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An Overview of Fisheries Problems Associated with the Proposed Lower Churchill Hydroelectric Development, Gull Island, Labrador

by
W.J. Bruce, C.J. Morry, L.W. Rowe and R.J. Wiseman

Internal Report Series No. NEW/I-75-2

Resource Development Branch
Newfoundland Region

Department of the Environment
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FRONT COVER PHOTO: Angling at the Lower end of Winokapau Lake, Lower Churchill River. Courtesy of L. Cave, Graphics Division, Environment Canada, Ottawa.

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1.0 INTRODUCTION

The Churchill River system supports many valuable recreational and commercial fish species that would be affected by the development of the river for hydroelectric purposes as proposed. These include the anadromous and resident Atlantic salmon, brook trout, and char; lake trout; lake whitefish; northern pike; longnose sucker; white sucker; burbot; and anadromous American smelt. In addition, there are at least four other non-consumptive use species which have their importance in the overall aquatic ecosystem.

Within the proposed transmission line corridor, there are, in addition to those fish species outlined above, four species of recreational-commercial value, and at least eleven others which are at present of no economic value. The four economically valuable species include, rainbow trout, brown trout, pink salmon, and the American eel.

Nine commercially important species are encountered within the corridor of the proposed Straits tunnel. These include cod, halibut, plaice, herring, salmon, capelin, scallops, lobster, and harp seals. In addition, many other marine species of ecological importance are found within the corridor, several of which possess potential for commercial exploitation.

Generally speaking, there is concern for the protection of fisheries and fish habitat within the are of influence of the proposed development. Three areas of concern have been identified in connection with the development, and the existing fisheries, fish populations and habitat have been reviewed and guidelines and recommendations presented

for the protection of same. The three areas of concern with respect to fisheries protection are (1) the Churchill River, (2) the transmission line corridor, and (3) the Straits tunnel corridor. Generally, our projections of possible fisheries - power development conflicts are ranked in the order as written above. That is, the most serious conflicts could occur within the Churchill River while the least sensitive activity should be the Straits tunnel crossing.

In summary then, the intent of this report is to provide an overview of the fisheries' problems to be encountered with the development of the Lower Churchill River for hydroelectric generation, and to provide recommendations for remedial measures to ensure the protection of the fishery resources. This report, although rather general in nature, is intended to be the basic working document for those workers having responsibility for the protection and management of fisheries within the area of influence of the proposed development.

2.0 THE PROPOSED PROJECT

Development of the Churchill (Hamilton) River system for hydroelectric production began in 1963 with the installation of dams at Twin Falls on the Unknown River. Production capacity at this site was increased in 1968; however, in the meantime plans were well underway for the massive Churchill Falls power project which would soon make Twin Falls obsolete. In 1972, the Churchill Falls dam and power plant was completed, with an installed capacity of 5,225 mega watts (roughly 7,000,000 horsepower).

This was the first and greatest step in the total harnessing of the Churchill River which will eventually supply a total of 7,625 MW. The remainder of this potential is to be achieved in two phases; the Gull Island Project, yielding 1,800 MW and Muskrat Falls Project which, at some time in the future will be developed to provide the final 600 MW, available.

It is the former of these two phases, the Gull Island Project, which is the area of immediate concern. Barring production delays the power is to go on stream in the beginning of the 1980's and as yet little is known of the River's fisheries resources which could be drastically altered.

Unlike the Churchill Falls site, Gull Island will be a "run-of-the river" scheme with minimal storage capacity in the newly created reservoir. The dam is to be located near Gull Island Rapids, 140 miles downstream from the Churchill Falls powerhouse and about 55 miles upstream of Happy Valley - Goose Bay. It will be an earthfill-type dam

providing 300 feet of head and the reservoir created will extend almost the full 140 miles to the Churchill Falls tailrace. Due to the precipitous nature of the river bed, however, the reservoir will be very narrow and deep. The only lake to be flooded is Winokapau, which itself is truly part of the Churchill River.

During operations, downstream effects are expected to be minimal because of the "run-of-the-river" nature of the project. Because the Churchill Falls Development and that at Gull Island are to be integrated, it is estimated that downstream flow should never be reduced by more than 6% of present levels. Daily drawdowns behind the dam should be between 1.2 and 5.5 feet and can be replenished in a matter of days. A total drawdown of 20 feet is hypothetically considered to be the maximum one can expect.

Six 300 MW generating units will be on stream at full capacity. The power thus generated will be carried to Insular Newfoundland by two 400 KV, 800 MW, transmission lines. The bipolar transmission lines from Gull Island to Newfoundland will cover a distance of 685 miles. The two lines from Gull Island to a converter station at Stony Brook (Grand Falls), a distance of 485 miles, will require a 350 foot right-of-way. A single line, two hundred miles long with a 150 foot right-of-way runs the remaining distance from Stony Brook to Soldiers Pond, near St. John's. In addition, it is planned to construct a transmission line from the Gull Island site to Churchill Falls, a distance of approximately 120 miles (Figure 1).

Actual construction of the transmission line involves the clear-cutting of the right-of-way, installation of towers and stringing of

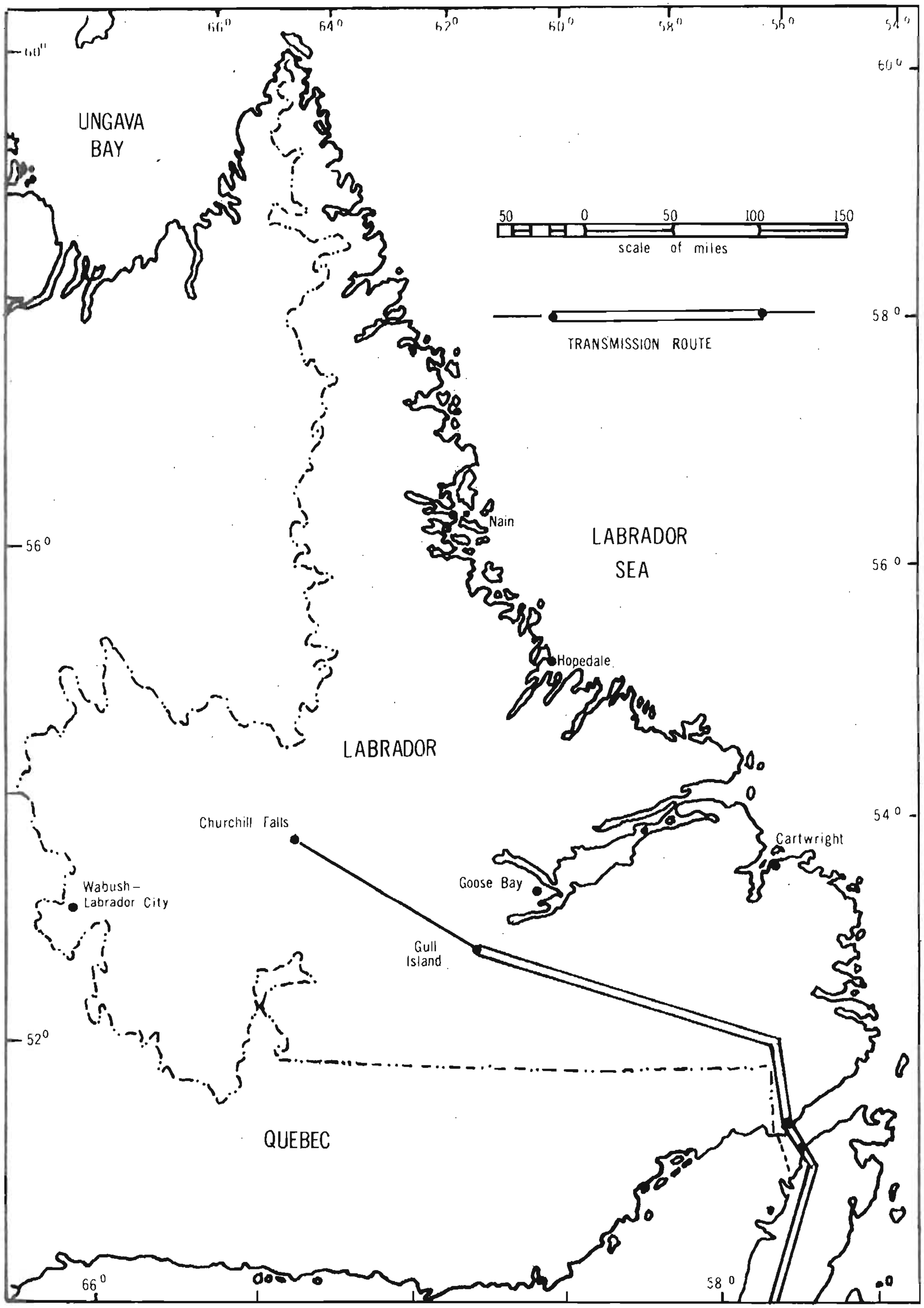
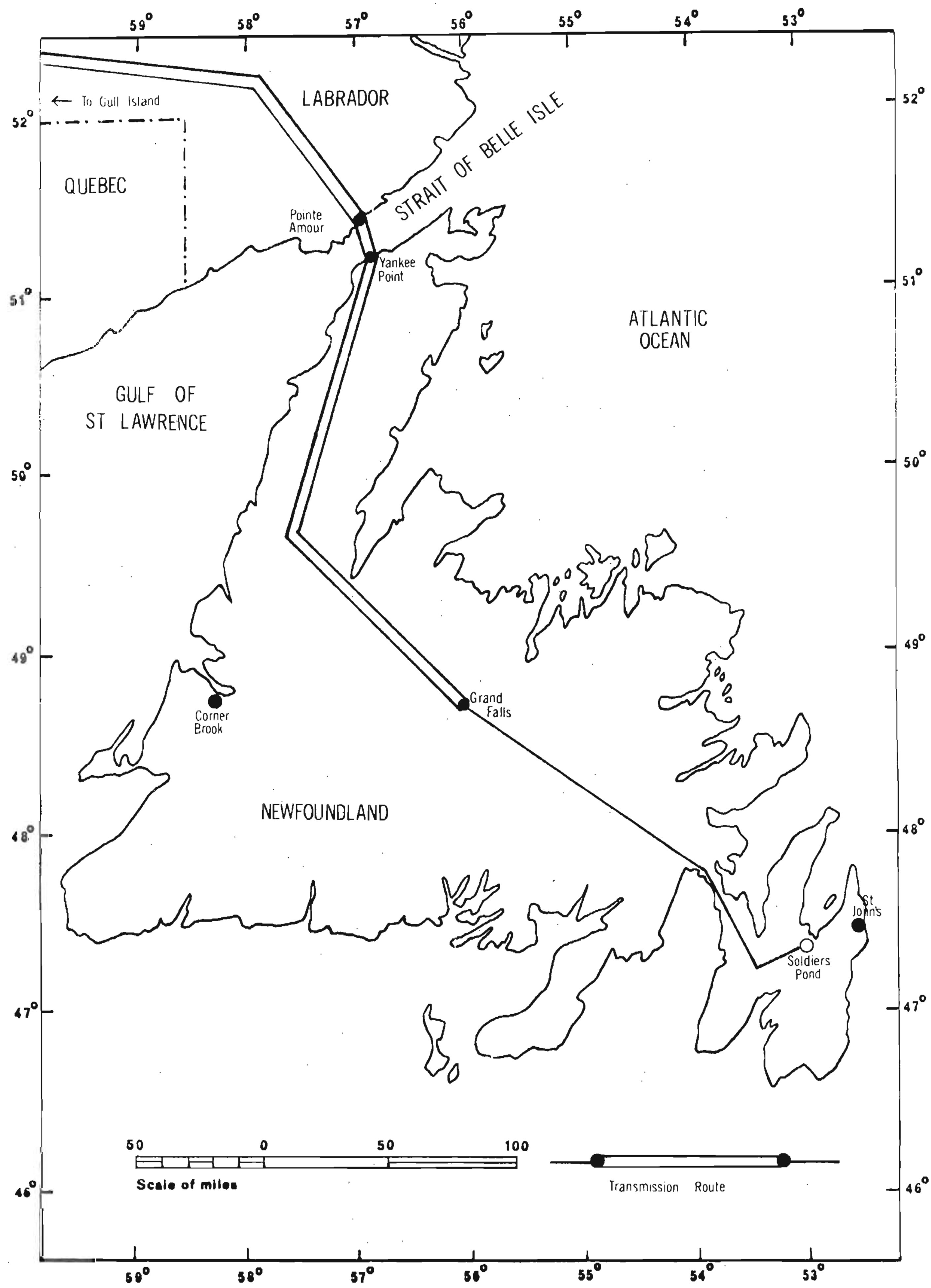


Figure 1. Location maps showing major centres mentioned in the text and the proposed transmission lines.



59°
58°
57°
56°
55°
54°
53°
52°
51°
50°
49°
48°
47°
46°
← To Gull Island
LABRADOR
QUEBEC
STRAIT OF BELLE ISLE
Pointe Amour
Yankee Point
ATLANTIC OCEAN
GULF OF ST LAWRENCE
Grand Falls
Corner Brook
NEWFOUNDLAND
St John's
Soldiers Pond
50 0 50 100
Scale of miles
Transmission Route

wire. Associated activities include the building of construction camps. marshalling yards for equipment and material storage and possibly access road construction.

The transmission route will be used as a roadway and will require the use of culverts and temporary bridges.

The maintenance of the right-of-way, in terms of vegetation control, after construction, will employ either hand-clearing, controlled burning, or the use of herbicides.

At the Straits crossing a tunnel 11 miles long by 14 feet wide and 17-1/2 feet high will be constructed at an approximate depth of 1,700 feet below the sea floor. Two vertical shafts, one at Pointe Amour, Labrador, and the other at Yankee Point, Newfoundland, will carry the transmission lines from the cable switching stations to the tunnel.

Construction activity during the development of the Project will be concentrated at the dam site, Point Amour, Yankee Point, and Stony Brook with smaller groups working the transmission line. At Gull Island a trailer camp to accommodate 200 men is presently being assembled. By 1976, this should have expanded to accommodate 2,100 or more workers. The permanent townsite originally thought necessary for the Project itself is now to be located at Happy Valley - Goose Bay, thus eliminating the need of a landing strip at Gull Island. On each side of the Straits a 120 man construction camp will be built. These will each be served with new air strips and wharves. At Stony Brook accommodation for 100 men will be necessary and 20 to 50 man camps will be dispersed along the transmission line route.

3.0 IMPACTS

3.1 The Churchill River

The Churchill River basin is the largest in the province and has a total drainage area of approximately 36,500 sq.mi. which is about 85 percent of the area of the entire island of Newfoundland. The drainage of the river can generally be divided into three parts: (1) the upper drainage consists of that area above Churchill Falls, including the Ashuanipi River drainage, the largest Churchill tributary; (2) the central drainage area includes the greatest part of the river valley and its tributaries, and stretches from Churchill Falls to Muskrat Falls, a distance of 175 miles; and (3) the lower drainage is that area between Lake Melville and Muskrat Falls, a distance of 25 miles.

This natural drainage system was altered with the beginning of the Upper Churchill hydroelectric program in 1971. This program meant the diversion of two large river systems, the Naskaupi and the Upper Churchill, and flow of water over Churchill Falls itself was greatly reduced. By means of diversions the water which normally cascaded over the Falls has been retained on the plateau and channelled to turbines above the river and east of the Falls (Duthie and Ostrofsky, 1975). A second alteration of the Churchill River is planned with the Gull Island hydroelectric development program. This program calls for the construction of a run-of-the-river plant and it will be tied in with Churchill Falls Development.

There is a 400 foot head available between Churchill Falls and the mouth of the river at Happy Valley - Goose Bay and this project will develop about 75 percent of the available head. The remaining 100 foot

head may be developed at Muskrat Falls at some future date.

3.1.1. Fish Resources

Most, if not all, of the freshwater fish species found in inland Labrador are present in the Churchill River and its drainage basin. The most important sport species are resident and sea-run brook trout, *Salvelinus fontinalis*; resident and sea-run Atlantic salmon, *Salmo salar*; sea-run Arctic char, *Salvelinus alpinus*; lake trout, *Salvelinus namaycush*; and northern pike, *Esox lucius*. Other species present are lake whitefish, *Coregonus clupeaformis*; round whitefish, *Prosopium cylindraceum*; longnose sucker, *Catostomus catostomus*; white sucker, *Catostomus commersoni*; sea-run American smelt, *Osmerus mordax*; burbot, *Lota lota*; threespine stickleback, *Gasterosteus aculeatus*; ninespine stickleback, *Pungitius pungitius*, and at least one species of minnow, the lake chub, *Couesius plumbeus*.

Muskrat Falls is considered a natural barrier to migrating anadromous or sea-run fish and as a result only about 1.3 percent of the total drainage area is available to anadromous forms of such species as the Atlantic salmon, brook trout and Arctic char.

In addition to the main river itself, there are a number of large river systems which drain into the Churchill River above the proposed dam site. These are the Metchin and the Cache on the north shore, and the Elizabeth Fig, Shoal, and Minipi on the south shore. All these rivers should be good producers of fish, particularly resident salmonids.

Below the dam site the Pinus River and Upper and Lower Brooks empty into the Churchill from the north, and the McKenzie River, Caroline Brook, and Traverspine River enter from the south. In addition to these major river systems there are a large number of smaller tributaries which

empty into the Churchill River.

3.1.2 Limnology of the Churchill River

Very little is known of the limnology of the Lower Churchill River. The only data available on the Churchill River system are those gathered on the Upper Churchill River, therefore we are required to extrapolate in any discussion of limnology of the section between Churchill Falls and Happy Valley - Goose Bay.

Water Quality:

Water quality studies conducted in various areas of Labrador reveal the waters are very soft, low in dissolved solids, and the pH values are generally slightly less than 7. Water quality analyses have been conducted on the waters making up the upper Churchill basin by Duthie and Ostrofsky (1974, 1975). They reported mean conductivity values between 10.2 and 32.0 and pH values ranged between 6.0 and 6.5. The lakes in western Labrador are generally ice-free between late June and late October with maximum surface temperature being reached in late July. Turbidity values are low and they seldom exceed 6 units except during the spring thaw. The lakes are usually saturated with oxygen during the ice-free periods.

Plankton:

Very little work has been done on either the phytoplankton or zooplankton populations of inland Labrador. Duthie and Ostrofsky (1974) sampling 10 lakes and a reservoir in the Churchill Falls region of western Labrador identified 44 taxa of phytoplankton and zooplankton. Diatoms were the most abundant group reported for the phytoplankters

while the cladocerans were the dominant zooplankton group. The zooplankton of western Labrador is very similar to that of other lakes on the Canadian Precambrian Shield. Limnological studies on a natural lake and reservoir in western Labrador, conducted by this Department in 1974, report similar findings of zooplankton as reported by Duthie and Ostrofsky (1974).

3.1.3 The Reservoir

The impacts arising from reservoir formation will be of a physical, chemical, and biotic nature.

Physical:

The construction of a 300 foot dam at Gull Island rapids will turn the river upstream of the dam into an artificial lake (reservoir). At its maximum design elevation of 403 feet, the reservoir will cover an area of approximately 77 sq.mi. and will contain a total volume of about 3 million acre-feet. The maximum depth will be about 300 feet near the dam, and its total drainage area will be 34,400 sq.mi. The morphometry of the existing river will be greatly changed; the water level, surface area and mean depth will be greatly increased, and most of the existing shoreline will be lost. The littoral zone which includes the lake shoreline is the most productive area within a lake or river system and is most influenced by morphometric, edaphic, and climatic factors. This area lies within the photic zone (zone of light penetration and biological production) and receives a high supply of nutrients. This is the area of plant growth and benthic communities, both of which are important links in the freshwater food web. Damming of the river will

eliminate this existing production zone. Many, if not all, of the rivers and tributaries entering the Churchill River will be partially flooded as a result of this hydroelectric development project. It is felt that these systems which are accessible to fish serve as spawning and rearing areas, particularly for salmonids and coregonids. These spawning and rearing areas will be lost as a result of inundation. Other areas upstream, if accessible, may become available for fish spawning. If barriers do exist even after flooding they could be removed either by blasting or by the construction of fish passage facilities.

Within the newly formed reservoir, daily load variations at the generating plant will be reflected in normal drawdowns of some 1.2 to 5.5 feet with the water being replenished within a matter of days.

Drawdowns of up to 20 feet have been predicted for the new reservoir if the operations of the Churchill Falls and Gull Island plants are non-integrated. Under a "no tie-in" system this maximum drawdown could possibly occur once a year, most probably during early spring before the run-off occurs. Also, a non-integrated operation would necessitate a possible drawdown of approximately a foot daily, or a 5-7 foot drawdown over a week. Should the two plants operate as an integrated system, which is most likely, the 20 foot drawdown would not be necessary. The adverse effects of drawdowns on the long term wellbeing of reservoir fish stocks is obvious.

The formation of the reservoir would undoubtedly alter the water temperatures of the existing river. As a result of increase in surface area more surface water would be receiving solar radiation and the epilimnion area would be greatly increased. Thermal stratification would undoubtedly occur during the summer months and a thermocline may develop.

Chemical:

Generally, with the flooding of terrestrial land surfaces there is an increase in nutrients as a result of leaching of the soils. The actual increase of any particular element depends upon the nature of the soils inundated and the soils of Labrador are generally poor nutrient wise. Duthie and Ostrofsky (1974) reported that the underlying bedrock appeared to be more important than flooding in determining the water chemistry of the newly created Smallwood Reservoir. Their studies showed there were no great changes in the chemical and physical factors they measured after 8 years of inundation.

Additional changes in water quality are expected if clear-cutting of the forests is not conducted. These changes included: reduced pH, increase in humic acid, increase in color and turbidity, increase in tannin - lignin levels (two very slow decomposing materials found in wood), increase in oxygen consumed, and a slight increase in total dissolved solids.

If the forests are clear-cut the adverse effects of dystrophy would be significantly reduced. Clear-cutting and subsequent disposal of the forest would, in effect, result in a smoothing out of the peaks and troughs normally associated with ecological succession in reservoirs. The over-riding effect would be an environmental stabilization.

In addition to the ecological benefits to be derived from clean-cutting, it would also facilitate operations during any commercial fishing venture which may be established.

Dissolved oxygen in the reservoir should be comparable to that in a large oligotrophic lake and there shouldn't be any appreciable depleting of same.

Biotic:

Some changes in species composition and biomass of plankters is anticipated as a result of flooding. Increased standing crops of phytoplankton during the first few years after flooding have been reported for reservoirs in the U.S.S.R (Prijmatchenko, 1961), Czechoslovakia (Javornicky, 1966), and the Smallwood Reservoir (Duthie and Ostrofsky, 1974). Similarly, associated with this increase in phytoplankton biomass, there is an increase in zooplankton standing crop. In addition to phytoplankton, increased particulate matter and bacteria in new reservoirs are food sources for zooplankton.

Very few investigations have been conducted on the benthic communities in the waters of Labrador. Changes in the mean level, and continuous fluctuations about the new mean, inevitably affect the benthos of the littoral zone. Flooding will not only alter the physical nature of the bottom but will also result in loss of macrovegetation. As a result of this many species may be deprived of a habitat and may be replaced either by new species or by increased number of existing species which are favoured by the new conditions. These changes which occur in the littoral zone will also affect the feeding and growth of fish. Generally speaking then, concurrent with an anticipated initial increase and subsequent levelling off of plankton biomass, there will probably be a similar pattern for the benthic community. Such is the generally accepted model for predicting changes in reservoir plankton and benthic communities.

The creation of this 140 miles, narrow, deep lake should provide suitable habitat for several fish species, particularly lake whitefish and lake trout. Lake whitefish is the most abundant fish species found

in the Smallwood Reservoir on the Upper Churchill River system, and appears to be doing quite well in the newly established habitat. Lake trout are typically a cold water species which inhabit deep, oligotrophic lakes similar to the one which will be established above Gull Island.

Other Labrador salmonids, e.g. brook trout and Atlantic salmon (ouananiche), appear to require fast flowing, well-oxygenated water and they perhaps will find it difficult to adapt to the environment of the created reservoir. They presently are found in concentrations near the mouths of the tributaries that empty into the Churchill River, as well as in the rapid sections of the main river (e.g. Horseshoe, Minipi, and Mouni Rapids).

Definitive statements concerning the future abundance of other fish species, i.e. suckers and northern pike, are difficult to make since we don't have quantitative data on their present abundance. However, these species are generally found in shallow lakes and the proposed reservoir wouldn't appear to provide much suitable habitat for these species. Pike spawn in weedy areas and this type of substrate won't be too abundant in the new reservoir.

Test net results from the Smallwood Reservoir show these species aren't very abundant in the newly flooded areas. It cannot be stated definitely that this is the result of flooding because we have no fish data for pre-impoundment conditions.

3.1.4 The Dam and Downstream Area

As already indicated, the proposed dam is to be of the earthfill

type approximately 300 feet high, and is to be located near the Gull Island Rapids, specifically at the head of Grizzle Rapid.

Associated with the dam will be twin diversion tunnels located on the north bank of the river. These are designed to regulate upstream levels during construction and for final closure of the dam during reservoir filling. They are designed to pass a diversion flow of 210,000 c.f.s.

The dam will have a concrete chute spillway with the spillway crest structure comprising seven vertical lift gates.

The intake, to be located between the most southerly tip of the main dam and the spillway structure, will contain the entrance to the six separate penstocks.

Dam:

The construction of a 300 foot-high dam (crest length of approximately 4,700 feet) across the river will obviously have impact on any fish migrations normally occurring in that section of river. To date there is no documentation of anadromous species above Muskrat Falls. Some recent, unsubstantiated reports suggest however that sea-run salmon have surmounted the obstruction at Muskrat Falls. Although of dubious nature, these reports cannot be dismissed in view of the obvious implications these would have if substantiated.

The section of river downstream from the proposed dam should not be greatly affected as flow regimes should be somewhat regulated. Increased erosion will occur immediately downstream of the proposed dam. It is not expected that ice-jamming will be any more severe than presently experienced.

Diversion Tunnels:

As indicated, the twin diversion tunnels are designed to divert flow during dam construction, and it is proposed to close these following construction to allow the reservoir to fill. It is anticipated this would require some 15 days at which time there would be no flows through the dam resulting in a major reduction in flow all the way to Lake Melville. It is estimated that this reduction would amount to over 90 percent. Over a quarter of a mile would be temporarily dried out between the dam and Gull Lake.

Spillway Structure:

The spillway will consist of a chute with a low level flip bucket; a plunge pool downstream of the flip bucket will dissipate the excess flow energy. The plunge pool will be designed to permit the formation of a hydraulic jump to facilitate energy dissipation. Frequently, with certain flow releases, hydraulic jumps have been known to attract fish and imprison them in the complex back-eddying current associated with such a jump. There is some suspicion that this is the cause of the recurring fish kills at the Lobstick Control Structure, in the Upper Churchill Falls Development.

It is difficult, with the existing information, to say whether oxygen and nitrogen supersaturation would occur in the water immediately below the spillway; this has not occurred at the Churchill Falls site, however.

Intake:

The intake structure will be located between elevation 393' (minimum water level) and elevation 320'. It will consist of six bellmouth intakes

each requiring a set of vertical trashracks. The trashracks will be handled by means of a rail-mounted gantry crane which is provided with a mechanical grab to remove trash accumulation. There is no provision in the project proposal for inclusion of intake fish barriers, such as revolving screens or electrical screens. Experience at the Upper Churchill Development intake indicates significant on-going fish mortalities are a problem, particularly for slow swimming, pelagic species. Whitefish in particular are "attracted" near the intake, become trapped in the vortex, travel through the penstocks, go through the turbines, and are flushed out with the tailrace water. The severity of this problem at the Churchill Falls installation is best illustrated by the fact that a small gull population is sustained, immediately off the tailrace area, on the mutilated fish being flushed through the power station.

Since the penstock intake will be located near the top of the dam, the temperature of the tailrace water, in summer, will perhaps be somewhat higher than that of the reservoir. This would be due to taking water from the warmer epilimnion. In addition, the intake water will be heated somewhat by its passage through the turbines. In winter, cold surface water will be taken off, but this will in turn be heated somewhat by turbine friction. The net heat gain or loss is difficult, if not impossible, to determine at this time. The resulting impact, if any, is to be determined.

3.2 The Transmission Line

Basically, the transmission line will involve (1) the construction of high voltage direct current (HVDC) facilities for delivery of 1,600

MW of Gull Island power to the 230 KV alternating current Island grid, and (2) the construction of an extra high voltage alternating current intertie with the Churchill Falls power development on the Upper Churchill River.

The development of the HVDC facility will include two $\pm$ 400 KV, 800 MW bipolar transmission lines interconnecting the Gull Island site with the converter station at Stony Brook (Grand Falls), and one $\pm$ 400 KV, 800 MW, bipolar line from there to Soldiers Pond near St. John's. In addition, the planned development calls for the construction of a 735 KV AC interconnection from Gull Island to Churchill Falls. In all, the selected route involves the construction of approximately 805 miles of bipolar transmission lines. This consists of: 250 miles from Gull Island to Pointe Amour, 235 miles from Yankee Point to Stony Brook, 200 miles from Stony Brook to Soldiers Pond, and 120 miles from Gull Island to Churchill Falls.

The right-of-way will consist of a 350 foot-wide corridor. Tangent and light angle suspension towers will be of the guyed mast type, while median angle towers will be of the guyed double mast of self-supporting type. The heavy angle deadend towers will be of the self-supporting type.

3.2.1 Fish Resources

It is impossible, as well as impractical, to attempt to quantify the fishery resource that could be affected by the construction of the Lower Churchill transmission line. It is sufficient to say that all rivers, streams, lakes and ponds support fish life to some degree.

All fish species as listed in Table 1 occur in the freshwater systems of Newfoundland and/or Labrador. The most abundant and most-utilized, in terms of the commercial and sport fisheries, are Atlantic salmon and eastern brook trout, both resident and anadromous forms.

Table 1. Checklist of fish species occurring in Newfoundland and Labrador.

Species	Occurrence	
	Newfoundland	Labrador
Brook trout	X	X
Brown trout	X	
Rainbow trout	X	
Arctic char	X	X
Ouananiche	X	X
Salmon - Atlantic	X	X
Salmon - Pacific pink	X	
American smelt	X	X
American eels	X	X
Lake whitefish	X	X
Round whitefish		X
Longnose sucker		X
White sucker		X
Northern pike		X
Burbot		X
Lake trout		X
Pigmy sucker		X
Minor species		
Brook stickleback		X
Fourspined stickleback		
Threespined stickleback		X
Twospined stickleback		
Ninespined stickleback	X	X

Table 1 (cont'd.)

Species	Occurrence Newfoundland	Labrador
Mummichog	X	
Banded killifish	X	
Tom cod	X	
Mottled sculpin		X
Slimy sculpin		X
Lake chub		X

X indicates presence.

Atlantic Salmon Fishery:

Of the 164 scheduled salmon rivers in the province the transmission line will pass through the watersheds of 26; 3 in Labrador and 23 in insular Newfoundland (Table 2). Although the 23 scheduled rivers on the island represent only 15.5% of the 148 scheduled rivers of insular Newfoundland, they represent approximately 31% of the total salmon angled and 39% of the total number of rod days. Similarily, the 3 scheduled rivers crossed in Labrador comprise only 18.3% of the territory's 16 scheduled rivers, however they contribute over 40% of the total number of fish angled and over 50% of the total number of rod days. In consequence, the relative importance of these 26 scheduled rivers, to the recreational fishery valued at 4.9 million dollars, for 1969 (Inder, 1973) cannot be played down. Also, these rivers are particularly important to the commercial salmon fishery of Labrador, the Great Northern Peninsula and the northeast coast, which for 1973 contributed 77.4% of the total landing. (Table 3).

It is important to note that many of the other river systems, to be crossed by the transmission line, though not scheduled, do support small runs of Atlantic salmon. Although these rivers may not be individually significant in their contribution to the commercial and sport fisheries, collectively they make a significant contribution to the total production of the province's salmon resource.

Table 2. List of scheduled salmon rivers to be crossed by the transmission lines.

Bellevue Brook	River of Ponds
Castors River	Riverhead Brook, West Brook
Come-by-Chance River	Salmon Brook, Port Blandford
East River (Hawke's Bay)	South Brook (Hall's Bay)
East River (St. Barbe Bay)	South River
Exploit's River	Southwest Brook (Port Blandford)
Gambo River	St. Genevieve River
Gander River	Terra Nova River
Humber River	Torrent River
Main River (Sops Arm)	West River (St. Barbe Bay)
North Arm River, Holyrood	Pinware River
Northwest River (Port Blandford)	Forteau River
Portland Creek	l'Anse au Loup River

Table 3. 1973 commercial salmon landings (lbs. and $) from fisheries contributed to by rivers crossed by the transmission line.

Statistical Section	Pounds
01	1,434
02	158,997
03	110,681
04	361,954
05	102,858
06	98,177
07	38,647
08	58,684
09	59,608
10	28,651
11	50,627
12	75,408
13	193,036
14	10,663
15	24,621
16	37,460
17	28,644
18	77,981
19	39,872
20	10,679
21	112,532
22	139,318
23	101,894
44	20,922
45	9,159
46	7,369
47	2,710
48	16,323
49	208,040
50	148,295
51	464,380
52	477,895
53	348,576
Total	3,446,125

Table 3 (cont'd.)

Statistical Section	Pounds
Total value	$2,360,036.
Provincial Total, 1973	$4,451,056
Provincial value, 1973	$3,053,622

Trout Fishery:

Unlike the salmon sport fishery, detailed data respecting the trout fishery are not available. However, Inder (1973) estimated the economic value of this resource to be $16.3 million for 1969. Though it is impossible to estimate the portion of this value that could be affected by construction of the transmission line, the overall benefit of each trout stream and pond becomes obvious.

3.2.2 Physical Effects of Construction

Sediment:

Fine grains of clay and sand referred to as silt probably have the greatest detrimental effect on fish productivity. Its introduction into the aquatic environment in any quantity above that normally carried by the stream can alter water quality, consequently reducing productivity.

(1) Effects on Food Supply: Excessive silt increases the turbidity of water which in turn results in decreased photosynthesis. Silt also covers bottom organisms thus eliminating an important food

supply. In general, streams with heavy sediment loads show marked reductions in productivity of fish foods.

(2) Impairment to Spawning: Fish spawn in gravel that is clean and well oxygenated. The addition of silt may deteriorate spawning gravels to such a condition that fish will not spawn. The addition of silt after spawning can kill eggs by completely covering them or by preventing flow of water through the gravel, and thus reducing the oxygen supply to a lethal level. In this respect, the timing of construction activity near streams is extremely important, so as not to interfere with incubation of eggs and fry emergence. In general, trout spawning takes place in insular Newfoundland waters between the first of October and the first week in December, depending on species and stream conditions. Salmon generally spawn during the period mid-October to mid-November. In Labrador, spawning in both trout and salmon populations may occur as much as a month earlier than on the island. The eggs over-winter in the stream bed and usually hatch during April and May with the young fish emerging from the gravel during May and June, at which time they are most susceptible to damage from silt.

(3) Effects on Swimming Fish: Silt has been shown to decrease the growth rate of fish, reduce their resistance to disease and in some instances directly kill them by covering the gills, preventing the intake of oxygen. Trout and salmon will move out of streams that are heavily silted.

Silt degrades the aquatic environment and all efforts should be made to prevent its entry into streams and ponds.

Removal of Stream-side Vegetation:

(1) Increase in Water Temperature and O_2 Reduction: In Oregon, it was found that removal of stream-side vegetation, due to clear-cutting operations, increased stream temperatures in Needle Branch Creek from a pre-cutting high of 60.8°F to 86°F (Hall and Lantz, 1968). Associated with this, dead juvenile coho salmon and trout were found in the clear-cut area. Decreases in the dissolved oxygen content were also observed; however, at a nearby stream where streamside vegetation remained after cutting, no significant increases in temperature or decreases in dissolved oxygen concentrations were noted. Green (1950) reported temperature differences of 13°F between forested and cleared stream sections. It is also possible that the warmer waters may increase disease and parasite problems.

(2) Reduction in Food Supply: Vegetation provides energy to the stream or pond through leaf fall, terrestrial insect drop and addition of dissolved nutrients. Aquatic insects depend upon terrestrail plant material for a large portion of their diet. In turn these insects provide food for salmon and trout. Consequently, removal of streamside vegetation may have detrimental effects on production of fish foods.

(3) Increased Predation: Overhanging vegetation provides protective cover to fish from predation by larger fish, animals and birds.

(4) Increased Bank and Channel Erosion: Vegetation, protects the stream bank from channel erosion, erosion from overland flow, and the erosive effects of precipitation. The major effect of erosion is the addition of excessive suspended solids into the aquatic environment.

(5) Increased Content of Organic Debris: Vegetation acts as a

buffer against the washing of organic debris, from overland flow, into the stream. Bacterial decomposition of large quantities of organic material such as leaves, tree trunks, branches, and soil, in combination with high water temperatures can rapidly deplete the dissolved oxygen content of a pond or stream.

Obstructions:

Obstructions to migration are classified under two headings. Firstly, complete obstructions, are those that prevent the up-stream movement of all fish and secondly, partial obstructions, are those that are obstructions only at certain water levels and that only a small portion of the fish population can surmount. Barriers to migration can be the result of natural phenomena (falls, rock slides and channel shifts) or man-made activities (dams, debris, culverts, pollution barriers caused by toxic materials or sediments, and temperature barriers caused by removal of vegetation or entry of heated waste water). Obstructions reduce productivity by reducing the area available for spawning and rearing.

3.2.3 Guidelines

The extent of construction activity and the absence of detailed information pertinent to each stream crossing, preclude the provision of specific guidelines. Therefore, general guidelines can only be presented at this time. These guidelines are designed to cover all cases and their strict application should minimize or eliminate environmental disturbance. If, in the event subsequent field surveys show specific areas to be highly sensitive (in terms of spawning

habitat, for example) the contractor should be made aware immediately of the problem area and of specific guidelines designed for that crossing.

Right-of-way Clear-cutting:

Essentially this operation involves cutting and burning of trees and high shrubs. It is conceivable that in some areas the merchantable timber will be transported for sale; however, the extent of this type of operation would depend on proximity to market, price, and volume of wood available. However, it can be expected that commercial extraction of timber, would, for the most part, be uneconomical due to the small width of the area to be cut. Consequently, the problems presented to the inland fishery by commercial cutting operations will be minimized due to a decrease in mechanical logging activity, particularly skidding. However, this does not preclude the use of other heavy equipment.

The following are suggested as guidelines for the clear-cutting operations:

(1) Tops, slash and other debris are not permitted to be piled or felled in any water body. All organic debris must be piled at least 150 feet from any water body. As well, debris cannot be burned within 150 feet of any water body or stream.

(2) Mechanical operations cannot be carried out within 300 feet of any water bodies either standing or river. Within this buffer zone cutting should proceed in such a manner as to maintain the ground vegetation layer intact, thus preventing the possibility of soil erosion.

(3) Skidding and other heavy equipment operations should be kept

to a minimum in this buffer zone; skid trails, if any, should run with the contour, and to a central collector road, the width of which should be minimal;

(4) Skid roads leading to water bodies must provide for the interception and dispersal of ditch drainage;

(5) In no event may stream beds be used as skid roads;

(6) Skidding across streams must be avoided. However, if this type of operation becomes necessary, the same crossing site must be used at all times. The crossing area should have a water depth of at least 8 inches at low water. Upon completion of activity, the crossing area should be returned to as natural a configuration as possible;

(7) Wood driving on any stream must first be approved by the Fisheries and Marine Service.

Road Construction:

The transmission line will comprise the construction roadway and as such will not exhibit the same extent of sediment problems as would the construction of a public road. This is due primarily to the use of tracked and low pressure rubber tired all-terrain vehicles, which do not require the preparation of a good road bed. The area available to erosion will be greatly reduced due to the absence or minimization of grubbed side slopes and ditches.

Since construction equipment will be of the tracked and rubber tire type vehicles, this equipment will ford all small rivers and bridging will only be used on those river sections which are excessively deep or turbulent. This creates a significant conflict with the fisheries resource, since small streams are usually more productive

in terms of available spawning and rearing area. This would certainly be most important for resident species in isolated habitats.

It is recommended that all care be taken near small streams, particularly if they possess potential spawning gravels, either at the crossing site or immediately down-stream. Guidelines for these crossing areas include:

(1) Maintenance of a vegetation buffer strip; ground vegetation should remain undisturbed. This can be accomplished by hand-cutting and removal of timber. The buffer strip should be at least 200-300 feet in width depending on degree of slope;

(2) Stream crossings should be facilitated by temporary bridging. The approach roads should be with the contour and should also provide for the retention of excessive ditch drainage. After completion of construction, these areas, if deemed unstable, should be revegetated. It should be pointed out to the contractor or engineering consultant on site that streams containing gravels of 3 inches or less in diameter with moderate water velocities are capable of providing spawning areas for trout. With respect to salmon, the gravel size can be increased from 3 to 6 inches. Guidelines for installation of culverts and bridges follow. (4 and 5);

(3) For small streams not possessing spawning potential at or below the stream crossing site, the requirement for temporary bridging can be deleted. In any event care must be taken to ensure the crossing area does not become an obstruction to fish migration, either by the presence of debris or by the disruption of the bed resulting in damming at low water levels;

(4) With respect to culvert installations, maximum desirable slope of culverts should comply with the following: culverts 50 feet or less, 5%; culverts 50-100 feet 3%; culverts 100 feet or greater, 1.5%.

Culverts should be installed on a uniform slope, preferably following the existing gradient of the stream, and set 6-12 inches into the stream bed;

The stream bed at the outlet area should be lined with coarse material to prevent erosion and consequent free fall;

Water velocity not greater than 4 ft./sec. in culverts under 80 feet in length, and not greater than 3 ft./sec. in culverts over 80 feet in length;

Culverts must be designed to carry the maximum instantaneous discharge as calculated for each stream;

Slopes resulting from cut and fill operations should be stabilized to prevent erosion and consequent siltation of the stream;

All construction debris must be removed from the culvert area, to a point above high water, to prevent its return to the stream and consequent probable clogging of the culvert;

Culverts should be checked frequently and cleaned of debris if required;

Construction activity must be confined to immediate area of the culvert. Streams cannot be channelized without prior approval.

(5) With respect to bridge construction, not more than 1/2 of the stream width shall be blocked at any one time;

Excavation for the piers, footings, and abutments should be conducted in such a manner as to keep the work area separated from the

flowing stream. A cofferdam may be used to separate the work area from the flowing stream but is to be limited to one side of the river at a time. Excavated materials shall not be allowed to enter the stream. Care must be taken during removal of cofferdams to prevent cofferdam material from washing into the stream. Ensure that excavations are filled to prevent fish being trapped during low stages;

Extreme care must be taken to see that no cement, lime, or fresh concrete is allowed to fall into or enter the flowing stream;

Creosote treated lumber or materials shall be completely dry before use in and near the water;

All construction debris shall be removed from the stream and adjacent stream area and be disposed of, burned, or placed where it cannot be washed back into the stream by high water. Excavated materials not used shall be placed away from the immediate area so heavy rains or high stream flow will not return it to the stream;

All work operations shall be conducted in a manner to casue a minimum of siltation and disturbance to the adjacent and downstream areas;

Minimize the use of heavy equipment in stream bed;

Slopes resulting from cut and fill operations should be grassed and stabilized as soon as possible to prevent erosion and subsequent siltation of the stream;

(6) Respecting borrow pits:

(a) Gravel cannot be removed from neither stream bed or bank nor the shoreline of a lake or pond;

(b) Borrow pits must be located so as to maintain a minimum vegetation buffer strip of 300 feet.

Application of these general guidelines will eliminate, or at least minimize excessive down-stream siltation, especially as it relates to the cumulative effect of many small tributary streams contributing to the sediment load of the main river stem. Application is also pertinent to ponds and lakes in reference to deposition of silt, and its possible effect on spawning and rearing habitats.

Placement of Towers:

This phase of the operation should not affect fish-bearing waters in any way, since towers will primarily be placed on high ground and in areas that provide good support (i.e. bedrock or coarse gravels). These structures do not require extensive drilling and blasting to establish footings nor will excessive amounts of concrete be used.

Stringing of Wire:

The only fishery problem during this phase could be the excessive use of heavy equipment in streams and ponds. Guidelines as proposed for stream crossings must be applied in this phase.

Construction Camps:

To date the only planned camp sites are at the Gull Island site and on both sides of Straits of Belle Isle tunnel. Temporary camp sites along the transmission route are being left to the contractors' discretion and will depend on factors such as location and length of contract and speed of work. Related fisheries problems are concerned with the water supply.

With respect to water supply it can be assumed that it will consist primarily of either a foot valve placed in a pond or stream or at worst, a temporary weir to back up water. Suggested guidelines for

this type of operation are as follows:

1) Under no circumstances can a stream or pond out-flow be dammed for water supply purposes unless prior approval is granted by the Fisheries and Marine Service;

2) Foot valves and other water uptake devices must be properly screened to prevent damage or loss of fry and young fish.

Marshalling Yards:

Equipment and material storage facilities will most likely comprise large areas, but should not detrimentally affect fish habitat as long as a 300 foot vegetation buffer strip is maintained.

3.2.4 Chemical Effects of Construction and Operation

Post Construction Vegetation Control:

Vegetation control along the right-of-way can be accomplished in three ways; hand-clearing controlled burning, or by the use of herbicides. The application of controlled burning techniques would be most unfavourable due to the resultant forest fire hazard.

Again hand-clearing of vegetation over a large area become highly expensive when considering the distance to be maintained. The only practicable solution is herbicides; its application requires a minimum of personnel, and the area covered per day can be considerable.

At present the Newfoundland and Labrador Hydro Corporation plans to apply the herbicide Tordon 10K to the right-of-ways every seven years. The active agent of Tordon 10K is picloram, which is water soluble. The lethal level of picloram has been found to range from 1

to 300 mg./l for various formulations tested.

For the purpose of this effort it is best to assume that Tordon is toxic and can have deleterious effects on fish populations. It is impossible to establish effective buffer strips for control through absorption. Since picloram is water soluble, its effect on ponds and streams could come from influent groundwater rather than just overland flow, which undoubtedly would contribute.

It has been estimated that concentrations of picloram should not exceed 1 mg./l provided the application rate does not exceed 601 lb/acre and less than 5% of the picloram is removed from a watershed by surface run-off (Thurlow et al. 1974). However, sufficient data are not available to effectively evaluate the effects.

It is recommended that bio-assaying be carried out on Tordon 10K to delineate tolerance levels for trout and salmon. As well, since the Hydro Corporation is presently using this herbicide, field investigations could be carried out in conjunction with the bio-assay to determine possible buffer strip widths.

However, it would be preferred if herbicides were not used within 1,000 feet of any water body. Vegetation control can be accomplished in these areas by hand-cutting and burning.

Sewage and Solid Waste Disposal:

Sewage and solid waste disposal regulations are under the jurisdiction of the Provincial Environment Department and they stipulate that untreated sewage and solid wastes are not permitted to outfall into any water body. Project plans call for a disposal system at Gull Island consisting of standard gravity piping, and treatment in an

aerated lagoon. For camps at Pointe Amour, Yankee Point, Stony Brook and Soldiers Pond, there are plans for sewage treatment systems, however, specific detail is lacking. For smaller camps, (primarily along the transmission line) there is no plan to treat sewage.

Biting Fly Control:

It is known that biting fly populations in and around the Gull Island site will be assessed to determine the advisability of insecticide application. Pesticides are to be used subject to Provincial and Federal regulations.

3.3 The Straits Tunnel

The transmission of power from Gull Island to Insular Newfoundland requires the construction of a tunnel under the Strait of Belle Isle. This tunnel will link Pointe Amour, Labrador and Yankee Point, Newfoundland. The tunnel will carry four HVDC cables; all cables are to be rated at $\pm$ 400 KV DC. Access to the tunnel will be via two vertical shafts.

At present, the project plans do not call for tunnel boring machines as these would not be feasible considering the hardness of the Precambrian rock formations. The work is scheduled around the use of conventional tunneling techniques involving, drill, blast, and muck cycles.

3.3.1 Fish Resources

An assessment of the fishery resource in the vicinity of the proposed tunnel is most easily made by examining the commercial catch

statistics for Statistical Sections 40 and 50 as delineated by Economics and Intelligence Branch, Fisheries and Marine Service of Environment Canada.

Statistical Section 49 covers the coast between Ferrole Point and Cape Norman on the Great Northern Peninsula and Section 50 is the corresponding coast of Labrador running between Blanc Sablon and Cape St. Charles. Within these two sections a total of 10,960,535 pounds of fish valued at $1,309,919 was landed in 1974. However, much of this catch was the result of off-shore fishing beyond the Straits and furthermore, not all of Sections 49 and 50 can be considered to be vulnerable to environmental disruption due to tunnel construction.

An arbitrary "vulnerable zone" extending 5 miles on either side of the tunnel site would encompass the following communities:

1) In Section 49: Deadman's Cove, Bear Cove, Flowers Cove, Nameless Cove, Savage Cove, Sandy Cove, Shoal Cove East, and Paynes Cove;

2) In Section 50: Forteau, Buckles Point, English Point, l'Anse Amour, Fox Cove, Schooner Cove and l'Anse au Loup.

The 1974 commercial catch for these communities was 3,698,358 pounds valued at $398,692. This is a relatively accurate estimate of the total value of the fishery because it is primarily based on inshore fishing results and furthermore no international catch data need be considered since the narrowness of the Straits (11 miles wide) prohibits fishing by foreign fleets.

The following species comprise the catch for the region; cod, halibut, plaice, herring, salmon, capelin, scallops, lobster, and harp

seals. Cod is by far the most abundant and important cash crop. Though there are no scheduled rivers within 5 miles either side of the tunnel site on the island, there are two on the Labrador side; Forteau Brook and l'Anse au Loup River. Also, just beyond the arbitrary 5 mile zone of effect are located several significant salmon rivers including the Pinware (Labrador), St. Genevieve and East and West Rivers (St. Barbe Bay). These rivers yield between 2,500 and 3,000 salmon to anglers annually, and represent a significant draw for tourism purposes, thus bolstering the otherwise commercial-fishing based economy of the region. As well as Atlantic salmon there are numerous local brooks and rivers which support resident and anadromous populations of brook trout and several also support a run of Arctic char.

3.3.2 Potential Impact of Tunnel Development

Excavation of a tunnel under the Straits of Belle Isle gives rise to the potential for three basic kinds of deleterious impact. These are: problems associated with the survey and preparation of the site, acoustic problems related to blasting and drilling operations and waste disposal problems (including excavated rock). Approached with care and common sense, none of these potential trouble areas need be of any concern to the fishery, marine or freshwater.

Initial survey of the tunnel site has been in progress for over a year now. Methods used have been exploratory drilling and off-shore seismic exploration by means of a sonic pinger. The method of drilling has been by means of a water-cooled diamond drill yielding a (one) inch core. So far cores have been drilled to a depth of 1,000 feet on the

Labrador side and 2,000 feet on the island side. Precambrian granitic rock is the basic substrate through which these cores have been taken. Because no drilling fluids or "muds" have been used as a coolant, toxicity problems are not an issue.

The sonic pinger used in 1973 and 1974 has proved ineffective because of the great depth at which the tunnel will be excavated. At the moment, the engineering firm performing the surveys is attempting a different method. Charges are being detonated on shore and the echos recorded by ship-borne geophones. If this method is successful then seismic blasting off-shore will be unnecessary. On-shore blasting of the type described above is considered to be harmless to marine life, though it could potentially divert migrating species. Off-shore blasting, on the other hand, is a serious hazard to most forms of marine life.

January 1, 1976, is the commencement date chosen for excavation of the tunnel. At that time, the two other impact areas will start to be an area of concern.

The first of these is the impact of tunnel construction itself. A great deal of concern has been expressed over the effect of sub-marine blasting and drilling on marine life. Most of this concern has been directed towards the possibility of diverting migrating species. The tunnel as planned will be excavated at a depth between 1,500 and 1,700 feet below the sea floor. It therefore seems quite unlikely that shock waves or even sound waves will penetrate to any extent into the waters above. Surely, if this were the case, the security of the tunnel itself would be in serious question.

The removal of rock from the tunnel and the 6 to 10 feet of overburden at the sites of the down shafts presents the single most visible problem associated with the tunnel development. Disposal sites for 142 million cubic yards, or 1.2 million tons, of rock must somehow be found in environmentally and aesthetically acceptable locations. Waste rock dump sites should be such as to prevent leachate pollution of fresh or salt waters, and should have minimal effects on the surrounding landscape. Several alternatives have been suggested but none has been definitively selected. One alternative, the creation of rock wharves at both l'Anse Amour and Yankee Point would probably be the least desirable from the fisheries point of view due to siltation problems. Dry land or bog land disposal is expected to be the final choice but selection of sites is still an area of discussion.

Other waste disposal problems associated with the project include the disposal of human wastes and refuse from the two trailer camps used by construction crews; shaft and tunnel discharge water; prevention of petroleum product spills; deposition of solid mine waste (construction debris) following tunnel completion; and deposition of waste petroleum products. With respect to these problems; the project plans call for:

(1) Shaft and tunnel discharge water will be impounded in settling ponds to allow settling of silt and treatment for any chemical content deemed deleterious;

(2) All petroleum product storage areas will be dyked to contain any spills;

(3) Solid mine waste (construction materials) will be consumed in closed incinerators;

(4) Petroleum wastes will also be burned in contained areas in closed incinerators.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 The Churchill River

This is the portion of the proposed project which we feel has the potential to cause the most serious impact to fisheries resources, and it is this portion of the development which requires the most extensive research and study to determine the present status of the resource, specific impacts to result, and suitable mitigation measures required to minimize same.

4.1.1 Fish Resources

At present the only data on the Lower Churchill River's fish resources are those obtained through personal communication and popular accounts. We can perhaps extrapolate from data on the Upper system, however a detailed resource inventory is required before the exact status can be documented.

4.1.2 Limnology of the Churchill River

As is the case for data on the Lower River's fish resources, very little limnological documentation is available on the portion of the Churchill River to be affected by the proposed project. It is recommended therefore that a detailed physical and chemical limnology survey be undertaken immediately to obtain background data on which to formulate sound predictions respecting changes in the river's ecology following development. An aquatic (biotic) inventory should also be done at this time.

4.1.3 The Reservoir

It is within the confines of the new reservoir that the most direct and long term impacts will occur. Basically it will cause a change in fish species composition, water quality, and plankton and benthic communities; a loss of spawning and rearing areas for fish; and create an unstable littoral zone.

With respect to fish species composition, the most likely long term effects will be to create a suitable habitat for lake whitefish, lake trout and suckers. Species such as brook trout, ouananiche, and northern pike may find the new environment unsuitable because of inundation of spawning areas, and reduction of suitable rearing and foraging areas. Even lake whitefish, lake trout and suckers will face a reduction in spawning area because of inundation. In the event that significant losses of spawning areas result from reservoir formation, alternate areas could possibly be made available. In this respect it is recommended that an immediate documentation of present spawning areas, both in the main stem and accessible tributaries be undertaken with a view towards quantifying possible losses. In addition, a detailed stream reconnaissance survey together with electrofishing studies, should be conducted on inaccessible tributaries to determine if these are presently being fully utilized as spawning and rearing areas by tributary stocks. Should underutilized areas be available to offset losses in the main stem, these could be made available through a program of stream remedial work and/or fishway construction.

In connection with water quality changes, an unstable littoral zone and development of a multi-use concept (power development,

recreation, commercial fishing, and subsistence fishing) for the reservoir, it is recommended that the entire reservoir basin be clear-cut. The full clear-cutting of the area would result in less dramatic fluctuations in reservoir water quality, aid in the stabilization of a new littoral zone, be aesthetically pleasing, and facilitate commercial and/or recreational fishing operations.

To reduce daily drawdown and long term reservoir level fluctuations it is recommended that there be an integrated approach in producing power at both Churchill Falls and Gull Island. Both a transmission and water release inter-tie should be functional.

4.1.4 The Dam and Downstream Area

Dam:

At the outset, it must be determined whether or not anadromous species can surmount Muskrat Falls. The implications of salmon, char and trout above Muskrat Falls are obvious as far as the proposed dam is concerned.

Even in the absence of migratory sea-run fish above Muskrat Falls, the proposed dam would totally obstruct migratory resident species should their migrations take them through Gull Island Rapids. This must also be determined at a very early date if mitigation measures are to be required.

With the exception of possible obstruction to migrations, the dam *per se* should cause no further problems with respect to flow regimes, bank stability, ice-jamming, etc.

Diversion Tunnels:

These tunnels are designed to by-pass river flow during construction, and these will be closed to allow reservoir filling. With respect to maintenance of flows at all times prior to, during, and after construction, as well as during normal operations, it is recommended that: Based on Sections 20(10) and 24(1) of the Fisheries Act and Section 19(1) of the Newfoundland Fishery Regulations, a guaranteed minimum flow, based on historic minimum mean monthly flows, will be required. It has been calculated that the minimum long term acceptable flow at Gull Island - 31,500 c.f.s. Flows below this may be acceptable in any given month during one (1) year in ten (10) but should not then fall below the appropriate minimum mean monthly flow.

At no time can the flow through Gull Island be cut off in its entirety, even when reservoir filling is occurring.

Spillway Structure:

The proposed hydraulic jump at the spillway exit may cause some fish entrainment and deaths. Should this result, steps should then be taken to provide fish protection devices below the jump; river weirs or electrical barriers are possible solutions.

With respect to possible O_2 and N_2 supersaturation problems at the plunge pool, it is recommended that monitoring for gas bubble disease be commenced immediately upon operation of the spillway.

Intake:

The intake is located near the reservoir surface and may cause problems in attracting fish. This problem is evident at the Churchill

Falls development where no provision was made for fish protection devices. It is recommended therefore, that consideration be given to requiring the proponent to install such devices. Intake fish barriers could consist of either revolving screens, or electrical screens, for example.

The penstock opening near the top of the dam could result in a change in the temperature of the tailrace water, most likely an increase in summer, and possibly a decrease in winter. It is proposed therefore, that monitoring be undertaken on the thermal properties of both intake and tailrace water once the project goes on stream to determine the magnitude and effect of this change.

4.2 The Transmission Line

It is felt that, following the impact expected on the river, the impact resulting from the transmission line activities will be the second greatest experienced as a result of the project. However, in the absence of adherence to sound environmental guidelines respecting construction, the cumulative negative impacts which would thereby result would far outnumber those on the river environment. Therefore, the rating of the transmission line activities as second to the river activities is based on the premise that all environmental guidelines and requirements will be met by the proponent.

4.2.1 Fish Resources

Significant data are available on the general status of fish populations in systems to be crossed by the transmission line. However,

specific detail respecting the status of the fish population at each particular crossing area is, in most areas, lacking. In this regard, it is recommended that any areas that are deemed particularly sensitive, or have little known about their fish populations, should be inventoried as soon as possible.

4.2.2 Physical Effects of Construction

The principle recommendation for protection of fish resources along the route is acceptance of and adherence to the "Habitat Protection Guidelines for Construction and Forestry" prepared by Fisheries and Marine Service.

Since work will be commencing on the location survey of the power-line this summer, each survey contract section should be viewed by Fisheries and Marine Service personnel to determine areas of high sensitivity, particularly in relation to spawning grounds.

a) This could provide for minor alignment changes designed to protect the resource.

b) Stream crossing areas that are deemed sensitive should be monitored during construction by Fisheries and Marine Service personnel to ensure adequate protection of the resource.

During construction the project should be monitored frequently. This would include discussions with on-site contractors and engineering consultants, to ensure that our guidelines are being followed. Unless the "flag is waved" it is pointless to insist on the use of guidelines.

4.2.3 Chemical Effects of Construction and Operation

Post Construction Vegetation Control:

The most favourable method of vegetation control along the right-of-way, from a fish protection viewpoint would be controlled burning and this is hereby recommended. However, it would appear that the use of herbicides will be employed due to the forest fire hazard of controlled burning. Project plans call for application of Tordon 10K; the active agent being picloram. In this respect it is recommended that, bio-assay investigations and subsequent field investigations should be carried out to assess the toxicity and possible effects of picloram (Tordon 10K).

Sewage and Solid Waste Disposal:

All sewage and solid wastes should be disposed of in a manner consistent with Provincial Solid Waste Disposal Regulations and Section 33 of the Fisheries Act. It would appear that the proponent intends to do primary treatment (aerated lagoons) at the larger camps. The smaller camps should not present any problmes if effluents are kept well back from water bodies.

Biting Fly Control:

Should biting fly control programs be required in and around the larger camps, it is anticipated these will be conducted in a manner consistent with Federal and Provincial Regulations respecting insecticides.

4.3 The Straits Tunnel

Of the three areas of concern for protection of fish resources,

the Straits Tunnel should result in the least impact.

4.3.1 Fish Resources

Considerable general data are available on the marine and fresh-water fish resources in the Straits of Belle Isle between Pointe Amour and Yankee Point. Although specific detail on resource concentrations, migration routes, population dynamics, gear placement, landings, etc. are not known at present, it is felt that the general data used will suffice in view of the expected minimal impact resulting from the tunnel crossing activities.

A valuable commercial and recreational fisheries resource exists in the area of the tunnel development which must be protected from any deleterious aspects of the project construction. Analyzed impartially, one would have to say that with the most minimal concern shown for this resource and the environment in general, no conflicts should be encountered in the development of such a tunnel. However, certain aspects of the project do give rise to concern and warrant close surveillance.

4.3.2 Potential Impact of Tunnel Development

If it should be deemed necessary by the engineering consultants responsible for acoustic exploration that off-shore blasting be used, this decision must be communicated to the Fisheries and Marine Service for approval. Where possible such activities should be co-ordinated or monitored by personnel of Fisheries and Marine Service. If serious mortality results the options available for obtaining the necessary information should be re-analyzed.

The second possible area of concern to fish resource protection is the disposal of tunnel waste rock. In this respect, sites must be approved by Fisheries and Marine Service ensuring that the leachant does not directly affect fish-bearing waters or indirectly contaminate them by silt-laden surface run-off. To this end, dry-land storage is recommended.

Proper septic systems and refuse disposal sites should be constructed to service the trailer camps housing the development's personnel.

Finally, throughout the life of the tunnel development and construction program monitoring should be carried out by Fisheries and Marine Service personnel to determine to what extent, if any, the various program segments are affecting the fisheries resource.

5.0 REFERENCES

ANNON. 1974. Powerline Clearing; Guidelines for the Protection of Fishery Resource in the Pacific Region. PAC/T-74-6. Southern Operations, Pacific Region.

BUTTON, C.E. and T.J. WELLS. 1975. Atlantic salmon:angled catch and effort data Newfoundland and Labrador, 1974. Data Rept. Series No. NEW-D-75-4. Res. Dev. Branch, Newfoundland Region. Fish. and Marine Service.

DUTHIE, H.C. and M.L. OSTROFSKY. 1974. Plankton, chemistry, and physics of lakes in the Churchill Falls region of Labrador. J. Fish. Res. Board Can. 31:1105-1117.

______. 1975. Environmental Impact of the Churchill Falls (Labrador) Hydroelectric Project:A Preliminary Assessment. J. Fish. Res. Board Can. 32(1):117-125.

GREENE, G.E. 1950. Land use and trout streams. Journal of Soil and Water Conservation. 5(3): 125-126.

GULL ISLAND POWER COMPANY LIMITED. 1975. Project Description and Environmental Policy Statement. 71 p.

HALL, J.D. and R.L. LANTZ. 1968. Effects of logging on the habitat of Coho salmon and cutthroat trout in coastal streams. Oregon Agriculture Experimental Station. Tech. Paper. 2510.

INDER, JAMES G. An economic survey of hunting and sports fishing in Newfoundland, 1969. Department of Tourism Newfoundland, Wildlife Division. Tech. Bull. #2. 1973.

JAVORNICKY P. 1966. Seasonal dynamics of the phytoplankton of Slapy Reservoir 1958-1960. Hydrobiol. Stud. 1:155-163.

PRIJMATCHENKO A.D. 1961. The phytoplankton of the Gorkovosk Reservoir in the first year of its existence 1956-1957. Tr. Inst. Biol. Vodokhran. Akad. Nauk. USSR 4:3-19.

ROWE, L.W. 1974. Habitat Protection;Recommended Guidelines for Construction and Forestry. Information Rept. Series No. NEW/W-74-1. Res. Dev. Branch Newfoundland Region. Fish. and Marine Service.

THURLOW and ASSOCIATES, ENVIRONMENTAL CONTROL CONSULTANTS LTD. 1974. Preliminary environmental overview of the Gull Island Hydroelectric Project Lower Churchill Power Development. 192 p.

WALDRON, DONALD E. 1973. Newfoundland and Labrador Atlantic salmon Commercial Catch Data. Data Record Series No. NEW/D-74-7. Res. Dev. Branch. Newfoundland Region. Fish. and Marine Service.

6.0 ENVIRONMENTAL PROTECTION UPDATE

Since work was commenced on preparation of this report in early 1975 several major developments have transpired with respect to environmental protection activities associated with the proposed project.

The scenario to date is as follows:

1. A Steering Committee, consisting of federal and provincial government resource officials was formed to provide for the Department of Provincial Affairs and Environment, a preliminary assessment of environmental concerns associated with the proposed project. The firm, Thurlow and Associates, Environmental Control Consultants Ltd., was retained.
2. The proposed Lower Churchill Development was registered by the Atlantic Regional S.C.C. Halifax, during September, 1974.
3. A report entitled "Environmental Overview of the Lower Churchill Power Development" was presented to the Province in November, 1974.
4. In February, 1975, the Province was informed of the E.A.R.P. process and Dr. R. Logie's review panel and indications were the proposed project would come up for review.
5. In March, 1975, upon careful review of the Thurlow report by the Regional S.C.C. it was recommended that further studies be undertaken in addition to those recommended in the Thurlow report.

6. In April, 1975, the Lower Churchill Environmental Assessment Panel (E.A.P.) chaired by Dr. Logie, met with Provincial officials and pointed out their further requirements. One of those was a biophysical inventory of the Churchill River and its tributaries. The other major requirement was an Impact Statement from the proponent.

7. In May, 1975, a "Proposal for the Assessment of Potential Fisheries Problems Associated with the Proposed Gull Island Reservoir" was prepared by this office and forwarded to the Newfoundland and Labrador Hydro Corporation for review. This was designed to meet the requirements of the E.A.P. The proposal involved mainstem and tributary surveys.

8. In June, 1975, Fisheries and Marine Service began a biophysical study of the main stem of the Lower Churchill River.

9. During June and July, 1975, the immediate fisheries requirements (under the Fisheries Act), of the project were relayed to the proponent.

10. By late July, 1975, there was tentative agreement between this Service and the proponent that we would complete the main stem study at our cost while the Hydro Corporation would be responsible for tributary studies. For tributary studies, either consultants or contract staff under F. & M.S. direction would be possibilities.

11. In early August, 1975 a detailed proposal entitled "A Biophysical Inventory of Major Tributary Streams to the Churchill River" was prepared and forwarded to the proponent for review and comment.

12. There was immediate acceptance of Phase I of the Proposal involving helicopter reconnaissance during September, 1975, at the proponent's expense.

13. During mid-August, 1975, an employment offer was made by the Province in staffing a Project Ecologist for the Lower Churchill Development. Employment offers to a fisheries biologist and a habitat ecology biologist were also being considered.

14. A draft Impact Statement entitled "Project Description and Environmental Policy Statement", part of the proponent's obligation to E.A.P. was forwarded to F. & M.S. in late August for comment.

15. By late August, 1975, the Power Corporation had advertized for a Senior Ecologist position on the staff of the Gull Island Power Company.

16. In early September, 1975, a helicopter reconnaissance survey was conducted on the major tributaries of the Lower Churchill River.