORT: June, 1972.

TASK 204 - DEFINE WATER MANAGEMENT OPPORTUNITIES AND ALTERNATIVES

OBJECTIVE: To identify water management opportunities and constraints in the Okanagan Basin.

SCOPE: The task will examine as part of the final evaluation process of alternatives, institutional constraints and opportunities that may affect the management of water resources in the basin.

LINKS: Institutional and Financial Studies, Task 203; Final Report; and Task 171, Public Involvement.

REPORT: May, 1973.

(EDITORS'S NOTE: This task was carried out in conjunction with final evaluations and development of recommendations. No specific report was prepared on this task.

TASK 205 - ECONOMIC GROWTH STUDIES

OBJECTIVE: To project, as accurately as possible, to 2020, changes in the economic structure and population characteristics of the basin.

SCOPE: (1) The study will identify and, with the aid of a dynamic economic model describe the exogenous and indogenous causes of growth acting upon the regional economy.

(2) Specialized studies of projections of growth or decline in several key sectors of the regional economy will be undertaken. The sectors include agriculture, manufacturing industry and recreation, and will examine possible future changes in technology, market potentials, economies of scale, input requirements.

(3) The study will provide projections of population characteristics (total, age, sex, distribution, labour force, retirement, personal income) based on alternative projections of economic growth.

LINKS: This study will provide information for water demand studies, evaluation of water use studies (Task 54) and the development of alternative plans.

REPORTS: 31 May, 1972.

TASK 206 - DEVELOPMENT OF ALTERNATIVES ECONOMIC GROWTH PLANS

OBJECTIVE: To integrate the results of Tasks 205 and 54 to develop feasible alternative economic development plans for the basin to 2020.

SCOPE: Various alternative plans for development in the basin will be assembled from economic data and resource requirement data obtained earlier in the study. These alternative plans will form the basis for devising final management alternatives for meeting water quantity and water quality requirements.

LINKS: Integration of several studies -- Water Demand (54); Economic Growth (205); Evaluation Studies; Definition of Irrigable Land (11) and Recreation Studies (200).

REPORT: Final Report 30 September 1972.

TASK 207 (A) - PRINCIPLES OF ECONOMIC AND SOCIAL EVALUATION (PHASE I)

OBJECTIVE: To prepare a guideline report which will identify the criteria required to evaluate the multiple objective function of the Okanagan Basin Study.

SCOPE: (1) The study will examine the parameters associated with economic efficiency criteria, for example, maximum regional income. The study will also examine the implications on benefit-cost analysis of a shift of emphasis in the economic efficiency criteria from the regional scale to the provincial scale.

(2) The study will identify possible social welfare criteria associated with income redistribution resulting from employment of persons presently unemployed or under-employed.

(3) The study will identify principles for evaluating intangible benefits associated with enhanced aesthetic values and improved environmental quality so that such benefits can meaningfully be included in the evaluation of alternative plans.

LINKS: Essential information to guide Phase II Evaluation Studies; an aid to determining the scope and nature of the economic base and economic growth studies, enable decision-making to evaluate the alternative comprehensive plans; Public Involvement studies.

REPORT: Final Report prepared April, 1971.

TASK 207 (B) - PRINCIPLES OF EVALUATION

OBJECTIVE: To establish operational procedures for Socio-Economic evaluation of water management alternatives in accordance to the principles of multiple objective planning.

SCOPE: (1) The study will review recent literature on evaluation techniques in multiple objective planning.

(2) The study will establish principles of economic analysis and develop an evaluation matrix where economic values associated with water can be directly compared with environmental and social values.

(3) The study will examine various ways of measuring benefits and costs, use of incremental analysis; sensitivity analysis and incremental decision-making procedures.

(4) The study will place this evaluation procedure in context of a specific water management alternative (Task 23).

LINKS: Evaluation Studies (207(A); Water Quantity Management Alternatives (Task 23).

REPORTS: Report presented in October 1971.

TASK 209 - LAND USE STUDY (FUTURE)

OBJECTIVE: Based on regional projections of population, industrial and agricultural development prepared under Tasks 205 and 206 to distribute these within the Okanagan Basin according to land use capability.

SCOPE: (1) To identify and map potential residential, agricultural, commercial and industrial growth based on a subjective assessment of land capability.

(a) to 1980
(b) to 2020

(2) To assess the capability of different sectors within the tributaries and mainstem to support a range of types of land occupancy.

(3) Identify areas of anticipated growth in relation to water demand.

LINKS: This study will provide information for water demand studies, water quality studies and the development of alternatives under Task 101.

REPORTS: 1980 Projections - September 1, 1972 (preliminary)

2020 Projections - December 15, 1972 (final)

APPENDIX C-6

STUDY COMMITTEE AND PUBLIC INVOLVEMENT

TASK 1 - FINAL REPORT

Task 1 is concerned with the preparation and printing of the final report for the Okanagan Basin Study, complete with technical supplements or appendices. The final report will deal primarily with the findings of the study, the development of alternative plans for water management and the evaluation of these alternatives so that the decision makers can select courses of action for implementation which most nearly satisfies the requirements of the people of the Okanagan Basin, from time to time in the future. It will be fully supported in technical detail by technical supplements or appendices.

A popular type summary report may also be prepared for general distribution to the public. This summary report would be limited to 40-50 pages and be printed on high quality paper with colored maps and photographs.

Time is a critical factor in the preparation of the final report and schedules for completion of all phases must be met. The reporting schedule for the main report is given in Appendix A attached.

Quantities to be printed are as follows:

Final Report	500 Copies
Summary Report	6,000 Copies
Technical Supplements	150 Copies

Task 1 has been subdivided into four sub-tasks.

TASK 1 (A) - Preliminary Outline of Final Report and Technical Supplements

OBJECTIVE: Develop preliminary outlines for the final report and technical supplements.

SCOPE: A preliminary outline of the contents and form of the final report and the technical supplements will be developed by the Study Committee and the Executive Secretary for review and approval by the Consultative Board.

COMPLETION DATES: Preliminary outlines - technical supplements - May 15, 1973

Preliminary outline - final report - May 30, 1973

Final Drafts of Outlines - July 30, 1973.

TASK 1 (B) - PREPARE TECHNICAL SUPPLEMENTS

OBJECTIVE: To consolidate and interpret the data and information collected under the various tasks carried out for the Okanagan Study and to prepare summary reports which will become technical supplements to the final report.

SCOPE: The information collected during the Study and contained in the various task reports will be drafted by the co-ordinators into technical supplements. These drafts must be satisfactory to the responsible agency before being submitted to the Committee and Executive Secretary for review.

COMPLETION DATES:

October 1973 (Actually completed April 1974)

TASK 1 (C) DEVELOPMENT OF DRAFT OF MAIN REPORT

OBJECTIVE: The Committee and the Executive Secretary to develop in detail the findings and recommendations to be included in the main report.

SCOPE: Tentative findings and recommendations for the main report will be developed from the evaluation studies.

These will be refined and consolidated through discussions, workshops, seminars, etc. to be conducted under the public participation program and through consultation with the Consultative Board.

COMPLETION DATES:

1980 Projections & Evaluations	- October 1972.
Future Alternative Scenarios	- March, 1973.
Preliminary Draft of Final Report	- May, 1973. (Actually completed November 1973)

(EDITOR'S NOTE: Draft of Main Report and Summary edition released for public comment in November 1973).

TASK 1 (D) - PREPARATION AND PRINTING OF FINAL REPORT

OBJECTIVE: To prepare, edit and print a final report and summary report.

LINKS: Input from Tasks 1 (A), 1 (B), 1 (C), and Technical Supplements.

COMPLETION DATE:

Final Report at October 15, 1973. (Actually completed April 1973).

TASK 5 - FINAL SELECTION OF WATER QUANTITY ALTERNATIVES TO MEET PRESENT AND FUTURE DEMANDS

OBJECTIVE: To develop one or more detailed water quantity alternatives to meet present and future demands under a variety of operating constraints.

SCOPE: Alternatives developed under Task 23 will be reviewed based on improved water demand and cost data. The effect of tributary sub-basins and the development of Indian lands will be included in this evaluation.

LINKS: Task 23 - Preliminary Selection of Quantity Alternatives
22 - Engineering Investigation and Cost Studies
54 - Detailed Water Demand Studies
47 - Groundwater Evaluation
21 - Shoreline Survey
20 - Flood Damage Studies
34 - Water Quantity Computer Models
206 - Various Economic Growth Projections

REPORTS: Final Report - November 3, 1972.

TASK 6 - DEVELOPMENT OF WATER QUALITY ALTERNATIVES

OBJECTIVE: To develop one or more detailed water quality alternatives for a range of economic growth projections.

SCOPE: Quality alternatives will be developed under a variety of constraints for:

(a) 1980 economic projections.

(b) greater economic activity with the constraint that water quality must be maintained sufficiently high to protect human health.

(c) higher levels of water quality even if this requires a lower level of economic activity.

LINKS: Task 206 - Alternative Economic Growth Plans.
5 - Water Quantity Alternatives
102 - Water Quality Evaluations
103 - Future Waste Loadings
104 - Limnology Evaluations
18 - Fishery Evaluations
113 - Waste Water Management Alternatives
17 - Recreation and Aesthetic Evaluations

FINAL REPORT: March 31, 1973.

TASK 7 - TROUT CREEK PILOT STUDY

OBJECTIVE: An evaluation of water resources management alternatives for the Trout Creek tributary sub-basin.

SCOPE: To examine a number of alternatives whereby the Trout Creek system might be managed to support multiple use of its water resources. The study will provide an example of a multi-disciplinary evaluation task on which to base or improve future similar evaluations.

LINKS: All task studies pertaining to Trout Creek sub-basin input to Task 101.

REPORT: Final Report - July 31, 1972.

(EDITOR'S NOTE: This task was not completed due to insufficient detailed data on this tributary basin.)

TASK 23 - PRELIMINARY SELECTION OF ALTERNATIVES TO MEET PRESENT AND FUTURE WATER DEMANDS

OBJECTIVE AND SCOPE: The Study Committee will review the estimates of water shortages under present and future development conditions and under a variety of operating constraints, and will select a range of alternatives for further study under Task 24.

LINKS: Input from B.C.W.I.B. Task 23 (Preliminary Matching of Supply and Demand) and Task 12 (Match Irrigation Land Supply-Demand).

REPORT: January 31, 1972.

TASK 101 - DEVELOPMENT OF COMPREHENSIVE PLAN

OBJECTIVE: To develop a comprehensive framework plan for the development and management of the basin's water resources.

SCOPE: The study will focus on the identification and analysis of water resource problems, and the evaluation of economic, engineering, ecological, financial and organizational alternatives for water resource utilization in the solution to these problems. The planning horizon of the study will belong to the year 2020.

LINKS:: All tasks.

REPORTS: To be prepared as part of Final Report

TASK 111 - EVALUATION OF ALTERNATIVES

OBJECTIVE: To evaluate benefits and costs of selected water quantity and water quality alternatives.

SCOPE: The benefits and costs of selected water management alternatives will be evaluated and compared against the present or "null" condition, to enable selection of the most desirable alternative. This assessment will include evaluation of the following resource components:

(a) Water Quantity (Present and Future)
- In Mainstem Okanagan (Task 23)
- In selected Tributaries (Task 35)
- Combined Mainstem and Tributary Basins (Task 5)

(b) Water Quality (Present and Future)
- In each major lake basin (Task 104)
- In selected tributaries (102)
- Combined lake and tributary basins (Task 104)

(c) Combined Quantity - Quality Evaluation of Basin - Comprehensive Plan (Task 101)

Water use to meet agricultural, municipal, commercial, recreational, tourism, ecological and aesthetic demands will be considered in these evaluations.

The evaluations under Task 111 will be carried out by an Evaluation Team representing all the sponsoring agencies and will be under the direction of the Executive Secretary.

REPORTS: Preliminary Reports will be prepared on each evaluation as these are completed by the Evaluation Team.

Final Report - April 30, 1973.

(EDITOR'S NOTE: The evaluation of sport fishery alternatives was subsequently included in this assessment.)

TASK 170 - STUDY OF SOCIAL SYSTEMS AND POWER STRUCTURE IN THE OKANAGAN VALLEY

GENERAL: The Agreement explicitly states that "The program will include... public involvement as required to enable a comprehensive plan to be truly responsive to the wishes of the people for which it is designed".

OBJECTIVE: (1) To develop interaction between various identified interests within the Valley and the "study" itself.

(2) To establish viable two-way communication links between representatives of these interest groups and the study itself.

SCOPE: Following an intensive review of the present level of public involvement in the study, and an extensive analysis of the progress of the study itself, personal and group contact will be pursued. Identified leaders of interest groups and other known interested citizens will be questioned as to their perceptions of the study and its potential for their involvement in it. The major thrust will be to gain the trust and confidence of Valley residents both in the aims of the Study and the study personnel.

LINKS: Essential background information for Task 171 and 172.

REPORTS: A tentative appraisal will be available by August 30, 1972.

RESOURCES: It is anticipated that due to the alteration in structure and personnel, the public involvement program will make considerable use of its findings of the socio-economic studies. Extensive re-orientation and re-introduction to the other technical studies will also be necessary. This report will provide valuable background as will the files presently assembled.

TASK 171 - PUBLIC INVOLVEMENT AND DEVELOPMENT OF ALTERNATIVES

GENERAL: Upon developing an understanding of the Valley residents, a program of communication and discussion between the planning group co-ordinators and the public is essential. A multi-media approach is desirable which makes use of public gatherings, special seminars, the printed and spoken word, the news media and personal contact.

OBJECTIVES: (1) To increase the degree of shared understanding of the preliminary alternatives for water resource management in the Okanagan.

(2) To meaningfully infuse the values, perspectives and priorities of the general public towards water and environmental management in the Okanagan into the planning and decision-making stage.

SCOPE: Upon development by the Co-ordinating Committee of the preliminary alternative plans along with approximate estimates of their benefits and costs obtained, opportunities for extensive interaction should be provided to the public within the Valley. Local group leaders, key influentials, members of the federal-provincial planning team and study personnel themselves all should be involved in this process. General meetings, small group gatherings and special interest get-togethers should all be arranged in order to reach as wide a cross-section of Valley interests as possible.

LINKS: Backward to Task 170 and forward to Task 172, with a strong linkage for Co-ordinating Committee Work.

REPORTS: This task is not suited to the traditional report writing, but constant feedback should be maintained with the Study Director and Co-ordinating Committee. June, 1973.

RESOURCES: Office of Public Involvement Program, Study Director, Co-ordinating Committee and news media.

TASK 172 - PUBLIC RESPONSE TO THE COMPREHENSIVE PLAN

GENERAL: Through Task 171, a number of alternative plans or a number of combinations within one plan, will emerge. Moreover, the calculus of costs and benefits (social, cultural, economic and political) will have been evaluated. By presenting all of these to, and receiving feedback from, the public, the decision makers will have a clearer understanding of the public commitment to the plans with which they can base their decisions.

OBJECTIVE: (1) To gain public response and understanding of the alternative comprehensive plans.

(2) To gain public commitment to the comprehensive plan most preferred.

SCOPE: All forms of public communication will be utilized to gain as wide an outreach as possible. The primary emphasis will be on personal interaction.

LINKS: Task 171 and Co-ordinating Committee work on formulating alternatives.

REPORTS: As a contribution of Task 171, this task should deal with finalized alternatives for water resource management. Conclusions would be worked at throughout the late spring and summer of 1973.

Final Report - May 31, 1973.
Technical Supplement - July 31, 1973.

RESOURCES: Offices of Public Involvement Program and Study Director, and the Study Committee and Agency Co-ordinators.

APPENDIX D

GOALS FOR THE OKANAGAN RIVER BASIN PLANNING STUDY

(Reprint of Draft Paper on Planning Philosophy used to Develop the Goals and Planning Objectives of the Study by E.R. Tinney, Member Consultative Board, Canada-British Columbia Okanagan Basin Agreement.)

LETTER FOREWORD

September 5, 1972

Goals for the Okanagan River Basin Planning Study

As I promised you in an earlier memorandum, I am sending you the enclosed statement entitled "Goals for the Okanagan River Basin Planning Study." In presenting this to the Committee, I cautioned them, that it was a statement in "layman's" language that could be used as a basis for preparing a much shorter statement in the final report. I also took the opportunity with the Committee to review the roles, as I saw them, of the research scientist, the engineer and the economist in the total planning function. I characterized the research scientist as providing basic understanding of phenomena, the engineer's role of translating this understanding into possible action programs with associated costs and the economist's role to select from these action plans alternatives best suited to objectives enunciated by the public or their elected representatives. The attached paper tries to explain this selection process.

E. Roy Tinney,
(Member Consultative Board,
Canada-British Columbia
Okanagan Basin Agreement)

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APPENDIX D

GOALS FOR THE OKANAGAN RIVER BASIN PLANNING STUDY

Comprehensive river basin planning is new in Canada - indeed there are few river basins in the world for which such an exercise has been undertaken. Because of this novelty, some explanation is needed on the objectives and nature of planning and some myths should be dispelled.

D.1 THE NATURE OF PLANNING

Planning deals with two kinds of unknowns; the uncertainties of the future and the lack of knowledge of the present. Because of the rapidity of change it is also entirely conceivable that our understanding of ourselves and of our environment may be greatly improved in the coming decades. The second category of unknown is the present state of affairs, for despite our best efforts, there are many aspects of a river basin we can never completely know. Groundwater resources are one example. Even after exhaustive studies, man has only spotty information on sub-surface features and underground flows. Another unknown is the precise behaviour of the natural environment when subjected to changing stresses. A third kind of unknown today, perhaps the biggest unknown of all, is the preference of residents. Each person has his own ranking of preference and so far man has not learned how to specify them, much less aggregate the preferences of tens of thousands of people.

Despite these numerous uncertainties, most people are convinced that it is best to make rational estimations of what is likely to occur in the coming decades if we choose a particular path into the future. Indeed, we would feel much better if we knew something about the various paths. This is the essence of planning. It is an attempt to describe, as far as experts in many disciplines working together can do, several possible courses of action and the likely consequences of each.

Contrary to popular opinion, those working on planning studies do not decide on a particular course of action. Indeed, it is not even necessary that they recommend one or another course. River basin planning is not analogous to designing a house. For the latter, the architect develops a very clear mental image and draws plans in meticulous detail so that the mental image becomes a reality in every respect when the house is built. Not only is this not possible for a river basin, it is probably not desirable. We do not want to lock our grandchildren into a future based upon our imperfect

perception of what we think it should be. It seems far more preferable to leave as many decisions to them as possible, not only because it is their right to choose their own destiny, but because hopefully, they will know better what to choose when the time for decision arrives. In short, we do not want to close off the options of those who follow after us. But this does not mean doing nothing, rather it means taking careful steps to protect those options and to provide our descendants the opportunity to improve their own lifestyle.

D.2 ASSUMPTIONS, OPTIONS, AND ALTERNATIVES

It is important in the planning process to distinguish between assumptions of desirable kinds of futures, the water management options designed to satisfy those assumptions, and the alternatives to each option. Since we do not know in advance what the precise desires of the public will be, we make instead a wide range of assumptions within which we are confident most public expression of desires will fit. The public and their representatives in government will subsequently make the selections. For this planning study we have made three basic assumptions:

1) if the public chooses to continue the present pattern of activities in the basin, it will insist that the environmental quality be at least no worse than it is today.

If the public chooses to deviate from 1), it will choose to do so within the following two limits:

2) greater economic activity than today constrained by the fact that the environmental quality must be maintained at a level sufficient to protect human health.

3) higher levels of environmental quality even if this requires a somewhat lower level of economic activity.

These three assumptions formed the basis for the three economic growth projections developed under the study plan.

Water management options are chosen in the planning process to meet each of these three assumptions. By selecting alternatives to each option, a broad spectrum of choices is provided. One alternative for each option is specifically designed to provide the greatest range of flexibility in subsequent future choices.

D.3 COMPLETENESS OF THE ALTERNATIVES.

The planner must be sure that each water management alternatives is consistent and complete within itself. For example, if an alternative is designed to fit assumption 3 above, then all the necessary steps to prevent pollution, to control water levels, to protect attractive landscapes, to enhance fisheries, to safeguard wildlife habitats, etc., are included. Similarly, if an alternative is designed to meet assumption 1, then the alternative describes the elements needed to provide sufficient water, the most efficient allocation of that water to various economic uses, the level of waste treatment required to maintain environmental quality and other similar features.

In addition, each alternative identifies all the likely consequences, both economic and environmental. The stages of each alternative are also presented, and finally, the legal, institutional and administrative constraints to each alternative are described.

D.4 PROCESS OF PLANNING

The band of alternatives for water resource management is generated in the following way: first, we begin by projecting present conditions, or more precisely the present pattern or mix of activities in the river basin, into the future - assuming various growth rates. Then, we ask what would be the main reason for deviating from this present course. As assumption 2 and 3 above indicated, we elect on the one hand to achieve better economic conditions and on the other hand to have a better environment in which to live. We do not rule out the possibility of achieving both simultaneously, for clearly that would be highly desirable to many.

On the economic side, we think in terms of higher personal incomes, fuller and more stable employment, a better tax base so that residents of the basin can have better education and transportation systems and the like. On the environmental side we envisage improved quality of air and water; clean, quiet neighbourhoods; attractive shorelines; good recreational opportunities, particularly abundant fish, birds and game animals; more parks, and other amenities, etc. These descriptions of two assumed futures can be displayed on a grid as shown in Figure D.1. Point P_2 reflects pristine environmental quality with little or no economic activity and point P_1 represents an extremely high level of economic activity. The curve from P_1 to P_2 represents the mix of both of these values. Point A reflects both high economic activity and high levels of environmental quality.

GRID OF CONFLICTING VALUES

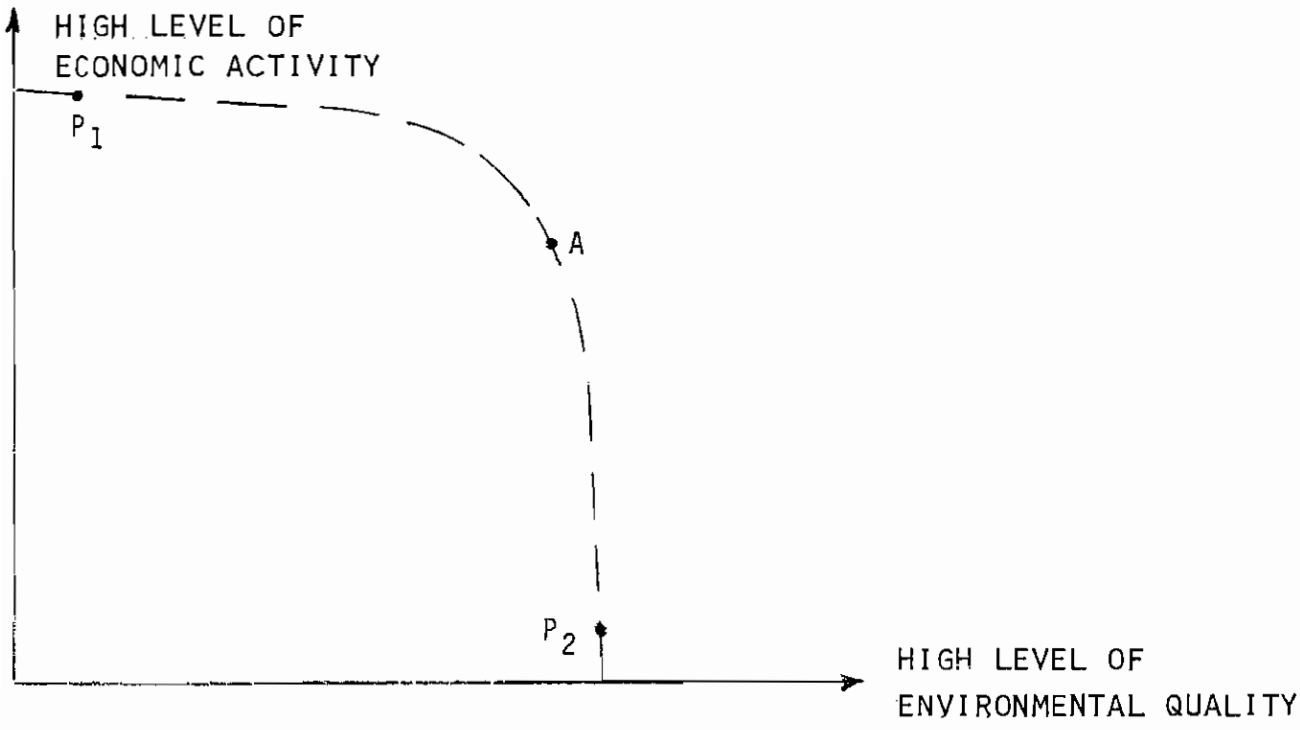


FIGURE D-1

PROJECTED HISTORICAL TREND

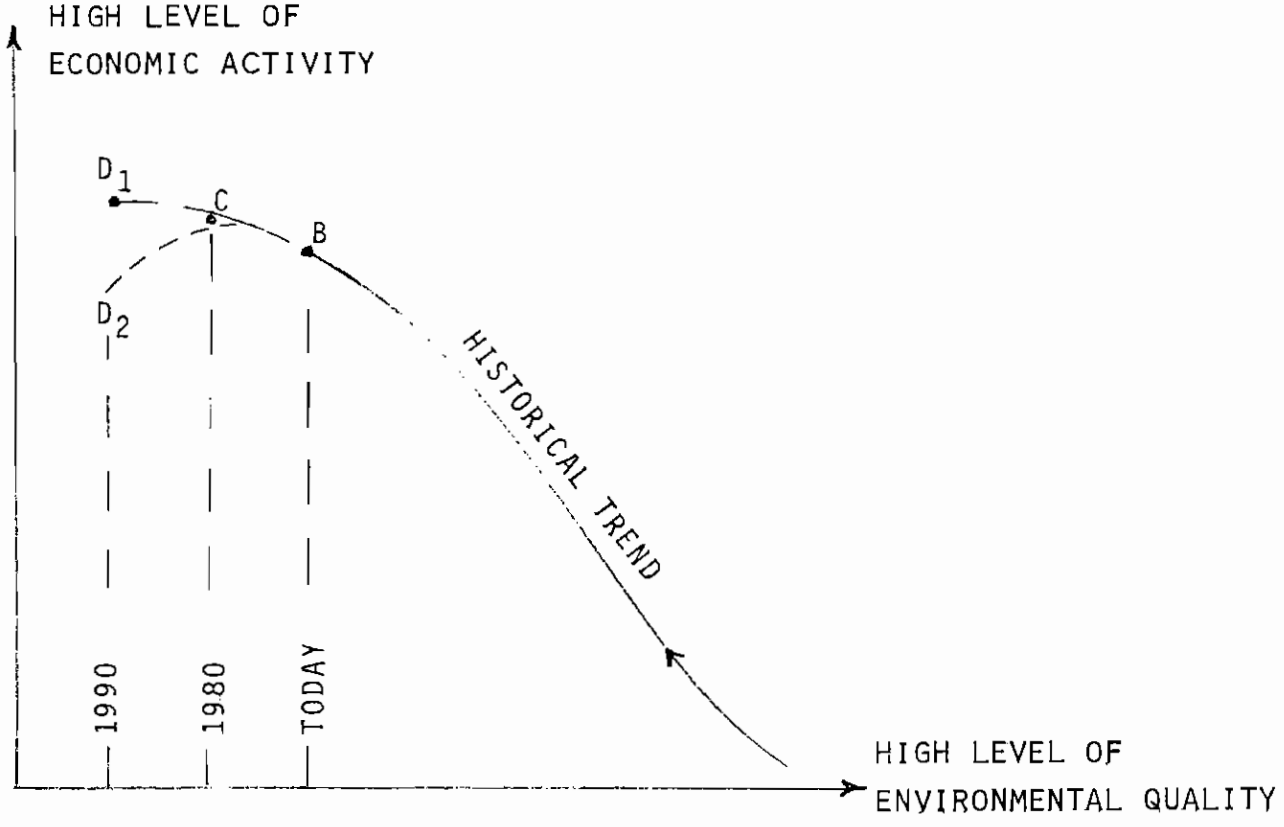


FIGURE D-2

Historically we have been increasing economic activity and decreasing environmental quality until we are now at some point B as indicated in Figure D.2. Because of the momentum of the present system, we are almost inevitably bound to reach a point near C in 1980 unless some very drastic events occur. If we continue on thereafter as we are now going, to say 1990, we are likely to head toward Point D_1 with somewhat improved economic conditions, but with a continually deteriorating level of environmental quality or even to point D_2 with lower than maximum values of both economic activity and environmental quality.

Ideally we would turn the curve or progress around and head for the region near Point A on the Curve P_1P_2 in Figure D.3, but the resources and opportunities available in the basin may not permit it. Indeed, the limitation of resources and general external conditions may restrict the attainable goal to a position on one of the curves parallel to P_1P_2 as shown in Figure D.3. Suppose however, by skillful management we were able to reach the curve marked Optimal Basin Goal at a certain date, say 2020, we could then choose any point on this curve between E_1 on Figure D.3 with much better economic conditions but with worse environmental quality, or Point E_2 with much better environmental quality, but with worse economic conditions. The zone within E_1, E_2, C, E_1 includes the full range of both desirable and attainable options, some of course more desirable than others depending on individual preferences.

Obviously we would not be content to choose a point within this zone since for every point inside the zone there is a point on the Curve E_1E_2 which represents both higher economic and environmental benefits. On the other hand, once on curve E_1E_2 one must be prepared to sacrifice either economic or environmental values when selecting an alternative scheme. Curve E_1E_2 is therefore the curve of optimality for this basin.

Returning to the earlier point of unknowns and uncertainties in planning, one cannot be certain of reaching any specific point on this grid. Wars, depressions, extended droughts, failure of world markets to materialize and other uncontrollable factors can significantly alter the result. Values and attitudes might very well change under such circumstances and what seems desirable today may not be as desirable tomorrow. If the options are left open as much as possible, the actual course of future events would be a zig-zag pattern shown by the solid line through the zone of options in Figure D.3. Obviously then, one of the important characteristics of each decision would be to retain as much flexibility in the future as possible so that contemporary conditions and attitudes can be included in the decisions of the future. At this point the planner's role ceases and the selection process of democratic government begins.

ALTERNATIVE FUTURE PATHS

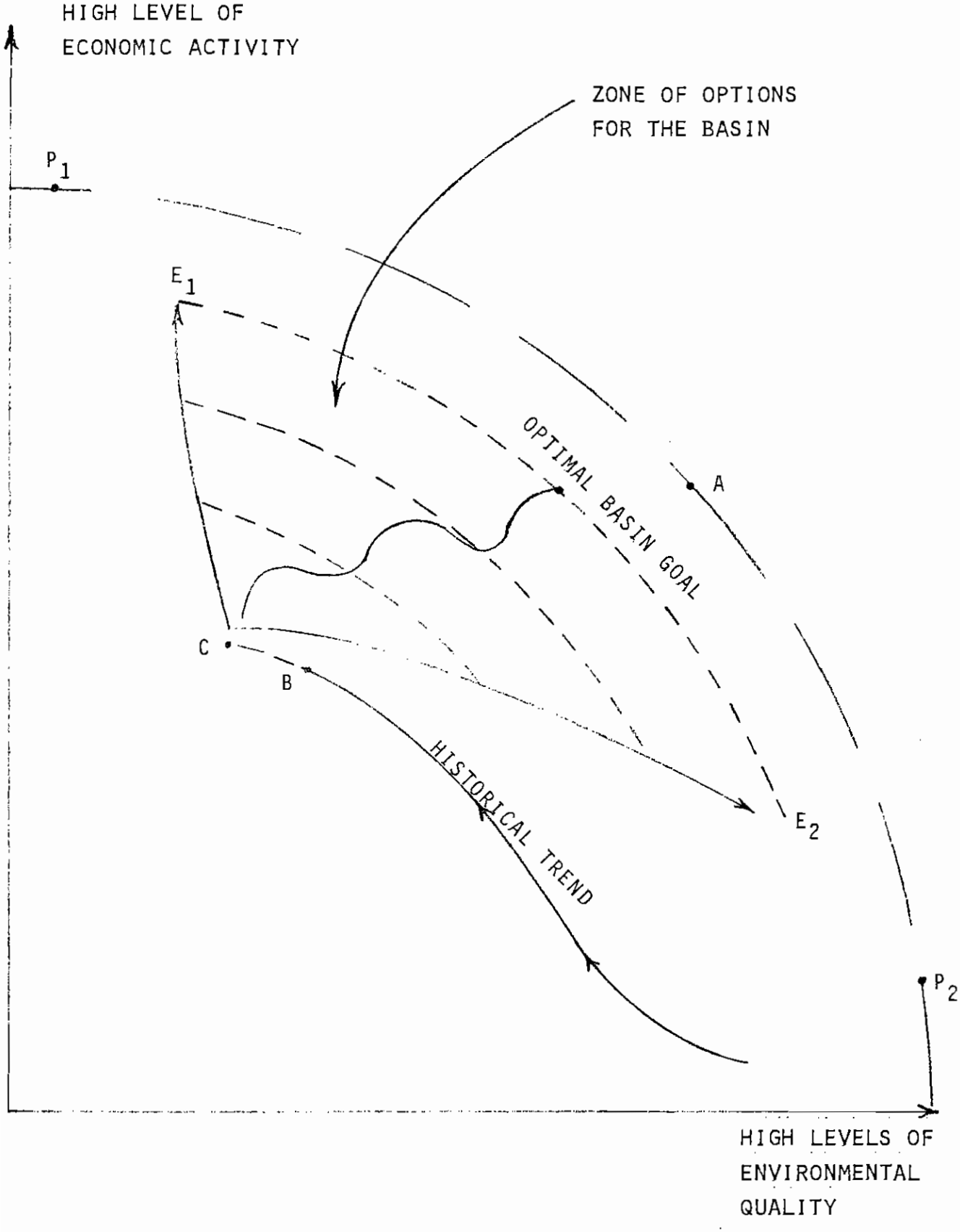


FIGURE D-3

D.5 SUMMARY

This report of the planning study presents several alternatives offering a wide range of choices to the decision-makers in the basin. The report describes the probable benefits, costs and consequences of choosing one or another, the ways in which the schemes can be undertaken in stages, and the legal, and administrative changes necessary to undertake each scheme. Expressions of public opinion on each of these alternatives obtained in a variety of ways are offered so that the governments and decision-making bodies have displayed for them not only these benefits, costs, consequences and constraints, but also a preliminary assessment of public preferences. At this point the planner's role ceases and the selection process of democratic government begins.

E. Roy Tinney,
June 1972

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APPENDIX E

THE EVALUATION PROCESS
IN
COMPREHENSIVE RIVER BASIN PLANNING
(TASK 207)

REPRINT OF PRELIMINARY REPORT #4
CANADA-BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

PREPARED BY
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VANCOUVER, B. C.

APRIL 1971

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PREFACE

Because some of the terminology used throughout this paper is placed in a context which may differ from that which the reader is accustomed, it seems appropriate at the onset to present the definition of certain terms that appear frequently in the text.

OBJECTIVE

A major policy goal set by the highest decision-making body in government. An objective has instrumental value because it leads to a higher valued goal, that of improving social welfare. The statement of objectives should include measurement parameters to indicate the degree to which they are achieved and to ensure that the objectives to not overlap. Examples of objectives include increased economic growth (regionally and/or nationally), improved environmental quality and an equitable distribution of opportunity.

TARGET

In this paper, the term target refers to a specific means of allocating resources to achieve one or more of the planned objectives. In the case of the Okanagan Study, targets will be expressed in terms of water management goals. For example the planning objective of achieving economic growth in the Okanagan basin might be achieved through the target of supplying water in the region for agricultureal needs to 2020. Similarly, the planning objective of improving environmental quality might be partially met by the target of providing water quality standards consistent with body-contact recreational sports.

SUB-TARGETS

Sub-targets relate targets to specified water resource demands in a study. For example, a sub-target related to the target of improving water quality might be to improve the water quality in a particular lake or reservoir to a specified water quality standard. Of course, the decision whether or not a sub-target should be achieved will depend upon a rigorous analysis of the benefits and costs associated with achieving this target.

BENEFITS

Benefits are defined as positive contributions to achieving objectives through meeting specified targets or sub-targets. When possible, the benefits associated with each target will be categorized into the multiple objectives. Because of the inter-linkages between objectives, aggregated or joint benefits

will arise, which will require special consideration to avoid double-counting. When possible, aggregated benefits will be distinguished from separable benefits, as the latter can be fully attributed to a particular objective.

In the case of the agricultural water supply target, direct benefits associated with the economic growth objective could include increased or more efficient production of agricultural outputs, while indirect or secondary benefits might involve the benefits stemming from the location of a new fruit processing plant. In terms of the environmental quality objective, such factors as aesthetic appeal due to landscape diversity or the psychic enjoyment of picking fresh fruit may be positively valued by the society and therefore accounted as benefits.

COSTS

Costs are defined as negative contributions to objectives through meeting specified targets or sub-targets. Not only are there economic costs associated with actual monetary expenditures, but there may be environmental costs such as the loss of recreational experience and social well-being costs such as an increase in flood risk for a certain community. Like benefits, joint costs may and must be treated with caution to avoid double-counting.

PROJECT

A project refers to any alternative means for achieving a specified water resource target or sub-target. Thus, a project may refer to a structural alternative such as a new reservoir or canal, or it may refer to a water management alternative such as metering and pricing water supplies or landuse zoning. Because of their nature, projects are usually associated directly with sub-targets.

COMPREHENSIVE PLAN

An array of water quantity and water quality projects which combined, form a complete comprehensive water management plan. Thus, while projects are designed to achieve targets and sub-targets, a comprehensive plan is designed to achieve the multiple objectives of the study.

APPENDIX E

THE EVALUATION PROCESS IN COMPREHENSIVE RIVER BASIN PLANNING

E.1 INTRODUCTION

The Okanagan Basin Study represents a new strategy for river basin planning in Canada. Therefore tne adequacy of the present planning approaches to water resource management in Canada to meet the challenge of this new strategy should be assessed at the onset of the study. In theory, the entire process at the policy, strategic and operational levels of planning should be scrutinized in this review, but becuase the Socio-Economic Task Force is mainly concerned with the evaluation process, only the evaluation procedures will be considered in depth in this report. However, the implications of the required changes in the evaluation process upon other dimensions of the planning process are indicated throughout the paper.

One of the basic tenents in any planning study is that a choice will have to be made between a number of water resource management alternatives for achieving the objectives of the study. Decision on the choice of alternatives is based on those that best meet the objectives of the study. Thus, the evaluation process which leads up to the point of decision-making is intimately connected to clear and precise definitions of the study objectives.

This paper reviews the basic principles for evaluating alternative plans and develops the concept of using an evaluation matrix in the evaluation process. It also outlines a number of important principles that will be taken into account by the Socio-Economic group when evaluating alternative plans.

Although this paper concentrates its attention on the evaluation process, it does attempt to review this evaluation process within the whole perspective of comprehensive basin planning. The paper begins by defining the scope of comprehensive basin planning through a review of the historical sequence of planning strategies. Then, the complete planning process is briefly discussed to indicate the inter-relationships between its three major components - the evaluation process; basic planning activities; and the institution structure. The main part of the paper examines in some detail each of the principle steps in the evaluation process, leading to a description of a conceptual model of the evaluation matrix. Finally, the implications of this evaluation matrix upon decision-making are discussed.

E.2 THE CONCEPT OF COMPREHENSIVE RIVER BASIN PLANNING

The concept of comprehensive river basin planning is perhaps best defined by reviewing the historical sequence of strategies in water resource development and planning. Four strategies have been identified (White, 1969). The first is single purpose development and is exemplified by private schemes for irrigation water supply, or the building of canals to improve inland navigable waterways. These projects were usually small in scale and localized in their impact upon the economic, social and physical environment.

The main purpose of this type of development was to promote economic growth. Scale economies were soon recognized by planners and led to larger scale projects which were multi-purpose projects were undertaken at public expense and have their most notable example in the T.V.A. development which produced water power, water supply and recreation benefits. Although this strategy is classified as multi-purpose, it had essentially a single objective, that of increasing national and in some cases, regional income. Economic efficiency criteria based on the technique of benefit-cost analysis were developed to evaluate projects and aid decision-making.

As readily available water resources were utilized, and new engineering techniques developed, planners devised more ambitious projects including large-scale diversions from one watershed to another. Such schemes produced major impacts on the economic and physical environment, giving rise to a growing public concern for protection of the natural environment, particularly the eco-systems that were threatened by such large-scale interventions. The increasing costs of water resource development in both financial and environmental terms ushered in a third strategy of multiple means - multipurpose river basin planning (National Academy of Sciences, 1966). This strategy explicitly increased the range of alternatives to solve water supply problems, encouraging more efficient use of water through proper management as an alternative to large-scale diversion. For example, land use zoning or flood proofing of buildings were examined as alternatives to constructing dams or dykes; water metering was introduced to reduce demands, and waste treatment was encouraged instead of increasing water supplies to dilute wastes.

I would like to emphasize at this point that the main objective of all of these strategies I have mentioned so far is to develop and/or manage the water resource to stimulate economic growth. So, essentially there was a single objective - economic development, which was realized by several purposes - supply for irrigation, industry, population growth, flood control, hydro power and navigation. But, people were also becoming aware that water is an important constituent of the environment - it is pleasing to look at, to swim in, to boat upon, to support valuable fish and wildlife resources. In addition, water can

play a major role in community life and development as I think it does in the Okanagan Valley in British Columbia,

This awareness of the environmental role of water has required that the objectives of planning must be expanded to include environmental and social goals in addition to the traditional economic one. This has resulted in a fourth strategy, which I term multiple objective - multiple means or comprehensive planning and it is this strategy that we are developing in the Okanagan Study. Comprehensive planning represents a new strategy in water resource management in Canada, built upon the well tested strategies of the past, but because it is new, it requires fresh approaches to evaluation, to decision-making and to multi-agency cooperation. This paper outlines a broader, and I believe, more appropriate approach to evaluation of comprehensive plans than has been used in the past.

With this historical review in mind, I think that it is now pertinent to examine the Okanagan Agreement and check how it matches up to the strategy of multiple-objective, multiple means planning. The Agreement explicitly states that there are at least two major objectives to the study:

> "...The purpose of the Agreement is to develop a comprehensive framework plan for the development and management of water resources for the social betterment and economic growth of the Okanagan Basin . . ."

The Agreement also stresses that multiple means, i.e. a wide range of alternatives will be examined to meet these objectives, when it states that the study will:

> "...focus on the evaluation of economic, engineering, ecological, financial and organizational alternatives for water resource utilization..."

Further, social values as well as economic values must be taken into account, for the Agreement declares that the public will be involved in the planning process:

> "...to enable the comprehensive plan to be truly responsive to the wishes of the people for which it is designed . . ."

Clearly then, the Agreement fits into the strategy of comprehensive planning. But, as a result, the broad scope of the study has its implications. Firstly, it costs more - up to $2 million can be spent for the planning phase of the study, which means that more money will be spent when we implement our plans. Secondly, the planning process is more complex - more disciplines are involved and more work is required to integrate the results of the various components of the study.

Whereas planning in British Columbia used to be undertaken by engineers, in this study we have biologists, ecologists, economists, sociologists as

well as engineers working on the problem. Thirdly, the scope of the study may expand geographically. Should the planners indicate that water must be brought into the basin from another watershed, then we would be required to examine in detail all the economic, social and environmental repercussions of such a diversion before a decision could be made.

E.3 THE PLANNING PROCESS

To understand the comprehensive approach to the evaluation process, I must first place it in context of the overall planning process. The description of planning presented here is based upon the concept that planning is a process of social change (Bishop, 1970). There are basically three components to the planning process:

1) The Evaluation Process - The evaluation process is based upon a hierarchical structure of objectives from those of broad policy goals down to detailed water resource sub-targets.

2) Sequential Structure of Planning Activities - The sequential structure of planning activities represents the main planning activities and decisions throughout the planning period.

3) The Institutional Structure - The Planning Participants - The institutional structure identifies all the interest groups both in the three levels of government and the general public and indicates how the decision-makers interact at any point in the planning process.

The interaction of these three components can perhaps best be visualized with the aid of a three dimensional diagram (Figure E-1). This figure is presented to indicate that planning is a highly dynamic process, which passes through a series of logically related steps (often repeating the cycle several times), and that at each step in the planning process a number of hierarchically related decisions must be made by the complex institutional structure. When discussing the evaluation process, I recommend that the reader refer to the diagram so that he can understand how each step of the evaluation process interacts with the appropriate steps in the other two components of the planning process.

E.4 THE EVALUATION PROCESS

As is the case for all components of the planning process, the evaluation process can be stratified into a hierarchy according to the level of detail required at any particular point of time in the planning process. Each element in the process can be decomposed into various subjects down to the smallest

A THREE DIMENSIONAL PLANNING SPACE
(After Bishop 1970)

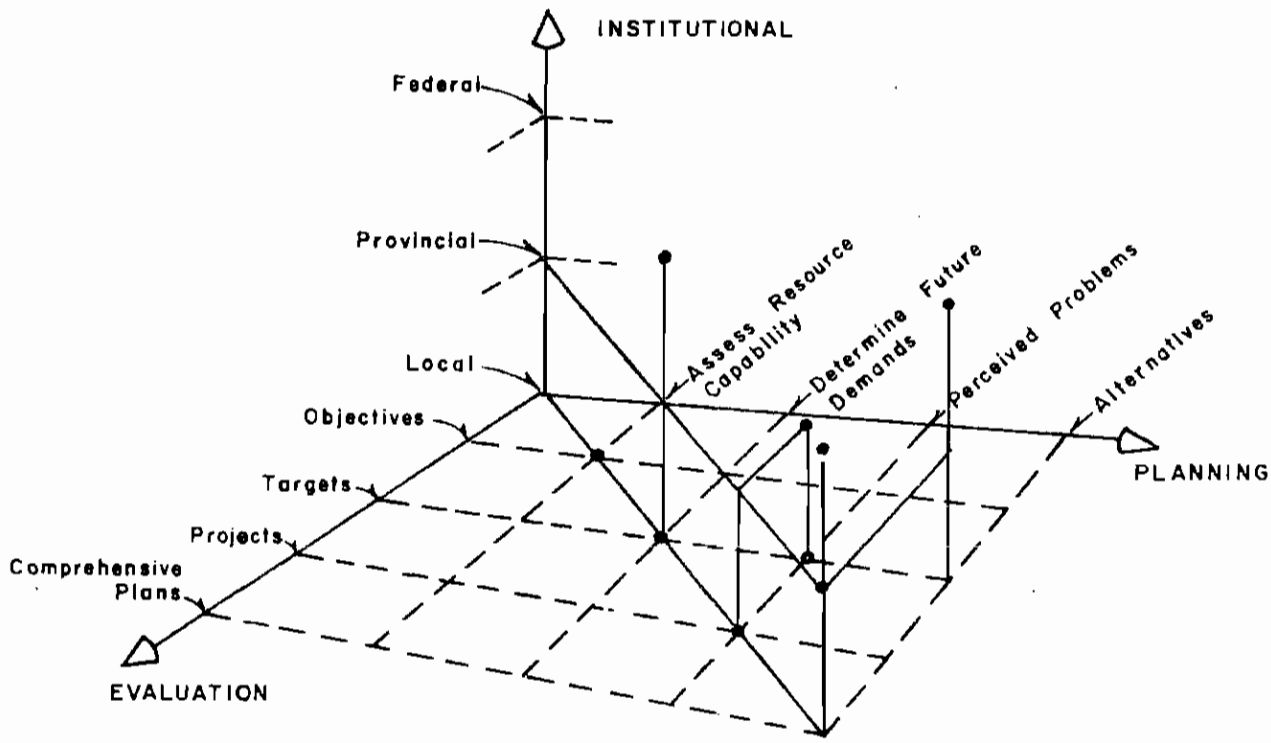


Figure E.1

element in the evaluation process which is called the sub-target, i.e. a specified water use for a particular location in the study region. A general hierarchical structure of the evaluation process with key linkages to elements of the other components is indicated in Figure E.2. The diagram shows that objectives are decomposed into targets and then sub-targets where particular problems are studied and then the sub-targets (and related projects) are aggregated into integrated planning alternatives. The whole process should be re-iterated for review and modification as time and money permits.

The remainder of this paper is devoted to a discussion of each of the hierarchical sequence of steps in the evaluation process as shown in Figure E.2. The reader is asked to review the definition of terms at the beginning of this paper as many terms are used in a rather special context.

E.5 THE OBJECTIVES OF COMPREHENSIVE RIVER BASIN PLANNING

The commonly stated idealized goal in water resource planning is to maximize social welfare. Generally speaking, a person's welfare is increased if he is somehow better off as a result of some action than he was before. But the objective must be more precisely defined and include specific measurement criteria before the decision-maker can be certain he has achieved this ideal goal.

Until recently, welfare was usually measured in monetary terms and welfare was said to be increased if a person's net private consumption of goods and services was increased. Today, the values associated with welfare appear to have broadened to include 'the quality of life' as well as a more equitable distribution of opportunity. Therefore we must be more explicit in our definition of social welfare if we are to include all relevant human values.

I have produced a hierarchical system of goals in Figure E.3 to help define the relationship between the different levels of goals in comprehensive planning. The figure indicates that social welfare can be achieved by meeting a number of broad objectives. These objectives are major policy goals, set by the highest decision-making body in the government and are therefore instrumental for achieving the higher values goal of improving social welfare. It is important, that these objectives are explicitly defined and shown to be non-overlapping (though they may conflict) and that their definition include measurement parameters to indicate how resource allocation decisions may achieve them.

The terms social betterment and economic growth used in the Okanagan Agreement are examples of broad objectives. However, they are ambiguously stated and although the decision-makers at the policy level of the Federal and Provincial governments[1] should ultimately be responsible for more precise

[1] In the Okanagan Study, the policy level is represented by the Canada-British Columbia Consultative Board.

SIMPLIFIED EVALUATION PROCESS

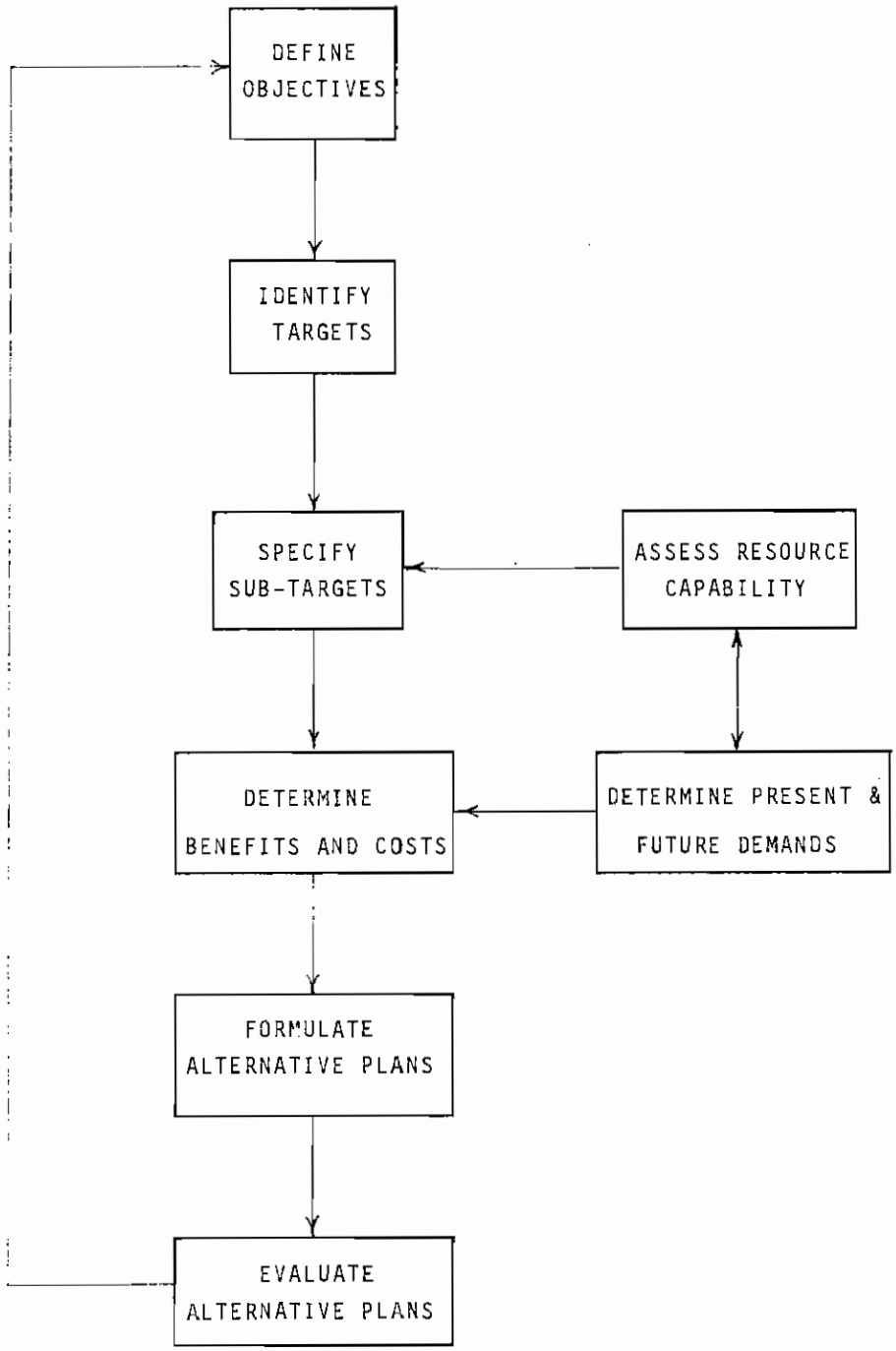


Figure E.2

GOALS AND OBJECTIVES

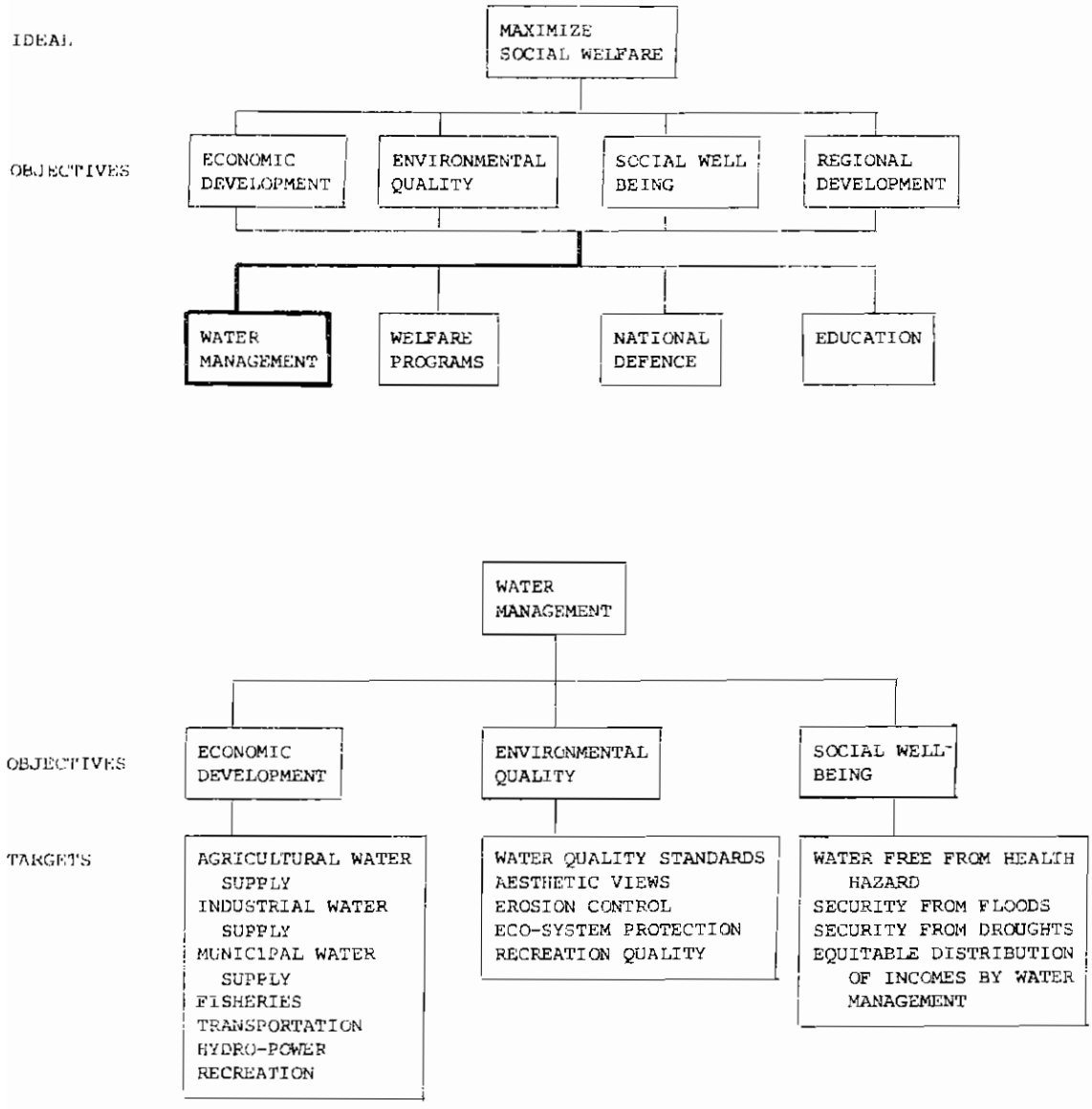


Figure E.3

definitions, it is perhaps the role of the planner to recommend such definitions, to the Consultative Board. In this context, I have identified three objectives for the Okanagan Study and define them accordingly.

1. To increase economic development in the Okanagan and Surrounding regions as measured by its net regional income - i.e. the net value of incomes, goods and services. The geographic boundaries of the region will be drawn wide enough to encompass all significant project effects.

2. To enhance environmental quality by management, preservation and improvement of certain natural and cultural resources and ecological systems. A social preference index net of costs required to produce a specified level of environmental quality will be developed as a measurement parameter

3. To enhance social well-being by creating a more equitable distribution of opportunity as measured by net per capita incomes, employment and population densities, and by contributing to security of life, health and property.

There are a large number of economic and social measures that can be chosen to achieve one or more of these broad objectives and thereby the ultimate goal of improving social welfare in the Okanagan, for example grants for industrial expansion, man-power retraining centres, subsidies for the agricultural industry. It is important to understand that water resource management is only one means of allocating resources to achieve these objectives. Ideally, comprehensive regional planning should examine a wide range of these social and economic means to achieve improved social welfare and allocate resources so that the marginal value of benefits (in terms of net social welfare) is the same for all social and economic programs. In fact, only water resource management was specified in the Agreement and therefore all targets are specified in water resource management terms.

E.6 IDENTIFICATION OF WATER RESOURCE TARGETS

The next step in the evaluation process is to specify how water resource management measures can achieve the previously stated multiple objectives. For this purpose, water resource management means or targets must be defined and again the definitions should include measurement parameters that are compatible with those of the broad objectives so that the decision-maker can evaluate the degree to which these objectives have been achieved. Although each water resource management target is primarily conceived as a means of achieving one or other of the multiple objectives, any target could also contribute to other objectives. For example, the target of increasing water supply to increase the net value of agricultural production in the Okanagan

obviously contributes to the economic -development objective, but also may contribute to environmental quality through the preservation of green spaces (diversification of landscapes) and to the social well-being objective through maintaining employment and therefore incomes to family farmers.

It is important to understand at this time that the merit of achieving the water resource targets listed below should be evaluated in terms of all of the multiple objectives. Under the more traditional benefit-cost analysis, targets were evaluated simply in economic terms, i.e. whether they contributed to an increase in net regional (or national) income, and decisions were based upon the performance criterion of maximizing net benefits. Under multiple-objective planning, each target should be evaluated in terms of economic growth environmental quality and social well-being, and decisions will have to be based upon a complicated trade-off performance criteria which hopefully will maximize net social welfare (see section on decision-making).

Listed below is a preliminary statement of water resource management targets, all of which are explicitly or implicitly stated in the Okanagan Agreement:

1. To meet agricultural water supply needs in the Okanagan basin to the year 2020.
2. To meet domestic and municipal water supply needs in the Okanagan basin in the year 2020.
3. To meet industrial water supply needs in the Okanagan basin to the year 2020.
4. To provide adequate water quantity and water quality to satisfy water-orientated recreational demands for the Okanagan basin to the year 2020.
5. To provide all communities and individuals in the Okanagan basin with adequate protection from floods to the year 2020.
6. To provide adequate lake and river levels in the Okanagan basin to support water based transportation.
7. To preserve, protect, manage and enhance fishery and wildlife resources in the Okanagan basin to meet the commercial, sport and aesthetic demands of the people in the basin.
8. To preserve, protect and enhance natural and cultural landscapes in the Okanagan to meet the aesthetic demands of the people in the basin.
9. To provide optimum water quality standards in the Okanagan basin to meet the needs and desires of the people in the basin.
10. To prevent and protect against water induced erosion in the Okanagan basin to the year 2020.

In effect then, water resource targets represent all relevant uses of water resources in the Okanagan basin which may ultimately contribute to the achievement of the multiple objectives. Thus, targets should not be identified until the Consultative Board has agreed to a set of precisely stated, non-overlapping multiple objectives. I see it as a function of the strategic level of decision making, represented by the Okanagan Study Committee to decide upon targets and for them to obtain feedback on these targets from the local agencies and organized groups in the Okanagan.

E.7 SPECIFY SUB-TARGETS AND WATER REQUIREMENTS

As defined at the beginning of this paper, sub-targets are specified elements of targets and are usually related to spatial components of the water resource system. Figure E-2, indicates that an array of sub-targets can only be specified once economic growth studies and other demand studies have been completed and the capability of the existing resource base to meet these demands has been assessed. For example, there may well be a need to improve water quality in the Okanagan basin, but that need will likely vary from one lake to another and therefore specified water quality sub-targets may have to be established to look at each component of the water resource.

Each sub-target must contain specified water quantity and water quality criteria and an appropriate time dimension. Possible qualitative examples of the associated water quantity, water quality, time and space requirements are indicated in Table E.1. In the case of many targets, such as irrigation, recreation and fish and wildlife management, important related land requirements should also be specified. Of course, the physical criteria outlined in Table E-1 only represent part of the evaluation process, for each sub-target would also be evaluated in terms of the multiple objectives to enable trade-offs to be determined when conflicts for scarce resources occur. The crucial step of evaluating sub-targets in terms of the multiple objectives, leads me to a discussion of the concept of benefits and costs, dealt with in thefollowing section.

E.8 IDENTIFICATION OF BENEFITS AND COSTS

Once the sub-targets have been specified in terms of water requirements, projects can be devised under the planning component wherever the existing water (and related land) resources cannot meet these requirements. As defined earlier, projects represent any water resource management means, either structural or non-structural, to meet a sub-target.

TABLE E-1

EXAMPLES OF WATER QUANTITY, WATER QUALITY, SPACE AND TIME DIMENSIONS ASSOCIATED WITH WATER RESOURCE TARGETS

TARGET	WATER QUANTITY REQUIREMENTS	WATER QUALITY REQUIREMENTS	SPATIAL REQUIREMENTS	TIME REQUIREMENTS
Agricultural Water Supply	Acre feet	Appropriate water quality standard	Sub-basin	Monthly irrigation season
Industrial Water supply	Acre feet	Appropriate water quality standard	Sub-basin	Monthly all year
Domestic and Municipal water supply	Acre feet	Appropriate water quality standard	Sub-basin	All year
Recreation	lake levels, stream flows	Appropriate water quality standard	major basins Sub-basin	Monthly all year
Flood control	Lake levels, stream flows	N/A	Sub-basin	Daily all year
Navigation	Lake levels, stream flows	N/A	Sub-basin	Daily all year
Fish and Wildlife	Lake levels, stream flows	Appropriate water quality standard	Sub-basin	Daily all year
Erosion Control	Lake levels, stream flows	Sediment loads	Sub-basin	Monthly all year
Water Quality	Lake levels, stream flows	Appropriate for all uses	Sub-basin	Daily all year
Scenic Aesthetics	Lake levels, stream flows, related land resource	Appropriate water quality for aesthetic demands	Sub-basin	Daily all year

Associated with each project are a number of benefits and costs, each expressed in terms of one or more of the multiple objectives. The important concept of benefits and costs in comprehensive planning is that they only have meaning when they clearly relate to the multiple objectives. Benefits are defined as positive contributions to the attainment of objectives, and costs are defined as negative contributions to specified objectives. Thus, there can be economic development benefits and costs, environmental quality benefits and costs, and social well-being benefits and costs.

Using the example of an agricultural water supply target and its sub-target of supply X acre feet of Y water quality to the Mission Creek sub-basin in the Okanagan, several possible projects may be conceived to meet this demand. For each project, economic benefits may be identified as the net value of agricultural production returned to the additional water supply. In addition, the sub-target will create a number of acres of irrigated landscape, which might be valued by the local public as environmental benefits. On the other hand, if the water in Mission Creek was able to support a sport fishery, should no diversion for irrigation take place, the loss of this fishery must be accounted as an environmental cost and as such weighed against the economic benefits (and other benefits) accruing to irrigation development. Examples of benefits and costs (expressed in qualitative terms at this stage) for possible targets are shown in Table E.2

From the example quoted above, it should be realized that not all of the consequences of alternative projects will be quantified in economic terms, but that there will be other consequences associated with the environmental and social well-being objectives that are often referred to as intangible, non-quantifiable, aesthetic or social impacts. To date these benefits and costs have rarely been explicitly included in decision making, because they have not been quantified in monetary terms and therefore have not appeared in the benefit-cost analysis. Indeed, in many cases, it seems inappropriate to quantify such such intangibles in monetary terms. Therefore, traditional benefit-cost analysis has not been able to weight all the pertinent information in decision-making, and while it may maximize economic returns in resource investment decision, it does not necessarily maximize net social welfare.

Depending upon the definition of the objective, benefits and costs may be expressed in one of the following categories:

1. benefits and costs that are ordinarily valued on the market and can be expressed in monetary terms,
2. benefits and costs that are not valued on the market but can be expressed in quantitative units, e.g. physical units (number of fish) or social units (employment opportunities).

TABLE E-2

EXAMPLES OF BENEFITS AND COSTS ASSOCIATED WITH WATER RESOURCE TARGETS

TARGET	ECONOMIC GROWTH	ENVIRONMENTAL QUALITY	SOCIAL WELL BEING
Agricultural water supply	Increased or more efficient production of agricultural output; secondary benefits.	Landscape diversity; fruit picking experience; eco-system management.	Diversified economy; family farm income; rural development; stabilization of incomes.
Industrial water supply	Increased or more efficient industrial output; secondary benefits.	Water quality deterioration; aesthetic benefits or costs.	Benefits accruing to identified disadvantaged groups.
Municipal Water supply	Service to increased population; land value enhancement	Lawn sprinkling; golf courses; open spaces; urban parks; water quality deterioration.	Urban crowding; health and sanitation costs.
Recreation	Expenditure impact on regional economy; land value enhancement.	Aesthetics of recreation enjoyment; expansion of recreational choice, overcrowding of facilities.	Increased opportunity for identified disadvantaged groups.
Flood Control and Management	Reduction of flood damage to existing and future facilities; land value enhancement; secondary benefits; economic opportunity costs.	Erosion control; aesthetic value of land-zoning; impacts upon eco-systems.	Increased feeling of security; stabilization of incomes and opportunity
Navigation	More efficient transportation of goods	Impact on eco-systems.	
Power	Market value of power supplies	Aesthetic impacts, impacts on eco-systems.	Stabilization of incomes of certain groups.
Fishery and wildlife protection and/or management	Expenditures of recreationists; commercial value of fishery and wildlife resource; more efficient resource productivity; economic opportunity costs.	Aesthetic value of hunting and fishing; wilderness values; landscape diversity	Increased recreational opportunity for certain disadvantaged groups, more diversified economy; option values.
Erosion Control	Improved resource productivity; land enhancement.	Water quality improvement; aesthetic impacts; landscape diversity.	
Preservation or enhancement of aesthetic landscapes.	Economic opportunity costs foregone; recreational expenditures.	Aesthetic enhancement; wilderness values; landscape diversity.	'Option' values.
Water Quality Standards	Economic opportunity costs; increased resource productivity.	Aesthetic impacts; increased choice of water uses.	Health hazard control; increased opportunity for 'latent' recreational demand for certain groups.

3. benefits and ts that cannot easily be quantified, and are expressed qualitative description or a social preference i.

Obviously, in a ehensive analysis of the effects of water resources development, some bas st be established for evaluating and communicating to the decision make the monetary and non-monetary consequences of alternative projects an mately of alternative comprehensive plans. To establish this, four tant aspects of the problem should be considered. These are (a) the q cation and separation of monetary and non-monetary consequences measur rms of the multiple objectives; (b) the viewpoint of the decision-mak the inter-personal distribution of benefits and costs and (d) the od of analysis.

E.8.1 Quantification

If alternati be compared in a rational manner, their relative advantages and d s must be quantified. As has been stated before, the units for qu n should be stated in the multiple objectives, and impacts of each should be measured and evaluated in these units wherever possib per does not detail how the environmental and social well-being unit defined, but Bishop (1970) has developed a scheme of 'factor pro enable the monetary and non-monetary consequences to be weighted other and to allow trade-offs between alternatives.

E.8.2 Viewpoint

The spati from which project and comprehensive plan impacts e evaluated ntal importance, especially as comprehensive river sin agreemen under the Canada Water Act* may involve both federal d provincia The viewpoint for evaluating the positive (bene- s) and neg impacts of water resource plans may well differ ween the r ncial and federal levels of government. For example, as the d f augmenting the supply of water into the Okanagan ey - a pu locate in the basin, then from a regional viewpoint economic efits and costs to the regional economy stemming the mil ributable to the increased water supply. If however, ill woul elsewhere in British Columbia, then from a Provin- viewpoi or costs accrue to the Okanagan as the decision of ill to kanagan simply becomes a re-allocation of resources the arly, from a national viewpoint, if the alternative n of cur elsewhere in Canada, then again the decision to n B represents only a re-allocation of resources.

l; for l roup.

nt was signed in October 1969, prior to that of came into effect in May 1970.

The problem of viewpoint may also be important at a regional level as the Okanagan Basin Agreement explicitly states that the evaluation of alternatives will be expanded to cover impacts on neighbouring areas. Thus, if improved water quality stimulates the recreation potential of the Okanagan basin and captures a demand that would otherwise have moved to the Shuswap watershed, then these recreational opportunities foregone in the Shuswap should be included as a cost in the evaluation matrix.

It is also likely that as the viewpoint adopted in the analysis broadens, some of the secondary effects tend to cancel each other out. For example, secondary benefits accruing to increased agricultural production such as an expansion in fruit processing industry may be a re-allocation of resources that may otherwise have located in the Niagara Peninsula in Ontario. Generally speaking, as the spatial scope of the analysis increases, evaluation of plans tends to rest more directly with primary benefits and costs and is less concerned with secondary effects.

E.8.3 Inter-Personal Distribution of Benefits and Costs

The distribution of benefits and costs from any project and the redistribution of opportunities are important considerations, especially because the multiple objective function explicitly identifies these impacts in terms of per capita net income, employment and other opportunities. Not only should these redistribution effects be identified and quantified, however, but the decision-makers must measure what value society places upon the distribution of gains and losses. This principle emphasizes the importance of a broadly based institutional structure interacting on decision-making. If the analysis were to be restricted only to the local level, Okanagan residents will obviously prefer any plan that increases their welfare at the expense of other regions. Thus, this approach will represent the weighting placed on redistribution of opportunity by Okanagan residents, but not by all British Columbians or by all Canadians. Obviously, provincial and federal decision-makers will have to provide their own weightings from their respective viewpoints before a decision can be made.

E.8.4 The Time Period

When analysing the alternatives the distribution of benefits and costs over time should also be taken into account (O'Riordan, 1970). An appropriate discount rate must be determined and applied to all benefits and costs, though changes in the relative value of outputs should be given special consideration. Thetime period of analysis should be carefully chosen to avoid biasing either short or long term effects unduly.

It is worth mentioning here that both the spatial viewpoint and time period or horizon will drastically affect the analysis in selecting and evaluating the benefits and costs of alternative plans. Both of these variables need to be clearly specified before the variables are quantified, and probably a complete evaluation will require sensitivity analysis in which a number of analyses are performed for each plan using different viewpoints and planning horizons.

E.9 EVALUATION OF ALTERNATIVE PLANS

Once a number of projects have been identified and their impacts on the water resource and social system of the Okanagan assessed, the institutional agencies should aggregate a number of projects into a comprehensive plan that represents an integration of water management and development alternatives to achieve the multiple objectives. At this point, an evaluation matrix, based on the goals-achievement matrix developed by Hill (1967) is proposed as the necessary tool to implement comprehensive evaluation analysis of alternatives.

A conceptual model of an evaluation matrix for one alternative plan is now presented (Table E.3). To develop the model, the following information is required:

1. A set of functional objectives - $O_1, O_2, O_3 \ldots . O_i$
2. An agreed system of weights for each objective

   $W_1, W_2, W_3, \ldots . W_i$ (see section on decision-making)
3. A set of targets and complimentary water resources needs to achieve the objectives $T_1, T_2, T_3 \ldots . T_n$
4. A set of sub-targets to achieve each target

   $T_{11}, T_{12}, \ldots T_{ij}; \; T_{21}, T_{22}, \ldots T_{2m} \ldots T_{i2} \ldots T_{in}$
5. A set of water resource projects to achieve one or more sub-targets.

   $P_{111}, P_{112} \ldots P_{ijk}$; etc.
6. A complete account of benefits and costs measured in terms of the achievement of a target for each objective.

   $(B_{111}, B_{112} \ldots B_{ijk}); \; (C_{111} \ldots C_{ijk})$
7. In some cases, benefits and costs may be represented by expected values or a range of values to account for risk and uncertainty.
8. The incidence of benefits and costs on each relevant group in the community and the relative weight attached to each group.

In the table, a vector of targets (T_n) is established to achieve all of the multiple objectives to be attained by water resource management. For

example, one such target - say T_1 - might be to meet demand for agricultural water supply in the Okanagan basin to the year 2020.

There may be a number of sub-targets (T_{1j}) to meet sub-basin requirements for T_1, such as the development of agricultural water supply in the Mission Creek watershed to meet future agricultural water demands in that watershed.

For each sub-target, T_{1k}, there may be a number of alternative methods of supplying the water, both structural solutions (reservoirs, groundwater wells) and for the managerial solutions (pricing of water, water licence transfers). These alternative methods are represented by a vector of projects (P_{11k}) for target T_{11} and vector (P_{121}) for target T_{12} and so on. Associated with each project are benefits and costs, which may be defined in monetary, other quantitative units or in qualitative terms as appropriate. The vector (B_{11k}) represents the benefits associated with projects (P_{11k}) required to meet sub-target T_{11} and the vector (C_{11k}) represents the costs associated with implementing these projects.

The external and/or joint benefits and costs associated with any project that directly or indirectly affect values associated with other objectives are also noted in the evaluation matrix. In the example described above, T_{11} was defined as the need to supply agricultural water in the Mission Creek sub-basin; P_{111}, P_{112} . . . P_{11k} are various storage reservoirs and groundwater wells that could be developed to supply the water; B_{111}, B_{112} . . . B_{11k} are benefits due to increased or more efficient agricultural production, C_{111}, C_{112} . . . C_{11k} are the costs of constructing and operating the reservoirs or wells and C_{2111} is the external cost resulting from the fact that project P_{111} destroys a potential sports fishing resource.

All direct and indirect social costs and benefits are recorded according to the relevant objective. A dash in a cell implies that no cost of benefit is related to that objective if the associated project is implemented. The major advantage of this accounting system is that all effects - internal and external - are explicitly shown according to their appropriate objective. Although for certain objectives all benefits and costs might be in the same units and therefore can be summed and compared, in most cases, the benefits and costs will be in different units which will make a grand benefit-cost summation impossible.

An evaluation matrix such as the one shown conceptually in Table E-3 should be prepared for each alternative plan. Because the measurement units of benefits and costs in each cell will be similar, it should be possible to directly compare and therefore, rank these alternative plans.

TABLE E.3

GENERAL EVALUATION MATRIX

PLAN A

	OBJECTIVE O_1 REL. WEIGHT W_1				O_2 W_2				O_i W_i			
TARGET	SUB-TARGET	PROJECT	BENEFITS	COSTS	SUB-TARGET	PROJECT	BENEFITS	COSTS	SUB-TARGET	PROJECT	BENEFITS	COSTS
T_1	T_{11}	P_{111}	B_{111}	C_{111}			B_{2111}	C_{2111}			-	C_{i111}
		P_{112}	B_{112}	C_{112}			-	-			-	-
	T_{12}	P_{121}	B_{121}	C_{121}			-	-			B_{i121}	-
		P_{122}	B_{122}	C_{122}			B_{2122}	-			-	-
	T_{1j}	P_{1j2}	B_{1j2}	C_{1j2}			-	-			-	-
		P_{1jk}	B_{1jk}	C_{1jk}			B_{21jk}				-	C_{i1jk}
T_2			-	-	T_{21}	P_{211}	B_{211}	C_{211}			B_{i211}	-
			B_{1212}			P_{212}	B_{212}	C_{212}			-	C_{i212}
			-	C_{1221}	T_{22}	P_{221}	B_{221}	C_{221}			-	-
			-	C_{1222}		P_{222}	B_{222}	C_{222}			B_{i222}	-
					T_{2m}	P_{2m1}	B_{2m1}	C_{2m1}				
			B_{12m}			P_{2m}	B_{2m}	C_{2m}			-	C_{i2m}
T_i			-	C_{1i11}			-	-	T_{i1}	P_{i11}	B_{i11}	C_{i11}
			-	C_{1i12}			-	-		P_{i12}	B_{i12}	C_{i12}
			-	-			-	C_{2in1}	T_{in}	P_{in1}	B_{in1}	C_{in1}
			B_{1in2}	-			B_{2in2}	-		P_{in2}	B_{in2}	C_{in2}
			-	C_{1inp}			-	-		P_{inp}	B_{inp}	

E.10 DECISION-MAKING IN MULTIPLE OBJECTIVE PLANNING

The application of the evaluation matrix approach in comprehensive planning has a number of important implications on the institutional component of the planning process, the most important being the need to develop a new strategy for decision-making. In the past, under cost-effectiveness and benefit-cost analysis, decision-making was effected by the choice of the least costly alternative or by the largest benefit-cost ratio and few additional factors were taken into consideration. Even under the more elaborate economic analysis undertaken for multi-purpose planning, decision-makers were asked to compare and 'trade-off' between different outputs (irrigation, flood control, etc), all of which were expressed in the same unit - namely dollars.

This concept of multiple-objective planning complicates the decision making process because economic benefits expressed in monetary terms have to be compared and weighed against social and environmental benefits which are not necessarily expressed in monetary values. Thus, the key to plan evaluation is to devise a rational weighting system so that all objectives can be compared simultaneously. In addition, the decision making strategy should also accommodate incremental analysis whereby the decision-maker can assess the impact of marginal adjustments in project size or resource use. In like manner, provision should be made in the evaluation of each major alternative plan to assess the contribution of each individual project to the achievement of objectives on a sequential or incremental basis. In this way, various contributions or projects could be examined to determine which combination will make the largest contribution to net social welfare.

Theoretical trade-off functions have been developed by some economists (Marglin 1967, Major 1970), but in practice it is doubtful whether these can actually be established. Furthermore, because decision-making will involve both senior levels of government, the local levels of government and the public itself, it seems inappropriate to attempt to devise complex trade-off functions. A more practical strategy based on the theory of games appears to be more appropriate whereby each participant in the decision-making process develops his own weighting system and then approaches the other participants with a bargaining position. In the likely event that the different levels of government will present different weighting functions, a process of bargaining should be initiated to resolve this initial conflict, based on the principle that all sides may have to give ground in order to gain ground.

Gains are made incrementally, and realized only slowly with the objective of the game to achieve what is desirable by searching for consensus between all parties (Chevalier, 1969).

This approach to decision-making is relatively untried in basin planning and will require a great deal of commitment and understanding on the part of the decision-makers as well as a strong linkage with the public through a well-organized public participation programme before it will be effective.

E.11 CONCLUSION

Social welfare is defined in this paper as a combination of economic, environmental and social objectives. The traditional concept of benefit-cost analysis based upon the superiority of the market place under competitive conditions as a dominant measure of value will not be a suitable performance criterion to achieve maximum social welfare. It is most likely to approximate the achievement of maximum economic welfare for those projects whose outputs have well-defined benefits and costs subject to monetary evaluation, but it appears likely to be an inefficient resource allocation tool for those projects where environmental and social well-being objectives are explicitly stated.

Because society has a definable welfare function when its values can be expressed according to the market mechanism (real or simulated), benefits and costs will be quantified in monetary terms wherever possible. But it is recognized that society does not have a clearly defined welfare function for certain environmental quality and other social values, as indicated by conflicts over local recreational and environmental issues.

The professional analyst has no right to dictate these values, but instead must attempt to determine more accurately society's well-being and environmental preferences and values. Optimum social welfare can be achieved through successive trade-offs between the three broad objectives according to economic, social and political criteria.

The evaluation and decision-making process is complex, but that is in keeping with the concept of comprehensive planning. While the approach chosen in this paper does not result in a single number outcome, as in the case of the more traditional benefit-cost analysis, it is more responsible to the complexity of the consequences of comprehensive river basin planning.

E.12 SUMMARY

This paper outlines the processes that will be used to evaluate alternative plans in the Okanagan Basin Study. The paper describes the main principles that affect the process of evaluation and indicates in theory how an evaluation matrix can be established to choose between alternative plans. The main findings of this report are summarized below:

1. The Okanagan Basin Study represents a new strategy for river basin planning in Canada, based upon the concept of multiple objective-multiple means planning.

2. The multiple objectives of the study are not clearly and precisely stated inthe Agreement, but appear to include economic development, environmental quality and social well-being objectives. More precise definitions of these objectives together with the measurement of parameters required to assess them are presented.

3. The paper recognizes that water resource management is only one policy alternative for achieving the multiple objectives of the Study. A number of proposed water resource targets or management means are defined which can contribute to all or part of the multiple objective function.

4. Benefits and costs of alternative plans are directly related to the defined multiple objectives. Therefore there may be economic, environmental and social benefits and costs related to each water management alternative.

5. When possible, all benefits and costs will be quantified, but only those directly related to the economic objective will be expressed in dollar values. However, social and environmental benefits and costs will be explicitly accounted in the evaluation matrix.

6. The spatial viewpoint from which the impacts of plan development can be evaluated is important and the implications of chosing the Okanagan region, British Columbia or Canada as a whole are discussed.

7. The distribution of benefits and costs of alternative plans between individuals and groups in the valley is discussed and a system of weighting the distribution of these gains and losses is emphasized.

8. A theoretical evaluation matrix which can account the economic, social and environmental benefits and costs of alternative water management plans is described and discussed. The paper emphasizes that this tool is required to replace the traditional benefit-cost analysis if the multiple objectives of this study are all to be achieved.

9. The implications of the use of an evaluation matrix upon decision-making are brought out, and the crucial importance of devising a rational weighting system with which to trade-off between the multiple objectives is emphasized.

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APPENDIX F

PRELIMINARY SELECTION OF WATER QUANTITY ALTERNATIVES IN THE MAINSTEM OKANAGAN LAKE AND RIVER SYSTEM TO MEET PRESENT AND FUTURE DEMANDS

(Reprint of Preliminary Report on Task 23)
Canada-British Columbia Okanagan Basin Agreement

This task was directed by Dr. H. Hill,
of Harry Hill Consulting Limited, Kitchener,
Ontario, and the report prepared by J. O'Riordan,
Okanagan Study Committee, dated March 1972

PREFACE

This summary report was prepared for two reasons. First, it does set out a number of alternative ways for managing water quantity in the mainstem Okanagan system. Although the analysis is too preliminary to allow definite decisions to be made, full implications of each selected alternative are discussed and areas for further study are identified.

Second, the report does illustrate in some detail the planning and evaluation procedures which have been devised by the Okanagan Study Committee to meet the rigorous challenge of comprehensive planning. As the Study Committee intends to use this evaluation procedure in future analyses of water quantity and water quality alternatives in various components of the Okanagan water resource system, it is being presented to the public for examination and comment. For those more interested in the first objective only, viz. a statement of the problem and analysis of selected water quantity alternatives, pages 15 to 30 inclusive may be omitted.

Finally, it must be emphasized that this report only contains an analysis of a limited number of water quantity alternatives in the mainstem Okanagan and consequently does not represent a comprehensive plan for water resource management in the Okanagan. Such a comprehensive plan will eventually integrate water quantity alternatives in the mainstem system with water quality management alternatives in selected tributaries. The Okanagan Study Committee proposes to release other summary reports containing preliminary studies of water management alternatives in various tributaries and a re-run of the analysis of mainstem alternatives incoroporating water quality management. These reports will be released during the summer and fall of 1972 for public review and comment so that the final comprehensive plan will "reflect the desires and preferences of the people for which it is designed" (Okanagan Basin Agreement).

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APPENDIX F

PRELIMINARY SELECTION OF WATER QUANTITY ALTERNATIVES IN THE MAINSTEM OKANAGAN LAKE AND RIVER SYSTEM TO MEET PRESENT AND FUTURE DEMANDS

F.1 INTRODUCTION

The Okanagan Basin Agreement represents a new strategy for river basin planning in Canada based on the concept of multiple objective planning and includes a more comprehensive approach to the evaluation of alternative plans to achieve the specified multiple objectives than traditional benefit cost analysis. Because the Okanagan Study Committee had identified water quantity problems in the mainstem of the Okanagan lake and river system, it was decided to undertake a preliminary analysis of a number of alternative plans for managing water supply in the mainstem to test this comprehensive evaluation approach.

It should be emphasized at the outset that this report only presents a preliminary analysis of water quantity alternatives for the mainstem system comprising of Okanagan, Skaha, Vaseux and Osoyoos Lakes and Okanagan River. It does not include an analysis of the adequacy of existing tributary flows to meet present and future water demands within each tributary watershed. Because of the inter-relationships between tributary flows and the operation of the mainstem system, improved analysis of the results will have to await an integration of tributary and mainstem water quantity management alternatives.

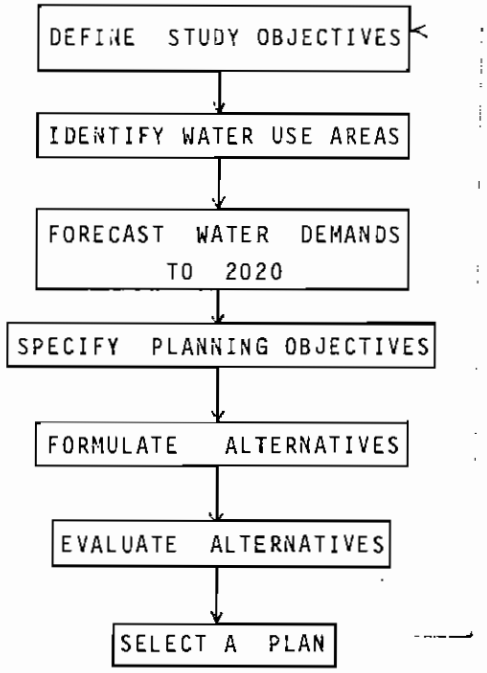
The report begins with a brief review of the planning process and then describes existing procedures for managing water quantity in the mainstem Okanagan. Following the specification of planning objectives, a number of assumptions and constraints used in the formulation and analysis of alternatives to achieve these planning objectives are described. A brief review of estimated water demands (both consumptive and non-consumptive) within the mainstem system to 2020 is then presented. The development of a computer model to analyse and evaluate alternatives is examined and finally a procedure for systematically evaluating formulated alternatives in terms of established objectives is discussed.

F.2 REVIEW OF THE PLANNING PROCESS

The main steps in the planning process are shown in Figure F.1, below:

FIGURE F.1

PLANNING PROCESS



The first step involves the definition of the major study goals of economic growth and social betterment, as these goals establish the set of human values with which decision makers can assess whether society as a whole is better or worse off. The major study goals have been further defined as economic growth, environmental quality and social well-being (provision of equal opportunity for all groups and individuals in the valley) and this re-definition was accepted in principle by the Consultative Board in October, 1971.

Within the context and scope of the Okanagan Basin Agreement, the set of values outlined in the study goals can only be realized through man's use of the water resource. In the case of mainstem Okanagan, these water uses include consumptive demands for agricultural, municipal and industrial purposes as well as non-consumptive uses for recreational, aesthetics, fishery and wildlife demands and transportational purposes.

The third step in the planning process is to forecast demands for both consumptive and non-consumptive uses of water to 2020. With these forecasts, a

set of planning objectives within the context of each major user area are specified. These planning objectives relate to factors of water resource management in each user area that it would seem desirable to improve, protect, maintain or avoid. To indicate the degree to which these objectives are achieved (or foregone), each planning objective must be clearly specified in terms of identity, place, time and magnitude of water quantity requirements.

Once a set of planning objectives in each user area has been defined and specified, alternative ways of managing the water resource system which will contribute to the achievement of these objectives, are devised within established constraints.

The various alternative plans can then be evaluated according to a two-stage process. First, the physical and biological impact of each plan or project upon the relevant planning objectives must be assessed. Second, these impacts must be evaluated in terms of the set of value premises established by the three broad study objectives. In theory, the establishment of priorities among the planningobjectives and a relative weighting of the three broad study objectives is necessary before the second stage of the evaluation process can be completed. In practice, neither the study goals nor the planning objectives were ranked so the evaluation process involved little more than physical impact analysis.

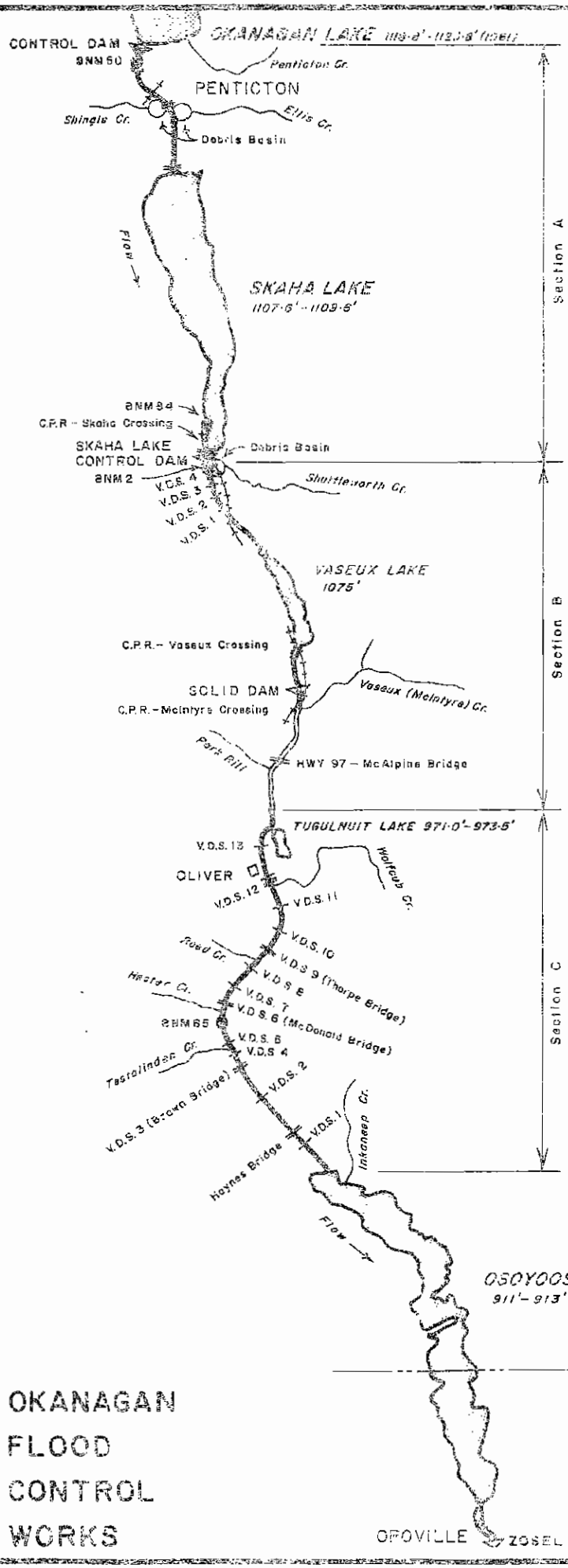
F.3 DESCRIPTION OF MAINSTEM OKANAGAN SYSTEM

This report deals with management alternatives for the mainstem Okanagan water resource system which includes the regulation of Okanagan, Skaha, Vaseux and Osoyoos Lakes (all of which are controlled by existing dams) and the effects of such operations on Okanagan River flows in Canada. Because a major proportion of the inflow to this system originates on tributary watersheds to Okanagan Lake, the mainstem can be conveniently divided into two regions:

(a) The Okanagan Lake Region upstream from Penticton dam and
(b) The Okanagan River Region from Penticton to the U.S. border (See Figure F-2).

F.3.1 Okanagan Lake Region

The total available water supply to Okanagan Lake Region is called the net virgin inflow. It is calculated as the observed net historic inflow to the basin plus consumptive use in irrigation, domestic-municipal and industrial use. The observed net historic inflow is calculated as the discharge of Okanagan River at Penticton dam plus change in Okanagan Lake storage as measured by change in lake levels at Kelowna and Penticton and has averaged 355,000 acre feet annually over the 50 years of record (1921-1969 inclusive). This net



ELEVATION RELATIONSHIPS FOR OKANAGAN LAKE DAM AT PENTICTON			
OPERATING LEVEL	PUBLIC WORKS CANADA DATUM	GEODETIC DATUM 1934	GEODETIC DATUM 1961
HIGH	102·5	1103·2	1125·6
LOW	98·6	1119·2	1119·6
EMERGENCY LOW	97·6	1118·2	1118·6

NOTE
SECTIONS A, B and C ARE MAJOR CONTRACT AREAS WITH REFERENCE TO OKANAGAN FLOOD CONTROL WORKS CONSTRUCTED 1950-1955.
IMPROVED CHANNEL SHOWN IN HEAVY LINE.

OKANAGAN FLOOD CONTROL WORKS

Figure F.3

inflow fluctuates widely, however, ranging from 730,000 acre feet in 1948 to 90,000 acre feet in 1930. Annual consumptive use in the Okanagan Lake basin has increased over the period of record totalling some 75,000 acre feet in 1970 with the result that the average net virgin inflow is approximately 400,000 acre feet annually. For below average inflow years, i.e. when net historic inflows are less than 355,000 acre feet, it is assumed that all irrigation demands in tributary watersheds around Okanagan Lake will not be met and consequently a reduction factor varying from 0.4 for extreme drought years to 1.0 in average years is applied.[2]

The Okanagan Lake surface covers 84,200 acres and is controlled by the dam at Penticton over a normal range of 4 feet (1123.8 feet to 1119.8 feet G.D.) for a storage capacity of 340,000 acre feet. Under the Okanagan Flood Control Agreement, the lake can be lowered an extra foot to 1118.8 feet to supply a total storage of 420,000 acre feet.

F.3.2 Okanagan River Region

Almost the total supply of water available for consumptive and non-consumptive uses downstream from Penticton is supplied by release of water from Okanagan Lake into Okanagan River. The river channel has been modified to serve multiple uses as part of the Okanagan Flood Control Project, undertaken by the Federal and Provincial governments between 1952 and 1958 under the Okanagan Flood Control Act.

To provide flood control, the river channel is modified over most of its course to the U.S. border. A four mile section immediately south of Vaseux lake has been preserved in a near natural state as spawning habitat for Columbia River sockeye salmon. The design capacities of the improved channel vary from 2100 c.f.s. at Penticton to 3400 c.f.s. at the inlet to Osoyoos Lake, but from experience it has been found that such discharges cannot be sustained for long periods due to downstream constraints. As this report deals with monthly discharges only, the assumption was made that only 80 percent of design channel capacity can be realized in any month.

The Okanagan River also provides water for irrigation, domestic and municipal use and supports important anadromous and sports fisheries and wildlife resources. To serve these multiple purposes, the flood control system includes a number of drop structures which control erosion and 'pool' the river in the summer months to facilitate diversions for irrigation and domestic use. Each structure in the lower reach below Oliver is served with fish passage facilities. During the freshet months of April to June, the system is operated for flood control, but in the summer, stop logs are placed manually on the drop structures to 'pond-up' water for irrigation intakes and to supply licenced irrigation intakes in natural ox-bows, which lie adjacent to the artificial

[2] T.A.G. Leach, "Okanagan Basin Inflow Determinations" B.C. Water Resources Service, September 1970.

channel. After completion of the Okanagan Flood Control project in 1958, the B.C. Department of Highways carried out the operation and maintenance of the works for several years. However, the system is now financed and maintained by the B.C. Water Resources Service, although the Department of Highways staff still undertake field operation of the project.

F.3.3 Operation of the System

There are two distinct phases in the operation of the Okanagan Lake and River system. During the spring freshet, Okanagan Lake is operated as a flood control reservoir, while for the remainder of the year the operation is concerned with the conservation of storage to supply downstream demands.

In normal years, Okanagan Lake is drawn down to approximately 1120.0 feet in March to accommodate the spring freshet. Because of the high annual variability of inflows each year, forecasts of net inflows are made by the B.C. Water Resources Service based on snow survey and precipitation data. Okanagan Lake levels are adjusted according to these forecasted runoffs with the objective of raising the lake level as close as possible to its maximum elevation of 1123.8 feet at the end of each freshet thus avoiding flooding but also providing sufficient storage for water supplies throughout the rest of the year.

Due to average high inflows over the past 15 years, Okanagan Lake has been controlled within its normal four foot range. In fact, annual fluctuations have been approximately three feet. As indicated in Appendix G.3, small fluctuations in Okanagan Lake levels are desired by shoreline users. On the one hand, high water levels would result in little economic damage - approximately $600,000 should the lake rise two feet above its maximum elevation, but there would be considerable social and environmental costs such as flooded basements and septic tanks, inundation of docks, marinas, recreation sites and wildlife habitats. On the other hand, although low water levels below a minimum elevation of 1119.8 feet would also result in small economic costs ($6,000 at 1116.8 feet)[3], significant environment costs could occur. These include the exposure of shoreline around many developed areas, notably Kelowna and the Vernon Arm, dessiccation of wildlife habitats, possible obstructions to sports fishery access to tributary streams and reduction in the quality of recreation facilities. It is assumed that all existing consumptive water demands supplied directly by the lake could be met at minimum levels of 1116.8 feet.

Present (1971) water demands in the Okanagan River Region are detailed in Table F-1. Under present operating conditions, downstream discharges at Oliver must equal or exceed 300 c.f.s. during the irrigation season, May to September inclusive to enable all intakes to operate efficiently.

[3] This figure does not include possible costs of adjusting the Kelowna floating bridge to withstand extremely low lake levels.

TABLE F.1

RECOMMENDED FLOWS IN OKANAGAN RIVER DOWNSTREAM OF VASEAUX LAKE

MONTH	FISHERY REQUIREMENTS			MINIMUM FLOWS FOR DOWNSTREAM CONSUMPTIVE USES C.F.S.[6]	TOTAL MINIMUM[6] C.F.S.
	MINIMUM[4] C.F.S.	MINIMUM[5] C.F.S.	MAXIMUM[5] C.F.S.		
April	170	175	1000	300	300
May	-	-	-	300	300
June	-	-	-	300	300
July	-	-	-	300	300
August	-	300	450	300	300
September	250	300	500	300	300
October	250	250	500	100	250
November	170	175	1000	100	175
December	170	175	1000	100	175
January	170	175	1000	100	175
February	170	175	1000	100	175
March	170	175	1000	100	175

[4] "Report on Fisheries Problems Associated with Proposed Diversion of Water from Shuswap River to Okanagan Lake" by Canada Department of Fisheries and International Salmon Fishery Commission in collaboration with B.C. Fish and Wildlife Branch, August 1969. These flows were used in this preliminary evaluation.

[5] Appendix C1 - Fishery Evaluations - These revised flows were prepared by the Federal Department of Environment in September 1971 and will be incorporated into a re-run of the evaluation, to test if such changes are significant.

[6] T.A.G. Leach, "Okanagan Basin Inflow Determinations" B.C. Water Resources Service, Victoria, September 1970. Minimum annual water requirements for the Okanagan River Region to meet both consumptive and non-consumptive uses total 180,000 acre feet.

In-channel use for sockeye salmon requires 300 c.f.s. during spawning from August to October and 175 c.f.s. during incubation and migration from November to April.[7] Such flows are also required to meet demands by sport fisheries and wildlife eco-systems in the channel and ox-bows respectively.

F.3.4 Definition of the Problem

In normal inflow years (200,000-500,000 acre feet) there is enough water to supply both the range of demands around Okanagan Lake for water supply, recreation, navigation and aesthetics, and to allow releases of water down Okanagan River for water supplies, aesthetics and minimum flow requirements. In low inflow years however, not all these demands can presently be met. Either Okanagan Lake must fluctuate outside its normal operating range, or water releases into Okanagan River must be reduced below those specified in Table F.1 with resultant costs to consumptive and/or non-consumptive users.

During the 1970-71 inflow year, for example, net inflow after consumptive use around Okanagan Lake had been satisfied totalled approximately 96,600 acre feet compared with the minimum recorded net inflow of approximately 80,000 acre feet in 1930[8]. Okanagan Lake level dropped to 1121.5 feet in November 1970 and consequently, releases into Okanagan River were reduced to 100 c.f.s. during the winter months in order to conserve water. These flows did reduce spawning and incubation opportunities in Okanagan River and may have resulted in as much as a 50 percent mortality. In addition, undocumented problems to sports fishing and wildlife resources probably also have occurred. It should be noted that without the present modifications to Okanagan River, natural flows might have been reduced to zero resulting in greater fish mortality.[9] Obviously, these problems and conflicts will intensify if smaller net inflows should be experienced such as those that occurred during the 1929-31 period,[10] or if consumptive demands should increase in the future.

In summary, water quantity management in the mainstem Okanagan system must attempt to satisfy a wide range of demands, not all of which can be met under present operating practices in low inflow years. Will this situation worsen in the future? Are there alternative ways of managing the system, and if so what are their costs and benefits? Preliminary answers to these questions are contained in the following sections of this report.

[7] Flows to meet fishery requirements in Okanagan River used in this study are slightly different from the ones used in the final evaluations, but are those listed in the "Report on Fishery Problems Associated with Proposed Diversions of Water from Shuswap River to Okanagan Lake". Ibid (See footnotes 4 and 4 under Table 1).

[8] Under present levels of irrigation and municipal demand, this net inflow would be reduced.

[9] Personal Communication, T. Willcocks, Fisheries Service, Department of Environment.

[10] The frequency of a drought of this magnitude is unknown, but is probably less than once in 50 years.

F.4 FUTURE WATER DEMANDS

Projected demands of consumptive water use for irrigation, domestic and industrial purposes were based on preliminary estimates [11] and [12] for this evaluation (Tables F-2 and F-3), and it was assumed that non-consumptive demands would remain unchanged.

These projections, predicted a relatively moderate increase in total water withdrawals from 225,000 acre feet in 1970 to 351,000 acre feet in 2020 and a smaller relative increase in consumptive use from 102,000 acre feet at present to 132,000 acre feet in 2020. This relatively small increase in consumptive use is based on a predicted transfer of water from irrigation use which consumes approximately 50 percent of the total water withdrawn for that purpose to municipal and industrial uses that consume less than 30 percent of water withdrawals for these purposes. Due to increasing competition for limited land resources, it was assumed that in lieu of zoning regulations, land use in the future would move toward higher valued uses. These forecasts might change considerably if government policy was orientated towards preserving agricultural lands through zoning regulations, tariffs, or improved technologies in irrigation systems.

It was further assumed that all forecasted demands in the Okanagan Lake region would be met either by diverting from tributary streams or by direct withdrawals from Okanagan Lake, regardless of pumping costs[13]. Thus, no reduction factors were applied to forecast demands even in extremely low inflow years.

Future development in irrigated agriculture was based upon market criteria only. Should Indian lands surrounding Okanagan Lake be developed, consumptive demand may be larger than indicated above and the analysis would have to be re-run.

F.5 SPECIFICATION OF PLANNING OBJECTIVES

As noted in the Introduction, planning objectives are specified according to their time, place, and water quantity characteristics for each major water use in the mainstem system. Examples of such planning objectives for Task 23 are shown in Table F.4. Table F.4 emphasizes one of the main features of comprehensive planning - namely, the systematic analysis of a wide range of objectives which together help to improve society's welfare.

[11] O'Riordan, J. "Preliminary Estimates of Future Water Demands in the Okanagan Basin," Water Planning and Operations Branch, Department of the Environment, Vancouver, April 1971.

[12] "Department of Industrial Development, Trade and Commerce", an economic survey of the Okanagan and Shuswap Regions", Task 201, Queen's Printers, Victoria, B.C., April, 1971.

[13] For the purposes of this preliminary analysis, this traditional constraint of meeting all consumptive demands was met. Further analysis of this Task should examine the implications of not meeting this constraint.

TABLE F.2

PROJECTIONS OF WATER WITHDRAWALS FOR ALL USES BY REGION FOR SELECTED YEARS, 1970 - 2020

(Acre Feet)

REGION	1970	1980	1990	2000	2010	2020
North Okanagan	9,830	12,240	15,060	18,380	24,400	29,710
Okanagan Lake	155,580	191,180	210,020	234,050	246,100	264,330
Okanagan River (S.O.L.I.D. North)*	10,250	9,800	9,100	8,500	8,300	8,800
Okanagan River (S.O.L.I.D. South)*	49,910	49,020	47,800	48,230	47,620	48,140
TOTALS	235,570	262,240	281,980	309,160	326,420	350,980

TABLE F.3

PROJECTIONS OF CONSUMPTIVE USE FOR ALL USES BY REGION FOR SELECTED YEARS, 1970 - 2020

(Acre Feet)

REGION	1970	1980	1990	2000	2010	2020
North Okanagan	4,660	5,630	6,770	8,020	10,730	13,030
Okanagan Lake	68,110	78,360	81,480	85,610	87,930	92,250
Okanagan River (S.O.L.I.D. North)*	5,170	4,750	4,350	3,990	3,830	4,000
Okanagan River (S.O.L.I.D. South)*	24,360	23,570	22,910	22,910	22,300	22,450
TOTALS	102,300	112,310	115,140	120,530	124,790	131,730

*S.O.L.I.D. South Okanagan Lands Irrigation Diversion Dam, near Oliver, B.C.

TABLE F4

EXAMPLES OF PLANNING OBJECTIVES FOR USER AREAS IN MAINSTEM OKANAGAN

PLANNING OBJECTIVES	WHERE	WHEN	HOW MUCH	WHO OR WHAT
A - Agricultural Use				
1. Maintain water supplies to existing and projected irrigated land to 2020.	Okanagan Lake Region	April to September inclusive	37,000 ac.ft. 1970 25,000 ac.ft. 2020	
	Okanagan River Region	April to October	31,000 ac.ft. 1970 23,400 ac.ft. 2020	
2. Expand agricultural acreage and provide adequate water supplies	North Okanagan (Vernon-Enderby)	Projected to 2020	19,740 acres 35,500 ac.ft.	
	Shuswap Area	Projected to 2020	9,510 acres 17,118 ac.ft.	
3. Improve efficiency of water use	Okanagan River Region	April to September inclusive	Reduce minimum flows from 300 cfs to 100 cfs at Penticton, in emergencies Apr.-July	
4. Expand agricultural production.	North Okanagan Shuswap Area	Projected to 2020	Unknown	Hay, pasture Vegetables
B - Industrial Use				
1. Maintain water supplies to existing and projected industrial development to 2020.	Okanagan Lake Region	All year	1970: 4,410 ac.ft. 2020: 36,050 ac.ft.	
	Okanagan River Region	All year	1970: 236 ac.ft. 2020: 650 ac.ft.	
2. Avoid flood damage to industrial land.	Okanagan Lake Shoreline	May - July	Levels 1,123.8'	Simpson Mill at Kelowna
C - Municipal and Domestic Use				
1. Maintain water supplies to existing and projected municipal and domestic needs to 2020.	Okanagan Lake Region	All year	1970: 8,270 ac.ft. 2020: 31,200 ac.ft.	
	Okanagan River Region	All year	1970: 808 ac.ft. 2020: 800 ac.ft.	
2. Maintain lake levels and flows to enable intakes to operate efficiently.	Okanagan Lake Okanagan River	All year All year	1,125.0'-1,116.8' 100 cfs anywhere in Okanagan.	City of Oliver, various individual domestic intakes
3. Avoid flood damage to municipal and domestic use.	Okanagan Lake shoreline	May - July	OK. Lake 1,123.8'	
	Osoyoos Lake	May - July	Os. Lake 913.0'	
D - Transportation Use				
1. Maintain water levels to facilitate barge traffic	Okanagan Lake	All year	> 1,119.8 feet < 1,123.8 feet	CNR Railway CPR Railway, Wharfs
2. Maintain water levels to protect Kelowna Floating Bridge.	Okanagan Lake	All year	> 1,118.8 feet < 1,123.8 feet	
3. Protect bridges from high river flows.	Okanagan River	All year	2,100 cfs to 3,400 cfs depending on location	McAlpine Bridge
E - Recreation Use				
1. Avoid inundation of recreational sites.	Okanagan Lake Shoreline	May to September	< 1,123.8 feet	Recreation, Beaches Campgrounds
2. Avoid loss of boating opportunities by maintaining lake levels.	Okanagan Lake	February to November	> 1,119.8 feet < 1,123.8 feet	Public boat access, Private boat docks, Private marin
F - Fish and Wildlife Use				
1. Maintain river flows to protect anadromous salmon spawning, incubation and migration opportunities.	Okanagan River	Aug. 1-Sept. 15 Sept. 16 - Oct. 30 Nov. 1 - April 30	> 300 - 450 cfs > 300 - 500 cfs < 1,000 cfs > 170 cfs	Sockeye Salmon
2. Protect salmon run for Indian population	Okanagan River	Aug. - Oct.	> 1,000 salmon per year	Indian population
3. Provide flows to support sports fishery requirements	Okanagan River	Aug-Nov. Dec.-Mar. Mar.-July	> 250 cfs > 170 cfs. > 100 cfs	Kokanee Rainbow trout Whitefish
4. Maintain lake levels to protect game bird habitats.	Okanagan Lake	All year	> 1,119.8 ft. < 1,123.8 ft.	Wildfowl
G - Aesthetic Use				
1. Maintain lake levels to avoid unsightly exposure of shoreline.	Okanagan Lake	All year	> 1,119.8 feet	Private properties, Public areas
2. Maintain lake levels and flows to protect important ecological systems.	Okanagan Lake Skaha Lake Vaseux Lake Lake Osoyoos	All year	1,119.8'-1,123.8' (Okanagan Lake) (Okanagan River)	Wildlife habitats aquatic eco-system habitats
	Okanagan River	All year	> 100 cfs.	
3. Maintain water quality standards to protect important ecological systems and aesthetics.	Okanagan River Skaha Lake Vaseux Lake Osoyoos Lake	All year	> 100 cfs. (Ok. R.)	

F.5.1 Identification of Constraints

Before alternatives to achieve the above planning objectives were formulated, a number of assumptions and constraints within these planning objectives were identified. These constraints were as follows:

1. Although the present Okanagan Flood Control Act specifies that the level of Okanagan Lake should be maintained between 1118.8 feet and 1123.8 feet, both these constraints were removed and the lake was allowed to fluctuate freely.

2. Maximum monthly discharges in Okanagan River at Penticton were set at 1680 c.f.s., i.e. 80 percent of channel capacity.

3. Minimum monthly discharges of 100 c.f.s. were established everywhere in Okanagan River plus downstream consumptive use.

4. It was assumed the entire sockeye salmon run would have to be maintained because of international obligations.

5. Diversion from Shuswap River could only be made when the flow in any one month as measured at Enderby, exceeded the mean of the five lowest flows recorded for that month.

6. No impacts of Shuswap diversion on the Shuswap watershed were evaluated in this preliminary analysis, but under the terms of the Okanagan Basin Agreement, would be included should Shuswap diversion alternatives appear feasible.

7. Downstream effects of alternatives on Okanagan River flow in the State of Washington were not evaluated in this report.

8. It was decided to use adjusted net historical inflows for the past 50 year as basic inputs to the mathematical model (see next section), thereby assigning the worst drought on record (1929-31), a probability of 1 in 50 years.

F.5.2 Mathematical Model of Mainstem System

The evaluation of alternatives was standardized by the development of a mathematical model of the mainstem system[14]. This model represents the observed pattern of net inflow into the basin as closely as possible, based on measured data collected between 1921 and 1970. As mentioned earlier in this report, the total available supply, to the mainstem system is the measured net historic inflow plus consumptive use in the Okanagan Lake region[15]. Because consumptive use has been generally increasing over the past 50 years of record, these net inflows were recomputed as net virgin inflows by adding estimated consumptive use for each year of record. These net virgin inflows represent

[14] Russell, S.O. and R.Y. McNeill, "Notes on the Development of and Results from, the U.B.C. Mathematical Model of the Operation of the Mainstream Okanagan River", University of British Columbia, July 1971.

[15] Natural evaporation is not included in these figures as it is never available for man's use.

the water supply that would have been available had man not diverted or stored water in tributary watersheds. The model then prorated these net virgin inflows onto a monthly time basis to give an estimate of net inflow to the Okanagan Lake (i.e. the amount of water than can be released into Okanagan River) for 1970, 1990 and 2020 forecast levels of development.

Because the model was operated on a monthly time unit, it was somewhat less flexible than the actual method of operation in which discharges are adjusted at more frequent invervals. However, modifications to the method of forecasting net inflows compensated for this factor. (Technical Supplement II). To simulate actual operating conditions as closely as possible, adjusted net historic inflows during the freshet period for the 50 years of record were deliberately randomized by the mathematical model to provide forecasted inflows using the following formula:

$$\text{Forecast for Period} = A + ij$$

Where A = actual net inflow for 1970, 1990 and 2020 levels of development.

j = standard error in forecast for each forecast period[16]

and i = a random normal deviate (i.e. a random number part of a set with a mean of zero and a standard deviation of one)

The output of the model was in the form of lake elevations for each month for the 50 years of record for each forecast level of development and monthly Okanagan River discharges at Penticton, Vaseux Lake and Oliver. These outputs were generated for each of the 26 alternatives specified below. It should be noted from Table F-4 that each planning objective contains a specification for levels on Okanagan Lake or discharges in Okanagan River. Consequently, the output of each of the 26 alternatives analysed by the model for each level of development could be directly compared with planning objective specifications and their level of achievement identified.

F.6 FORMULATION OF ALTERNATIVES

Six general alternative ways of managing the mainstem Okanagan sytem were identified.

1. Present method of operation, henceforth designated as the null alternative.
2. Increase the four-foot operating range of Okanagan Lake to develop more storage.

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[16] These standard errors are as follows:
March - June forecast = 90,000 acre feet
April - June forecast = 93,100 acre feet
May - June forecast = 59,900 acre feet

3. Adjust intakes in Okanagan River Channel and ox-bows so that they can operate at lower minimum discharges.
4. Ration water uses in times of water shortage.
5. Import water into Okanagan basin
6. Improve operation of mainstem Okanagan by better forecasting and system modelling.

In this preliminary evaluation, only alternatives 1, 3, 4 and 5 were modelled and analysed. For convenience, this set of alternatives falls into five categories (Table F.5).

SET A - contained one alternative - The null or present method of operation based upon the 1970 drought year. This alternative had a minimum flow of 300 c.f.s. at Oliver during the irrigation season (April to September) and met fishing requirements during October to March. In drought years however, minimum flows in October to March were reduced to 100 c.f.s. This alternative is numbered zero.

SET B - contained a number of alternatives which involved structural changes to flood control and irrigation systems in the Okanagan River. As noted previously, the present systems are inefficient because a discharge of approximately 450 c.f.s. at Penticton is required to ensure that all intakes operate properly (this flow is composed of 150 c.f.s. for consumptive use plus 300 c.f.s. 'flow through' to Osoyoos). Various changes in these systems were assumed so that minimum flows of 100, 200 and 300 c.f.s. at Oliver could be maintained during the irrigation season without restrictions on water supply. For each of these flows, the system was modelled assuming fishery flows were or were not met. These alternatives are numbered 1 to 9.

SET C - contained alternatives that did not involve redesign of irrigation systems in Okanagan River, but assumed that if flows in Okanagan River were reduced, irrigators would construct emergency systems to maintain their supply. When Okanagan Lake levels dropped below 1121.8 feet and 1121.3 feet respectively, 90, 70 and 50 percent of required Okanagan River discharges would be released. These alternatives are numbered 10 to 15.

SET D - included alternatives which imported water from the Shuswap Watershed over a seven month period in drought years and involved storage on the Shuswap system. These alternatives are numbered 20 to 24 according to various capacities of diversion canal.

SET E - contained a set of alternatives which involved diversions of water from the Shuswap watershed without storage on the Shuswap system. Alternatives numbered 26 to 28 involved diversions as required during the freshet months of May, June and July, while those numbered 29 to 31 involved additional diversions during October, November, March and

TABLE F.5

TASK 23 - MODEL ALTERNATIVES

NUMBER	SET	MINIMUM FLOW IRRIGATION SEASON AT OLIVER C.F.S.	MINIMUM FLOW AUGUST TO OCTOBER AT OLIVER C.F.S.	MINIMUM FLOW NOVEMBER TO MARCH AT OLIVER C.F.S.	PERCENT OF DOWNSTREAM REQUIREMENTS SATISFIED IN AN EMERGENCY	LAKE LEVEL TRIGGER INDICATING EMERGENCY	RUN OF RIVER DIVERSION WHEN REQUIRED MAY-JULY C.F.S.	RUN OF RIVER DIVERSION MAY-JULY OCTOBER-NOVEMBER MARCH-APRIL C.F.S.	DIVERSION WITH STORAGE DIVERSION CAPACITY C.F.S.
0	A	300	100	100					
1	B	50	50	50					
2	B	50	250	170					
3	B	100	100	100					
4	B	100	250	170					
5	B	150	150	150					
6	B	150	250	170					
7	B	200	250	170					
8	B	300	250	170					
9	B	300	250	170					
10	C	300	250	170	90	1121.8			
11	C	300	250	170	70	1121.8			
12	C	300	250	170	50	1121.8			
13	C	300	250	170	90	1121.3			
14	C	300	250	170	70	1121.3			
15	C	300	250	170	50	1121.3			
20	D	300	250	170					180
21	D	300	250	170					300
22	D	300	250	170					200
23	D	300	250	170					300
24	D	300	250	170					400
25	D	300	250	170					500
26	E	300	250	170			300		
27	E	300	250	170			600		
28	E	300	250	170			900		
29	E	300	250	170				300	
30	E	300	250	170				600	
31	E	300	250	170				900	
29 &4	E	100	250	170				300	

April. Both sets were designed with various capacities of canal and irrigation pumping requirements.

F.7 EVALUATION OF ALTERNATIVES

The purpose of the evaluation process is to determine the degree to which the alternatives mentioned above achieve the 21 planning objectives for the 7 user areas specified in Table F.4. The conflicts and complexity involved in these planning objectives requires a rational and systematic approach to evaluation. While it is unlikely that any single alternative will be able to accommodate all competing uses equally, the development of the evaluation matrix should provide the decision-makers with an information system which will enable them to assess fully the implications of any chosen alternative.

The development of an evaluation matrix involves 3 steps.

1. Impact Analysis: Consequences or impacts of each alternative upon all planning objectives are stated in annual terms. Those impacts that contribute positively or negatively to the economic growth objectives are measured in dollar terms. Impacts which contribute positively or negatively to the social and environmental objectives are measured in appropriate physical or biological units.
2. Comparison with Zero Alternative: The annual impacts for each alternative in Sets B, C, D, and E, stated in both economic and non-economic units for all planning objectives are compared with zero alternative (Set A). The difference (positive or negative) in the annual impact is referred to as the incremental impact.
3. Weighting Schemes: Weights are placed upon the annual incremental impacts on non-economic planning objectives to reflect the relative value of these gains and losses to society.

Each of these steps is now reviewed in detail.

F.7.1 Impact Analysis

As mentioned previously, the output of each of the 26 modelled alternative operations of the Okanagan mainstem system was stated in monthly lake levels of Okanagan Lake and discharges in Okanagan River at Penticton and Oliver. It will be noted from Table F.4 that each planning objective contains a specification for levels on Okanagan Lake or discharges for Okanagan River. Consequently, the output for each of the 26 alternatives generated by the mathematical model was inspected and actual events of monthly fluctuations of lake levels or discharges outside the specifications for each planning objective were noted for the 50 year data period. The impact occurring for each event for each planning

objective was calculated from stage-damage or discharge-damage relationships established by the evaluators. For example, the evaluation of impacts of alternatives on the anadromous fishing in Okanagan River was undertaken by the Federal Department of the Environment. Similar evaluation studies on sports fisheries, wildlife resources, water quality and ecology of the Okanagan River system and shoreline landuse around Okanagan Lake were also undertaken. (See Appendix G). In each of these evaluations, where the impact contributed positively or negatively to the economic growth objective such as flood damage to private property or engineering costing studies, the impact was measured in dollar terms. Where the impact contributed to environmental or social objectives, it was assessed in physical, biological or qualitative terms.

In theory, for each alternative modelled, the damage accruing to all planning objectives for all extreme events in the 50 years of record should be summed and the total divided by 50 to obtain annual impact values. In practice, this quantitative approach was achieved for the impacts on the recreation use, flood control planning objectives, and to some extent, for the planning objective for sockeye salmon, but only qualitative descriptions of impacts on sports fishery and wildlife planning objectives were available.

F.7.2 Comparison with Zero Alternative

The second step in the evaluation process was to estimate the incremental effects of each alternative on each planning objective by comparing all annual damage values for all modelled alternatives (Sets B, C, D, and E) with the zero alternative (Set A - present-day operating procedures). This step can best be described by separating the economic impact and the non-economic impact evaluations.

(a) Economic Evaluations - For those alternatives which involved the design, construction and operation of structures (e.g. Shuswap diversion canal), the incremental annual costs are equal to the total annual costs as such works do not presently exist. The capital costs for all structures were amortized at 5, 7, and 9 percent interest over 25 years and were added to the estimated annual operation, maintenance and repair works to provide total annual costs. These total annual costs are specified in Table F-6 under the heading designated "Annual Costs". Where costs have not been estimated in detail, + or ++ or +++ represent order of magnitude of expected costs.

The cost of adjustments to the Okanagan River irrigation and flood control system required to implement Alternatives 1 to 9 inclusive were included along with the cost of general repair work to the downstream system ($134,000 annual cost) which is apparently required now and is therefore common to all alternatives including the zero alternative (Table F-6). Because the annual operating costs of the redesigned irrigation and flood control works in Set B are

TABLE F-6

PRELIMINARY EVALUATION MATRIX - TASK 23 - WATER QUANTITY ALTERNATIVES

ALTERNATIVE		ECONOMIC CONSIDERATIONS											ENVIRONMENTAL CONSIDERATIONS								BENEFITS MINUS COSTS	OVERALL RANKING	
		ANNUAL COSTS (X $1000)							ECONOMIC BENEFITS (ANNUAL)				QUALITATIVE RANKINGS										
Number	Set	Diversion Canal and Pumping Plan	Storage Costs	Down-Stream Canal	Pumping	Operating Costs	Other	Total	Lake Levels	Upstream Irrigation	Salmon BenefitsOther	Total	Salmon	Other Fish	Wild-Life	Lake Levels High	Lake Levels Low	Water Quality	Other	Composite Ranking	ANNUAL (X $1000)	Within Set	Overall
0	A	0	0	0	0	0	134	0		0			0	0	0	0	0	0		0		4	4
3	B	0	0	35	0	-30	134	5	147	0	35.0	-34.8	-6	-6	5	-2	4	-1		-6	- 39.8	8	14
4	B	0	0	35	0	-30	134	5	392	0	0	392	+4	2	2	0	4	-1		+11	- 4.6	1	1
5	B	0	0	35	0	-30	134	5	384	0	29.0	384	-5	-4	3	1	4	0		-1	- 33.6	7	13
6	B	0	0	35	0	-30	134	5	678	0	0	678	3	1	2	0	2	0		+8	- 4.3	2	2
7	B	0	0	35	0	-30	134	5	570	0	0	570	3	1	1	-1	0	0		+4	- 4.4	3	3
8	B	0	0	35	0	-30	134	5	-393	0	0	-393	3	2	-2	-2	-6	2		-3	- 5.4	5	7
9	B	0	0	35	0	-30	134	5	-401	0	0	-401	3	2	-1	-5	-6	2		-5	- 5.4	6	10
10	C	0	0	0	0	Not	134	0	36	0	0	36	3	2	0	0	-3	1		+1	36	1	5
11	C	0	0	0	0	Estimated	134	0	563	0	-11.4	-10.8	-2	-2	0	4	+3	-1		+2	- 10.8	3	8
12	C	0	0	0	0	But	134	0	684	0	-29.0	-28.3	-5	-4	+3	5	5	-1		+3	- 28.3	5	11
13	C	0	0	0	0	Positive	134	0	-124	0	0	-124.0	3	2	-1	1	-4	+1		+2	- 124	2	6
14	C	0	0	0	0	"	134	0	150	0	-11.4	-11.3	-2	-2	0	2	1	0		-1	- 11.3	4	9
15	C	0	0	0	0	"	134	0	490	0	-29.0	-28.5	-5	-4	2	4	3	0		0	- 28.5	6	12
20	D	836	Not	0	+	0	134	836	500	0	0	500	3	2	3	5	6	2		+21	- 835.5		
21	D	866	Estimated	0	+	0	134	866	500	0	0	500	3	2	3	5	6	2		+21	- 865.5		
22	D	936	"	0	+	0	134	836	500	0	0	500	3	2	3	5	6	2		+21	- 835.5		
23	D	866	"	0	+	0	134	866	500	0	0	500	3	2	3	5	6	2		+21	- 865.5		
24	D	896	"	0	+	0	134	896	500	0	0	500	3	2	3	5	6	2		+21	- 895.5		
25	D	926	"	0	+	0	134	926	500	0	0	500	3	2	3	5	6	2		+21	- 925.5		
26B	E	866	0	0	231	Included	134	1097	507	0	0	506	3	2	2	4	4	2		+17	-1096.5	2	
27B	E	969	0	0	279	In	134	1248	732	0	0	732	3	2	3	6	7	2		+23	-1247.3	1	
28B	E	1053	0	0	318	Pumping	134	1371	491	0	0	491	3	2	4	2	6	2		+19	-1370.5	3	
29	E	866	0	0	315	0	134	1181	568	0	0	568	3	2	2	5	5	2		+19	-1180.4		
30	E	969	0	0	378	0	134	1347	1089	0	0	1089	3	2	4	7	8	2		+26	-1345.9		
31	E	1053	0	0	350	0	134	1403	571	0	0	571	3	2	5	3	6	2		+21	-1402.4		
$26B_1$	E	899	0	0	250	0	134	1149	506	-	0	506	3	2	2	4	4	2		+19	-1148.5		
$27B_1$	E	993	0	0	294	0	134	1297	732	-	0	732	3	2	3	6	7	2		+23	-1296.3		
$28B_1$	E	1072	0	0	331	0	134	1403	491	-	0	491	3	2	4	2	6	2		+19	-1402.5		
$26B_2$	E	912	0	0	262	0	134	1174	506	-	0	506	3	2	2	4	4	2		+19	-1173.5		
$27B_2$	E	1014	0	0	307	0	134	1321	732	-	0	732	3	2	3	6	7	2		+23	-1320.3		
$28B_2$	E	1091	0	0	344	0	134	1435	491	-	0	491	3	2	4	2	6	2		+19	-1434.5		
$26B_3$	E	939	0	0	274	0	134	1213	506	-	0	506	3	2	2	4	4	2		+19	-1213.5		
$27B_3$	E	1027	0	0	315	0	134	1342	732	-	0	732	3	2	3	6	7	2		+23	-1341.3		
$28B_3$	E	1103	0	0	352	0	134	1455	491	-	0	491	3	2	4	2	6	2		+19	-1454.5		

are less than the existing operating costs under the zero alternative, column 7 of Table F-6 designated "operating costs" shows negative costs, i.e. benefits. Annual costs of the main canal for diverting water for various flow capacities with and without addition pumping for irrigation requirements in the North Okanagan are also summarized in Table F-6. Costs of storage on the Shuswap system for alternatives in Set D were not estimated for this preliminary analysis

Economic benefits were also estimated in annual terms, and based on 1970 levels of development only. No attempt was made in this preliminary report to discount benefits for future levels of development. As mentioned previously, only impacts that could be realistically evaluated in dollar terms were assessed as economic benefits or costs. These included annual flood damage to structures around Okanagan Lake and rental losses to boat mooring sites. Incremental economic losses to the commercial salmon fishery in the United States were calculated, however the incremental benefits were not evaluated in dollar terms, since the stated planning objective was to avoid fish losses, not to enhance the salmon run. The incremental benefits accruing to an expansion of irrigated agriculture in the North Okanagan was not quantified in dollar terms, though it was recognized that these incremental benefits would likely be less than the incremental costs required to supply the water. While these benefits are based on irrigation of pasture and alfalfa crops, the feasibility of irrigating other types of crops was also considered. All annual benefits are specified in Table F-6 in the columns entitled "Economic Benefits (Annual)".

(b) Non-Economic Impacts - Incremental impacts accruing to planning objectives related to the environmental and social goals were analysed according to a scoring procedure. For any such planning objective, the extreme range of annual impacts was noted and the difference between the annual value for the zero alternative and both extreme values (above and below the zero alternative) was calculated. The larger difference whether positive (benefit) or negative (cost) was scored as 10. Differences between the annual values for the zero alternative for all other alternatives were scored as a percentage of this absolute maximum difference, incremental decreases in annual damage being scored positively and increases in annual damage being scored negatively. Quantitatively, the scoring process can be stated as follows:

$$S_n = \frac{\left(X_i - X_o\right)_n}{\left|\left(X_i - X_o\right)\right|_{n\ \text{maximum}}} \times 10$$

Where S_n is the score for planning objective n

X_i = annual impact of alternative i on planning objective n

X_o = annual impact of alternative zero on planning objective n.

F.7.3 Weighting Planning Objectives

Once the non-economic impacts for each planning objective have been scored, the scores should be weighted to reflect the relative value of this gain or loss to society. Because of the mechanics of the scoring procedure as outlined in equation 2, at least one alternative will have a maximum score of plus or minus 10 in terms of achieving (positively or negatively) each planning objective. Unless the achievement of different planning objectives are equally valued by society, the maximum score of plus 10 for one objective will not be valued equally as a score of plus 10 relating to another planning objective. Thus, all the scores for each planning objective should be adjusted by a weighting factor, which reflects society's evaluation of the achievement of that planning objective.

As mentioned earlier, because Task 23 represented the first attempt at completing the evaluatio matrix, the theory presented above was not always observed in practice. Only the planning objectives relating to user areas affected by fluctuations of Okanagan Lake were weighted and integrated into a composite score. In the absence of any guidelines or public feedback for weighting the appropriate planning objectives, sensitivity analysis based on three distinct weighting schemes was used. A modified system of scoring and weighting was used in the sport-fishery evaluation and for evaluating the aesthetic implications of various discharges in Okanagan River. The incremental impacts on anadromous salmon and wildlife were not weighted. Thus, the composite scores shown in the evaluation matrix attached to the summary report represent varying degrees of conformity with the evaluation theory presented above. The scoring for each designated non-consumptive water use is specified in Table F-6 under the heading "Qualitative Rankings".

F.8 SELECTION OF A PLAN

The final step in the planning and evaluation process is the selection of the plan that best achieves the study objectives of economic growth, environmental quality and social well-being under the established constraints. This step consisted of a two-stage process;

1. reduction of all economic benefits and costs for each alternative into a benefit-cost ratio, and
2. comparison of the incremental benefits and costs accruing non-economic impacts with incremental economic net benefits.

The incremental net economic benefits as compared with the zero alternative were calculated and are shown on the evaluation matrix (Figure 5.2) under the

column entitled "Benefits minus Costs". It can be seen that no alternative has a positive benefit/cost ratio in terms of the economic growth objective; all net annual benefits were negative.

To facilitate comparison of alternatives, the scoring values or qualitative rankings related to each non-economic impact were summed to form an integrated parameter called a composite ranking. Composite rankings for each alternative are shown in Table F.6.

Once the incremental net economic benefits and costs and composite scores were calculated, the selection of the best alternative was accomplished by a method of paired comparisons. The zero alternative was first compared with alternatives in Set B (numbered 3 to 9)[17]. As alternatives in each set are mutually exclusive, it was decided to choose the most favourable in each set separately and then compare these favoured alternatives.

Within Set B, alternative 4 was considered to be the most favourable as it involved low annual costs ($4,608) and the highest composite ranking (+11). Within Set C, alternative 10 was highest ranked, and it should be noted that in this set, alternatives with the most water rationing (10, 13) were favoured as they reduced negative impacts of anadromous and sports fisheries in Okanagan River. Alternative 4 was then compared with alternative 0 and alternative 4 was favoured on the basis of higher scorings for all non-economic impacts except water quality in Okanagan River, the incremental cost of which was considered small (Appendix G-1). Alternatives 4 and 10 were then compared and alternative 4 chosen on the basis of more favourable impacts on anadromous salmon and a reduction of environmental costs resulting from low water on Okanagan Lake, despite a small increase in annual costs.

The alternatives in Set E were ranked higher than those in Set D, because storage costs on the Shuswap watershed associated with Set D would cause Set D to be more expensive than Set E. Alternative 27 was chosen on the basis of high composite scoring (+23) and relatively moderate annual costs for diversion alternatives ($1,247,268). None of the diversion alternatives 26 to 28 which included irrigation pumping facilities to serve land adjacent to the main canal was considered economically feasible as the additional costs to supply irrigation water were greater than the irrigation benefits returned.

Because alternatives 4 and 27 were not considered to be mutually exclusive, a computer simulation of these alternatives in combination was carried out[18]. It was agreed that the incremental non-economic benefits were small

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[17] Alternatives 1 and 2 were removed as their minimum flows of 50 c.f.s. at Oliver fell below the acceptal constraint of 100 c.f.s.

[18] In fact, alternative 29 and 4 were combined, but this combination gives a good estimate of the impact of alternatives 27 and 4.

(composite rankings of +25 for alternatives 4 and 29 combined compared with +21 for alternative 27) compared to the additional annual costs ($5,000), and thus it became a question of choosing between alternative 4 and 27.

The measurable annual economic benefits of maintaining Okanagan Lake within its five foot range (1123.8 to 1118.8 feet) compared with the more extreme fluctuations under alternative 4 are minimal (approximately $100.00). However, the overall composite ranking increases from +11 for alternative 4 to +23 for alternative 27. It should be noted that the positive non-economic impacts under alternative 27 as compared to alternative 4 relate to reductions in Okanagan Lake fluctuations; scoring for fisheries (sports and anadromous) and wildlife resources in Okanagan River are similar for both alternatives Table F.6).

To illustrate Okanagan Lake problems, Table F.7 compares maximum and minimum Okanagan Lake levels for alternatives 0, 4 and 27 for 1929-31 and 1926. Because of adjustments to irrigation systems in Okanagan River assumed under alternative 4 so that only 100 c.f.s. need pass Oliver during the irrigation season (compared to 300 c.f.s. at present), there is a significant reduction in lake level fluctuations under alternative 4, compared to the present-day operation of the lake (alternative zero). Implementation of alternative 27 would further reduce minimum lake levels by approximately one foot compared with alternative 4 under present conditions. However, as stated earlier, the probability of lake levels dropping below the operating minimum of 1118.8 feet is probably less than once in 50 years for either alternative.

TABLE F.7

COMPARISON OF OKANAGAN LAKE LEVELS

FOR ALTERNATIVES 0, 4 and 27

	ZERO ALTERNATIVE				ALTERNATIVE 4				ALTERNATIVE 27			
	PRESENT 1970 DEVELOPMENT		FUTURE 2020 DEVELOPMENT		PRESENT 1970 DEVELOPMENT		FUTURE 2020 DEVELOPMENT		PRESENT 1970 DEVELOPMENT		FUTURE 2020 DEVELOPMENT	
	(1)[19]	(2)[19]	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
MAX	1124.6	1124.6	1124.7	1124.7	1124.7	1124.7	1124.8	1124.8	1124.6	1124.6	1124.7	1124.7
MIN	1116.8	1119.5	1116.2	1118.8	1117.8	1120.0	1117.2	1119.7	1118.7	1119.3	1118.1	1118.8
RANGE	7.8	5.1	8.5	5.9	6.9	4.7	7.6	5.1	5.9	5.3	6.6	5.9

[19] These columns present minimum elevations in 1929-31 (Column 1) and 1926-27 (Column 2). The maximum elevations were observed in 1928 in all cases.

If alternative 4 were implemented and such an extreme drought did re-occur, Okanagan Lake levels could drop to 1117.8 feet today and 1117.2 feet in 2020. Such an event would result in exposure of large sections of shoreline, temporary desiccation of wildlife habitats in the North Arm, inconvenience at private and public boat launching sites, temporary adjustment to railway wharfs and a reduction in the general quality of water-based recreation opportunities.

Potentially more serious would be the consequences to the Kelowna floating bridge, which is presently designed to withstand a minimum lake level of 1118.8 feet. As alternatives 0, 4, and 27 all indicate minimum levels below this under 2020 development, some adjustment to the bridge might be required should either alternative 4 or 27 be implemented. If this is the case, the costs of such adjustments should be accounted as a benefit to those alternative which maintain lake levels within the accepted 5 foot range.

The mathematical model also indicated that on one occasion in the 50 years of record, lake levels could exceed the maximum design elevation of 1123.8 feet by 0.9 feet in alternative 4 as compared to 0.8 feet in alternative 27. Because lake levels fluctuated up to 1124.5 feet before the Okanagan Flood Control scheme was implemented, many older properties have adjusted to this level. Although there has been some encroachment onto the shoreline around Okanagan Lake, at present the economic consequences of such a flood total some $100,000 while environmental and social consequences would be small.

Within the limitations of this preliminary analysis, the decision of the Okanagan Study Committee was that the costs of diversion ($1.2 million annually) could not justify social and environmental benefits which would occur probably less than once in 50 years. Implementation of alternative 4 however, could provide significant environmental benefits at a low annual cost ($4,400) and it was agreed that more detailed cost estimates for this alternative be prepared.

The Study Committee fully recognizes the limitations of this preliminary analysis and recommends that the analysis be re-run using alternative projections of water demands. These projections should include possible development of Indian lands in the valley and the most recent estimates of minimum flows in Okanagan River to support the salmon fishery. In the final development of a comprehensive plan, the analysis will not only include such alternative projections, but will also integrate tributary stream studies and water quality management alternatives.

F.9 SUMMARY

This report has presented a preliminary evaluation of a number of alternative plans to manage water quantity in that portion of the mainstem Okanagan system comprising of Okanagan, Skaha, Vaseux and Osoyoos Lakes and Okanagan River. As such, it is the first attempt by the Okanagan Study Committee to develop a systematic and rational approach to plan evaluation as envisaged under the Okanagan Basin Agreement. Subsequent evaluation Tasks will incorporate both water supply and demand studies in tributary watersheds under present and future levels of development and water quality management alternatives.

The main conclusions of this preliminary evaluation are as follows:

1. In most years, under existing management practices there is sufficient water in the system to serve all consumptive (irrigation, municipal, industrial) and non-consumptive (recreation, aesthetics, navigation, fishery and wildlife) requirements. On 1 occasions in the 50 years of recorded data (1921 to 1969 inclusive), available inflow to the system (excluding the relatively small local inflow downstream of Penticton) was not sufficient to meet the total consumptive use in the valley of 102,000 acre feet plus minimum flow requirements in Okanagan River of 144,000 acre feet. Although all consumptive demands could be met, either Okanagan Lake level would drop below the present minimum operating level of 1119.8 feet G.D., or discharges from the lake to Okanagan River would have to be reduced, thus producing social and environmental costs to recreation, aesthetic and fishery resources.

2. Preliminary projections of annual consumptive use in irrigation, municipal and industrial use for the entire valley for the year 2020 indicate an increase from 102,000 acre feet in 1970 to 132,000 acre feet in 2020. These projections would not significantly aggravate the existing problem assuming non-consumptive demands remain unchanged.

3. To ensure a cumprehensive evaluation of the problem, a number of relevant planning objectives for each major water use in the system were defined in terms of factors it would seem desirable to achieve, maintain, protect or avoid. These major water uses included both consumptive use in agriculture, industry and municipalities, as well as non-consumptive uses for recreation, aesthetics, support of fishery, wildlife and other ecological resources and transportation. A total of 21 planning objectives were identified.

4. A mathematical model of the mainstem system based on observed patterns of net inflows during the 50 years of record was developed. The model was operated on a monthly time unit and simulated actual operating conditions as closely as possible by adjusting observed inflows to account

for uncertainty in forecasting them each year. The output of the model was in the form of monthly lake levels of Okanagan Lake and discharges in Okanagan River at Penticton and Oliver for the 50 years of record and for 1970, 1990, and 2020 levels of development.

5. Five sets of alternatives were formulated:

SET A - Present management of mainstem system (referred to as zero alternative, which partially met fishery requirements in Okanagan River.

SET B - Adjustments to flood control and irrigation systems in Okanagan River to reduce existing minimum required flow during April to September inclusive from 300 c.f.s. to 100 c.f.s.

SET C - Rationing of consumptive water use in Okanagan River region during low inflow years.

SET D - Importation of water from the Shuswap watershed by diverting freshet flows without storage on the Shuswap system (known as run of the river diversion).

SET E - Importation of water from the Shuswap watershed with storage on that system.

6. These alternatives were analyzed using the mathematical model under the following constraints and assumptions:

(i) Okanagan Lake levels were allowed to fluctuate freely so that downstream requirements could be met.

(ii) Minimum monthly discharges anywhere on Okanagan River were set at 100 c.f.s. plus downstream consumptive use.

(iii) The sockeye salmon run in Okanagan River must be maintained due to international obligations.

(iv) Downstream effects of alternatives on Okanogan River flows in the State of Washington were not evaluated; nor were downstream effects on the Shuswap watershed or the Okanogan River in the State of Washington arising from alternatives in Sets D and E evaluated in this preliminary report.

(v) The extreme drought of 1929-31 was assigned a probabilty of 1 in 50 years, thus the evaluation probably exaggerates the probability of annual damage, as such a drought in all liklihood occurs less frequently.

7. The evaluation of the alternatives consisted of a three-phase process. First, the consequences of failing to meet the water supply and flood control criteria for each planning objective were evaluated in physical terms for all alternatives. Second, the physical impacts associated with each alternative were compared with those associated with the zero alternative (model of present conditions), positive increments being

considered as benefits and negative increments considered as costs. Third, these incremental impacts were evaluated either in dollars where they contributed (positively or negatively) to the economic objectives or by a system of scoring where they contributed to the environmental and social objectives. Theoretically, a weighting scheme should be applied to these scores to reflect the relative value society places upon the achievement of different planning objectives. However, as no estimate of a rational weighting system was available, the scores for different water uses were not weighted in this study.

8. Alternatives were ranked through a series of paired comparisons between favoured alternatives in each of the 5 sets using economic data and qualitative scoring in an evaluation matrix. The best alternative in Set B (alternative 4) was favoured over the zero alternative (Set A) and all alternatives in Set C. Should alternative 4 be implemented, in extreme droughts Okanagan Lake levels could still drop to 1117.8 feet or 1.3 feet higher than they would at present. Run of river diversions in Set D would maintain Okanagan Lake levels above 1118.0 feet, but only diversions with storage on the Shuswap (Set E) would maintain levels within the normal four foot operating range of 1119.8 to 1123.8 feet. The annual costs of both diversion schemes exceed $1 million, while economic benefits to Canada total some $500 excluding costs of preventing possible damage to the Kelowna floating birdge. In addition, aesthetic and recreational values would only be significantly improved once in 50 years.

APPENDIX G

PRELIMINARY EVALUATION OF WATER AND WATER RELATED ACTIVITIES AFFECTED BY MAINSTEM WATER QUANTITY ALTERNATIVES (Task 23)

G.1 Freshwater Fisheries

G.2 Wildlife

G.3 Shoreline Damage

G.4 Water Quality (Limnology)

FOREWORD

This appendix includes examples of the evaluation procedures used to assess the economic, social and environmental consequences of the mainstem management alternatives outlined in Appendix F, on:

1. Sport Fisheries
2. Wildlife
3. Shoreline Damage
4. Water Quality

It should be recognized that these are included to illustrate the evaluation process rather than the results, which were very preliminary at this stage of the Study.

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APPENDIX G-1

PRELIMINARY EVALUATION OF THE EFFECT OF MAINSTEM WATER QUANTITY ALTERNATIVES ON FRESHWATER SPORT FISHERIES

(Reprint of report prepared by G.D. Koshinsky, Fisheries Research Board, Department of the Environment, Canada)

The evaluation of the consequences of the various mainstem water quantity management alternatives as set out in Appendix F on Sport fisheries, was confined to the anticipated effects of the different flow regimes on the three angling species which appear to utilize the river for reproduction, and to some extent for feeding. This evaluation has been based primarily on verbal reports from B.C. Fish and Wildlife personnel and from local anglers, along with a consideration of the literature and the known general habits and requirements of the species concerned. In most cases it has not been possible to confirm the assumptions which are made.

G.1.1 Role of the Okanagan River in the Regional Freshwater Sport Fisheries

The Okanagan River contributes directly to the regional sport fishery in two discrete ways:

(a) As reproductive habitat for fishes which are angled in Osoyoos, Vaseux, and Skaha Lakes.

(b) As habitat for fishes which are angled within the river itself.

Although utilization of the river by fishes for reproduction is poorly known, the following uses are reasonably well established:

(a) Spawning of kokanee (*Oncorhynchus nerka*) from Osoyoos, Vaseux and Skaha Lakes,

(b) Spawning of mountain whitefish (*Prosopium williamsoni*) from Osoyoos and Vaseux Lakes,

(c) Spawning of rainbow trout (*Salmo gairdneri*) from (mainly) Osoyoos Lake.

In addition to supplying recruitment to the mainstem lakes, spawning runs are also primary factors in those sport fisheries which take place within the river, viz:

(a) For rainbow trout below Vaseux Lake and, to a lesser extent, at Okanagan Falls.

(b) For mountain whitefish above and below Vaseux Lake.

A "casual" sport fishery takes place in summer at access points throughout the length of the river. This fishery takes mainly coarse fishes (squaw fish and peamouth chub), and rainbow trout only incidentally.

The present evaluation of Okanagan River operation alternatives was confined to the fishery aspects indicated above. Numerous other aspects could have been considered, but were too poorly known to permit meaningful specific treatment. Reference is made to some of these aspects in Section G.1.9

G.1.2 Magnitude of the Sport Fisheries Being Considered

Preliminary estimates of angling effort in the Okanagan were available for part of 1971 (Tasks 66 and 161). These estimates, along with local information and certain other assumptions, suggested the following orders of current annual participation along the Okanagan mainstem below Okanagan Lake:

SECTION	MAJOR FISH SPECIES TAKEN	ESTIMATED ANGLER-DAYS
Okanagan River at Penticton	Coarse fish	500-1000
Skaha Lake	Kokanee	6000-8000
Okanagan River, Okanagan Falls to Vaseux Lake	Coarse, rainbow,	1000-1500
	Mountain whitefish	200-300
Vaseux Lake	Several	<500[a]
Okanagan River below Vaseux Lake	Rainbow	200
	Mountain whitefish	100
	Coarse	300
Osoyoos Lake	Several including kokanee, rainbow	2500-3500[a]

[a] Estimates exclude participation by shore anglers

On the basis of the above, a working ratio of the proportions contributed to angling participation by the three species evaluated was derived as kokanee:rainbow:whitefish = 7.5:2:0.5.

G.1.3 Evaluation Procedure

Critical periods in the life histories of the three species as related to their utilization of the river were identified as far as possible by nearest whole months and discharges compatible with these life history objectives estimated (Table G.1). The various model outputs were then rated according to how they matched these preferred discharges. Reference was made to the frequency tables of discharge in the model output. Full evaluation was confined to the 1970 level of development: a brief consideration of the other levels failed to disclose significant shifts in ratings.

TABLE G.1

CRITICAL PERIODS AND DISCHARGE REQUIREMENTS OF THREE FISH SPECIES AS RELATED TO THEIR UTILIZATION OF THE OKANAGAN RIVER BELOW OKANAGAN LAKE.

SPECIES	MONTH(S)	LIFE HISTORY OBJECTIVE(S)	CRITICAL FLOW CHARACTERISTICS AND RELATED REQUIREMENTS
RAINBOW TROUT	April	Ascent	Minimum flow requirement 300 c.f.s.
	April-May	Spawning	Optimum flow 300-1000 c.f.s.
	May-June	Incubation, hatching	Optimum flow 300-1000 c.f.s.; related to discharge at spawning
	June-July	Rearing, descent	Optimum flow 300-1000 c.f.s.
	April-June	Feeding (fishery)	Optimum flow 300-1000 c.f.s.; related to sockeye hatch, invertebrate availability
	Sept.-Oct.	Ascent	Minimum flow requirement 300 c.f.s.
	Oct.-Nov.	Feeding (fishery)	Related to sockeye spawning success
MOUNTAIN WHITEFISH	November	Ascent	Minimum flow requirement 300 c.f.s.
	Nov.-Dec.	Spawning	Optimum flow 100-500 c.f.s.
	Dec.-March	Incubation	Optimum flow 100-500 c.f.s.
	March-April	Hatching, descent?	Optimum flow probably 100-1000 c.f.s.
	March-May	Feeding (fishery)	Optimum flow probably 300-1000 c.f.s.
KOKANEE	Sept.-Oct.	Ascent	Minimum flow requirement 300 c.f.s.
	Sept.-Oct.	Spawning	Optimum flow 300-500 c.f.s.
	Oct.-April	Incubation	Optimum flow 300-1000 c.f.s.; related to discharge at spawning
	April	Hatching	As for incubation
	April, May	Descent	As for incubation

TABLE G.2

SCORING OF OKANAGAN RIVER OPERATIONAL ALTERNATIVES WITH RESPECT TO SUITABILITY FOR SPORT FISH

ALTERNATIVE	RAINBOW TROUT	MOUNTAIN WHITEFISH	KOKANEE	COMPOSITE[a] SCORE
0	0	0	0	0
3	-40	-40	-60	-60
4	-30	-20	+40	+20
5	-30	-20	-50	-40
6	-40	-20	+30	+10
7	-40	0	+30	+10
8	0	0	+30	+20
9	0	0	+30	+20
10	0	0	+30	+20
11	-10	0	-20	-20
12	-10	-20	-50	-40
13	0	0	+30	+20
14	0	0	-20	-20
15	0	-20	-50	-40
20-25	0	0	+30	+20
26	0	0	+30	+20
27	0	-20	+30	+20
28	0	-20	+30	+20
29	0	0	+30	+20
30	0	-20	+30	+20
31	0	-20	+30	+20

[a] Composite score = 2 (Rainbow) +0.5 (Whitefish) +7½ (Kokanee)

G.1.4 Results

(a) Rainbow Trout

A notable but little utilized sport fishery for rainbow trout is reported to exist in the Okanagan River in spring, particularly in the "unimproved" section above Oliver. This fishery is apparently based on migration of stocks out of (mainly) Osoyoos Lake. This migration is partly for spawning purposes and partly for feeding, particularly on emerging sockeye. Because of the difficulties in fishing the river at high flows, this fishery is effective only at discharges below 1000 c.f.s. It ceases in the summer months when the trout either return to the mainstem lakes or become inactive because of high temperatures. There is some resumption of rainbow trout fishing in the river in autumn when the trout again become active and are reported to move into the river in quest of sockeye salmon eggs.

(b) Mountain Whitefish

Although they are seldom taken in the lower mainstem lakes, at least in summer, a small but consistent sport fishery for mountain whitefish is reported to take place in the river, particularly in late winter and early spring. Whitefish apparently ascend the river about November to spawn; presumably they maintain residence here in considerable numbers throughout the winter.

Somewhat lower flow requirements for reproduction are postulated for whitefish than for rainbow trout and kokanee. Primarily on this basis, two-thirds of the model alternatives, including most of those for diversion, scored slightly lower than the null. As with rainbow trout, no alternative could be definitely predicted to improve upon present operation.

(c) Kokanee

Kokanee ascend the Okanagan from all there of the lower mainstem lakes. The nature of the lateral tributaries makes this species even more dependent than rainbow trout on the Okanagan River for recruitment. There is virtually no fishery for kokanee within the river however.

The preliminary evaluation of modelled alternatives regarding sockeye salmon, as derived by the Department of the Environment formed the basis of the kokanee evaluation. This approach was considered justified since these fishes are known to have essentially similar reproductive behaviour. Since kokanee do not begin their ascent until late in September however, the August scores derived for sockeye were omitted from consideration. As for sockeye, enhancement over existing operation would seem to be achieved by alternatives 4, 6-10, 13, and by all the diversion runs (Table F-2).

(d) Overall Sport Fishery

It was anticipated that the diverse fish species which utilize the river might pose different and conflicting optima for the operation of the Okanagan mainstem. To a considerable extent, this proved to be the case (Table G.2). A composite score was nevertheless derived by weighting each species according to its estimated contribution to the regional fishery. For the purposes of the freshwater fisheries, alternatives 4, 6-10, 13 and all the diversion alternatives were about equally suitable. Particularly objectionable were alternatives 3, 5, 12 and 15.

(e) Other Considerations

As noted earlier, there are many other aspects of Okanagan fisheries on which the operation of the mainstem has a direct or indirect bearing, but which are not sufficiently known or quantifiable to permit thorough evaluation. Some of these aspects are listed below, with a short explanation and statement of possible water management implications:

(i) Production of littoral benthos and forage fishes in the mainstem lakes This is important, particularly as regards the continuing production of rainbow trout. It is susceptible to fluctuating lake levels, and particularly to reduced levels over winter or through the spring. In general this aspect may be considered as paralleling the wildlife requirements.

(ii) Production of invertebrates and forage fishes in the river. Again, the most important benefitting species would appear to be rainbow trout. Production tends to be augmented by steady flows and generally by those regimes which are conducive to fisheries.

(iii) Beach spawning of fishes. Lake whitefish and probably kokanee spawn in in late autumn along the shallows of the mainstem lakes. The spawn may be susceptible to falling lake levels over winter. Beach spawning of sunfishes could be similarly affected by falling levels in spring.

(iv) Spawning access to tributary streams. Rainbow trout, kokanee and probably some forage species ascend tributaries to spawn. Kokanee are probably the most susceptible to denied access by low autumn lake levels.

(v) Fish production in oxbows. The by-passed segments of the original river channel in the Oliver-Osoyoos area are potentially viable habitat for warm-water species. Their usefulness in this regard is severely diminished by current water and land management practices. In general, the oxbows appear at present to be denied the critical flows to sustain fish life over winter.

It must be emphasized that the model outputs take no account of habitat manipulations which may be feasible outside of river discharge. A full evaluation of alternatives would have to consider such possibilities as;

1) Manipulating the disposition of spawning habitat by importing gravels, altering bottom profiles, etc.,
2) Reducing river temperatures by providing cover vegetation.
3) Providing artificial spawning environments.

It should also be noted that if a detailed evaluation of mainstem lake habitat for fisheries were to be made, quite different score patterns would probably result. However, it seems likely that the lake habitat would generally be less sensitive to ordinary operational alternatives for the system.

APPENDIX G-2

PRELIMINARY EVALUATION OF THE EFFECT OF MAINSTEM WATER QUANTITY ALTERNATIVES ON WILDLIFE

(Reprint of Report Prepared by A.C. Brooks, Consulting Biologist)

This assessment is primarily concerned with an evaluation of the effects on wildlife that might result if levels in Okanagan Lake seasonally fluctuate within the limits predicted by the 1971 U.B.C. Mathematical Model of the Okanagan Basin Study (Appendix F). At the end of this report, brief reference is made to (a) the region, referred to in the Study as "the Oxbows" bordering the Okanagan River channel and (b) to the importance of wildlife on Okanagan lakes.

For the purposes of Task 23, I have considered that the critical times of the year in terms of lake levels related to the wildlife of the shorelines of the lakes are early summer and mid-winter.

G.2.1 Basis for Evaluation

I have presented my evaluation of the effects of changing water levels in terms of the degree of severity changing water levels may have on wildlife of the lake; for instance, extremely low lake levels during the winter could, especially during a cold winter, affect natural food supplies of various water birds and mammals that frequent the shoreline. It could also deprive such species of adequate cover and protection; low water during the early summer would affect nesting requirements for various species of waterfowl; and unusually low water - i.e. below 1117.8 feet during the spring and fall would result in changes of the shoreline habitat.

G.2.2 Scoring

The scoring on which my evaluation is based is outlined in Table G.3.

TABLE G.3

SCORING BASIS FOR EVALUATIONS

WATER LEVEL	SEASON	SCORE
Less than 1117.8'	December - February	3
1117.8' - 1118.7'	December - February	2
1118.8' - 1119.8'	December - February	1
Less than 1117.8'	March - April	1
Less than 1117.8'	August - November	1
Greater than 1117.8'	March - April	0
Greater than 1117.8'	August- November	0
Greater than 1119.8'	December - February	0
Less than 1118.7'	May - July	3
1118.8' - 1119.7'	May - July	2
1119.8' - 1121.6'	June Only	2
1119.8' - 1121.6'	May and July	1
1119.8' - 1121.6'	May - July	0

Note that scores range from "0" to "3" points. "0" represents no adverse effect during the season involved; "1", certain species may be slightly affected; "2", certain species may be severely affected, and "3" practically all species of wildlife dependent upon the shoreline may be severely affected.

G.2.3 Comparison with the Zero Alternative of the Mathematical Model

Using the above scoring, first the zero alternative, then alternatives 3 to 15 and 26 to 31 were scored by month for each year. Subsequently, these scores were grouped into their respective seasons, which in turn were totalled for each alternative. Finally, the total scores for each alternative were ranked against the total score for the zero or null alternative. The zero alternative was rated as "0", the remaining runs were rated from -5 to +5, their actual rating being calculated on the basis of 1/10th the difference between the total score for the null alternative (59) and the total score of the run under comparison. Scores and rating for each of the alternatives were tabulated in Table G.4.

TABLE G-4

SCORES FOR VARIOUS ALTERNATIVES

RUN	SCORING BY SEASON					RATING
	March and April	May to July	August to Novemoer	December to February	TOTAL	
Null	4	33	4	18	59	0
3	2	8	-	3	11	+5
4	2	18	3	11	45	+2
5	2	17	3	9	32	+3
6	2	16	6	12	36	+2
7	4	25	4	12	45	+1
8	4	40	10	28	82	-2
9	5	35	9	21	70	-1
10	5	38	4	15	62	0
11	2	33	4	15	54	0
12	-	27	-	6	33	+3
13	7	35	6	24	72	-1
14	4	33	4	18	59	0
15	2	20	4	9	35	+2
26	4	20	4	16	44	+2
27	-	22	-	8	30	+3
28	-	16	-	1	17	+4
29	-	23	2	11	36	+2
30	-	15	-	-	15	+4
31	-	12	-	-	12	+5

(Wildlife 'Scoring' and Evaluation from the 1970 level of Development of the 1971 U.B.C. Mathematical Model for Okanagan Lake).

G.2.4 Comments on the Evaluation

It will be noted that Alternatives 8, 9 and 13 each have a negative rating and may therefore be considered disadvantageous to wildlife. Runs 10, 11 and 14, having a zero rating and compare to situations anticipated in the zero alternative. The remaining runs indicate improved situations for wildlife, numbers 3, 28 and 30 with ratings of 5, 4, 5, respectively - providing the most favorable situations of all the runs under comparison (Table G.5).

TABLE G-5

SUMMARY WILDLIFE EVALUATIONS FOR OKANAGAN LAKE

RUN	RATING	RUN	RATING
Null	0	13	-1
3	+5	14	0
4	+2	15	+2
5	+3	26	+2
6	+2	27	+3
7	+1	28	+4
8	-2	29	+2
9	-1	30	+4
10	0	31	+5
11	0		
12	+3		

G.2.5 The Oxbows

The oxbows in the vicinity of the Okanagan River channel are relatively unproductive for water birds and muskrat. I attribute this situation to the eratic fluctuations of the water levels and flows in the river channel and to fluctuations in water levels in the oxbows themselves, which are partly dependent upon water levels and flows in the channel, and in a number of cases, on irrigation demands from the oxbow itself. These changing water levels, which can occur at any season, result in unstable conditions. Added to this is the nature of the oxbows: many are shallow in all seasons; some dry up when water flows in the channel drop below 600 c.f.s.; some of the larger have gravel bottoms which are unfavorable for the establishment of pond weeds; while a number of the small oxbows have been virtually destroyed by being used as fills for trash from orchards and for garbage and wrecked cars. The only oxbows of any significance in terms of water fowl are those leading into the marshes of Osoyoos Lake. As the water levels in these oxbows are largely governed by the level of this lake, they may be considered a part of that system rather than that of the river channel.

Assuming that the oxbows are relatively unproductive in terms of wildlife species usually associated with wetlands and that their water levels follow no fixed pattern, imposes limitations on any form of evaluation related to the mathematic model. I have, therefore, not endeavored to evaluate them for the purposes of Task 23. Let not these few cursory remarks give the impression that the oxbows are valueless with respect to wildlife; the wildlands and riparian habitat associated with these water areas harbor one of the richest and most varied land-bird fauna to be found during the spring and summer anywherein British Columbia. These lands are also highly productive in upland game birds and land mammals.

G.2.6 Importance of Wildlife on Okanagan Lake

The quantity of the wildlife in Okanagan Lake ranks high from the point of view of the number of species of birds and mammals that may frequent the lake and its shorelines. In forms of productivity however, if we are to compare this area with such areas as the Creston Flats, the southern part of Lake Winnipeg, or some of the larger marshes and lakes of the prairies, it is relatively low. The Canada Land Inventory of 1969 classifies the center and deeper parts of the lake - in other words - the greater part of the surface area of the lake, as an area which has severe limitations to the production of waterfowl. It recognizes the margins of the lake and the north arms of the lake as not useful for waterfowl production, but as areas important for migrating and wintering waterfowl. It further identifies the extreme end of the north arm of the lake as the only part of the lake that has a high capability rating for the production of wildlife. This assessment, valid in itself, should not influence us to underweigh wildlife when we are evaluating other aspects of the natural environment and human usages of the lake. When wildlife is to be evaluated in any project such as Task 23, it is my opinion - and I think also of others connected with the Study - that it should be given preferential consideration, possibly being ranked on a par with each of the other evaluations. Wildlife is a qualitative resource. It is one of the intangibles!

APPENDIX G-3

PRELIMINARY EVALUATION OF THE EFFECT OF MAINSTEM WATER QUANTITY ALTERNATIVES ON THE SHORELINE OF OKANAGAN LAKE

(Reprint of Report Prepared by J. O'Riordan, Planning Branch, Department of the Environment)

G.3.1 Introduction

This report presents the principal steps and findings in the evaluation of shoreline damage around Okanagan Lake for each of the various water management alternative models of the mainstem Okanagan (Appendix F). The evaluation procedures are designed to assess the economic, social, and environmental consequences of Okanagan Lake levels which fluctuate outside the normal operating range upon specified landuse categories around the shoreline.

All the data used in this evaluation process were obtained during the summer of 1971 from the shoreline survey of Okanagan Lake. The methodologies used in that survey plus the first-order analysis of the data are contained in Technical Supplement VIII. To clarify the steps in the evaluation of the water quantity management models on shoreline landuse developments around Okanagan Lake, a brief summary of Task 21 (Shoreline Survey) is presented here.

The first step in the shoreline survey involved the identification of various landuse developments around the shoreline of Okanagan Lake which might be affected by extreme fluctuations of lake levels outside the normal operating range. Each identified landuse was then categorized according to whether the consequences of fluctuating lake levels contributed (positively or negatively) to the achievement of the study goals of economic growth, environmental quality or social well-being (Appendix D). The various landuse categories as shown in Table G.6 were evaluated under one of the three major goals according to the following criteria:

(1) Any impact that could be properly assessedin dollars was accounted under the economic goal.

(2) Impacts on the recreational and aesthetic qualities of the shoreline that were affecting the public at large rather than individual property owners were accounted under the environmental goal.

(3) Any effects on the loss of opportunities by private property owners due to fluctuating lake levels were accounted under the social well-being objective. Damage to landuse types under the environmental and social goals were accounted in quantitative but non-monetary units.

TABLE G.6

LANDUSE CATEGORIES FOR OKANAGAN LAKE SHORELINE SURVEY

GOAL	LANDUSE TYPE	UNIT OF MEASUREMENT
Economic	Navigation wharves	dollars
	Kelowna floating bridge	"
	Simpson Mill (Kelowna)	"
	Flood damage to private property	"
	Revenues lost (marina rental, oil and gas sales)	"
Environmental	Recreation beaches flooded	Acre-days
	Public boat access ramps inoperable	Ramp-days
	Shoreline area exposed by drawdowns	Area-days*
Social	Private property flooded	Acre-days
	Private structures affected	Structure-days
	Private boat docks inoperable	Boat dock-days

* Because of the difficulty in accurately surveying the area exposed by lake level drawdowns below the minimum level of 1119.8 feet, a dimensionless index of 'area-days was used. The area of shoreline that suffered the maximum drawdown when the lake level was at 1116.8 feet was rated at 100, and incremental drawdowns between 1119.8 and 1116.8, for this and other sections of the shoreline were pro-rated to 100. The pro-rated numbers for each section were then multiplied by the number of days the drawdown at each 0.5 foot increment occurred to produce the index 'area-days'.

Care was taken to avoid double counting in the evaluation of lake level fluctuations on the identified landuse categories. For example, it was reasoned that inundation of private property would create two distinct types of consequences. There would be the social consequences resulting from the loss of opportunity for individuals to use their property and their private dwellings during the period of high lake levels, and there would be economic costs associated with restoring the property and structures to their pre-flood conditions. The first category of damage cannot be evaluated in monetary terms, yet it is believed to be real, and is thus assessed in quantitative but non-monetery units (Section G.3.2).

These identified landuse categories immediately adjacent to Okanagan Lake were surveyed during the summer of 1971 and an inventory was made of the type and extent of damage that would occur for 0.5 foot increments up to 2.0 feet above the present maximum level of 1123.8 feet and for 0.5 foot increments down

to 3.0 feet below the present minimum level of 1119.8 feet. A stage-damage curve was developed for each landuse type where relevant for the high and low water levels.

G.3.2 Evaluation Procedures

(a) Damage Estimation

Monthly Okanagan Lake elevations for each of the 22 planning alternatives generated by the U.B.C. model were inspected and actual events of monthly fluctuations of lake levels outside the normal 4-foot operating range were noted. The damage occurring at each event for each landuse type was interpolated from their respective stage-damage curve. In the case of the landuse types accounted under the environmental and social goals, damage was estimated in unit-days, which represented the total opportunity lost in days during the period of extreme high or low water levels. Thus, if 10 private boat docks were rendered unoperable by high water for two months (60 days), a total of 600 boat-dock-days would be lost. To account for seasonal variations in use (for example, boat docks are mainly used during the summer months), each social and environmental landuse category was adjusted by a monthly weighting factor (Table G.7).

TABLE G-7

MONTHLY WEIGHTINGS IN DAYS FOR SHORELINE DAMAGE

(Maximum 31)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Public Boat Access Ramps	0	0	5	10	15	25	31	31	20	10	5	0
Private Boat Docks	0	0	5	10	15	25	31	31	20	10	5	0
Public Recreation Beaches	0	0	0	0	5	15	31	31	10	0	0	0
Marinas	0	0	0	0	20	30	31	31	20	10	0	0
Campgrounds	0	0	0	0	10	20	31	31	10	0	0	0

For each alternative modelled, the total damage in dollars and unit-days for all extreme events in the 50 years of record was summed and the total divided by 50 to obtain annual damage values. In the case of the diversion with storage alternatives (No's 20 to 25 inclusive) which were not modelled, it was assumed that damage for each landuse category would be equal to the minimum values recorded for other alternatives. Total annual damages for each of the 22 modelled alternatives for all landuse categories are presented in Table G.8.

TABLE G.6

ANNUAL DAMAGES FOR SELECTED LANDUSE CATEGORIES
AROUND OKANAGAN LAKE FOR MODELLED ALTERNATIVES

ALTERNATIVE NUMBER	ECONOMIC		ENVIRONMENTAL			SOCIAL		
	DIRECT DAMAGE* $	LOSS OF REVENUE $	PUBLIC BOAT RAMPS RAMP-DAYS	PUBLIC RECREATION SITES ACRE-DAYS	LAND EXPOSED AREA-DAYS	PRIVATE PROPERTY FLOODED ACRE-DAYS	PRIVATE STRUCTURES FLOODED STRUCTURE-DAYS	PRIVATE BOAT DOCKS BOAT-DOCK DAYS
0	2340.00	774.92	78.4	6.95	843.3	52.82	170.8	5068.6
1	2585.00	274.00	8.9	9.04	24.4	66.80	219.1	717.3
2	2360.00	329.42	30.0	7.87	237.4	57.92	189.4	1832.5
3	2665.00	302.54	13.0	9.04	77.1	66.80	219.1	1129.8
4	2360.00	362.98	31.4	7.87	366.5	57.92	189.4	2538.2
5	2360.00	370.40	13.8	7.87	319.3	57.92	189.4	2488.7
6	1960.00	477.16	49.0	7.87	506.9	57.92	189.4	3031.8
7	2480.00	64.82	71.0	7.87	712.7	57.92	189.4	4189.7
8	2280.00	1164.46	153.5	6.53	1679.4	49.22	161.8	8208.0
9	2440.00	1075.64	130.0	7.87	1469.0	57.92	189.4	6592.5
10	2200.00	950.52	112.8	6.53	1267.0	49.22	161.8	6677.1
11	2040.00	511.80	55.1	6.53	600.3	49.22	161.8	3832.6
12	2120.00	310.08	21.9	6.53	660.0	49.22	161.8	1997.8
13	2200.00	1039.00	124.0	6.53	1401.2	49.22	161.8	7530.7
14	2240.00	725.06	78.9	6.53	856.2	49.22	161.8	5027.9
15	2120.00	504.74	51.0	6.53	560.2	49.22	161.8	4051.6
26	2080.00	529.22	58.3	6.53	667.0	49.22	161.8	3813.2
27	2120.00	262.46	14.5	6.53	194.7	49.22	161.8	1586.1
28	2360.00	264.11	3.4	7.76	36.7	57.80	189.0	875.2
29	2200.00	347.22	28.3	6.53	336.9	49.22	161.8	2437.3
30	1840.00	175.82	6.9	6.53	24.4	49.22	161.8	649.7
31	2280.00	264.16	7.7	7.76	24.4	57.80	189.0	732.2

* These economic values omit possible damage to Kelowna Bridge and Simpson's Mill which have yet to be evaluated. Because of the large fluctuations in lake levels for the zero alternative however, comparative economic values for the other alternatives are likely to be small.

(b) Comparison with Zero Alternative

In accordance with the principles of evaluation (Appendix E), an estimate of the incremental effects of each alternative on environmental and social landuse types was obtained by comparing all annual damage values for alternatives 1 to 15 inclusive and 26 to 31 inclusive with the zero alternative (present-day operating procedures). This comparative analysis procedure is illustrated for one land use category - public boat ramps, in Table G.9. The extreme range in annual damage values for each landuse category was noted and the difference between the annual value for the zero alternative and both extreme values (above and below the zero alternative) was calculated. The larger difference whether positive (benefit) or negative (cost) was scored as 100. Differences between the annual values for the zero alternative and the respective annual values for all other alternatives were then scored as a percentage of this maximum difference, decreases in annual damage being scored positively and increases in annual damage being scored negatively. The matrix of unweighted scores for all landuse types is shown in Table G.10.

(c) Weighting of Environmental and Social Values

Inspection of Table G.10 indicates that several alternatives reduced the annual damage for some landuse categories and increased it in others, as compared to the zero alternative. In most cases, this is due to the fact that alternative operations of the mainstem system which reduce the frequency and magnitude of low water levels at the same time increase the frequency of high level occurrances. Because of this conflict, it seemed advisable to adjust the scores of the various social and environmental landuse categories according to a weighting system reflecting their relative priorities.

In the absence of any guidelines for weighting the social well-being and environmental goals, the author chose three different weighting schemes and compared their outcomes through sensitivity analysis.

The three weighting schemes are shown in Table G-11. The first scheme placed the same weight on each landuse category; the second scheme emphasized the environmental landuse types (recreation, boat ramps, boat-docks and aesthetic aspects) while the third scheme emphasized the social factors (private property, private boat-docks, and private structures).

For each alternative, the scores for each landuse type was multiplied by the appropriate weight and the products totalled to obtain an integrated score, which was averaged to obtain a composite score. This composite score reflects the net contribution of each alternative to the achievement of the environmental and social well-being goals as compared to the zero alternative. Table G.12 illustrates the procedure for obtaining the composite score for Alternative 1.

TABLE G.9

COMPARISON WITH ZERO ALTERNATIVE-PUBLIC BOAT RAMPS

ALTERNATIVE NUMBER	RAMP-DAYS	ZERO ALTERNATIVE	DIFFERENCE	MAXIMUM RANGE	SCORE
1	8.9	78.4	+69.5	75.1	+93
2	30.0		+48.4		+64
3	13.0		+65.4		+87
4	31.4		+47.0		+63
5	13.8		+64.6		+86
6	49.0		+29.4		+39
7	71.0		+ 7.4		+10
8	153.5		-75.1		-100
9	130.0		-56.6		-69
10	112.8		-34.4		-46
11	55.1		+23.3		+31
12	21.9		+56.5		+75
13	124.0		-45.6		-61
14	78.9		- 0.5		- 1
15	51.0		+27.4		+36
26	58.3		+20.1		+27
27	14.5		+63.9		+85
28	8.4		+70.0		+93
29	28.3		+50.1		+67
30	6.9		+71.5		+95
31	7.7		+70.7		+94

Extremes - Alternative 8 - 153.5 boat-ramp days
- Alternative 30- 6.9 boat-ramp days
Difference above zero alt. 78.4-153.5 = -75.1 boat-ramp days
Difference below zero alt. 78.4- 6.9 = +71.5 boat-ramp days
Maximum difference = -75.1 boat-ramp days

TABLE G.10

UNWEIGHTED SCORING OF ENVIRONMENTAL AND SOCIAL IMPACTS FOR ALL ALTERNATIVES IN COMPARISON WITH ZERO ALTERNATIVE

ALTERNATIVE NUMBER	PUBLIC BOAT RAMPS	PUBLIC RECREATION SITES	LAND EXPOSED	PRIVATE PROPERTY FLOODED	PRIVATE STRUCTURES FLOODED	PRIVATE BOAT DOCKS
1	93	-100	98	-100	-100	99
2	65	- 44	73	- 39	- 39	73
3	87	-100	92	-100	-100	89
4	63	- 44	57	- 39	- 39	57
5	86	- 44	63	- 39	- 39	58
6	39	- 44	40	- 39	- 39	46
7	10	- 44	16	- 39	- 35	20
8	-100	20	-100	21	57	-71
9	- 69	- 44	- 75	- 39	- 35	-35
10	- 46	20	- 51	21	57	-36
11	31	20	30	21	57	28
12	75	20	22	21	57	69
13	- 61	20	- 67	21	57	-56
14	- 1	20	- 2	21	57	1
15	37	20	24	21	57	23
26	27	20	21	21	57	75
27	85	20	78	21	57	79
28	93	- 39	97	- 39	- 39	95
29	67	20	61	21	57	60
30	95	20	98	21	57	100
31	94	- 39	98	- 39	- 39	98

TABLE G.11

ALTERNATIVE WEIGHTING SCHEMES

(Scale 1-5)

LANDUSE TYPE	SCHEME 1 EVEN WEIGHTS	SCHEME 2 ENVIRONMENTALLY BIASED	SCHEME 3 SOCIALLY BIASED
Public boat ramps	3	4	2
Public Recreation sites	3	3	1
Public land exposure	3	5	3
Private property	3	1	4
Private structures	3	1	5
Private boat docks	3	4	3
TOTAL	18	18	18

TABLE G.12

WEIGHTING SOCIAL AND ENVIRONMENTAL LANDUSE TYPES

Example - Alternative 1

LANDUSE TYPE	WEIGHT	UNWEIGHTED SCORE	WEIGHTED SCORE
Public boat ramps	4	93	372
Public recreation beaches	3	-100	-300
Land exposed	5	98	490
Private property	1	-100	-100
Private buildings	1	-100	-100
Private boat docks	4	99	396
Integrated Score	18		758
Composite Score	758 ÷ 18		+ 42

(d) Final Evaluation of Alternatives

The final step in the evaluation procedure was to present the total composite scores for environmental and social impacts for each weighting scheme alongside the annual dollar damage accounted under the economic goal (Table G.8). As was the case for the non-monetary impacts, the annual economic values shown represent the difference between each alternative and the zero alternative respectively. Thus, only incremental benefits and costs are shown in Table G-13.

Alternatives with negative dollar damages and/or negative composite scores will create more damage to selected landuse types around the shoreline of Okanagan Lake in terms of the overall study objectives than the present method of operating the mainstem Okanagan system. The reverse holds for alternatives with positive values. The maximum absolute value of the composite scores for any alternative is 10, while a score of zero means that there is no change from the existing situation.

G.3.3 Results

The most important result is that the incremental economic benefits and costs of each alternaive compared with the present situation for the shoreline survey are very small. The maximum annual incremental benefit being $1,089.10 for Alternative 30. This appears to be due to two reasons: Firstly, there are few dollar costs associated with high or low lake levels. During low water periods, the principal economic damages involve low cost adjustments to the navigation facilities and some loss of revenue at marinas and boat rental wharves. The highest level indicated in the model outputs was approximately one foot above maximum, at which level there is a relatively small amount of flood damage to properties. If any alternative had indicated a two foot rise in lake level above the maximum, the resulting economic damage would have been five times as large. Secondly, because of the relatively large range of lake level fluctuation associated with the zero alternative, the annual dollar damages for this alternative are comparatively large (fifth largest of all alternatives) which tends to dampen the magnitude of the incremental differences between the zero and other alternatives.

Alternatives 1 to 5 inclusive are sensitive to the different weighting schemes and appear to be favorable if emphasis is placed upon the environmental goal. Alternatives 6 to 10 inclusive and 13 are generally unfavorable on all accounts. As anticipated, the alternatives involving diversion - 26 to 31 inclusive - are favorable according to all accounts, especially in terms of the social and environmental goals. However, the incremental benefits in the non-monetary evaluation categories for the diversion alternatives appear to be only marginally greater than the benefits accruing to alternatives 4, 11 and 12.

TABLE G.13

FINAL EVALUATION OF ALTERNATIVES

ALTERNATIVE	ECONOMIC BENEFITS & COSTS	ENVIRONMENT AND SOCIAL *		
		EVEN WEIGHTS	ENVIRONMENTALLY BIASED WEIGHTS	SOCIALLY BIASED WEIGHTS
0	0	0	0	0
1	+ 255.62	0	+ 4	- 1
2	+ 425.50	+ 1	+ 4	+ 1
3	+ 147.08	- 1	+ 4	- 2
4	+ 391.94	+ 1	+ 4	0
5	+ 384.52	+ 1	+ 4	+ 1
6	+ 677.76	0	+ 2	0
7	+ 570.10	+ 1	0	- 1
8	- 392.54	- 3	- 6	- 2
9	- 400.72	- 5	- 6	- 5
10	- 35.60	- 1	- 3	0
11	+ 563.12	+ 3	+ 3	+ 4
12	+ 684.84	+ 4	+ 5	+ 5
13	- 124.08	- 1	- 4	+ 1
14	+ 149.86	+ 1	+ 1	+ 2
15	+ 490.18	+ 3	+ 3	+ 4
26	+ 505.70	+ 4	+ 4	+ 4
27	+ 732.24	+ 6	+ 7	+ 6
28	+ 490.76	+ 3	+ 6	+ 2
29	+ 567.70	+ 5	+ 5	+ 5
30	+1,089.10	+ 7	+ 8	+ 7
31	+ 570.76	+ 3	+ 6	+ 3

* The composite scores for the environmental and social landuse categories are rounded off to a scale of 10 to conform with other evaluation studies associated with Task 23.

The results also show that the present operation of Okanagan Lake and River as modelled by the zero alternative, is rather inefficient. Only alternatives 8, 9, 10 and 13, all of which demand large releases of water to Okanagan River, would create more annual damage around the Okanagan Lake shoreline than the present operation. Generally speaking, any restriction on water release to Okanagan River, especially during the irrigation season, will reduce lake level drawdowns in dry years, thereby reducing the associated economic, environmental and social problems to shoreline landuse around Okanagan Lake.

G.3.4 Summary

This report has presented the principal steps and findings in the evaluation of shoreline damage around Okanagan Lake for each of 22 preliminary water management alternatives (Task 23) in the mainstem Okanagan system. The impact of extreme fluctuations of Okanagan Lake on shoreline landusé was evaluated in terms of the three major goals of the Study - economic growth, environmental quality, and social well-being. The economic consequences were measured in dollars, while the environmental and social consequences were measured in unit-days to represent the total opportunities lost. The annual damages for each identified landuse category for each alternative was compared with present annual values associated with the zero alternative and the results presented as incremental differences. The incremental differences in social and environmental outputs were scored in relation to the zero alternative and weighted according to three different weighting systems (see Table G-11). The main findings are as follows:

1) Annual economic damages resulting from lake level fluctuations in the range presented by the alternatives are small, mainly because low cost adjustments are available for low lake levels, and because high water levels were no greater than one foot above maximum, i.e., within the range at which only minor flood damage to private properties would occur.

2) The major impacts of low lake levels accrue to the social and environmental goals and should be considered an inconvenience rather than a disaster. Most problems would involve exposure of unsightly shoreline around public recreation areas and private property, a lower quality of boat access onto the lake from marinas, public and private launching facilities, and somewhat reduced swimming opportunities.

3) With the exception of alternatives 8, 9, 10 and 13, all modelled alternatives would reduce the economic, social and environmental problems that occur under present operating rules as modelled in the zero alternative. The diversion alternatives 27-31 inclusive, indicate the most favorable incremental improvement in the social and environmental landuse categories, but this improvement appears to be only marginally better than the benefits of other alternatives 4, 11, 12 - none of which involves high cost implementation.

APPENDIX G-4

PRELIMINARY EVALUATION OF THE EFFECT OF MAINSTEM WATER QUANTITY ALTERNATIVES ON WATER QUALITY

(Based on Material submitted by J. Stockner, Fisheries Research Board of Canada).

G.4.1 Introduction

The probable effect of the various mainstem water quantity alternatives set out in Appendix F (Task 23), on water quality, are evaluated in this report. This evaluation is based on preliminary data from water quality and limnology studies and is confined to the effect of the different flow regimes on the water quality of Skaha, Vaseux and Osoyoos Lakes, and on the ecology of Okanagan River.

G.4.2 Evaluation Procedure

The effect of increasing or decreasing the flow of water through Skaha, Vaseux and Osoyoos Lakes (Alternatives 1 to 15 and 26 to 39) was compared to that of the existing regime(zero alternative), to determine if such changes would reduce or increase the nutrient concentrations in these lakes. This nutrient concentration, in turn, is related to the trophic state of a lake, and the amount of objectionable rooted aquatic and algal growth that may be present. All three lakes under the null or zero alternative had high nutrient contents, and were considered to be in the mesotrophic to entrophic range in respect to biological production. The effect of various flows on objectionable rooted vegetation in Okanagan River was also considered in this evaluation.

G.4.3 Results

Within the range of flow alternatives being considered, no significant change in the water quality of any of the lakes was anticipated. Even in the case of water importation, the additional amounts proposed would not be sufficient to provide any appreciable reduction of nutrients through flushing action.

Scores established for the various alternatives, based on an examination of the monthly discharge patterns, are set out in Table G-14. Those alternatives which were rated as providing marginal improvement to the water quality of these lakes (Alternatives 8, 9, 10, 13 and 26 to 31) all had minimum flows of 250 to 300 c.f.s. during the summer and fall months. Those alternatives which were considered inferior to the zero alternative (Alternatives 1 to 4) had minimum flows of 100 c.f.s. or less during the same period. A brief discussion of the probable affect of flow changes on each of these mainstem lakes is presented below.

TABLE G-14

SCORING OF ALTERNATIVES (TASK 23) FOR WATER QUALITY VALUES

ALTERNATIVE	SCORE	ALTERNATIVE	SCORE
0	0	8	+2
1	-4	9	+2
2	-4	10	+1
3	-1	11	-1
4	-1	12	-1
5	0	13	+1
6	0	14	0
7	0	15	0
		26 to 31	+2

(a) Skaha Lake

The most important factor contributing to the high nutrient content of Skaha Lake is considered to be the discharge of treated effluent from the Penticton Sewage Treatment Plant. Under high flow conditions, nutrients from this discharge will be diluted to a greater extent than under low flow conditions, and will be displaced further into the main body of the lake before being assimilated by algal populations. Only alternatives 1 and 2 with a minimum discharge of 50 c.f.s. appear to have an adverse effect on Skaha Lake. This would occur through the buildup of a concentration of nutrients in the lake, thereby enhancing the possibility of blooms in the north end.

The explanation for the apparent insensitivity of Skaha, as well as the other lakes in the system, to the range of flows considered, lies chiefly with the dynamics of the phosphate-phosphorus $PO_4(P)$ cycle. Simply stated, "available" $PO_4(P)$ is taken up within minutes by algae, retained in the cell for a matter of hours or days, depending on the particular algae, then either sedimented or recycled. Thus, the ebb and flow of "available" $PO_4(P)$ can be measured in minutes or days, while the exchange of water in the epilimnion as a function of varying discharges rates is measured in months, or in some instances, years. It therefore appears unlikely that changes in epilimnetic residence time (flushing) would play a substantial role in altering water quality in Skaha or in other lakes in the system.

(b) Vaseux Lake

Nutrient sources to this small lake are chiefly from Skaha Lake discharge [residual $PO_4(P)$] and from shoreline development - septic tanks, etc.

Though direct evidence is lacking, it appears that this lake acts as an effective nutrient sink, trapping and retaining a high percentage of its total nutrient input. Massive weed growths in the north end are evidence of this effect. With improvement in Skaha Lake water quality, it is likely the extent and magnitude of the weeds would diminish. What was said previously regarding flushing also applies to Vaseux Lake.

(c) Osoyoos Lake

At present Osoyoos Lake receives most of its nutrient input from Skaha Lake outflow and effluent discharges to Okanagan River between Skaha and Osoyoos Lakes. Though weed and algal growths are a common feature of this lake, they have not reached such magnitude as to create a serious public nuisance. It is also felt, based on the preliminary results of limnology studies that Osoyoos, like Skaha, can rather effectively and efficiently assimilate its nutrient input, and the value of flushing from increased flows would not be a significant factor in altering water quality of Osoyoos Lake.

A second point concerning biological production in Osoyoos Lake is that this lake is an important rearing ground for the sockeye salmon smolt. Any significant decrease in the nutrient concentration in this lake would alter this rearing capacity. Further studies beyond the scope of the Agreement may better explain this nutrient-algae-zooplankton-sockeye interation.

6.4.4 Okanagan River

The effect of increased or decreased flows on objectionable aquatic growth in Okanagan River was also considered in this evaluation. Excessive growth of epilithic algae on stones in the stretch of the Okanagan River below Skaha Lake is likely attributable to the nutrient carryover from Skaha Lake, plus any additional nutrients received from the Village of Okanagan Falls. Low discharges - 50 to 100 c.f.s. - prevents sloughing of long, braided algal filaments and consequently the growths become unsightly and more noticable. Lack of normal stream vegetative cover also provides optimal growth conditions for these plants. Therefore, in "improved" sections of the river the growths are much more conspicuous.

Growth of epilithic diatoms on small stones is quite normal in flowing streams and generally goes unnoticed by the general public. However, excessive growth of this material in low flow situations may impair salmon spawning in the lower stretch below the South Okanagan Land Irrigation District Diversion Dam. Flows in excess of 100 c.f.s. will likely alleviate most of these problems.

G.4.5 Summary

An examination of the monthly discharge patterns for the various water quantity alternatives considered under Task 23 indicate that these will not have any significant effect on the water quality of Skaha, Vaseux and Osoyoos Lakes, provided minimum flows are in excess of 100 c.f.s. Most objectionable aquatic growth in Okanagan River may also be controlled by maintaining flows above 100 c.f.s.