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AN INVESTIGATION OF POSSIBLE SMALL HYDRO GENERATING SITES

Contract Report No. 7

An Investigation of Possible Small Hydro Generating Sites in Northwest Territories Communities

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Prepared for the
Science Advisory Board
of the Northwest Territories

August 1983

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Small Hydro Generating Sites
in the Northwest Territories

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Introduction

At present, electricity is supplied almost exclusively by diesel generators in 62 NWT communities. Such generators are quite inefficient, being capable of converting only one third of the thermal energy of diesel fuel into electricity. As a result of this inefficiency, the ever increasing cost of petroleum products, and some concern regarding security of supply, attention has recently been focused on alternative methods of generating electricity.

In many parts of the world one of the more reliable alternatives now being evaluated and developed is small scale hydrogeneration. The present study was initiated by the Science Advisory Board in conjunction with the Energy and Resource Development Secretariat, GNWT, to identify possible sites in the NWT where small scale hydrogeneration (100 to 5000 KW) might be installed and to evaluate, on the basis of available information, their cost effectiveness compared to existing generation methods.

Since the funds allocated were sufficient only for a desk evaluation of existing data, the study's conclusions must be put into perspective. This is most easily done by identifying the major shortcomings in the data base.

1. For some sites hydrological data was either sketchy or non-existent. Hence information such as mean, maximum and minimum flows had to be estimated.

2. Where hydrological information was not available, there was insufficient data regarding basin characteristics and precipitation to estimate such flows. Hence comparisons had to be made with nearby basins for which such information was available.

3. Present topographical maps for most sites do not provide sufficient detail to allow precise calculations of impoundment volumes. Storage estimates as well as calculations of available heads are therefore approximate.

4. No on-site evaluations were possible under the terms of the study. Hence estimates of development costs, and therefore feasibility, are very approximate and serve only to determine directions for future study.

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ᖃᐅᔨᒥᐊᖅᐸᓪᓕᐊᓂᖅ ᑰᕐᓂᑦ ᐆᒪᖅᑯᑎᓄᑦ ᐊᑐᖅᑕᐅᔪᓐᓇᕋᔭᕐᒪᕐᒥᑦᑕ ᓄᓇᓕᕐᓂᑦ ᖁᕗᒥᔭᕐᒥᓐᓅᕐᑐᓂ

ᒫᓇᐅᔪᖅ, ᐆᒪᖅᑯᑏᑦ ᐊᐅᓚᑎᑕᐅᖃᑦᑕᖅᐳᑦ ᐊᐅᓚᑎᐅᔪᓄᑦ 62-ᓂᒃ ᓄᓇᓕᐅᔪᓂᒃ. ᑕᒪᒃᑯᐊ ᐊᐅᓚᐅᑏᑦ ᓈᒻᒪᓗᐊᖃᑦᑕᕐᒥᓪᓚᑦ, 13-ᑐᐃᓐᓇᕐᓪᓚᓐᓂᒃ ᐊᐅᓚᔾᔪᑎᒥᔭᐅᔪᓂᒃ ᐊᑐᖅᑎᖃᑦᑕᖅᒪᑕ ᐆᒪᖅᑯᑎᓄᑦ. ᑕᒪᓐᓇ ᖃᐅᔨᓪᓗᒍ ᓈᒻᒪᒍᑕᐅᕐᒥᓐᓂᕋᔭᕐᓚ, ᑕᐃᒪ ᑕᒪᒃᑯᐊ ᐱᔾᔪᑎᒥᔭᐅᔫ ᐊᑭᑐᖅᐸᓪᓕᐊᓗᐊᖅᓂᕐᒥᑦ ᐅᖅᓯᐊᓗᐃᑦ, ᐊᒻᒪᓗ ᐃᓯᒫᓘᖁᑎᒥᔭᐅᓕᖅᐳᑦ ᑕᒪᓐᓇ ᐱᑕᖃᐃᓐᓇᕋᔭᕋᓗᐊᖅᒪᕐᒥᑦᑕ, ᐃᓯᒪᒥᔭᐅᓐᓂᖅᓴᐅᓕᖅᐳᖅ ᑕᒪᓐᓇ ᐊᓯᐊᒍᑎᒎᕐᑲᖅ ᐊᑐᕈᓐᓇᕋᔭᖅᓂᕐᒥᓐᓄᑦ ᐊᐅᓚᔾᔪᑕᐅᔪᖅᑐᓂᒃ ᐆᒪᖅᑯᑎᓂᒃ.

ᐊᒥᓯᓂᒃ ᓄᓇᓕᐅᔪᓂᒃ ᓄᓇᖅᔪᐊᕐᒥᑦ ᐊᑕᐅᓯᖅ ᑖᐃᒪ ᓈᒻᒪᒥᔭᐅᔪᖅ ᐊᑐᖅᑕᐅᔪᓐᓇᕋᔭᖅᑐᖅ ᑕᐃᒪ ᖃᐅᔨᓴᖅᑕᐅᓕᖅᐸᓪᓕᐊᔪᖅ ᐊᒻᒪᓗ ᐊᑐᖅᑕᐅᓪᓚᓕᐊᓕᖅᓱᑎᒃ ᑕᒪᒃᑯᐊ ᒥᑭᔫᑎᓂᒃ ᑰᔾᔪᔪᓂᒃ ᐆᒪᖅᑯᑎᓄᑦ ᐊᑐᖅᑕᐅᓂᐊᖅᑎᓪᓗᒥᑦ. ᒫᓇ ᖃᐅᔨᓴᖅᑕᐅᓪᓚᓕᐊᔪᖅ ᐱᒥᐊᖅᑎᑕᐅᓚᐅᖅᐳᖅ ᑭᓯᑐᐃᓐᓇᕐᓂᒃ ᖃᐅᔨᓴᖅᑏᑦ ᑲᑎᒪᔩᒥᓄᑦ ᐱᓕᕆᐊᖃᑎᖃᖅᓱᑎᒃ ᐆᒪᖅᑯᑎᓄᓪᓗ ᓄᓇᒥᐅᑕᕐᓂᓪᓗ ᐱᓪᓕᕆᐊᔪᓕᕆᔾᔨᒃᑯᑦ ᐱᓕᕆᔩᒥᓄᑦ ᓄᓇᓯᐊᑦ ᒪᓕᒃᑯᒥᓐᓂᑦ, ᖃᐅᔨᓇᓯᐊᖅᓱᑎᒃ ᐊᑐᕈᓐᓇᕋᔭᖅᑐᓂᒃ ᓄᓇᓯᐊᕐᒥ ᑕᒪᑐᒥᓚ ᐊᖅᑭᒃᓯᔪᓐᓇᕋᔭᖅᑎᓪᓗᒥᑦ ᒥᑭᔪᓂᒃ ᐆᒪᖅᑯᑎᓄᑦ ᐊᑐᖅᑕᐅᔪᓐᓇᕋᔭᖅᑐᓂᒃ (100-ᓂ 5000-ᓄᑦ) ᐋᖅᑭᒃᑕᐅᔪᓐᓇᕋᔭᖅᑐᓂᓪᓗ ᐊᒻᒪ ᖃᐅᔨᓴᖅᑕᐅᓗᑎᒃ, ᑐᓴᐅᒪᔾᔪᒥᑦ ᒪᓕᒃᓗᒥᑦ, ᐊᑭᒥᓇᕋᖅᑕᕐᒥᓐᓂᓪᓗ ᖃᓄᖅ ᐊᑐᖅᑎᖃᖅᓂᖅᓴᐅᓇᔭᕐᓂᕐᒥᓐᓄᑦ ᒫᓇ ᐆᒪᖅᑯᑎᒥᔭᐅᔪᓄᑦ ᐊᑐᖅᑕᐅᖃᑦᑕᖅᑐᓂᒃ.

ᑮᓇᐅᔭᖃᑦᑎᐊᓚᐅᕐᒥᓐᓂᕐᒥᑦ ᐊᒻᒪᓗ ᖃᐅᔨᓴᓇᐊᕈᑕᐅᓇᔭᖅᑐᓂᒃ ᑕᒪᐃᓐᓂᒃ ᓄᓇᒥᔭᐅᔪᓂᒃ ᑕᐃᒪᓕ ᖃᐅᔨᒥᐊᖅᑳᓇᐊᖃᓚᐅᖅᐳᑦ ᑭᓯᓂᒃ ᑎᑎᕋᖅᓯᒪᔪᖃᖅᓂᕐᒥᓄᑦ. ᐃᓚᕐᒥᑦ ᑎᑎᕋᖅᓯᒪᓂᓇᔭᐅᔪᑦ ᐱᔭᕇᖅᓯᒪᓚᐅᕐᒪᓚᑦ. ᑕᐃᒪ ᑕᒡᕙ ᐃᓚᕐᒥᑦ ᑎᑎᕋᖅᓯᒫᓂᒃᓯᒪᓚᐅᕐᒥᑦᑐᖅ:

1. ᐃᓚᕐᒥᑦ ᖃᓄᑎᒥ ᐃᒪᖃᖅᓂᕐᒥᓐᓄᑦ ᓇᓗᓇᖃᑦᑕᓚᐅᖅᐳᑦ ᐅᕝᕙᓘᓐᓃᑦ ᐱᑕᖃᖃᑦᑕᓚᐅᕐᒥᔾᔪᑦ. ᑕᐃᒪᓕ ᖃᓄᑎᒥ ᑰᖃᖅᒪᕐᒥᑦ,ᐊᕐᒥᓂᖅᓵᓇᔭᕐᒥᓗ ᒥᑭᓂᖅᓵᓇᔭᕐᒥᓗ ᑰᒥᖃᑦᑕᖅᑕᕐᒥᑦ ᖃᐅᔨᔭᐅᒥᐊᖃᓚᐅᖅᐳᑦ.

2. ᑕᒪᒃᑯᐊᓗ ᐃᒪᕐᒥᑦ ᑰᕐᔪᖃᑦᑕᖅᑐᖅ ᑐᓴᓚᒃᓴᖁᑎᒥᔭᕐᒥᑦ ᐱᑕᖃᕐᒥᒃᑳᕐᓚᑕ,ᓈᒻᒪᕐᒥᑦᑐᓂᒃ ᑐᓴᓚᒃᓴᖃᓚᐅᖅᐳᑦ ᐱᔾᔪᑎᖃᖅᑐᓂᒃ ᓇᑭᑦ ᑰᕐᒪᕐᓚᑦ ᐊᒻᒪᓗ ᖃᓄᑎᒥ ᐃᒪᕐᒥᒃ ᑰᖃᑦᑕᖅᒪᕐᓚᑦ. ᖃᐅᔨᓴᖅᑕᐅᒥᐊᖃᓚᐅᖅᐳᑦ ᖃᓂᒥᔭᕐᒥᓐᓅᑦᑐᓂᒃ ᑕᓯᐅᔪᓂᒃ ᐊᒻᒪᓗ ᑐᓴᓚᒃᓴᕆᔭᕐᒥᑦ ᐱᑕᖃᖅᑎᓪᓗᒥᑦ.

3. ᒫᓇ ᓄᓇᕐᔪᐊᕐᔪᔪᑦ ᐃᓚᕐᒥᓄᑦ ᑎᑎᕋᓂᒃᓯᒪᔪᖃᕐᒥᓪᓚᑦ ᖃᐅᔨᔫᑕᐅᓇᔭᖅᑐᓂᒃ ᖃᓄᑎᒥ ᐃᒪᕐᒥᒃ ᑰᖃᑦᑕᕐᒪᕐᒥᑦᑕ ᐅᑭᐅᕐᒥ ᐊᑕᐅᓯᕐᒥᑦ. ᑎᑎᕋᖅᑕᐅᓚᐅᖅᑐᖅ ᖃᐅᔨᔭᐅᓚᐅᖅᑐᓗ ᖃᓄᖅ ᖁᑦᑎᕐᓂᖁᔭᕐᒥᓗ,ᖃᓄᑎᒥᓗ ᑰᖃᑦᑕᕐᓂᕐᒥᓐᓄᑦ ᓇᓚᐅᓯᒪᖃᑦᑕᖅᐳᑦ.

4. ᖃᐅᔨᓴᕐᐱᐅᓇᔭᖅᑐᓂᒃ ᑰᔾᔪᔪᓂᒃ ᖃᐅᔨᔪᓐᓇᖅᑐᖃᓚᐅᕐᒥᓪᓚᖅ ᖃᐅᔨᓴᖅᑎᓗᒥᑦ. ᑕᐃᒪ ᖃᓄᑎᒥ ᐊᑭᖃᕋᔭᕐᓂᕐᒥᑦ ᐱᓪᓕᐊᒍᑕᐅᓇᔭᖅᑐᓂᒃ, ᐊᒻᒪᓗ ᐊᔪᕐᓇᕋᔭᕐᒥᓪᓚᖅ, ᓈᒻᒪᕐᓯᐊᖅᓯᒪᔪᑦ ᐊᒻᒪᓗ ᐋᖅᑭᒍᑕᐅᓇᔭᖅᐳᑦ ᖃᓄᐃᓕᐅᕋᔭᕐᓂᕐᒥᓐᓄᑦ ᓯᕗᓂᒃᓴᕐᒥᓐᓂᒃ ᖃᐅᔨᓴᕈᑕᐅᓇᔭᖅᑐᓂᒃ.

NAIGLIHIMAYOK

IHIVGIONGNIK KUGLUNIK ATUKTAOYOKHANIK ALGOYAKTOKTONUT HANIANI INULGIT NUNAN.

TAYA, ALGOYAKTOKTONIK ATUNGNIK PIYAOVAKTOK INGNIKUTIKUT OKHOKYOAKTOKTONIK 62 NI NUNANI NUNATIAMI. TAPKOA INGNIKUTIN IHOALUANGITON, 1/3 UNANGNIA OKHOKYOKTONGNIOP ATULAGAMI ALGOYAKTOKTONUT. IHOALUANGINAMI UVUNA, AKITTOKPALIANIN OKHOKYOAN, OKHOKYOANGIGAHOGINIKLU, AHIKUT ALGOYAKTOKTONIK ATUNGNIKUT IHOMALIKTON.

AMIGAITONI NUNAMI TAMANI IHIVGIOKTAOLIKTOK ATUKTAKHAK KAKUGU MIKAIT KUGLUN ALGOYAKTOKTOKUT ATUGIANGANI. TAMNA TAYA ILITOKHAINIK AULLAKTIHIMAYAN SCIENCE ADVISORY BOARD KUT ILAGIPLUGIN ENERGY AND RESOURCE DEVELOPMENT SECRETARIAT, NUNATIAM KAVAMAINI, NAONAIYAGAHOAKHUGIN KITON NUNAN NUNATIAMI KUGLUNIK ATUKTUKHAN (100 MIT 5000 KW MUT), TAYA NAONAIYAOTINIK ATUKHUTIK TALVALU KANUK AKIKHAN IHOMAGIPLUGU KANUK AKIKANGNIAKTOK TAYA ATUKTAPTINGNIT.

AKIKHAKANGINMAT ILITOKHAIYAMI TAMAINIK ILITOKHAIVAKTON PIHIMAYAMINGNIK TAYA NAONAIYAOTIKUT. ILAIT ILITOKHAINIT NAONAIYAOTAIN INIKHIMAITON. HAPKOA PIHIMANGITAVUT:

1. ILAINI IHIVGIOKTAOYONI KANUK KUGLUNGNIA IMAM NAONAKTOKLUNIT KUGLUITOKLUNIT. TALVANGA NAONAIYAOTIKHAN TITIGAKTAOHIMAYON KANGIKHIMATTIANGIPLUGIN KANUK KUGLUNGNIA.

2. NAONAIYAOTIN KUGLUKUT PIHIMAINIATIGUT NAONAITTIAKHIMAITOK HUMIT KUGLUKTUK KANUGLU IMAKANGNIA. TALVANGA NAONAIYAKPAGAN HANIANITOKUT TAHIN NAONAIYAOTIKAGANGAMIK TAHINGNIK.

3. TAYA NUNAOYAT KANGIKHINAITON KANUK KUGLUANGNIAGIAKHAITA KUGLUN OKIOMI ATAUHINGMI. NAONAIYAOTIN ATUKPAGAIN MIKHAGUT KANUK KULVAHIGIAN GATALU KANUKLU IMAKAGIANGATA NAONAIYAKAFUKHIMAYON.

4. HAVAKHUNI NAONAIYANGNIK HAVAKVIMINI PILIMAITAN ILITOKHAIPLUTIK. TALVANGA AKIKHANIK, ATULINGNIMIKLU NAONAIYATTIAKHIMAITON TALVALU KAKUGU ATUKTAOYOKHAKAFOIT ILITOKHAINAHOALIGUMIK.

Past Studies

In the last 25 years some 10 studies have been carried out to investigate potential sites for hydroelectric development in the NWT. However most have dealt with large scale development schemes and were, in fact, investigations of full river development. The studies all concluded that although potential was present, the demand was not. All schemes would be dependent on large scale mining or pipeline developments to be economically justifiable. Therefore most of the information was only of peripheral use to this study.

A study entitled "Hay River Hydroelectric Development" was prepared for Alberta Power by Crippen Consultants. It investigated three rivers to assess their capability of generating 5 MW, the present peak power demand of Hay River. The sites investigated included the Mellor Rapids on the Buffalo River, Alexandra and Louise Falls on the Hay River, and the Upper Kakisa Rapids and Lady Evelyn on the Kakisa River. The study did not recommend a preferred site, but did estimate development costs, including transmission as:

Buffalo River	$\$16.1 \times 10^6$
Alexandra Falls	$\$11.4 \times 10^6$
Lady Evelyn Falls	$\$14.5 \times 10^6$

On the basis of fuel replacement all three schemes appear feasible (the present value of fuel is 29.4×10^6). However Alexandra Falls, in our opinion, is the best site and should be developed. It is interesting to note that even after development the site would still attract tourists because of the relatively high flows during June, July and August. There is little tourist traffic during periods of low flow (November to March).

Underwood McLellan Ltd. prepared "Power Site Survey, Northwest Territories" which covered the Anderson, Horton and Hornaday Rivers. The report, prepared in 1981 for DIAND, identified one site on the Hornaday River about 70 km from Paulatuk as having potential for small scale development. The projected costs appear high. Nevertheless, the remoteness of the site renders development unfeasible.

In 1974 and 1975 NCPC conducted a number of "in-house" studies dealing with the development of the Lac La Martre Falls. It was found that the site, if fully developed, has a potential of 27.5 MW. Heads of 27 m at the falls, 60 m within the first kilometre, and 88 m within 8 km were identified.

The development of the Sylvia Grinnell River near Frobisher Bay was studied by NCPC in 1975. The consultant concluded that, if fully developed, the river could satisfy the electrical needs of the community.

T. Igledow & Associates Ltd. prepared a report for DIAND entitled "Power Survey of the Liard River Basin, Yukon and Northwest Territories" in 1969. One site near Fort Liard on the Petitot River was estimated to have a potential of 44.6 MW, but a large dam would be required. The study also considered some attractive sites now in Nahanni Park. However these are no longer available for development.

NCPC commissioned a study in 1972 called "Great Bear River Power Development." Crippen and Associates Ltd. identified several sites having a combined capacity of 602 MW. However the sites identified are not well suited for conventional small-scale development.

In another report, "Power Site Survey, Northwest Territories," prepared for DIAND by Underwood McLellan Ltd., possible development of the Maguse River was examined. Eskimo Point is some 50 km from the possible hydro-generation site. The analysis of the site is utilized in our report.

"Power Survey in the Central Mackenzie District, Northwest Territories" was prepared in 1969 for DIAND. Two sites were identified which could be used for full-scale hydro — Bloody Falls on the Coppermine, and the falls on the Snowdrift River. The sites have a maximum installed capacity of 55.9 and 9.8 MW respectively. For this study the information on Bloody Falls was utilized, but the Snowdrift River site information was rather sketchy.

The Approach

OVERVIEW

Although there are many sites within the NWT that have hydroelectric generation potential, these sites are frequently found far from population centres. In such cases the costs of transmitting the electricity outweigh any savings that might be realized from diesel fuel displacement. Hence the distance of a site from the community it may serve becomes a key factor in determining its economic feasibility.

In this study a "radius of search" was developed for each community. This radius was based upon the cost of the fuel consumed (and therefore available for displacement) by each community. It was assumed that 50% of those possible savings would be available to construct a transmission line. Thus the radius of search would vary directly with the size of the community and its energy consumption. The entire search was carried out using only maps and air photos. Some personal knowledge of the various sites was utilized.

Using this method, NWT communities were divided into three categories; those having no potential, marginal potential, and good potential for hydroelectric development. Only those communities in the last category received detailed attention. For each of these latter communities development costs of the promising sites were approximated. The development costs were then compared to the value of the fuel that would be displaced using a "present value" approach. If the hydro site appeared capable of meeting both the electricity and heating requirements of a community then comparisons were based on savings which would be gained through the displacement of fuel used for both purposes.

Where possible, site generation capacities were based on stream flow data supplied by Environment Canada. For sites where no data were available, statistical transfers were used. Details of this procedure are given in Appendix 1.

TRANSMISSION LINE COSTS

Since transmission costs represent a relatively greater portion of the total development costs in small scale applications, considerable emphasis was placed on estimating that factor.

Assuming a generation capacity of 100 KW to 5 MW and a transmission line length of from 4 to 80 km, the most economic operating voltage would range from 12 to 66 kV. The lower voltage is suitable for low power and short transmission distances while the high voltage would be used for greater power and long distances. Table 1 provides a guide for the most economic voltages based on distance alone.

Table 1

ECONOMIC VOLTAGES FOR TRANSMISSION LINES CONSIDERING DISTANCES ONLY

Distance, km	Voltage, kV
4 to 20	12
20 to 30	25
30 to 40	33
40 to 80	66

The cost per km of the transmission line of the size being considered here is relatively insensitive to voltage but quite sensitive to the conductor size, which is in turn determined by the generation capacity. To deal with larger capacities larger conductors are required. The added weight requires either larger poles or a greater number of poles power km, thus increasing the cost of the line. For this feasibility study which offers a ± 35% accuracy in cost estimates, we assumed a 33 kV system using 2/Q ACSR conductors and 40 western red cedar poles per km. However the estimates adequately cover the 12 to 66 kV transmission line range. Calculations yielded an estimate of $21,300 per km (in 1982 dollars). This estimate assumed flat terrain and allows no contingency for adverse weather during construction. The average span used was 90 m with 12 pole-and-crossarm structure per km. Of the total estimate, 56% was for materials, the remainder being labour. Labour costs were broken down as 70% wages and 30% depreciation/rental of equipment such as a digger, trucks, front end loaders and trailers.

The main components of the transmission line with 1982 unit costs are listed in Table 2. We assumed three insulators for each pole-and-crossarm structure and three conductors.

Table 2

COST OF TRANSMISSION LINE COMPONENTS

Material	Cost in 1982 Dollars
40' WRC class 3 poles	$ 300.00 ea.
8.5' fir crossarm	$ 30.00 ea.
33 kV pin insulator	$ 26.00 ea.
2/Q ACSR conductor	$1350.00/mile
2 ACSR conductor	$ 690.00/mile
4 ASCR conductor	$ 460.00/mile

The above standard could be relaxed or modified in uninhabited areas. For example, pole heights have been determined in relation to the heights of common vehicles in urban areas. Further if local trees were used, significant savings could be achieved. This would also be true if advantage were taken of local employment programs for some parts of the construction, such as right-of-way clearing and pole erection.

ENERGY DEMAND CALCULATIONS

One of the obstacles to hydroelectric development for most NWT communities is their small power demand. Since the unit cost of generated electricity is indirectly proportional to the installed capacity, it is sensible to consider hydrogeneration, where the capacity is available, for all community energy demands. Accordingly, the total energy use in each community was considered (fuel used for heating as well as electrical generation) and the total value of replaced oil was calculated. It was assumed that the annual fuel savings, discounted over a 40 year period, represented a capital cost which could be cost-effectively allocated to plant and transmission line construction.

To calculate the energy in the form of electricity required for replacement of present heating systems, the following assumptions were made:

- one litre of furnace fuel represents 26,984 BTU
- the average furnace is 65% efficient
- 3413 BTU equal 1 kilowatt hour
- electric heat within the house is 100% efficient

Initially, we used an interest rate of 17% and a 20 year term. The 17% interest reflected the then current inflation rate and a real return on investment of 4% to 6%, a figure which is historically accurate. This now appears conservative in both the interest rate and amortization period. To illustrate the effect of different interest rates we also developed tables showing present values calculated using interest rates from 6 to 14% and a 40 year term.

CONSTRUCTION COST ESTIMATES

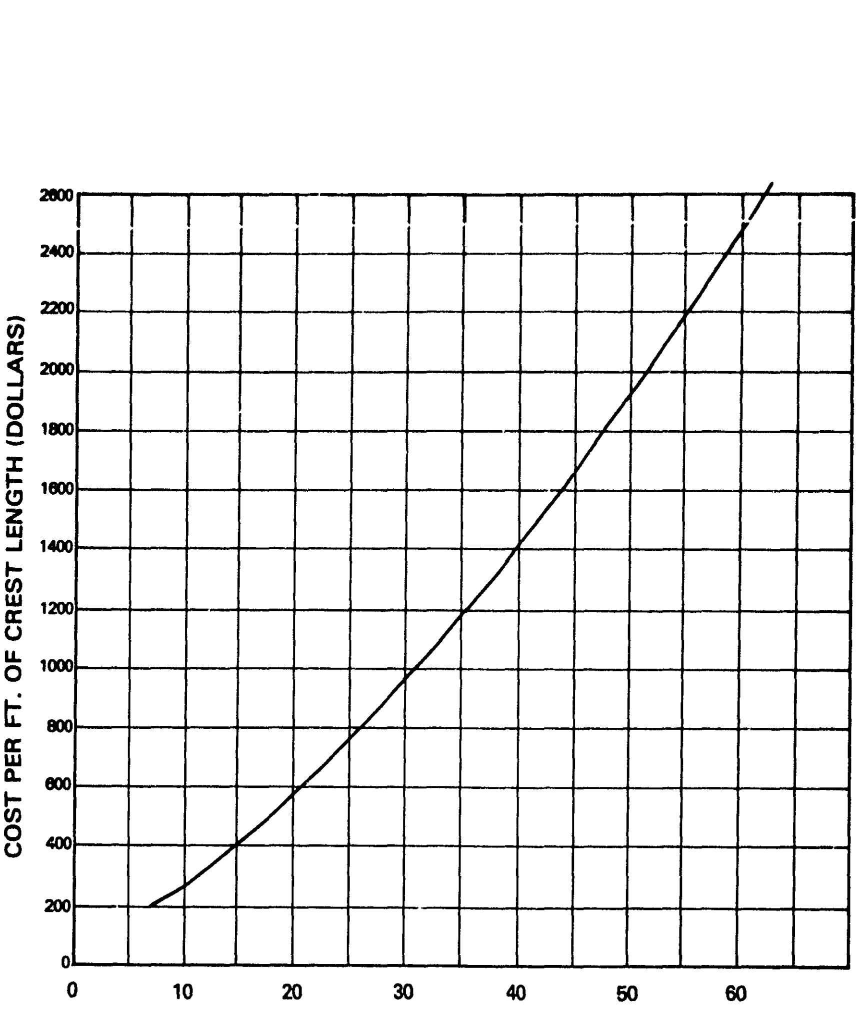
Figures 1, 2 and 3 were used in the determination of construction costs for the embankments and power houses. Such costs are generally higher in the Northwest Territories than in Southern Canada. However, there may be several advantages in building hydro installations in the sparsely occupied North.

The safety factors incorporated into a retaining dam could be lowered because of the minimal consequences of a flood wave. Hence the level of the engineering investigation could be reduced and local building materials utilized.

Usually there is an abundance of labour and basic earth moving equipment in northern communities. Advances in the prefabrication of generating equipment have made installation on the site only marginally more expensive. Transportation to most communities would be by sea, a relatively inexpensive mode of transportation. However, one community, Pelly Bay, poses considerable difficulty since it can be supplied by air only. Here, particularly, the utilization of a frozen dam core could also be a cost advantage.

For the estimation of construction costs the following approximations were used:

- access road (gravel road 6 m. wide) $50 to $60,000/km.
- dam (constructed from local materials) see Figure 1,
- multiply by 1.0 index to obtain 1981 construction costs.
- power features, see Figure 2, multiply by 1.4 index.
- switchyard equipment, see Figure 3, multiply by 1.4 index.
- transmission line $25,000 to $30,000/km.



NOTES:

1. *Date of costs is April 1979.*
2. *Total costs obtained by multiplying the cost per foot by the dam crest length.*
3. *The cost must be multiplied by the valley shape coefficients shown. See also Figure A-2.*
4. *The cost is based on a unit price of $10 per cubic yard for embankment fill.*
5. *Costs include 20 percent for excavation, foundation treatment, drainage and other minor items.*

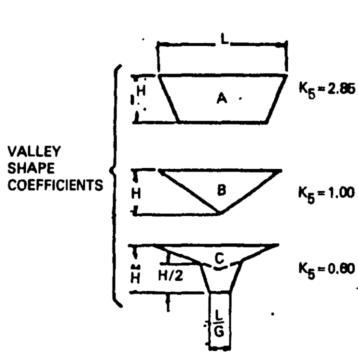
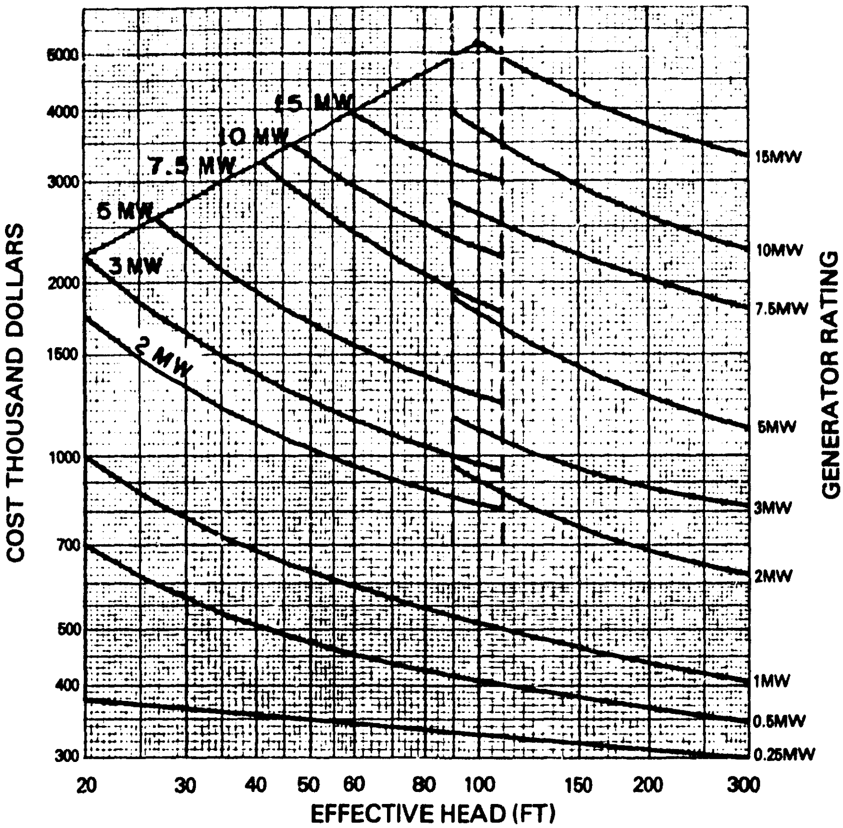


Figure 1 Embankment Dam Costs

REF. DAVID C. WILLER

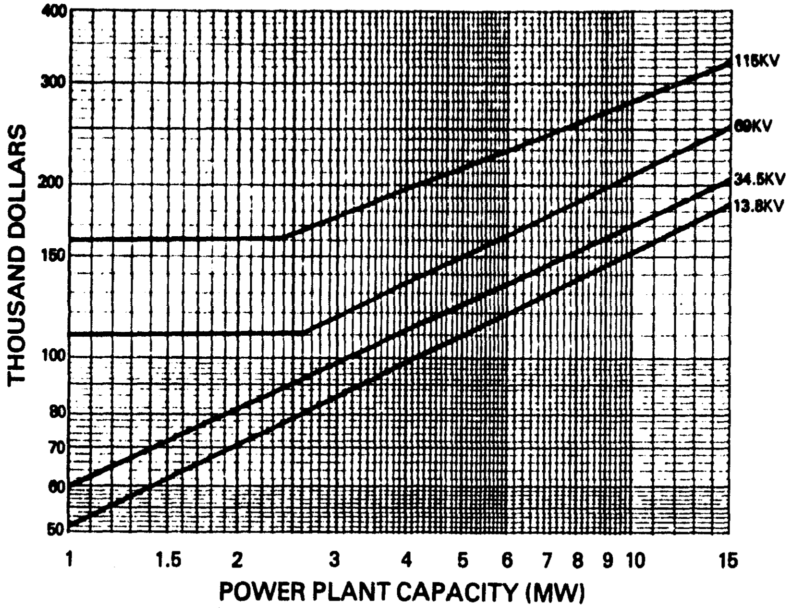


NOTES:

1. *Estimated costs are based upon a typical or standardized turbine coupled to a generator either directly or through a speed increaser, depending on the type turbine used.*
2. *Costs include turbine/generator and appurtenant equipment, station electric equipment, miscellaneous powerplant equipment, powerhouse, powerhouse excavation, switchyard civil works, an upstream slide gate, and construction and installation.*
3. *Costs not included are transmission line, penstock, tailrace construction and switchyard equipment.*
4. *Cost base July 1978.*
5. *The transition zone occurs as unit types change due to increased head.*
6. *For a Multiple Unit powerhouse, additional station equipment costs are \$20,000 + \$58,000 x (n-1) where n is the total number of units.*
7. *Data for this figure was obtained from figures and tables in Volumes V and VI.*

REF. U.S. ARMY CORPS OF ENGINEERS

Figure 2 Power features cost — reconnaissance



NOTES:

1. *The major Equipment is listed below:*
   a. *Main Step-up Transformer*
   b. *Line Side Oil Circuit Breaker*
   c. *Lightning Arresters*
   d. *Air-Break Switches*
   e. *Bus work*
2. *Costs include 25 percent for freight and installation.*
3. *Foundations and Switchyard structures are covered in the Civil Features (Volume VI).*
4. *Above costs reflect a design of 45 feet of generator buswork. For extension beyond 45 feet, use a factor of $200 per foot for generator buswork.*
5. *Cost index is July, 1978.*

Figure 3 Switchyard equipment costs

REF. U.S. ARMY CORPS OF ENGINEERS

Results

Using information from Tables 3-5 to calculate a "radius of search," potential sites close to N.W.T. communities were identified. This approach resulted in the development of the following three categories of communities.

COMMUNITIES WITH NO POTENTIAL HYDRO SITES

In the following communities the study indicated that there was no possibility for hydrogeneration to replace other methods of electrical generation. Although some of the communities were located on or near rivers, the catchment areas were too small to provide substantial sustained flows.

Arctic Bay	Nanisivik
Bay Chimo	Pond Inlet
Chesterfield Inlet	Repulse Bay
Gjoa Haven	Resolute Bay
Grise Fiord	Sanikiluaq
Hall Beach	Spence Bay
Holman Island	Whale Cove
Igloolik	

COMMUNITIES WITH MARGINAL POTENTIAL FOR COMMUNITY SCALE HYDRO DEVELOPMENT

Communities in this group were identified as having some potential for hydro development, but for the purposes of this study they have been set aside for a variety of reasons. However they may be categorized as follows:

Communities Requiring Large Scale Development

There are a number of potential sites on the Mackenzie, Peel, Arctic Red and Liard Rivers where hydrogeneration is possible. However site development using current technology would be extremely expensive and possibly environmentally unacceptable. If the vertical axis water turbine which is currently under development is successful, then the possibilities for these communities should be re-evaluated.

Aklavik	Fort Providence
Arctic Red River	Fort Simpson
Fort Franklin	Inuvik
Fort Good Hope	Jean Marie River
Fort Liard	Norman Wells
Fort McPherson	Wrigley
Fort Norman	

In the case of Fort Liard, an additional site on the Petitot River is of interest. However it is some 30 km from the community and would require a transmission line costing in excess of one million dollars. Further, to develop sufficient head a relatively high dam would be required. These factors make the site only marginally feasible.

As the power demand increases at Norman Wells, the development of sites on the Mountain, Carcajou and Great Bear Rivers may become attractive. From an economic standpoint, of these rivers the Great Bear seems most suited.

The Fort Simpson area has some smaller streams which were of some interest, but in our opinion not suitable.

Communities Directly Affected by Larger Scale Development

Discussions are currently underway examining the development of "world class" sites on the Slave River. The possibility of subsequent grid developments to link south Slave communities is sufficiently great to cause us to recommend that no consideration be given to community-scale installations until the situation clarifies. Communities affected include:

Fort Smith	Pine Point
Enterprise	Fort Resolution
Hay River	

Communities in the vicinity of Yellowknife are presently linked by a grid. Opportunities exist for the development of medium scale sites within the grid. For example, there is potential for up to 28 MW on the Lac La Martre River. We recommend that the full potential be developed and that Lac La Martre be tied into the grid.

Other sites may bear examination. The Wicho River, which has a drainage basin of 2800 km has one site almost directly under the transmission line leading to Yellowknife which has a possible head of 30 metres.

Pending examination of the above, the following communities should be excluded from consideration for small scale development:

Yellowknife
Detah
Rae-Edzo

Table 3

ESTIMATED FUEL OIL CONSUMPTION FOR NWT COMMUNITIES AND ITS PRESENT VALUE OVER TWENTY YEARS

Community	Population 1981	Electricity Generated* 1981 (kWh ÷ 10^6)	Diesel Oil Used for Generation* (l ÷ 10^3)	Heating Oil Consumed (l ÷ 10^3)	Unit Cost of Oil** ($/l)	Total Cost of Oil ($ ÷ 10^6)	Present Value 20 year term ($ ÷ 10^6) i = 17%	i = 10%	Net Energy Use*** (kWh ÷ 10^6)
Aklavik	750	1.981	794.5	1615	0.500	1.205	6.781	10.256	13.356
Arctic Bay	377	0.909	369.3	719	0.493	0.537	3.022	4.567	5.973
Arctic Red River	79	0.178	107.3	116	0.443	0.098	0.551	0.842	0.995
Baker Lake	1017	2.720	1139.0	1802	0.500	1.471	8.278	12.519	15.412
Bathurst Inlet	29					0.030†			
Bay Chimo	60					0.076†			
Broughton	314	0.778	302.8	765	0.463	0.494	2.780	4.209	6.166
Cambridge Bay	864	3.919	1351.0	2937	0.557	2.388	13.439	20.333	24.606
Cape Dorset	725	2.057	727.8	1642	0.483	1.145	6.443	9.744	13.622
Chesterfield	281	0.660	295.7	755	0.483	0.507	2.853	4.320	5.798
Clyde River	443	1.304	377.5	789	0.463	0.540	3.039	4.598	6.861
Colville Lake	73	0.080	100.0	6	1.000	0.106	0.596	0.902	0.122
Coppermine	766	1.999	716.1	1384	0.503	1.056	5.943	8.993	11.747
Coral Harbour	414	0.997	732.9	607	0.493	0.661	3.720	5.623	5.272
Detah‡	162								
Enterprise	40			91	0.303	0.028	0.157	0.234	0.641
Eskimo Point	980	2.164	772.3	1821	0.483	1.253	7.051	10.663	14.990
Fort Franklin	554	0.982	384.0	638	0.511	0.522	2.937	4.446	5.476
Fort Good Hope	446	0.915	382.0	808	0.471	0.560	3.151	4.763	6.592
Fort Liard	344	0.394	197.3	185	0.512	0.196	1.103	1.666	1.697
Fort McPherson	781	1.936	737.4	1587	0.393	0.913	5.138	7.777	1.315
Fort Norman	312	0.742	366.5	565	0.443	0.413	2.324	3.513	4.722
Fort Providence	571	1.436	681.4	2029	0.303	0.821	4.620	6.991	15.727
Fort Resolution	523	1.613		977	0.559	0.546	3.072	4.649	8.495
Fort Simpson	1001	5.867	1870.0	3810	0.303	1.721	9.685	14.652	32.703
Fort Smith	2234	14.397	429.6	4970	0.303	1.636	9.207	13.928	49.403
Frobisher Bay	2454	16.142	5529.0	5038	0.480	5.072	28.544	43.182	51.628
Gjoa Haven	493	1.174	376.6	927	0.583	0.760	4.277	6.470	7.703
Grise Fiord	95	0.348	194.8	344	0.503	0.271	1.525	2.307	2.771
Hall Beach	396	0.722	295.5	655	0.493	0.469	2.639	3.989	5.335
Hay River	3345	22.948	8363.0	8901	0.303	5.231	29.439	44.534	85.643
Holman	336	0.617	279.8	412	0.490	0.339	1.907	2.885	3.519
Igloolik	766	1.688	661.0	1764	0.463	1.123	6.320	9.558	14.113
Inuvik	2892	23.256	8801.0	5529	0.340	4.872	27.418	41.479	62.200
Jean Marie River	49	0.041	50.9	25	0.564	0.049	0.275	0.364	0.217
Kakisa	40					0.049†			
Lac La Martre	231	0.183	103.9	89	0.599	0.116	0.652	0.983	0.810
Lake Harbour	300	0.701		463	0.463	0.214	1.204	1.825	3.962
Nahanni Butte	92	0.058	57.8	41	0.544	0.054	0.303	0.457	0.347
Nanisivik	291	7.500		2448					
Norman Wells	361	2.675	1298.0	15725					
Pangnirtung	909	1.861	699.7	1580	0.473	1.078	6.066	9.180	12.990
Paulatuk	166	0.272	181.7	216	0.503	0.200	1.125	1.703	1.793
Pelly Bay	281	0.596	261.6	461	0.683	0.494	2.780	4.201	3.843
Pine Point	1719	12.614	1438.0	568	0.320	0.642	3.613	5.465	16.615
Pond Inlet	652	1.718	711.2	1610	0.483	1.121	6.308	9.544	13.058
Port Radium	140			2654					
Rae-Edzo	1367	3.496		540	0.342	0.185	1.041	1.572	7.299
Rae Lakes	172					0.338†			
Rankin Inlet	956	5.214	1819.0	2793	0.483	2.228	12.538	18.964	24.887

Table 3 continued

ESTIMATED FUEL OIL CONSUMPTION FOR NWT COMMUNITIES AND ITS PRESENT VALUE OVER TWENTY YEARS

Community	Population 1981	Electricity Generated* 1981 (kWh + 10^6)	Diesel Oil Used for Generation* (l + 10^3)	Heating Oil Consumed (l + 10^3)	Unit Cost of Oil** ($/l)	Total Cost of Oil ($ + 10^6)	Present Value 20 year term ($ + 10^6) i = 17%	i = 10%	Net Energy Use*** (kWh + 10^6)
Repulse Bay	328	0.781	394.8	651	0.473	0.495	2.785	4.211	5.367
Resolute	177	3.848	2312.0	706	0.543	1.639	9.224	13.951	8.820
Sachs Harbour	170	0.520	334.0	331	0.513	0.341	1.919	2.904	2.851
Sanikiluaq	334	1.071	1817.0	492	0.445	1.028	5.785	8.747	4.536
Snowdrift	264	0.421	215.7	247	0.473	0.219	1.232	1.863	2.161
Spence Bay	470	1.505	524.3	1213	0.583	1.013	5.701	8.621	10.041
Trout Lake	61			5	0.663	0.003	0.016	0.027	0.034
Tuktoyaktuk	747	3.425		1581	0.483	0.764	4.299	6.501	14.561
Tungsten	506	0.023		1133	0.663	0.751	4.227	6.375	8.003
Whale Cove	203	0.518	243.7	482	0.473	0.343	1.930	2.920	3.910
Wrigley	163	0.518	195.8	120	0.486	0.153	0.861	1.305	1.362
Yellowknife	9918	65.996	6530.0	27423	0.342	11.612	65.350	98.858	259.150

* From *Energy in the NWT, A Summary of Electricity and Petroleum Product Consumption,* Science Advisory Board of the NWT

** Pers. Comm. GNWT Petroleum Products Division

*** Energy available to user taking into account conversion efficiency

† Estimated

‡ Included in Yellowknife data

Table 4

PRESENT VALUE OF FUEL USED FOR ELECTRICAL GENERATION IN SELECTED NWT COMMUNITIES

Community	Population 1981	Fuel Used for Generation l + 10^3	Fuel Cost $/l	Total Fuel Cost $ + 10^6	PRESENT VALUE OVER 40 Years $ × 10^6 6%	8%	10%	12%	14%
Baker Lake	1017	1139	0.500	0.569	8.561	6.785	5.564	4.691	4.043
Coppermine	766	716	0.503	0.360	5.417	4.293	3.520	2.968	2.558
Coral Harbour	414	733	0.493	0.361	5.432	4.305	3.530	2.976	2.565
Eskimo Point	980	772	0.483	0.373	7.267	5.760	4.723	3.982	3.432
Frobisher Bay	2454	5529	0.483	2.671	40.189	31.851	26.120	22.019	18.978
Kakisa				0.028	0.421	0.334	0.274	0.231	0.199
Lac La Martre	231	104	0.599	0.062	0.933	0.739	0.606	0.511	0.441
Lake Harbour	300		0.463	0.121	1.821	1.443	1.183	0.998	0.860
Pelly Bay	281	262	0.683	0.179	2.693	2.135	1.750	1.476	1.272
Rankin Inlet	956	1819	0.483	0.879	13.22[illegible]	9.456	8.596	7.246	6.245
Snowdrift	264	216	0.473	0.102	1.53[illegible]	1.216	0.998	0.841	0.725

Table 5

PRESENT VALUE OF FUEL USED FOR BOTH ELECTRICAL GENERATION AND SPACE HEAT IN SELECTED NWT COMMUNITIES

Community	Population 1981	Fuel Used for Generation $l \times 10^3$	Fuel Used for Heating $l \times 10^3$	Fuel Cost $/l	Total Fuel Cost $ \times 10^6$	PRESENT VALUE OVER 40 Years $ \times 10^6$: 6%	8%	10%	12%	14%
Baker Lake	1017	1139	1802	0.500	1.471	22.131	17.541	14.385	12.127	10.462
Coppermine	766	716	1384	0.503	1.056	12.889	12.592	10.327	8.705	7.503
Coral Harbour	414	733	607	0.493	0.661	9.946	7.882	6.464	5.449	4.696
Eskimo Point	980	772	1021	0.483	1.252	18.838	14.930	12.243	10.321	8.896
Frobisher Bay	2454	5529	5038	0.483	5.104	76.796	60.863	49.912	42.076	36.264
Kakisa					0.049	0.737	0.584	0.479	0.404	0.348
Lac La Marte	231	104	89	0.599	0.116	1.745	1.383	1.134	0.956	0.824
Lake Harbour	300		463	0.463	0.398	5.988	4.746	3.892	3.281	2.828
Pelly Bay	281	262	461	0.683	0.494	7.433	5.891	4.831	4.072	3.510
Rankin Inlet	956	1819	2793	0.483	2.228	33.523	26.568	21.788	18.367	15.830
Snowdrift	264	216	247	0.743	0.219	2.295	2.611	2.142	1.805	1.556

Communities Discounted For Miscellaneous Reasons
The following communities have some potential for hydroelectric generation, but they should not be considered at present for a variety of reasons.

Colville Lake — population too small to justify cost of transmission line.

Bathurst Inlet — excellent streamflow and head, but minimal demand. The site should be considered when the permanent population reaches about 20 families.

Cambridge Bay — marginal potential. Site development would also have a significant environmental impact.

Nahanni Butte — some excellent sites. However they are now within the boundaries of the Park.

Paulatuk — insufficient demand to support transmission costs.

COMMUNITIES WITH HYDROELECTRIC GENERATION POTENTIAL

The following communities appear to have good potential for the development of hydrogenerating facilities to meet the current demand.

Baker Lake	Lake Harbour
Coppermine	Pelly Bay
Coral Harbour	Rankin Inlet
Eskimo Point	Snowdrift
Kakisa	Frobisher Bay
Lac La Martre	

Since the sites at both Frobisher Bay and Lac La Martre would support development on scales larger than 5 MW they were considered to be outside the terms of this study.

Site Evaluations

BAKER LAKE

The total peak energy requirement of the Baker Lake community is about 4425 kW. This can be almost entirely supplied by hydrogeneration.

The proposed scheme on Prince River would utilize a head of 52 metres between Unnamed lake (elevation 181 feet) and Baker Lake (elevation 8 feet). The dam and spillway on the Prince River would have top elevation at 181 feet. The required flow (9.43 m^3/sec.) is the mean minimum flow. It also appears that a simple diversion from the Quoich River is possible. This would provide supplementary flow in a year with below average precipitation.

It is proposed that 6.4 kilometres penstock be constructed, as shown on the drawings. The power house would be located on the shore of Baker Lake.

A second alternative which should be investigated would utilize the head created by the dam. However, an additional 5 m^3/sec. flow would have to be diverted from Quainch River to generate 3.640 kW of electricity.

The environmental impact of a dam on the Prince River should not be significant. There would be some interruption in fish runs upstream from the Baker Lake, but this is not a major river. Flooding due to higher water level should not cause significant alteration to the environment.

A careful design of the power house outlet (deep submerged) could prevent ice flooding on Baker Lake. Some reduction of ice thickness may occur at the power house.

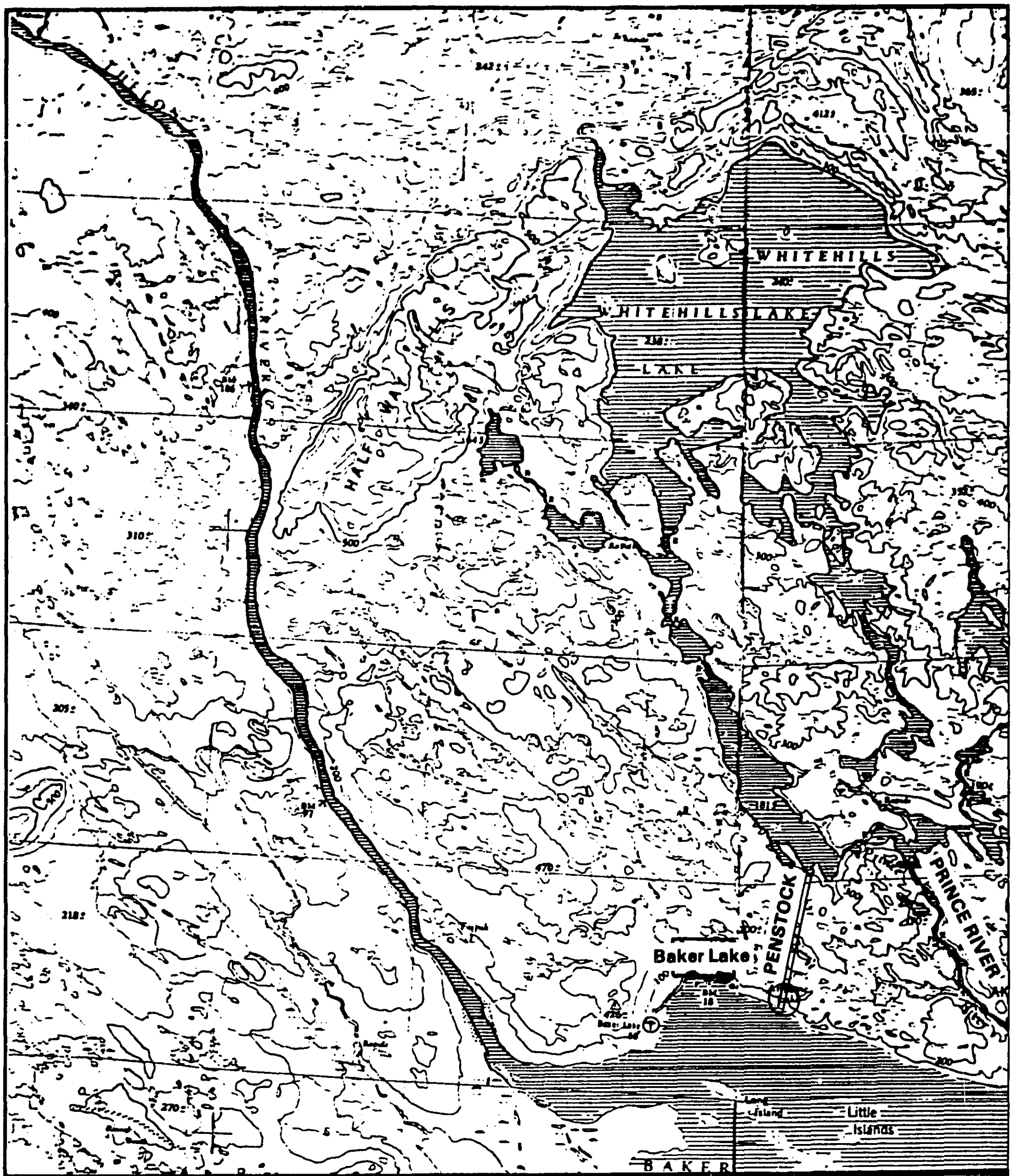
SITE CHARACTERISTICS

Energy Requirements	
Total Energy Consumption	15,502 × 10^6kWh
Average Demand	1770 kW
Peak Demand	4420 kW
Total Electrical Energy Consumption	2.72 × 10^6kWh
Average Demand	311 kW
Peak Demand	725 kW
Installed Capacity	2445 kW

Plant Characteristics:

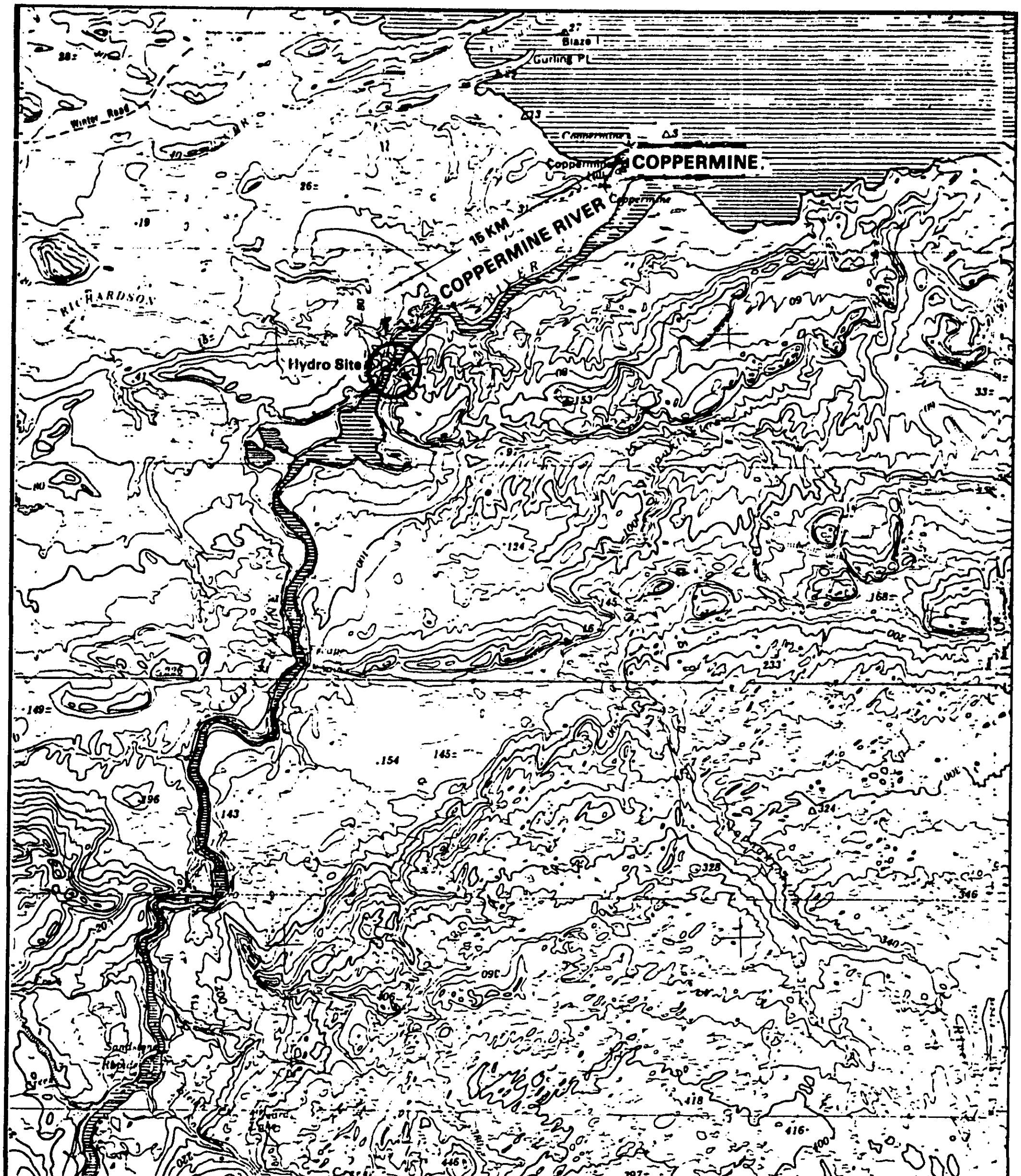
Prince River and Diversion Quoich River	
Mean Minimum Flow	9.43 m^3/sec.
Head	52 m
Turbine	Pelton
Power Potential	700 KW
Elevation Above Sea Level	2.0 m

Cost of Development	3700 kW
Road, 7 km @ 50,000	$ 350,000.00
Dam, 3400 m^3 @ $20	$ 1,000,000.00
Spillway	$ 200,000.00
Penstock, 6.4 km @ $400,000	$ 2,560,000.00
Power Plant, 3.7 MW	$ 2,900,000.00
Transmission Line, 4 km	$ 120,000.00
Switchyards	$ 100,000.00
Transportation	$ 100,000.00
Quoinch Diversion	$ 1,000,000.00
Additional Distr. System	$ 1,000,000.00
	$ 9,330,000.00
20% Contingency	$ 1,866,000.00
20% Engineering	$ 1,866,000.00
	$13,062,000.00
Unit Cost	$ 3,530.00/KW



DRAWING TITLE	Baker Lake — Prince River
JOB TITLE	Small Scale Hydro Sites in N.W.T.

FERGUSON, NAYLOR, SIMEK, CLARK LTD. CONSULTING ENGINEERS & ARCHITECTS P.O. BOX 1777 YELLOWKNIFE N.W.T. CANADA X1A 2P4	JOB NO. 82-240 SCALE 1:250 000 DATE APRIL 1982	FIGURE 4



DRAWING TITLE	Coppermine — Coppermine River
JOB TITLE	Small Scale Hydro Sites in N.W.T.

FERGUSON, NAYLOR, SIMEK, CLARK LTD. CONSULTING ENGINEERS & ARCHITECTS	JOB NO.	82-240	FIGURE 5
	SCALE	1:250 000	
P.O. BOX 1777 YELLOWKNIFE N.W.T. CANADA X1A 2P4	DATE	APRIL 1982	

COPPERMINE

The total peak power demand in Coppermine, considering all requirements, is about 3,370 kW while the peak electrical power demand is 665 kW. The small scale hydro site at Bloody Falls has a natural drop of about 3 m. If the total minimum flow were utilized, this could generate 1,200 kW. However, to generate the total peak energy demand for the community, including heating, a 6 metre weir or dam would have to be constructed to raise the head to 9 metres.

In this analysis both alternatives were considered. It was assumod that for the first alternative, the generation of 665 kW, only small diversion weir would have to be constructed.

In the second alternative the construction of more sophisticated weir would have to be undertaken.

From an environmental view, the impact of a diversion structure at Bloody Falls appears minimal since the falls block major fish migrations. However the outfall would have to discharge under the ice cover to prevent ice flooding and eventual choking of the river.

Special attention would have to be given to the presence of frazil ice which could be more of a problem if the rapids were not flooded.

SITE CHARACTERISTICS

Energy Requirements:	
Total Energy Consumption	11.816 kWh × 10^6
Average Demand	1350 kW
Peak Demand	3370 kW
Total Electrical Energy Produced	2.0 kWh × 10^6
Average Demand	228 kW
Peak Demand	665 kW
Installed Capacity	1575 kW
Plant Characteristics:	
Coppermine River Bloody Falls	
Minimum Flow	57.2 m^3/sec.
Head	3 m natural
Turbine	Tube
Incr. to 5 m or 10 m	
Potential Power	2000 kW or 3800 kW
Elevation Above Sea Level	1 m

Costs	**Alt. 1-700 KW**	**Alt. 2-3400 KW**
Road Construction 16 km @ $50,000	$ 800,000.00	$ 800,000.00
Dam	$ 500,000.00	$ 3,000,000.00
Power Plant	$ 665,000.00	$ 2,720,000.00
Transmission 16 km @ $25,000/km	$ 400,000.00	$ 400,000.00
Transformers	$ 100,000.00	$ 100,000.00
Transportation	$ 100,000.00	$ 100,000.00
Additional Distr. System within Coppermine		$ 1,100,000.00
	$ 2,565,000.00	$ 8,120,000.00
20% Contingency	$ 513,000.00	$ 1,624,000.00
20% Engineering	$ 513,000.00	$ 1,624,000.00
	$ 3,591,000.00	$11,368,000.00
Unit Cost	$5,130/KW	$3,343.00/KW

CORAL HARBOUR

The total peak energy requirement in Coral Harbour is about 1,500 kW. It appears possible to satisfy this entire requirement by hydrogeneration. However, a large storage lake would be necessary. Since the feasibility of the storage lake could not be fully verified at this time, a smaller scheme (500 kW) was analyzed as well. For either scheme, the most suitable site is some 10 km from the community.

The environmental impact of a dam would likely be negligible since there is no char migration above the falls. The storage reservoir created above the dam could be utilized by the community for its supply of potable water. The rapids above the dam would have to be flooded to prevent the formation of frazil ice.

SITE CHARACTERISTICS

Energy Requirement:

Total Energy Consumption	5.3×10^6 kWh
Average Demand	610 kW
Peak Demand (2.5 Average)	1525 kW
Total Electrical Energy Consumed	0.997×10^6mW
Average Demand	114 kW
Peak Demand	475 kW
Installed Capacity	1,250 kW

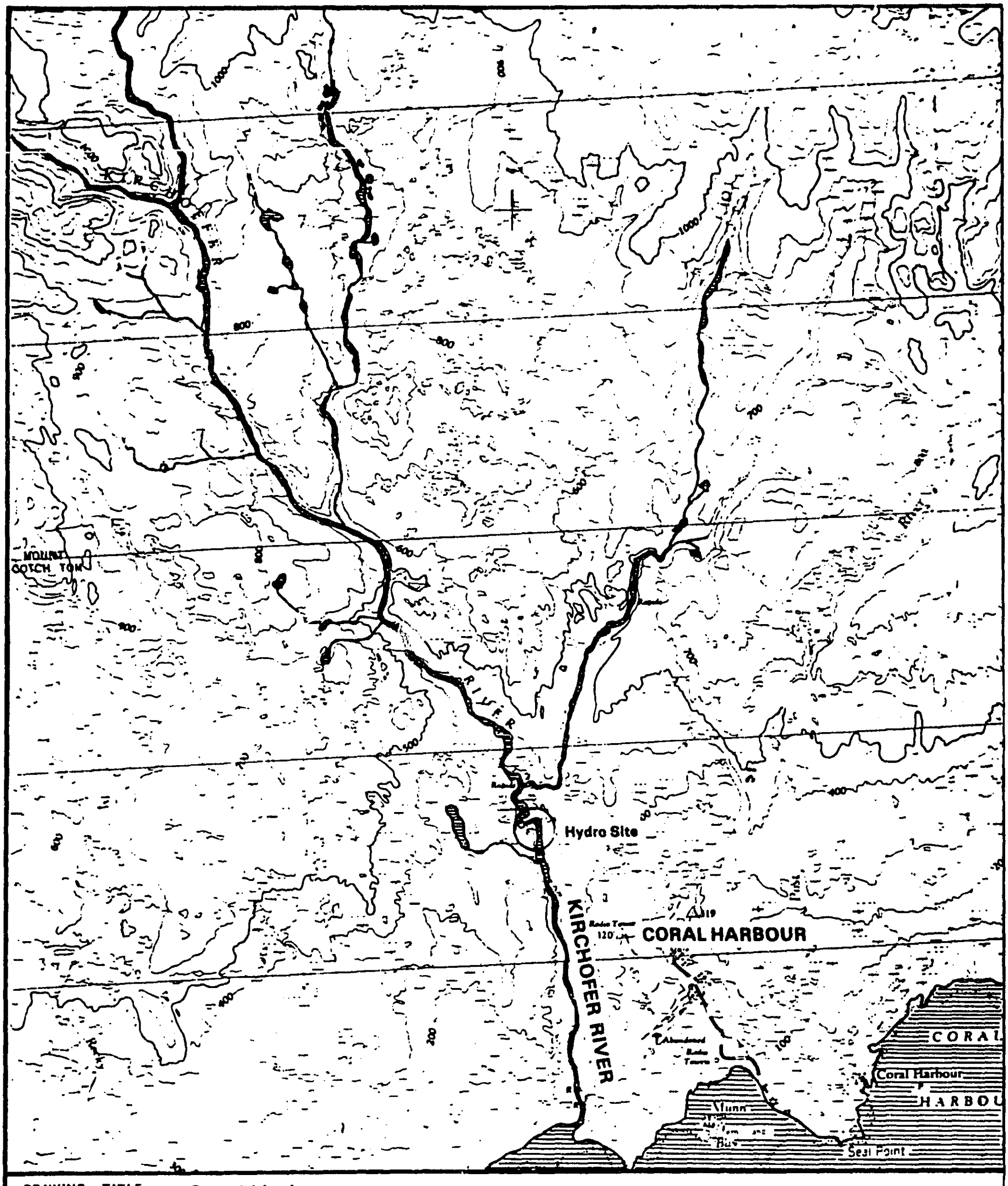
Plant Characteristics:

Kirchoffer River — Falls

Head	15 m
Minimum Flow	0.00
Average Flow	20.32 m^3/sec.
Potential Power	2.200 kW
Elevation above sea level	60 m

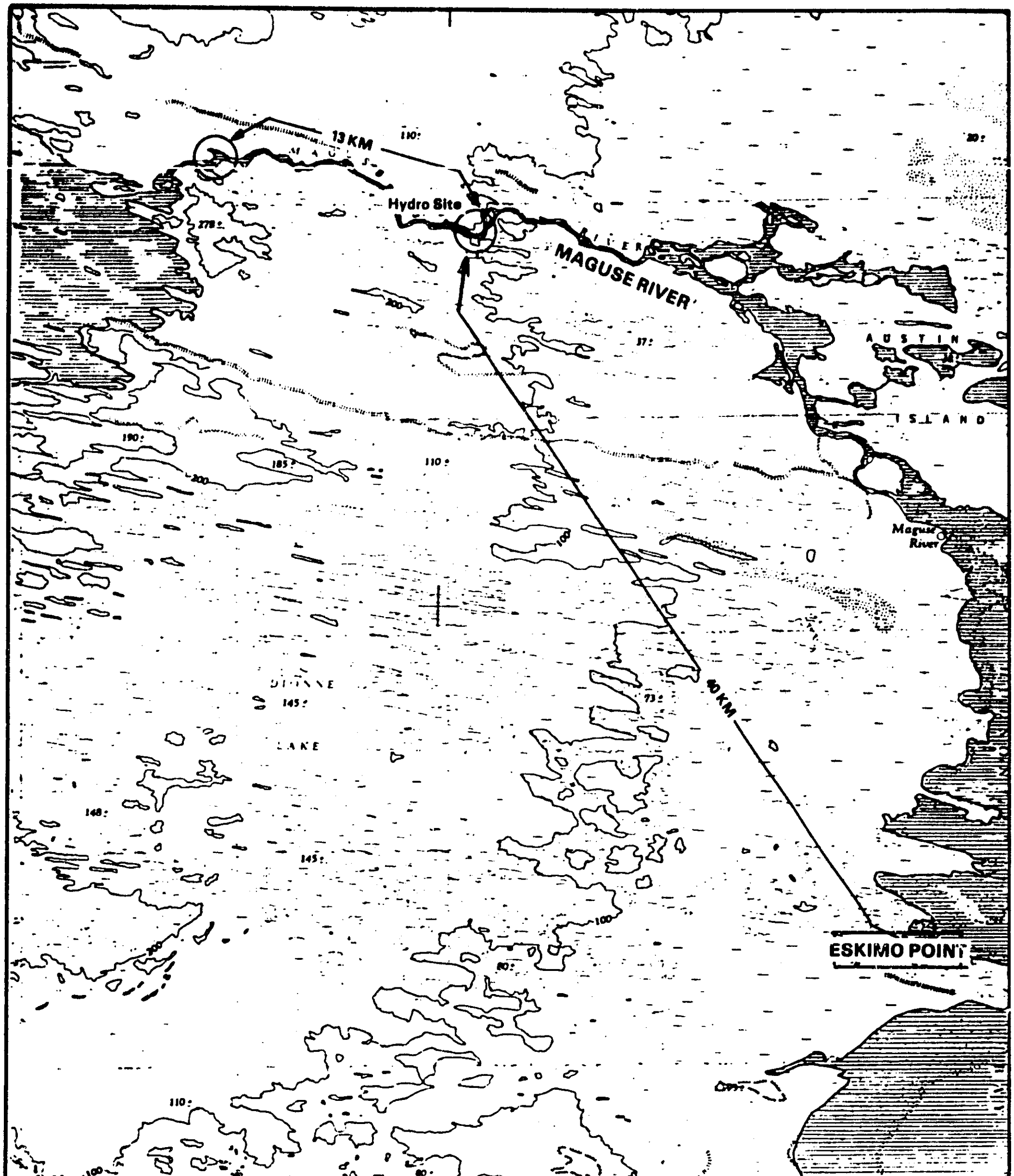
Two Alt. Possible 500 kW or 1500 kW

Costs	**Alt 1:500 KW**	**Alt 2:1,500 KW**
Road Construction, 10 km @ $60,000	$ 600,000.00	$ 600,000.00
Dam Structure	$ 750,000.00	$2,200,000.00
Spillway	$ 200,000.00	$ 200,000.00
Power Plant	$ 500,000.00	$1,000,000.00
Switchyard	$ 50,000.00	100,000.00
Transmission Line, 10 km @ $30,000	$ 300,000.00	$ 300,000.00
Transportation	$ 100,000.00	$ 100,000.00
Upgrading Existing Distr.	$ —	$ 500,000.00
	$2,500,000.00	$5,000,000.00
20% Contingencies	$ 500,000.00	$1,000,000.00
20% Engineering	$ 500,000.00	$1,000,000.00
	$3,500,000.00	$7,000,000.00
Unit Costs	$7,000.00/KW	$4,666.00/KW



DRAWING TITLE	Coral Harbour — KIRCHOFER RIVER
JOB TITLE	Small Scale Hydro Sites in N.W.T.

FERGUSON, NAYLOR, SIMEK, CLARK LTD. CONSULTING ENGINEERS & ARCHITECTS P.O. BOX 1777 YELLOWKNIFE N.W.T. CANADA X1A 2P4	JOB NO.	82-240	FIGURE 6
	SCALE	1:250 000	
	DATE	APRIL 1982	



DRAWING TITLE	Eskimo Point — Maguse River	
JOB TITLE	Small Scale Hydro Sites in N.W.T.	

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JOB NO.	82-240	FIGURE 7
SCALE	1:250 000	
DATE	APRIL 1982	

ESKIMO POINT

The Maguse River small scale hydro generating sites can produce about 2,400 kW. Since the sites are over 50 km from the community, their full capacity must be developed. This capacity exceeds the electrical power demand (640 kW) but does not fully satisfy the total power demand.

Because of the distance from the community and cost of transmission lines, the development of this site is only very marginal. It is therefore recommended that further study be delayed.

The environmental impact of a dam would likely be significant for the char population since it would interfere with their migration. As a result the construction of a dam would meet community opposition.

SITE CHARACTERISTICS

Energy Requirement:	
Total Energy Consumption	15,081 × 10^6kWh
Average Consumption	1.72 MW
Peak Consumption	4.3 MW
Total Electrical Energy Consumed	2.164 × 10^6kWh
Average Demand	247 kW
Peak Demand	650 kW
Installed Capacity	1,900 kW
Plant Characteristics:	
Maguse River	
Minimum Flow	52 m^3/sec.
Head	5.5 m
Turbine	Tube
Potential Power	2,400 kW
Elevation above sea level	25 m

Cost	**2,400 kW**
Road 53 km @ $50,000	$ 2,650,000.00
Transmission Line 53 @ $30,000	$ 1,590,000.00
Power Plant	$ 2,400,000.00
Dam and Spillway	$10,000,000.00
Switchyard	$ 100,000.00
Transportation	$ 100,000.00
	$16,840,000.00
20% Contingency	$ 3,368,000.00
20% Engineering	$ 3,368,000.00
	$23,576,000.00
Unit Cost	$9,823.00/KW

KAKISA

At present Kakisa does not have electricity. The estimated peak demand is about 190 kW. Since the natural head at the Lady Evelyn Falls is about 27 metres, partial diversion of flow through twin penstock could generate all power requirements.

This diversion could be achieved by constructing a small weir from gabion baskets. The twin penstock would be constructed from exposed pre-insulated polyethylene pipe.

Since only a portion of the flow would be diverted, environmental impact would be small.

SITE CHARACTERISTICS

Energy Requirement (Estimate):

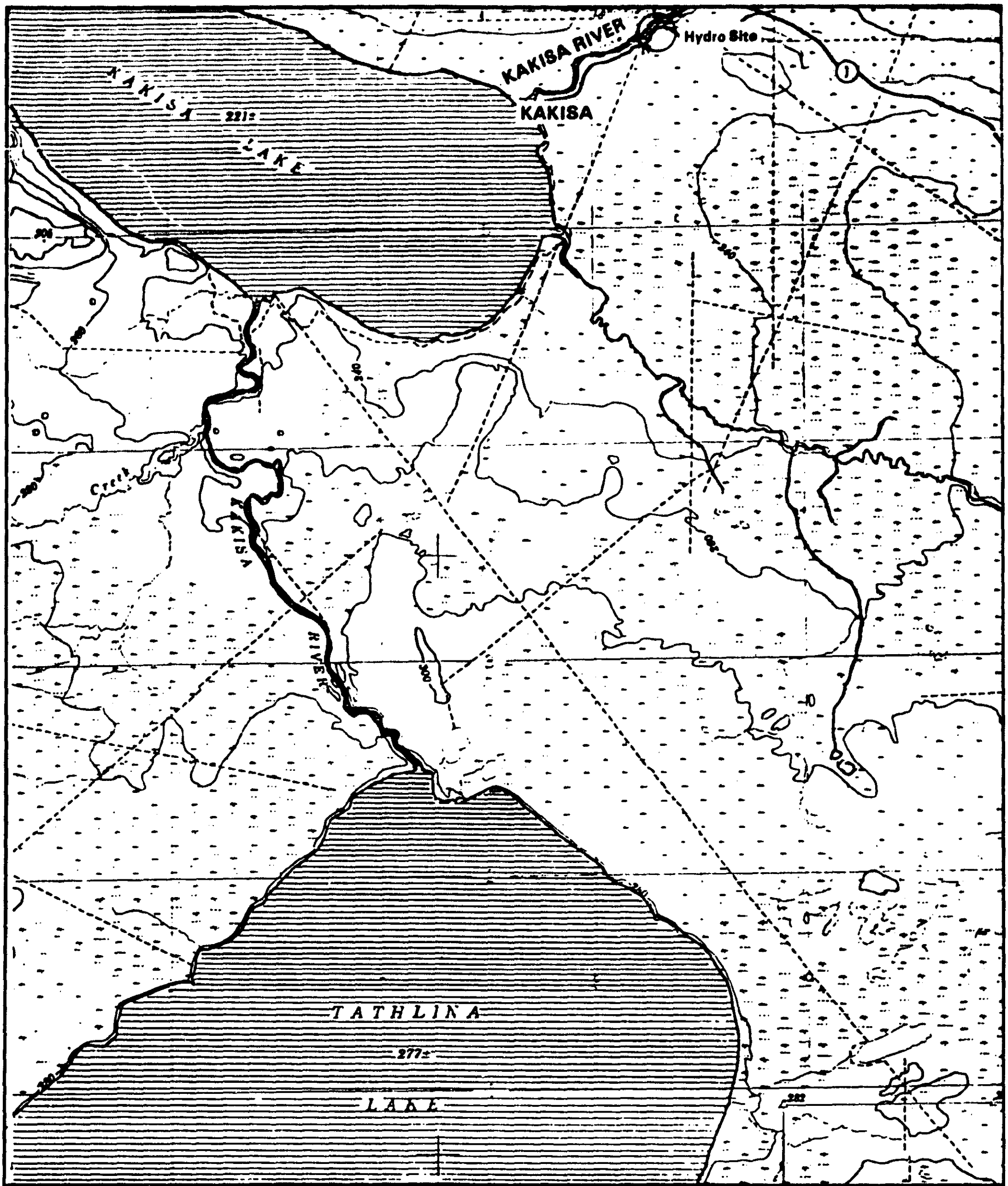
Total Power requirements (estimated)	0.662×10^6kWh
Average Demand	75 kW
Peak Demand	190 kW

Plant Characteristics:

Kakisa River

Head	27 m
Minimum Flow	2.2 m^3/sec.
Turbine	Pelton or Cross-Flow
Potential Energy	440 kW
Elevation at sea level	220 m

Costs	**190 kW**
Dam	$150,000.00
Penstock 700 m @ $120	$ 85,000.00
Power Plant	$160,000,00
Transmission Line	$ 60,000.00
Switchyard	$ 50,000.00
Transportation	$ 50,000.00
	$555,000.00
20% Contingency	$111,000.00
20% Engineering	$111,000.00
	$777,000.00
Unit Cost	$4,089.00/KW



DRAWING TITLE	Kakisa — Kakisa River
JOB TITLE	Small Scale Hydro Sites in N.W.T.

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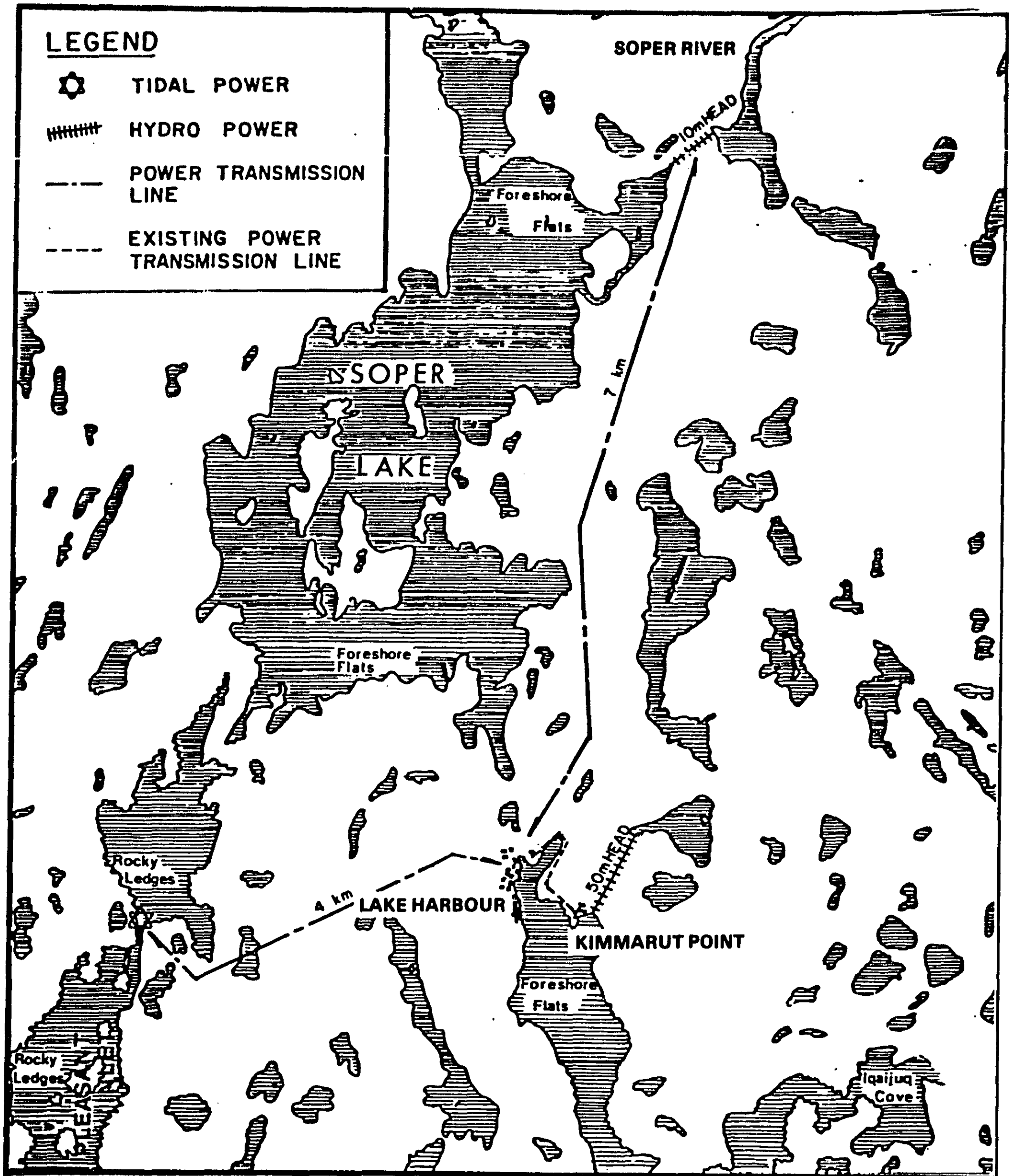
JOB NO.	82-240	FIGURE 8
SCALE	1:250 000	
DATE	APRIL 1982	



DRAWING TITLE	Lake Harbour — Soper River
JOB TITLE	Small Scale Hydro Sites in N.W.T.

FERGUSON, NAYLOR, SIMEK, CLARK LTD. CONSULTING ENGINEERS & ARCHITECTS P.O. BOX 1777 YELLOWKNIFE N.W.T. CANADA X1A 2P4	JOB NO.	82-240	FIGURE 9
	SCALE	1:50 000	
	DATE	APRIL 1982	

LAKE HARBOUR

The peak energy demand at Lake Harbour is about 1,130 kW. This energy could be provided by a hydro development on the Soper River, but a large storage dam would be required. Advantage could also be taken of the extremely high tides (20 feet) and the availability of a suitable inlet. The tides could then be used for the generation of most energy needs but conventional hydro from the Soper River would still be required to supply power at low and high tides.

It is likely that there would be some environmental damage from the installation of tidal and river generation facilities. This could be of major significance if the river is used by a char population. Effects on Soper Lake where there is presently a "herring" fishery for dog food will also have to be assessed.

SITE CHARACTERISTICS

Energy Requirement:	
Total Energy Consumption	3.962×10^6
Average Demand	452 kW
Peak Demand	1131 kW
Total Electrical Energy Consumed	0.701×10^6kWh
Average Demand	80 kW
Peak Demand	185 kW
Installed Capacity	625 kW

Plant Characteristics:

Soper River

Mean Flow	26.5 m^3/sec.
Head	10 m
Turbine	Tube
Power Potential	1950 kW
Elevation at sea level	10 m

Tides in Pleasant Inlets

Very Large Development Possible for the costing assume that 1200 KW will be developed.

Cost of Development	1,200 kW
Roads (7 km + 4 km) @ $90,000	$ 990,000.00
Transmission Line, 11 km @ $40,000	$ 440,000.00
Soper River Dam, Spillway & Penstock	$ 600,000.00
Pleasant Inlet Dam	$ 500,000.00
Power Plant — Soper River	$1,200,000.00
Switchyard	$ 100,000.00
Additional Power Distr.	$ 500,000.00
Transportation	$ 100,000.00
	$5,630,000.00
20% Contingency	$1,126,000.00
20% Engineering	$1,126,000.00
	$7,872,000.00
Unit Cost	$6,560.00/KW

PELLY BAY

Since the Kugajuk River could not provide for all energy requirements (1,100 kW), only electrical power was considered. The Kugajug River has numerous rapids at its mouth but a dam would have to be constructed to allow for water storage. Such an impoundment could also be used as a water supply for the community.

A dam on this river would cause major disruption in the char runs, a major resource for the community. An environmental impact study must be carried out before any other work proceeds.

SITE CHARACTERISTICS

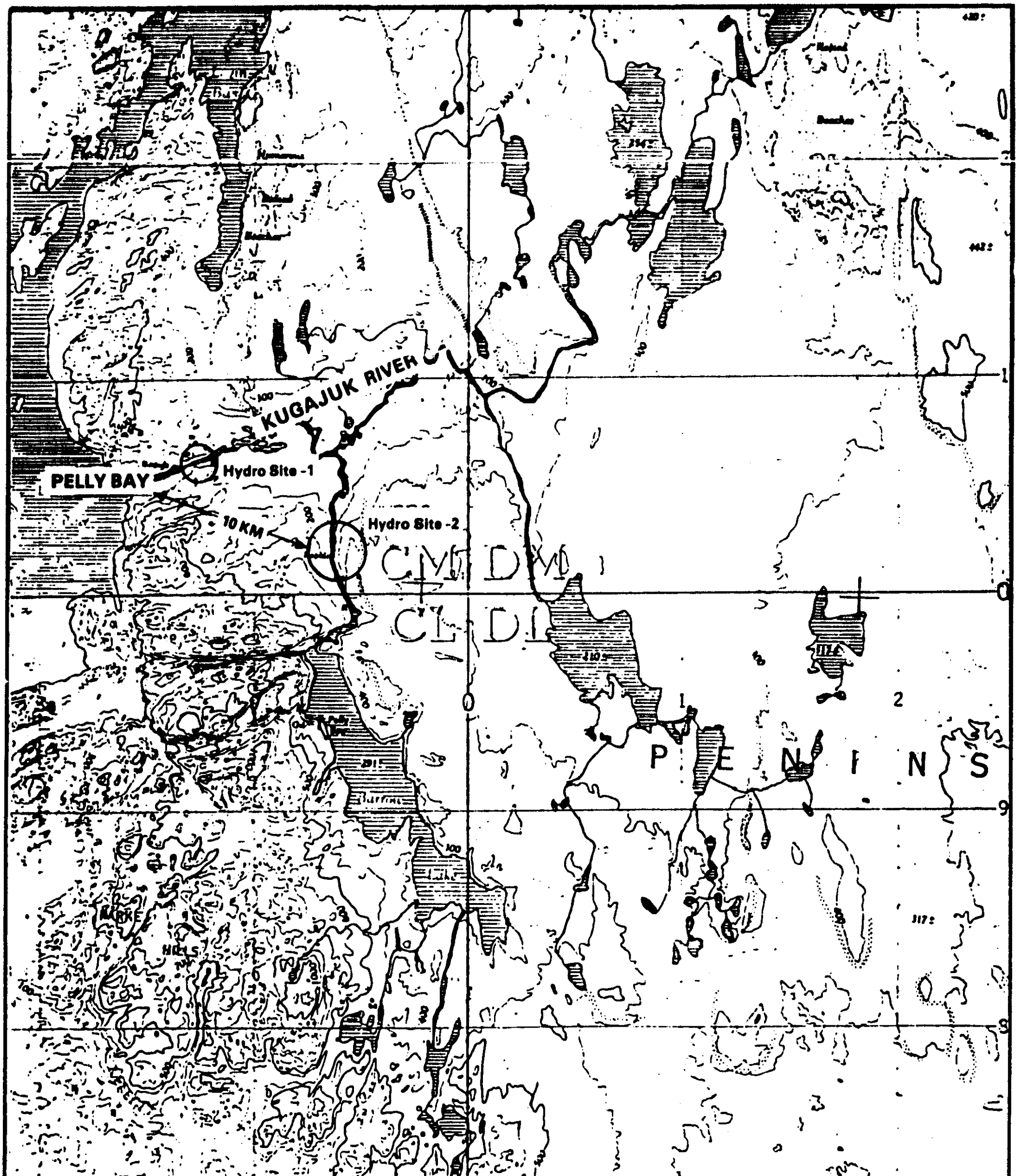
Energy Requirement:	
Total Energy Consumption	3.866 × 10^6kWh
Average Demand	440 kW
Peak Demand	1100 kW
Total Electrical Energy Consumed	0.596 × 10^6kWh
Average Demand	68 kW
Peak Demand	160 kW
Installed Capacity	565 kW

Plant Characteristics:

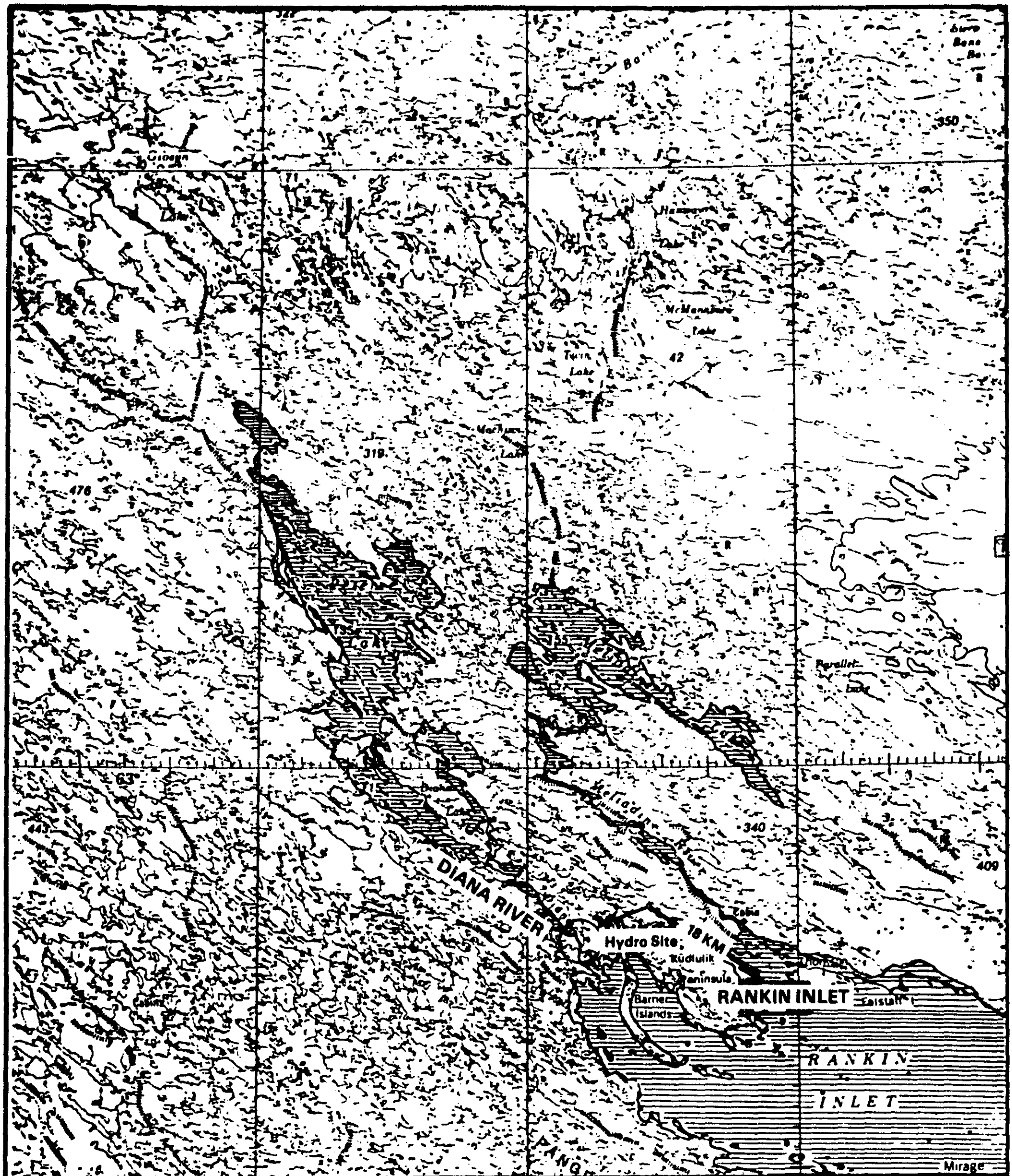
Kugajuk River

Average Flow	4.22 m^3/sec.
Head	6 m
Turbine	Tube
Power Potential	251 kW
Elevation at sea level	5 m

Costs	**160 kW**
Roads 4 km @$50,000	$ 200,000.00
Dam and Spillway	$ 900,000.00
Power Plant	$ 200,000.00
Transmission 4 km @ $40,000	$ 160,000.00
Switchyard	$ 50,000.00
Transportation	$ 400,000.00
	$1,910,000.00
20% Contingency	$ 382,000.00
20% Engineering	$ 382,000.00
	$2,674,000.00
Unit Cost	$16,712.00/KW



DRAWING TITLE	Pelly Bay — Kugajuk River		
JOB TITLE	Small Scale Hydro Sites in N.W.T.		
FERGUSON, NAYLOR, SIMEK, CLARK LTD. CONSULTING ENGINEERS & ARCHITECTS	JOB NO.	82-240	FIGURE 10
	SCALE	1:250 000	
P.O. BOX 1777 YELLOWKNIFE N.W.T. CANADA X1A 2P4	DATE	APRIL 1982	



DRAWING TITLE Rankin Inlet — Diana River

JOB TITLE Small Scale Hydro Sites in N.W.T.

FERGUSON, NAYLOR, SIMEK, CLARK LTD.
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P.O. BOX 1777 YELLOWKNIFE
N.W.T. CANADA X1A 2P4

JOB NO. 82-240

SCALE 1:500 000

DATE APRIL 1982

FIGURE 11

RANKIN INLET

Topographical information about Diana and Meliadine River is sketchy. It is known that the Diana River has significand drops in its vertical profile near its mouth, but a quantitative evaluation was not possible. Therefore, the cost estimates and the power potential were crude guesses only.

This river is well known for its abundant char, and is used for commercial fishing. It is unlikely that any development could proceed with present technology.

SITE CHARACTERISTICS

Energy Requirement:

Total Energy Consumption	24,887
Average Demand	1.77×10^6 kW
Peak Demand	1.770 kW
Total Electrical Energy Consumed	2.7×10^6 kWh
Average Demand	310 kW
Peak Demand	780 kW
Installed Capacity	

Plant Characteristics:

Diana River + Diversion From Meliadine River

Minimum Flow	8.31 m³/sec.
Head	10 m
Turbine	Tube
Power Potential	610 kW
Elevation at sea level	610 m

Cost of Development	**600 kW**
Roads 18 km @ $50,000	$ 900,000.00
Transmission Line, 18 km @ $30,000	$ 540,000.00
Dam, Spillway	$4,000,000.00
Power Plant	$ 600,000.00
Switchyard	$ 100,000.00
Transportation	$ 100,000.00
	$6,960,000.00
20% Contingency	$1,393,000.00
20% Engineering	$1,393,000.00
	$9,724,000.00
Unit Cost	$16,206.00/KW

SNOWDRIFT

There are two sites suitable for development on the Snowdrift River. The first, located some 15 km upstream, would utilize a 5 metre falls. A weir would be constructed to increase the total head to 10 metres, thus producing 400 kW at minimum recorded flow.

The second site is located at the outflow from Stark Lake. Usually, a natural head of 4 metres exists but when the water level in Great Slave Lake is at maximum, this head can be reduced to aobut 3 metres. Therefore, a 3 metre weir would have to be constructed.

There should not be any significant environmental impact from the construction of a weir at the first site. The second appears far more sensitive. As a result it is suggested that the first site be utilized. However it should be recognized that this site will be prone to frazil ice formation because of numerous rapids above the falls.

SITE CHARACTERISTICS

Energy Requirements:

Total Energy Consumption	2.173 × 10^6kWh
Average Demand	250 kW
Peak Demand	615 kW
Total Electrical Energy Consumption	0.421 × 10^6kWh
Average Demand	48 kW
Peak Demand	117 kW
Installed Capacity	330 kW

Plant Characteristics:

Site No. 1 — Snowdrift River Fall

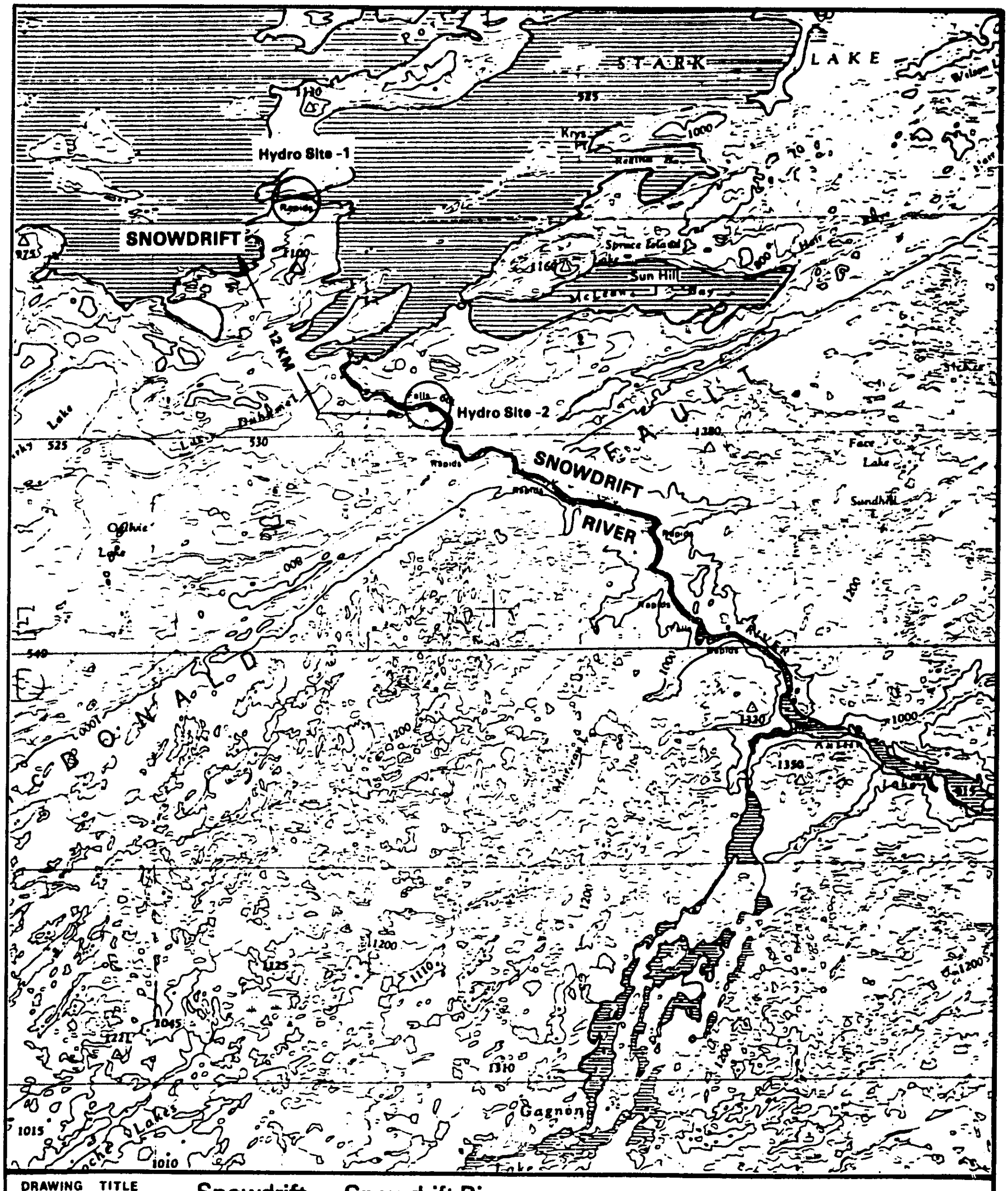
Natural Head	5 m
Increased to	10 m
Minimum Flow	6.0 m^3/sec.
Turbine	Tube
Potential Power	400 W
Elevation at sea level	200 m

Site No. 2 — Snowdrift River, Stark Lake

Natural Head ± 4 m but it varies, 2 m dam required.

Minimum Flow	8.0 m^3/sec.
Turbine	Tube
Potential Power	400 kW
Elevation at Sea Level	200 m

Costs	Site No. 1	Site No. 2
Road Construction 15 km @ $50,000	$ 750,000.00	$ —
Dam Structure	$ 300,000.00	$ 300,000.00
Spillway	$ 100,000.00	$ 100,000.00
Power Plant	$ 320,000.00	$ 500,000.00
Transmission Line @ $10,000	$ 150,000.00	$ 30,000.00
Switchyard	$ 75,000.00	$ 75,000.00
Transportation	$ 100,000.00	$ 100,000.00
Additional Distr. System within Snowdrift	500,000.00	$ 500,000.00
	$ 2,295,000.00	$ 1,605,000.00
20% Contingency	$ 459,000.00	$ 321,000.00
20% Engineering	$ 459,000.00	$ 459,000.00
	$ 3,213,000.00	$ 2,247,000.00
Unit Cost	$8,040/KW	$5,617.00/KW



DRAWING TITLE	Snowdrift — Snowdrift River	
JOB TITLE	Small Scale Hydro Sites in N.W.T.	
FERGUSON, NAYLOR, SIMEK, CLARK LTD. CONSULTING ENGINEERS & ARCHITECTS P.O. BOX 1777 YELLOWKNIFE N.W.T. CANADA X1A 2P4	JOB NO. 82-240 SCALE 1:250 000 DATE APRIL 1982	FIGURE 12

Summary and Conclusions

Table 6 summarizes our estimates of development costs for each site and compares them with the present value of the fuel they would displace if the interest rate were 10%. Since the apparent viability of each project can be affected by the interest rate used in the present value calculation, figures 13 to 16 present for the most promising sites the construction costs and the present value under a variety of interest rates.

Development costs in Kakisa exceed our estimates of the present value of displaced fuel but only marginally. Therefore a detailed feasibility study for this site should be initiated.

Our estimates show that the site at Coral Harbour is attractive. However, our estimates here have a high degree of uncertainty. The writer did not have an opportunity to work in the community and the available mapping is large scale. A simple reconnaissance study should be carried out to determine the feasibility of a reservoir.

Sites in:
- Baker Lake
- Coppermine
- Snowdrift

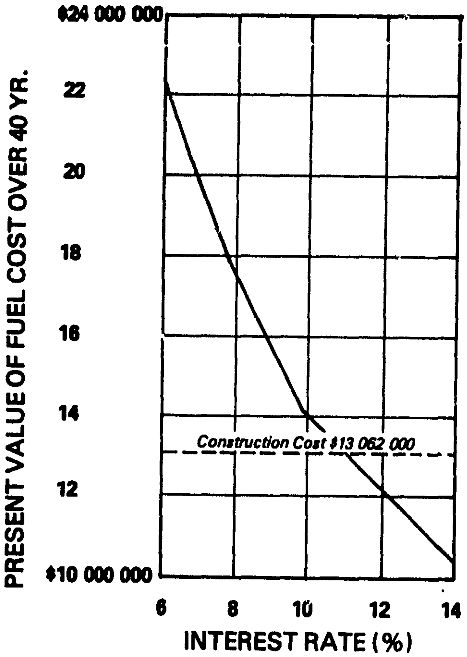
are promising under most economic circumstances. More detailed on-site studies should be carried out.

Table 6

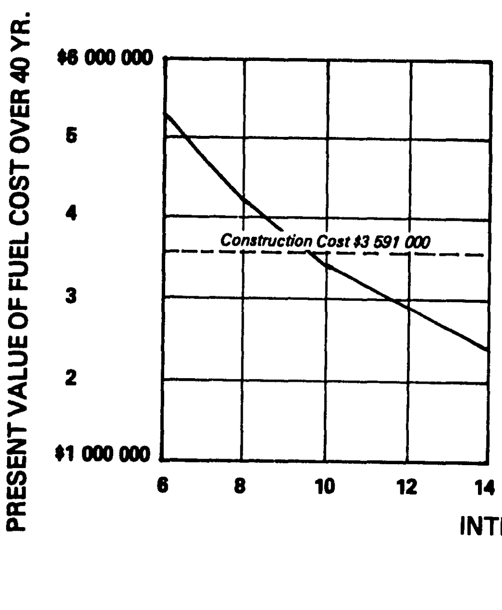
DEVELOPMENT COSTS AND THE PRESENT VALUE OF FUEL SAVED FOR THE MORE PROMISING IDENTIFIED SITE

Site	Estimated Development Cost ($\$ \times 10^6$)	Unit Cost of Installation ($\$/kW \times 10^3$)	Possibility of Replacing Fuel Used For Heating	Present Value of Displaced Fuel (i = 10% p = 40 yr.) $\$ \times 10^6$
Baker Lake	13.1	3.5	yes	14.4
Coppermine				
Site #1	3.6	5.1	no	3.5
Site #2	11.4	3.3	yes	10.3
Coral Harbour				
Site #1	3.5	7.0	no	3.5
Site #2	7.0	4.7	yes	6.5
Eskimo Point	23.6	9.8	no	4.7
Kakisa	0.8	4.0	no	0.48
Lake Harbour	7.9	6.6	yes	3.9
Pelly Bay	2.7	16.7	no	1.8
Rankin Inlet	9.7	16.2	no	8.6
Snowdrift				
Site #1	3.2	8.0	yes (?)	2.1
Site #2	2.2	5.6	yes (?)	2.1

BAKER LAKE



COPPERMINE



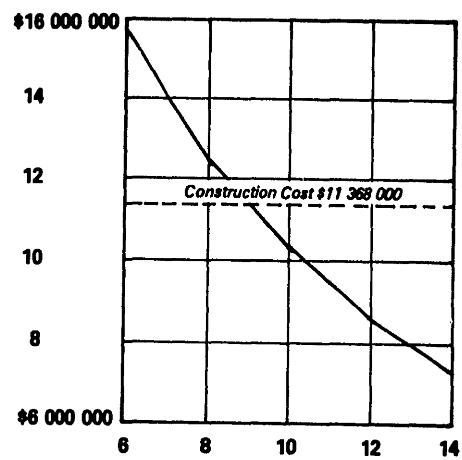
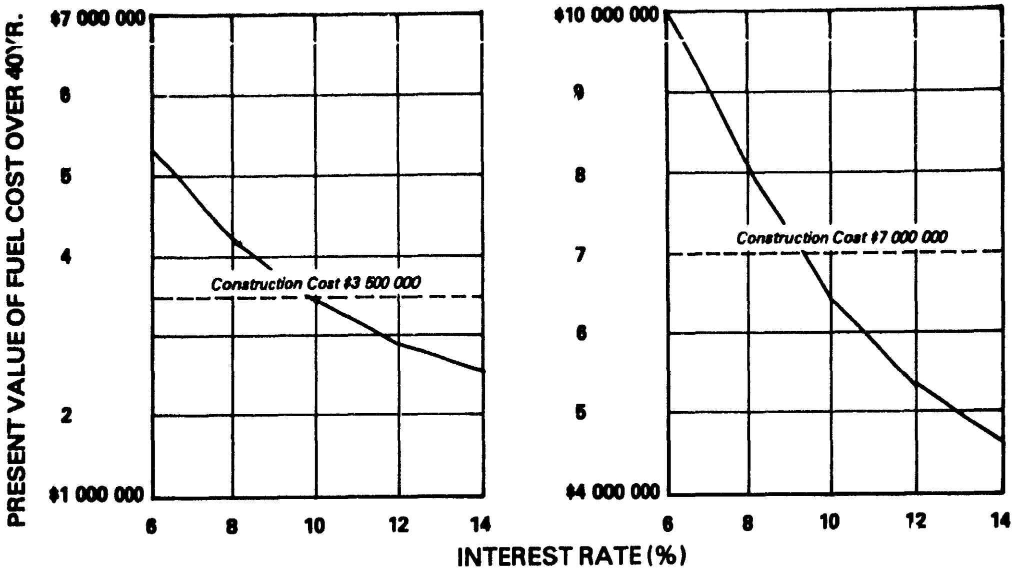


FIGURE 13

CORAL HARBOUR



KAKISA

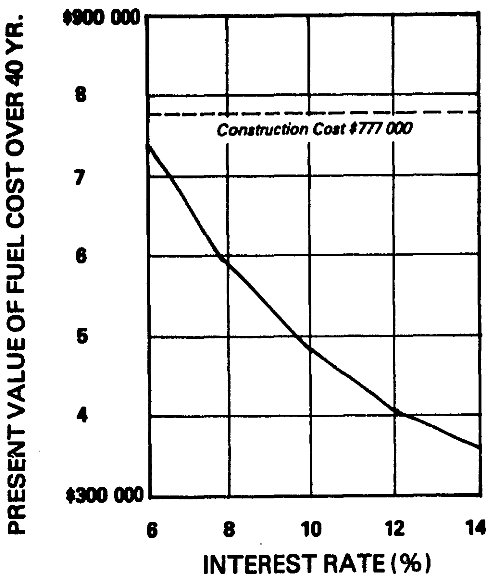
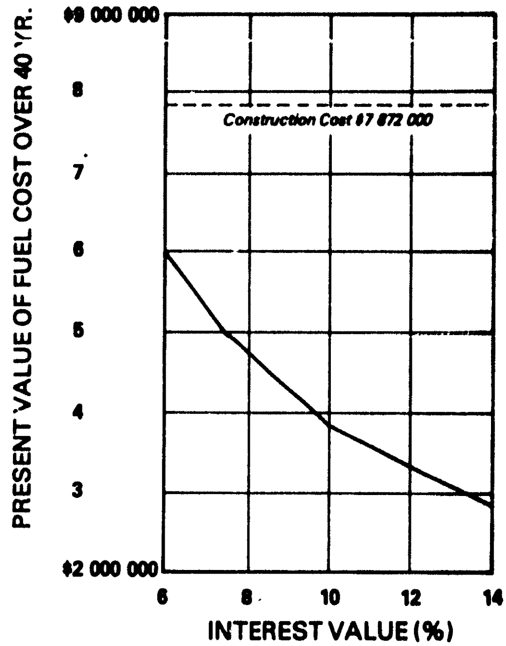


FIGURE 14

LAKE HARBOUR



SNOWDRIFT

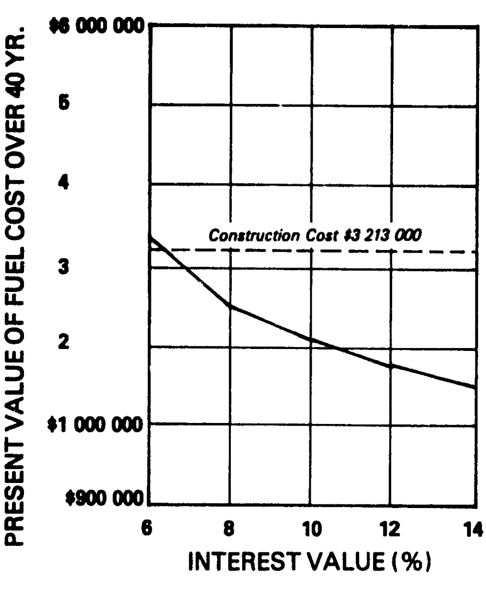
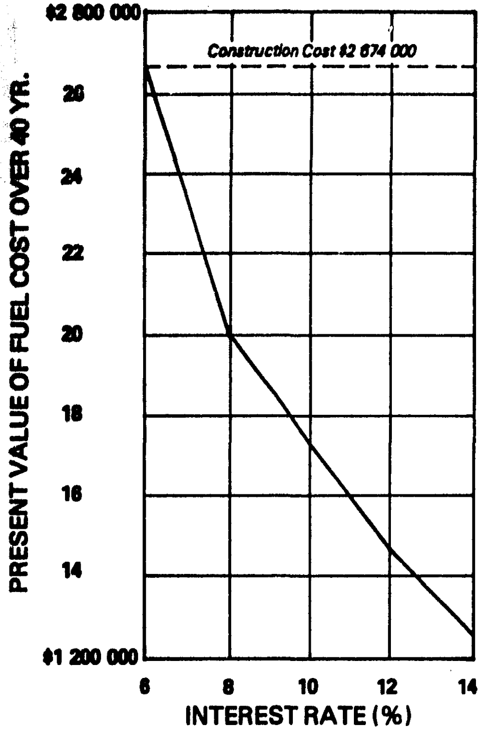


FIGURE 15

PELLY BAY



RANKIN INLET

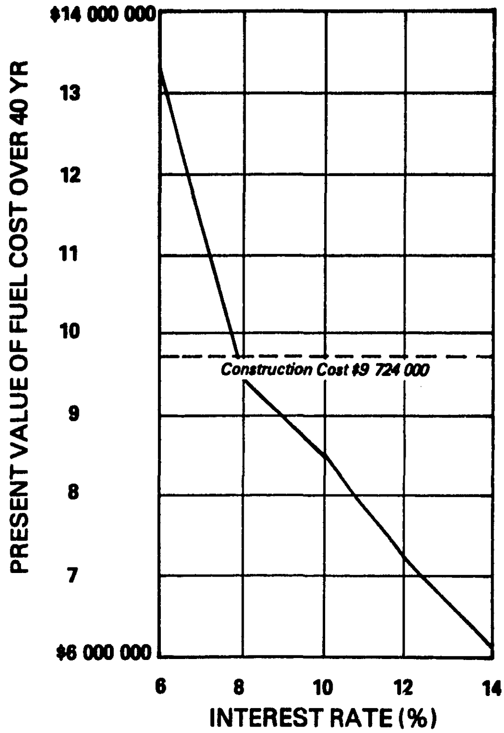
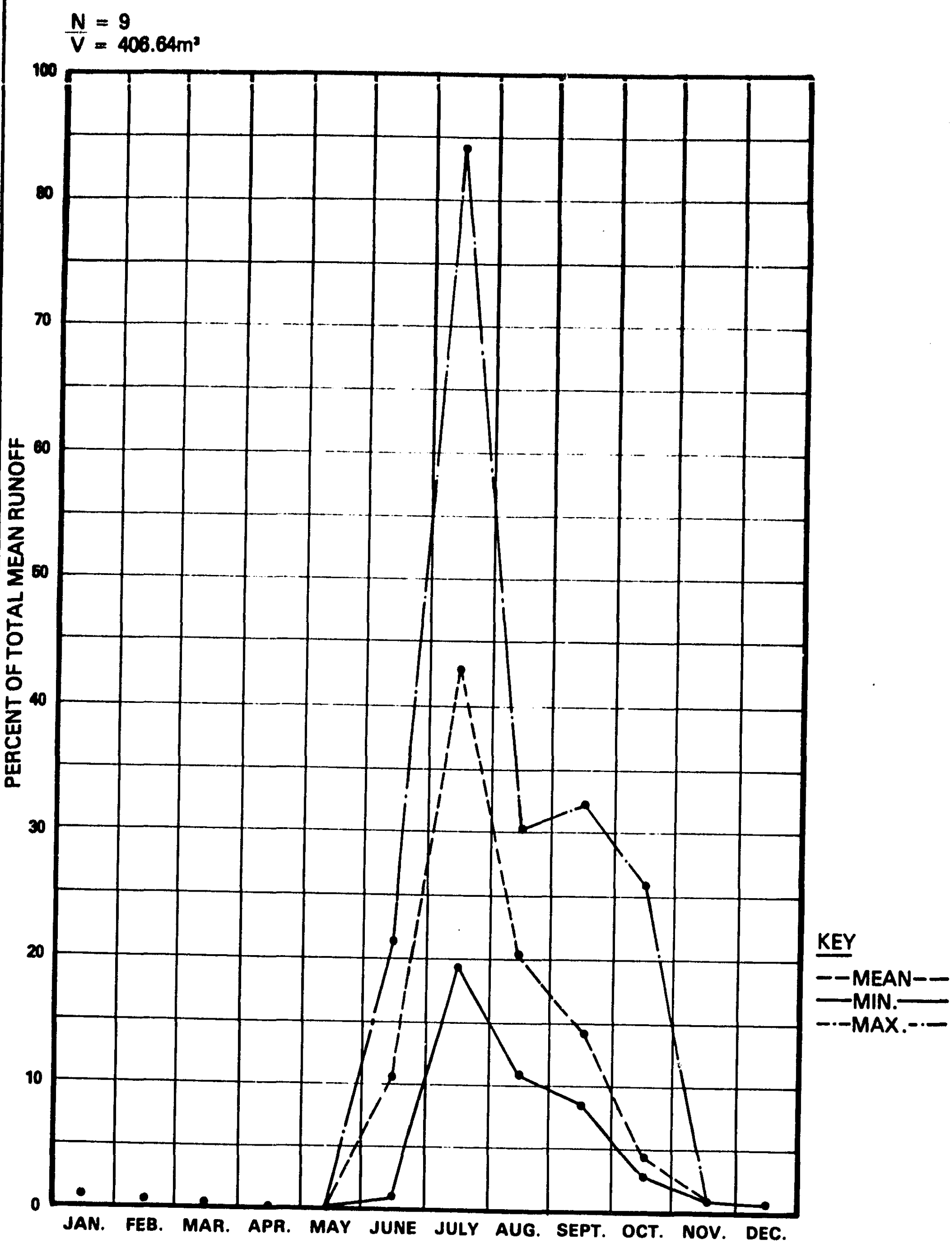
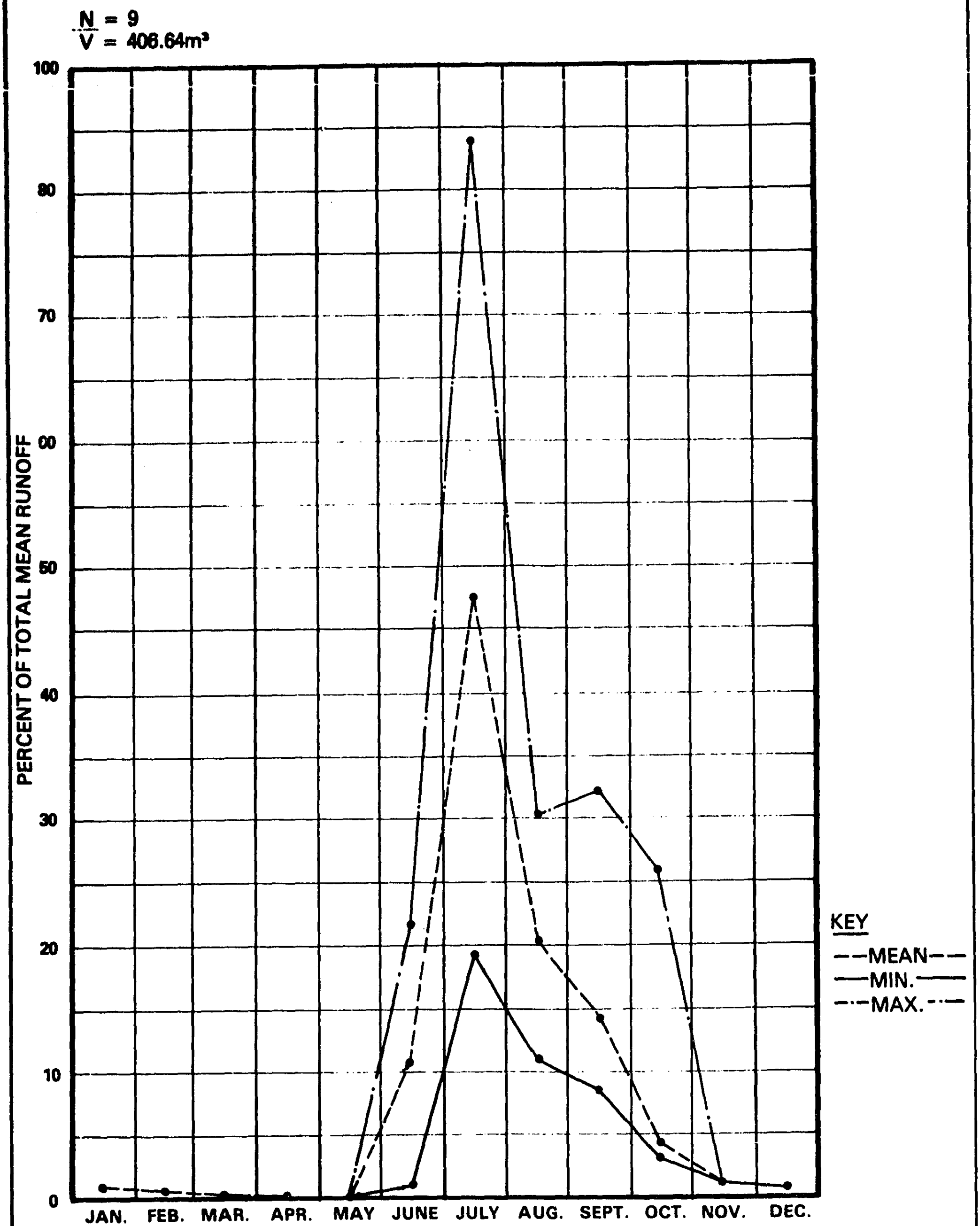


FIGURE 16



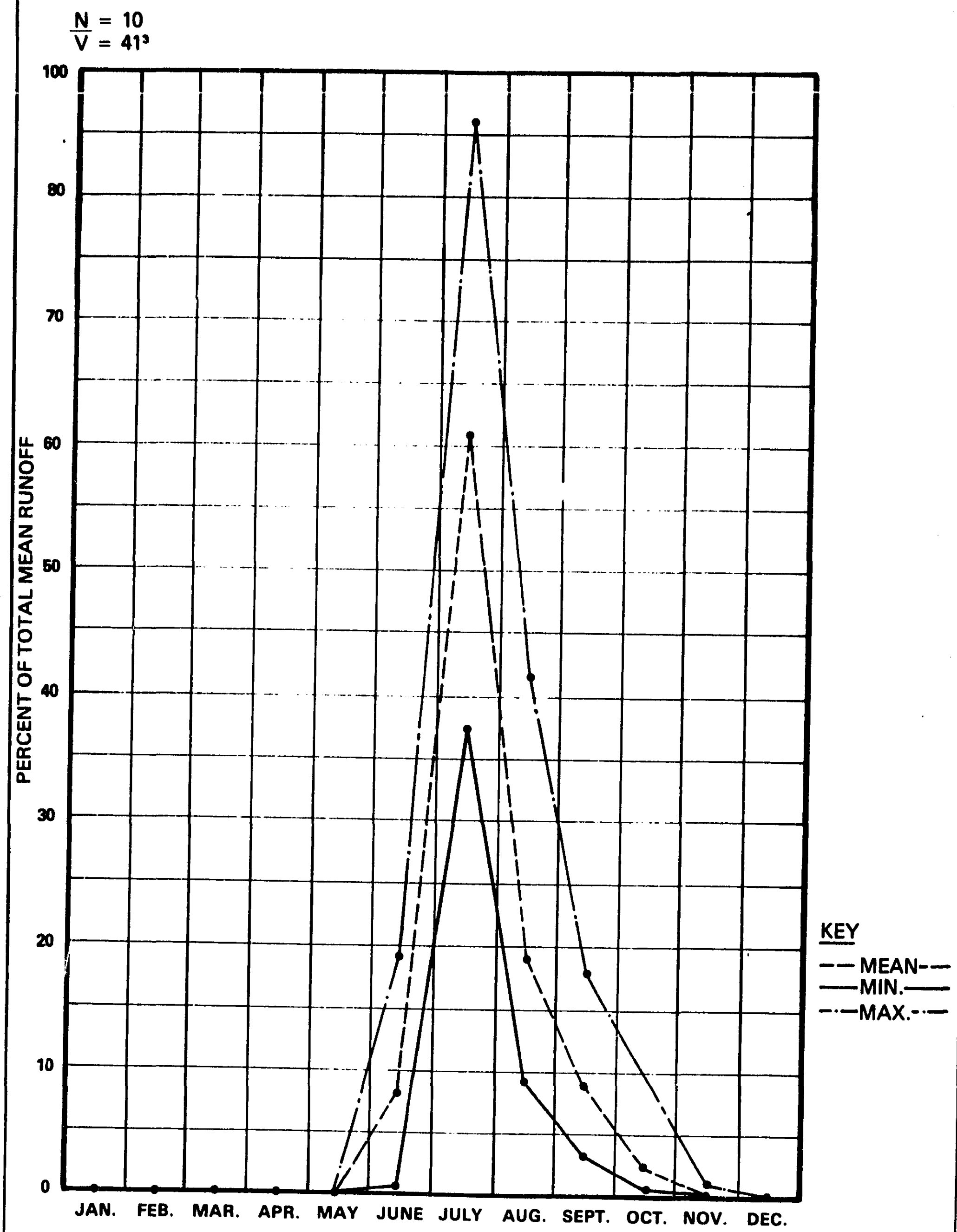
Study Area: **CORAL HARBOUR**
Gauging Station: Sylvia Grinnell River
Station No:IOTEOOI

FIGURE 17



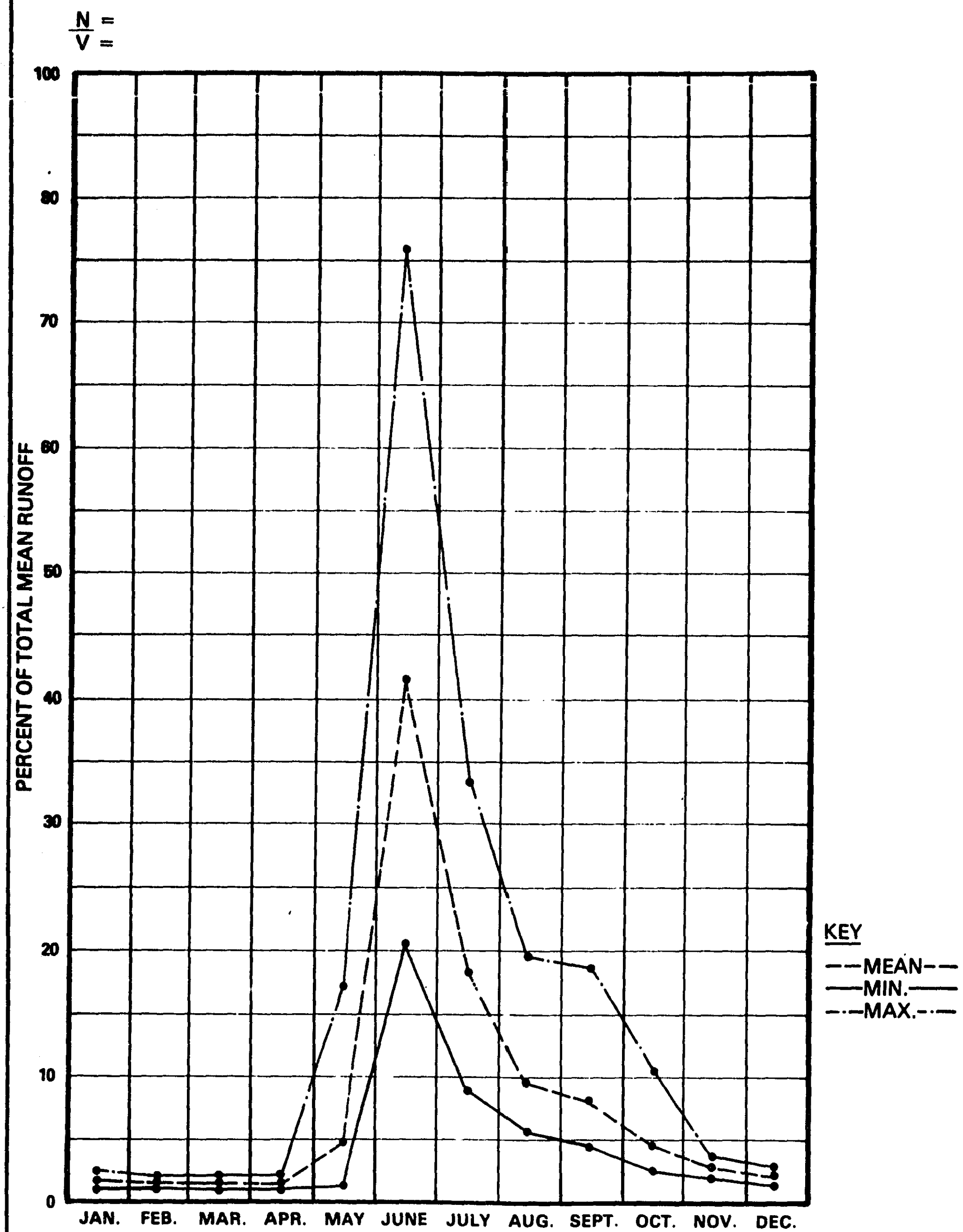
Study Area: **LAKE HARBOUR**
Gauging Station: Sylvia Grinnell River
Station No: IOTEOOI

FIGURE 18



Study Area: **PELLY BAY**
Gauging Station: Freshwater Creek
Station No:IOTAOOI

FIGURE 19



Study Area: **RANKIN INLET**
Gauging Station: Thelon & Kingyouk

FIGURE 20

Appendix I

HYDROLOGY

METHODOLOGY

Of the eleven chosen sites, four did not have sufficient river discharge data; Coral Harbour, Lake Harbour, Pelly Bay and Rankin Inlet. It was therefore necessary to carry out a theoretical analysis.

Our approach was broken down into three phases:

(i) Data Collection and Review:
(ii) Review of Available Data on the Regional Hydrologic Regime and,
(iii) Hydro-Meterological and Water Balance.

Data Collection and Review

As a first step, previous power studies conducted in the NWT were collected for review. However, these studies were concentrated in the central portion of the N.W.T. and hence were not directly applicable to the four communities to be analyzed in this section.

The Regional Hydrologic Regime

Water Survey of Canada streamflow records for the NWT and Yukon were analyzed to obtain regional flow records for basins nearest to the communities. Eight rivers were selected. Analysis of these records was undertaken to assess annual yields and monthly distributions. Maximum, minimum and average values were determined.

The Hydro-Meteorologic Regime and Water Balance

Since there were no streamflow records available for the sites of interest it was necessary to collect meteorological information to relate regional runoff distributions to annual yield. This was done using an annual water balance estimate for each community.

THE HYDROLOGICAL ANALYSIS

A summary of the results of our hydrological analysis is shown on Table 8. It was found that the Apex, Duval, Prince and Akkutuak Rivers had inadequate records for our purpose. Therefore data from the remaining stations were used. (Monthly distributions for all the stations are listed in Appendix I). Maximum and minimum values for each month were also plotted. It should be noted that these extreme values should not be used in sequence as they only represent the maximum and minimum values recorded in that month over the period of record.

Comparisons of the average annual yields of these basins were made with the results from an analysis of hydrometeorological information from Map No. 25 of the Hydrological Atlas of Canada, 1978. The annual runoff calculated from streamflow records and the computed water balance from Map No. 25 are shown below in Table 7.

The results show that in our examples the estimated annual yield from a water balance approach is within 12% of the observed value. We also found an over prediction for three out of four basins. We therefore suggest a ten (10) percent reduction in the results presented as a conservative approach.

In summary, for each basin the regional monthly flow distributions were selected for the study communities. Then the annual yields were computed using the water balance map.

Table 7
COMPARISON OF OBSERVED AND CALCULATED STREAMFLOW DATA FOR SELECTED RIVERS

	Observed Annual Runoff (dam^3)	Estimated Water Balance (dam^3)	Percentage Difference
1. Freshwater	119,000	134,100	+ 12%
2. Sylvia Grinnell	940,000	893,050	- 5%
3. Thelon	24,800,000	27,720,000	+ 12%
4. Kingyouk	78,200	82,270	+ 5%

Table 8

MEAN, MAXIMUM AND MINIMUM ANNUAL RUNOFF VOLUMES

Gauging Station	Mean of to Total Discharge (dam³)	Min. Discharge (dam³)	% Min. Discharge to Mean	Max. Discharge (dam³)	% Max. Discharge to Mean	Basin
1. Freshwater	119,000	81,600	68.57	165,000	138.66	Pelly Bay
2. Apex	—	—	—	—	—	
3. Sylvia Grinnell	940,000	738,000	78.51	1,250,000	142.98	Lake Harbour
4. Duval	—	—	—	—	—	
5. Thelon	24,800,000	22,100,000	89.11	25,300,000	106.25	
6. Akkutuak	—	—	—	—	—	Rankin Inlet
7. Prince	298,000	—	—	—	—	
8. Kingyouk	78,200	44,700	57.16	125,000	159.85	
	18,439,100	Average 73.14		Average 132.95		

CORAL HABOUR

Since there are no streamflow records near this community, regional distributions for Rankin Inlet and Lake Harbour were compared for their applicability to this site. The Lake Harbour results were selected since there is a fair amount of storage as a result of the lakes in the Rankin area.

This does not occur in the Lake Harbour region. However, it should be noted that there is little difference between the two distributions. The estimated average monthly runoff for the Kirchoffer River is shown in the accompanying Table.

Min Discharge is 79% of mean-total discharge.
Max Discharge is 133% of mean-total discharge.
Spread is 54%

Average Annual Yield — 632000 dam³.
Average Yield — 20.32 m³/s.

Use Sylvia Grinnell.

	% Mean	Kirchofer R. Flow
J	0.31	0.06
F	0.19	0.04
M	0.06	0.01
A	0	0
M	0.01	0.01
J	11.14	2.26
J	47.46	9.65
A	30.84	4.12
S	14.53	2.95
O	4.30	0.87
N	1.30	0.26
D	0.45	0.09
	100%	20.32m³/s

LAKE HARBOUR

The flow distribution used for this community was that of the Sylvia Grinnell River which empties into Frobisher Bay. We feel that the runoff characteristic should be comparable. The estimated monthly runoffs for the Soper and Unnamed Rivers are shown on the following table.

Min Discharge is 79% of mean-total discharge.
Max Discharge is 133% of mean-total discharge.
Spread is 54%

	Soper R.	Unnamed
Average Annual Yield —	825000 dam³	102300 dam³
Average Yield —	26.52 m³/s	3.29 m³/s

	% Mean	Soper R. Flow	Unnamed Flow
J	0.31	0.08	0.01
F	0.19	0.05	0.01
M	0.06	0.02	0.002
A	0	0	0
M	0.01	0.01	0.003
J	11.14	8.95	0.37
J	47.46	12.59	1.56
A	50.24	5.37	0.67
S	14.53	3.85	0.47
O	4.30	1.14	0.14
N	1.30	0.34	0.04
D	0.46	0.12	0.02
	100%	26.52m³/s	3.29m³/s

PELLY BAY

The closest known regional flow distribution is that of the Freshwater River near Cambridge Bay. Runoff and hydro-meteorologic characteristics should be comparable. The estimated monthly runoff results for the Kugajuk and Unnamed Rivers are shown on the following table.

Min Discharge is 69% of mean-total discharge.
Max Discharge is 139% of mean-total discharge.
Spread is 70%

	Kugajuk	Unnamed
Average Annual Yield —	131400 dam³	22060 dam³
Average Yield —	4.22 m³/s	0.71 m³/s

	% Mean	Kugajuk Flow	Unnamed Flow
J	0	0	0
F	0	0	0
M	0	0	0
A	0	0	0
M	0	0	0
J	8.51	0.36	0.06
J	60.79	2.56	0.43
A	19.38	0.82	0.14
S	8.99	0.38	0.06
O	2.09	0.09	0.02
N	0.09	0.004	0
D	0	0	0
	100%	4.22m³/s	0.71m³/s

RANKIN INLET

The closest rivers for which substantial data are available are the Thelon and the Kingyouk. Our results showed that the Thelon River had a more attenuated annual runoff distribution probably as a result of its size and the large amount of storage in the system. Even though the drainage systems in the Rankin region also appear to have large amounts of storage, it was considered that a more conservative approach would be to average the Thelon and Kingyouk Rivers data. The resulting estimated monthly runoff flows for the Diana and Melladine Rivers are shown on the following table.

Min Discharge is 73% of mean of total discharge.
Max Discharge is 133% of mean of total discharge.
Spread is 60%

	Diana	Melladine
Average Annual Yield —	258400 dam³	152000 dam³
Average Yield —	8.31 m³/s	4.89m³/s

Use Thelon and Kingyouk.

	%Mean	Diana Flow	Melladine Flow
J	1.70	1.40	0.08
F	1.40	0.12	0.07
M	1.32	0.11	0.06
A	1.44	0.12	0.07
M	5.12	0.42	0.25
J	41.92	3.48	2.05
J	18.79	1.56	0.92
A	9.98	0.83	0.49
S	8.18	0.68	0.40
O	5.02	0.42	0.25
N	5.95	0.25	0.14
D	2.18	0.18	0.11
	100%	8.31 m³/s	4.89 m³/s

HYDROLOGIC RECOMMENDATIONS

The results suggest that it is possible at a preliminary planning level to obtain approximations of annual yields (water balance) using the Water Balance Map No. 25 from the Hydrologic Atlas of Canada. Our results were within 12% of observed streamflow values for all the communities in this study, and those communities varied in location from the eastern arctic to the central and north central arctic.

Monthly distributions were obtained from existing streamflow records. Special attention was paid to their variations both in their observed minimal annual values and their minimum monthly values.

Once it is determined that these sites are viable for hydro-electric generation, additional work should be undertaken. The work recommended would include:

(i) annual and monthly drought analysis on the regional streamflow data;
(ii) refinement of the annual water balance information;
(iii) establishment of an hydro-meteorological monitoring program and
(iv) stochastic modelling and continuous simulation for selected basins.

Although existing streamflow records for many of the water survey stations have under ten years of data it would be useful to obtain basic drought flow statistics. This would provide a better description of flow characteristics in the different areas. The current practice of selecting a low year for comparison does not provide a sound basis for planning or design. Records where possible could be extended by regression analysis. Regional drought index maps could be plotted for use in planning.

Our study found that the water balance approach provided good results on annual water yields. This can be attributed to the homogeneous nature of many of the northern basins. However a more detailed water balance map should be prepared using existing meteorologic data and regionalized flow information. One should be able to reduce the difference between observed and simulated yields to well below the twelve percent found in our study.

Meteorological and hydrologic data is not presently being collected for any of the four sites of interest to this study. It is recommended that a monitoring program be established to obtain data for these areas. Even a limited program would assist in confirming the regional information. It would also be useful in any stochastic or continuous simulation modelling. At a minimum the information collected would assist in the calibration of the models.

Finally, it would be extremely useful to planners to have some results either from stochastic modelling or from simultaneous simulation for the selected basins. This would provide additional information which should be looked at from the point of view of the assumptions made in the modelling and the data base from which the simulations were undertaken. There is a great deal of meteorologic data available in the N.W.T., certainly far more than for streamflows. A model could be produced which would provide additional data from which planning decisions could be made.

The economic return in undertaking the preparation of additional hydrological information would greatly exceed its costs. It would also reduce the possibility of initiating a project later found to be not viable because baseflow estimates were found to have been over estimated.

ADDITIONAL HYDROLOGIC DATA

Records from stream gauges:

Baker Lake — Prince River
Coppermine — Coppermine River
Eskimo Point — Maguse River
Frobisher Bay — Sylvia Grinnel River
Kakisa — Kakisa River
Lac La Martre — Lake La Martre River
Snowdrift — Snowdrift River

PRINCE RIVER NEAR BAKER LAKE - STATION NO. 06HA005

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1979	0	0	0	0	1.81	81.2	31.0	13.5	5.73	0.073	0	0	9.43	1979
MEAN	0	0	0	0	1.81	61.2	31.0	13.5	5.73	0.073	0	0	9.43	MEAN

LOCATION - LAT 64 18 00 N DRAINAGE AREA, 2 130 km²
LONG 95 45 00 W NATURAL FLOW

PRINCE RIVER NEAR BAKER LAKE - STATION NO. 06HA005

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m^3/s)	MAXIMUM DAILY DISCHARGE (m^3/s)	MINIMUM DAILY DISCHARGE (m^3/s)	TOTAL DISCHARGE (dam^3)	YEAR
1979	---	83.8E ON JUN 12 *	0B ON JAN 1 *	298 000	1979
				298 000	MEAN

B - ICE CONDITIONS
E - ESTIMATED
* - EXTREME RECORDED FOR THE PERIOD OF RECORD

QUOICH RIVER ABOVE ST. CLAIR FALLS - STATION NO. 08HB001

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1972	2.85	2.42	3.54	4.51	5.32	75.3	870	233	187	70.5	31.4	8.21	126	1972
1973	4.69	3.65	2.93	7.16	78.8	392	213	216	468	247	76.9	14.8	144	1973
1974	9.66	6.33	6.75	7.38	61.5	727	299	135	134	45.7	23.7	12.2	122	1974
1975	4.41	1.77	4.29	7.37	26.9	828	289	139	320	110	42.6	13.6	148	1975
1976	2.00	1.32	0.975	0.787	3.85	527	644	207	207	83.4	17.6	2.02	159	1976
1977	1.05	1.44	1.55	4.35	6.23	547	911	334	269	160	57.1	16.9	194	1977
1978	1.89	0.857	0.880	0.932	1.01	95.1	1 090	297	181	48.7	20.1	8.67	147	1978
1979	8.57	7.07	5.78	5.25	4.41	278	566	138	273	59.5	22.3	12.1	116	1979
MEAN	4.34	3.11	3.34	4.72	23.5	433	635	212	255	103	36.5	11.1	145	MEAN

LOCATION - LAT 64 27 30 N DRAINAGE AREA, 28 700 km²
LONG 94 07 10 W NATURAL FLOW

QUOICH RIVER ABOVE ST. CLAIR FALLS - STATION NO. 06HB001

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m^3/s)	MAXIMUM DAILY DISCHARGE (m^3/s)	MINIMUM DAILY DISCHARGE (m^3/s)	TOTAL DISCHARGE (dam^3)	YEAR
1972	---	1 270E ON JUL 10	2.12 B ON FEB 10	3 970 000	1972
1973	---	595 ON SEP 16	2.18 B ON MAR 21	4 530 000	1973
1974	---	1 130E ON JUN 16	5.68 B ON FEB 15	3 850 000	1974
1975	---	1 180E ON JUN 9	1.18 B ON FEB 13	4 680 000	1975
1976	---	1 480 ON JUN 29	0.623B ON MAY 8 *	5 020 000	1976
1977	---	1 900B ON JUN 29 *	0.850B ON JAN 13	6 110 000	1977
1978	---	1 670E ON JUL 8	0.850B ON JAN 25	4 650 000	1978
1979	1 040 AT 17:03 CST ON JUN 30 *	1 030 ON JUN 30	3.68 B ON MAY 30	3 650 000	1979
				4 560 000	MEAN

B - ICE CONDITIONS
E - ESTIMATED
* - EXTREME RECORDED FOR THE PERIOD OF RECORD

COPPERMINE RIVER AT OUTLET OF POINT LAKE - STATION NO. 10PB001

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1965	---	---	---	---	---	---	---	252	188	132	95.1	74.5	---	1965
1966	62.4	51.9	44.0	40.0	51.2	197	250	215	169	---	---	---	---	1966
1967	---	---	41.0	34.8	34.3	95.5	237	262	220	203	178	106	---	1967
1968	74.3	65.7	56.7	45.2	38.7	94.5	224	207	169	151	140	109	115	1968
1969	70.7	49.3	43.7	39.3	41.1	75.9	166	206	227	203	161	125	118	1969
1970	93.9	64.0	47.4	46.1	40.5	103	179	173	169	154	125	101	108	1970
1971	81.9	63.9	53.2	46.0	58.8	194	233	186	156	151	123	111	122	1971
1972	82.2	62.4	45.8	---	---	---	---	225	176	132	101	75.5	---	1972
1973	57.7	46.6	40.6	35.9	50.5	145	181	161	154	130	106	84.3	99.6	1973
1974	64.9	51.7	43.9	38.7	44.5	102	174	186	166	131	106	87.7	100	1974
1975	72.3	57.5	46.5	37.8	57.2	195	255	197	181	107	85.6	69.4	110	1975
1976	54.4	44.3	35.1	30.4	41.0	109	169	150	105	79.1	65.1	55.4	78.3	1976
1977	46.7	40.0	35.3	32.1	42.4	166	211	172	129	99.1	78.7	65.3	93.4	1977
1978	54.5	45.5	36.8	30.3	30.6	65.3	137	182	137	107	86.4	65.6	90.1	1978
1979	51.1	42.7	34.9	32.6	38.7	110	199	184	133	93.9	75.9	63.7	89.7	1979
MEAN	66.7	52.7	43.2	37.6	43.8	126	201	196	162	134	109	85.2	101	MEAN

LOCATION - LAT 65 25 00 N DRAINAGE AREA, 20 300 km²
LONG 114 00 30 W NATURAL FLOW

COPPERMINE RIVER AT OUTLET OF POINT LAKE - STATION NO. 10PB001

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m^3/s)	MAXIMUM DAILY DISCHARGE (m^3/s)	MINIMUM DAILY DISCHARGE (m^3/s)	TOTAL DISCHARGE (dam^3)	YEAR
1965	---	---	---	---	1965
1966	---	259 ON JUL 7	37.9 ON MAY 2	---	1966
1967	---	275 ON AUG 12 *	33.6 ON APR 27	---	1967
1968	---	238 ON JUL 17	37.4 ON MAY 25	3 630 000	1968
1969	---	230 ON SEP 17	37.1 ON APR 30	3 710 000	1969
1970	183 AT 09:30 MDT ON JUL 23	191 ON JUL 23	38.5 ON MAY 21	3 820 000	1970
1971	---	241 ON JUL 4	42.2 ON MAY 9	3 840 000	1971
1972	---	250A ON JUL 6	---		1972
1973	---	185 ON JUL 21	33.1E ON MAY 7	3 140 000	1973
1974	---	193 ON AUG 10	36.8 ON MAY 4	3 160 000	1974
1975	---	266 ON JUL 6	36.0 ON APR 20	3 460 000	1975
1976	---	174 ON JUL 30	39.7E ON APR 19	2 480 000	1976
1977	---	218 ON JUL 5	30.0 ON MAY 12	2 950 000	1977
1978	172 AT 01:30 MST ON AUG 7	170 ON AUG 7	28.6 ON APR 26 *	2 530 000	1978
1979	212 AT 18:15 MST ON JUL 24 *	218 ON JUL 25	31.8 ON MAY 9	2 800 000	1979
				3 190 000	MEAN

A - MANUAL GAUGE (SEE REFERENCE INDEX) E - ESTIMATED * - EXTREME RECORDED FOR THE PERIOD OF RECORD

SYLVIA GRINNELL RIVER NEAR FROBISHER BAY - STATION NO. 10TE001

MONTHLY MEAN DISCHARGES AND MEAN DISCHARGES FOR JUN TO OCT IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1971	1.26	0.757	0.261	0	0.037	43.2	158	57.2	42.5	13.1	4.87	1.84	62.9	1971
1972	---	---	---	---	---	4.40	132	79.6	48.6	13.4	5.69	---	55.9	1972
1973	---	---	---	---	---	89.3	223	76.6	56.0	26.1	---	---	94.6	1973
1974	---	---	---	---	---	---	78.7	67.9	---	---	---	---	---	1974
1975	---	---	---	---	---	---	120	71.2	59.3	---	---	---	---	1975
1976	---	---	---	---	---	---	236	95.7	35.5	---	---	---	---	1976
1977	---	---	---	---	---	---	164	48.3	41.9	---	---	---	---	1977
1978	---	---	---	---	---	---	342	123	---	---	---	---	---	1978
1979	---	---	---	---	---	---	283	121	120	---	---	---	---	1979
MEAN	1.26	0.757	0.261	0	0.037	45.3	193	82.3	59.1	17.5	5.28	1.84	71.1	MEAN

LOCATION - LAT 63 45 37 N LONG 68 35 38 W DRAINAGE AREA, 3 030 km^2 NATURAL FLOW

SYLVIA GRINNELL RIVER NEAR FROBISHER BAY - STATION NO. 10TE001

EXTREMES OF DISCHARGE AND TOTAL DISCHARGE FOR JUN TO OCT FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m^3/s)	MAXIMUM DAILY DISCHARGE (m^3/s)	MINIMUM DAILY DISCHARGE (m^3/s)	TOTAL DISCHARGE (dam^3)	YEAR
1971	---	283A ON JUL 8	0.566B ON JUN 1	831 000	1971
1972	---	306 ON JUL 22	0.113B ON JUN 1 *	738 000	1972
1973	445 AT 06:43 AST ON JUL 3 *	425 ON JUL 3 *	11.3 B ON JUN 1	1 250 000	1973
1974	---	---	---	---	1974
1975	---	---	---	---	1975
1976	---	---	---	---	1976
1977	---	---	---	---	1977
1978	---	---	---	---	1978
1979	---	---	---	---	1979
				940 000	MEAN

A - MANUAL GAUGE (SEE REFERENCE INDEX) B - ICE CONDITIONS * - EXTREME RECORDED FOR THE PERIOD OF RECORD

KAKISA RIVER AT OUTLET OF KAKISA LAKE - STATION NO. 07UC001

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1962	---	---	---	---	---	---	172	101	76.4	65.4	---	---	---	1962
1963	---	---	---	---	---	---	---	---	---	100	85.0	60.3	---	1963
1964	39.5	23.1	12.8	11.7	73.9	147	65.8	37.9	46.1	70.1	75.5	50.4	54.5	1964
1965	32.5	23.9	19.7	17.1	56.9	113	72.0	62.5	51.7	50.2	41.0	31.2	47.8	1965
1966	24.7	19.0	14.5	13.4	64.2	139	91.1	51.5	38.9	34.8	30.2	21.9	45.4	1966
1967	14.8	11.0	9.23	9.17	35.4	167	105	65.3	44.8	36.5	28.2	21.7	45.7	1967
1968	14.7	12.3	8.69	7.25	32.1	70.7	48.0	63.8	63.4	58.0	42.0	30.2	37.6	1968
1969	21.1	15.5	13.1	13.2	63.3	102	51.9	28.5	24.8	29.2	24.6	16.4	33.7	1969
1970	12.1	10.2	8.19	8.21	54.6	95.0	50.2	31.4	25.6	23.8	16.9	11.6	29.0	1970
1971	11.2	11.3	9.39	7.43	40.2	47.3	---	---	16.5	13.6	9.09	8.43	---	1971
1972	5.03	3.55	2.66	5.15	28.1	108	70.3	39.3	27.0	22.1	18.2	14.8	28.7	1972
1973	12.7	10.7	9.06	8.24	24.6	31.9	23.6	27.1	35.5	25.2	14.4	13.2	19.7	1973
1974	11.1	8.62	7.17	10.0	34.9	95.3	65.9	50.8	46.4	42.8	35.5	28.3	36.5	1974
1975	18.4	14.6	9.73	10.5	66.3	106	55.4	35.6	51.7	59.8	50.6	39.8	43.3	1975
1976	26.6	19.4	15.0	19.7	128	179	126	70.7	97.9	124	86.7	48.8	78.6	1976
1977	29.3	21.1	15.3	12.9	29.4	78.4	75.8	65.8	61.3	54.9	44.0	34.0	43.6	1977
1978	22.3	14.5	10.8	8.49	23.6	41.7	28.8	30.0	34.0	31.6	22.9	16.7	23.8	1978
1979	15.1	12.4	11.0	9.60	16.1	152	120	60.0	45.1	44.6	38.2	28.3	46.2	1979
MEAN	19.4	14.4	11.0	10.8	48.2	105	76.4	51.3	46.3	49.3	39.0	28.0	40.9	MEAN

LOCATION - LAT 60 56 15 N LONG 117 25 00 W DRAINAGE AREA, 14 900 km^2 NATURAL FLOW

KAKISA RIVER AT OUTLET OF KAKISA LAKE - STATION NO. 07UC001

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m^3/s)	MAXIMUM DAILY DISCHARGE (m^3/s)	MINIMUM DAILY DISCHARGE (m^3/s)	TOTAL DISCHARGE (dam^3)	YEAR
1962	---	208 ON JUN 28 *	---	---	1962
1963	---	---	---	---	1963
1964	---	168 ON JUN 12	9.51B ON APR 16	1 720 000	1964
1965	---	128 ON JUN 18	15.9 ON APR 13	1 500 000	1965
1966	---	161 ON JUN 21	12.0 ON APR 9	1 430 000	1966
1967	202 AT 22:10 MST ON JUN 19	167 ON JUN 17	8.21 ON MAY 1	1 440 000	1967
1968	99.4 AT 18:00 MST ON SEP 28	81.8 ON JUN 13	6.57 ON APR 25	1 190 000	1968
1969	138 AT 23:00 MST ON JUN 8	117 ON JUN 7	10.5 ON APR 7	1 060 000	1969
1970	131 AT 07:00 MST ON JUN 5	110 ON JUN 5	6.57B ON APR 6	916 000	1970
1971	---	71.9 ON JUN 3	6.12B ON APR 16	---	1971
1972	---	121 ON JUN 16	2.27B ON MAR 15 *	906 000	1972
1973	57.5 AT 10:00 ON SEP 9	45.3 ON SEP 9	7.25B ON APR 18	622 000	1973
1974	129 AT 21:00 MST ON JUN 24	106 ON JUN 19	6.80B ON MAR 8	1 150 000	1974
1975	137 AT 20:00 MST ON JUN 11	126 ON JUN 11	7.70B ON MAR 30	1 370 000	1975
1976	218 AT 19:15 MST ON JUN 24 *	193 ON JUN 18	12.2 B ON APR 15	2 400 000	1976
1977	---	94.6 ON JUN 25	12.0 ON APR 12	1 380 000	1977
1978	62.3 AT 16:00 MST ON JUN 15	47.9 ON JUN 5	7.62 ON APR 27	751 000	1978
1979	197 AT 10:57 MST ON JUN 24	196 ON JUN 24	8.91B ON APR 19	1 460 000	1979
	B - ICE CONDITIONS	* - EXTREME RECORDED FOR THE PERIOD OF RECORD		1 290 000	MEAN

LA MARTRE RIVER BELOW OUTLET OF LAC LA MARTRE - STATION NO. 07TA001

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1975	---	---	16.0	---	---	---	---	35.1	30.0	24.4	20.0	16.6	---	1975
1976	14.5	13.3	---	---	---	---	31.5	28.5	23.7	21.2	17.3	12.8	---	1976
1977	11.0	9.70	11.4	18.5	20.6	25.3	23.9	20.1	18.5	19.3	16.8	14.4	17.5	1977
1978	13.8	13.3	9.74	12.7	20.3	29.2	30.0	26.1	22.4	22.9	17.7	15.2	19.5	1978
1979	14.5	13.1	11.0	15.2	25.3	35.8	33.8	28.1	24.4	22.0	17.2	14.0	21.2	1979
MEAN	13.5	12.3	12.0	15.5	22.1	30.1	29.8	27.6	23.8	22.0	17.6	13.6	19.4	MEAN

LOCATION - LAT 63 06 27 N, LONG 116 58 20 W

DRAINAGE AREA, 15 900 km^2

NATURAL FLOW

LA MARTRE RIVER BELOW OUTLET OF LAC LA MARTRE - STATION NO. 07TA001

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m^3/s)	MAXIMUM DAILY DISCHARGE (m^3/s)	MINIMUM DAILY DISCHARGE (m^3/s)	TOTAL DISCHARGE (dam^3)	YEAR
1975	---	---	---	---	1975
1976	---	---	11.5 B ON DEC 31	---	1976
1977	---	28.9 ON JUL 1	9.34B ON FEB 24	552 000	1977
1978	34.0 AT 21:35 MST ON JUN 16 *	32.8 ON JUN 17	9.00B ON MAR 19 *	614 000	1978
1979	---	37.1E ON JUN 18 *	10.3 B ON MAR 27	669 000	1979
	B - ICE CONDITIONS E - ESTIMATED	* - EXTREME RECORDED FOR THE PERIOD OF RECORD		612 000	MEAN

SNOWDRIFT RIVER AT OUTLET OF SILTAZA LAKE - STATION NO. 07QB002

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1976	---	---	---	7.92	60.1	76.7	44.9	24.3	18.0	15.3	13.2	9.64	---	1976
1977	6.79	5.52	4.68	3.89	114	103	43.4	29.3	28.1	27.9	26.2	19.3	34.5	1977
1978	15.4	12.8	10.0	7.80	78.9	144	81.5	44.8	25.0	19.3	17.3	13.4	39.3	1978
1979	10.6	8.18	6.82	6.14	70.0	141	57.9	30.3	22.2	17.7	14.1	9.97	33.0	1979
MEAN	10.9	8.83	7.17	6.44	80.8	116	56.9	32.2	23.3	20.1	17.7	13.1	35.6	MEAN

LOCATION - LAT 62 10 30 N, LONG 109 51 10 W

DRAINAGE AREA, 5 980 km^2

NATURAL FLOW

SNOWDRIFT RIVER AT OUTLET OF SILTAZA LAKE - STATION NO. 07QB002

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m^3/s)	MAXIMUM DAILY DISCHARGE (m^3/s)	MINIMUM DAILY DISCHARGE (m^3/s)	TOTAL DISCHARGE (dam^3)	YEAR
1976	---	118E ON MAY 25	---	---	1976
1977	---	226E ON MAY 15	3.68B ON APR 27 *	1 090 000	1977
1978	210 AT 20:00 MST ON JUN 7	204 ON JUN 7	7.36B ON APR 17	1 240 000	1978
1979	291 AT 22:00 MST ON MAY 30 *	285 ON MAY 30 *	5.79B ON MAY 9	1 040 000	1979
	B - ICE CONDITIONS E - ESTIMATED	* - EXTREME RECORDED FOR THE PERIOD OF RECORD		1 120 000	MEAN

Appendix II

REVIEW OF SMALL SCALE HYDRO EQUIPMENT

SMALL SCALE TURBINE MANUFACTURERS IN CANADA

Barber Hydraulic Turbine Ltd. from Ontario have developed a Mini-Hydro Station which "is an integrated hydro-electric power package designed to permit the development of low-head hydraulic potential."

The station can operate at heads from 3 m to 7.5 m and flows ranging from 5.5 m³/sec. Corresponding output may vary from 100 kw to 400 kw. A section through the station is shown in Figure 7.2. The station may be used with a prefabricated syphon penstock, which can be installed after the dam is completed, eliminating the concrete work required to seal the penstock in the dam.

The standard package is supplied complete with turbine (Kaplan , Francis) governor, and voltage regulator. The station is designed to operate unattended with only periodic maintenance.

Barber Hydraulic also manufactures Propeller and Francis turbines for a wide range of heads and flows.

F. W. E. Stapenhorst Inc. from Pointe Claire, Quebec, supplies Ossberger Cross-Flow Turbines manufactured in Germany. They are presently capable of providing installations of up to 1000 kw. Under development are units to 4000 kw.

AMCS International Ltd. formerly Dominion Bridge Co. Ltd. has an agreement with Escher Wyss from Switzerland to manufacture Straflow units (Polar Turbines). These units could be used widely in N.W.T. on larger rivers for run-of-river applications.

Gelt Energy Systems Ltd. from Ontario is a newcomer to this field. They manufacture propeller type turbines in the low head range.

TURBINE TYPES

A variety of turbines are used in small hydro. However, the type used will depend on the head and flow. Fig. 21 shows the approximate ranges. A brief description of the various types of turbines follows:

Francis Turbines have a runner with fixed vanes into which water enters radially and is discharged axially in relation to the shaft. (Fig. 22). Units can be mounted with vertical or horizontal shafts. A Francis turbine will best operate at a range of 40 to 105 percent of its rated flow. At the lower range, vibrations may occur. The upper range is limited by the rated capacity of the generator. Francis turbines can be used with heads from 3 to 600 m.

Propeller (kaplan) Turbines have a runner with four, five or six blades where water passes through the runner in an axial direction with respect to the shaft. The blade pitch can be fixed or adjustable (Fig. 23).

The efficiency curve of the propeller turbine is steeper than that of the Francis turbine. Propeller turbines are used for heads ranging from 3 to 60 m.

Tabular Turbines are horizontal or slope slant mounted units with propeller runners. Generators are located outside of the water passageway. The efficiency curve is similar to the propeller type turbines. (Fig. 24).

Bulb Turbines are horizontal units which have propeller runners connected directly to the generator. The generator is located in a sealed enclosure located in the turbine water passageway. Performance characteristics are similar to propeller turbines. The advantage of bulb turbines is the reduction in space requirements (Fig. 25) and their improved efficiency.

Polar Wheel (Rim Type) Turbines have the generator rotor mounted directly on the periphery of the turbine runner blades. (Fig. 26). These units require about 10 - 15% less space than bulb units. They can be used with very small heads and are well suited for tidal installations.

Crossflow Turbines are radia, impulse type turbines with partial air admission (previously described turbines were of the reaction type). Their performance efficiency is very good over a wide range of flows. Further improvement to the effective range is made by the use of a guide vane at the entrance which directs the flow to a limited portion of the runner, depending on the flow. These units are inexpensive and the vanes are self-cleaning. They are ideally suited for small scale installations with heads of up to 200 meters and outputs of 1000 kw (See Fig. 27 for schematic section).

Pelton Turbines are of the impulse type having one or several (up to 4) free water jets discharging into an aerated space and impinging on the buckets of a runner. A typical section is shown of Figure 28. This type of turbine is used only with very high heads and hence will not have an application in the N.W.T.

"The Turbodyne Watermill" is a vertical axis water turbine under development in Nova Scotia. This turbine, according to the developer, can be used anywhere there is deep and fast flowing water.

The 20 kw unit presently under construction is 8 feet deep and 12 feet wide. The optimum flow velocity is 5 to 7 feet/sec.

The turbine could be tried in any community on the Liard, Mackenzie, Arctic Red and Peel Rivers, where any other small hydrogeneration system would be extremely expensive.

The cost of the 20 kw unit under construction is $47,000.00

SMALL SCALE HYDRO IN THE N.W.T.

The single most important element which affects small scale hydro in the N.W.T. is the long harsh winter. Below freezing temperatures prevail for almost eight months and the ice thickness may exceed 2 meters. These conditions prevent utilization of rivers with a drainage area of less than about 2000 square kilometers. Further, precipitation in the N.W.T. is lower than anywhere else in Canada.

The remoteness of hydro sites is not a major obstacle. In most communities in the N.W.T. the level of expertise in earth works is substantial and the construction of all approach roads and the erection of poles for the transmission line could be carried out by local residents and some resident equipment. New equipment, which would have to be brought in for the construction of the dam could be utilized for many other projects in the community. Delivery could be made on the annual sea lift, except for Pelly Bay where an air lift is required.

For the construction of a dam local material should be utilized. Snowdrift and Kakisa have an abundance of local timber for rock filled cribs. In the High Arctic dams with frozen core could be utilized and gabion baskets could be used for overflow structures. Frozen core dam technology is yet to be utilized in Canada. However there is considerable experience in the Soviet Union and a number of papers have been published on this subject.

Problems with frazil ice have been encountered by many hydro operators in Canada. However, NCPC has operated 3 hydro generating sites on the Snare River for a number of years and has not had any problems. All 3 hydro sites have significant reservoirs above the dams. During the winter the ice acts as an insulating blanket and prevents frazil ice formation.

NCPC has had problems with frazil ice in Whitehorse. At that location rapids above the dam are open. To solve the problem NCPC constructed log booms and installed heating for the intake valves.

The cost of construction of hydrogenerating stations should not vary significantly from costs in Southern Canada. Most of the equipment which will have to be brought in for the construction can be utilized on other projects. There are usually enough skilled operators for heavy earth moving equipment and there is an abundance of unskilled labour which can be trained or employed using various subsidy programs. Finally, the movement of equipment or the building of roads is actually helped by the frozen ground.

COMMON APPLICATION RANGES

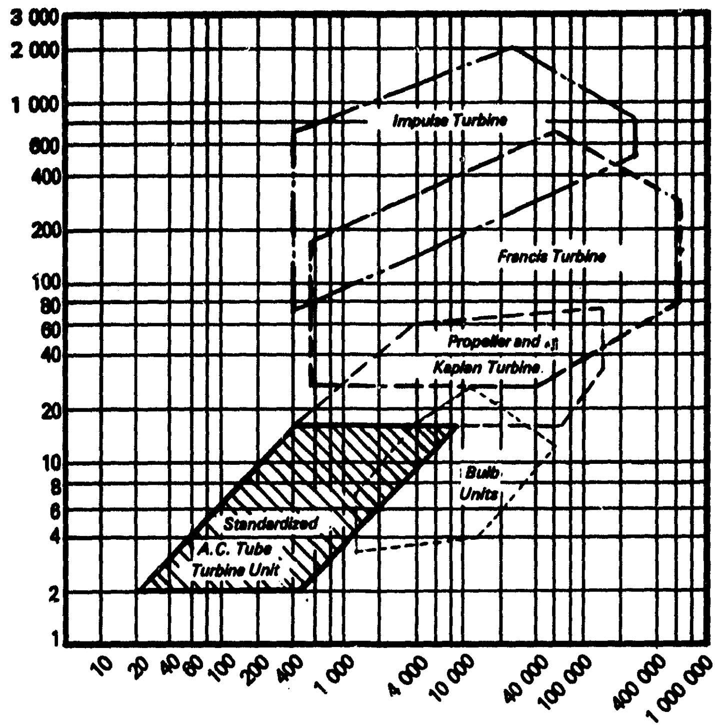
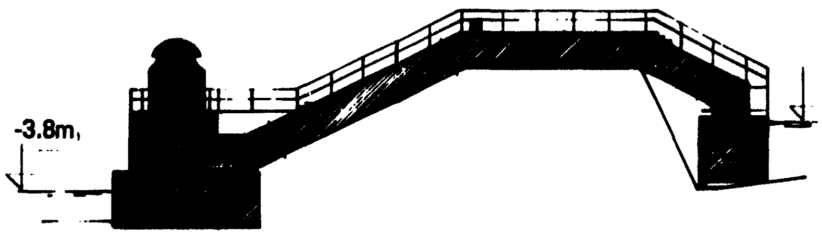
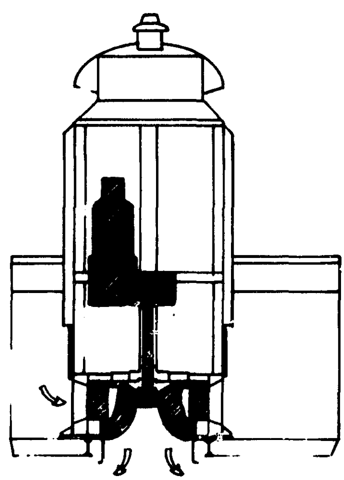


FIGURE 21

TYPICAL HYDROELECTRIC INSTALLATION LAYOUT



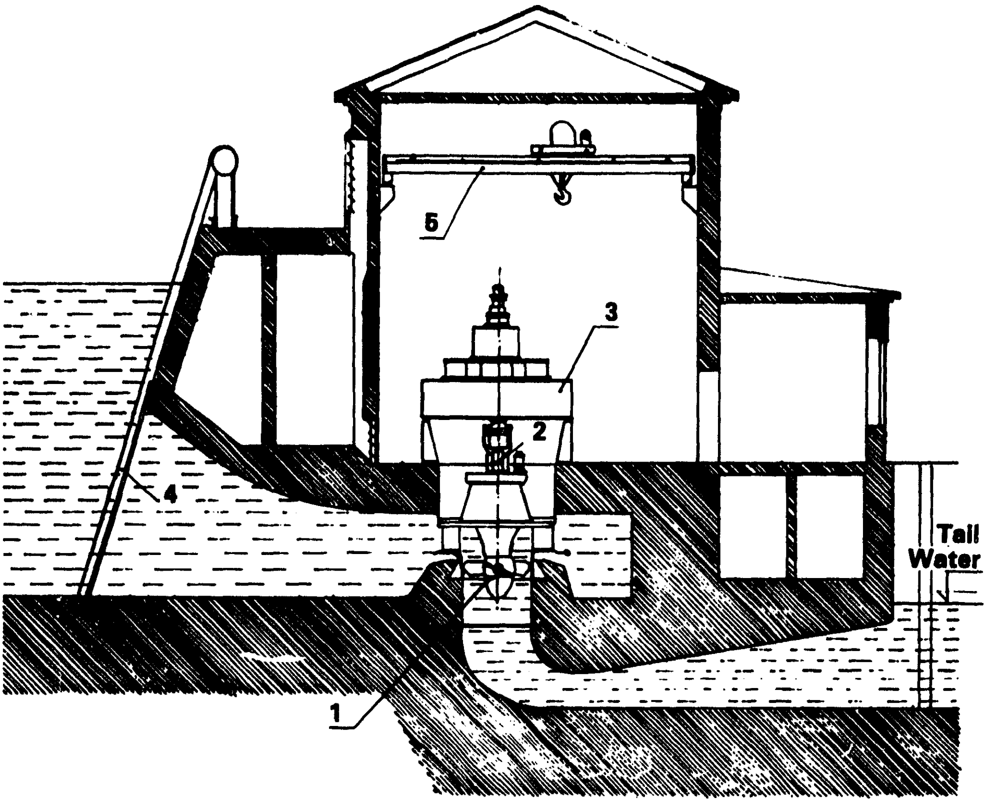
SECTION SHOWING FRANCIS TURBINE



* *Wasdell Falls Mini Hydel by Barber*

FIGURE 22

KAPLAN TURBINE



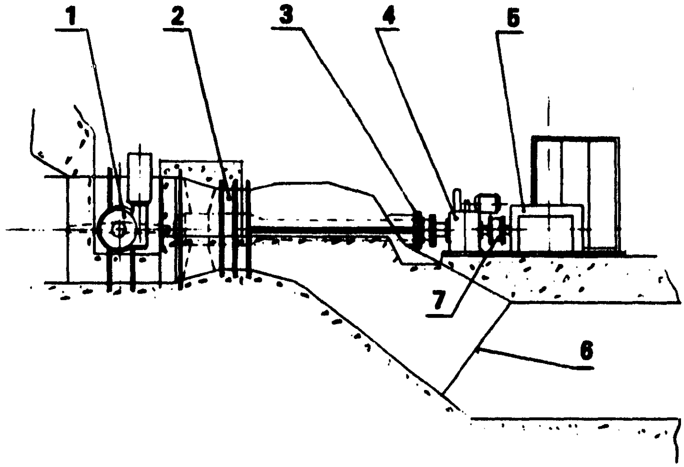
Low Head Application Shown

1 Runner
2 Shaft
3 Generator
4 Intake Screen
5 Gantry Crane

FIGURE 23

* *After: Elma-G, Graz, Austria*

TUBE TURBINE UNIT SECTION

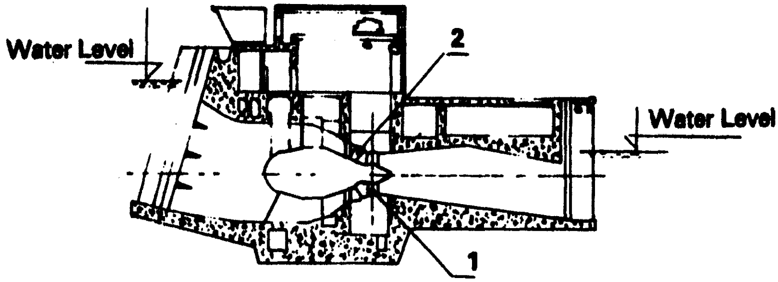


1 Intake Valve
2 Runner
3 Packing Box
4 Speed Increaser
5 Generator
6 End of Steel Draft Tube
7 Disconnect Coupling

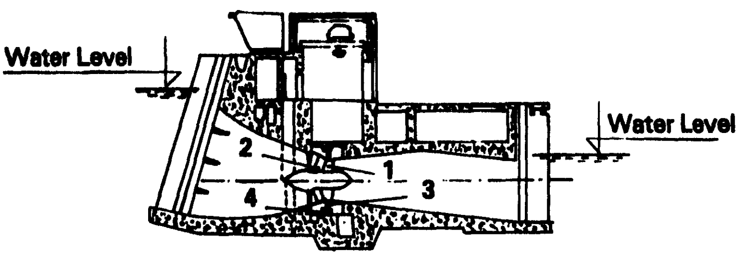
* *Allis-Chalmers*

FIGURE 24

CONVENTIONAL BULB UNIT



POLAR WHEEL UNIT (STRAFLO)

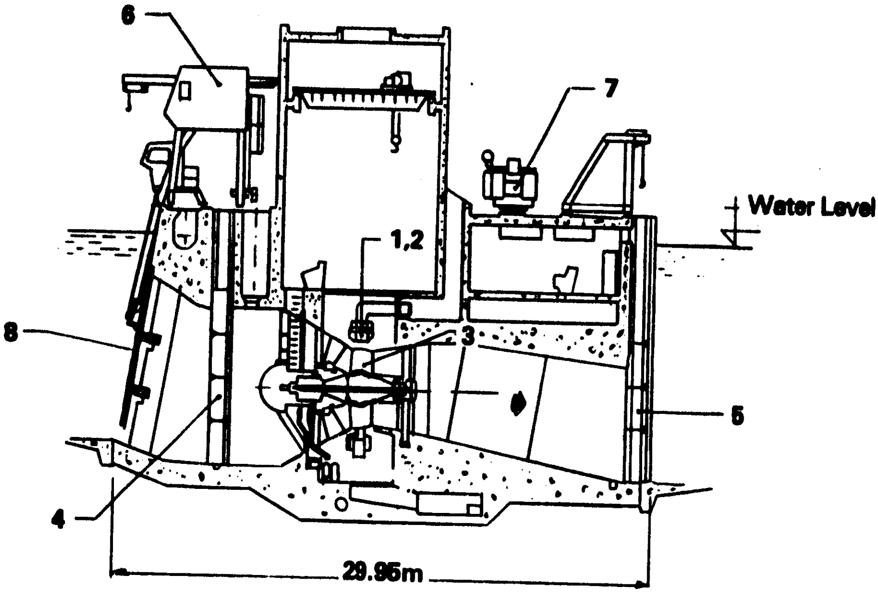


1 Runner
2 Adjustable Distributor
3 Generator Rotor
4 Generator Stator

FIGURE 25

* *After: Elma-6, Graz, Austria*

ANDENNE STATION



1 Generator Rotor
2 Generator Stator
3 Turbine Runner
4 Upstreame Stop Logs
5 Downstreame Stop Logs
6 Rock Cleaning Machine
7 Transformer
8 Intake Screen

* *After: Ateliers de Constructions Electriques De Chareroi, Belgium*

FIGURE 26

CROSS-FLOW TURBINE For 1KW to 1 000KW (4 000KW Under Development)

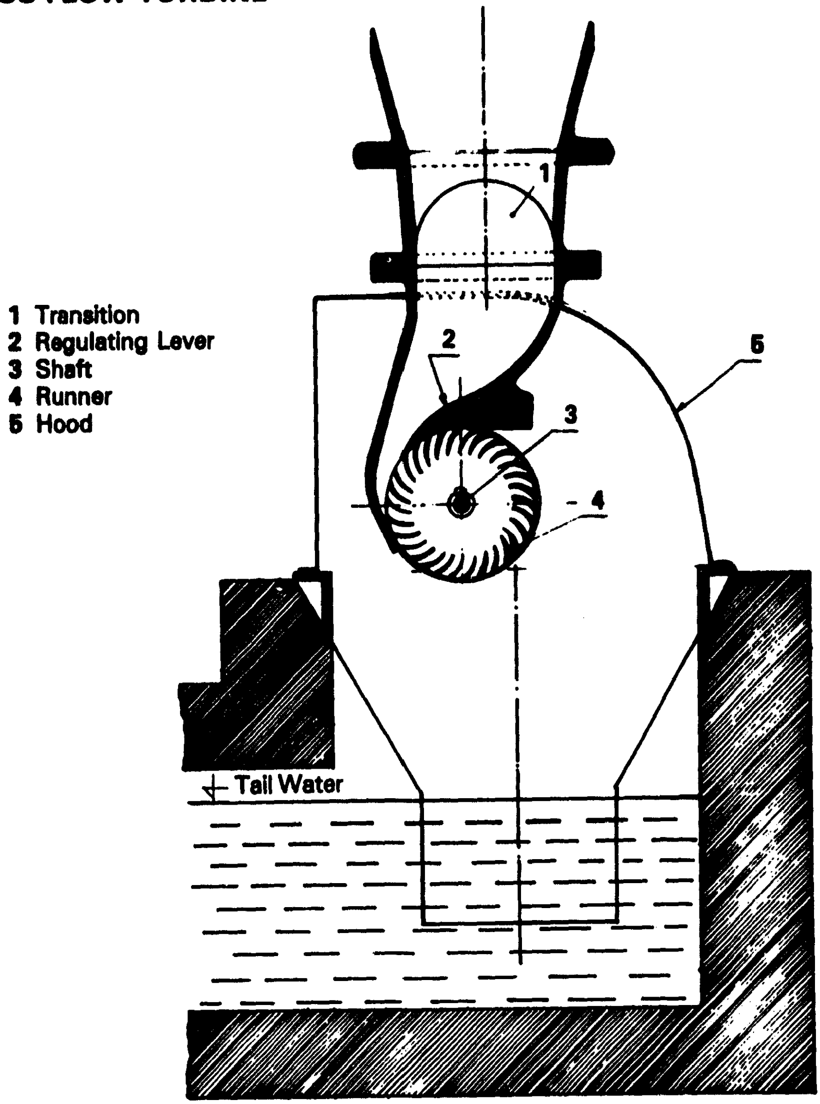
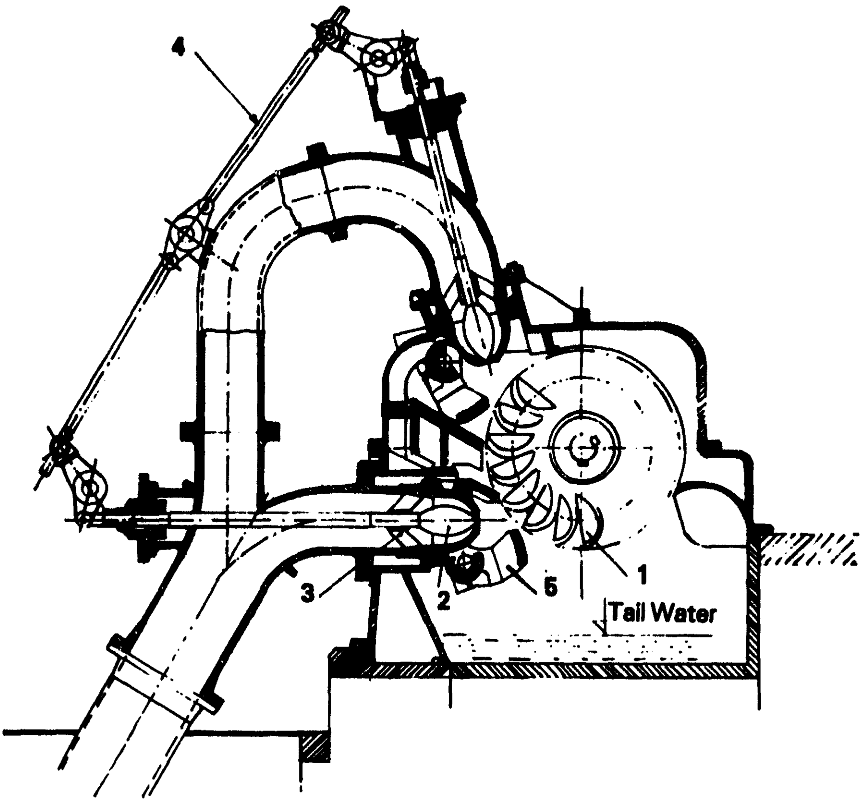


FIGURE 27

* *After: Elma-6, Graz, Austria*

PELTON TURBINE

For High Heads



1 Runner
2 Nozzle Tip & Spear
3 Guide
4 Regulation Shaft for Adjusting the Spear
5 Adjustable Jet Deflector

** After: Elma-6, Graz, Austria*

FIGURE 28

Contractor's Biography

Ferguson, Simak, Clark Limited provides a complete scope of services in the northern engineering and architectural disciplines. The firm originated in 1976 and has been an integral part of development in the north since that time. Dana Ferguson, P. Eng., Stefan Simak, P. Eng., and Clive Clark, M.R.A.I.C., are the principal owners.

The company employs over twenty specialists, familiar with the technical, logistical and administrative demands of the Canadian Arctic. The company is involved with varied projects from Baffin Island in the East to the Mackenzie Delta in the West.

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