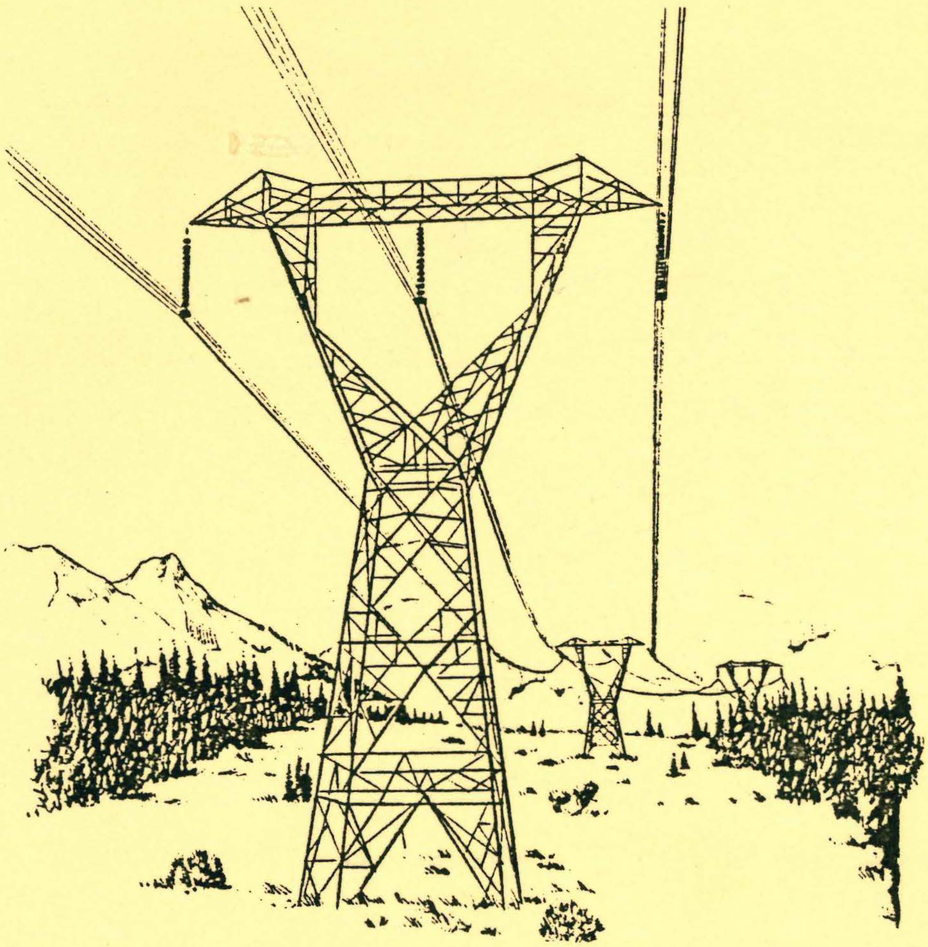
ENERGY WORK GROUP

PROGRAM REPORT



YUKON RIVER BASIN STUDY

This project was completed for the Yukon River Basin Study, an intergovernmental study funded by the governments of Canada, Yukon and British Columbia.

November 30, 1984.

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Whitehorse, Yukon

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DISCLAIMER

This report was funded by the Yukon River Basin Committee under the terms of "An Agreement Respecting Studies and Planning of Water Resources in the Yukon River Basin" between Canada, British Columbia and Yukon. Statements made are those of the Energy Work Group and not necessarily those of the Yukon River Basin Committee nor parties to the Basin Agreement.

A cross section of opinions and interests is represented by members of the Energy Work Group. While a substantial degree of agreement was reached on a majority of issues, there are different degrees of support for some views and recommendations in the Report. Accordingly it should be recognized that there are some dissenting minority opinions not expressed in the Report.

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CHAPTER ONE: INTRODUCTION

Potential hydroelectric development is likely the most significant water management issue in the Yukon River Basin. Through the Energy Work Group, the Yukon River Basin Study has provided a mechanism for an overall appraisal of the Basin's energy regime. The work group included members from the Yukon, British Columbia and Federal governments as well as both private and public utilities.

Early in its deliberations, the work group established the following general principles as a framework:

1. **Long Term Perspectives**

   At the present time, most prevailing forecasts project very little growth in electrical energy requirements. These forecasts are typically limited to the next twenty year period. However, the work group has not restricted itself to only considering the implications of minor perturbations on the existing energy system. Conditions can change rapidly both in terms of social requirements and technology. The result is that present day unforeseen possibilities quickly become real options. For this reason the work group adopted a long term perspective from which to view all the Basin's energy resources.

2. **Comprehensive Energy Review**

   While the priority energy issue facing water managers is hydroelectric development, this issue can only be evaluated with consideration of all relevant energy sources and forms. It is only through such an overall approach that the role of electrical energy (one of a number of optional energy forms) and particularly electrical energy from hydroelectric developments (one of a number of optional electrical energy sources) can be assessed.

3. **External Sources and Export of Power**

The work group did not limit itself solely to consideration of energy use within the Basin. Markets for export of power could result in major water management decisions within the Basin. A similar impact could also result from development of an energy source outside the Basin and interconnected with the existing system.

4. **Geographic Coverage**

Any river basin study is partially motivated by the recognition that many natural processes are more appropriately studied withinthe geographic limits of a river basin rather than imposed political boundaries. However, because energy decision-making is governed by political boundaries, coverage for all work group projects was extended beyond the Yukon River Basin to include the entire Yukon Territory.

5. **Subsequent Project Improvements**

The work group attempted to initiate projects that could be subsequently updated or further developed.

6. **A Balanced Approach**

The work group was not charged with evaluating environmental and social implications of hydro electric development or other sources and forms of energy. However, in contributing to those discussions elsewhere in the Yukon River Basin Study, the work group was committed to contributing to a fair and balanced treatment of all implications.

Within the above framework, a specific set of objectives was established and six projects were subsequently initiated. Following completion of the projects, the work group held a two day working session during which a review and assessment of the projects was undertaken. In preparation for this session, each member prepared additional analysis of a number of topics related to the objectives of the Study but not necessarily covered by the Project reports. A second two-day working session was held to complete the preparation of this Program Report.

This Program Report is based on the two year program of the Energy Work Group described above. Its purpose is to summarize the concerns of the work group and set out a series of recommendations that will stand as guidelines to managers involved with energy planning and water management.

No attempt is made in this report to provide a complete summary of all the issues, observations, conclusions or recommendations contained in the various project reports. The reader is urged to consult project reports directly to review the opinions expressed by individual authors of those reports.

Following this Introduction, Chapter Two contains a description of the specific objective and work program followed by the Energy Work Group. Previously completed energy related studies are briefly commented upon in Chapter Three. A summary of Yukon energy use projections is given in Chapter Four. The hydroelectric resource potential and the importance and characteristics of storage options are dealt with in Chapters Five and Six respectively. Implications for interconnecting the Yukon electrical system with an external source are described in Chapter Seven and a comparative analysis of existing and potential energy alternatives is found in Chapter Eight. In Chapter

Nine energy planning and conflict resolution are briefly addressed and a summary of recommendations is presented in Chapter Ten.

Several Projects completed for the work group received staff support in addition to funds provided through the Yukon River Basin Study. In particular the assistance received from B.C. Hydro, Monenco Consultants Pacific Ltd., Northern Canada Power Commission and Yukon Electric Co. Ltd. is gratefully acknowledged.

Mel Orecklin initially joined the work group as representative of Energy, Mines and Resources, Whitehorse. Following his departure from Energy, Mines and Resources, he continued to participate on invitation from the Chairman and at no cost to the Study. His contribution is also gratefully acknowledged.

CHAPTER TWO: SPECIFIC OBJECTIVES AND PROJECTS

The following set of specific objectives were developed in concert with the Study Director's Office:

1. To compile all available energy-related reports; organize and assess the material; and prepare selected abstracts.

2. To review and evaluate the energy resources of the Yukon River Basin and Yukon.

3. To examine electrical power interconnections with potential major power developments adjacent to the Basin.

4. To articulate the complexities and practicalities of using sources of energy alternatives to hydroelectricity.

5. To review and assess the existing forecasts of energy use and support the Socio-Economic Work Group in developing, if feasible, an energy use forecasting capability.

6. To review and assess existing institutional arrangements related to energy planning and decision-making.

7. To develop recommendations aimed at improving the decision-making process related to energy planning and development in the Basin.

To achieve the above objectives, the Energy Work Group completed six projects with a total budget of $120,000. Work group members and their staff contributed significant resources beyond this budget. In the following paragraphs each of the projects is briefly described.

Results of the projects are summarized in Chapters Three to Eight.

Project 1: Archival Task
Contractor: Al Wright & Associates Ltd. and R.A. Hodge, P. Eng.
Total Expenditures: $10,000

A bibliography of all available reports related to Yukon energy was prepared. A partial collection of those reports was gathered and lodged in the Yukon Territorial Archives along with a cross-referenced subject index. This collection together with the bibliography have been titled the Yukon Energy Collection.

Project 2: Inventory of Yukon Hydroelectric Sites
Contractor: Monenco Consultants Pacific Ltd.
Total Expenditures: $45,000

A review was completed of the available hydroelectric studies completed during the last 25 years. Reports were summarized and the information evaluated relative to standards adequate for an up-to-date and reliable inventory of potential projects. Where possible, findings of earlier studies were compared with recent and more complete studies and differences identified.

The review included an assessment of project importance as well as the requirement for upgrading and updating site assessment studies.

Project 3: Electric Transmission Interconnection Study
Contractor: B.C. Hydro
Total Expenditures: $5,000

The engineering and economic feasibility of alternative electric interconnections between Yukon and Regional load centres and generation sources outside the Yukon was investigated. Five alternative interconnections were evaluated:

British Columbia Alternatives:	1) Stikine - Whitehorse
	2) Stikine - Faro
	3) Liard - Faro
Northwest Territories Alternative:	4) Bennett Field - Ross River
Alaska Alternative:	5) Susitna River - Whitehorse

Project 4: Review of Yukon Energy Demand Studies
Contractor: R.A. Hodge, P. Eng.
Total Expenditures: $5,000

An assessment was undertaken of nine Yukon energy demand projections completed between 1968 and 1983. For each study a description was developed of the data base, methodologies and assumptions. Major points of comparison were highlighted and an assessment made of gaps in coverage with respect to the Yukon River Basin, difficulties in projecting Yukon energy requirements and the role of Yukon energy use projections.

Project 5: Storage and the Yukon Hydroelectric Potential A Long Range Planning Issue
Contractor: Moneco Consultants Pacific Ltd.
Total Expenditures: $25,000

A study was undertaken of the importance of water storage to the Yukon hydro electric potential. The value of adequate flow control for economic hydro projects was assessed and a discussion developed of a number of related topics including:

1) The comparative merits of artificial reservoirs and augmented natural lake storage based on technical economic and socio-environmental factors.

2) Negative and positive socio-environmental impacts from storage and potential mitigative measures.

In addition, a preliminary re-evaluation was completed of full Yukon mainstream development with headwater lake storage limited to historic levels.

Project 6: Yukon Electric Inventory and Utilization Review
Contractor: Marvin Shaffer & Associates Ltd.
Total Expenditures: $30,000

This study was undertaken to review of all Yukon energy supply alternatives with particular analysis undertaken to assess the implications to future hydroelectric development. A summary was developed of all available resource inventory information; energy costs were reviewed; limitations and advantages of utilizing various forms were discussed; and areas for further study were identified.

CHAPTER THREE: PREVIOUSLY COMPLETED ENERGY RELATED STUDIES IN THE YUKON RIVER BASIN

Prior to initiation of the Yukon River Basin Study over two hundred reports had been published relating to energy developments in Yukon. By far the majority of these are site specific investigations evaluating various aspects of potential dam sites. A summary of hydroelectric site inventory studies is given by Monenco (1983). Non-hydro energy options have begun to receive more attention in the past few years. Studies related to these alternatives are reviewed by Marvin Shaffer & Associates Ltd. (1983). A third category of energy related studies involves energy planning and projection of Yukon energy requirements. This topic and related reports are described by Hodge (1983).

A complete listing of available energy related reports has been prepared by Al Wright & Associates Ltd. and R.A. Hodge (1983) for the Energy Work Group as Project No. 1. The bibliography along with a partial collection of reports has been filed with the Yukon Archives as a Yukon Energy Collection.

Yukon Energy Collection

1. The Yukon Energy Collection under the auspices of the Yukon Territorial Archivist should serve as a centralized collection for all Yukon related work.

2. The Territorial, British Columbia and Federal governments along with the power utilities should ensure the maintenance and growth of the Yukon Energy Collection.

3. A representative committee should be formed to initiate this project and to meet annually with the Territorial Archivist to review the status of the collection.

CHAPTER FOUR: PROJECTIONS OF YUKON ENERGY USE

Projections of energy use are critical to energy related decision-making. Over the past 15 years, nine different studies have been undertaken to project Yukon energy requirements. These studies were reviewed for the Energy Work Group by Hodge (1983).

A wide variety of assumptions underlie the various studies. The most significant assumptions include:

1) The degree of expected economic and population growth involving related assumptions on trends in world metal markets and government development policies.

2) The level of penetration of conservation measures and improved energy use efficiencies.

3) The nature and degree of various interfuel substitutions.

4) Whether or not energy developments are limited to supplying internal Yukon needs or include exports.

Two distinctly different purposes underlie energy forecasts.

Firstly, detailed forecasts are necessary to aid government and utilities in immediate financial decision-making. Such decision-making may or may not include decisions related to construction of major energy facilities. This type of forecast is an attempt to predict future conditions as accurately as possible.

A second type of forecast is also possible and should not be confused with the first. This second type is not an attempt to predict the future but rather is intended to model a variety of future possible conditions and "test" the implications of these conditions. This second type of forecast is a tool for those designing public policy for it is clear that government policies will have a dramatic impact on future energy decisions.

Projections of electrical energy use are presently undertaken by the utilities for their own internal use. No agency or organization has undertaken in an ongoing way, the responsibility for a comprehensive energy review.

Comprehensive Energy Projections

4. **To provide baseline data for energy planning, comprehensive energy projections should be completed on a regular basis.**

5. **These projections should assess all energy forms for all end uses, conservation possibilities and interfuel substitutions.**

6. **Preparation of the energy projections should be a coordinated effort involving the Territorial and Federal governments as well as utilities.**

Comprehensive Yukon Energy Statistics

7. **A comprehensive energy data bank on Yukon energy use should be established with the cooperation of all utilities and government agencies.**

8. **The data bank should document energy end use over time by sub-sector, form, community and quality.**

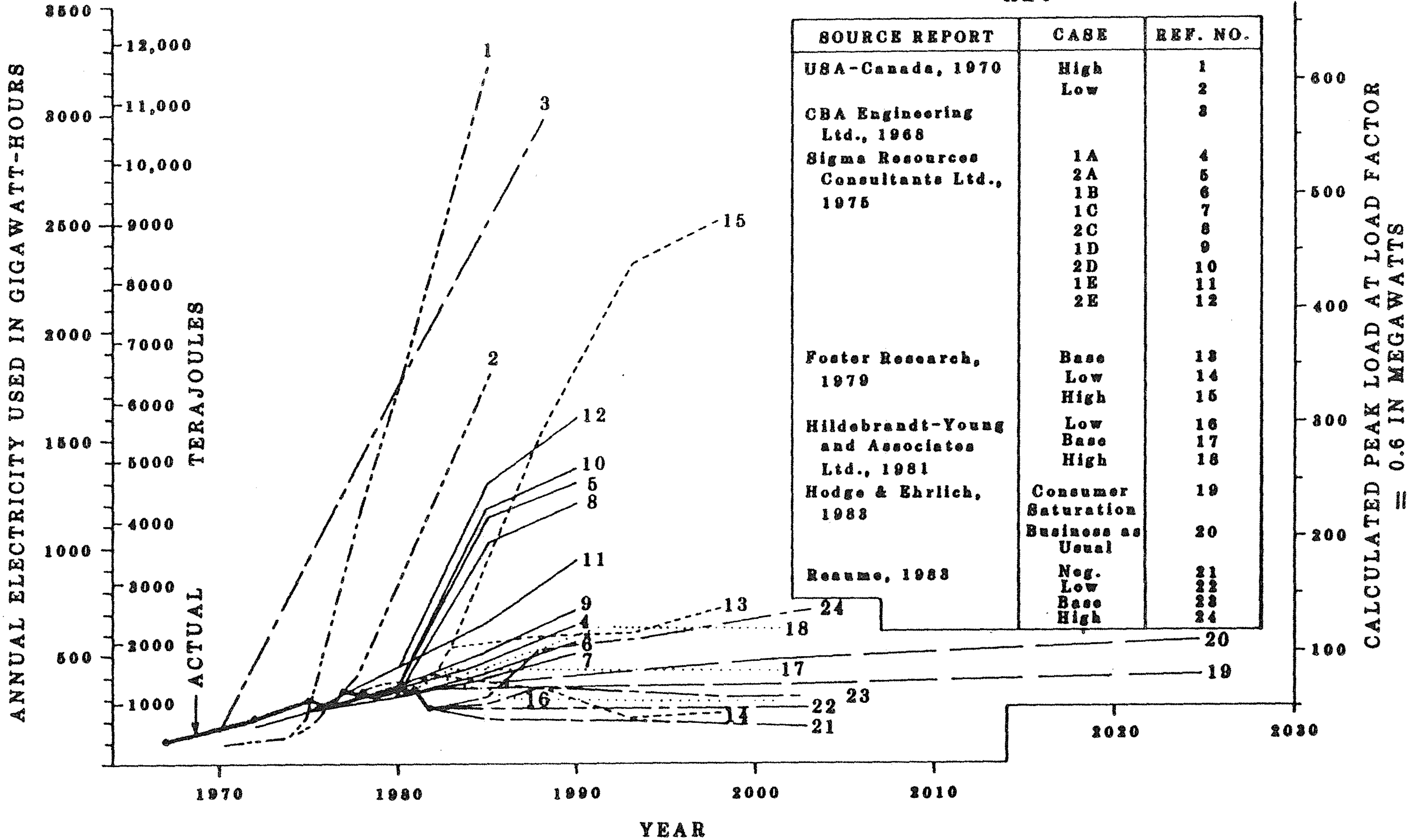
Conservation, Interfuel Substitution and Improved Fuel Use Efficiencies

9. Most existing documentation of these factors relates to southern conditions: The economic and technical significance of these factors for Yukon conditions should be established through appropriate review and documentation.

Detailed descriptions of the various energy forecasts were prepared for the Study by Hodge (1983). With the exception of two recently completed studies these forecasts have been concerned solely with projecting electrical energy requirements for the general purpose of assisting the electrical utilities and government in financial and facility planning related to electricity supply. The two more recent studies undertook a comprehensive review and projection of all energy forms, including electricity.

Figure 1 is a summary of the various electrical energy projections.

Hodge (1983) grouped these studies into three categories. A first group was generally completed in the late sixties and early seventies and assumed major industrial and energy use growth. A second group was generally completed in the mid-seventies and assumed industrial and energy use growth at much lower levels than the first group. A final group was completed in the last few years and projected very little if any growth in electrical energy use either because of low industrial activity combined with some energy conservation and interfuel substitution or moderate industrial activity combined with more extensive introduction of conservation measures.



KEY

SOURCE REPORT	CASE	REF. NO.
USA-Canada, 1970	High	1
	Low	2
CBA Engineering Ltd., 1968		3
Sigma Resources Consultants Ltd., 1975	1A	4
	2A	5
	1B	6
	1C	7
	2C	8
	1D	9
	2D	10
	1E	11
	2E	12
Foster Research, 1979	Base	13
	Low	14
	High	15
Hildebrandt-Young and Associates Ltd., 1981	Low	16
	Base	17
	High	18
Hodge & Ehrlich, 1983	Consumer Saturation	19
	Business as Usual	20
Reaume, 1983	Neg.	21
	Low	22
	Base	23
	High	24

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Figure 1 Yukon Electric Energy Use Projections

March, 1984

The most recent projections were prepared by Reaume (1983) as part of the Yukon Economic Model developed for the Socio-Economic Work Group. These projections of electrical energy use (Ref. Nos. 21 - 24 on Figure 4) bracket the studies completed in the last three years and imply additional capacity requirements of a maximum of aproximately 40 megawatts by 1988 and 75 megawatts by 2003.

Although recent forecasts indicate low growth in Yukon electricity uses, the work group cautions that the following factors can cause major changes in those projections:

1) **Economic Activity**

- an increase in world metal prices;
- introduction of chemical industries with high power requirements but low transportation costs;
- a requirement to supply pipeline pumping stations;
- a requirement to supply pumping loads for water export;
- placer mining requirements.

2) **Factors which could make power export a more attractive alternative:**

- technical advances in transmission such as a break through in solid state technology for DC transmission;
- environmental and social pressures in the south (e.g. greenhouse effect and acid rain) changing the acceptability of continued thermal generation in the south;
- mining development in adjacent areas of B.C. making regional development more attractive.

3) **Interfuel Substitution:**

- electricity substituting for other energy forms.

4) **Hydrogen generation and export**

5) **Unknowns**

CHAPTER FIVE: HYDROELECTRIC RESOURCES

Monenco Consultants Pacific Ltd. (1983) completed a review of the available hydroelectric studies in Yukon and the B.C. portion of the Basin (Project Report No. 2). About 100 potential hydro sites were identified of which data to assess potential were available for 75. Available data were too limited to include mini hydro sites (less than five megawatts) in the review.

Yukon sites along with descriptive data are listed in Table 1. B.C. sites and a number of Yukon sites for which inadequate study information is available are listed in Table 2. Locations of the Yukon and B.C. sites are shown on Figures 2 and 3 respectively.

The total Yukon hydro potential is about 11,000 MW (Smith, 1976) assuming a 60% capacity factor (proportion of the installed capacity that can generate continuously). This potential does not include diversion schemes from the Yukon River Basin such as the Yukon Taiya (4050 MW) or Yukon-Taku (3692 MW). Including these diversions the total Yukon generating capacity would increase by about 2500 MW. This increase is less than either one of the alternative diversions because their construction would reduce potential use of the main stem at other sites.

An <u>approximate</u> sub-basin breakdown of the hydro potential within the Yukon River Basin based on existing studies is given below in Table 3. The data presented in this Table are summarized from Project Report No. 2. The Taku and Taiya alternative Diversion projects noted above are not included. These figures illustrate the relative importance of each of the sub-basins to potential hydro development in the Yukon River Basin. Note that the Porcupine drainage in the Northern Yukon was excluded from the Yukon River Basin Study and is also excluded from this Table.

TABLE 1

Data for Potential Hydroelectric Sites in the Yukon (from Monenco, 1983)

Basin	River	Project	Installed Capacity(5) (MW)	Capacity Factor(3) (%)	Net Head (m)	Firm Flow (m^3/s)	Capital Cost(8) ($\$\times10^6$)	Price Level	Reservoir Clearing Included?	Socio-environmental Factors Reviewed
Alsek	Tatshenshini	Tatshenshini(I-II)	160	60	175(1)	77	145(6)	1973	Yes	Yes
	Bates	Bates Canyon	110	60	335(1)	24	98(6)	1973	Yes	Yes
Liard	Liard	Liard Canyon	119	60	41	178(7)	60	ca 1969	Yes	No
	Liard	Liard Canyon	90	60	47(1)	144(7)	103(6)	1973	Yes	Yes
	Frances	Upper Canyon	58	60	37	113	25	1969	No	No
	Frances	False Canyon	58	60	45(1)	93(7)	252	1982	Yes	No
	Frances	Lower Canyon	56	60	26	146(7)	22	ca 1969	Yes	No
	Frances	Lower Canyon	75	60	43(1)	116(7)	60(6)	1973	Yes	Yes
	Hyland	Hyland Diversion	Diversion	-	-	61(2)	24	ca 1969	Yes	No
	Beaver	Saucy Creek	46	60	43	71	31	ca 1969	Yes	No
	Beaver	Beaver Crow	82	60	75	74	?	ca 1969	Yes	No
	Beaver	Fantasque	78	60	75	71	59	ca 1969	Yes	No
	Coal	Quartz Creek	38	60	79	33	?	ca 1969	Yes	No
Peel	Peel	Aberdeen Falls	448	65	108	204	205	1964	?	No
	Peel	Aberdeen Falls	300	60	120(1)	176	263(6)	1973	Yes	Yes
	Peel	Bonnet Plume	198	65	70	204	86	1964	?	No
	Peel	Peel Diversion	755	65	-	204	450	1964	?	No
Pelly	Pelly	Detour Canyon	Storage	-	-	?	43	1961	Yes	No
	Pelly	Detour Canyon	100	60	55(1)	136	124(6)	1973	Yes	Yes
	Pelly	Low Granite Canyon (I-II)	120	60	40(1)		305	1980	Yes	Yes
	Pelly	High Granite Canyon (III)	254+	77	62		469	Dec 1981	No	No
	Pelly	Braden's Canyon	180	75	52	?	63	1961	Yes	No
	Pelly	Braden's Canyon	150	60	30(1)	326	95(6)	1973	Yes	Yes
	Pelly	Hoole Canyon	40	60	45(1)	64	146	1982	Yes	Yes
	Pelly	Slate Rapids	42	60	64	45	165	Dec 1981	Yes	No
	Anvil	Anvil Creek	10	60	175	4	13	ca 1968	Yes	No
	Tay	Tay	31	60	81	27	43	ca 1968	Yes	No
	Earn	Earn	7	60	61	8	14	ca 1968	Yes	No
	Ross	Ross Canyon	30	60	51(1)	43	181	1982	Yes	No
	Ross	Prevost Canyon	12	50	20	25	10	1961	No	No
	Ross	Prevost Canyon	8	75	26	24	9	ca 1966	No	No
	Ross	Prevost Canyon	12	60	32	24	15	ca 1968	Yes	No
	Mica	Mica Creek	10	60	82	8	16	ca 1968	Yes	No

TABLE 1 (Cont'd) Table 1

Basin	River	Project	Installed Capacity(5) (MW)	Capacity Factor(3) (%)	Net Head (m)	Firm Flow (m^3/s)	Capital Cost(8) ($\$x10^6$)	Price Level	Reservoir Clearing Included?	Socio-environmental Factors Reviewed
Porcupine	Porcupine	Bell	110	65	40	201	82	1964	?	No
	Porcupine	Bell	110	60	44(1)	184	126(6)	1973	Yes	Yes
	Porcupine	Porcupine Canyon	190	65	42	292	97	1964	?	No
	Porcupine	Porcupine Diversion	1241	65	-	295	546	1964	?	No
Stewart	Stewart	Fraser Falls (I-II)	347	75	69	?	115	1961	Yes	No
	Stewart	Fraser Falls	300	60	79(1)	283	244(6)	1973	Yes	Yes
	Stewart	Independence	431	75	80	?	212	1961	Yes	No
	Stewart	Independence	450	60	81(1)	396	375(6)	1973	Yes	Yes
	Stewart	Porcupine	223	75	30	?	88	1961	Yes	No
	Stewart	Porcupine	83	60	?	172	-	-	-	No
	Stewart	Seven Mile Canyon	10	60	?	25	16	ca 1968	Yes	No
	Stewart	Big Kalzas Lake	17	60	268	5	27	ca 1968	Yes	No
	Hess	Two Mile Canyon	53	60	?	59	48	ca 1968	Yes	No
	Hess	Hess Canyon	18	60	?	34	29	ca 1968	Yes	No
	Hess	Rogue	12	60	?	15	34	ca 1968	Yes	
	Pleasant	Pleasant Creek	5	60	?	7	16	ca 1968	Yes	No
	Ethel	Ethel Lake Diversion	8	60	290	2	8	ca 1968	Yes	No
	Mayo	Mayo B	9	60	30	20	8	ca 1968	Yes	No
	Lake	Lake Creek Diversion	13	60	?	5	19	ca 1968	Yes	No
	McQuesten	North McQuesten	5	60	46	8	19	ca 1968	Yes	No
White	White	Upper Canyon	?	-	?	?	?	-	-	-
	White	Upper Canyon	16	60	?	18	25	ca 1968	Yes	No
	White	Lower Canyon	?	-	?	?	?	-	-	-
	White	Lower Canyon	16	60	?	20	42	ca 1968	Yes	No
	Kluane	Kluane Canyon	17	50	11	70	11	1961	No	No
	Kluane	Kluane Canyon	12	60	?	75	10	ca 1968	Yes	No
	Donjek	Donjek	43	60	58	52	158	ca 1968	Yes	No
Lower Yukon	Sixty Mile	Sixty Mile Diversion	18	60	?	9	32	1968?	Yes	No
	Forty Mile	Forty Mile	16	60	?	22	18	1968?	Yes	No
	Fifteen Mile	Fifteen Mile Diversion	7	60	?	6	16	1968?	Yes	No
	Indian	Indian	6	60	?	11	16	1968?	Yes	No

Basin	River	Project	Installed Capacity(5) (MW)	Capacity Factor(3) (%)	Net Head (m)	Firm Flow (m^3/s)	Capital Cost(8) ($\$ \times 10^6$)	Price Level	Reservoir Clearing Included?	Socio-environmental Factors Reviewed
Yukon	Yukon	Miles Canyon	Storage	-	-	?	45	1961	Yes	No
	Yukon	Hootalinqua	259	75	35	?	103	1961	Yes	No
	Yukon	Big Salmon	301	75	38	?	111	1961	Yes	No
	Yukon	Mid-Yukon (I/II)	240	59	86(1)	225	414	1980	No	Yes
	Yukon	Mid-Yukon (III)	240	66	86(1)	456	231	1980	No	Yes
	Yukon	High Five Finger Rapids	455	75	56	?	124	1961	Yes	No
	Yukon	Low Five Finger Rapids	75	60	24(1)	212	167(6)	1973	Yes	Yes
	Yukon	Wolverine	476	75	59	?	160	1961	Yes	No
	Yukon	Britannia	459	75	46	?	147	1961	Yes	No
	Yukon	Ogilvie	896	75	44	?	267	1961	Yes	No
	Yukon	Dawson	571	75	27	?	163	1961	Yes	No
	Yukon	Boundary	1006	75	49	?	235	1961	Yes	No
	Yukon	Yukon-Taiya (I-III)	4050	85.	563	595	1071	1964/65	Yes	No
	Yukon	Yukon-Taku (I-VI)	3692	85	505	606	1284	1964/65	Yes	No
	Atlin	Atlin Storage (4)	Storage	-	-	-	3	1979	No	Yes
	Yukon	Tagish Storage	Storage	-	-	112	2	1973	No	No
	Teslin	NWPI (9)	55	60	27(1)	180	236	1980	Yes	
	Teslin	Swift	158	75	36	?	102	1961	Yes	No
	Wolf	Wolf	13	60	88	10	25	1968?	Yes	No
	McNeil	McNeil	10	60	73	9	13	1968?	Yes	No
	Big Salmon	Quiet Lake/Nisutlin	15	60	46	18	28	1968?	Yes	No
	Takhini	Primrose	19	60	259	5	16	1968?	Yes	No
	Takhini	Primrose	30	60	192(1)	11	39(6)	1973	Yes	Yes
	Takhini	Kusawa	17		15					
	Little Salmon	Little Salmon	15	60	44	24	>97	1980	Yes	No
	Little Salmon	Drury Lake	4	60	107	3	5	1968?	Yes	No

Notes:
(1) Gross head
(2) With storage at False Canyon
(3) Load Factor for all projects in YB62, YT65, KL62, PP65, RP62 and PS66
(4) Site in northern British Columbia
(5) Maximum development with upstream storage
(6) Interest during construction not included
(7) Not including Hyland Diversion flow
(8) Capital costs are given in current \$ for Price level year
(9) North West Power Industries site
(10) For key to report reference see part 4 p.4-5
(11) For other sites not reviewed see Part 4 Table 4-3 and Table 4-2 (Surprise Lake)

Table 2

Data for Potential Hydroelectric Sites in the B.C. Portion of the Basin and for Sites not Included in the Inventory Study (from Monenco, 1983. Table 4-3)

Site/Capacity		Study Level	Reason for no Review	Potential	Remarks
Lapie	1 MW	B	Mini hydro	Unpromising	
Kathleen R.	2 MW	C	Mini hydro	Unpromising	
Watson R.	3 MW	B	Mini hydro	Unpromising	
Squanga Cr.	2 MW	D	Mini hydro / recent study to D level	Attractive	
Aishihik Diversions		D	Plant addition / recent study to D level	Possible	
Nisutlin River		B	Inadequate description and data		
Beaver Canyon			Inadequate description and data		
Cassiar Bar		A	Inadequate description and data	Possible	Important as next stage to Mid-Yukon Project.
Alsek Canyon		A	Not yet studied	Substantial	In Kluane Park.
Hoole R.	15 MW	A	Not yet studied	Promising	Important for optimum Upper Pelly River development.
Campbell Cr.	20 MW	A	Not yet studied		
Chandindu	6 MW	A	Dam only appraised and estimated	Unpromising	
Racine	8 MW	A	Inadequate description, data, with no field investigation	Low for B.C.H.P.A.	Some of B.C. sites may have potential for Yukon loads.
Tutshi	13 MW	A	Inadequate description, data, with no field investigation	Low for B.C.H.P.A.	Some of B.C. sites may have potential for Yukon loads
Powerhouse Wann	9 MW	A	Inadequate description, data, with no field investigation	"	"
Taku	17 MW	A	Inadequate description, data, with no field investigation	"	
Hall Lake Gladys	11 MW	A	Inadequate description, data, with no field investigation	"	Some B.C. sites may have potential for Yukon loads

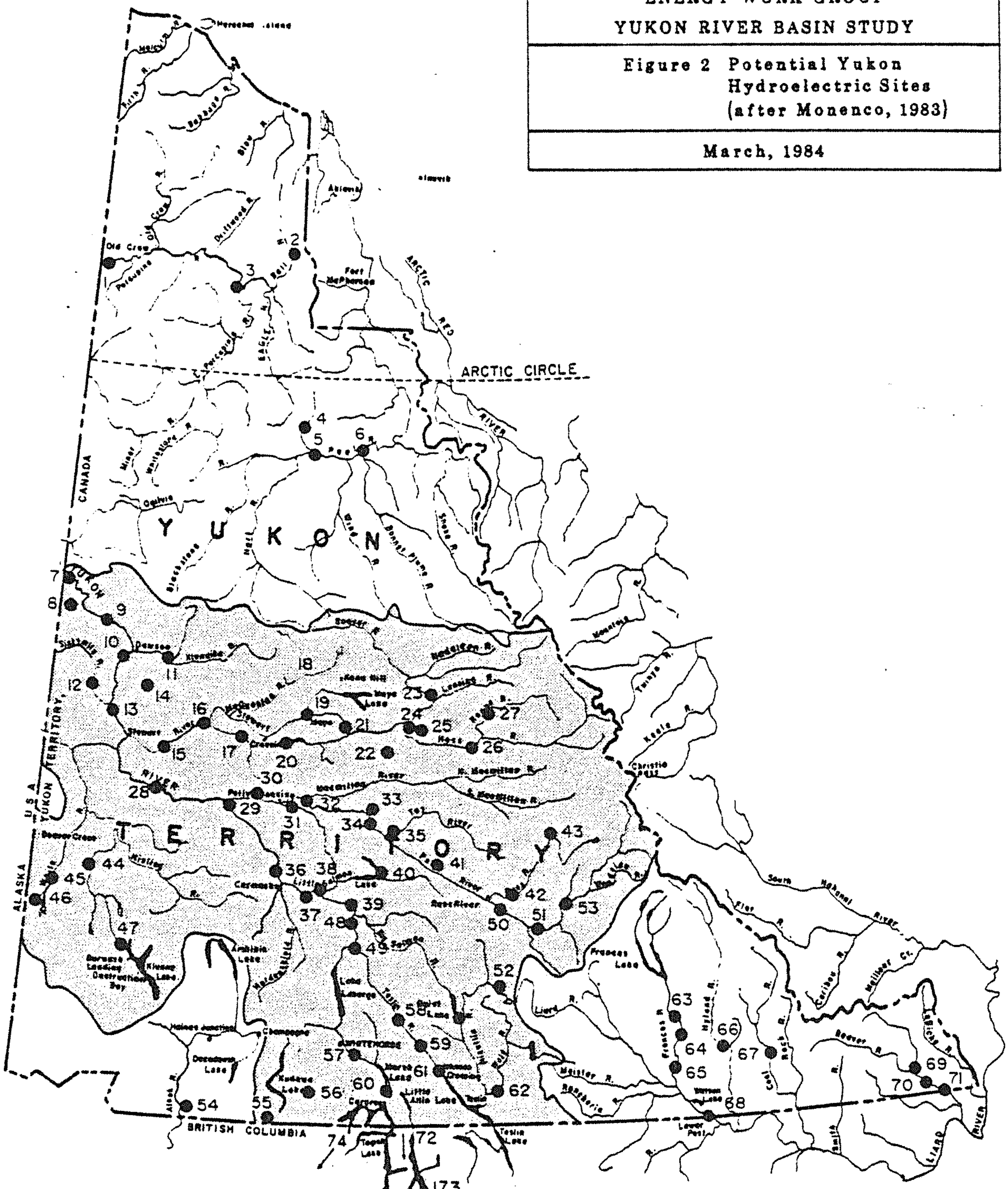
Table 2 (Continued)

Site/Capacity	Study Level	Reason for no Review	Potential	Remarks
Gladys 7 MW	A	Inadequate description, data, with no field investigation	"	Some B.C. sites may have potential for Yukon loads
Swift 52 MW	A	Inadequate description, data, with no field investigation	"	"
Jennings 8 MW	A	Inadequate description, data, with no field investigation	"	"
Bennett Homan 15 MW	A	Inadequate description, data, with no field investigation	"	"
Kirtland Warm Ck. 12 MW	A	Inadequate description, data, with no field investigation	"	"
O'Donnell 8 MW	A	Inadequate description, data, with no field investigation	"	"
McNaughton 12 MW	A	Inadequate description, data, with no field investigation	Low for B.C.H.P.A.	Some of B.C. sites may have potential for Yukon loads
Morley River 0.75 MW	B	Mini hydro/recent study		Studies by Yukon Electrical
McIntyre Creek 0.75 MW	F	Mini hydro/recent study		Studies by Yukon Electrical
Frances River 5 MW	B	Mini hydro/recent study		Studies by Yukon Electrical
Liard River 5 MW	B	Mini hydro/recent study		Studies by Yukon Electrical
Watson Lake McDonald Creek 2.5 MW	B	Mini hydro/recent study		Studies by Yukon Electrical
Alsek/Tatshenshini Diversion		Partial study cannot be assessed		Map study only, with no allowance for storage
Klondike River 10 MW		Rehabilitation of obsolete plant		Mini hydro
Fort Selkirk	Yukon	Geological and topographic only		
Selwyn	Yukon	Geological and topographic only		
Gerc	Pelly	Geological and topographic only		Alternate to Braden's Canyon
Five Mile Rapids	Stewart	Geological and topographic only		
Fort Selkirk Saddle	Yukon	Geological and topographic only		
Wolverine Draw	Yukon	Geological and topographic only		
Five Fingers Draw	Yukon	Geological and topographic only		
Lower Ogilvie	Yukon	Geological and topographic only		
Lower Dawson	Yukon	Geological and topographic only		

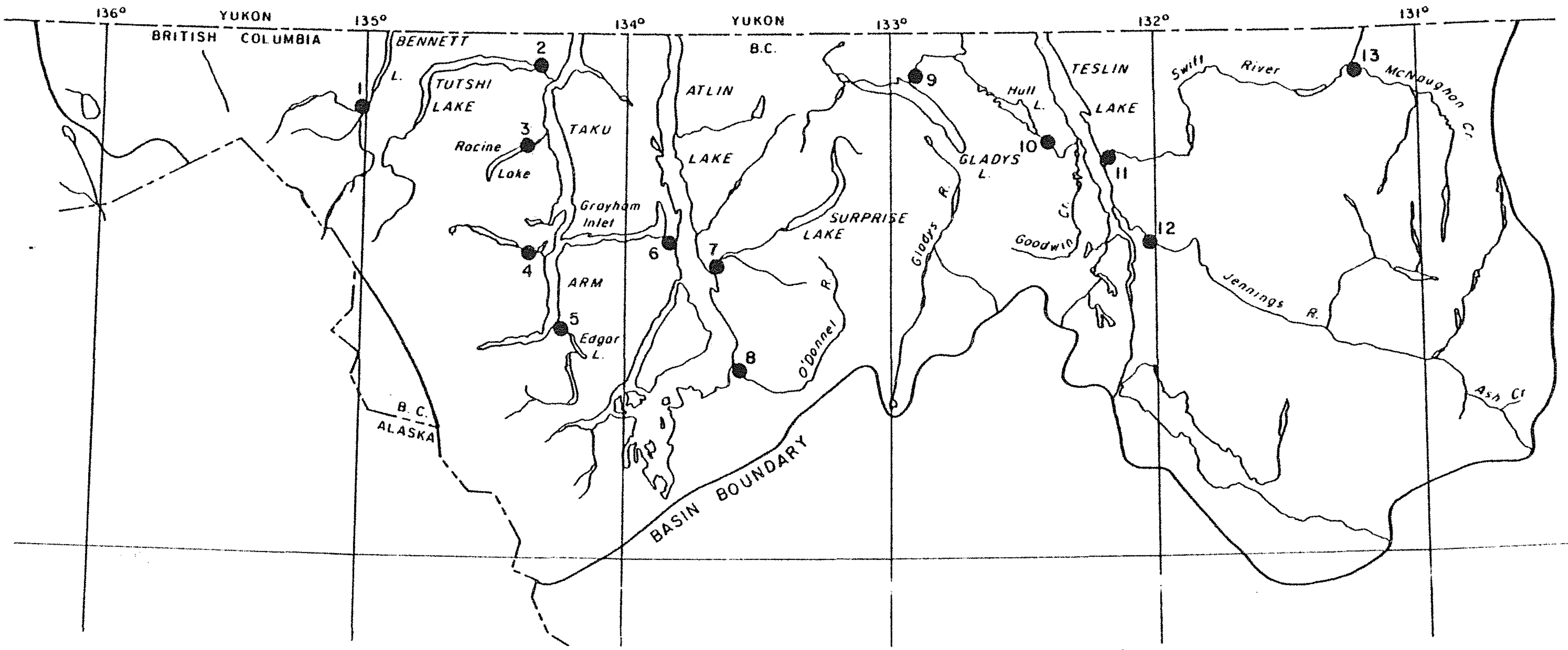
ENERGY WORK GROUP
YUKON RIVER BASIN STUDY

Figure 2 Potential Yukon Hydroelectric Sites (after Monenco, 1983)

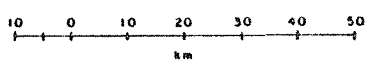
March, 1984



1 Porcupine Canyon
2 Bell
3 Porcupine Diversion
4 Peel Diversion
5 Aberdeen Falls
6 Bonnet Plume
7 Boundary
8 Forty Mile
9 Fifteen Mile Diversion
10 Dawson
11 North Fork
12 Sixty Mile Diversion
13 Ogilvie
14 Indian
15 Porcupine
16 Independence
17 Lake Creek Diversion
18 North McQuesten
19 Mayo "B"
20 Ethel L. Diversion
21 Fraser Falls
22 Big Kalzas Lake
23 Seven Mile Canyon
24 Two Mile Canyon
25 Pleasant Creek
26 Hess Canyon
27 Rogue
28 Britannia
29 Wolverine
30 Braden's Canyon
31 Mica Creek
32 Granite Canyon
33 Earn
34 Detour Canyon
35 Tay
36 Five Finger Rapids
37 Mid-Yukon
38 Little Salmon
39 Big Salmon
40 Drury Lake
41 Anvil Lake
42 Rose Canyon
43 Prevost Canyon
44 Donjek
45 Lower Canyon
46 Upper Canyon
47 Kluane Canyon
48 Cassiar Bar
49 Hootalinqua
50 Hoole Canyon
51 Hoole River
52 McNeil
53 Slate Rapids
54 Bates Canyon
55 Tatshenshini
56 Primrose-Kusawa
57 Miles Canyon
58 N.W.P.I.
59 Swift River
60 Tagish Storage
61 Squanga Creek
62 Wolf
63 Upper Canyon
64 False Canyon
65 Lower Canyon
66 Hyland Diversion
67 Quartz Creek
68 Liard Canyon
69 Fantasque
70 Beavercrow
71 Saucy Creek
72 Atlin Storage
73 Taku Diversion
74 Taiya Diversion



1. BENNET
2. TUTSHI
3. RACINE
4. KIRTLAND
5. WANN
6. TAKU
7. PINE CREEK
8. O'DONNEL
9. GLADYS
10. HALL LAKE
11. SWIFT
12. JENNINGS
13. McNAUGHON



ENERGY WORK GROUP
YUKON RIVER BASIN STUDY

Figure 3 Potential Hydroelectric Sites in the B. C. Portion of the Yukon River Basin (after Monenco, 1984)

March, 1984

Table 3

Sub-Basin Hydro Potential Within the Yukon River Basin Based on Existing Studies

Sub-Basin			Potential Installed Capacity in Megawatts
Yukon River Main Stem:	Yukon	5500	
	B.C.	90	
	Total	5590	5590
Stewart River			1100
Pelly River			800
Teslin River:	Yukon	230	
	B.C.	80	
	Total	310	310
White River			90

The following factors underlie the importance of an adequate and reliable hydroelectric inventory:

1) A reliable inventory is essential to making energy decisions that optimize long term benefits to society;

2) A reliable inventory is essential to making the best possible immediate energy decisions;

3) Energy projects require lead times for both regulatory approval and construction that are often significantly greater than the lead times required by the industrial, commercial or residential loads that are to be supplied. A reliable inventory is important for minimizing time delays;

4) A reliable inventory is important for ensuring the best possible water resource and related land use planning and management.

For assessing inventory information, Monenco (1983, pp.3-3.6) defined six levels of study. These levels are listed below in Table 4 along with the probable range of costs per project studied. These cost estimates do not apply to mini hydro.

Table 4

Levels of Dam Site Investigation

Study Category	Description	Cost Range per Project ($ X 1000)
A. Prereconnaissance	office study only	5 - 25
B. Reconnaissance	office study plus brief field visit	5 - 25
C. Inventory	up to two weeks of field work. Additional hydrological studies, some geotechnical studies.	25 - 150
D. Pre-feasibility 1	One season of field investigation including drilling. Detailed hydrologic studies. Detailed estimates produced as well as conceptual drawings.	200 - 500
E. Pre-feasibility 2	More field work than D. A confident recommendation on site choice is made.	200 - 500
F. Feasibility	Full investigation in a two year program. Detailed subsurface exploration. Complete conceptual design and optimization is produced with a definitive cost estimate.	2000 - 5000

In addition to individual site studies, it is necessary, where several potential projects are located on the same river, to undertake a regional analysis to establish optimum river development.

To establish priorities for study upgrading and updating, Monenco developed a ranking system based on factors listed in Table 5.

Table 5

Hydro Project Rating Factors
(From Monenco, 1983 Chapter 5)

A. IMPORTANCE RATING

A subjective evaluation of project importance which depends on the following factors:

1) **Power Benefit Factor:** The greater the installed capacity and the lower the unit cost, the higher the importance.

2) **Timing/Location Factor:** The earlier the expected development, depending on suitable site location, the higher the rating.

3) **Socio-Environmental Factor:** Any identifiable socio-environmental factor that would significantly reduce project site or cause other major modifications affecting viability has the effect of reducing the importance rating.

The above factors were combined using professional judgment to produce an "Importance" rating ranging from Important through Average to Minor.

B. ADEQUACY RATING

A subjective evaluation of the adequacy of existing project data and the level to which the studies were carried out. The following factors were considered.

The extent of:

1) completed field work
2) available topographic mapping
3) completed geotechnical investigation
4) available hydrologic data
5) adequacy of cost estimate
6) overall level of inventory assessment
7) degree of correspondence with current practice and construction costs (outdate factor).

In assessing the reliability of hydro inventory studies, Monenco (1983, p.p. 3.0 - 3.10) documented how results of low level inventory work can be dramatically changed with more in-depth studies. They compared nine projects of which only four show agreement between early and recent studies.

Monenco (1983) found that inventory studies fell roughly into three groups. Each group is described below.

Group 1

These studies mainly describe mega projects that were generally identified by the Water Resources Branch, Department of Northern Affairs and National Resources between 1960 and 1966. While the adequacy of the studies is satisfactory in most respects, overall adequacy is severely flawed by the failure to consider socio-environmental impacts. Some updating of project layouts to conform to modern hydroelectric design practise is also required. Group 1 projects include about 20 projects averaging 335 MW with aggregate capacity of 6700 MW.

Group 2

Group 2 includes about 40 projects, mainly in south central Yukon, that were studied by a variety of consultants between 1968 and 1978. Project size is significantly smaller than in Group 1 with average of 32 MW and an aggregate capacity of 1300 MW. Group 2 projects were assessed of minor to average importance and studies generally inadequate for inventory purposes. Greater study depth and upgrading of most study factors is required.

Group 3

Group 3 includes nine projects studied between 1979 and 1983 and varying widely in size. Projects are located in south central Yukon and are seen as suitable possibilities to meet early developing loads. Average project capacity is 122 MW with an aggregate capacity of 1100 MW. Monenco considers these projects of average to major importance with studies generally adequate for inventory purposes.

The work group discussed at length the subject of hydroelectric inventory. In addition to the points raised directly in the Monenco Report the topic of the usefulness of a full scale mini hydro inventory was also addressed. The work group concluded that such a full scale review was not warranted but that the mini hydro option close to centres of existing load was important to consider along with other options. The work group noted that this approach is consistent with the present policy of both the Northern Canada Power Commission, who are investigating a small scale (2MW) facility at Squanga Creek near Johnson's Crossing, and the Yukon Electric Co. Ltd., who have completed feasibility studies for expansion of their small scale operation on McIntyre Creek near Whitehorse (.75MW), and are also considering another site on the Morley River near Teslin.

The work group believes that the hydroelectric potential in the Yukon River Basin represents an important long term natural resource. This belief underlies the following set of recommendations

Hydroelectric Inventory Studies

10. An ongoing and phased hydro inventory program should be undertaken with studies to at least the 'inventory' level of detail.

11. Sites should not be studied in isolation: A regional review for each river or sub-basin should be taken.

12. Priority should be given to the more 'important' sites and sites described by studies most in need of revision and updating.

13. The 'importance' rating should be continuously re-evaluated.

14. Priorities should include:

Short and Medium Term

a) Continuing the study of selected sites close to potential and existing load centres in south and central Yukon. These sites include sites ranging in capacity from a few megawatts (mini hydro) to roughly 50 megawatts installed capacity. These studies should be to 'prefeasibility' level and complemented by socio-environmental studies.

b) The upgrading of other sites in the south and central Yukon to 'inventory' level of detail. Emphasis should be given to the more 'important' sites and those most requiring revision and updating.

c) A search for undiscovered sites.

Hydroelectric Inventory Studies (Cont'd)

14. Priorities Should Include: (Cont'd)

Long Term

d) Establishing the realistic potential of mainstem and related mega projects taking into account socio-environmental restraints and modern design practice.

A final important point was raised as a result of the inventory study. Exact comparisons between studies undertaken by different consultants was extremely difficult to complete because of different criteria used in the estimating and design process. In some cases supporting documentation was not available.

Hydro Inventory Report Standards

15. Future studies undertaken by different consultants should use standardized estimating and design criteria and reports should include full support data and information.

CHAPTER SIX: STORAGE AND THE YUKON HYDROELECTRIC RESOURCE

Because storage is particularly important in the north with the high winter demand for power coinciding with the low natural stream flow period in rivers, the Energy Work Group initiated a study of storage (Monenco, 1984). In this Chapter a brief discussion is given of the principles of storage followed by comments on natural lake storage versus man made reservoirs and environmental impacts from storage.

Principles of Storage

Natural river flows vary seasonally. Table 6 lists minimum and maximum recorded flow data for three Yukon Rivers including one with no natural regulation (Firth), one with moderate regulation (Upper Pelly) and one relatively well regulated example (Upper Yukon). These data while not taken from any single year, serve to illustrate the seasonal variation in flow that occur.

Table 6 Minimum and Maximum Recorded Flows of Three Yukon Rivers (After Monenco, 1984, p.11)

	Flow in cubic meters/second			Max/Min	Years of
	Minimum	Maximum	Average	Ratio	Record
Firth River	0 (Jan-Apr)	773 (May)	39	infinite	3
Upper Pelly (measured at Ross River)	6 (Mar)	2000 (June)	187	333	15
Upper Yukon (4) (measured at Whitehorse)	33 (May)	600 (Aug)	240	18	36

Notes:
1. South Historical Streamflow Summary to 1979, Water Survey of Canada.
2. Figures rounded for simplicity
3. Because daily flow extremes are listed, both seasonal and cyclical (changes over several years) variations are reflected in these data.

Cyclic variations also occur from year to year and are included in Table 6. This cyclic variation is not as wide as the seasonal variation: the wet year to dry year ratio is generally about two to one. Table 7 lists average annual flows for the driest and wettest years of three Yukon Rivers on which there are existing or potential hydro projects.

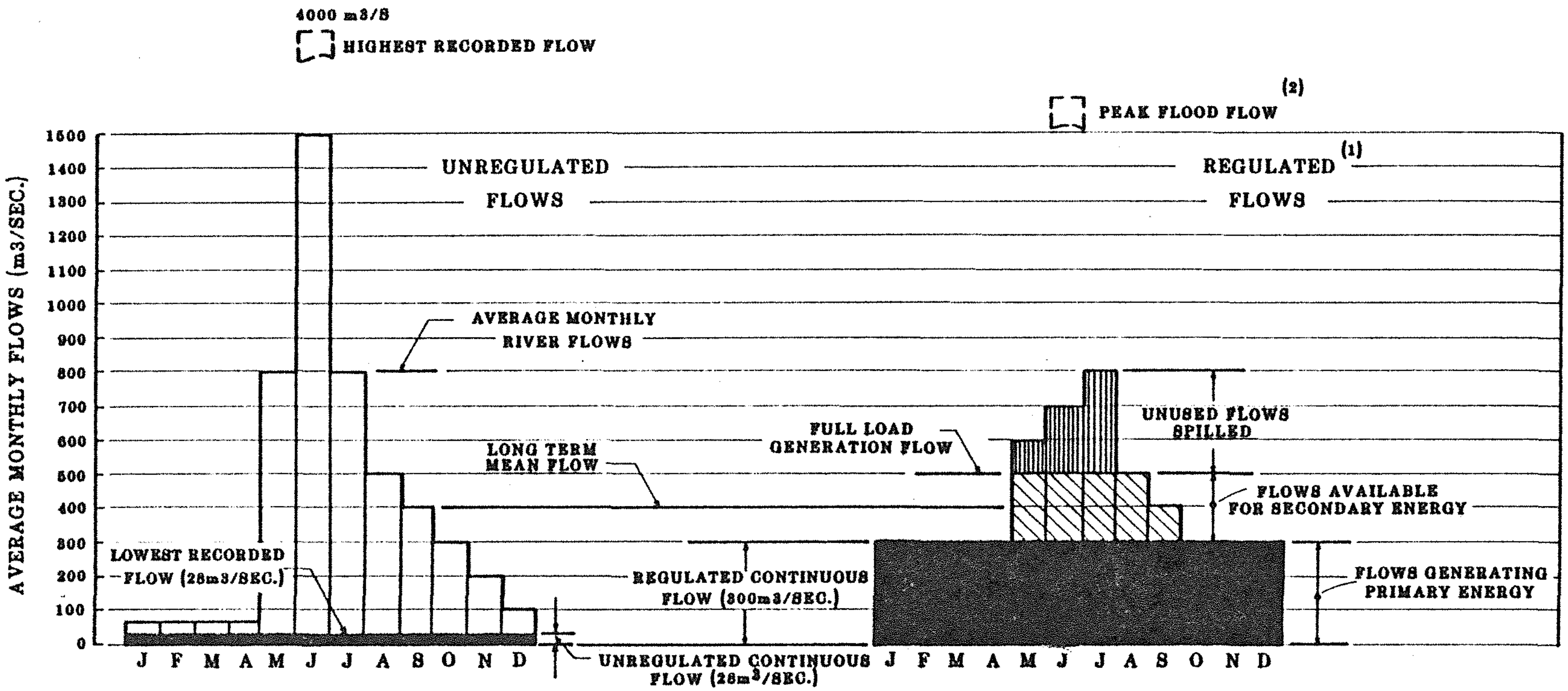
Table 7 **Average Annual Flows in Driest and Wettest Years of Three Yukon Rivers (After Monenco, 1984, p.13)**

	Average Annual Flows (cubic meters/second)		Ratio	Number of Years Recorded
	Driest Year	Wettest Year		
False Canyon Frances River	132	186	1.4	14
Whitehorse Rapids Upper Yukon River	186	317	1.7	36
Aishihik Aishihik River	7	25	3.6	30

The effect of a storage dam is to smooth out the peaks and troughs caused by the natural seasonal and cyclic variations. While storage cannot increase the average annual flow, it can both change the distribution in time so that more of it is usable as well as raise the minimum amount of flow that is continuously available.

The power output that can be produced continuously throughout the year is called the "dependable", "firm" or "primary" power. It is limited by the minimum regulated flow described above.

Figure 4 shows typical regulated and unregulated flows of the Pelly River. The regulated continuous flow of 275 M^3/sec can be compared with unregulated continuous flows of 28 M^3/sec. Although more energy can be produced than is suggested by the dependable flow,



NOTES

1. SUBSTANTIAL BUT NOT OPTIMUM STORAGE IS ASSUMED
2. PEAK FLOW INDETERMINATE DEPENDING ON RESERVOIR OPERATION

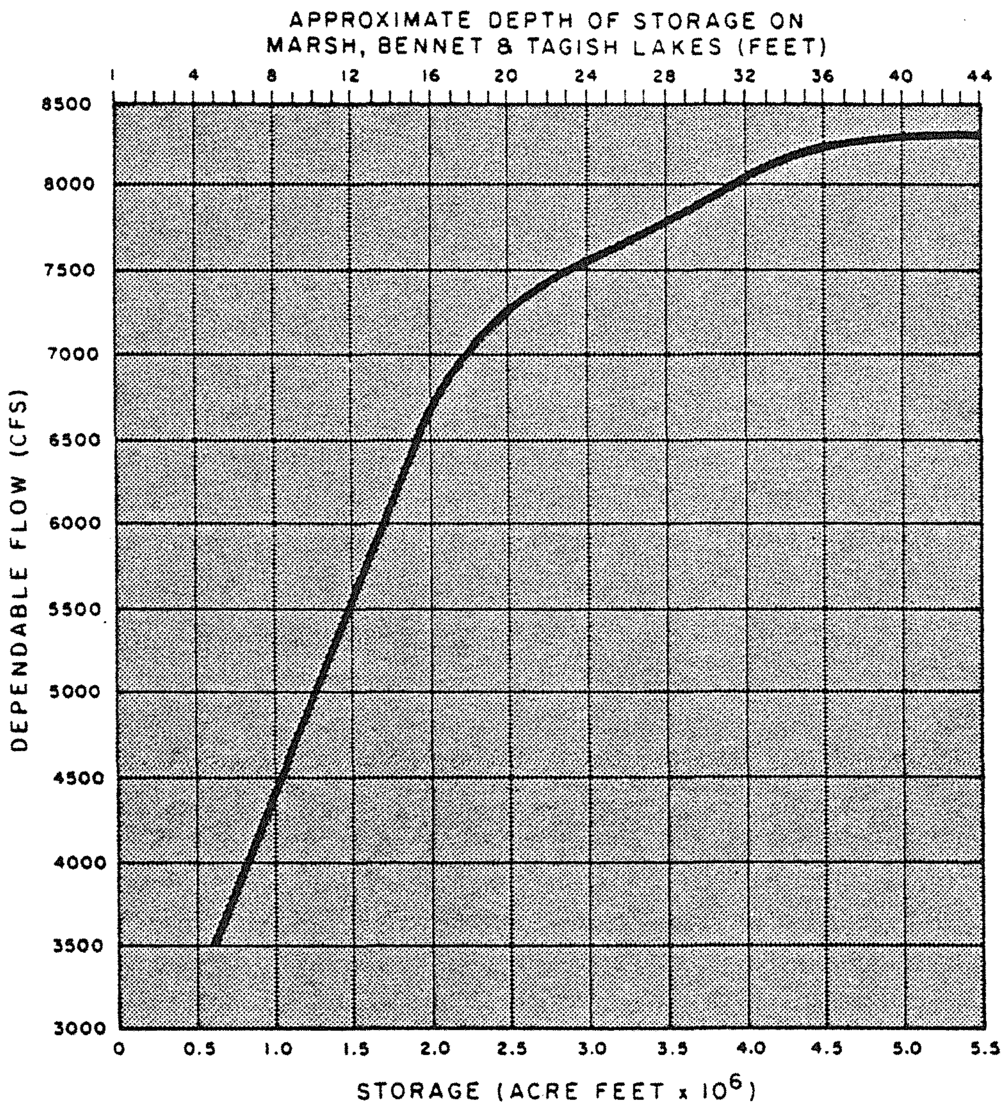
ENERGY WORK GROUP YUKON RIVER BASIN STUDY
Figure 4 Typical Regulated And Unregulated Flows of the Upper Pelly River (after Monenco, 1984)
March, 1984

(secondary energy produced in high flow months), it is the dependable flow that is normally used to determine the size of the plant and the level of revenue it will generate. For this reason, a storage reservoir at any given site can increase minimum flows such that an uneconomic project becomes economic.

Further, when storage can increase dependable flow, a larger capacity hydro project can generally produce energy at a lower unit cost. There is a limit, however, to the benefits of increased storage; because of lake geometry and other factors, the benefits of increased storage eventually diminish. Such diminishing returns are illustrated on Figure 5 which is a "Dependable Flow Curve" at the Marsh Lake outlet. It can be seen that as the potential storage volume gets very large, the dependable flow no longer increases.

Storage on Tributary Rivers in the Yukon River Basin

Smaller plants on tributary rivers often have little natural regulation. Provision of storage for these projects is critical as is demonstrated in Table 8 which lists the dependable power available from three potential projects using varying amounts of storage.



ENERGY WORK GROUP
YUKON RIVER BASIN STUDY

Figure 5 Dependable Flow Curve of the Marsh Lake Outlet (after Monenco, 1984)

March, 1984

Table 8 Dependable Power Available From Three Potential Projects Using Varying Amounts of Storage (After Monenco, 1983, p.34)

	Available Dependable Power in Megawatts (% of full regulation shown in brackets)		
Project	Full Regulation	No Regulation	Practical Regulation
Hoole Canyon	39(100)	1(3)	25(64)
False Canyon	55(100)	5(9)	35(64)
Ross Canyon	26(100)	1(4)	18(69)

The "No Regulation" case shown in Table 8 is an extreme theoretical case where not even the plant forebay provides any regulation. However, the table serves to demonstrate that practical regulation will allow use of about 65% of long term mean flow (full regulation case) while elimination of that storage drops dependable power to that corresponding to 3-9% of long term mean flow.

Storage on the Yukon Main Stem

To assess the significance of storage to Yukon mainstream development Monenco (1984, pp.34-44) undertook a preliminary analysis of various storage options associated with the mega projects proposed in the 1962 Yukon River Basin Study prepared by the Water Resources Branch of the Federal Department of Northern Affairs and Natural Resources. The potential sites associated with this plan are shown on Figure 6.

The 1962 study considered two development scenarios:

1) "Major Plan". Optimum development assuming no diversion for the headwaters of the river.

2) "Modified Plan". Mainstem development only on the Lower Yukon and utilizing residual flows after headwater diversion from the Yukon-Taiya or Yukon-Taku mega projects.

Monenco's 1983 analysis considered only variations on the "Major Plan". This plan assumed development of all the available head on the river by assuming the forebay of each plant extended to the tailwater of the next plant upstream. The plan included 12.5m (41 feet) of storage on Marsh/Tagish/Bennett Lakes, many times the historic ranges, as well as 7.6m (25 feet) on Teslin Lake and 2.3m (7.5 feet) on Atlin Lake. These later two levels approximate historic highs (see Monenco, 1983, p.36).

Monenco reasoned that full head development as well as the 12.5 meters (41 feet) of storage on the Marsh/Bennett/Tagish Lakes were no longer realistic given that socio-environmental factors were not considered as part of the 1962 study. Monenco assessed the power potentials for seven scenarios for development of the Yukon mainstem, Pelly, Stewart and Teslin Rivers.

The most significant conclusion that emerges from this work is that if the storage requirements from the headwater lakes are limited to levels within historic ranges, 79% of power potential can still be realized (Monenco, 1983, p.42). Monenco (1983, p.40) considered this scenario "reasonable and realistic in terms of its socio-environmental impact". The unexpectedly small reduction in power potential with reduced head water storage reflects, in addition to unchanged Lower Yukon storage, the natural regulation provided by the headwater lake storage.

■ DAMSITE INVESTIGATED 1956-1957

▲ EXISTING DAM

DRAINAGE BASIN

REFERENCE: YUKON RIVER BASIN REPORT PLATE 25
DEPARTMENT OF NORTHERN AFFAIRS
AND NATIONAL RESOURCES,
WATER RESOURCES BRANCH, 1962

km 40 0 40 80 km

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Figure 6 Potential Sites Associated with Full Development of the Yukon River Hydroelectric Potential

March, 1984

The above storage analysis allows identification of the relative importance of the headwater lakes to power development. Table 9 lists the area, lake level changes and storage volumes associated with regulation within historic ranges. Control dams are assumed to be located at lake outlets in each case.

Table 9 Storage Characteristics of the Headwater Lakes for Regulation Within "Historic" Ranges (after Monenco, 1984, p.42)

Lake		Area (km2)	Lake Level Range (m)	Storage Volume (m3 x 106)
Teslin		380	6.8	2580
Atlin		580	2.3	1330
Marsh	98.5			
Bennett	93.5	550	1.9(1)	1050
Tagish	357			
Laberge		200	2.7	550
Kusawa		140	2.6	360

Notes: (1) existing licensed range.

Interestingly, although Teslin Lake has an area of about twothirds that of either Atlin or the combined Marsh/Bennett/Tagish, its much greater historic level range results in an available storage volume that is comparable to the combined total of Atlin, Marsh, Bennett and Tagish.

The above discussion of the principles of storage related to Yukon hydroelectric development combined with the fact that land use decisions adjacent to water bodies can have a major impact on subsequent water development decisions has led the work group to the following recommendations.

The Implications of Land Use Decisions to Storage Projects

16. Any water or water-related land use decision should be made recognizing the fact that storage is critically important to Yukon hydro development.

17. If any land alienations are being considered, impacts on future potential hydro developments should be clearly delineated.

The following storage locations have been identified as important to maintain development:

1) Teslin Lake
2) Atlin Lake
3) Marsh-Bennett-Tagish Lakes
4) Lake Laberge
5) Kusawa Lake

Many other Yukon lakes may ultimately be important to storage projects. The work group believes that the following recommendation is compatible with protection provided by appropriate flood plain management.

Land Developments Adjacent to Water Bodies

19. As a general rule any land developments should be kept at least above historic high water levels.

A Comparison Between Natural Lake Storage and Man-Made Reservoirs

Choice of projects can depend on the relative economic, social and environmental costs of storage alternatives. In some cases it may be possible to choose between natural lake storage and man-made reservoirs. Lake storage is most often used by controlling or augmenting lake levels with an outlet control structure. In some cases lowering the lake outlets allows an increase in "bottom storage" thus minimizing the need to raise the maximum levels.

Monenco (1984, pp 21-26) gives a comparative discussion of economic and socio-environmental factors affecting Yukon storage options. Table 10 summarizes that discussion and the various factors are discussed below.

Economic Comparison

In general, utilization of natural lake storage will involve less economic cost than construction of an artificial reservoir.

Three major factors can be compared:

1) cost of control structure;
2) cost of reservoir clearing;
3) cost of mitigation/enhancement requirements.

1) Cost of Control Structure

The area of a natural lake controlled for storage is often greater than that of a man made reservoir. As a result a small drawdown of the lake must be matched by a large drawdown of the artificial reservoir to obtain equivalent storage. It follows that the equivalent control structure required for an artificial reservoir must be higher and is therefore more costly.

Table 10 Cost Comparison Between Natural Lake Storage and Man-Made Reservoirs (After Monenco, 1983, pp 21-24)

Cost Factor	Relative Cost Comparison Natural Lake Storage	Artificial Reservoir
<u>Economic</u>		
1. Control structure	low	high
2. Reservoir clearing	low	high
3. Mitigation	Could be high	Could be high
<u>Socio-Environmental</u>		
4. Fish migration as affected by dam height and impoundment depth	Less affected, fish ladder possible.	Greatly affected. No fish ladder reliable if dam is higher than 30m.
5. Bank stability problems caused by drawdown.	Usually very few problems.	Can be significant.
6. Aesthetic problem from exposure of flooded areas with drawdown.	Generally low.	High.
7. Total area of land flooded with reservoir filling....agriculture, forestry, wildlife habitat affected.	Generally little	Much
8. Lake shore land use	Could be high	Low
9. Other land uses	Could be high	Could be high

2) Cost of Reservoir Clearing

Reservoir clearing costs associated with river valley flooding can be very high. Table 11 lists clearing cost estimates for seven potential Yukon projects based on a full clearing standard.

Table 11 Reservoir Clearing Cost Estimates for Seven Potential Projects (After Monenco, 1984, p.25)

Project	Capacity MW	Reservoir Area Hectares	Clearing Area Hectares	Project Cost* $ M's	Clearing Cost $M's	% of Project Cost
Low Granite Canyon	120	26,400	28,800	305	76	25%
High Granite Canyon	254	51,000	-	629	160	25%
Mid Yukon 1/11	240	15,200	10,500	447	36	8%
Hoole Canyon	40	9,800	6,000	146	24	16%
Slate Rapid	42	14,400	10,200	165	39	24%
Ross Canyon	30	7,300	6,150	181	25	14%
False Canyon	58	21,000	8,650	252	36	14%

* including reservoir clearing

It can be seen that clearing costs could represent up to 25% of total project costs. This figure would be reduced if a lower clearing standard was appropriate. Because the effect of clearing costs on total costs varies widely from project to project, the relative economic attractiveness of alternative sites would change depending on the assumed level of required clearing standard. This conclusion has led the Energy Work Group to the following recommendation.

Reservoir Clearing Standards

19. Due to the potentially significant impacts of reservoir clearing on project costs and selection, any hydroelectric project proponent should address this issue early in the site selection decision-making process and seek direction from the regulatory authority on site specific requirements for reservoir clearing standards. There should be a recognized procedure by which the proponent may receive guidance from the regulatory authority.

3) Costs of Mitigation and Enhancement

Mitigation/enhancement costs depend on site specific conditions and generalized statements are not usually possible. For both natural lake storage and man made reservoirs, significant mitigation costs could be incurred, depending on existing land use.

Socio-Environmental Comparison

Table 10 lists a number of socio-environmental costs taken from Monenco (1984). Because the implications to fish migration, bank stability, aesthetics of flooded areas as well as the total area flooded are generally less significant for natural lake reservoirs than man made reservoirs, it appears that natural lake storage may often involve a lower level of socio-environmental cost than an artificial reservoir. However for each case a site specific assessment must be undertaken.

Follow-Up Socio-Environmental Studies

The work group believes that an invaluable exercise would be follow-up studies on the observed impacts of already constructed projects. These types of studies have never been completed in the north.

The need for follow-up studies is emphasized in the Report of the B.C. Utilities Commission into B.C. Hydro's application for an Energy Project Certificate for the Peace River Site C Project (Recommendation 46). The Utilities Commission voiced concern about the lack of information on the productivity of northern reservoirs and pointed out the importance of developing a body of knowledge of the biological impact of the conversion of rivers to reservoirs.

Follow-Up Socio-Environmental Studies

20. A review of socio-environmental impacts that have resulted from constructed reservoirs in northern British Columbia and Yukon, should be undertaken.

Opportunity for Mitigation and Enhancement in Northern Conditions

Related to the previous topic is the need to undertake a review and evaluation of opportunities for mitigation and enahncement under northern conditions. The international literature should be fully researched as part of this exercise to ensure that the best possible options are considered for any future Basin hydro electric developments.

Mitigation and Enhancement Studies

21. A study should be undertaken to research and establish practical mitigation and enhancement measures appropriate for Basin conditions. As part of this exercise a complete review of the international literature should be undertaken.

CHAPTER SEVEN: INTERCONNECTION OF THE YUKON AND EXTERNAL POWER GRIDS

A review of potential interconnections was undertaken for the Energy Work Group by the British Columbia Hydro and Power Authority.

Electrical grid interconnections are completed to reduce system costs, increase reliability and increase opportunities for purchase and sale of energy and capacity. Specific reasons include the following:

1) An interconnection can provide a portion of the generation reserve necessary to ensure that loads can be served when units are out of service.

2) If there is diversity in each utility's downtime, energy can be taken from a neighbour during these periods and a reduction in necessary reserves again achieved.

3) If there is a load diversity (hourly, daily, seasonal) or generation diversity (hydro, fossil, diesel) between two regions, more economic dispatch of generation can be arranged if an interconnection exists.

4) During forced outages of generation, an interconnection would provide immediate back-up supply.

5) System voltages remain more constant.

6) System operation is more flexible.

7) An interconnection creates the possibility of exports of excess power to a much larger market.

An entire interconnected network would be affected by a major disturbance. It is therefore important to recognize that once an interconnection is established, it is possible to export or import trouble as well as energy. Further, each utility while being prepared to aid its neighbour, must also design its own system in such a way that impacts of internal disturbances are not felt by the neighbour beyond the extent planned for and agreed to. To ensure the reliable design and operation of the interconnection and to limit interruptions in one region causing further interruptions in adjoining regions, system planning guidelines are established.

This interconnection study considered only a single line link between potential sources and the Yukon grid. Such an interconnection, to be economically viable would have to supply firm year round power although with lower reliability as a result of the long, single line. Because of the lower reliability, local generating capacity must be maintained and construction of such an interconnection would not automatically preclude requirements for additional capacity within the Basin. While the interconnection could be used to serve a significant portion of future Yukon load, its ultimate effect on development of Yukon hydro electric facilities would have to be rigorously assessed in light of prevailing conditions.

B.C. Hydro (1983) evaluated the five interconnection alternatives listed in Table 12.

Table 12 Potential Interconnection Alternatives Considered by B.C. Hydro

	Length in km
British Columbia Alternatives	
1. Stikine - Whitehorse	465
2. Stikine - Faro	575
3. Liard - Faro	585
Northern Territories Alternatives	
4. Bennett Field - Ross River	680
Alaska Alternative	
5. Susitna River - Whitehorse	980

Each of these alternatives along with the existing Yukon grid are shown on Figure 7.

Three cases were defined by the Energy Work Group for consideration by B.C. Hydro.

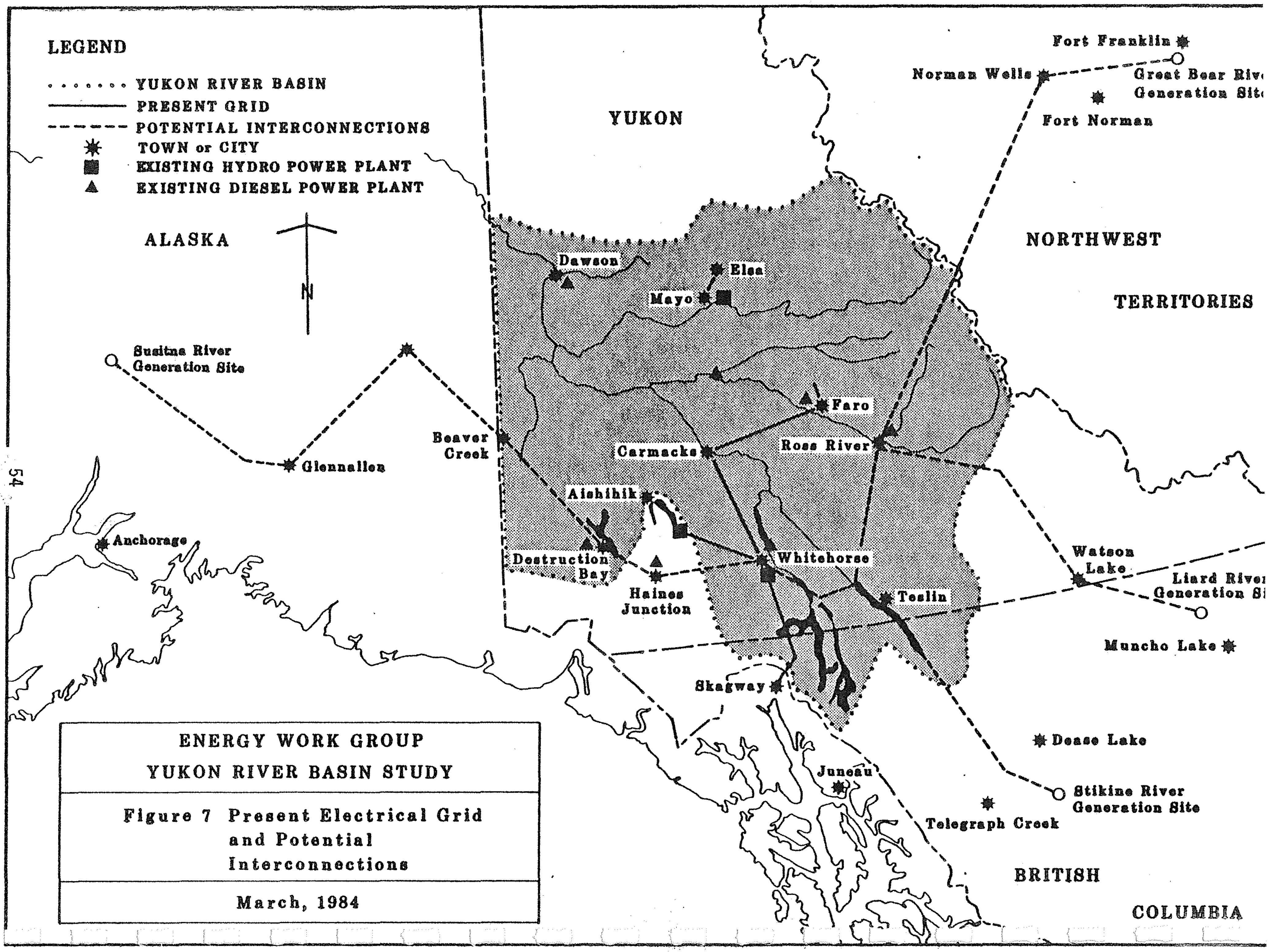
Case 1 150 MW — An additional 60 MW capacity required to provide an average of 280 gigawatt hours per annum. (Load estimate for a major increase in Mac Pass mining causing a 50% increase in industrial energy use and a 20% increase in other sectors.)

Case 11 300 MW — An additional 200 MW capacity required to provide an average of 1050 gigawatt hours per annum. (Load estimate necessary to meet high population growth, high mining growth and a 100 MW smelter.)

Case 111 475 MW — An additional 400 MW capacity required to provide an average of 3100 gigawatt hours per annum. (Load estimate for high population growth, high mining growth, 100 MW smelter, partial electrification of Alaska Highway Natural Gas Pipeline, and exports to Canada Tungsten, Cassiar and Skagway.)

B.C. Hydro established that a single 500 KV interconnection would be feasible for each of the alternatives. The most economic tie of the five alternative studies would be the Stikine-Whitehorse alternative.

Table 13 summarizes the average delivery cost for transmission of the three B.C. interconnection alternatives.



ENERGY WORK GROUP

YUKON RIVER BASIN STUDY

Figure 7 Present Electrical Grid and Potential Interconnections

March, 1984

Table 13 Average Delivery Costs of Transmission From the Three B.C. Alternatives

	Yukon Load MW	Average Delivery Cost of Transmission (mills/KWH)
1. Stikine - Whitehorse	150	23.8
	300	12.2
	475	8.0
2. Liard - Faro	150	28.3
	300	14.6
	475	9.6
3. Stikine - Faro	150	29.5
	300	15.2
	475	10.2

The greater transmission distances and construction costs for the Alaska and NWT alternatives as well as higher energy costs result in them being less economically attractive options.

The total cost of energy delivered to the Yukon would include the delivery cost (Table 15) as well as the selling price of energy. This later item would be a negotiated price based on B.C. Hydro long-term energy and capacity values and is estimated as likely to be approximately (see B.C. Hydro, 1983, p. 8-2) 30 mills/KWH ($1982). Using these estimates, if either the Stikine or Liard projects were to be completed and if a substantial Yukon load developed, cost of energy delivered to Whitehorse through an interconnection would be in the range of 50-100 mills/KWH. Electricity at this cost would likely be competitive with locally produced electricity.

Following completion of the review by B.C. Hydro, the Energy Work Group became aware of a link with B.C. Hydro through Southeast Alaska. This option is also shown on Figure 3. It may also prove attractive.

As a result of the above analysis the following recommendations are made.

Interconnecting the Yukon and External Power Grids

22. If either the Liard or Stikine project is built, a potential interconnection with the British Columbia grid should be rigorously evaluated.

23. If Alaska maintains an interest in providing a link between Yukon and British Columbia through southeast Alaska, this option should be carefully considered.

CHAPTER EIGHT: ENERGY ALTERNATIVES

While the priority energy issue facing water managers is hydro development, this issue can best be evaluated with consideration of all relevant energy sources and forms. Interfuel substitutions can have a significant impact. For example, construction of the Alaska Highway Natural Gas Pipeline and distribution systems to adjacent communities would result in a significant drop in electricity use because of the availability of natural gas. Conversely, use of wood for heating in the Riverdale area of Whitehorse has caused a severe pollution problem and one solution to this problem that balances economic and environmental factors may be incentives to increase electricity use and decrease wood use. However, a third factor must be noted: the price of energy in the north is now so significant that measures to reduce energy use through conservation offer the most economically attractive option for reducing both environmental impacts and energy costs to the consumer.

Thus, it is only through an overall examination of all energy alternatives that the role of electrical energy (one of a number of optional energy forms) and particularly electrical energy from hydroelectric developments (one of a number of optional electrical energy sources) can be assessed.

Marvin Shaffer & Associates Ltd. completed a broad overview that provides order of magnitude indications of the availability and relative merits of alternative energy sources.

Table 14 is a summary of energy potential in Yukon by source. It can be seen that Yukon is well endowed with energy resources. Unfortunately the cost of utilizing some of these sources are prohibitive at this time.

To compare costs of utilization it is necessary to define the particular end use application thus defining the cost of converting to a useable energy form (e.g. electricity to heat). In every case a comparison can be made by estimating the cost per unit of output heat.

The metric unit of heat measurement is "joules" and comparisons are made in terms of cost per gigajoule (GJ). The prefix "giga" indicates 10^9. Hydroelectric literature commonly uses units of kilowatt hours: 1,000 kilowatt hours = 3.6 gigajoules. Literature describing other forms of energy commonly uses British Thermal Units (BTU): 1 gigajoule = approximately a million BTU's.

Tables 15 and 16 list energy alternatives for use in the residential and industrial/commercial sectors respectively. These two tables include an estimate of cost expressed as the average levelized cost per output gigajoule. The average levelized cost refers to the constant real cost per unit of energy output. It is calculated by dividing the present value of total lifetime costs by the present value of lifetime energy output. A discount rate of 7% was used (Shaffer, 1983 pp.82 - 83). Cost per output gigajoule is the cost of utilizing the fuel in specific applications taking combustion efficiencies and user equipment costs into account. It is distinct from the input or fuel cost.

Table 14 Summary of Potential Energy Sources

Renewables	($GJ \times 10^6$/yr.)
Hydroelectric (a)	208
Wood and Wood Waste (b)	16
Geothermal	n.a.
Wind	n.a.
Solar	n.a.
Non-Renewables	**($GJ \times 10^6$)**
Oil (c)	20,480 - 38,480
Natural Gas (c)	8,760 - 19,300
Propane (c)	325 - 675
Coal (d)	1,000 - 2,000
Peat	n.a.

Notes:

(a) Potential annual availability of electrolytic hydrogen is about 145 x 10^6 GJ/yr based on estimate of hydroelectricity not required for direct consumption in Yukon.

(b) Energy content of total estimated standing green timber volume available for energy purposes plus that of the waste derived from sawmill timber.

(c) Based on ultimate potential, i.e. all of the oil, gas and propane in known sedimentary basins regardless of producibility.

(d) Energy content of resources which can be measured or inferred from existing data.

Table 15

Energy Alternatives for Use in the Residential Sector
(from Shaffer, 1983, p 203)

Energy Source	Average Levelized Cost per Output GJ	Technical Constraints/ Resource Availability	Environmental Factors	Economic Impacts
1. Conservation - Overall Audit Results	5.20	- front end costs inhibit adoption - wide range of returns depending on existing dwelling and measures selected	- reduces environmental impacts of displaced sources	- employment in installation
2. Natural Gas - Alaska Hwy. offline purchase	7.80	- Alaska Hwy. line may not be built - other natural gas sources much more expensive (2 1/2 to 7 times more)	- pipeline impacts - 'clean' fuel	- employment in pipeline construction - limited on-going employment
3. Wood - air tight	11.20	- well established - in aggregate supply no constraint; may be in some communities	- low in sulphur dioxide emission, high in CO particulates - requires proper forest management in long run	- wood harvesting labour-intensive - local production of wood heaters could be expanded
4. Coal - briquettes	14.70	- costs highly variable depending on source of supply - development costs for small market may be prohibitive	- low in ash and sulphur but still a concern	- coal mining and distribution provides substantial development and on-going employment
5. Heating Oil	19.00	- costs could be somewhat lower with Dempster oil line and Whitehorse topping plant	- air pollution	- existing sources provide limited employment - topping plant would provide construction and some on-going employment
6. Electricity - existing mix of sources	19.50	- costs from new sources of supply (or in diesel areas) generally much higher	- depends on source	- depends on source
7. Propane	25.40 - 27.40	- well established	- 'clean' fuel	- existing sources provide limited employment - propane vapour would provide construction and some on-going employment
8. Peat	37.50	- based on southern examples - resource exists but problems of extraction in north not known	- water disposal - land reclamation	- labour intensive in extraction
9. Solar - active or passive retrofit	48.40 - 98.20	- only feasible as complement to other fuels - lower costs possible combining space with water heat - lower passive costs in new structure	- reduces environmental impacts of displaced fuels	- employment in installation

Note: Cost estimates are approximate and in some cases subject to considerable uncertainty.

Table 16

Energy Alternatives for Use in the Industrial/Commercial Sector
(from Shaffer, 1983, p 206)

Energy Source	Average Levelized Cost per Output GJ	Technical Constraints/ Resource Availability	Environmental Factors	Economic Impacts
1. Conservation - Overall Audit Results	3.70	- front end costs inhibit adoption	- reduces environmental impacts of displaced sources	- employment in installation
2. Wood Chip Boiler	6.60	- requires low cost chip supply	- high in CO and particulates	- employment supplying chips - improves viability of local sawmils
3. Diesel Waste Heat Recovery	7.40 - 10.00	- established technology - may not meet full heating loads - demand for diesel generation may be a constraint	- negligible	- small initial employment impacts
4. Geothermal	7.30 - 12.10	- technology well established but not quality of resource - subject to "exploration" risk	- limited	- significant development employment but most personnel likely to be from outside region

Note: Cost estimates are approximate and in some cases subject to considerable uncertainty.

Of greatest interest to the assessment of potential impacts on hydro development are comparative costs of alternative sources of electricity. Tables 17 and 18 list the estimated costs and other assessment factors for these alternatives. Table 17 applies to alternatives operating near full potential output (high load factors) while Table 18 shows costs of alternatives operating at low load factors.

The following conclusions can be drawn regarding energy alternatives:

Inventory

1) Yukon has major reserves of both renewable and non-renewable sources.

2) The hydro potential is very large though the exploitation of this resource is constrained by the low existing demand and the remoteness of many of the sites.

3) Electrolytic hydrogen can be viewed as an alternative but it requires electricity for its production and is therefore significantly more expensive than hydro produced electricity.

4) Wood and wood waste together are a significant Yukon energy resource.

5) The magnitude and cost of geothermal resources is unknown.

6) Solar and wind are vast sources of renewable energy however their "low density" and unfavourable economics severely limits present utilization.

Table 17

Summary of high Load Factor Electricity Alternatives
(from Shaffer, 1983, p 208)

Source	Capital Cost per Kw	Average Levelized Cost per Output GJ	Technical Constraints/ Resource Availability	Environmental Factors	Economic Impacts
1. Selected Large Hydro	2380-5130	10.30 - 30.00	- small Yukon requirements	- depends on site	- construction employment
2. Selected Small Hydro (under 5 MW)	3560-4760	13.60 - 34.60	- limited storage - high "feasibility investment" risk	- depends on site	- construction employment
3. Inter-connection	-no firm capacity	15.80	- costs based on Stikine which may never be built - costs based on 150 MW @ 60% capacity factor - very large relative to Yukon requirements	- right-of-way clearing impacts	- right-of-way clearing employment - limited transmission installation employment
4. Coal (Bonnet Plume)	1746	25.30	- costs based on 70 MW @ 80% load factor - very large relative to Yukon requirements	- air pollution concerns	- in addition to mining there would be plant construction and operating employment impacts
5. Large scale Wind (5MW - 40MW)	1540-2350	21.70 - 27.60	- Not proven reliable at this scale - costs speculative - only displaces fuel which would be zero in case of hydro	- some land requirements	- some installation employment
6. Municipal Waste	2500	28.30	- restricted to Whitehorse location - cogeneration more attractive	- air pollution - reduced land fill require-ments	- construction employment, limited operating employment
7. Wood Gasi-fication	5190	53.60	- complicated technology - cogeneration more attractive	- disposal of toxic organic compounds and tars	- construction, minor on-going employment
8. Small Scale Wind (with some storage) (2KW - 40KW)	4500-6690	78.90 - 183.20	- well established - serves only as supplement to other sources	- limited	- installation employment
9. Solar (Photo-voltaics and Power Tower)	6300-10600	183.30 - 220.60	- only displaces energy costs	- limited	- installation employment

Notes:

1. Cost estimates are approximate and in some cases subject to considerable uncertainty.

2. Output and capacity characteristics vary among the alternatives. Economics of the alternatives depends not only on average energy or capacity cost but on how the output characteristics suit the nature of the demand and existing system.

Table 18

Summary of Low Load Factor Electricity Alternatives
(from Shaffer, 1983, p 209)

Source	Capital Cost per Kw	Average Levelized Cost per Output GJ	Technical Constraints/ Resource Availability	Environmental Factors	Economic Impacts
1. Natural Gas Alaska Hwy.	300	19.70	- flexible in use and timing - limited in location - depends on Alaska Hwy. line	- clean in use	- minor installation employment
2. Coal (Bonnet Plume)	1750	39.20	- based on 70MW plant, large relative to requirements	- air pollution concerns	- construction plus operating employment
3. Municipal Waste	2500	41.71	- restricted to Whitehorse	- air pollution - reduced landfill requirements	- construction employment - limited operating employment
4. Diesel	935	52.26	- flexible in use and location	- air pollution	- minor installation employment
5. Wood Gasification	5192	96.02	- complicated technology - cogeneration more attractive - requires chip supply	- disposal of toxic organic compounds and tars	- construction - some on-going

Notes:

1. Cost estimates are approximate and in some cases subject to considerable uncertainty.

2. Output and capacity characteristics vary among the alternatives. Economics of the alternatives depends not only on average energy or capacity but on how the output characteristics suit the nature of the demand and existing system.

7) Yukon likely has large reserves of oil, gas and to a lesser extent coal. Exploitation is limited by the lack of Yukon demand and the remoteness of resources.

Utilization

8) Energy alternatives currently in widespread use include refined petroleum products, electricity (mainly hydro, some diesel), propane and wood.

9) Energy alternatives used on a limited or demonstrated level basis include coal, wind, solar, geothermal and waste diesel.

10) Alternatives which are not currently used but which could be considered or available in the future include natural gas, peat, municipal waste, hydrogen and electrical grid interconnection.

11) Conservation opportunities constitute a very attractive method of reducing Yukon's energy requirements. The estimated cost of conservation measures is lower per output gigajoule than the cost of all the existing and potential supply sources considered.

12) Of existing supply sources, wood and coal appear attractive for heating applications. Waste diesel and geothermal may offer relatively low costs for direct use in institutional and commercial uses. All of these options may provide energy supply at costs competitive with or lower than refined petroleum products, with greater positive local economic impacts and less dollar "leakage" out of the Territory.

13) Of potential new sources, natural gas appears to be the most promising alternative if available from the Alaska Highway line or possibly trucked as liquified natural gas (LNG) from British Columbia.

14) Hydro generated electricity offers the lowest cost source of baseload supply. Natural gas, if available from the pipeline, would be most economic source of supply at a low load factor. Coal, interconnection, large-scale wind and municipal waste may have merits but are subject to serious limitations.

15) For providing electricity in remote, off grid locations, except for the special situation of a suitable small hydro site, diesel generation may remain the most economic option. Considered or available in the future include natural gas, peat, municipal waste, hydrogen and electrical grid interconnection.

Based on the analysis and conclusions described above, the Energy Work Group has concluded that in the short term, alternative energy possibilities are not expected to have a significant impact on Yukon hydroelectric development. On the long term, economic conditions can change dramatically and all options should be kept open to allow the best decision-making.

The work group has identified the following information gaps regarding energy alternatives other than hydro electricity:

Information Gaps

Wood

1) community specific wood inventories;

2) methods of mitigating environmental problems associated with wood burning;

3) technical and economic feasibility of wood chipping operations.

Coal

1) the feasibility of coal utilization particularly for small scale heating applications based on coal resources.

Geothermal

1) identification and evaluation of specific promising geothermal locations;

2) the technical and economic feasibility of geothermal exploitation and use.

Other Electricity Sources

1) the technical and economic feasibility of coal-fired thermal;

2) the technical and economic feasibility of large-scale wind generation and wind-assisted diesel;

3) the technical and economic feasibility of cogeneration of heat and electricity from wood, coal, peat and municipal waste;

4) the technical and economic feasibility of using waste heat from diesel generators.

Regarding these information gaps the following recommendation are made:

Information Gaps: Energy Alternatives Other than Hydro

24. The information gaps identified in this report regarding energy alternatives other than hydro should be reassessed from time to time and if economic conditions warrant research, funds should be sought to eliminate the gaps.

25. This review should be undertaken by a group responsible for coordinated energy planning. (See Recommendation 28.)

Many of the data and information gaps identified by the work group relate to northern specific conditions. Given the limited facilities and resources presently located in Yukon to address these Yukon specific problems, the following recommendation is made:

Northern Research Institute

26. Consideration should be given to establishing a Yukon based research institute. That could specifically address northern energy issues.

27. Such a research institute should be a cooperative venture undertaken to provide support for government, private industry, utilities and public interest groups.

CHAPTER NINE: ENERGY PLANNING AND CONFLICT RESOLUTION

Coordinated Energy Planning

Throughout the deliberations of the Energy Work Group, the need for a coordinated approach to energy planning was repeatedly identified. At the present time, concerned parties include the Federal, Territorial and Provincial governments, Yukon Territory Water Board, Yukon Electrical Public Utilities Board, B.C. Utilities Commission, public and private utilities, petroleum product distribution companies, public interest groups and consumers.

The issue is of particular concern to utilities who hold no authority for energy planning and policy decisions of government but are held responsible by customers for provision of a service on demand. Lack of that service brings criticism. Inevitably, to fulfill this service, utilties embark on planning exercises tailored to their particular needs which brings them into the area of long-term planning and policy decision-making. Once again they can find themselves criticized, this time for doing too much. In the most accurate sense, utilities can be "damned if they do and damned if they don't".

The solution to much of the uncertainty surrounding Yukon energy planning lies in the creation of a mechanism that generates a well defined, coordinated, and ongoing approach to energy planning and decision-making. With initiatives on Land Use Planning underway, Land Claims Settlement appearing imminent and further devolution of the Yukon Government ongoing, the initiative is particularly critical to ensure that energy planning becomes an integral part of overall resource decision-making.

Coordinated Energy Planning

28. A mechanism that ensures a coordinated and ongoing approach to Yukon and Yukon River Basin energy planning and decision-making should be established as soon as possible.

Multiple Use Hydro Development

At any hydro site good planning necessitates early consultation with other resource users and full consideration of non-power implications, both positive and negative. It is only through such an approach that the best possible use of the water resource can be achieved. The Work Group supports the view that all hydro facilities should be designed around a multiple use theme.

Multiple Use Hydro Development

29. Hydro facilties should be designed within a theme of multiple use of the water resource. Early consultation with other resource users should be undertaken and full consideration given to non-power implications, both positive and negative.

Conflict Resolution

Several members of the work group raised concerns about the difficulties faced in the present system of regulatory approval and its ability to efficiently and fairly deal with conflicting interests. They suggested that the existing system was too "adversarial" in its approach and not condusive to cooperative decision making. Others in the group suggested that the system was not at fault but rather the attitude of the various players. The Work Group did not come to a concensus on this issue.

The work group recognized that the issue of defining and implementing the best possible Yukon regulatory approvals system is complex. Further, the work group itself did not embark on any specific study of this topic. However, based on the experience of the work group, the following recommendation is made.

Conflict Resolution

30. A streamlined regulatory approvals system should be sought that minimizes time delays and maximizes the fair resolution of competing interests.

CHAPTER TEN: SUMMARY OF WORK GROUP RECOMMENDATIONS

Yukon Energy Collection (p.10)

1. The Yukon Energy Collection under the auspices of the Yukon Territorial Archivist should serve as a centralized collection for all Yukon energy related work.

2. The Territorial, British Columbia and Federal governments along with the power utilities should ensure the maintenance and growth of the Yukon Energy Collection.

3. A representative committee should be formed to initiate this project and to meet annually with the Territorial Archivist to review the status of the collection.

Comprehensive Energy Projections (p.12)

4. To provide baseline data for energy planning, comprehensive energy projections should be completed on a regular basis.

5. These projections should assess all energy forms for all end uses, conservation possibilities and interfuel substitutions.

6. Preparation of the energy projections should be a coordinated effort involving the Territorial and Federal Governments as well as utilities.

Comprehensive Yukon Energy Statistics (p.12)

7. A comprehensive energy data bank on Yukon energy use should be established with the cooperation of all utilities and government agencies.

8. The data bank should document energy end use over time by sub-sector, form, community and quality.

Conservation, Interfuel Substitution and Improved Fuel Use Efficiencies (p.13)

9. Most existing documentation of these factors relates to southern conditions: The economic and technical significance of these factors for Yukon conditions should be established through appropriate review and documentation.

Hydroelectric Resources (p.31)

10. An ongoing and phased hydro inventory program should be undertaken with studies to at least the 'inventory' level of detail.

11. Sites should not be studied in isolation: A regional review for each river or sub-basin should be taken.

12. Priority should be given to the more 'important' sites and sites described by studies most in need of revision and upgrading.

13. The 'importance' rating should be continuously re-evaluated.

14. Priorities should include:

Short and Medium Term:

a) Continuing the study of selected sites close to potential and existing load centres in south and central Yukon. These sites include sites ranging in capacity from a few megawatts (mini hydro) to roughly 50 megawatts installed capacity. These studies should be to 'prefeasibility' level and complemented by socio-environmental studies.

b) The upgrading of other sites in the south and central Yukon to 'inventory' level of detail. Emphasis should be given to the more 'important' sites and those most requiring revision and upgrading.

c) A search for undiscovered sites.

Long Term

d) Establishing the realistic potential of mainstem and related mega projects taking into account socio-environmental restraints and modern design practice.

Hydro Inventory Report Standards (p.32)

15. Future studies undertaken by different consultants should use standards estimating and design criteria and reports should include full support data and information.

The Implications of Land Use Decisions to Storage Projects (p.42)

16. Any water or water-related land use decision should be made recognizing the fact that storage is critically important to Yukon hydro development.

17. If any land alienations are being considered, impacts on future potential hydro developments should be clearly delineated.

Land Developments Adjacent to Water Bodies (p.43)

18. As a general rule any land developments should be kept at least above historic high water levels.

Reservoir Clearing Standards (p.47)

19. Due to the potentially significant impact of reservoir clearing on project costs and selection, any hydroelectric project should address this issue early in the site selection decision-making process and seek direction from the regulatory authority on a site specific requirements for reservoir clearing standards. There should be a recognized procedure by which the proponent may receive guidance from the regulatory authority.

Follow-Up Socio-Environmental Studies (p.48)

20. A review of socio-environmental impacts that have resulted from constructed reservoirs in northern British Columbia and Yukon should be undertaken.

Mitigation and Enhancement Studies (p.49)

21. A study should be undertaken to research and establish practical mitigation and enhancement measures appropriate for Basin conditions. As part of this exercise a complete review of the informational literature should be undertaken.

Interconnecting the Yukon and External Power Grids (p.56)

22. If either the Liard or Stikine project is built, a potential interconnection with the British Columbia grid should be rigorously evaluated.

23. If Alaska maintains an interest in providing a link between Yukon and British Columbia through southeast Alaska, this option should be carefully considered.

Information Gaps: Energy Alternatives Other than Hydro (p.68)

24. The information gaps identified in this report regarding energy alternatives other than hydro should be reassessed from time to time and if economic conditions warrant research, funds should be sought to eliminate the gaps.

25. This review should be undertaken by a group responsible for coordinating energy planning. (See Recommendation 27.)

Northern Research Institute (p.68)

26. Consideration should be given to establishing a Yukon-based research institute that could specifically address northern energy issues.

27. Such a research institute should be a cooperative venture undertaken to provide support for government, private industry, utilities and public interest groups.

Coordinated Energy Planning (p.70)

28. A mechanism that ensures a coordinated and ongoing approach to Yukon and Yukon River Basin energy planning and decision-making should be established as soon as possible.

Multiple Use Hydro Development (p.70)

29. Hydro Facilities should be designed within a theme of multiple use of the water resources. Early consultation with other resource users should be undertaken and full consideration given to non-power implications both positive and negative.

Conflict Resolution (p.71)

30. A streamlined regulatory approvals system should be sought that minimizes time delays and maximizes the fair resolution of competing interests.

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