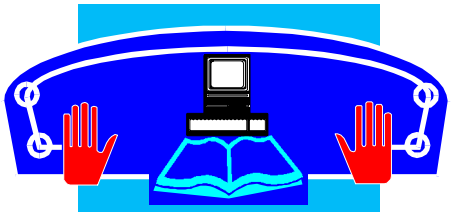

Northern Canada Power Commission Proposal For Small Scale Hydreo Development In The Northwest Territories

Type of Study: Feasibility Studies

Date of Report: 1983

Author: Northern Canada Power Commission

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NORTHERN CANADA POWER COMMISSION

PROPOSAL FOR

SMALL SCALE HYDRO DEVELOPMENT IN THE NORTHWEST TERRITORIES

NORTHERN
CANADA
POWER
COMMISSION

File: 1200

1983 09 07

Mr. J. Cumming
Energy, Mines & Resources Canada
P.O. Box 68
Yellowknife, N.W.T.

Dear Mr. Cumming:

Attached herewith please find a proposal for consideration under the Remote Community Demonstration Program. It is our wish to study, initially at a reconnaissance level, opportunities for development of hydroelectric stations to replace diesel generation at:

Frobisher Bay	Rankin Inlet
Coppermine	Fort Simpson
Baker Lake	Rae Lakes

Based upon the findings of these reconnaissance level studies, we would hope to select one community for more-detailed pre-feasibility investigation, as part of this same Study Program, with a view to its construction under Phase II of the R.C.D.P. which we understand is expected to be implemented commencing in 1984.

The Study Program proposed will be co-ordinated on our behalf by R.L. Walker & Partners Ltd., Edmonton. Management of the work will be handled by Northern Canada Power Commission under my direct control. In order that work may proceed on the site reconnaissance during the remaining suitable weather this year, we have assembled a team of experts that are available immediately to undertake this essential work. Accordingly, your approval to commence work by September 15, 1983 with initial Stage I costs incurred from September 6, 1983 is respectfully requested.

The total budget for the work proposed is as follows:

Stage I - Reconnaissance Study	$173,000
Stage II - Pre-feasibility Study	68,000
Contingency	9,000
TOTAL	$250,000

2/....

HEAD OFFICE 7909-51 AVE. MAILING ADDRESS P.O. BOX 5700 STN. "L" T6C 4J8 EDMONTON, ALTA. CANADA.
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Details of the work to be done, the budget and the reporting and administrative requirements are presented in the proposal. In this regard I wish to acknowledge your assistance in previewing this proposal and I look forward to receipt of your approval to proceed.

Yours truly,

J.D. Allan
Assistant General Manager
Operations and Engineering

Attch.

c.c.: L. Shapiro - R.C.D.P.) 6th Floor, Killeany Building
E. Roger) 460 O'Connor Street
Ottawa, Ontario

JDA/sl

Proposal for Small Scale Hydro Development in the Northwest Territories

Proposal for Small Scale Hydro Development in the Northwest Territories

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PROPOSAL FOR SMALL SCALE HYDRO DEVELOPMENT IN THE NORTHWEST TERRITORIES

1. BACKGROUND AND OBJECTIVE

The Remote Community Demonstration Program (RCDP) sponsored by Energy, Mines and Resources, Canada (EMR) aims at the replacement of oil consumption in remote communities by encouraging the development of alternative sources of energy and of energy conservation. A subsidiary objective is to make the communities more self-reliant in terms of energy supply. Under the first phase of the program, studies which result in the identification of attractive projects will be financed. Under a subsequent second phase, financing will be made available for the implementation of selected projects.

All communities in the Northwest Territories are remote communities in the sense that they are far removed from the main population centres of Canada and are not connected to one of the major electric power grids. Oil and oil products are a major source of energy in the Northwest Territories, for electric power generation, space heating and transport.

The scope for the development of alternative sources of energy is quite limited. Natural gas is available in the far North, in and around the Beaufort Sea, but the cost of development and distribution is such that it's role as a source of energy in the Northwest Territories is likely limited to spurlines to adjacent communities from a major, future, north-south pipeline, if and when such a pipeline is built.

Solar energy is generally unattractive because solar radiation is very limited during the winter, the period of highest demand. Wind energy is likely to provide some opportunities on a very small scale in the future. Wood, which is used extensively for space heating in isolated communities in southern Canada, also has very limited prospects. A large part of the Northwest Territories lies above the tree line and productivity in the rest of the territory is low to moderate.

Hydroelectric energy is an alternative source of energy which has been exploited for many years and has significant potential for further development. Some 60 percent of electric power supplied in the Northwest Territories is already hydroelectric power. The existing hydro power plants serve Yellowknife and some adjacent centres and the communities of Fort Smith, Pine Point and Fort Resolution on the south shore of Great Slave Lake.

Though there is a significant potential for additional hydroelectric development in the Northwest Territories, it is quite difficult to identify and develop specific projects which can meet existing demand at reasonable cost. Some of the reasons for this are:

i) Most of the demand centres are isolated, at long distances from each other, and have a small potential demand. Unless suitable sites can be found in the immediate neighbourhood, transmission costs will be prohibitive.

ii) Most of the sites identified are for potentially large developments and are either too far removed from the demand centres or are not suitable for small scale development.

iii) Many of the smaller streams dry up in the winter. Development of seasonal storage is in many cases very expensive. The region generally has a moderate level of annual precipitation and low unit runoff.

iv) Much of the area is also rather flat. Thus it may be necessary to build dams for the purpose of head development on those streams which have adequate winter flow.

v) Streams with adequate winter flow near communities are frequently important sources of fish for the residents or serve, during the summer, as local transport routes (canoes). A proposal to develop a hydro plant in such a river may run into strong opposition.

vi) Generally, the ecological balance in northern climates is delicate and adequate environmental protection measures can be prohibitively expensive for small hydro plants.

vii) Finally, basic information in the form of adequate topographic, geologic and hydrologic data, is relatively scarce.

The preceding enumeration of factors which tend to limit the scope for hydroelectric development in the Northwest Territories may serve to explain why small scale hydroelectric development has made so little progress in the past. However, there appear to be opportunities which are not being exploited that have not yet been adequately investigated. NCPC has been eager to investigate these opportunities but has not been able to proceed due to a lack of funds for investigations.

This proposal aims at a systematic investigation of a small number of hydroelectric opportunities to serve remote communities in the Northwest Territories under the RCDP. The detailed proposal, which describes the work to be carried out, is presented in Chapter 5. Six communities ranging in size from Frobisher Bay with a population of about 2,500 to Rae Lakes at less than 200, have been selected as offering reasonable opportunities for development of small hydroelectric facilities within a reasonable distance from each community. During Stage I each of these six communities will be considered at a reconnaissance level of investigation. One will then be selected for more-detailed analysis in Stage II. Thus the proposal covers six reconnaissance investigations and one pre-feasibility study in total.

Five communities, Fort Simpson, Coppermine, Baker Lake, Rankin Inlet and Rae Lakes, have been selected for reconnaissance/pre-feasibility level investigations. Based upon an office study of available maps and aerial photography, the communities will be visited in Stage I by a small team of experienced engineers that will inspect one (or more) potentially viable sites. This team will prepare a conceptual project design and a cost estimate with an accuracy in the order of ±50 percent. An assessment will then be made whether any of these schemes remains potentially viable and thereby justifies additional investigation.

Provision has been included in the study budget for more-detailed study of the most-promising of these sites during Stage II. This study would provide for large-scale photography and mapping, as necessary, as well as detailed ground inspection but would fall short of full-scale feasibility analysis since costly site-drilling would be postponed until a provisional decision to proceed to construction has been taken. Thus a cost estimate accuracy in the order of ±20 to 35 percent can be anticipated depending upon the nature of the terrain and geology at the project location.

The objective of the Stage I study for the sixth community - Frobisher Bay- is to review all existing information, including previous reconnaissance assessments to determine whether it would be appropriate to conduct a full-scale feasibility study. Of particular concern is the Arctic Char fishery that exists at the mouth of the Sylvia Grinnel River. An important objective of this initial investigation is to assess whether this issue could be mitigated if NCPC were to seek approval to develop a hydroelectric station upstream on this river.

2. OIL CONSUMPTION IN THE NORTHWEST TERRITORIES

A study by the Science Advisory Board of the Northwest Territories (Energy in the Northwest Territories, 1981) reported oil consumption for the year 1979 as follows:

Electric power generation:	diesel oil	14 mln gallons
	fuel oil	2 mln gallons
		16 mln gallons
Heating oil:		25 mln gallons
Mining companies:	diesel oil	17 mln gallons
Transportation:	various	24 mln gallons
Other:	various	8 mln gallons
		90 mln gallons

The prime categories for possible replacement by hydro energy are the 16 mln gallons of oil used for the generation of electric power. Some realistic prospects for actual replacement are discussed in this proposal.

A second category with at least some scope for replacement by hydro energy is heating oil. The scope is limited because of relative price factors. Significant population centres, including Yellowknife, in the southern part of the Northwest Territories and near the MacKenzie River receive heating oil at prices which are not much higher than those in southern Canada. Electric energy, on the other hand, even if generated by rather small hydroelectric plants likely to be feasible in the North, would generally be far more expensive than in southern Canada. Thus the relative price does not favour early substitution of electric heating for oil-heating in those communities. An opportunity for early introduction of electric space heating may exist in those more remote communities where oil is very expensive and where a hydroelectric plant could be built under conditions such that the marginal cost of electric energy (over the base cost for replacement of diesel generated power) is relatively small. This proposal provides for a study of the possibility of replacing heating oil by electric energy in the second stage of the Study program.

The Science Advisory Board study provides no information regarding the specific use of the 17 mln of diesel oil consumed by the mining companies. It is likely that (internal) transport and prime movers are the major categories of use. Part of this oil will be used for power generation.

Most of the products under the "Other" category are bunker oil and propane.

3. ELECTRIC POWER GENERATION IN THE NORTHWEST TERRITORIES

More than 90 percent of the electric power generated in the Northwest Territories is supplied by the Northern Canada Power Commission. About 5 percent is generated by industries for their own use and about 4 percent by Alberta Power for supply to Hay River and some adjacent communities.

In the financial year of 1982/83, NCPC sold 381 GWh of electric energy in the Northwest Territories. Of this, 41 percent was sold to industrial consumers (mainly mining companies), 21 percent was sold wholesale (mainly to a distribution company in Yellowknife), 18 percent to direct residential customers and 19 percent to direct commercial customers.

NCPC operates some 45 separate systems in the Northwest Territories. By far the largest is the Snare-Yellowknife system. Under normal water conditions, virtually all of current demand can be supplied from hydro plants. However, significant quantities of diesel oil are used in dry years. Thus, in 1982/83 some 1.25 mln gallons of diesel oil were used to supplement hydro energy in this system. If future demand remains stable at current levels, investment in some additional hydro capacity should be considered. One project, the Emile River Diversion, has already been identified as a potentially attractive addition from an economic point of view. However, current load projections imply the possibility of a considerable reduction of demand by about 1985/86.

The Taltson system, supplying Pine Point, Fort Smith and Fort Resolution, is also primarily a hydro system. Diesel energy is used for peaking and dry year supplement. In 1982/83 when water flows were above average, 360,000 gallons of diesel oil were used. Current demand forecasts provide for some increase of demand by mid-1985 but a very sharp reduction of demand by the late 1990's. This makes investment in additional hydro capacity a doubtful proposition.

By far the largest oil consuming system is at Inuvik. Currently, Tuktoyaktuk is also supplied from Inuvik, but the transmission line is near the end of its useful life and replacement is not justified under current conditions. In 1982/83 about 1.4 mln gallons of diesel oil and 1.8 mln gallons of fuel oil were used in this system. While all of the diesel oil is used for power generation, some of the fuel oil is also used for power generation and supply of hot water to the utilidor system (space heating). The diesel oil used by oil companies, and some other self-generators, for power generation in Tuktoyaktuk probably amounted to another 1 to 1.25 mln gallons.

A preliminary investigation, on behalf of NCPC, to use gas from wells near the Beaufort Sea to replace oil was not encouraging. The cost of developing a well and transporting the gas is too high for the relatively small amount required. However, gas could become quite an attractive source of energy if large-scale gas exploitation in the area is undertaken. It is likely that this issue will be reconsidered in a wider context in a study of potential gas use in the Northwest Territories which EMR intends to sponsor in the near future.

Attractive hydro opportunities which have been identified to date are large potential developments at a considerable distance from Inuvik. It would be worthwhile to investigate whether a relatively small plant could be built at a reasonable distance.

With the expansion of Esso's facilities in Norman Wells, electric power demand in that area will increase from some 10 GWh to 100 GWh. NCPC has commissioned a preliminary study of the possibility to supply hydroelectric energy to Norman Wells and the Esso operations. Screening of a number of possible sites resulted in the selection of a site on the Bear River as the most promising one. However, the results of the study indicate that this would not be an attractive proposition. The main reasons for this are that Esso's current plans provide for an economic life of the secondary oil recovery project of 20 years and that initially surplus associated gas, with a zero market value, will be used to generate electric energy.

The remaining 41 systems are single community systems which vary in size, in terms of 1982/83 peak load, from 3900 kW in Frobisher Bay to 15 kW in Jean Marie River. Oil consumption was 1.25 mln gallons in Frobisher Bay and 10,000 gallons in Jean Marie River. Diesel oil costs varied frm $4.24 per gallon in Pelly Bay to $1.48 per gallon in Jean Marie River.

These 41 single community systems are considered to be appropriate candidates for an investigation of opportunities for hydro development under the RCDP. They are all listed in Annex 1. The tabulation provides some basic characteristics of the electric power supply systems and a preliminary indication of the maximum cost of investment which could be incurred to replace the existing diesel plants, with respect to power generation only. (See notes to Annex 1 for explanation and important qualifications).

NCPC's costs of operation and, therefore, average rates, are very high compared to those of other utilities in Canada. In 1981/82 the average rate per kWh sold by NCPC in the Northwest Territories was 11.7 cts per kWh. In the rest of Canada average rates varied in 1981 from 3.3 cts per kWh in Quebec to 9.7 cts in urban areas in Prince Edward Island (Source: Electric Power North of 60°, House of Commons, Canada, 1982). The average rate in the Northwest Territories is dominated by the relatively low cost of power in the two hydro systems. Rates, which must reflect cost of operation in each system according to NCPC's mandate, vary considerably from system to system. For example, the rate charged in the 41 communities to Government officials for domestic service, a rate more or less representative of actual cost of service, varies from 27.39 cts per kWh in Fort Simpson to 70 cts per kWh in Arctic Red River, Paulatuk, Nahanni Butte and Pelly Bay. This may be compared with 9.68 cts per kWh for the first 300 kWh per month and 7.38 cts per kWh for additional energy in Fort Smith, a community in the Taltson hydro system. All domestic customers are also charged a fixed sum of $5.30 per month.

Generally, non-government domestic customers are charged a significantly lower rate, which implies a cross-subsidy within each system. Domestic, non-government customers are further subsidized under the Federal Power Support Program, a program which was originally designed to last one year but which has been renewed annually. Under this program, all non-government domestic customers in the Northwest Territories will not be charged more for the first 700 kWh of monthly consumption than the average rate charged for such consumption in Yellowknife. This was recently 8.44 cts per kWh. Commercial customers can apply for a subsidy from the Territorial Government. Government officials, with few if any exceptions, have their bills paid by their employers.

Thus, very few residents and businesses in the 41 communities listed in Annex 1 pay rates anywhere near the actual cost of supplying them with electricity.

The implication of this is that very few residents, who fully expect that current subsidy programs will remain in force in one way or another, have any direct interest in a reduction of the cost of power supply unless there is a reasonable expectation that the future cost of supply will be well below the average cost in the Snare-Yellowknife system. For the 41 small communities, this is extremely unlikely.

On the other hand, some residents will have objections to a proposed hydro scheme, related to environmental concerns. But they are not encouraged, under the present rules of the game, to weigh the disadvantages against the advantages of a (proposed) hydro project since they will suffer the disadvantages whereas the governments will reap the benefits.

This is a serious problem under the current rules of the RCDP, as has been demonstrated already, since the program requires that local communities take the initiative by requesting the Government to undertake a study aimed at reducing the cost of supply of electric power.

4. THE NORTHERN CANADA POWER COMMISSION

The Commission is a federal crown corporation which operates under the authority of the Northern Canada Power Commission Act. Under the provisions of the Act of 1956 the Commission would have been entitled to supply public utilities in the widest sense in the Northwest Territories and the Yukon. In practice the Commission has restricted itself, with one exception, to the supply of electric power and, to a limited extent, heat. Primary heat is supplied in Inuvik and Frobisher Bay. Residual or waste recovery heat from the NCPC electric power plants is supplied currently in Cambridge Bay, Igloolik, Rankin Inlet, Lac la Martre, Fort Simpson, Coppermine and Pelly Bay. Current provisions for waste heat recovery are that the Commission will supply waste heat free of charge to government agencies, provided that all capital, maintenance and incremental operation costs attributable to the supply are borne by the user. The Commission also operates a water and sewerage system in Inuvik.

As mentioned in Section 3, NCPC supplies about 90 percent of all the electric power generated in the territories. NCPC has no formal monopoly as supplier of electric power for sale to the public, though it has been held that federal government policies imply a de-facto monopoly.

The Commission's head office is located in Edmonton and regional offices are located in Yellowknife and Whitehorse.

The Commission has five members. Day-to-day operations of the Commission are directed by the Chief Executive Officer (the Chairman of the Commission), a General Manager, two Assistant General Managers and a Comptroller.

The Commission's mandate requires that rates charged to customers cover all expenses, including capital charges and cost of operation, maintenance and administration plus an allowance for general overhead expenses. This allowance is currently 4 percent of direct expenses.

Federal Government funds are the exclusive source of finance of the Commission. All investments are financed through federal government loans at current interest rates established by the Treasury Board. Outstanding loans carry rates of interest varying from 4 to 15 percent. The total obligations of the Commission to the Government of Canada were, on March 31, 1982, $206 mln including overdue obligations of $9 mln.

The financial autonomy of the Commission is limited by the requirement that it's budget be approved by the Minister of Indian and Northern Affairs and that all investment proposals must be submitted to the Treasury Board for approval of funding. Funds for investigation of new projects included in the normal budget are extremely small and any significant investigation requires approval of a special grant. Such grants must be rolled into the loan for a project if the investigation leads to implementation.

The Commission's staff has very limited capacity to undertake investigations or long-term planning studies. Consultants are hired to undertake studies which require more input than the capabilities of the NCPC's staff permit.

5. THE PROPOSED STUDY PROGRAM

On the basis of currently existing information, NCPC and its planning consultants, R.L. Walker & Partners Ltd., have selected six communities which may have one or more attractive sites at not too great a distance, suitable for the development of a small hydro plant. These are Frobisher Bay, Rankin Inlet, Baker Lake, Coppermine, Fort Simpson and Rae Lakes.

The principal reasons for selection of these communities are:

i) Existing studies and reports. Many studies have been made of possible hydro developments in the Territories. Their conclusions are generally irrelevant for they were not made with specific reference to the communities as potential local markets. Many had as objective the identification of sites with a potential of several hundreds of MW, for which only the pumping stations associated with a large pipeline or mining activities could provide a market, or, in a distant future, perhaps southern Canada via a large collector transmission system. Other studies have identified sites with small potential but without reference to potential markets.

Even though the conclusions of many of these reports are not relevant to the present situation, much useful information can be extracted from the studies and this was used, whenever possible, to assess opportunities under the RCDP mandate.

ii) A combination of local conditions, supported by sufficient topographic and hydrologic data, that indicate the availability of an adequate hydro potential.

Northern rivers are generally one of two types. The larger streams that carry significant winter discharges are often incised into wide, flat valleys where sufficient head can

only be mobilized with large barrages. The smaller streams frequently have negligible winter flows. Hydro installations are only practical on these rivers where sufficient storage can be mobilized in existing lakes.

iii) Potentially acceptable costs for transmission between the hydro site(s) and the community to be served. Approximate transmission costs were derived from NCPC experience data, as shown in Annex 2. These costs were compared with the preliminary estimates for total warranted investment costs, as shown in Annex 1, to determine whether, after providing for the cost of a transmission line, sufficient investment was likely to be available for construction of a suitable hydro facility. At this stage, any benefit of doubt was given in favour of the hydro development.

In selecting the study communities, consideration has been given to all 41 communities listed in Annex 1. While not necessarily eliminating all of the remaining locations from future consideration, the reasons for their initial exclusion are as noted hereunder.

a) All of the undernoted communities are located on the Arctic Islands where streams mostly have small catchment areas with little if any natural storage, and generally no runoff for at least six months during the winter:

Cambridge Bay
Resolute Bay
Pangnirtung
Cape Dorset
Igloolik
Coral Harbour
Gjoa Haven
Grise Fiord
Pond Inlet
Broughton Island
Clyde River
Arctic Bay
Lake Harbour
Holman Island
Sachs Harbour

b) With few exceptions, communities on or close to the MacKenzie River are situated in rather flat terrain where, even if there is sufficient winter flow in the nearby streams, head concentrations are not available within a realistic transmission distance from the community. Locations provisionally eliminated for this reason include:

Fort Franklin	Fort Norman
Aklavik	Wrigley
Fort McPherson	Arctic Red River
Fort Good Hope	Jean Marie River

To these eight communities can be added Fort Liard and Nahanni Butte, both very small, where the potential fuel savings are too low to consider distant sites.

c) While potentially interesting from the viewpoint of reasonable proximity to each other, Chesterfield Inlet, Whale Cove and Eskimo Point are provisionally excluded because the indicated fuel savings are too small to justify even the costs of transmission line interconnections. Rankin Inlet is the largest community in this area and is included in the program for a reconnaissance investigation. If the results of this study prove encouraging and if the potential for substitution of heating loads subsequently proves attractive, these communities should be reconsidered at a later date.

d) Five communities located on the Melville Peninsula and along the northern coastline of the mainland have been excluded because of unfavourable local topography and/or hydrology and their small size. These are:

Spence Bay	Hall Beach
Pelly Bay	Paulatuk
Repulse Bay	

e) Careful consideration was given to Lac La Martre but this community was excluded because the only apparent site in the area is the La Martre Falls. The potential of this site has been considered as a future addition to the Snare-Yellowknife system and it may be economically attractive for that purpose. As a site for a small hydro development it could be interesting, even though this would tend to foreclose the larger scheme, but the possible fuel savings are unlikely to be sufficient even to finance the cost of a transmission line from the Falls to the community.

f) Finally, the community of Snowdrift has previously been selected as a potentially interesting opportunity for a small hydro project although community leaders have expressed some opposition to the idea. NCPC has excluded this community from the proposed program pending further consideration.

Thus, six communities as follows, have been selected for consideration, during this initial reconnaissance study, as having reasonable prospects for development of a small hydro station to serve the electric load:

	Peak Electrical Demand (1982/83)
Frobisher Bay	3900 kW
Rankin Inlet	1205 kW
Baker Lake	900 kW
Coppermine	580 kW
Fort Simpson	1000 kW
Rae Lakes	67 kW

NCPC proposes to proceed, under the program to be financed by Energy, Mines and Resources, with a staged process of successive elimination to permit the concentration of study resources on the most promising sites.

5.1 Stage I Office Study and Reconnaissance

5.1.1 Frobisher Bay

Background and related information pertaining to this Stage I study are presented in Annex 3. As will be observed from the information contained therein, several previous desk and reconnaissance studies of the Sylvia Grinnel and other rivers close to Frobisher Bay have been carried out in the past. In view of this, it will not be necessary to conduct a technical reconnaissance of the damsite location(s) for the purpose of this investigation. The work will involve a desk study of the available information, to a level comparable with that adopted for the other communities as described in Section 5.1.2 hereunder and in Annex 3, so that a conceptual layout and cost estimate can be prepared for a suitable installation. In addition, it is essential that a careful analysis, involving a visit to Frobisher Bay if essential and a detailed review of all available information, be made of the Arctic Char fishery on the Sylvia Grinnel River to assess whether this issue could be satisfactorily mitigated if a hydro development was constructed on this river. The Study Team, discussed hereafter in Section 5.1.2, together with a fisheries specialist, will be responsible for completing this study component.

5.1.2 Rankin Inlet, Baker Lake, Coppermine, Fort Simpson and Rae Lakes

Stage I of the study program will consist of a field visit by a small team of experienced professionals to inspect selected sites near each of the four communities. The technical team would consist of a geotechnical specialist, a hydro-design specialist and a construction specialist. A reconnaissance inspection by such a team is considered to be the most efficient and effective way to submit the pre-selected areas to a first stage of screening. Existing information on pre-selected sites is generally scarce.

The field visit would be preceded by an analysis of all hydrologic information and a careful scrutiny of available maps and aerial photographs to determine likely sites in the area surrounding the communities. This will serve to confirm the sites on which the community selection was based and to identify other potential sites.

This work will be undertaken by a member of NCPC's planning consultant firm, R.L. Walker & Partners Ltd. It will be done partly in the EM&R offices in Ottawa where the most complete selection of maps and photographs is available.

To further focus this preliminary site-identification work, the specialist consultants will be given an indication of the size of development necessary to achieve replacement of existing diesel generation by hydro power, the maximum warranted investment and the cost of transmission. The figure will be based on the type of information shown in Annexes 1 and 2, modified so as to be as specific as possible to the selected communities. This information will help to focus the field visits on the type of development required.

In addition to this level of hydro installation needed to meet all of the projected electrical demand, the Study Team will be requested to consider the potential of the site for two other levels of generation - a smaller variation of about one-half size that might be suitable for a mixed hydro-diesel system; and larger variation of up to four times the above size that would provide for replacement of oil used for cooking and space-heating demands.

The three-man technical reconnaissance team will be supplemented by a communications specialist as the fourth team member. This specialist, in co-operation with the designated NCPC and EMR management representatives (see Section 7), will help to inform community leaders about the intent of the study program. He will solicit comment from the community leaders as well as from experienced local people, such as trappers, on the suitability of the pre-selected sites and on possible other potential sites in the same general area and

will gather information regarding potentially important environmental concerns of developing a small project, as outlined by the technical specialists. Finally, he will attempt to create a positive community interest in development if the technical team considers the selected site to be potentially viable.

Terms of reference will be given to the four-man Study Team during a briefing session in Edmonton before they leave on their reconnaissance mission. All available information will be discussed and available maps, photographs, and background data for each community will be provided. Study requirements together with a synopsis of the background information are provided in Annex 3.

After returning from the field trip, the hydro-design specialist will, with appropriate support from the geotechnical and construction specialists, assess the findings and prepare a preliminary layout for each of the sites considered to offer realistic opportunities. He will then prepare preliminary cost estimates for these sites and co-ordinate the preparation of a number of site reports, in addition to a general field study report. The project co-ordinator will prepare the final report.

5.1.3 Study Reporting

A separate report will be presented for each community detailing all study findings and recommending such further action as appears justifiable. Each report will contain a marked-up map of all sites considered for inspection and a statement concerning the reasons for acceptance or rejection of each. All field information gathered at each site that is inspected will be presented, generally in the form of marked-up maps and aerial photographs, together with a discussion on field conditions including terrain, geology, construction materials, access and transmission line routing, construction methods and schedule. Water availability, storage potential and requirement, energy demand and capability will also be addressed.

Each report will present a sketch layout and cost estimate for the most effective means of meeting the defined load requirement and an economic assessment of its viability that takes into account all maintenance of operating costs including the savings in fuel charges. A discussion of the smaller and larger alternatives, with a provisional cost estimate (±50%) will also be provided. For this stage, the report will give due consideration to energy demand, energy growth and the substitution of heating demand as well as to the potential social and environmental issues but with the exception of the Frobisher Bay Arctic Char fishery issue, will not dwell on these aspects in any detail. Should the Stage I study program indicate that further investigation of one (or more) sites is justified, the relevant report will provide terms of reference and a budget for the next stage of analysis.

5.2 Stage II - Pre-Feasibility/Feasibility Study

On the basis of the Stage I report, NCPC and it's planning consultants will select communities where prospects are apparently sufficiently attractive to warrant a follow-up in the form of a more-detailed study of one or two sites. In consultation with EM&R, one community will be selected for the preparation of a more-detailed study under Stage II of this program. If more communities offer sound prospects, NCPC may request additional funding either from other sources or from the RCDP.

On the technical side, provision will be made for additional aerial photography as required, air photo interpretation and the related ground surveys, soil testing and surficial geologic surveys. Site drilling will not be carried out. The study will generate a design for the hydro facility, the transmission line and the associated requirements. Construction methods would be considered and cost estimates prepared for one or more alternatives in accordance with the demand projections.

On the demand side, specific conditions in the community will be identified and assessed. This would include actual and potential use of electric power and growth prospects of the community. A detailed analysis will be made of the prospects for, and implications and costs of, introducing electric energy for the purposes of cooking and space heating and possibly other uses of electricity for purposes for which it is not currently used. With respect to costs and implications, both those relevant to NCPC and the customers will be considered. Other elements to be taken into account are existing or possible uses of waste heat from diesel plants and opportunities for energy conservation through, for example, better insulation of residences and other buildings.

The study would also identify and assess probable environmental concerns relating to the specific project proposals arising out of the study. An Initial Environmental Evaluation will be prepared in accordance with NWT Government requirements.

Finally, attempts will be made to involve the community in the study and to create an atmosphere of positive cooperation towards a possible hydro development near the community.

If the study results in a positive assessment, NCPC may request EM&R to finance final pre-investment studies and construction under Phase II of the RCDP program. This pre-investment study would also be phased carefully. Initially, site drilling is likely to be necessary to confirm or modify the cost estimate. If the project remained attractive, additional environmental work would be necessary in order to obtain regulatory approval. Once such approval is obtained, a commitment could be made followed by final design and construction.

5.3 NCPC - Funded Activities

In addition to the study program outlined above, NCPC proposes to undertake another study with its own funding as a direct contribution to the development of hydro potential in the NWT. As mentioned in Section 3, the Inuvik-Tuktoyaktuk system has a very large oil consumption. More than 3 million gallons of diesel oil and fuel oil are used annually by NCPC and another 1 to 1.25 million gallons by private industries. A special characteristic of this system is the use of waste heat and of boiler fuel for the utilidor system. Though NCPC concluded that the use of gas from a dedicated well used exclusively for replacement of oil in NCPC's installations would not be economically attractive, EM&R will, presumably, assess the possible use of gas in a wider context in an announced study, to be made in the winter of 1983/84, of potential use of gas in the NWT. It would be valuable, both for NCPC and EM&R, to have also a preliminary assessment of hydro opportunities in this area. Several reconnaissance studies have been made of opportunities for large hydro sites at distances of several hundreds of kilometers from Inuvik but attention has not yet been focussed on the supply of electric power to the existing communities to replace current and expected oil consumption for electric power generation and, possibly, space heating. NCPC has already initiated some work to review opportunities.

6. TIME SCHEDULE

EM&R and NCPC are eager to initiate and complete the Study Program without delay. It remains possible to arrange for the fieldwork of the first stage to be undertaken during 1983. This requires a very tight schedule, as follows:

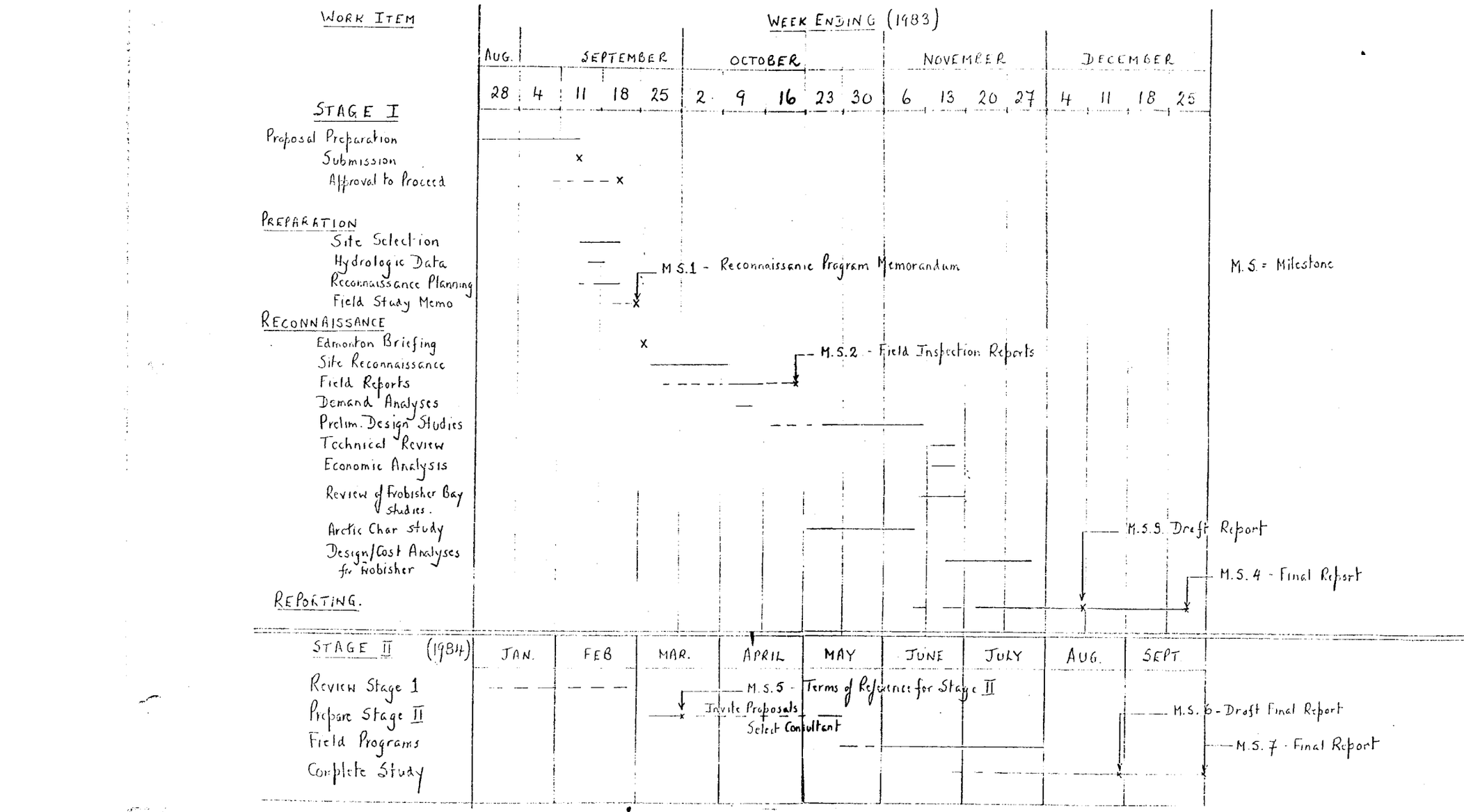
September 9 or before:	discussion of proposal and informal approval of the same with such modifications as may be agreed upon;
September 15:	formal approval to proceed;
September 9-19:	final site selections and organization of the field reconnaissance;
Sept. 19 - Oct 15:	field reconnaissance.

Assuming that this time schedule can be met, the winter period would be used to prepare the first stage report, select a community for more-detailed study, prepare Terms of Reference for this study, invite proposals, select a consultant and initiate the work. The necessary ground surveys would be undertaken as soon as possible in 1984, say June and by the end of September of 1984 (as required under the RCDP-Phase I), the second stage could be completed. NCPC could then decide, in cooperation with EM&R, whether it would be justified to proceed to site drilling, environmental surveys as necessary, regulatory approval, detailed design and subsequent construction (assuming that the Stage II findings are confirmed) all to be financed under Phase II of the RCDP.

The schedule for both Study Stages is indicated on Figure I.

FIGURE - I

NORTHERN CANADA POWER COMMISSION - SMALL HYDRO INVESTIGATION PROGRAM, N.W.T.



7. STUDY MANAGEMENT AND PERSONNEL

The Study Program will be managed by a Committee consisting of four persons, two from NCPC and two from EM&R, under the chairmanship of Mr. John D. Allan, Assistant General Manager, Operations and Engineering, NCPC. The Committee will meet routinely, to review progress and ensure that the study funds are wisely spent, and from time-to-time specifically for the purpose of assessing the significance of milestone outputs (see M.S. Notations on Figure I) and re-directing or curtailing the scope of work as appears appropriate. The Committee will also be responsible for giving direction to and approval for all communications activities associated with this study program.

The Management Committee will be assisted by R.L. Walker & Partners Ltd., who have assisted NCPC for some years with a number of small economic and planning studies. The involvement of R.L. Walker & Partners Ltd as Study Co-ordinator, will be limited to assistance with study planning and management, minor preparatory technical studies, preparation of Terms of Reference, evaluation of proposals, supervision of consultants, economic and financial evaluation of results and preparation of summary reports. NCPC values their ability to provide intermittent assistance of this type and they have become thoroughly familiar with NCPC and its operations. Depending on requirements, particular tasks may be performed by either or all of Messrs. Diddens (economist), Kirch (civil engineer - hydrologist) and Swales (civil engineer - hydraulic and systems specialist). All three are senior professionals with appropriate small hydro experience and are resident in Edmonton, NCPC's headquarters. Preliminary site selection based on detailed analyses of maps and aerial photographs at the EM&R offices in Ottawa, will be performed by R.L. Walker of the Ottawa office of R.L. Walker & Partners Ltd. Mr. Walker is eminently qualified for this work. C.V.'s of these four consultants are attached (Annex 4).

It is NCPC's normal practice to request proposals from at least three reputable consultant firms for specific site studies as well as for other studies requiring a significant effort. This procedure will be followed with respect to the Stage II studies to be performed with RCDP funds. Typical letters of invitation and Terms of Reference for a pre-feasibility study, to be modified and adjusted on the basis of Stage I findings, are attached for information only as Annex 5.

NCPC intends to follow a different procedure with respect to the selection of the members of the reconnaissance team who will undertake the first screening of communities and sites, during September - October of this year. In the first place, time constraints would not permit NCPC to follow a normal proposal call and evaluation procedure after receipt of approval to proceed from EM&R. In addition, the qualifications of the experts are of such overriding significance for this job that selection on a personal basis is preferable.

NCPC has, for the technical members of the team, contacted several consultant firms and construction companies and explained the particular requirements. These firms have responded by submitting one or two names of experts on their staff or of others they know who would be qualified and would likely be available in the period September 15 - October 15. NCPC has selected a team of three whose C.V's are attached. Back-up experts of similar qualifications are also available in case the nominated experts have been assigned to other work in the meantime.

The nominated experts are:

Hydro Design Engineer — Mr. Roland M. Jost.

Mr. Jost is currently employed by Lavalin-Shawinigan Consultants Inc., Montreal. Mr. Jost has more than 30 years of experience as design engineer, predominantly in hydro projects. Much of his experience has been accumulated on projects of various sizes in Quebec, New Brunswick, Newfoundland and Labrador and has included work in northern areas. Of particular interest is his work in

Newfoundland and Labrador. During his period as Manager of Engineering for Shawmont Newfoundland Ltd., the company performed a screening study of 40 isolated communities in order to determine opportunities for small hydro plants in Newfoundland and Labrador. The company was also responsible for the modernization of the Deer Lake plant in Newfoundland. Generally, Shawinigan has developed extensive experience in the small hydro plant area in Canada, the USA and overseas.

Construction Specialist — Mr. Earl G. Brunsdon

Since 1981, Mr. Brunsdon has been a staff engineer for Acres Consulting Services Limited, located in Winnipeg. His responsibilities cover construction methods and techniques, estimating, construction planning and scheduling and contracting procedures.

Prior to joining Acres, Mr. Brunsdon had 30 years of construction experience from junior engineer to Vice-President and Chief Engineer of a major construction company. He has worked on large and small projects, including a number of hydro projects, in Northern Quebec, Northern Manitoba, Northern Saskatchewan and Northern British Columbia.

Geotechnical Engineer — Mr. Fred Claridge

Mr. Claridge is President of Komex Consultants in Calgary. A geotechnical specialist, he has about 20 years of experience on many projects, large and small, in Canada and overseas. He has done extensive work in the Northwest Territories, the Yukon and Alaska and Northern BC mainly concerned with pipeline projects, Esso's Norman Wells project and mining projects. He is a specialist in construction problems associated with permafrost conditions. His expertise is acknowledged in his role as an expert witness before several regulatory and environmental boards or commissions, including the United States Federal Power Commission.

Communications Specialist — Mr. Ben A. Hubert

Mr. Hubert is President of Boreal Ecology Services Ltd., Yellowknife. He has obtained degrees in Zoology (1970) and boreal ecology (1974) and has made the environment of the north his special area of expertise. Between 1974 and 1977 Mr. Hubert was employed by the Government of the Northwest Territories in the area of wildlife management and from 1977 until formation of his consulting practice was Executive Secretary to the NWT Science Advisory Board. In addition to studies in Alaska, Scandinavia and the USSR, he has travelled extensively in the NWT.

As a consultant, Mr. Hubert has been retained by both the Federal and Territorial Governments as well as by Inuit, Dene and Metis organizations. His experience with the Science Advisory Board has led him into communications with many northern groups concerning renewable resources, energy, population growth and many development issues.

8. STUDY PROGRAM-BUDGET

STAGE I

Preparation		
Map and Photo Analysis	$3,600	
Hydrologic data review	1,200	
Site selection and reconnaissance planning	3,000	
Expenses, including maps & photographs	750	
		8,550
Reconnaissance (six communities)		
Travel to and briefing in Edmonton	4,000	
Reconnaissance of sites (15 days)	32,700	
Reconnaissance reports:		
- technical	8,650	
- community issues	1,000	
- environmental issues (including Frobisher)	6,000	
Preliminary design studies (including Frobisher)		
- technical	22,500	
- demand/economic analyses	1,800	
- air photo interpretation	5,000	
- review	2,000	
Report Preparation	6,500	
Study Co-ordination	9,000	
Typing and Drafting Services	7,000	
Expenses:		
travel to Edmonton	1,250	
travel to Frobisher	750	
aircraft rental	9,500	
Helicopter usage		
- mobilization allowances	13,000	
- usage	20,150	
Board accomodation	10,800	
Office expenses	2,850	
		$164,450
Total Stage I		$173,000

STAGE II

Pre-feasibility Study of One Community

Site Investigations:	
- Ground surveys, geology, soils, construction materials	$15,000
- Demand, heating loads, environment	5,000
Office Studies:	
- Technical	12,000
- Demand, heating loads, environment	5,000
- Economic and financial assessment	5,000
Transport, including local labour allowances	15,000
Photography	4,000
Miscellaneous, including report	4,000
Co-ordination	3,000
Total Stage II	$68,000
Total Stage I and Stage II	$241,000
Contingency	9,000
Total	$250,000

Explanatory Notes

Personnel

Daily fees are as follows:

Messrs Diddens, Kirch, Swales and Walker of R.L. Walker & Partners Ltd., study co-ordinators	$600
Mr. Jost	630
Mr. Brunsdon	500
Mr. Claridge	600
Mr. Hubert	450

A fee of $300 per day has been estimated for technical support to Mr. Jost for the purpose of preparing preliminary designs and cost estimates. A rate of $25/hour has been used for estimating typing and drafting services. In all cases, personnel will be required to confirm that the services provided for this project will be charged at 'most-favoured' rates.

Transport

Flights on the reconnaissance trip have been estimated on the basis of rates for scheduled flights. Preliminary inquiries suggest that it may be possible to charter a small two-engine plane in Edmonton or Yellowknife for the whole trip at a comparable or even somewhat lower price. This would make it possible to schedule the trip to the five communities in 15 days or somewhat less depending upon weather conditions.

A provision has also been made for bringing helicopters from base to Coppermine and Rankin Inlet - Baker Lake. However, until at least 15 September, a helicopter will be available at Rankin Inlet, according to current work schedules. Early approval of the proposal may make it possible to avoid an mobilization fee for Rankin Inlet and a reduced fee for Baker Lake.

ANNEX 1

TABLE 1

REGIONAL

NCPC-ISOLATED PLANTS 1982/1983
IN RANK ORDER OF NET PRESENT VALUE @ 5PERCENT

COLUMN	1	2	3	4	5	6		8	9	10	11	12
	PLANT	ENERGY MWH	PEAK LOAD Kw	INST CAPACITY Kw	FUEL CONS 1000 GALLONS	FUEL GR PRICE CTS PER GALLON	TO 2/3 R 4 Y	NPV,$MLN CONST PRICES, 1983 40 YEAR, PERCENT 3	5	7	CAPACITY REQUIRED Kw	NPV @ 5 % CONST PR 1983 $1000/Kw
NORTHWEST TERRITORIES												
1	FROBISHER BAY	20972	3900	9945	1245.4	186.1	2.0	99.2	69.9	51.7	4516	15
2	RANKIN INLET	6378	1205	2720	460.7	211.7	1.6	38.1	27.1	20.2	1342	20
3	CAMBRIDGE BAY	4918	1010	2685	316.0	202.9	1.9	26.4	18.7	13.9	1156	16
4	BAKER LAKE	3752	900	2104	284.0	211.7	2.4	26.3	18.6	13.7	1084	17
5	RESOLUTE BAY	5883	1030	4450	396.3	192.0	.4	25.4	18.3	13.8	1018	18
6	ESKIMO POINT	2872	660	1680	235.1	211.7	3.4	25.3	17.7	12.9	876	20
7	FORT SIMPSON	5768	1000	5485	389.3	154.7	1.2	24.1	17.1	12.7	1070	16
8	PANGNIRTUNG	2641	650	1355	183.6	266.1	3.5	23.9	16.8	12.3	871	19
9	FORT FRANKLIN	1904	350	900	110.9	163.3	9.1	24.0	15.8	10.8	794	20
10	CAPE DORSET	2178	460	1500	145.1	266.1	2.8	17.0	12.1	8.9	576	21
11	COPPERMINE	2603	560	1975	171.4	208.0	2.7	16.4	11.5	8.4	719	16
12	IGLOOLIK	2286	460	1200	164.5	158.9	3.7	15.1	10.4	7.5	628	17
13	SPENCE BAY	1783	450	900	131.9	265.6	1.9	13.6	9.7	7.2	516	19
14	CORAL HARBOUR	2301	470	550	167.9	211.7	1.3	13.3	9.5	7.1	508	19
15	GJOA HAVEN	1424	350	750	118.0	260.4	2.5	13.1	9.2	6.9	426	22
16	AKLAVIK	2099	560	1800	152.9	172.3	2.5	12.4	8.7	6.4	681	13
17	POND INLET	2511	610	1300	179.1	158.0	9.8	12.3	8.6	6.4	764	11
18	FORT McPHERSON	2386	600	1350	168.9	165.5	1.8	12.0	8.4	6.2	681	12
19	PELLY BAY	995	220	560	75.7	424.3	2.0	11.7	8.4	6.3	255	33
20	BROUGHTON ISLAND	1213	250	700	91.0	266.1	2.9	10.9	7.7	5.7	316	24
21	CLYDE RIVER	1502	320	750	107.0	158.0	2.5	8.2	5.7	4.2	389	15
22	ARCTIC BAY	1218	315	900	94.4	162.8	2.9	7.8	5.4	4.0	398	14
23	LAKE HARBOUR	1045	190	625	68.4	266.1	2.6	7.8	5.5	4.1	233	24
24	HOLMAN ISLAND	990	267	625	79.7	220.6	2.3	7.5	5.3	3.9	318	17
25	FORT GOOD HOPE	1201	320	450	95.3	174.9	1.8	7.0	5.0	3.7	363	14
26	REPULSE BAY	1050	220	565	86.0	158.9	2.7	6.8	4.7	3.4	273	17
27	SACHS HARBOUR	1137	321	700	81.5	208.5	1.4	6.5	4.6	3.4	350	13
28	HALL BEACH	1138	215	575	80.7	159.8	3.0	6.7	4.6	3.4	274	17
29	CHESTERFIELD INLET	800	200	650	65.8	211.7	2.5	6.2	4.4	3.2	243	18
30	FORT NORMAN	1422	290	800	92.8	167.4	1.3	6.2	4.4	3.2	313	14
31	PAULATUK	538	135	380	43.9	220.2	2.6	4.3	3.0	2.2	166	18
32	WHALE COVE	763	185	650	39.5	211.7	1.9	3.4	2.4	1.8	212	11
33	SNOWDRIFT	504	132	430	45.2	157.5	2.2	3.3	2.3	1.7	156	15
34	LAC LA MARTRE	581	145	310	45.0	158.7	1.6	3.0	2.1	1.6	161	13
35	FORT LIARD	503	197	450	41.9	154.9	1.8	2.8	2.0	1.5	224	9
36	GRISE FJORD	492	120	490	40.6	158.0	1.6	2.7	1.9	1.4	134	14
37	WRIGLEY	273	68	425	42.6	153.8	.9	2.5	1.8	1.3	71	25
38	ARCTIC RED RIVER	393	82	280	30.3	164.0	1.1	1.9	1.4	1.0	67	16
39	RAE LAKES	265	67	160	26.4	162.1	1.5	1.6	1.3	.9	74	18
40	NAHANNI BUTTE	77	20	121	10.5	157.9	1.0	.7	.5	.4	21	24
41	JEAN MARIE RIVER	53	15	61	9.6	148.0	2.0	.6	.5	.3	17	29

Notes on Table 1 Annex 1

Columns

1 All communities in the NWT served by NCPC except Norman Wells, Inuvik, Tuktoyaktuk and the communities connected to the Snare-Yellowknife and Taltson systems.

2 - 6 Basic data from NCPC's operational records. Checks consisting of calculations of efficiency and load factors suggest certain discrepancies and internal inconsistencies due to the provisional nature of the data when compiled. When specific figures are to be used, basic data should be confirmed.

7 Growth of demand per 1982 forecasts prepared by Hildebrandt-Young and Associates. The growth rates show certain anomalies such as, for example, the extremely high growth rate for Fort Franklin. These forecasts must also be confirmed when used for specific purposes.

8 - 10 The net present value of 40 years of fuel use in 1983 prices. The following observations are in order:

- It is assumed that the value of fuel to be replaced by a hydro plant determines, in order of magnitude, the investment which can be justified for the hydro plant and associated transmission facilities. This implies that savings from a possible reduction of diesel capacity and replacement of

Whereas the balance of assumptions may be somewhat unfavourable to a possible hydro plant, a hundred percent of potential fuel savings have been credited. This will be too much, since proper operating procedures, and in many cases operating economics, will require that some energy be generated by the standby diesel plant.

- Existing fuel consumption in 1982/83 is taken as a basis for fuel consumption. This implies that technical parameters such as fuel efficiency and load factors are assumed to remain constant. It also implies that the 1982/83 fuel demand is assumed to be representative in terms of exogenous factors such as climate.

  No allowance is made for additional fuel consumption which may result from waste heat recovery.

- Fuel prices have been escalated, in constant prices, over a 20 year period and are then held constant at the level reached in the year 2003.

  Fuel prices were related to a base price which is the bulk delivery price, in Edmonton, of May 1983. Half of the difference between the plant gate price and the base price is assumed to consist of fuel associated cost which escalates at the same rate as the base price. The other half is assumed to remain constant in 1983 prices.

  The portion of the fuel price which escalates, in constant prices, is assumed to escalate proportionately to the escalation assumed for off-road diesel oil and industrial fuel oil in Alberta by EM&R in it's tables supporting the National Energy Program, Update 1982 (June 1982). In terms of indices,

assuming an index of 100 for 1983, diesel oil would escalate to 168 and fuel oil to 148 by the year 2003.

- Fuel use (demand) is also increased over 20 years using the rates of column 7. After these 20 years, demand was held constant.

- The discount rate of 3 percent is representative, in constant price terms, of the long-term financial cost of money of NCPC. The discount rate of 7 percent is frequently used by EM&R for the purpose of assessing off-oil projects and programs. An intermediate discount rate of 5 percent may be used to determine values which may be used, as a first and rough order of magnitude, to determine warranted investment.

11 The capacity required is a rather arbitrarily determined figure to indicate the order of magnitude of this parameter. The following assumptions are made:

- Hydrocapacity will be set to serve about 90 percent of peak demand. Combined with a 5 percent transmission loss to the receiving substation, the basic 1983 capacity is 95 percent of peak load.*

- Capacity will be built for projected demand after 10 years.

12 Column 5 (NPV of 40 years of fuel use at 5 percent discount rate) divided by column 11 (capacity required).

These figures are not comparable to similar figures usually quoted since, in this case, the figures include the cost of transmission. The figures are of some interest as relative indicators of warranted investment but should be used with great caution.

*N.B. This is not consistent with current NCPC practice.

For example, explanations for some of the high figures are very low current efficiencies at Wrigley, Nahanni Butte and Jean Marie River. For Pelly Bay, Broughton Island and Lake Harbour, high fuel prices are important factors as well as, in the case of Lake Harbour, a high load factor. At the bottom end of the scale, a very low load factor is responsible for the low value for Fort Liard, whereas low fuel price is a significant factor in the case of Pond Inlet. A very (impossibly) high efficiency factor affects the values for Whale Cove.

The preceding explanations are partly reasonable but also suggest that there are some anomalies caused by inconsistencies in basic data. These should be checked when figures are to be used in specific cases.

ANNEX 2

ANNEX 2

Transmission Line Cost

The following costs of transmission lines represent average costs of construction in the Northwest Territories in "normal" terrain. Costs in particularly isolated areas or in rough terrain may be significantly higher. All costs are in 1983 prices.

The costs exclude substation facilities at the plant side of the line which are assumed to be included in the plant cost.

1. Up to about 1.5 MW plant capacity

Fixed cost:	$25,000
Cost per km:	$50,000 for distances up to 125 km
	$75,000 for distances over 125 km over total length

Costs based on 35 kV and 69 kV lines, respectively.

2. Plants with a capacity from about 1.5 MW to 7 MW

Fixed cost:	$750,000
Cost per km:	$75,000 for distances up to 125 km
	$125,000 for distances over 125 km, over total length

Costs based on 69 kV and 138 kV lines, respectively.

3. Plants with a capacity of more than 7 MW

For smaller plants in this size range and relatively short distances, $1,5 mln + $125,000 per km may be appropriate (138 kV).

ANNEX 3

FROBISHER BAY

1. Background

The Commission's interest in identifying a hydroelectric project to meet some or all of the electrical (and heating) needs of the community of Frobisher Bay dates back to at least the early 1970's when arrangements were made with the Water Survey of Canada to obtain hydrometric measurements on the Sylvia Grinnel River.

A preliminary study was carried out by NCPC in 1972 to identify a possible development concept for a hydroelectric development on this river. The short report prepared at that time provides a useful description of the area and some of the development difficulties. Sections A - I inclusive of that report are attached for information.

Shortly after preparing this report, NCPC was advised by the Fisheries Service of Environment Canada that:

> "The location of the falls on the Sylvia Grinnel is particularly fortuitous from a fishery point of view, as char can only pass this barrier during high spring tides. The fish are thus readily available to fishermen for a period of about a month. The river can yield about 25,000 lbs. of char annually. These fish are now of great significance to the community and are utilized both for sport and domestic purposes. If most of this were utilized for a sport fishery it could be of still greater importance to the community both economically and sociologically. They were, of course the reason for the establishment of the original Eskimo settlement.
>
> We consider it highly unlikely that any facilities could be built in to a hydro development which would permit passage of the Arctic Char, since this species does not readily mount major obstacles, nor does it persist on long migration routes. The community and govern-

ment would therefore have to accept the probable loss of this run of fish if the development should proceed. We believe that it is important that this fact be recognized."*

In 1975, NCPC again looked at the Sylvia Grinnel River and concluded that a scheme very similar to the one identified in 1972 could produce about 6 MW of firm power for electric and heating energy use and that, based upon a preliminary cost estimate of $18 million and anticipated escalation of fuel prices, such a scheme would be economically justified for an early construction start.

In the same year, NCPC also carried out a reconnaissaance of several alternative sites on the Armshaw, Ward Inlet and Anna Maria Port Rivers. Consideration was also given to a possible diversion from the McKeand River. It was considered unlikely that there were any economically-attractive possibilities for development on any of these watersheds.

Also in 1975, a Consultant was retained to make an overview assessment of the hydroelectric potential of these other river basins in the Frobisher Bay area. He concluded that:

- the Sylvia Grinnel River provides the best alternative for development;
- a technical and economically feasible scheme can be developed on this river; and
- in view of the depleted arctic char existing in the Sylvia Grinnel system, an annual program of fish stocking with freshwater char was worthy of consideration as an alternative to the salt water variety as a mitigative measure.

* Letter dated October 2, 1972 to D. Steen from R.J. Paterson, Head, Resource Development Branch, Fisheries Service, Environment Canada, Winnipeg, Manitoba.

A copy of this report by Margison and Associates can be viewed in the Commission's offices in Edmonton.

NCPC personnel upgraded its proposals for a development on the Sylvia Grinnel River in March, 1976 and concluded tha a 4 MW installation would provide operating economics over the existing diesel generation system for earliest possible commissioning and a 6 MW installation would be economic by 1974.

A study, based upon photogrammetric analysis of 1" to 4,800 feet and 1" to 1,000 feet photography of the proposed damsite areas, was carried out by J.D. Mollard and Associates Ltd., Regina in 1976. Other information available to Mollard was 1:5,000 topographic maps with 2m contours of both Sylvia Grinnel Lake outlet and potential power dam storage areas. Access to all of this material, including the Mollard report, from NCPC can be arranged.

During 1975 and 1976, additional study of the Arctic Char fishery was also carried out to improve the documentation on the life cycle of this species and assess the impact of a hydroelectric project on its environment. Since that time, it is understood the Arctic Char has continued to be heavily overfished below the rapids at the mouth of the river. Steps were being taken to restrict fishing in 1982 so as to allow the species to recover.

2. Study Requirement

This study is required to:

a) ascertain on the basis of desk studies, whether there is any reasonable alternative to the Sylvia Grinnel River for development of a hydroelectric generating station to serve Frobisher;

b) review all available information on the Sylvia Grinnel River hydroelectric development proposals and prepare realistic preliminary project designs and cost estimates for stations in the small to 12 MW capacity range; and

c) gather all pertinent information on the Arctic Char fishery and provide a statement on the relationship between this fishery and a potential hydroelectric development on the Sylvia Grinnel River as identified in b) above.

Based on reasonable future diesel prices, and the 1981 Hildebrandt-Young load growth forecast, R.L. Walker & Partners Ltd. have estimated that the present value (in 1983) of costs for a diesel fuel replacement at Frobisher for 40 years is in the order of $70 million (in 1983 dollars) at a discount rate of 5% or $52 million at 7%.

Before proceeding with any further evaluation of the Sylvia Grinnel hydro potential previously identified, which would involve expensive field investigations, NCPC would like to be confident that no other hydroelectric options appear to be available and also that the Sylvia Grinnel development, as proposed, is technically and economically feasible and likely to be environmentally acceptable.

NORTHERN CANADA POWER COMMISSION

OUTLINE OF SYLVIA GRINNEL RIVER POWER PROPOSAL

DESCRIPTIONS

A. Sylvia Grinnell River

The Sylvia Grinnell River is fed by one major lake, Sylvia Grinnell Lake, which drains a total of 300,000 acres. As a comparison, the drainage area of the entire river at its mouth is 750,000 acres.

The river flows easterly from Sylvia Grinnell Lake to the confluence with the northern branch of the river. From here, it flows south about 20 miles where it empties into Frobisher Bay. Total drop from Sylvia Grinnell Lake to the mouth is an estimated 475 feet.

B. Tributaries

There are several minor streams, flowing into the River, although the only major tributary is the north branch. The entire area is dotted with small lakes which drain into the Grinnell in summer.

C. Climate

The Sylvia Grinnell drainage area has a mean annual temperature of 15°F and approximately 15 in. mean annual total precipitation. Snowfall averages 80 in. while rainfall averages 7 in. per year.

Lakes in the region have had up to 100 in. of ice depth measured.

D. Geology

The Sylvia Grinnell Basin comprises part of a lowlands between two major physiographic features, the Frobisher Bay Upland and the Hall Upland. This lowland is an area of low-lying, lake-studded granitic rocks.

On the southwest, the area is bordered by a fault line scarp with steep faces, while the northern margin slopes more gradually with no obvious features indicative of faulting.

Linear features are common in the bedrock and as a result there are many long, narrow lakes. Bouldery drift covers much of the surface, but is extremely thin, and bedrock can be found easily almost everywhere. The area is underlain by both Precambrian and Paleozoic strata.

The Sylvia Grinnell Lake outlet works would be located in an area of gneissic granite bedrock. This rock is described by the Geological Survey of Canada as pink or grey, well foliated, exhibiting a wide range of grain size within a single specimen, with an uneven texture best described as interlocking and inequigranular.

D. Geology Cont'd.

The main dam and canal would be located in an area of glacial drift, underlain by quartz-feldspar gneiss, while the powerhouse would be constructed directly on the quartz-feldspar gneiss. These rocks weather to a buff colour, and have a texture described as interlocking and inequigranular.

E. Hydrology

A program of stream flow measurement was undertaken during 1971. This consisted of continuous flow measurements near the mouth from January to December, and revealed that virtually no flow was present during the months of October to May.

With a total drainage area of 1170 sq. mi. at the mouth, last year's mean flow corresponded to .82 cfs/mi^2. Maximum daily discharge was 10,000 cfs early in July.

Preliminary hydrologic work indicates that a long term mean flow at the mouth of approximately 1200 cfs can be expected. The long term mean annual flow at the outlet of Sylvia Grinnell Lake is estimated to be 500 cfs.

Further flow measurements are to be taken this summer to help firm up our hydrologic work. As well as flow measurements at the mouth, periodic measurements at the outlet of Sylvia Grinnell Lake will be taken to correlate flows at the outlet with those at Frobisher Bay.

F. River Profile

Sylvia Grinnel Lake is approximately 475' a.s.l. The water empties into the river through a narrow channel through a set of rapids and then flows through a meandering channel to the confluence with the north branch. From here, it swings south and drops through a U-shaped valley for about 10 miles to the favoured project area. Here the river drops some 150 ft. in about 4 miles, in a series of rapids. At the outlet to the Bay, there is a waterfalls which varies from 10 to 40 ft. with the tides in Frobisher Bay. In most reaches of the river, gravel and coarse sand deposits are abundantly spread across the channel.

G. Existing Facilities and Structures

The proposed dam site is located about 10 miles north of Frobisher Bay, while the proposed storage works are thirty miles further north at Sylvia Grinnell Lake. The nearest existing structures or access roads are at Frobisher Bay townsite.

H. Site Plan and General Concept

It is estimated that a regulated flow of approximately 875 cfs can be achieved developing 450,000 acre ft. of storage on Sylvia Grinnell Lake. This corresponds to about 30 ft. of storage, which could be obtained by either raising Sylvia Grinnell Lake, or drawing from bottom storage, or any combination of both.

The preferred site, as envisaged at this time, is as follows:

A 40' high storage dam would be located about 1 mi. downstream of the lake outlet. The spillway would probably consist of a gated canal located in a saddle about 1/2 mi. west of the dam, and emptying into the river about 1/2 mile downstream of the dam.

The main dam would be located 30 miles downstream from the lake in a narrow canyon 9 miles upstream of Frobisher Bay. A 600 ft. long dam, 80 ft. high with a crest elevation of about 300 ft. would be required.

The spill flows would be discharged through either a tunnel or canal spillway. Both dams would likely be of rockfill type.

The water could be diverted around the main dam by an open cut canal excavated the rock. The canal will route the water some 10,000 ft. along the top of the embankment to the penstock intake. The 1,000 ft. long penstock, either of steel or wood stave, would drop the water 150 ft. to the powerhouse. For full development of the river, one or two turbine units would be used to generate approximately 12 - 15 MW with up to 85 x 10^6 kwh per year available.

The existing generating equipment in Frobisher Bay would likely be maintained as standby and peaking in later years.

I. Problems Relevant to Viability of the Hydro Site Development

A. Environmental

The large drawdown which would be required on Sylvia Grinnell Lake for maximum utilization of the river's hydro potential would likely affect lake flora productivity. As there is a suspected good char run in the Grinnell River, means of escorting the fish around the canal diversion and dam would likely have to be incorporated.

Should our engineering feasibilities studies indicate the desirability of developing the area, studies would be undertaken to determine the effect of the development on the environment.

B. Engineering

At least two of the major concerns for the feasibility of this site, the magnitude of water losses due to freezing in the river section between Sylvia Grinnell Lake and the main dam, and location and quantities of suitable construction materials in the area will be given special consideration.

FORT SIMPSON

1. Background

Located on the Mackenzie Highway at the junction of the Liard and MacKenzie Rivers (61°52'N, 121°23'W), Fort Simpson's history dates back to 1804 when it was established as a fur-trading centre by the North West Company. It's present population is very close to 1,000. Parks Canada's headquarters for the Nahanni National Park is located in the community.

Annual electric energy consumption for 1982/83 was 4,768 MWh and the peak load was 1.0 MW. The installed capacity of diesel plant is 5.485 MW. Diesel fuel consumption was about 390,000 gallons.

For the year 1978/79, electrical demand was about the same at 5,867 MWh. Heating oil consumption in that year was 838,829 gallons - equivalent to 27,700 MWh of electrical demand at the consumer's location assuming reasonable rates of generation efficiency. Thus the total heating demand would appear to be about five times the electrical demand.

Order-of-magnitude computations have indicated that the net present value (in 1983) of fuel consumption to meet the electrical load only over a period of 40 years, at a discount rate of five percent, is $17.1 million*. No estimate is possible, based on readily available data, to assess the potential benefits of heating oil substitution.

Over the past twenty years, a number of studies of hydroelectric potentials in the area of Fort Simpson have been carried out. Several of these were of the Nahanni River which is now a National Park. Other rivers considered include the Petitot, a tributary of the Liard, the North Nahanni, and the Willow

* Provisional value to be confirmed.

Lake Rivers, both tributaries of the MacKenzie to the north of the community. However, in all these cases, long transmission lines would be necessary and the net economic benefits appear unsatisfactory.

The Commission carried out a desk study of the area in 1975 and concluded that a small development on the Trout River, while superior to one on the Willowlake River - the next best alternative, would not be competitive with the existing system until perhaps 1981/82. The scheme considered would comprise a storage control structure at the outlet of Trout Lake and generating facilities at Whittaker Falls near the MacKenzie Highway. The transmission line, generally following the Highway, would be some 130 km in length.

The Commission's analysis indicated a possibility of providing a firm flow of up to 23 m^3/sec during the winter. If all of the approximately 20m head at the Falls could be developed, a maximum continuous output of 4 MW would be available. A crude estimate of costs in 1975 prices suggested that the scheme would cost in the order of $8-9 million including the transmission line. Costs have probably doubled over the last eight years but the order-of-magnitude is sufficiently close to justify a more-detailed examination.

The Commission has available for examination (ozalid) copies of aerial photography prepared by Burnett Resource Surveys Ltd in 1976. Mapping at scales of 1:2,000 with 2m contours for the development sites and 1:5,000 with 5m contours throughout the area, is available.

2. Study Requirement

Study of the potential for serving Fort Simpson with a small hydro development will be limited to consideration of the Trout Lake/Whittaker Falls scheme only. While it is acknowledged that this project would have some adverse environmental impacts, and these will be noted briefly in the final report, the Stage I study will be restricted to an analysis of the engineering and cost aspects only to determine whether a technically feasible and economically attractive development is conceivable.

COPPERMINE

1. Background

Located at the mouth of the Coppermine River, (N67°50', W115°05'), the Inuit community of Coppermine has been a permanent settlement since the late 1920's. The present population is about 760. The total consumption of electric energy in 1982/83 was 2,703 MWh, and the peak load was 580 kW. NCPC supplies power from a diesel installation of 1,975 kW total capacity. Fuel consumption in 1982/83, for meeting the electric load only was 171,400 gallons.

Data for 1978/79 indicate that the total electrical demand was 1,999 MWh while the heating oil consumption was 304,583 gallons. At reasonable efficiency levels, this usage is equivalent to some 10,000 MWh of electrical demand at the consumer's location - about five times the actual electrical demand.

Fuel-savings computations have indicated that the net present value (1983) of total fuel consumption over 40 years for the electrical demand only, at a discount rate of 5 percent, is $11.5 million*. This value provides an order-of-magnitude estimate of the capital investment that would be acceptable for an alternative hydroelectric scheme. Assuming that a 69 kV transmission line can be constructed at a cost in the order of $60,000/km, one-third of this level of investment for example, would permit a line of some 65 km to be constructed leaving $7.6 million or $7,600 per kW for a total installation of one megawatt to serve the electrical load.

None of the hydroelectric studies carried out in the past have given consideration to development of a small plant of this size. The Ingledow and Associates Limited report of January, 1969 identifies six sites on the lower reaches of the Coppermine River and presents a number of alternative development proposals varying between 23 and 56 megawatts of firm capacity. A cost estimate

* Provisional value to be confirmed.

($16.8 million) is provided for a partial development of 6.7 MW at the Bloody Falls site but it was concluded that such a scheme would not be attractive by comparison with the thermal alternative. No other details are provided.

Opportunities for small hydro developments on other watercourses in the immediate area do not look encouraging. There are no other significant streams and few lakes of suitable size and location to provide winter storage capability. Thus a partial development on the main stem of the Coppermine River or a storage/diversion type development on one of the rivers to the west of Coppermine (the Rae, Richardson and Kendall Rivers), which are not readily accessible and at considerable distance, would appear to represent the full range of conceivable possibilities.

2. Study Requirement

Initially, the Study Team will assemble all relevant maps and photographs of the Coppermine area to search for one or more potentially attractive hydroelectric sites that would be worth reconnoitering. If sites can be found, the study will concentrate upon assessing their technical and economic viability. If other sites cannot be located, the study will be devoted to an analysis of partial development schemes on the Coppermine River that are within a reasonable distance of the community. A conceptual layout, cost estimate and economic evaluation of the least-cost solution shall be presented.

For the purposes of this initial reconnaissance, no account will be taken of possible environmental constraints. However, if a potentially attractive scheme can be defined, the Study Team will prepare terms of reference and a scope of work statement, including environmental and socio-economic aspects, for a more-detailed follow-up study.

RANKIN INLET

1. Background

Rankin Inlet is now a community of close to 1,000 people located at 62°49'N, 92°05'W on the western shore of Hudson's Bay. It is the home of the regional offices for the Keewatin District of the NWT Government and is a key centre for transportation and communication linkages within the area.

The annual consumption of electrical energy in 1982/83 was 6,378 MWh. It was supplied from a diesel installation 2.7 MW utilizing about 460,000 gallons of diesel fuel. Heating oil consumption in 1978/79 (the most recent data to hand) was 614,839 gallons - equivalent to some 20,300 MWh of electrical energy assuming reasonable rates of efficiency and close to four times the electrical demand load during the same period.

Order-of-magnitude calculations have indicated that the net present value (in 1983) of fuel consumption to meet the electrical load only over a period of 40 years, at a discount rate of 5 percent, is $27.1 million*. This estimate provides an indication of the level of capital investment that would be justified for an hydroelectric development and transmission line to be economically competitive. Consideration of the potential costs and benefits of substitution for all or part of the heating load may indicate the viability of a substantially larger development but that is a subject for more-detailed assessment during a second study phase should results of the reconnaissance prove encouraging.

Studies of the potential for meeting the needs of this community with a small hydroelectric project have not been carried out. Power surveys sponsored by the federal government (UMA Group 1980) have demonstrated the potential for hydroelectric developments on the Ferguson and Maguse Rivers to the southwest of

* Provisional value to be confirmed.

Rankin Inlet but the schemes considered are all too big and much too costly to rank as "potentially-viable". Nevertheless, the immediate hinterland is not generally attractive for hydroelectric development. The reconnaissance survey should be sufficient to determine whether a potentially economic opportunity exists. That is the purpose of this study program.

A suggestion has also been made that a modest site on one of the four rivers considered in the UMA, 1980 report could serve more than one of the several communities along this coast, i.e. Chesterfield Inlet, Whale Cove and Eskimo Point in addition to Rankin Inlet and perhaps also Baker Lake. However, the distances between these communities are considerable and it is evident that the cost of the transmission line interconnections alone would exceed any potential savings in fuel costs over a reasonable economic life. Thus consideration of such a scheme is excluded, at least until heat load substitution analyses for one or more of the larger communities indicates that such an option is potentially viable and acceptable.

2. Study Requirement

Initially, the Study Team will assemble maps and aerial photographs of the area inland from Rankin Inlet to assess the potential for a small hydroelectric development. The map study, in conjunction with an hydrologic analysis based on the methodology described in "NWT Water Resources Study", Acres 1982, will indicate whether lake storage, possibly with diversions, could conceivably provide sufficient water to meet the winter demand. It will also demonstrate whether any suitable head concentrations exist for a development within an acceptable distance from the community. The Diana River, augmented by level control on either Peter or Diana Lake and possibly diversion from an adjacent catchment, would appear to be an option.

BAKER LAKE

1. Background

Baker Lake is an Inuit community of 1,017 people located at 64°18'N, 96°03'W on the lake of the same name about 300 kms west of Hudson's Bay. It's peak electric demand is currently about 900 kW and the annual electrical energy consumption is 3,750 MWh. Electrical energy is supplied from 2.1 MW of installed diesel plant.

Up-to-date information on total heating demand is not readily available. Between April 1978 and March 1979, the community used approximately 397,000 gallons of heating oil with a MWh equivalent of 13,100 assuming reasonable rates of consumption efficiency. Since the electrical energy consumption for the same period is stated to be 2,720 MWh, it would appear that the total heating load is nearly five times the electrical load.

Order-of-magnitude computations have indicated that the net present value (1983) of fuel consumption to meet the electrical demand load only over 40 years at a discount rate of 5 percent, is $18.6 million*.

Hydroelectric studies, apart from desk analyses, to identify one or more sites that could serve the community of Baker Lake have not been completed. In 1970, under contract to the Government of Canada, T. Ingledow and Associates Limited, completed a "Power Survey of the Kazan, Dubawnt, Thelon and Hanbury River Basins, NWT". The community of Baker Lake is located at the extreme downstream confluence of these rivers which all flow through Baker Lake and thence through the Chesterfield Inlet into Hudson's Bay. However, the study was oriented towards the assessment of hydro site potentials, not the location of suitable community-specific small hydro developments. Recognizing the transmission distances involved and the affordable cost of an economically-viable development, it appears probable that the Kazan Falls site is the only alternative considered in this report that is conceivably attractive.

* Provisional Estimate - to be confirmed

In March 1980, the UMA Group completed a similar study for the Department of Indian and Northern Affairs, of the Ferguson, Maguse, Tha-Anne and Thlewiaza River Basins to the southeast of Baker Lake. Again, however, the sites examined on the Ferguson River (the nearest to Baker Lake) are all considerably larger than would be required. Together with the cost of access and a transmission line, it would appear that all of these sites could not be economically viable to serve this community alone. A similar study of the Back (and other) River Basin(s) to the north of Baker Lake by UMA completed in March 1979, shows the same difficulties.

During more recent times, NCPC has carried out some reconnaissance and desk analysis studies of smaller developments immediately to the north and west of Baker Lake. These include an un-named river between Schultz and Pitz Lakes with the hydro development located to the north of Pitz Lake, only some 25 kms from Baker Lake, and the Prince River on the northeast side of the community. Both of these alternatives would necessitate the control of additional storage on natural lakes within the basins. Conceivably, a set of rapids on an un-named stream on the north side of the Thelon River, some 60 kms upstream of Baker Lake could provide both reasonable access and a sufficient concentration of 'head' if sufficient water could be controlled (perhaps including diversions) upstream of this location. Other sites of the same type may be available in the area.

2. Study Requirement

The Study Team will assemble maps and aerial photographs of the area within 100 km or so of Baker Lake. These will be inspected for potential hydro sites in the one to five MW range. Hydrologic analyses will be carried out (utilizing the assessment methodology contained in "NWT Water Resources Study" March 1982, Acres Consulting Services Ltd.) to estimate water availability and assess the potential of modest lake storage for flow augmentation. On the basis of these desk studies, one or more sites in the area may be selected for site reconnaissance.

RAE LAKES

1. Background

Rae Lakes is a small community of some 177 people situated about 150 km northwest of Yellowknife ($64^{o}10'N$, $117^{o}20'W$). In 1982/83 the total electrical energy demand was 265 MWh and the peak load, 65 kW. Information on the heating demand is not too hand.

Consideration has not been previously given to the potential for developing a small hydroelectric scheme to meet the needs of this community. Mapping of the area indicates the possibility of mobilizing a small head across a short diversion between adjacent lakes on the Camsell River system, within a few kilometers of the community.

2. Study Requirement

The available 1:50,000 mapping, hydrologic data and aerial photography will be studied to determine whether a suitable site can be located. If this activity is successful, the site will be reconnoitred and a small hydro development studied as for the other communities included herein.

ANNEX 4

JAKOB DIDDENS, ec. drs.

Mr. Diddens received a post-graduate degree in economics from the Economic University of Rotterdam, Netherlands. He joined R.L. Walker & Partners as a founding member in 1972 following more than eleven years of experience in developing countries.

Over the last few years, Mr. Diddens has undertaken several studies in northern Canada. One concerned alternative sources of energy for oilfield expansion at Norman Wells, N.W.T. while others have dealt with the economic comparisons of alternative new generation options for Tuktoyaktuk, the Yellowknife area, Whitehorse and the Yukon system.

Within the energy sector, Mr. Diddens has studied the potential for small hydro projects at off-grid locations in Canada, has advised on the feasibility of and financing requirements for a 2,000 kW rehabilitation of a hydro project as well as on economic policies and institutional arrangements for encouraging the development of small hydro potential in Ontario and Canada. On a larger scale, he took responsibility for the economic, financial and associated system planning aspects of the firms' work on the Bay of Fundy tidal power study, the Manitoba Hydro Enquiry and the recently completed Slave River hydroelectric project feasibility study in association with Dr. Swales. In 1980, he was retained as a specialist economic advisor on the Western Grid study, a major electrical interconnection and long-term electric power transfer in the prairie provinces. Currently, he is serving as economic consultant for appraisal of a proposed multi-purpose hydroelectric irrigation development in South America.

Other assignments in Canada involved the study and preparation of reports on economic development policies in the Maritime provinces, industrial development policies in Newfoundland and Labrador and employment policies in Saskatchewan.

Overseas, Mr. Diddens led a mission to Indonesia to prepare a draft agreement in a program of technical assistance concerning regional development in West Irian and participated in a survey of the electric power/energy sector in Indonesia. He served as senior project economist, in association with other consultants, in several studies investigating a hydroelectric project and its associated system implications in Nepal, a small hydro project in Indonesia, a road project in Malawi and irrigation projects in Lesotho and Mozambique.

He was the project director of a major study in Bangladesh covering policies, project appraisal and investment programming throughout the energy sector. This study was performed by an international consortium of consulting firms (Canada, Italy and USA) and was sponsored by the Asian Development Bank and the United Nations Development Program.

In 1971-72, Mr. Diddens took a sabbatical year in England where he was a Senior Associate at the University of East Anglia. During this year he lectured in a post-graduate course on economic development and participated in a mission to Papua-New Guinea at request of the Australian Government under auspices of the United Nations Development Program and the World Bank.

Between 1966 and 1971 he was a senior economic consultant with Advisory Groups fielded by the Harvard University in Liberia, Bangladesh and Malaysia. He worked on such issues as national and regional development planning, natural resource development policies and agreements regarding foreign investment in mining, forestry and agriculture; and appraisal of projects in various economic sectors.

During 1964 and 1965 he taught various courses at the Graduate School of Business Administration of Lima, Peru, under auspices of the Graduate School of Business of the Stanford University. He also served as consultant on industrial development projects in Northern Peru. Prior to this assignment with the University, he worked as advisor on regional and transport economics with the National Planning Office of Peru and as consultant on project appraisal to the Institute of Natural Resources and the Institute of Agrarian Reform of Peru. Before this period in Peru he was attached as transport economist to the Economic Commission of Latin America of the United Nations in Chile.

Mr. Diddens started his professional career as economist attached to the office of the Director General of Public Works in the Netherlands. He participated in comparative cost studies of various transport modes, in studies regarding the coordination of policies for rail, road and water transport and in studies of the economic feasibility of ports and land reclamation projects. Subsequently he joined the Institute of Land and Water Management in Wageningen (Netherlands) and worked on economic aspects of land and water use, land consolidation and rural reconstruction projects.

October, 1982 Location: Edmonton

JAMES B. KIRCH, P.Eng., CONSULTING ENGINEER, D.I.C., MEIC

Mr. Kirch is a civil engineering graduate of the City and Guilds College, London, England (1954) and a diploma holder in public health engineering from Imperial College, London (1959). He has been in the practice of consulting engineering for most of his professional career and has specialized in the study and planning phases of water resources, water supply and sanitation projects in both Canada and overseas.

In 1972, he was a founding member of R.L. Walker & Partners Ltd. and since that time has participated in all of the major assignments carried out by the firm, generally taking responsibility for the hydrologic, hydraulic and environmental aspects. During the period 1980-82, he assisted Dr. Swales with management of the hydrologic and environmental study components of the Slave River hydroelectric project and has assisted the Northern Canada Power Commission with the planning of hydroelectric project investigations.

Assignments in Canada have included a national survey of water quality data users related to ongoing development of the NAQUADAT data bank; an assessment of the need for storage and retrieval facilities to handle routine and research chemical quality data on Canadian drinking water supplies; and a review of volumetric metering trends for trade purposes in Canada. Mr. Kirch has carried out several flood studies and was retained in studies on damages to water pollution in Ontario, environmental assessment guidelines for dredging projects in the Great Lakes, reviews of major studies by others and in a survey to assess the availability and capability of Canadian public and private sector organizations for providing operational assistance for water and wastewater systems in developing countries.

For CIDA and other development assistance agencies, including the World Bank and the Asian Development Bank, he has carried out sector analyses and participated in project appraisal missions in both the water supply/sanitation and energy sectors in Sierra Leone, Malaysia, Nepal, Nigeria and several Caribbean countries. He also assisted in the analysis of reservoir filling problems associated with potential developments on the Euphrates River.

Mr. Kirch spent ten years with the Acres organization, mostly working overseas as a hydrologist/hydraulic engineer on multi-purpose, river basin developments in Kenya, Taiwan and East Pakistan (now Bangladesh) and served as a hydrologic advisor to the Water & Power Development Authority in the latter country as part of a General Consultancy team. Prior to that he was with the Ontario Water Resources Commission as a Sanitary Engineer for two years. His first four years in Canada (1956-60) were with the Montreal Engineering Company, principally working on hydroelectric studies and the planning and design of utilities for the community of Inuvik, N.W.T. Immediate post-graduate experience was acquired in London with Sir Alexander Gibb and Partners on water supply and sewerage projects.

October, 1982 Location: Edmonton

MARTIN C. SWALES, Ph.D., P. Eng.

Dr. Swales graduated as a civil engineer at the University of Sheffield in the UK, where he subsequently earned his Ph.D. in power sources optimization. He arrived in Canada in 1968 and is a Canadian citizen.

Dr. Swales is a specialist in systems analysis, particularly related to hydrology, hydraulics and electric power systems. He has developed mathematical models and associated computer programs in connection with the planning and operation of thermal, hydro and mixed thermal-hydro power systems, reservoir and multi-reservoir operation for power generation, irrigation and water supply, pumped storage schemes and tidal power projects.

In 1980 he joined R.L. Walker & Partners Ltd. as Resident Manager in Edmonton and Study Manager for the Slave River hydroelectric project feasibility evaluation until its completion in mid-1982. He was fully responsible for management and coordination of the ten component disciplinary studies that contributed to the final feasibility assessment and was the principal author of the Final Report published by the Alberta Government. During this period, he also provided assistance to the Alberta Electric Utilities Planning Council for upgrading their generation planning model for the provincial electrical system.

More recently, Dr. Swales has been providing on-going assistance to the Alberta Electric Utilities on further investigation of the Slave River hydroelectric project and has been working with the Alberta Government to prepare water resources planning policies for rivers in northern Alberta.

Dr. Swales was employed by Montreal Engineering Company Ltd. between 1968 and 1980. In 1979 and 1980 he was the Assistant Manager in the Energy Division, responsible for project management and business development activities. His work included electric generation planning in multi-purpose developments as part of the Kabul River Basin Study in Afghanistan; advice to the Pacific Gas and Electric Company of California on reliability of design criteria and reserve planning techniques; and advice to the Korean Ocean Research Institute on tidal power developments along the east coast of Korea. He also developed an economic commitment and dispatch model for planning the operation of mixed hydro-thermal power systems in order to improve the operating efficiency of existing hydroelectric and steam electric power plants for Calgary Power Limited.

From 1976 to 1978 Dr. Swales was a senior engineer in the Generation Planning and Hydrology Department of Montreal Engineering. Much of his work was on assignment to Tidal Power Consultants Ltd., for whom he developed and utilized tidal power simulation and optimization models for studies in the Bay of Fundy. In addition he worked on power projects and generation and operation planning studies for Saskatchewan, New Brunswick and Newfoundland. During this period, he worked with R.L. Walker & Partners Ltd., on the development of a computerized simulation model of the Euphrates River for a reservoir filling study in Turkey and as an expert reviewer on system planning practices for the Manitoba Hydro (Tritschler) Inquiry.

Dr. Swales was on assignment to Calgary Power Ltd. during 1971 and 1976, where he assisted with coordinated generation planning development of probabilistic generation reliability techniques and the evaluation of benefits of high voltage interconnections. He also chaired the task force committee on system reliability studies for the Alberta Electric Utilities Planning Council.

Dr. Swales has published a number of papers on tidal power and on project management, including "Tidal Power Development in the Bay of Fundy" which was presented to the Engineering Institute of Canada in 1978. His paper entitled "Managing a Multi-disciplinary Study, The Slave River Hydro Feasibility Study" was presented to the Canadian Electrical Association in March 1983.

August, 1983 Location: Edmonton

R.L. WALKER, P.Eng., CONSULTING ENGINEER, MEIC, MCSCE, MASCE

Mr. Walker is a civil engineering graduate of the University of British Columbia (1950). He has been in consulting practice for most of his professional career, and has had extensive experience in the management of multi-disciplinary groups involved in the planning, design, and implementation of water resource related developments, both in Canada and overseas.

Since 1971 he has been in private practice in Ottawa, Canada, and in 1972 initiated the formation of R. L. Walker & Partners Ltd. Personal assignments during the last decade have included appraisal studies of overseas projects for CIDA and IBRD; technical reviews of several major water planning studies on behalf of federal-provincial and international boards; and state-of-the-art studies of environmental aspects of dredging practices and status of soil conservation measures as related to urbanization and other intensive land uses within the Great Lakes basin.

An ongoing assignment involves the monitoring of a CIDA-sponsored project to assist the Government of Nepal in establishing a Water and Energy Resources Commission with broad responsibilities for developing policies and strategies for these key sectors of its economy. The project also encompasses the establishment of economic and technical planning capabilities within the departments responsible for development of electric power and irrigated agriculture. Other recent assignments for CIDA have included missions to both China and India to identify and help prepare projects for Canadian participation in power sector development. An extensive review of the power sector in Indonesia included an assessment of Canadian industry capabilities to meet potential export requirements.

In 1979, Mr. Walker took prime responsibility for planning the feasibility study of the Slave River hydroelectric project and assisted Alberta Environment with the engagement of consulting firms to carry out the detailed work. As Study Director he maintained overall responsibility for the successful completion of this assignment.

In 1978 and 1979 he had the major responsibility for coordinating consulting services in respect of a formal inquiry into the practices and procedures of Manitoba Hydro, a primarily hydroelectric provincial utility, in the planning and expansion of generation supplies.

From mid-1975 to early 1978 Mr. Walker was the study coordinator for the Management Committee of the Tidal Power Review Board with responsibility for the planning and coordination of the reassessment study of tidal power developments in the Bay of Fundy.

During the period from 1961 to 1971, Mr. Walker was employed by H.G. Acres Ltd. and Acres International Ltd., as project engineer, executive engineer and vice-president. Major domestic assignments during this period included design of wharf facilities at Baie Comeau, Quebec; the control structures for the Red River Floodway, Winnipeg, Manitoba; and the intake works and supply tunnel for the Westerly Water Purification Plant, Toronto, Ontario. Overseas assignments included a ranking study of the hydroelectric potential for Guatemala; feasibility studies of power and irrigation development of the Tana River in Kenya and of a major power transmission grid link in East Pakistan; and direction of the water resources division of a general consultancy group assisting the East Pakistan Water and Power Development Authority.

Prior to 1961 he was with Hunting Technical and Exploration Services Ltd., and from 1957 through 1959 was responsible for investigations of the development potential of various river basins on the island of Ceylon as well as for technical coordination of other aspects of the multi-disciplinary resource studies. Subsequent assignments included an evaluation of the hydroelectric potential of British Honduras; regimen studies of the stability of Kingston Harbour, Jamaica; and an evaluation of water resources aspects of development potential of the Valencia region of Venezuela.

During the years 1953 to 1957 Mr. Walker was employed by the Fraser River Board, a federal-provincial agency investigating the water resources potential of the Fraser River in British Columbia. From 1954 through 1957 he was responsible to the Board for management of its program of studies to investigate the potential for flood control, power development and navigation improvements and to evaluate the impact of such developments upon fisheries, agriculture, forestry and other water use interests.

Following graduation he served briefly as a training officer in roads and airfields construction at the Royal Canadian School of Military Engineering. In late 1950 he accepted appointment as an assistant engineer with the Drainage and Irrigation Department of the Federation of Malaya. During the following two years he served in Selangor and Johore States in the design and supervision of construction of new irrigation and reclamation projects and in the maintenance of existing schemes.

March, 1983 Location: Ottawa

JOST, Roland M.

Occupation:	Civil Engineer
Birth:	1926
Citizenship:	Canadian
Language:	English

EDUCATION

1951	B.Eng., Civil Engineering	Nova Scotia Technical College, Nova Scotia, Canada

EXPERIENCE

Since 1982 **LAVALIN – Shawinigan Consultants Inc., Montreal, Quebec, Canada**

Operations Manager, Abra-Bago Project, Manila, Philippines

1951-82 **Shawinigan Consultants Inc., Montreal, Quebec, Canada**

1981-82 Operations Manager, Abra Bago Project, Manila, Philippines

Responsible for administration and coordination of an in-house training program for National Power Corporation personnel through conduct of a Pre-Feasibility Study of hydro-resources of the Abra River Basin in Northern Luzon. Provision of guidance and assistance to an in-house feasibility investigation being performed by staff engineers of National Power Corporation on the Bago River in Negros Occidental, Visayas Region.

1967-81 **ShawMont Newfoundland Lld., St. John's Newfoundland, Canada**

(Seconded from Shawinigan Engineering Co. Ltd.)

During the period from 1977 to 1981 responsible as Manager of Engineering for general engineering work of the company and also served on board of Directors of ShawMont Newfoundland Limited.

1971-77 Manager of Engineering

In charge of integrated Civil, Mechanical and Electrical Department in St. John's, Newfoundland. Working on design and layout of structures and equipment for hydro and thermal electric developments, industrial plants, municipal facilities and general civil works. Experience includes pre-feasibility and conceptual investigations, feasibility studies, preliminary layout studies and evaluations, estimating, planning and drafting of civil and mechanical aspects of installations, as well as preparation of specifications and contract documents for construction of facilities and supply of equipment.

1969-71 Senior Civil Engineer

Working on several projects for modification and extension of facilities of the Newfoundland and Labrador Power Commission system. Also involved in design and construction of several utility, municipal and industrial projects for other clients in Newfoundland.

1967-69 Project Civil Engineer

Working on civil and mechanical design of structures and equipment for the 150 MW Stage II extension of the Bay d'Espoir Hydroelectric Power Development of the Newfoundland and Labrador Power Commission.

1964-67 **Shawmont Newfoundland Limited, Montreal, Quebec, Canada**

Senior Design Engineer

Seconded from Shawinigan Engineering for layout and design of the 300 MW Stage I powerhouse of the Bay d'Espoir Hydroelectric development built for the Newfoundland and Labrador Power Commission.

1951-64 **The Shawinigan Engineering Company Limited, Montreal, Quebec, Canada**

1962-64 Design Engineer

Employed on various projects including design of substructures for the reactor building of the Atomic Energy of Canada, Whiteshell Nuclear Reactor No. 1 in Manitoba.

1959-62 Project Civil Design Engineer

Worked on site investigations, layout and design of the Rapide Des Coeurs Hydroelectric Development originally proposed by the Shawinigan Water and Power Company.

1957-59 Design Engineer

Engaged on design of substructures of the powerhouse at Hydro Quebec's 660 MW Carillon Development on the Ottawa River and on preparation of proposals and estimates for various hydroelectric development sites on the St. Maurice, St. Francis and St. Charles Rivers in Quebec.

1955-57 Assistant Project Engineer

In charge of civil layout and design for the Dufferin Falls Hydro Development of James McLaren Co., Ltd., Buckingham, Quebec.

1951-55 Design Engineer

Engaged with the Shawinigan Engineering Company Limited on reinforced concrete and general civil design for a number of projects including Alcan's Peribonka No. 1 Hydroelectric Power Development, St. Maurice Chemicals Plant at Varennes, Quebec and the Beechwood 100 MW Hydroelectric Development in New Brunswick.

ASSOCIATIONS

Order of Engineers of Quebec
Association of Professional Engineers of Newfoundland
Engineering Institute of Canada

EARL G. BRUNSDON

Education — University of Manitoba, Winnipeg, Manitoba
B.Sc. Civil Engineering, 1949

Professional Association — Association of Professional Engineers of Manitoba
- Member

Experience

1981 to Present - Acres

Staff Engineer, Project Services Department

Responsible for planning and scheduling; cost estimating; and advice on construction methods and techniques, construction management, and contract documents. Major projects worked on include

- Limestone 1,100-MW hydroelectric development, Manitoba
- Nipawin 252-MW hydroelectric development, Saskatchewan
- proposed Conawapa 1,500-MW hydroelectric development, Manitoba.

1967 - 1981 BACM Construction and Genstar Construction, Winnipeg, Manitoba and Calgary, Alberta

1979 Vice-President and Chief Engineer

Responsible for engineering aspects of construction projects and preparation of tender documents. Major projects included

- cement plant, Edmonton, Alberta
- uranium and potash mine buildings, Saskatchewan
- spillway reconstruction, Great Falls, Manitoba
- spillway and dikes, James Bay, Quebec
- tender preparation for tunnel and spillway contracts at Dickson Dam in Alberta, and Revelstoke Dam and powerhouse in British Columbia.

1975 Division Manager

Responsible for contract management. Major projects included

- copper, lead and zinc concentrator building complete at Snow Lake, Manitoba
- site development, mine stripping and pit development for copper mine at Pickle Lake, Ontario.

1973 Assistant Area Manager

Responsible to Area Manager for contract management. Major projects included

- Jenpeg generating station, Jenpeg, Manitoba
- Kiskitto Dikes, Manitoba

ACRES

- Ominawin Channel excavation - Manitoba
- tender preparation for Long Spruce generating station, Manitoba.

1967 Construction Manager

Responsible for contract management. Major projects included

- transmission lines; dc line, 230-kV lines, 500-kV line, all in Manitoba
- mine stripping and site preparation, Ruttan Lake, Manitoba
- preliminary contract, Jenpeg Generating Station, Manitoba.

1955 - 1967 Mannix Construction Co., Calgary, Alberta

1963 Heavy Construction Division Engineer

Responsible to Division Manager for engineering aspects of division contracts and preparation of tender documents. Major projects included

- dam and spillway, Duncan Lake, British Columbia
- powerhouse and arch dam, Metaline Falls, Washington
- tender preparation for High Arrow Dam, Peace River Spillway in British Columbia
- subway contracts in Toronto and Montreal.

1959 Railroad Division Manager

Responsible for contract management. Major projects included

- 190 miles track construction, Shelter Bay, Quebec
- 56 miles track construction, Two Harbours, Michigan
- 52 miles railroad grade, Optic - Chisel Lake, Manitoba

1955 Estimator

Responsible to Chief Engineer for estimates in all phases of highway, railroad and heavy construction tenders.

1951 - 1955 Junior Engineer, Canadian Pacific Railway, Winnipeg, Manitoba

Responsible to Division and District Engineer for track and building maintenance and construction.

FREDERIC B. CLARIDGE, M.S., P. Eng.

Geotechnical Engineer

Mr. Claridge has extensive experience in soil and rock mechanics, foundation engineering and permafrost engineering. During the past 15 years, he has directed geotechnical activities and provided technical assistance for major civil engineering projects, including earth and rock structures. More recently, he has undertaken designs for open pit excavations, waste dumps and tailings retention structures in the mining industry. His work has taken him throughout Canada and the United States, as well as to Norway, Great Britain, Brazil, Bangladesh, Chile and Ethiopia.

Mr. Claridge has conducted studies on a variety of technical aspects for proposed pipeline corridors in the Yukon, Northwest Territories and Alaska. He served as an expert witness on behalf of the pipeline proponent at public hearings before the National Energy Board, the United States Federal Power Commission, the Berger Commission, and an Environmental Assessment and Review Panel from Environment Canada. He is currently assisting in design reviews for the Alaska Natural Gas Transmission System.

Mr. Claridge recently served as a consultant to an Inquiry in the Province of Manitoba which conducted a broad review of hydroelectric projects undertaken and planned for the development of power along the Nelson and Churchill River systems. Presently, he is reviewing the geotechnical design aspects of a proposed hydroelectric complex on the Slave River near the Alberta-Northwest Territories border. He is also consulting to a major energy company on the design of artificial islands to be placed in a river as access for developing an oil field. In addition to these activities, he is providing consulting assistance to several mining companies in the design of waste dumps in western Canada.

FREDERIC B. CLARIDGE M.S., P.Eng.

Geotechnical Engineer

ECIAL FIELDS OF COMPETENCE

- Extensive experience in geotechnical engineering applied to earth and rock fill dams, tunnels, deep excavations, and other major civil engineering projects; permafrost engineering and other northern engineering related work such as terrain mapping and corridor selection.

EDUCATION

- M.S. in Civil Engineering, specializing in Soil Mechanics and Foundations, and Engineering Geology, University of Illinois, 1968.
- B.A.Sc. (with Honours) in Civil Engineering, and 3 years towards degree in Applied Geology and Mining Engineering, University of Toronto, Toronto, Ontario, 1965.

EXPERIENCE

- 1977 to Present - President, Komex Consultants Ltd., Calgary, Alberta
- Consultant to Unified Industries Inc., Washington D.C. on geotechnical design reviews for Alaska Natural Gas Transmission System, the facility planned to link with the Alaska Highway Gas Pipeline through Canada. Initial studies have included an overview of the pipeline proponent's proposed methods for treating frost heave problems associated with gas transmission at freezing temperatures.
- Investigations and designs for a series of artificial islands to be constructed in the Mackenzie River at Norman Wells, N.W.T., by Esso Resources Canada. Related investigations and recommendations for a pipeline network, foundations of structures placed on permafrost and a settling pond in permafrost.
- Investigations for and assessment of stability of large mine waste dumps to be formed at the Kitsault Mine in northern B.C. (Amax of Canada). Coordinated program of studying downstream effects of slumping of dumped waste and effects of sediment transported down a stream valley and into an ocean fiord.
- Review of design of a tailings retention dam on behalf of Codelco Chile at its Andina Mine.
- Route assessment and geotechnical recommendations for a branch line railway in Northeastern B.C. (British Columbia Railways).
- Coordination of study of stability and reinforcement requirements for a high wall at the proposed Line Creek Mine, southeastern British Columbia (Crows Nest Resources Ltd.).
- Coordination of groundwater investigations program at Luscar, Alberta open pit Mine (Cardinal River Coals Ltd.).

EXPERIENCE CONT.

. Studies for Foothills Pipe Lines (Yukon) Ltd. proposed Dempster Lateral gas pipeline, Yukon and N.W.T. Reports on route location and slope designs at major river crossings, measures for drainage, buoyancy and erosion controls along route. Assisted client in preparation of environmental impact statement and application to National Energy Board.
. Sub consultant to Inquiry in Province of Manitoba reviewing development of hydro-electric sites in the Nelson-Churchill River Systems. Presented testimony during hearing phase.
. Review of slope stability of proposed open pit mine - Blizzard Uranium project, Kelowna, B.C.
. Final geotechnical report for Trans Alaska oil pipeline.

. 1974/77 - Executive Engineer, Klohn Leonoff Consultants Ltd., Calgary, Alberta.
. Feasibility assessments and preliminary geotechnical designs for proposed natural gas pipelines in the Yukon and the MacKenzie Valley, N.W.T. Represented Foothills Pipe Lines Ltd. at hearings before the National Energy Board, the United States Federal Power Commission, an Environmental Assessment Review Panel and the Berger Commission.
. Project Manager responsible for engineering feasibility study and cost estimate for on-stream storage and alternative pumping schemes to supplement the flow in Fish Creek, Alberta, for Alberta Environment.
. Slope designs of open pits - two in operation and one proposed pit for Coleman Collieries Ltd. Also designs and evaluations for waste dump stability. plant foundations and water retention structure.
. Assessment of slope failures and recommendations for remedial treatments at stream crossings on existing gas pipeline routes in northern Alberta, for Alberta Gas Trunk Line Ltd.
. Investigations and designs for heavy industrial foundations for Cominco Ltd., Canadian Kellogg Ltd., and Foster Wheeler Inc.

. 1968/74 - Senior Geotechnical Engineer, Acres Consulting Services Ltd., Niagara Falls, Ontario.
. Coordinated geotechnical studies, designs and construction specifications for a hydro-electric generating station. Analysis of stability and settlement of an earth dam founded on soft marine clay; design of grout curtain and drainage works for a combined earth fill and concrete dam founded on pervious limestone; designs and specifications for rock excavations for a spillway and powerhouse; slope and dewatering designs for a railroad cut.

EXPERIENCE CONT.

- Site supervision of construction of earth and rock fill dykes at the Lower Notch Generating Station on the Montreal River, Ontario. Investigation of seepage and slope instability in reservoir.
- Evaluation of rock and water conditions around an existing deep penstock at the Nilo Pecanha power station, Brazil. Recommendations for unwatering the penstock, incorporating a separate drainage tunnel and network of drainage holes.
- Determined rock stress conditions and assisted with design of tunnel foundations for road/rail tunnel under the Welland Canal. Design of excavations and cofferdams in soft laminated clays.
- Canadian International Development Agency - Design of transmission tower foundations on 175 Km long transmission line in Bangladesh. Investigation, design and contract documents for crossing of Jamuna River flood plain.
- Site investigation and designs for earth fill dams required for storage reservoirs at Binbrook and Thamesford, Ontario.

- 1967/68 - Post-Graduate Student and Research Assistant, Departments of Civil Engineering and Geology, University of Illinois, Urbana, Illinois. Recipient of A.E. Cummings Memorial Fellowship.
- Research and design of equipment to measure in situ properties of ocean sediments.

- 1966 - Engineer, Norwegian Geotechnical Institute, Oslo, Norway.
- Investigations of failures in marine clay slopes. Field measurements of lateral earth pressures.

- 1965 - Junior Engineer, Caseco Consultants Limited, Vancouver, B.C.
- Site investigations for Mica Dam.

BIRTHDATE & CITIZENSHIP

- 1942 - Canadian

LANGUAGE CAPABILITIES

- English, French, working knowledge of Spanish and Portuguese.

PROFESSIONAL MEMBERSHIPS

- Associations of Professional Engineers of Alberta and Ontario.
- Canadian Geotechnical Society.
- International Society for Soil Mechanics and Foundation Engineering.

EXPERIENCE SUMMARY OF F.B. CLARIDGE RELATING TO EARTHWORKS

A) SLOPE STABILITY

- Natural slopes, fills, excavations and waste dumps

- Hydro Inquiry Manitoba	- review of slope designs - channel excavations and earth dams.
- Kilborn Engineering and Norcen Energy Resources	- Blizzard uranium mine (B.C.) - footwall stability.
- Crows Nest Resources	- Line Creek Mine excavation.
- Coleman Collieries (Alta. & B.C.)	- pits and waste dumps - existing #3 and 4 pits, proposed #5 pit.
- Foothills Pipe Lines (Yukon & N.W.T.)	- slope designs for major river crossings for 1200 Km long Dempster Lateral Gas Pipeline.
- Foothills Pipe Lines (Yukon)	- slope stability assessment along Yukon portion of Alaska Highway Pipeline.
- Foothills Pipe Lines (N.W.T.)	- slope stability assessment and designs along Mackenzie Valley Pipeline.
- System Development Corporation (Alaska)	- review of stability analysis for Trans Alaska Oil Pipeline.
- Ontario Hydro	- Arnprior Generating Station - slopes in reservoir and tailrace, deep excavations for powerhouse and railway cut, embankment stability.
- Alberta Gas Trunk Line	- failing slopes on pipeline route.
- Department of Public Works Canada (Yukon)	- highway embankment.
- St. Lawrence Seaway Authority (Ontario)	- natural and excavated slopes at Welland Canal.
- Canadian International Development Agency (Bangladesh)	- natural slopes on transmission line.
- Norwegian Geotechnical Institute	- stability of natural slopes.

B) DRAINAGE, SEEPAGE AND EROSION CONTROL

- Foothills Pipe Lines - designs for drainage and erosion control along Dempster Lateral Gas Pipeline, Alaska Highway Pipeline and Mackenzie Valley Pipeline.
- System Development Corporation - review of drainage control and erosion protection along Trans Alaska Oil Pipeline.
- Light Services de Eletricidade (Brazil) - seepage and piezometric levels around buried penstock.
- Ontario Hydro - Lower Notch Generating Station - remedial treatment for seepage out of a reservoir.
- Canada West Insurance - City of Edmonton - flooding study relating to sewer backup.
- Ontario Hydro - Arnprior Generating Station - erosion control in tailrace and on reservoir slopes.
- University of Illinois - seepage research in organic clays.
- Cominco Ltd. (Alta.) - rate of seepage of impurities from waste storage reservoirs.

C) DAM DESIGN

- Hydro Inquiry Manitoba - review of series of major dams and related works constructed or proposed at 12 different sites during the past 16 years.
- Northern Canada Power Commission (N.W.T.) - Snare Forks Dam - earth fill.
- Canada Cement Lafarge (Alta.) - water supply dam - rock fill.
- Ontario Hydro - Arnprior Generating Station - earth and rock fill dam and dykes.
- Niagara Peninsula Conservation Authority - earth dams (2).
- Alberta Environment - earth dam

- Cominco Ltd. (Alberta)	- reservoirs for containing industrial wastes.
- Stanley Associates Engineering	- City of Fort McMurray - sewage containment lagoons.
- Caseco Consultants	- Mica Dam.

Benjamin Arthur Hubert

Biographical Notes

Mr. Hubert was born at Coaldale, Alberta, in 1945 and received his early education there. After attending Mount Royal College in Calgary and the University of Lethbridge he graduated from the University of Alberta in 1969 with a B.Sc. with honours in Zoology.

Entering the University of Manitoba in 1970, Mr. Hubert pursued graduate studies in boreal ecology and wrote a thesis for his Master's of Science degree on the productivity and energy requirements of Muskox. Mr. Hubert's field studies were conducted at Truelove Inlet on Devon Island, N.W.T. His studies there, including the entire winter of 1972-73, contributed to the arctic ecosystem studies, sponsored by the Internation Biological Program, which were co-ordinated by Dr. L.C. Bliss then of the University of Alberta.

Graduating in 1974, Hubert returned to the Northwest Territories as Supervisor of Big Game Management with the Government of the Northwest Territories. He later was promoted to Head of Wildlife Management. He left the Wildlife Service in 1977 to take up duties as Executive Secretary to the Northwest Territories Science Advisory Board. In that capacity he either co-ordinated or conducted studies and publications on human population growth in the Northwest Territories, northern renewable resources, supply and demand of conventional energy in the Northwest Territories, and more.

His paper with Dr. W.A. Fuller on the potential of fish, fur and game in the Northwest Territories was an invited paper at the 147 Annual Meeting of the American Association for the Advancement of Science at Toronto, in January 1981. His search for new methods of integrating scientific knowledge with the conventional wisdom of the general public at large and in particular northern native people to provide for an improved quality of life led Hubert to leave the public service and establish Boreal Ecology Services Ltd. Clientel of this consulting service includes government, industry and northern native and community groups.

Mr. Hubert's studies have led to extensive travels throughout the Canadian north as well as Alaska, Scandinavia and the U.S.S.R. Ben Hubert and his wife Linda and their two sons live in Yellowknife, N.W.T.

Publications:

Hubert, B.A. 1974. Estimated Productivity of Muskox on Northeastern Devon Island. M.Sc. Thesis. University of Manitoba, Winnipeg. 448 pp.

Jonkel, C.A.,D.R. Gray and B.A. Hubert 1975. Immobilizing and Marketing wild muskoxen in Arctic Canada. J. Wildl. Mgmt. Vol. 39: 112-117.

Hubert, B.A. 1977 Productivity of Muskox. In: Bliss, L.C. (ed). Truelove Lowland, Devon Island, Canada: A High Arctic Ecosystem. Edmonton. University of Alberta Press. 736 pp.

Fuller, W.A. and B.A. Hubert 1981. People and Renewable Resources in the Northwest Territories: The outlook for 2001. Invited paper presented at 147 Annual Meeting of AAAS 4 January 1981.

White, R.G., F.L. Bunnel, E. Gaare, T. Skogland and B.A. Hubert 1981. Ungulates on Arctic Ranges in Tundra Ecosystems: A Comparitive Analysis edited by L.C. Bliss, J.B. Cragg, P.W. Heal, J.J. Moore. International Biological Program 25 Cambridge University Press.

Fuller, W.A. and B.A. Hubert 1981. Fish, Fur and Game in the Northwest Territories: Some Problems of and Prospects for increased harvests. Invited paper presented at the Symposium on Circumpolar Renewable Resources sponsored by the Association of Canadian Universities for Northern Studies Banff. May 1981.

Science Advisory Board of the Northwest Territories
Studies and Publications Co-ordinated by Hubert

Hamelin, L.E. 1880. Contribution to Northwest Territories Population Studies, 1961-1981. Science Advisory Board Report No. 1. 71 pp.

McCart, P.J. and J. Den Beste 1980. Aquatic Resources in the Northwest Territories. Science Advisory Report No. 2. 55 pp.

Davis, R.A., K.J. Finley and W.J. Richardson 1980. The present status and future management of Arctic Marine Mammals in Canada. Science Advisory Board Report. No. 3.

Dickinson, D.M. and T.B. Herman 1980. Management of Some Territorial Mammals in the Northwest Territories for Sustained Yields. Science Advisory Board Report No. 4. 71 pp.

Schaefer, O. and J. Steckle 1981. Dietry Habits and Nutritional Base of Native Populations of the Northwest Territories. Science Advisory Board Report No. 5. 36 pp.

Nutritional Liaison Committee. 1980. Cost, Availability and Nutritional Value of Foods imported into the Northwest Territories. Department of Information, Government of the Northwest Territories. Yellowknife. 140 pp.

Janz, B., D.G. Howell, and A. Serna (in press) Wind Energy in the Northwest Territories.

Eaton, D. (in press) Methyl-mercury in the Aquatic Environment of the Northwest Territories.

Science Advisory Board
Papers Prepared by Hubert

Energy in the Northwest Territories: a summary of Petroleum and Electrical consumption 153 pp.

Fish, Fur and Game in the Northwest Territories: 44 pp.

Memberships

American Association for the Advancement of Science
Arctic Institute of North America
— member board of directors
Canadian Nature Federation
Royal Canadian Geographical Society
Northern Heritage Society

Boreal Ecology Services Ltd., Box 277, Yellowknife, N.W.T. X1A 2N2 (403) 873-5847

Clientele of Boreal Ecology Services Ltd.

Inuit Development Corporation - Ottawa

Metis Association of the Northwest Territories - Yellowknife

Hunter' & Trappers' Association - Fort Smith

Northwest Territories Wildlife Service - Yellowknife

Thebacha College - Fort Smith

Dene Nation - Fort Resolution

Pallister Resource Management - Calgary

Science Advisory Board of the Northwest Territories - Yellowknife

Energy, Mines and Resources Canada - Yellowknife

Energy Conservation Branch, Government of the Northwest Territories - Yellowknife

Cree Development Corporation - Little Buffalo Lake

ANNEX 5

ANNEX 5

EXAMPLE OF A TYPICAL LETTER OF INVITATION
TO SELECTED CONSULTANTS

RE: NWT Power Investigation Program - Study Package No.....

The following firms have been invited to submit a proposal to the Northern Canada Power Commission (the Commission) for engineering, economic and environmental services to fulfill the study requirements defined in the terms of reference attached hereto:

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If you do not wish to submit a proposal for the work, please advise the undersigned without delay. If you intend to submit a proposal, it should be received at the following address on or before.....[date].....

Northern Canada Power Commission
7909 - 51 Avenue
P.O. Box 5700, Station 'L'
Edmonton, Alberta
T6C 4J8

ATTN:.....

In submitting your proposal, you are free to form a joint-venture with any other firm (except those listed above) or to sub-contract work to others as you see fit. However, your proposal must explain the relevant contractual arrangements you propose and identify the responsibilities to be undertaken by each associate or sub-contractor and, in particularly, the methods of study integration and management proposed. If your proposal is accepted, these arrangements and responsibilities, including the names of those responsible for actual performance of the work, will be reflected in the Agreement you will be required to conclude with the Commission covering the work.

Selection of a consultant for this assignment is expected to completed by [date]..... and an Agreement negotiated without delay. The work should be completed by.....[date].....

Proposals received for executing this assignment will be evaluated on the basis of a point system , as follows:

a)	Work Program and Study Management	30 points maximum
b)	Personnel Experience	55 points maximum
c)	Study Execution	15 points maximum

Under item a), most points will be awarded for a clear description of your proposed program of work and level of effort to achieve the study objective(s). Under item b), most of the points will be awarded for the relevant experience of the personnel to be assigned to the work. Not more than ten points will be awarded for the firm's general background experience in the areas of study specialization. Under item c), the majority of points will be awarded for a clear delineation of the manner in which study activities will be coordinated and integrated into the preparation of a Final report.

Any clarification of the terms of reference for this assignment may be referred to the undersigned [or to R.L. Walker & Partners Ltd., Edmonton. (1-403-422-6327)]

Your proposal should contain a section indicating your estimate of the numbers of man-days of all categories of personnel required to complete each item of the scope of work. An itemized budget estimate should also be provided covering cost of staff, based on specified time rates, and all other costs, including expenses for surveys, travel, office services, and other miscellaneous items. The Commission would expect to pay all approved invoices in full on a monthly basis for both services and acceptable reimbursible expenses and will advise the successful consultant on the invoice format to be adopted. The Commission intends to hold back the final fifteen percent of the Agreement price pending receipt of acceptable final documentation. A draft copy of the Agreement that the successful consultant will be required to sign with the Commission is attached for information.

This request for proposals covers one specific activity within a larger program aimed at the identification of opportunities for hydroelectric development in the Commission's service area. A separate note attached to this letter explains some aspects of this program which may be of interest to you.

The Commission has appointed.....to manage this study on its behalf and plans to appoint.....as co-ordinator to assist the Manager. This co-ordinator will be held responsible for:

- providing the Commission with a recommendation for acceptance/rejection of the proposals received in response to this invitation;

- obtaining from the relevant authorities all necessary land and water use authorizations to permit the work to proceed;

- monitoring progress on the assignment, helping to resolve study difficulties, and establishing reporting and review procedures;

- maintaining a comprehensive file on the project work;

- establishing study standards and evaluation criteria as appropriate;

- preparing for the Commission a composite monthly progress report on this, and other studies currently underway;

- reviewing all Consultant's proposals for additional work and providing recommendations to the Commission for acceptance, modification or rejection of such proposals; and

- reviewing all draft reports with the Consultant for conformity with these terms of reference prior to their finalization.

Northern Canada Power Commission
Program for Identification of Opportunities for Development of Hydroelectric Facilities

The Commission regularly reviews the scope for additional hydroelectric facilities to serve its larger demand centres or possible future loads of significant size.

With special funding from the Federal Government the Commission has also embarked on a program aimed at the identification of such opportunities to serve loads in smaller, isolated, load centres in it's service area. The high cost of diesel fuel used to generate power in these load centres provides a clear incentive to identify opportunities for the development of economic hydro facilities or other sources of generation. It may be noted that many, though not all, consumers of electric power in these communities are shielded by various subsidy programs from the full cost of providing power to them.

The Commission intends to proceed with a number of specific studies in a carefully graduated fashion such that more detailed and expensive investigations are undertaken only when preliminary studies have clearly indicated that there are sound prospects for a project. Such prospects will be judged sound if the project is deemed likely to be feasible from technical, economic and financial points-of-view and acceptable both socially and environmentally.

Wherever there are indications that an hydroelectric development is possible but when limited site-specific information is available, a reconnaissance study may be commissioned. A reconnaissance will consist of a brief review of available information and a site inspection visit by experienced professionals. They will prepare order-of-magnitude cost estimates for one or more possible optional developments and report briefly on important issues such as hydrology, availability of construction materials, type of development preferred, construction logistics and any significant social and environmental concerns which may be apparent. In the terms of reference, the Commission will provide an order-of-magnitude indication of the size of development required and of the amount of investment money which might be justified for the community in question.

If the reconnaissance study suggests that one or more developments may be possible at a cost which is approximately equal to or lower than the indicated benefits and that probable social and environmental concerns would not likely be of a nature to mitigate against development, a pre-feasibility study may be commissioned. The pre-feasibility study will be designed to select a single preferred site (if more than one has been identified) and to prepare a more-precise cost estimate, in the range of $\pm$30 percent of final cost in constant

prices, based on preliminary layouts and designs together with some fieldwork, although not generally including subsurface drilling. The cost estimate will cover all facilities including transmission.

Effort will also be made in pre-feasibility studies to identify and assess site-specific social and environmental concerns, to evaluate the implications of the load characteristics of the relevant market and to scrutinize alternative levels of development.

If a pre-feasibility study demonstrates that the prospects for a hydro-electric project are good, a feasibility study or studies may be commissioned. This study would result in cost estimates with a margin of error, in constant prices, of $\pm$15 percent. In most cases, site drilling will be necessary to support such a cost estimate. The study or studies will cover all technical, economic and financial aspects in sufficient detail to enable the Commission to arrive at an investment decision and will include a socio-economic and environmental assessment statements in sufficient detail to be submitted to regulatory agencies.

The Commission will evaluate the results of each study carefully in order to direct the limited funds available into study of the more-attractive project prospects.

Northern Canada Power Commission
Hydroelectric Development Programs
Request for Proposals

Terms of reference for a pre-feasibility study of the hydroelectric potential at ..... to serve the community(ies) of.....

1. Purpose

To execute, at the pre-feasibility level, studies designed to assess the probable costs and benefits of developing the hydroelectric potential at the .....site(s) on the .....river(s) to serve the community(ies) of.....

2. Background

This section will contain an enumeration of, and reference to, all relevant previous studies data and other information. Key information will be annexed to these terms of reference and locations identified where other references may be viewed.

3. Scope for hydroelectric development

Currently the community of.....is served by a diesel plant with a capacity of.....kW. In (last year) the peak load was.....kW and the annual generation was .....MWh. Monthly generation varied from.....MWh in the month of.....to.....MWh in the month of.....(minimum and maximum)

Considering normal expected growth of demand, an approximate installation of.....kW would likely be appropriate if current demand were to be supplied, wholly, from a hydroelectric plant. Considering growth of demand, expected fuel prices and fuel consumption, the present value (at a 5 percent real discount rate) of 40 years of fuel replacement would be about $..... in prices of 19... This may serve as a preliminary indication of the maximum investment which could be justified for such a hydro plant and its associated transmission facilities.

4. Scope of the Studies

i) The consultant will confirm or modify the suggested level of installation noted in the preceding section, assuming that the hydroelectric plant would supply all (if possible) of the power needs in the community without allowing for a significant change in the type of use of electric power (such as a conversion to electric space heating). This requires the incorporation of community and site-specific considerations such as likely growth of demand and transmission losses.

ii) With the required size of development in mind, the Consultant shall prepare one or more conceptual project layouts based upon all available site data and, within one month of commencing work, present to the Commission a proposed field investigation program that it considers to be the minimum essential to satisfy the purposes and objectives of this study program. Following receipt of approval to proceed, including receipt of all necessary exploration permits (which the Commission will acquire on behalf of the Consultant), the Consultant shall execute all approved investigations with the minimum of delay.

iii) Having acquired all necessary field information the Consultant shall refine (or reject) these layouts for the purpose of preparing component designs, construction schedules and development cost estimates to an accuracy of within $\pm$30 percent, expressed in constant 1983 dollars. Particular attention shall be paid to the site-specific hydrology, local conditions of terrain, permafrost, climate and ice-formation as well as to the availability of suitable construction materials. However, if possible, the Commission prefers that the investigation program not include site drilling at the pre-feasibility study stage. The Consultant should advise the Commission without delay if, after an initial site inspection, it considers site drilling to be essential to support cost estimates within the required margin of error.

iv) The consultant will prepare cost estimates to a similar degree of accuracy for the construction of a transmission line to the community to be served and its associated facilities. The consultant will seek advice from the Commission concerning appropriate design standards and relevant cost experience in preparing his estimate for transmission facilities.

v) If the site-specific conditions warrant, the consultant shall also give consideration to alternative options under which the hydro plant would serve a smaller base load and would be supplemented by diesel power for the purpose of daily or seasonal peaking. One or more alternative levels of installation shall be analyzed, and all costs of the plant and associated transmission facilities shall be assembled for the purpose of demonstrating the relationship between the level of development and its economic benefit/cost ratio (expressed in present-worth terms, 1983 dollars).

vi)* At the upper end of the scale the Consultant will, if practical, estimate the probable cost of developing a larger hydroelectric station, so that consideration can be given to suppling new loads for electric power such as arise from both residential and government/ commercial building space heating as well as from other oil-replacement activities.

The consultant will estimate the additional community load to be served if a maximum electric penetration is obtained and shall estimate the cost of hydroelectric plant and associated transmission facilities to serve this load. In addition, the consultant shall analyze, describe, and estimate the nature and size of investment required to prepare the residences, buildings and other facilities for such maximum use of electric power including the installation of all necessary equipment and facilities. Appropriate sampling techniques to establish the nature and cost of the conversion to electric use shall be used, when possible. Due consideration shall be given to the reliability aspect and to the extent to which it would be necessary to maintain stand-by facilities, either centralized or decentralized. In addition, the consultant shall analyze the need or desirability of energy conservation measures including, but not limited to, insulation of buildings and residences.

vii) The consultant will provide estimates of the monthly generation and peak capacity of the plant options considered for both an average year and a dry year (95 percent probability) and shall provide such additional information on output variations as is possible with the available hydrologic data base.

viii) The consultant shall estimate the expected benefits of replacing the existing diesel facility by a hydro plant (but shall not consider the option of a larger plant than required to serve the load under current use patterns)**. A distinction shall be made between

* This item will be included for one or two studies only, where appropriate to local conditions, to provide an initial analysis of probable costs, benefits and implications.

** Optional, if item vi) is deleted.

benefits deriving from fuel replacement and other benefits. Due consideration shall also be given to a possible loss of benefits due, for example, to a loss of (potential) of unrecovered waste heat. The Commission will supply the consultant with indices of future fuel prices.

ix) The consultant will identify significant potential socio-economic and environmental concerns which may arise from construction of the hydro-electric station and its associated transmission facilities. This identification will be based upon available published information, a reconnaissance survey of the areas likely to be affected and shall include a comprehensive discussion covering the possible facilities with community leaders and other knowledgeable local people as well as with relevant government officials. The consultant will suggest ways of minimizing these concerns and shall provide an indication of the cost of mitigative measures that may be necessary (to the extent that these costs have not been incorporated into the project cost estimates).

x) Notwithstanding the specificity of the foregoing scope items, the Consultant shall plan his work program to provide the Commission, at minimum cost, with a sound justification for either retaining the development for further study at the full feasibility analysis level or rejecting it as not economic under existing forecast circumstances.

5. Schedule

The consultant will initiate his work without delay immediate following the completion of contract negotiations with the Commission and shall complete the study, with submission of a final report, in draft, within ..... months.

6 Reports

The consultant will submit brief monthly reports summarizing all activities and expenses (including time) incurred to date. At the request of the Commission, progress will be reviewed periodically, with Mr. .....

..... copies of each monthly progress report will be required. The final report will be required in ..... copies, but only .... copies of the draft will be needed for review purposes.