WATER RESOURCES STUDY

of the

PROVINCE OF NEWFOUNDLAND AND LABRADOR

for

ATLANTIC DEVELOPMENT BOARD

Volume SIX B

RIVER BASINS

THE SHAWINIGAN ENGINEERING COMPANY LIMITED
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VOLUME SIX B

RIVER BASINS

Water Resources Study - Newfoundland and Labrador

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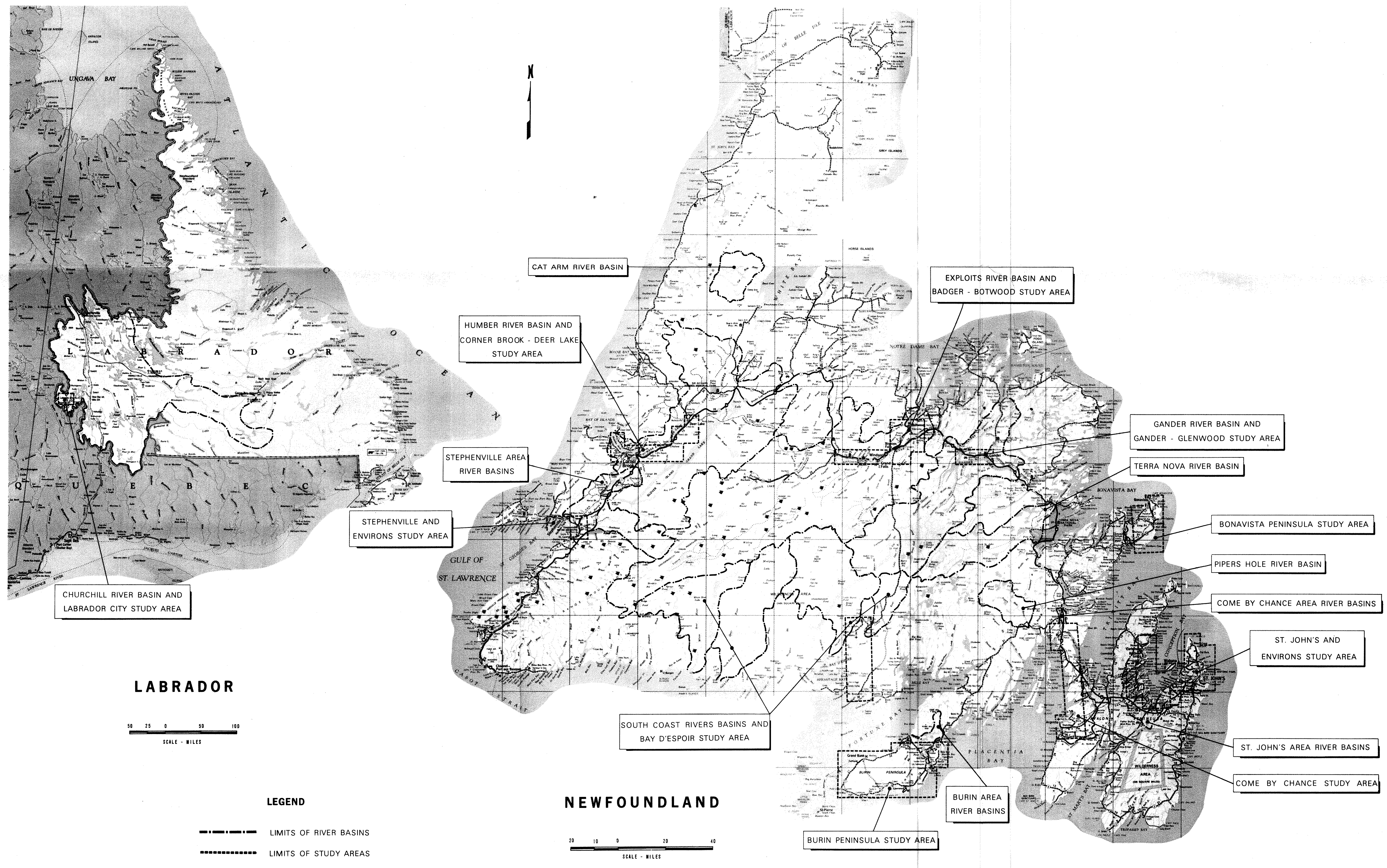

NEWFOUNDLAND AND LABRADOR
RIVER BASINS AND
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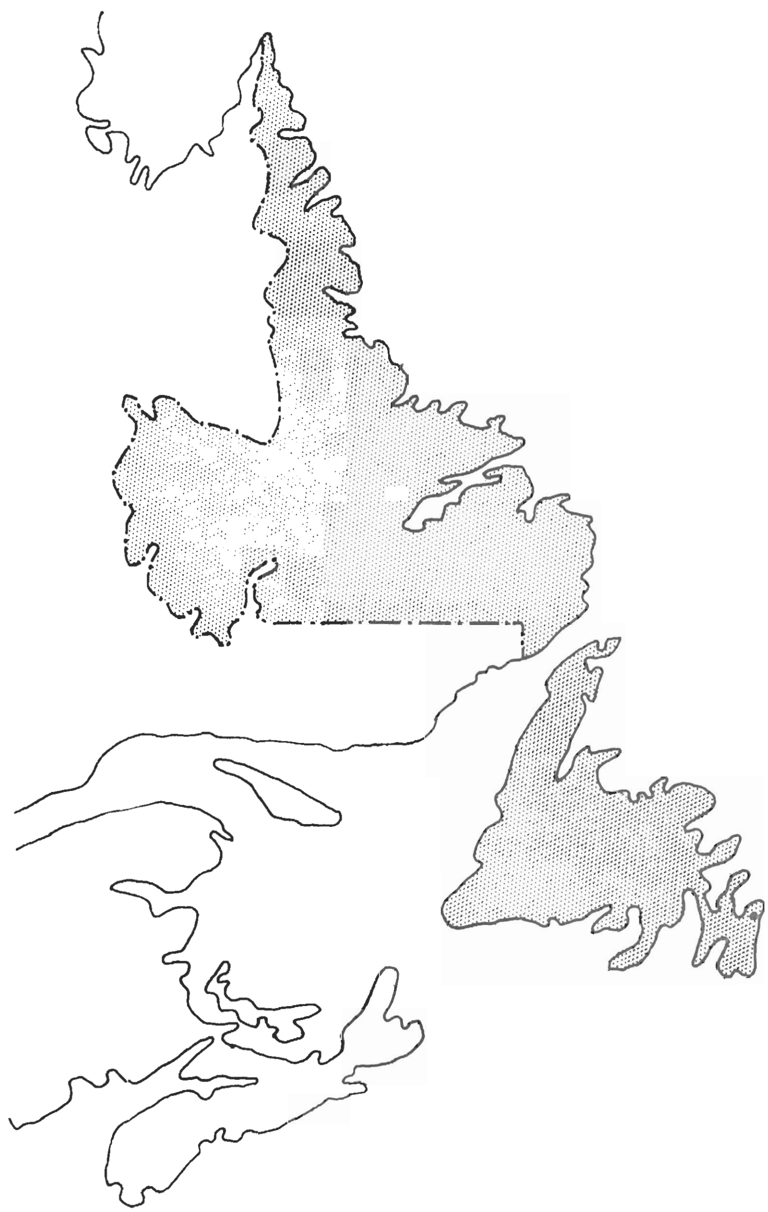

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TERRA NOVA RIVER BASIN

PART IV - TERRA NOVA RIVER BASIN

14 NATURAL CONDITIONS

The Terra Nova River is the only large river on the east coast of the Island which drains into the sea. It is exceeded in size of drainage area by the Exploits, Humber, Gander, Salmon, and Grey Rivers, in that order.

Access to the basin is easy as the Trans-Canada Highway crosses the river within one mile of the river mouth (Figure 14-1). A 12-mile gravel highway connects the village of Terra Nova, the only community in the basin, to the Trans-Canada Highway. An east-west network of some 50 miles of temporarily abandoned woods roads connects the village to a good portion of the basin area in the interior of the Island. In addition, the main line of the CNR traverses the basin in a north-south direction and passes through the village of Terra Nova.

The forest resources have been the predominant resource of the basin. At the present time, logging operations have been discontinued leaving the area to reforest itself naturally. The present day uses of the basin's resources are limited to recreation, sport fishing, and big game hunting.

14.1 Physiographic Conditions

The total drainage area of the Terra Nova Basin as outlined on Figure 14-1 is 740 square miles of which 86 square miles are covered by lakes, 125 square miles are covered by marshes or bogs, and 122 square miles are covered by barrens according to the 1:250,000 scale maps of the area. The proportion of lakes, bogs, and barrens in the different sections of the drainage basin is indicated in Figure 14-2.

The drainage pattern, topographic features, roads, towns, etc. are shown on Figure 14-1. Other physiographic characteristics of the basin, land surface slope and elevation distribution are shown on Figure 14-3. The hypsographic curve of the basin is given on Figure 1-4.

The bedrock of the Terra Nova Basin consists of Ordovician and Silurian sedimentary and metamorphic rocks, which are bordered to the north and south by major instrusions of granite. Over much of the basin there is ground and ablation moraine overlying the bedrock, but the upper reaches are in an area of ribbed moraine with a fairly thick drift cover.

The variation of mean annual temperature, precipitation, and evaporation in the basin is shown in Figure 14-4. The climate is cool with a mean annual temperature of 39 deg. F and a mean annual precipitation of 49 inches. The mean annual evaporation in the basin is 13 inches. Climatic characteristics are summarized in Table 14-1.

14. 2 Water Resources and Potential Uses

14. 2. 1 Surface Water

A river gauging station is located on the Terra Nova River just upstream of Terra Nova Lake and records the runoff from 459 square miles. As mentioned in Volume Two it is surmised that the flows of the Terra Nova River are over-estimated. A possible source of error may be the stage - discharge relationship. Preliminary measurement results at a new gauging station just upstream of the old location indicates that this assumption may be correct. However, it is also possible that part of the discrepancy between the recorded runoff and that estimated from neighbouring basins could be due to the fact that the Eastern Meelpaeg drainage area of 56 square miles, which flows into the Long Harbour River, also contributes a small portion of its runoff to the Terra Nova Basin. Therefore, the runoff distribution in the area as derived from the generalized relationships with physiographic factors have been accepted, although the past results from the direct flow measurements, assuming no added flow from neighbouring basins, indicate that the runoff would be 15 percent higher. The variation of the mean annual runoff in the basin, as derived from these relationships is indicated in Figure 14-4. According to this figure, the average annual runoff from the basin is 36. 1 inches or 2. 7 cfs per square mile. Hydrologic characteristics are summarized in Table 14-2.

The extrapolations of the water quality in different parts of the Terra Nova Basin for use in fresh water fisheries, pulp and paper raw water supply, and domestic raw water supply have been assisted by data from the existing International Hydraulic Decade station downstream of Terra Nova Lake and by the samples obtained by the Shawinigan-MacLaren team during their water quality sampling program in September and October of 1967. Chemical analysis of the Terra Nova River was commenced in 1966 and has continued on a regular basis since that time. Data from 21 analyses of river samples secured during 1966 and 1967 indicate that the water is very low in total dissolved solids, the equivalents per million being less than 0. 3. Total hardness expressed as $CaCO_3$ is usually less than 10 ppm although one sample showed a hardness of 23. 8 ppm.

Colour averaged about 50 units, ranging from a minimum recorded value of 30 units to a maximum value of 70 units. Most turbidity readings were less than 5 units although a maximum of 32 units was recorded on one occasion. Only two coliform determinations of river water were available; upstream of Terra Nova Lake a value of 300 coliform per 100 ml was established and below Terra Nova Lake at the Trans-Canada Highway a concentration of 100 coliform per 100 ml was determined. It is most unlikely that the coliform count of 300 above Terra Nova Lake where the drainage area is uninhabited results from faecal contamination of human origin.

The results of the assessment of the acceptability of the water quality in different parts of the basin is summarized in Table 14-3.

The relatively good water quality reflects the fact that the basin's water resources are essentially untouched by man's activities and the water quality has not been adversely affected by natural factors.

14. 2. 2 Groundwater

The groundwater potential of the basin is summarized on Table 14-4. Groundwater provides the main source of supply for the small number of dwellings in the basin. Most of the groundwater is obtained from dug wells in the surficial materials. The distribution of the surficial materials on the Island is discussed in Volume Two. The basin has a cover of ground ablation and end moraine which varies in thickness with a mean depth of about 20 feet and covers 90 percent of the basin area. Seven percent of the basin is covered by ribbed moraine, which is generally thicker but occurs in the inland area of the basin which is largely uninhabited. Three percent of the basin is covered by sands and gravels of various types, including several eskers inland and terrace gravels near the mouth of the Terra Nova River.

In some areas, deep wells into bedrock are used for water supply, the distribution of the hydropetrologic units in the bedrock is shown in Volume Two, and the mean depth of wells in each unit and their expected yield are given in Table 14-4.

The bedrock unit which underlies the greatest part of the basin is unit R4 made up of lower Paleozoic metamorphic rocks. Thirty-two percent of the basin is underlain by unit R1, major igneous intrusions, while there are minor areas of units R2, R5, and R6.

The quality of the water in the surficial materials should be generally good, except in the bog or marsh areas which occupy 17 percent of the basin. The water in the bedrock should be of good quality in the whole of the basin, as none of the usual sources of bad quality groundwater occur in the basin.

14. 2. 3 Hydro Power

The gross river potential of the main stem is shown on Figure 14-5. As indicated, the potential of the river itself is relatively low. However, the Terra Nova river is one of the few rivers remaining on the Island which has possibilities of economical hydro-electric development if diversions of adjacent river basins are included in the development. The basin has been investigated in detail by ShawMont [1] and a report on the potential is summarized in Section 16. 1. 1.

14. 2. 4 Fresh Water and Anadromous Fish

Although the Terra Nova has not been one of the major salmon rivers on the Island, the recent completion of the paving of the Trans-Canada Highway combined with the fact that the drainage area lies partly within the increasingly popular Terra Nova National Park is expected to create increased demands for recreational fishing in the river. As shown on Figure 14-1, the main stem of the river presently lies outside of the Park boundary.

There are several natural barriers on the main river and its tributaries which have hindered natural development of the Atlantic salmon in the basin.

14. 3 Natural Resources

Forests, wildlife, minerals, and agricultural resources exist in the basin in addition to the water resources previously outlined.

14. 3. 1 Forests

The natural forest resource has been the main reason for the present day road network in the basin and accounts for the only significant resource exploitation to date.

The forested areas of the basin covers 407 square miles or about 55 percent of the total area according to the 1:250, 000 scale maps of the area. The major part of the accessible timber limits of the Price (Nfld) Pulp and Paper Company Limited have been cut over and are presently regrowing under natural conditions. The square grid distribution of forest in the basin is shown in Figure 14-2.

14. 3. 2 Mineral Resources

There are several known occurrences of minerals in the basin area, the majority of which are in the upper basin area as shown in Figure 1-2 . To date, there have been no mining developments operated in the basin. [2].

14. 3. 3 Agriculture

The ground moraine areas cover the major part of the basin and are generally considered unsuited to cultivation but suited to forestry, wildlife, and recreation. Generally, the bedrock is at or near the surface and controls topography and distribution of unconsolidated deposits, restricts internal drainage and limits normal soil development processes. The land is generally excessively bouldered.

The areas of bogs or marshes located mainly in upland areas in the basin are poorly drained lands with gleisolic sub soils. Some of these poorly drained areas may be reclaimed to agriculture with appropriate engineering and agricultural ammendment practices.

15 PRESENT-DAY DEVELOPMENT

15.1 Non-withdrawal Water Demand and Supply

Fisheries, navigation, recreation, tourism and wildlife constitute the present-day non-withdrawal uses of the water resource in the basin. Log driving does not presently occur in the basin as the forests are undergoing a period of natural regrowth having been harvested in the mid 1950's.

15.1.1 Fisheries

The following outline of the present-day development of the fisheries resource in the Terra Nova River has been obtained from the Department of Fisheries of Canada.

The Terra Nova River is inhabited by Atlantic salmon, Arctic char, American eel, stickleback, American smelt, brook trout and ouananiche.

Quantitative data are available for the number of salmon caught and number of rod-days fished in the river since 1951. These data are presented in graphic form in Figure 15-2.

The number of rod-days ~~spent~~ on the river was high for the years 1952 to 1954, and peaked again to an all time high in 1956. This probably coincides with the logging activity in the basin during that period. Since 1957 the number of rod-days has shown a tendency to fluctuate about an average of 674 rod-days per year. The ratio of number of fish caught per day spent has increased from an average of 0.2 during the 1951 to 1961 period to 0.6 for the 1962 to 1966 period. This is possibly due to an increase in fish in the river due to management of the river by the Department of Fisheries.

The Department of Fisheries estimates that the present environmental area available to the Atlantic salmon, which is the area below Mollyguajeck Falls, is capable of supporting a total population of about 3,000 salmon.

Access facilities have been provided in the basin in past years by the Department of Fisheries. Rock cutting was carried out in Maccles Brook in 1953. The main river now contains two fishways, one located seven miles from the river mouth and the other one located one mile below Terra Nova Lake. The present-day cost of these access facilities has been estimated at $55,000 by the Department of Fisheries.

Main river obstructions still remaining consist of two partial obstructions located 5 and 14 miles from the river mouth. There is a falls about 20 feet high above Terra Nova Lake which may be impassable, according to the Department of Fisheries. Abandoned logging dams at Mollyguajeck Lake and Deer Pond and Mollyguajeck Falls itself presents a complete obstruction to the anadromous fish.

Upstream migration of the salmon occurs from early June to October. Angling is permitted from May 24 to September 15.

Other species which have some economic importance but for which there are no available statistics are the sea run and resident brook trout, ouananiche, and eels. The first three species support a limited sports fishing and sufficient quantities of eels are present to support a small commercial venture.

Commercial fisheries do not exist in the Terra Nova River basin proper. Statistics on fish landings have been provided by the Department of Fisheries on an area which extends about 15 miles from each side of the river mouth. The statistics for this area are summarized here because the basin undoubtedly produces a substantial portion of the salmon catch in this area.

The landed value of ground fish, salmon and lobster amounting to 5,175 thousand pounds and valued at $155,000 in 1961 increased to 7,539 thousand pounds valued at $370,000 in 1966.*

Capital investments in the primary fisheries are estimated at $500,000 up from $200,000 in 1962. Vessels in 1966 represented about 40 percent of the total investment, fishing gear 50 percent and shore installation 10 percent.

The number of fishermen in the area increased by 85 percent from 329 to 610 between 1962 and 1967. Employment in the principal fisheries are shown below:

Fisheries	Number of Fishermen	
	1962	1967
Cod	220	451
Salmon	212	327
Lobster	149	284
Total **	329	610

* The majority of the fish included in these figures are not dependent on fresh water.

** More than one species fished.

The greater number of fishermen in the area is a result of the centralization program of the Provincial Government.

While development projects on the Terra Nova River have been carried out to provide an increased stream sport fishery, the over 300 commercial salmon fishermen in the area obviously benefit by these projects as well.

15. 1. 2 Recreation, Tourism and Wildlife

The basin has excellent natural resources suitable for recreational purposes. The many large and small lakes (several with natural sand beaches), the salmon and game fish in its unpolluted waters; the natural beauty of its forested areas; the size of the main river stem which permits use by small pleasure craft and the relative ease of accessibility give the basin distinct advantages over many other river basins on the Island.

Whilst the Terra Nova National Park has been extensively developed for recreational use with provision of camping and boating facilities, fishing and hiking trails and the like, the Terra Nova Basin is thus far practically untouched by this activity as little effort has been made to develop similar facilities in the basin. The basin receives only a very few of the tourists which are attracted to the National Park. The majority of the visitors are salmon fishermen and big game hunters.

However, the National Park extends westward to include Pitts Pond, a small part of the basin area, as shown in Figure 14-1. Expansion of the recreational facilities may occur in the future in this part of the Park since Pitts Pond with its natural sand beaches is particularly good for swiming.

The drainage area of the Terra Nova River is inhabited by big game animals found in Newfoundland. Moose are plentiful throughout the basin; caribou inhabit the interior sections of the basin and black bear can be found in many parts of the basin as well.

The Terra Nova Basin receives many big game hunters from St. John's, which is about 170 miles away, as it is one of the better areas for hunting near the capital city. As an indication of the economic importance of the big game resource, two hunting camps attracted 32 hunters who spent $16,000 in 1967. However, the majority of the hunters who enter the basin via the abandoned logging roads are not included in these figures as they set up their own camps in the hunting area. The upper basin area is part of a moose management area and access to the upper basin is controlled during the hunting season. Deterioration of the woods-roads and bridges inland from Terra Nova village makes hunting access increasingly difficult.

In addition to the big game animals, the basin contains fur-bearing land mammals such as muskrat, beaver, fox, otter, and hare.

15.1.3 Navigation

Present-day navigation is limited to small pleasure craft used mainly by hunters and sports fishermen.

One of the canoe routes suggested by the Provincial Tourist Development Division Office in St. John's includes a section from the village of Terra Nova up to Lake Kepenkeck. The section of the route from Lake St. John to Lake Kepenkeck is difficult and many short portages are required.

15.2 Withdrawal Water Demand and Supply

There are no industrial developments on the basin and withdrawal use is limited to the village of Terra Nova and a small farm near the village.

Many of the villagers were employed in the basin when Price (Nfld.) Pulp and Paper Company Limited (then the Anglo-Newfoundland Company Limited) was active on their timber limits on the upper basin.

Presently, several of the houses in the village are unoccupied and the population is about 150. Figure 15-1 shows the variation in the population for the 1951-66 period.

No data are available on the water supply and treatment facilities for either the village or the farm. However, adequate water quantity should not be a problem as the village is located on the shores of Terra Nova Lake and this area has good groundwater potential. Dug wells have been utilized as a source of supply for the individual dwellings in the community.

Population in the village averaged 192 during the years 1951 to 1961, decreased to 151 in 1966 because of the lack of employment in the basin area.[3]

Land development for agricultural use is limited to 100 acres near the village which has been utilized for potatoes, turnips, and cabbage.[4] The one small farm irrigates about 20 of the 100 acres by pumping from Terra Nova Lake. The farm is basically a chicken farm, having over 1,200 chickens in 1966. In addition, there are about 30 head of cattle in the area.

16 PLANNED AND FORECAST DEVELOPMENT

16.1 Non-Withdrawal Uses

16.1.1 Hydro Power

Detailed investigations of the hydro-electric potential of Terra Nova Basin were reported by ShawMont [1].

The recommended scheme of development as shown in Figures 14-1 and 16-1 requires the diversion of the following areas:

Diversion Area	Drainage Area (Square miles)
Eastern Meelpaeg	56
Upper Northwest River	192
Upper Pipers Hole River - North	31
Lower Northwest River and Salmon Brook	89

The Terra Nova Development would realize the hydro-electric potential of the Terra Nova River and adjacent streams at Clode Sound and at the outlet of Mollyguajeck Lake. The average gross head developed at the Clode Sound plant would be 316 feet with a rated installed capacity of 100 Mw. The average gross head developed at the Mollyguajeck plant would be 201 feet with a rated installed capacity of 44 Mw.

The annual firm output of the plants at the busbars would be 740×10^6 kwh.

The total drainage area utilized by the Mollyguajeck plant would be as follows:

Upper Terra Nova River	426 square miles
Eastern Meelpaeg	56 square miles
Upper Northwest River	192 square miles
Upper Pipers Hole River - North	31 square miles
TOTAL	705 square miles

The total drainage area utilized by the Clode Sound Plant would include the above plus the following:

Lower Terra Nova River	186 square miles
Lower Northwest River and Salmon Brook	89 square miles
TOTAL	980 square miles

As shown in Figure 16-1, there are a large number of structures required in the development. The dams required are listed below.

Name	Max. Height feet	Crest Length feet	Probable Type
Mollyguajeck Dam	165	1,420	rockfill
Terra Nova Lake Dam	45	1,300	rock and earthfil
Eastern Meelpaeg Dam	8	-	timber crib
Terra Nova North Dam	70	5,050	earthfill
Clode Sound Dam	55	1,260	earth and rock-fill
Upper North West River Dam	100	1,625	rockfill
Salmon Brook Dam	10	-	timber crib
Upper Pipers Hole North Dam	10	250	timber crib

There are several canals required in the Development. A power canal is required to connect the Terra Nova drainage area to the power-house at Clode Sound; a diversion canal is required to connect the Mollyguajeck plant with the Upper Northwest drainage area; a diversion canal is required to connect the Upper Pipers Hole to the Upper Northwest River area; a diversion canal is required to connect the lower Northwest River and Salmon Brook to the Clode Sound plant.

The total capital cost of the Development, including transmission lines, was estimated to be $55,126,000. The cost of energy was estimated to be 5.85 mills/kwh. The costs did not allow for the following:

a) Clearing of flooded areas and/or loss of merchantable timber;

b) Relocation or reconstruction of logging camps and logging roads inundated by the reservoir;

c) Facilities which may be required at the dams for log driving and fish conservation.

16. 1. 2 Fisheries

The Department of Fisheries believes it is doubtful that management procedures can greatly increase the potential of resident fresh water species in this system.

The future policy of the Department of Fisheries in the basin is to:

a) Preserve existing Atlantic salmon stocks;

b) Increase Atlantic salmon stocks to the river's full potential;

c) Increase recreational and/or commercial use of fish species other than Atlantic salmon, and to maintain these species at optimum population levels;

d) Maintain the "status quo" regarding pollution. At present there is no pollution problem on the river.

The two to four thousand salmon produced in this system are supported by about 25 miles of river. An additional 125 miles of river can become a production area for Atlantic salmon if the necessary measures are taken to provide access to these areas. Access facilities required include a fishway around Mollyguajeck Falls and the two falls on Maccles Brook. In addition, natural stocks of Atlantic salmon will have to be augmented in the newly acquired rearing area by hatchery produce.

Costs of future development of the river for fishery use has been estimated by the Department of Fisheries to be about $205, 000 with an additional $25, 000 per year for five to ten years for providing hatchery stock. The Department of Fisheries estimates that the river would then produce about 19, 000 adult salmon.

Future activities in the basin to make the entire river available to Atlantic salmon will require the controlling of future logging operations to minimize the log driving and fisheries conflicts outlined in Volume Four.

16. 1. 3 Log Driving

Price (Nfld) Pulp and Paper Company Limited presently lease 129 square miles of forest area in the basin, of which 20 square miles is considered exploitable. In past years, wood cutting and log driving was extensive in the basin. In 1951, 31,000 and in 1956, 21,000 cords of wood were driven on the main river to the village of Terra Nova. Log driving required the use of low timber crib dams to provide storage to augment flows during the log driving period. Presently, log driving does not occur in the basin.

Future use of the river for log driving will depend on alternative costs of other means of log transport and on the intensity of future fisheries and recreational activities in the basin.

16. 1. 4 Recreation, Tourism, and Wildlife

Although the river is practically unused for recreation it has excellent possibilities for future development. Several small and large lakes exist in the basin, all having unpolluted water. Many of the lakes have natural sandy beaches which is the exception rather than the rule on the Island, and all the lakes are well supplied with game fish. A large part of the main river is accessible to small pleasure craft. The basin is generously endowed with forest lands located all along the main river helping to make the area appealing to camping, and hiking enthusiasts. The cut-over timber limits that were abandoned several years ago have grown over leaving few signs of man's previous basin activities.

The full recreational potential of the basin may not be reached for many years as it is located about 170 miles from St. John's, the only population centre of significant size on the Island. Also, the upper limits of the basin are valuable forest lands which are presently within the timber limits of Price (Nfld) Pulp and Paper Company Limited and will undoubtedly be re-cut in future years.

However, it is conceivable that the main river basin between the mouth and Terra Nova Lake will become a part of the Terra Nova National Part in the future. This acquisition would provide the Park with a salmon river located within its boundaries and a large fresh water lake which has natural sandy beaches. Development possibilities of the Terra Nova Lake - Pitts Pond area and the main river to the mouth are numerous and would enhance the national park's attraction to tourists immensely.

16.2 Withdrawal Uses

The basin is capable of supporting the water requirements of a large population because of the abundance of good quality fresh water, and it will easily be able to accommodate any expected increases in population in the basin. Future population forecasts for the basin are shown in Figure 16-2.

16.3 Future Water Resource Problems

Should the hydro project be implemented in the basin, conflicts in use would result with fisheries, recreation, wildlife, and forest exploitation.

Flow releases and fish access structures would be required to maintain the present fish run. These requirements would result in higher costs of power. In addition, the various dams would create reservoirs which would inundate about 28,000 acres of productive forest lands which the Provincial Forestry Department estimates has a capitalized value of $3.8 million. This liability will have to be considered in the hydro development. Future recreational facilities would be adversely affected by the creation of large lakes which would have appreciable storage level fluctuations. In addition, big game grazing areas would be inundated and the basin could not support its present moose and caribou population.

Future water resource problems will be limited to use conflicts between log driving, recreation, and fishery interests if the hydro development is not implemented.

17 CONCLUSIONS AND RECOMMENDATIONS

17.1 Conclusions

a) The main resources of the Terra Nova River basin consist of forests, fresh water fisheries, and wildlife with related recreation and tourism potential. In addition, the basin has significant hydro-electric potential.

b) The potential hydro-electric development involves a series of conflicts of interest with other existing and potential water resource users in the basin.

c) There are no natural resources or other conditions in the Terra Nova River basin which would favour industrial development over other Island basins.

d) Human occupation exerts little requirement on the resource, and therefore there is no measurable consumptive use of its quality.

17.2 Recommendations

a) It is recommended that industrial development should not be encouraged in this basin, and that emphasis should be put on forestry, recreation and tourism, wildlife, and fisheries development.

b) The full implications of the proposed hydro-electric scheme, which involves several diversions and will create several reservoirs consequently affecting the fisheries, forestry, and wildlife resources of several adjacent basins, should be determined. It is recommended that a water resources management study be carried out in advance of a decision to proceed with the hydro development to permit a careful evaluation of all factors and prevent ad hoc solutions similar to those necessary in the Exploits basin as a result of a lack of comprehensive water resource management planning.

c) Full attention should be given in the recommended study to the potential conflicts of interest between log driving and fisheries should forest exploitation recur in the basin.

d) It is recommended that consideration be given in the water resources management study to the possibility of enlarging the present boundary of the Terra Nova National Park to include the area shown in Figure 14-1, that is, the Terra Nova Lake area and the area along the main river stem from the lake to the river mouth. This part of the basin could then be included in the recreation and tourism development plans of the National Park and would bring an Atlantic salmon river into the park boundary, provide a large fresh water lake with sandy beaches in the park area, and enhance development opportunities in the west end of the park. In addition, houses in the Terra Nova village may be acquired to provide additional accommodation for park visitors.

REFERENCES

1 "Interim Report on the Terra Nova Development", ShawMont Newfoundland Limited - Report SM-3-66.

2 Fogwill, W. D., "Mines and Mineral Occurrences Map of the Island of Newfoundland", Department of Mines, Agriculture and Resources, Mineral Resources Division, St. John's, Newfoundland - 1965.

3 1966 Census of Canada, Catalogue No. 92-608 - March 1968.

4 1960 Census of Canada, Agriculture Bulletins.

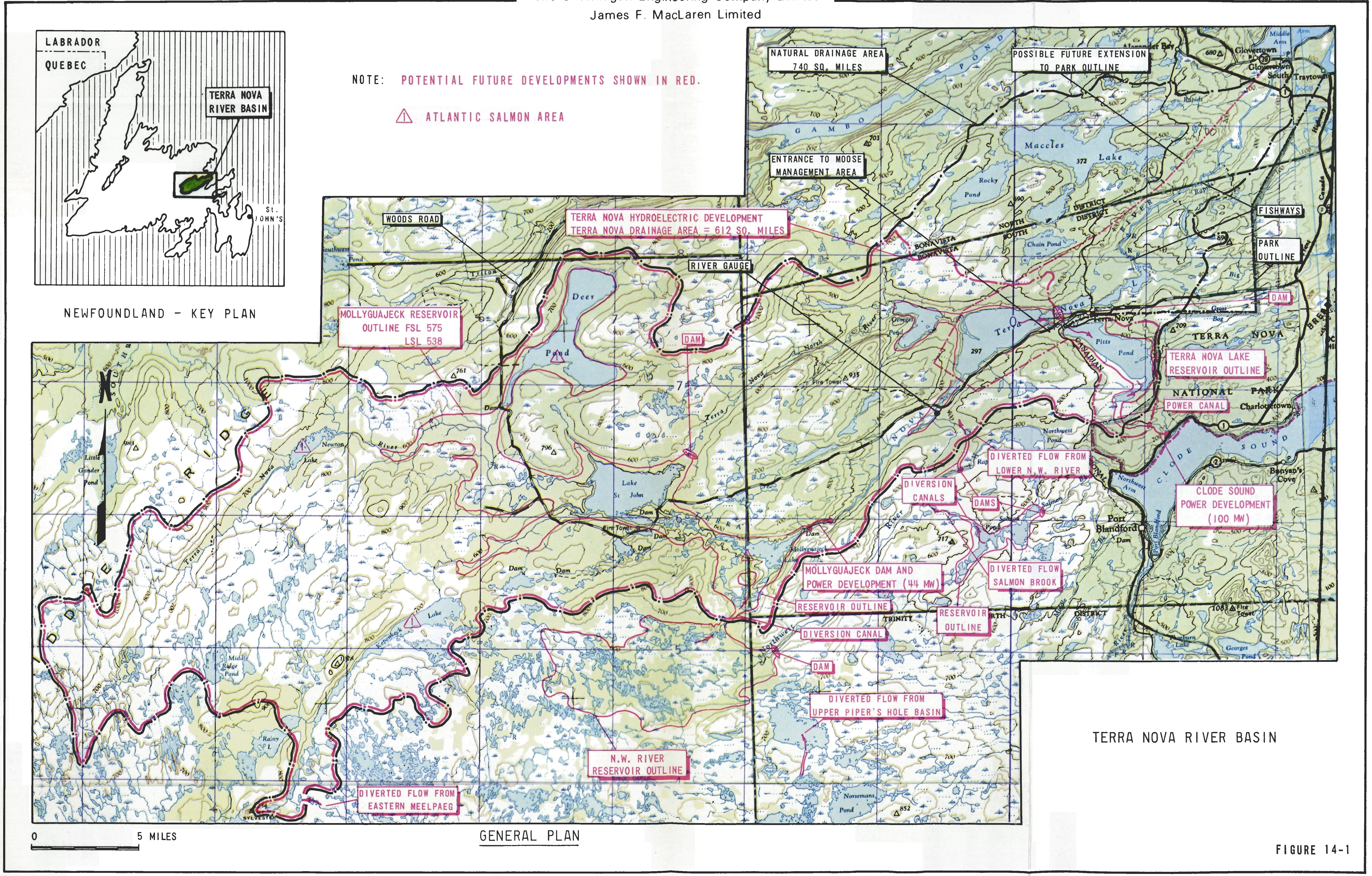
By implication though not direct assertation this report does not support the development of hydroelectric potential on the Terra Nova.

Aside from this, the recommendations appear sound.

VOLUME SIX B

LIST OF FIGURES

PART IV TERRA NOVA RIVER BASIN



TERRA NOVA RIVER BASIN

FIGURE 14-1

TERRA NOVA RIVER BASIN - SQUARE GRID DISTRIBUTION OF LAKES, BOGS, BARRENS, AND FORESTS

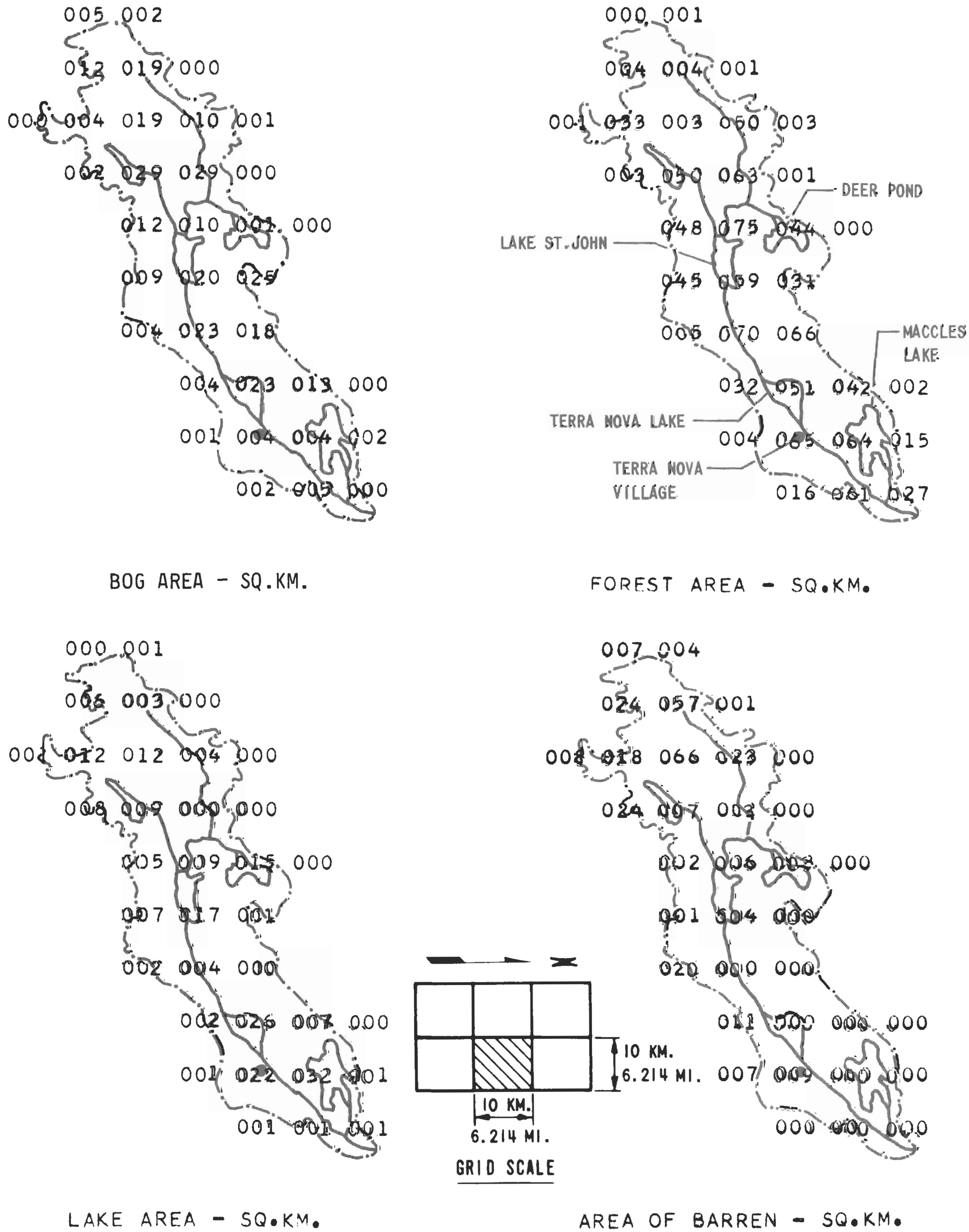
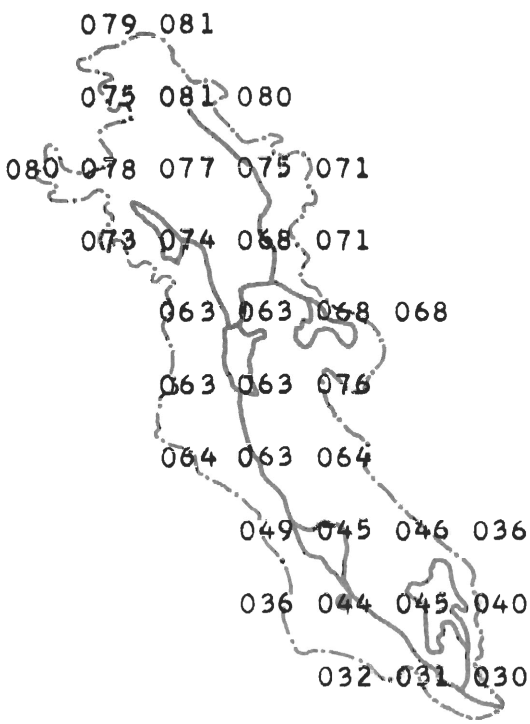
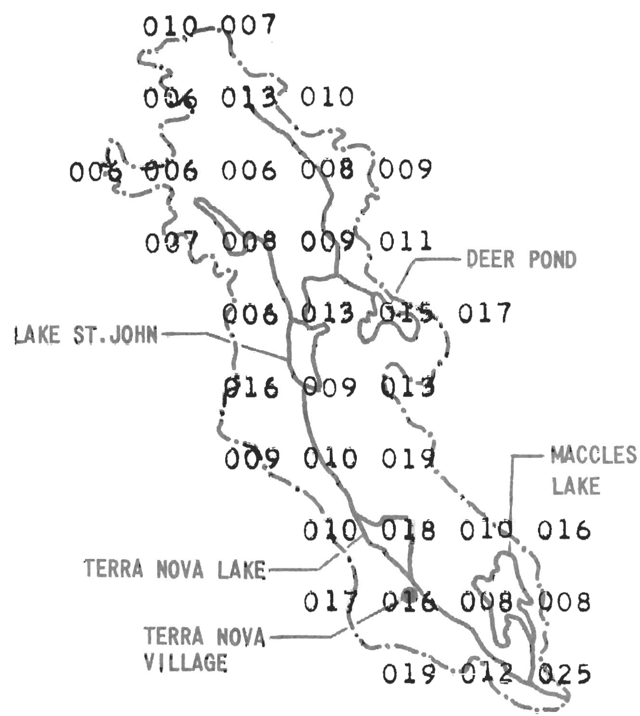


FIGURE 14-2

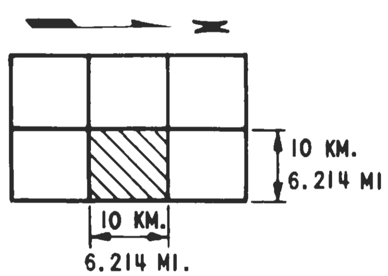
TERRA NOVA RIVER BASIN - SQUARE GRID DISTRIBUTION OF LAND SURFACE SLOPE AND ELEVATION



AVERAGE ELEVATION OF SQUARE - TENS OF FEET



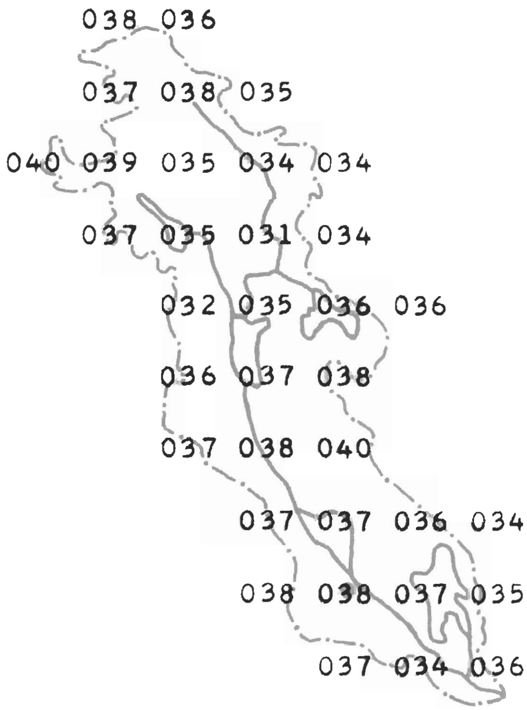
SLOPE - TENTHS OF A PERCENT



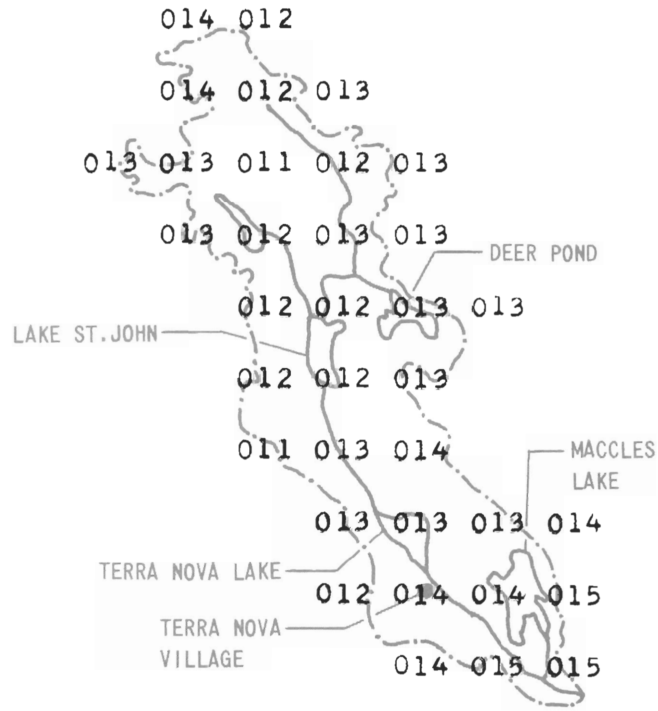
GRID SCALE

FIGURE 14-3

TERRA NOVA RIVER BASIN - SQUARE GRID DISTRIBUTION OF MEAN ANNUAL TEMPERATURE, PRECIPITATION, EVAPORATION AND RUNOFF

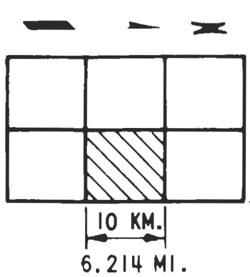


AVERAGE YEARLY RUNOFF - INCHES OF WATER

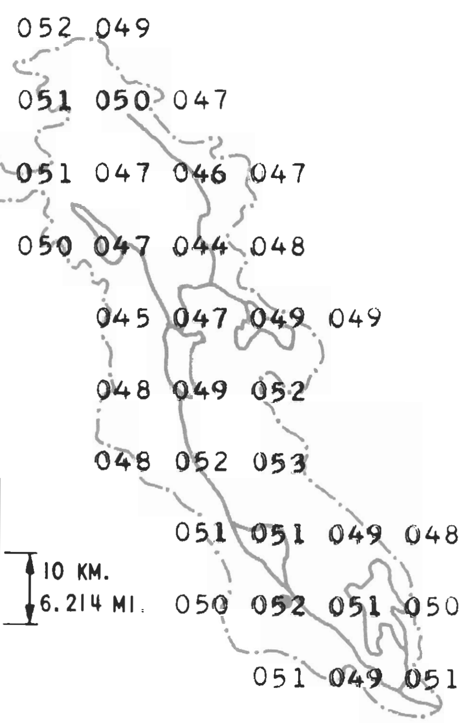


AVERAGE YEARLY EVAPORATION - INCHES OF WATER

AVERAGE YEARLY TEMPERATURE -DEGREES FAHRENHEIT



GRID SCALE



AVERAGE YEARLY PRECIPITATION - INCHES OF WATER

FIGURE 14-4

TERRA NOVA RIVER BASIN
GROSS HYDRO ELECTRIC POTENTIAL
ON TERRA NOVA RIVER

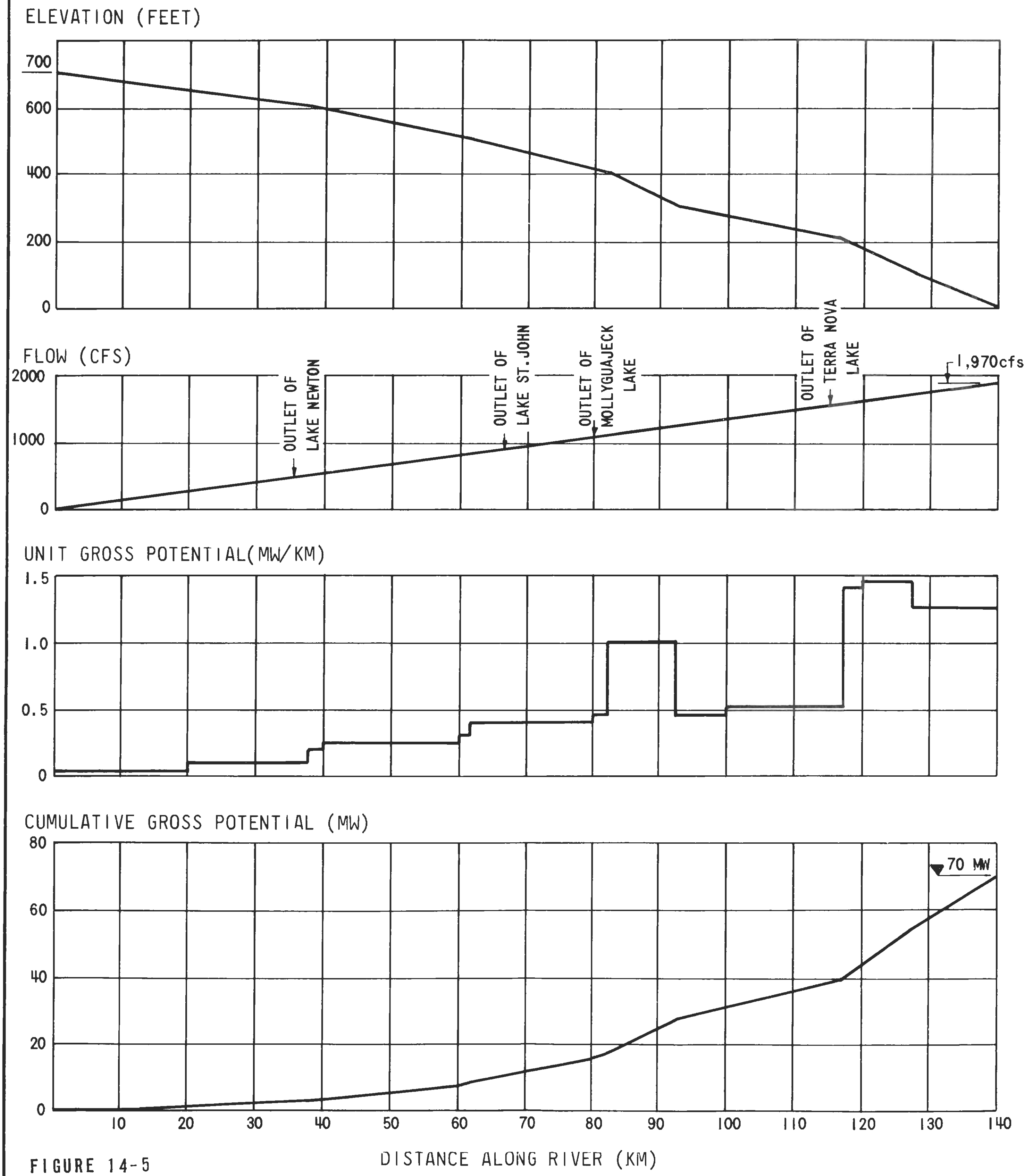


FIGURE 14-5

TERRA NOVA RIVER BASIN - SQUARE GRID DISTRIBUTION OF RECORDED POPULATION 1951 - 1966

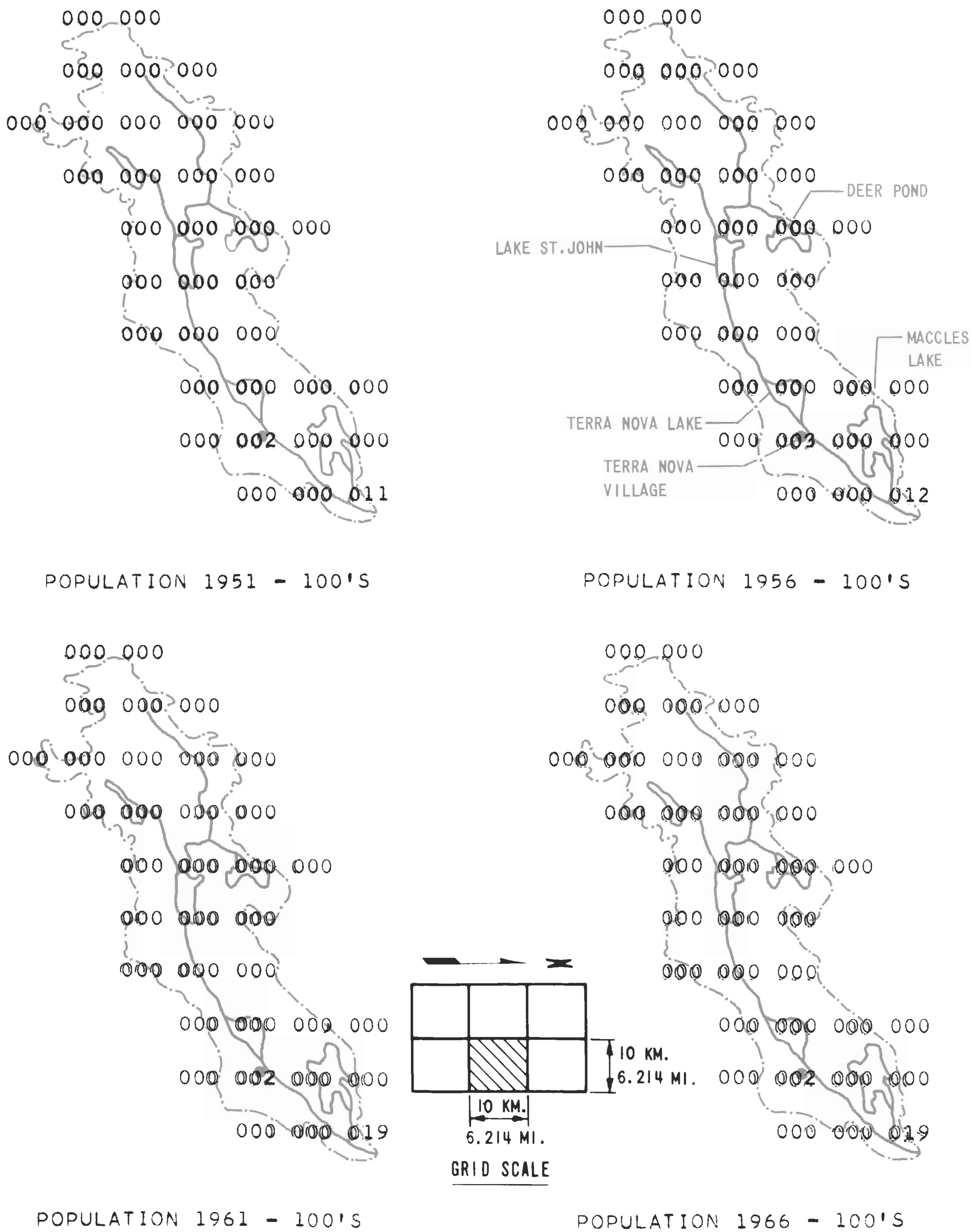


FIGURE 15-1

TERRA NOVA RIVER BASIN
ANNUAL ANGLERS CATCH
(SALMON AND GRILSE)

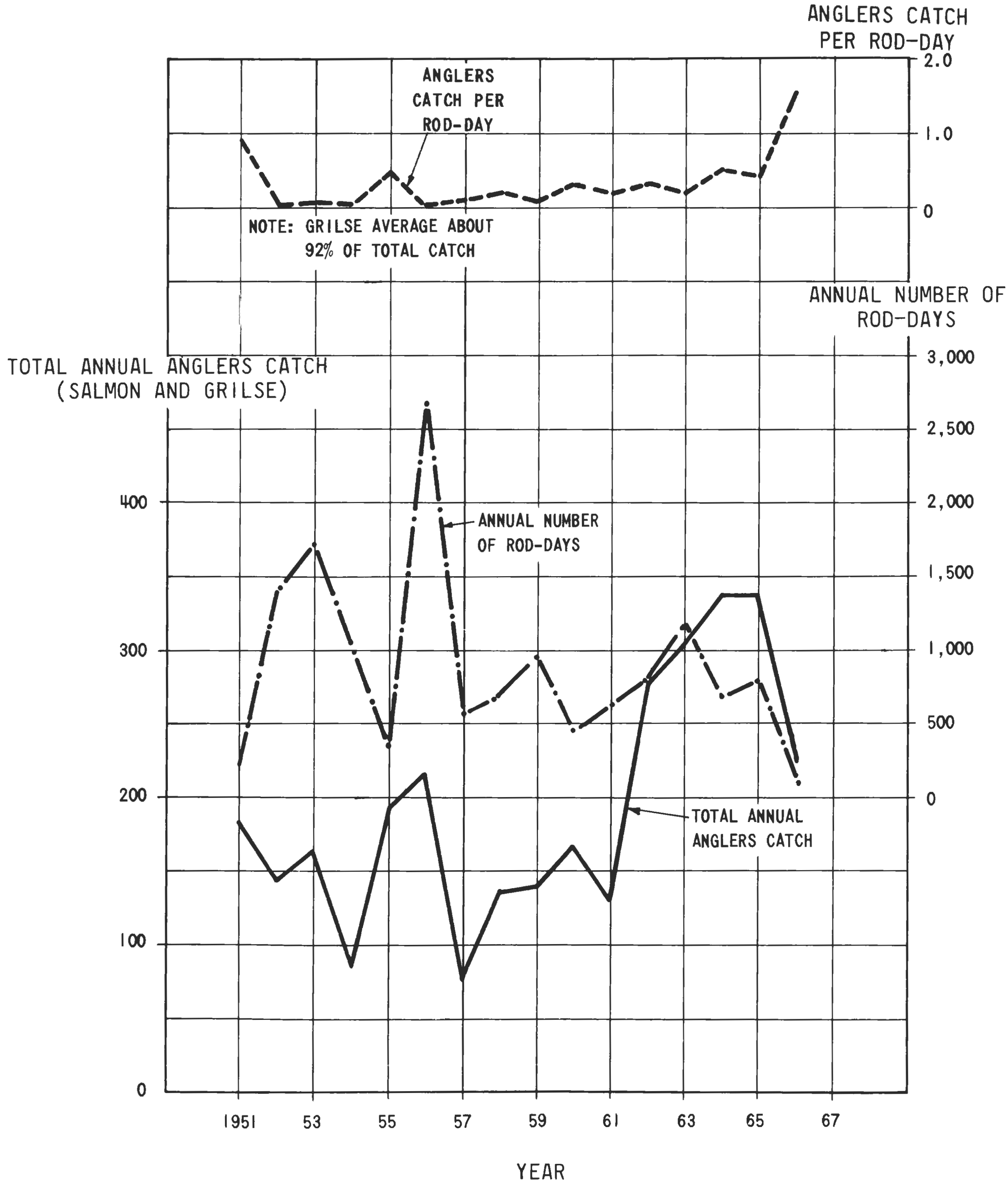
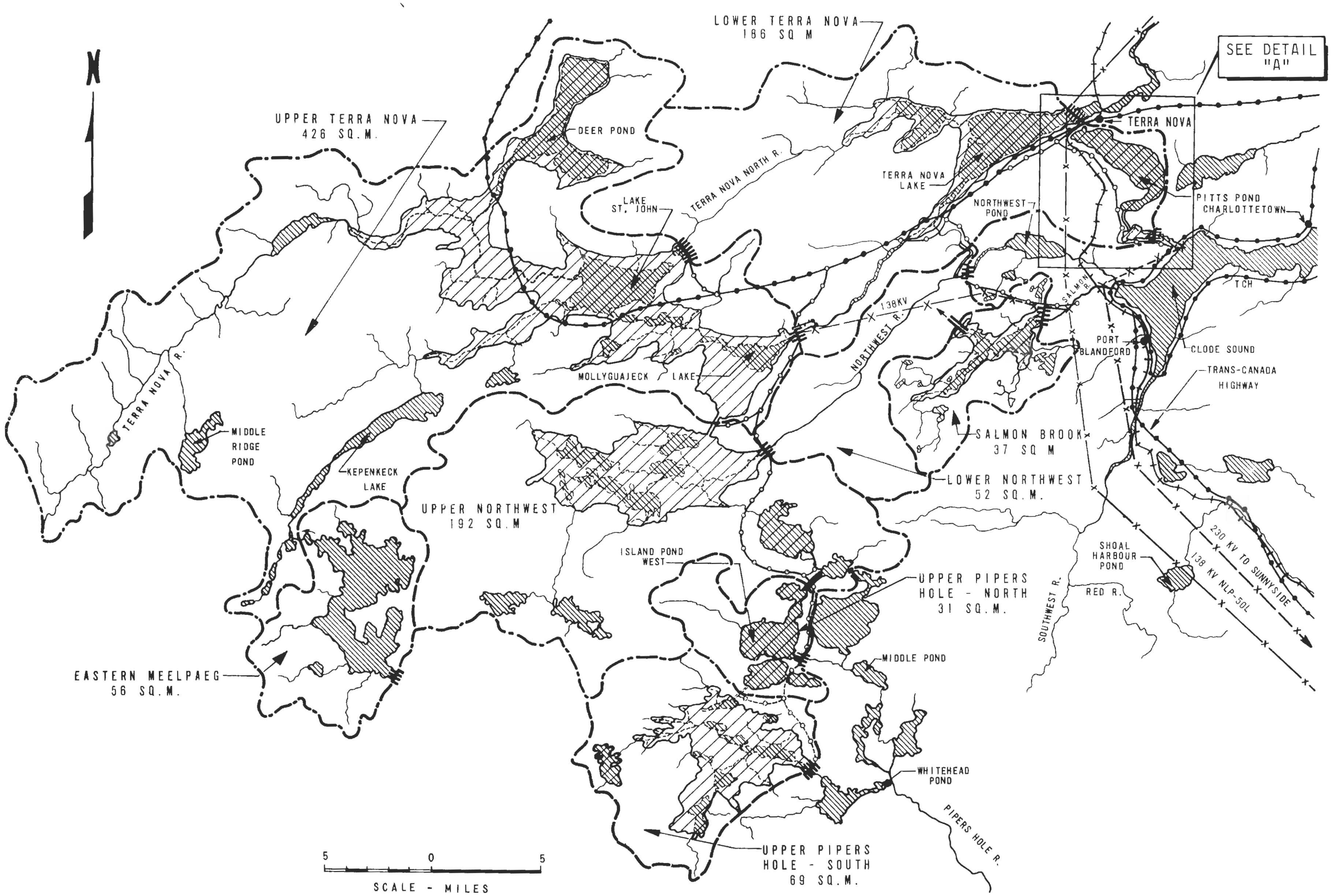
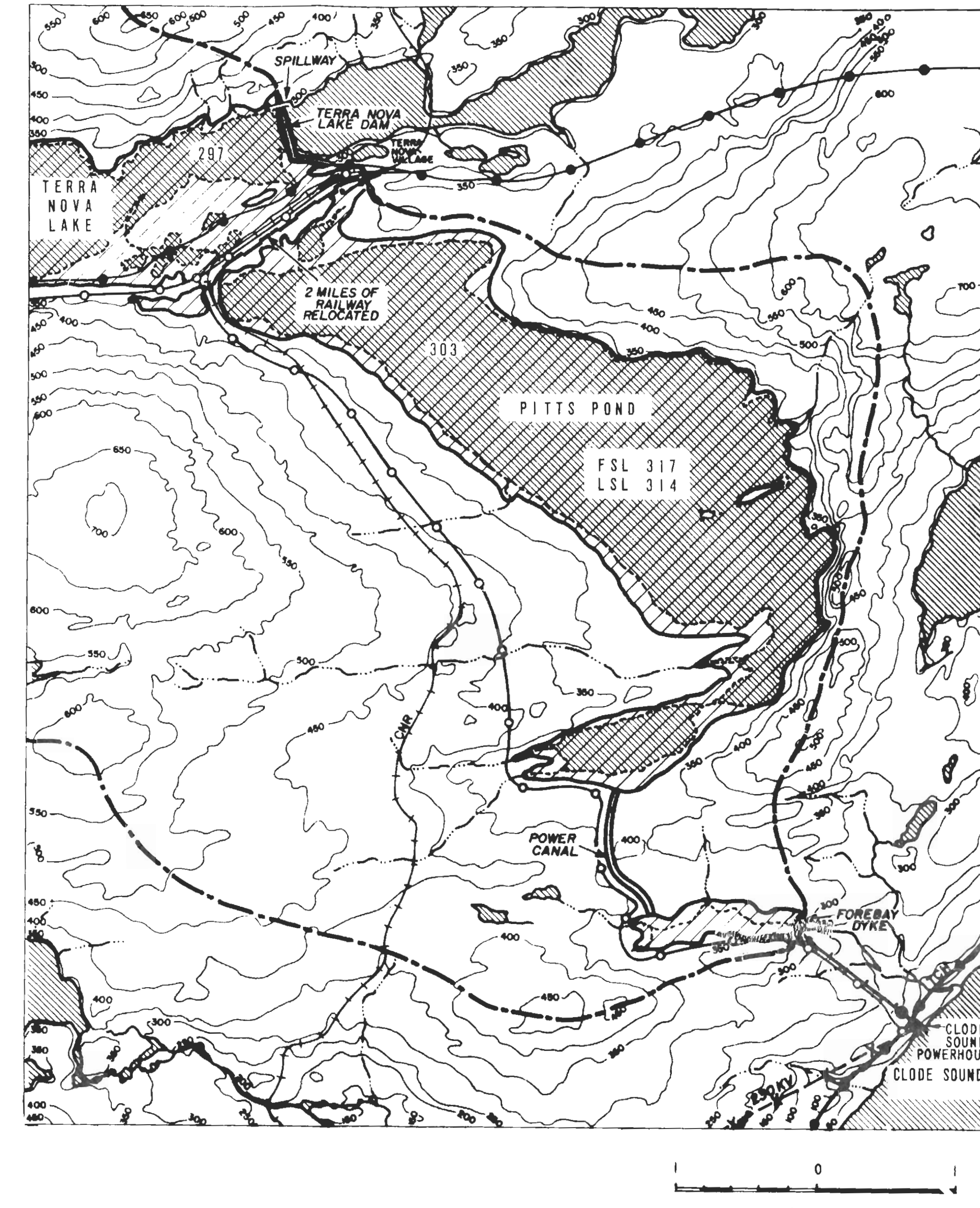


FIGURE 15-2





DETAIL "A"

LEGEND

(dam symbol)	DAM	(line symbol)	ROAD-ACCESS
(powerhouse symbol)	POWERHOUSE	(line symbol)	ROAD EXISTING
(line symbol)	CANAL AND TAILRACE	(line symbol)	RAILWAY
(line symbol)	DRAINAGE BASIN OUTLINE	(line symbol)	TRANSMISSION LINE - EXISTING
(line symbol)	SUB-BASIN OUTLINE	(line symbol)	TRANSMISSION LINE - NEW
(hatching)	FLOODED AREA	(line symbol)	PIPE LINE
(hatching)	LAKE AREA		

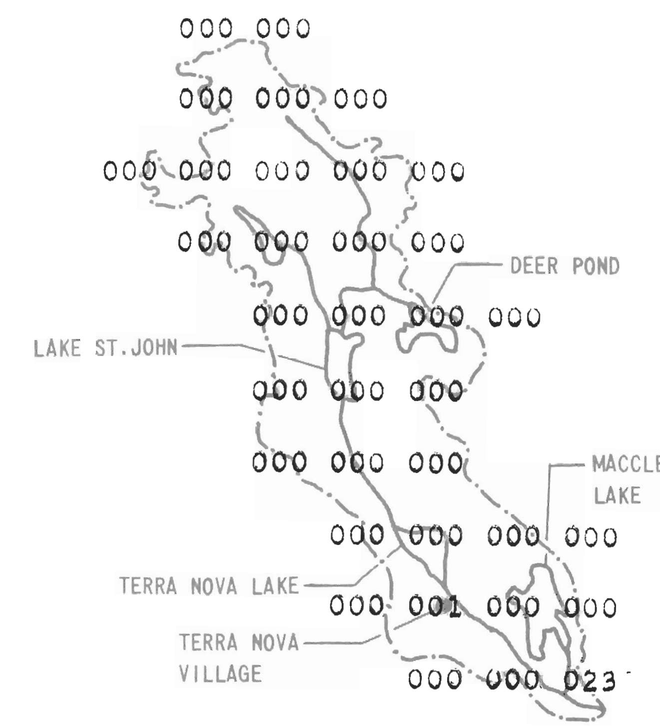
NOTE: BASIC DATA FROM SHAWMONT NEWFOUNDLAND LIMITED REPORT NO SM-3-66

PROPOSED HYDRO ELECTRIC DEVELOPMENT
TERRA NOVA RIVER
GENERAL PLAN

FIGURE 16-1

TERRA NOVA RIVER BASIN - SQUARE GRID DISTRIBUTION OF POPULATION FORECAST 1971 - 1981

POPULATION 1971 - 100'S



POPULATION 1976 - 100'S

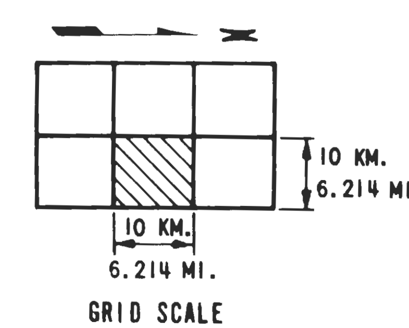


FIGURE 16-2 POPULATION 1981 - 100'S

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PART IV TERRA NOVA RIVER BASIN

TERRA NOVA RIVER BASIN

SUMMARY OF CLIMATIC CHARACTERISTICS

A ANNUAL MEANS

Precipitation (inches)	Air Temperature (deg F)	Potential Evaporation (inches)	Relative Humidity (percent)
49.2	38.6	19	84

B MEAN MONTHLY PRECIPITATION (inches)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Basin Mean Synthesized	3.8	4.2	3.7	3.2	3.4	3.7	3.8	4.6	4.0	4.9	5.2	4.7	49.2

C MAXIMUM POSSIBLE STORM PRECIPITATION (inches)

Area (sq. mi)	Storm Duration (hours) 6	12	18	24	36	48	72
100	4.25	7.50	8.85	10.30	12.25	12.50	14.15
300	4.20	7.35	8.70	10.10	12.00	12.35	14.10
500	4.12	7.20	8.60	10.00	11.90	12.25	14.00
740	4.08	7.10	8.50	9.90	11.70	12.10	13.80

D MAXIMUM POSSIBLE SEASONAL SNOWFALL (inches of water equivalent): 34.0

E CRITICAL SEQUENCES FOR SNOW MELTING (degrees F)

Interval	Date: March 1	March 10	March 20	April 1	April 10	April 20	May 1	May 10	May 20
4 - day	40.0	42.5	45.5	49.5	53.0	57.0	61.0	64.5	69.0
8 - day	38.5	41.0	43.0	46.5	49.0	51.0	54.0	58.0	63.5
16 - day	35.0	36.5	38.0	41.5	44.0	47.5	51.0	54.0	55.5

F DROUGHT

Return Period	2.33-Year	5-Year	10-Year	20-Year	50-Year	100-Year
Length of Drought	13 days	16 days	19 days	23 days	27 days	30 days

SUMMARY OF HYDROLOGIC CHARACTERISTICS TERRA NOVA RIVER BASIN

I - SYNTHESIZED DATA

A. ANNUAL MEANS FOR THE TOTAL BASIN

FLOW (CFS)	RUNOFF (CFS/SQ.MI)	RUNOFF (INCHES)	ACTUAL EVAP. (INCHES)
1,970	2.7	36.1	13.0

B. MEAN MONTHLY FLOWS (Q) AND STANDARD DEVIATIONS (S) (CFS)

RIVER AND LOCATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
TERRA NOVA RIVER AT EIGHT MILE BRIDGES	Q	1270	1040	925	2015	3030	1220	705	650	730	815	1630	1340	1280
	S	710	538	569	815	1050	570	315	420	500	455	718	534	190
TERRA NOVA RIVER AT GLOVERTOWN SOUTH	Q	1790	1480	1470	3170	4700	1940	990	980	1080	1390	2450	1990	1970
	S	1200	780	910	1260	1650	830	520	720	780	784	1120	850	305
	Q													
	S													

C. MAXIMUM FLOWS (CFS) AND FLOOD VOLUMES (CFS DAY) OBTAINED BY THE MAXIMIZATION PROCEDURE (INSTANTANEOUS PEAKS)

RIVER AND LOCATION	MAXIMIZED RAIN ON SNOW PACK		MAXIMIZED RAIN ONLY		SNOW PACK & AVERAGE RAIN	
	PEAK	VOLUME	PEAK	VOLUME	PEAK	VOLUME
TERRA NOVA RIVER AT EIGHT MILE BRIDGES	50,000	277,000	36,500	156,000	16,200	140,000

D. MAXIMUM FLOWS OBTAINED BY STATISTICAL ANALYSIS (CFS) (DAILY AVERAGES)

RIVER AND LOCATION	GENERATED BY SNOW MELT & RAIN		GENERATED BY RAIN ONLY	
	1/10000 YEARS	1/1000 YEARS	1/10000 YEARS	1/1000 YEARS
TERRA NOVA RIVER AT EIGHT MILE BRIDGES	18,600	15,200	10,900	8,860
TERRA NOVA RIVER AT GLOVERTOWN SOUTH	28,300	22,900	18,400	14,800

SUMMARY OF HYDROLOGIC CHARACTERISTICS
TERRA NOVA RIVER BASIN

E. MINIMUM FLOWS OBTAINED FROM RECESSION CURVES (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/10 YEARS	1/20 YEARS
TERRA NOVA AT EIGHT MILE BRIDGES	90	50		10
TERRA NOVA AT GLOVERTOWN SOUTH	180	75		30

F. MINIMUM FLOWS OBTAINED FROM STATISTICAL ANALYSIS (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/20 YEARS	1/100 YEARS
TERRA NOVA RIVER AT EIGHT MILE BRIDGES	162	82	20	
TERRA NOVA RIVER AT GLOVERTOWN SOUTH	295	154	42	

G. FULL REGULATION STORAGE

RIVER AND STATION	STORAGE (CUBIC FEET x 10^9)
TERRA NOVA RIVER AT EIGHT MILE BRIDGES	38.4
TERRA NOVA RIVER AT GLOVERTOWN SOUTH	70.9

II - RECORDED DATA

H. MEAN MONTHLY AND ANNUAL FLOWS (CFS)

RIVER AND STATION	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
TERRA NOVA R. AT EIGHT MILE BRIDGES	16	1670	1120	1190	2750	2180	915	630	800	810	1030	1810	1680	1380

I. EXTREMES RECORDED (CFS)

RIVER AND STATION	MAXIMUM FLOWS			MINIMUM FLOWS		
	FLOW	DATE	COMMENTS	FLOW	DATE	COMMENTS
TERRA NOVA R. AT EIGHT MILE BRIDGES	11600 CFS	APR. 20 1964	DRAINAGE AREA = 459 SQ.MILES	82 cfs	JULY 28 1957	PERIOD OF RECORD FEB. 1951 TO JUNE 52 AND NOV.52 TO SEPT.66

TERRA NOVA RIVER BASIN

SUMMARY OF WATER QUALITY EXTRAPOLATIONS

	----- Effects of Characteristics on Use for -----								
Location	Fish			Pulp & Paper			Domestic and Raw Water		
	P	C	B	P	C	B	P	C	B
Upstream of Terra Nova Lake	-	0	0	+	+	0			
Mouth of Terra Nova River	+	0	+	+	-	0			

NOTE

P - Physical Characteristics
C Chemical Characteristics
B Biological Characteristics
+
0 Comparative Ratings

See Volume Two for description of Water Quality Extrapolations

TABLE 14-3

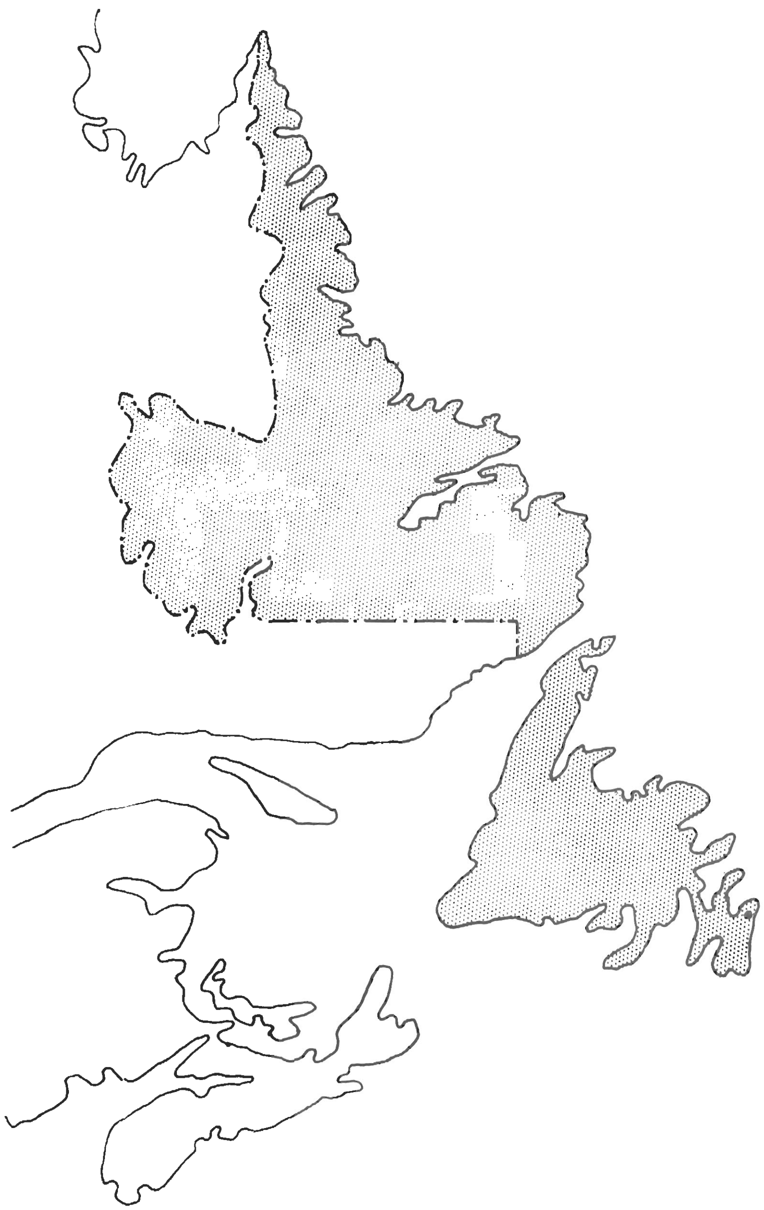
TERRA NOVA RIVER BASIN

GROUNDWATER POTENTIAL

Hydrogeologic Unit	Mean Well Depth (bedrock)	Estimated Yield Range (gpm)	Percentage of Basin	Area in Basin (sq. mi)	Comments
Bedrock Units:					
R1	159	0 to 40	32.0	237	
R2	155	0.5 to 10	8.3	61	
R4	113	1 to 20	57.2	424	
R5	88	1 to 30	2.3	17	
R6	127	1 to 20	0.2	1	
Surficial Units:					
S2		10 to 50	90.0	666	
S3		5 to 50	7.0	52	
S4		50 to 1000	3.0	22	
S5			26.0	193	Poor quality

A detailed discussion of hydrogeology is given in Volume Two.

TABLE 14-4



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GANDER RIVER BASIN AND
GANDER - GLENWOOD STUDY AREA

PART V - GANDER RIVER BASIN AND GANDER-GLENWOOD STUDY AREA

18 NATURAL CONDITIONS

The Gander River basin is located in the northeast part of the Island as shown on Figure 18-1.

A major international air terminal is located in the basin and the people required to operate the facilities at the airport live in the community of Gander. The livelihood of Gander, the largest community in the basin, has been largely dependent on the air terminal and it is expected that it will remain an important factor[1].

The existing road network is fairly extensive. A 36-mile gravel highway connects the river mouth at Gander Bay to the town of Gander located near Gander Lake. Over 30 miles of the paved Trans-Canada Highway is located in the basin, and it runs parallel to the lake, passing through the communities of Gander and Glenwood. There are over 60 miles of woods roads which connect the lake area to the forest resources in the interior. In addition, more than 30 miles of the newly constructed north-south gravel highway, which connects Bay D'Espoir to the Grand Falls area, passes through the upper Gander basin. The Canadian National Railway parallels the Trans-Canada Highway in the lower basin area.

This network of road, rail, and air transport facilities has enabled Gander to broaden its economic base over the years, and it now has a growing regional importance as a service centre.

18.1 Physiographic Conditions

The Gander River has a total natural drainage area of 2,074 square miles, which makes it the third largest drainage area in the Island, being exceeded by the Exploits River and the Humber River. In terms of stream length, it is the second largest, being next in this respect only to the Exploits River. The total stream length of the Gander River is about 930 miles, including tributaries.

Figure 18-1 shows the drainage basin outline, the topography, roads, communities, and main lakes of the basin.

The total drainage area includes 189 square miles of marshes or bogs, 140 square miles of lakes, and 170 square miles of barrens. The proportion of lakes, marshes, and barrens in the different sections of the basin is indicated in Figure 18-2. There are several lakes and ponds in the basin, and all of these are comparatively small except for Gander Lake, which is the largest natural lake in the eastern half of the Island.

The hypsographic curve of the basin is shown on Figure. 1-4. The curve reflects the gradual rise in the topography along the entire river length, a feature which has prevented economic development of hydro power in the basin, but which has aided in making the river a significant salmon producer. The square grid distribution of land surface slope and elevation are shown in Figure 18-3.

The variation of the mean annual temperature, precipitation, and evaporation is shown in Figure 18-4. The average annual temperature is 39 deg F, the average annual precipitation is 46 inches, and the average annual evaporation is just over 13 inches.

The climate of the Island is discussed in detail in Volume Two, Section 8. The pertinent information on the climatic conditions of the basin are summarized in Table 18-1.

18.2 Water Resources

18.2.1 Surface Water

Hydrologic data on the basin are available from three river gauging stations which have recorded the flow at various times since the mid-1920's. The river gauge operating at present is located at Big Chute on the main stem upstream of which there is a drainage area of 1,690 square miles.

The records from the river gauging stations have been used with physiographic and meteorologic characteristics in the basin to obtain the areal distribution of the average annual runoff, which is indicated on Figure 18-4. The average annual runoff is relatively low when compared to other basins on the Island, being 32.4 inches or 2.4 cfs per square mile. The main hydrologic characteristics of the basin are summarized on Table 18-2.

The quality of the surface waters of the Gander River basin has been little affected by man's activities to date. This is particularly true of that part of the basin above Gander Lake where activity has been limited to logging and some hunting and angling. In recent years a road has been opened to Bay D'Espoir from the Trans-Canada Highway at Bishops Falls cutting across the upper portion of the drainage area. It is unlikely, however, that this road will occasion sufficient increase in activity in the area to adversely affect the quality of the surface water. Most of the population of this basin live in Gander, Glenwood, or small communities adjacent to the north shore of Gander Lake. With the exception of minor bacteriological affect on the water quality through discharge of treated and untreated domestic wastewaters into the river, even the surface water downstream of Gander Lake is close to a natural condition.

Approximately forty chemical analyses of surface waters, obtained during the period 1955 to 1967, were available for review. The Gander River water is exceptionally low in total dissolved solids having a total equivalents per million of less than 0.5. Hardness of the river water is also very low, ranging from 4 ppm to 12 ppm as $CaCO_3$. The pH of the Gander River averaged 6.2, ranging from 5.7 to 6.8. Colour varied from a minimum of 15 units to a maximum of 60 units with most analyses indicating a colour of 40 units, slightly higher than the majority of Newfoundland surface waters. Turbidity was normally less than 5 units, the maximum recorded value being 30 units.

None of the analyses reviewed showed excessive concentrations of iron, manganese, fluorides, or similar minor chemical constituents which would adversely affect the quality of the water. The one bacteriological analysis of Gander River water taken near Glenwood indicated a coliform count of 40 per 100 ml, somewhat lower than might be expected downstream of the town of Gander.

Water quality extrapolations for the basin are summarized in Table 18-3.

18.2.2 Groundwater

The groundwater potential of the basin is summarized in Table 18-4. Groundwater provides the main source of supply to small communities in the basin. Most of the groundwater is obtained from dug wells in the surficial materials. The distribution of the surficial materials for the Island is discussed in Volume Two. Most of the basin has cover of ground ablation and end moraine which varies in thickness but probably has a mean depth of about 20 feet in this area. There are some small areas of exposed rock in the areas mapped as moraine, but they are scattered and cannot be indicated at the scale used. Twenty-seven percent of the basin is covered with ribbed moraine, which in this area is generally thicker than the other moraines, with an average depth of about 30 feet. Five percent of the basin has a cover of sands and gravels in the form of alluvial and outwash deposits along the Gander River and at the east end of Gander Lake, and as eskers south of Gander Lake; 18 percent of the basin has a cover of marsh and bog.

In some areas deep wells into bedrock are used for water supply, the distribution of the hydropetrologic units in the bedrock is discussed in Volume Two, and the mean depth of wells in each unit, and their expected yield are given in Table 18-4.

The bedrock unit which underlies 47 percent of the basin is R6 which consists of relatively unmetamorphosed Lower Paleozoic sediments. Unit R1, major igneous intrusions, underlies 32 percent of the basin. In this basin there are a number of basic and ultrabasic intrusions as well as granitic ones; they occur in a strip to the east of the Gander River, and in the southern part of the basin. The remainder of the basin is occupied by metamorphosed Lower Paleozoic rocks.

The quality of the groundwater in the surficial materials will be good except in the marshy areas. The bedrock water quality will be poor in some of the basic and ultrabasic intrusions in the basin.

18. 3 Natural Resources

Suitable topographic and meteorologic conditions were partly responsible for the selection of the international air terminal location just north of Gander Lake.

The townsite of Gander was selected in 1952 as a suitable location for the personnel who operate the airport. This community is now the largest in the basin. In addition to the air terminal, the forest resources have provided a major source of employment.

18. 3. 1 Forests

A high percentage of the Gander basin is covered by forests. According to the 1:250, 000 scale topographic maps, 76 percent of the total drainage area or 1, 575 square miles is forest covered. The area of forest leased by Price (Nfld) Pulp and Paper Company Limited in 1967 was 212 square miles, of which 140 square miles was exploitable forest.

Bowaters Newfoundland Limited has the largest timber limits, which contain 412 square miles of merchantable timber, 282 square miles of unmerchantable timber, and 822 square miles of waste area.

Figure 1-10 indicates the distribution and ownership of timber limits in the basin.

18.3.2 Minerals

There are several occurrences of minerals throughout the basin. These are shown on Figure 1-2 and are summarized below.

Metallic	No. of Mineral Occurrences		Non-metallic	No. of Mineral Occurrences	
	Significant	Minor		Significant	Minor
Chromium	3	2	Asbestos	2	6
Copper	1	2	Magnetite	4	-
Lead	1	-	Granite	-	1*
Zinc	1	-			
Silver	1	-			

* past producer

Although a number of mineral occurrences in the basin are of significant physical size, according to a study prepared by the Department of Mines[2], none of the deposits are known to be of potential commercial significance.

19 PRESENT DAY DEVELOPMENT

Partial development of the forestry and water resources has already taken place in the Gander River basin. Part of the timber limits of the Price (Nfld) Pulp and Paper Company Limited and its predecessor companies, and the Bowater Pulp and Paper Company have been harvested. The water resources have been partially developed for purposes of log driving and fisheries. Recreation and navigation have been developed to only a small extent and fresh water supplies have been utilized by the existing communities. Permanent settlement in the community of Gander has been encouraged by the establishment of the international air terminal.

19.1 Non-withdrawal Water Resource Uses

The utilization of the river for fisheries is the only use of the water resource which has grown over the years. In this basin the other main non-withdrawal use of the water resource, that of log driving, is dependent on the activity in the harvesting of the forest, and conflicts to some extent with the use for fisheries.

19.1.1 Hydro Power Development

Although the Gander River has a large drainage area, this advantage has been offset by its relatively low runoff and its topographic features which do not permit an economical concentration of head. As a result, the hydro-electric potential of the basin is low. This is reflected in the river gross hydro-electric potential along the main river stem as shown in Figure 18-5.

19.1.2 Fisheries

Information on the present-day fisheries resource has been provided by **the Department of Fisheries of Canada .**

19.1.2.1 Sport Fisheries

The most valuable fish population supported by the Gander River is the Atlantic salmon. The river usually ranks second on the Island in terms of yield to the angler, with an average take during the past decade of 2,000 fish annually.

The variation in the annual number of rod-days and the Atlantic salmon catch is shown in Figure 19-1. The annual number of rod-days recorded for the total Gander River has fluctuated widely during the 1951-1966 period. However, the general trend has been to an increase from about 1,440 to over 2,000 rod-days during the 16-year period. The fluctuations in annual rod-days is probably due to fluctuations in woods-workers in the basin. The number of rod-days in the upper Gander basin has shown similar fluctuations, but the trend has been to a decrease from about 1,150 rod-days in 1951 to 775 rod-days in 1966. However, with the new gravel road which passes through the basin area and connects the Grand Falls area to Bay D'Espoir, angling can be expected to increase in this part of the river. Small pleasure craft can be used by anglers and will now be able to commence a trip from the upper river area and float downstream with short portages in some sections of the river. The lower Gander River, on the other hand, has shown a steady increase from about 300 rod-days in 1951 to about 1,300 rod-days in 1966. This section of the river is not fished as extensively by woods-workers and relies more on local tourist anglers. It is interesting to note that while the annual catch per rod-day for the total river averages 0.8, it is only 0.6 for the upper Gander River but is 1.2 for the lower Gander River. The reason for the larger catch per rod-day may be a greater abundance of fish or the fact that guides are employed more extensively in the lower Gander River.

The Gander River differs significantly from many Newfoundland rivers in that almost all of its stream area is accessible to anadromous fish as there are few natural barriers. Consequently, it is believed that the river should be producing Atlantic salmon above the present levels. The Department of Fisheries has not yet been able to devote sufficient time to confirm the validity of this belief, as problems in other rivers are more critical.

The Department of Fisheries believes that the forestry exploitation in the basin, with its associated use of streams for log driving and the construction of woods roads, has probably reduced salmon production to lower levels than would otherwise be the case. Nonetheless, the average adult escapement to the river is substantial, being in the order of 6,000 to 10,000 fish, and the Gander River was the first in the Province with an average of 277 adult fish of 6 pounds or over landed during the 1959-1966 period.

The numerous lakes and ponds of the Gander River system support a substantial sport fishery for speckled trout and "overfishing" in the area is believed to occur only in isolated cases. Due to relative inaccessibility, there is little or no fishing in most standing waters. Gander Lake does not contribute significantly to this fishery except in the vicinity of the inlets of tributary streams.

In addition, other species of fish present include sea-run brook trout, resident brook trout, ouananiche, arctic char, American smelt, stickleback, and eels. The first three species support a worthwhile local sport fishery.

At present, there is no significant pollution in the basin. In the past, log driving impaired water quality to some extent but this is not presently a problem as logging operations have been temporarily discontinued.

The Department of Fisheries has installed a fishway on Salmon Brook, a tributary of the Gander River near the community of Glenwood, at a cost of $30,000. There are no major obstructions on the main stem of the river, although there are several small brooks which feed into Gander Lake and the main river stem which still have partial obstructions to the fish. These are not considered significant, however, and there are no immediate plans for additional fisheries developments.

19.1.2.2 Commercial Fish

Fishing for smelt takes place in the estuary, but it is of no great commercial importance as the annual returns are seldom more than a few hundred dollars. Eels and mussels are located in the estuary and have some possible economic importance; however, there are no statistics available on these species.

In the area which extends for 30 to 40 miles on each side of the mouth of the Gander River, fish landings decreased in quantity by 5 percent during the last six years but increased in value 70 percent during the same period. In 1966, the main species landed in the area were as follows:

Item	Volume (pounds)	Value (dollars)
Ground fish	6,061,000	258.000
Lobster	208,000	189,000
Capelin	2,219,000	19,000
Salmon	6,000	2,000

Salmon is the only species of commercial importance which spends part of its life in fresh water, and the recorded catch shows a decline from 73,000 pounds to 6,000 pounds in 1966. However, these figures are believed to overstate any decline in capture that may have taken place, and it is estimated that in 1966 additional salmon with a landed value of about $8,000 were captured by local fishermen but recorded elsewhere.

Capital investment in the primary fisheries in the area extending about 30 to 40 miles on each side of the mouth of the Gander River is estimated by the Department of Fisheries for 1962 and 1966 as follows:

Item	1962	1966
Vessels	$143,000	$266,000
Fishing Gear	216,000	474,000
Shore Equipment	129,000	201,000
	$488,000	$941,000

During these same five years, the number of fishermen in the area increased by 10 percent with the increase taking place in the category of fishermen who fished during 10 or more months each year. In 1966, 40 percent of the fishermen were reported fishing during 10 or more months.

Participation in the more important fisheries is indicated below:

Item	Number of Fishermen 1962	1966
TOTAL*	609	676
cod fishing	355	228
herring fishing	149	12
salmon fishing	102	128
lobster fishing	419	433

* Many of the fishermen in this total fish for more than one species.

In summary, the commercial fisheries in the Gander River area (radius of 30 miles) provide employment for 676 inshore fishermen (65 percent of whom fish during five or more months each year) with capital investment in the primary fisheries approximating $940,000, and furnish them with a gross revenue in excess of $468,000.

19.1.3 Log Driving

Harvesting of the forest resources in the basin was carried out in the years 1951 to 1961 but was discontinued by 1966. In 1951 to 1956, about 25,000 cords were driven on the river per year, but this reduced to about 12,000 cords in 1961. Present-day driving is very limited as the harvesting has temporarily discontinued in the basin.

19.1.4 Recreation, Tourism, and Wildlife

Present-day development of the area has probably suffered because of proximity of the Terra Nova National Park which attracts tourists away from the Gander Basin. This park is located only about 40 miles from the basin.

Summer time recreational opportunities exist in abundance with the large fresh water Gander Lake easily accessible to the main basin population centres. Furthermore, the fishing and boating opportunities are equal to any on the Island. A boating area has been established about one mile west of Gander and a boating committee, appointed by the Gander Town Council, is presently active in supervising recreational activities on the lake.

Despite the small population, modern accommodations for tourists are available in the town of Gander. Motels have been located on the Trans-Canada Highway to accommodate overnight visitors from the Gander Airport and tourists who pass through the basin via the highway.

Two Provincial parks have been established in the basin and their location is shown in Figure 18-1. The Glenwood Park is a Trans-Canada Highway roadside park established in 1960 by the Provincial Government as a picnic ground only. An average of over 25,000 visitors came to the park each year from 1964 to 1966. The park has an area of 228 acres, about twice the average size of similar roadside parks in the Province.

In 1966-67, "Come Home Year" in Newfoundland, increasing demands were placed on the Provincial Parks Service, as the number of visitors to all parks increased by about 37 percent. In 1966, Jonathan's Pond Provincial Park was opened on Highway 40, north of Gander. The park is a multiple-purpose park, having camping, trailer, and picnic facilities, and over 8,000 visitors were recorded during its first season.

Present-day recreation in the basin is very limited during winter periods. Although the area has abundant snowfall, the small population and the lack of high hills similar to those found on the west coast near Corner Brook inhibit the development of skiing facilities in the area.

All the big game animals found on the Island are represented in the Gander basin. In addition, the fur bearing land mammals common to the Island are found in the area. There is an open season for caribou hunting south of the Trans-Canada Highway, and moose and bear hunting is presently permitted in all parts of the basin. Moose management areas are located in part of the upper basin area. There are four hunting camps in the basin which generally attract mainland hunters who are obliged to use the services of guides.

Trapping of the fur-bearing species in the basin has declined and, as is typical of the Island, is no longer profitable for the seasonal trapper.

There are no known conflicts in use of the water resource between the wildlife in the basin and other present-day users.

19.1.5 Navigation

Small tugs were formerly used for the log driving operations in the navigable sections of the Gander River. Between Gander Lake and the river mouth, a distance of 31 miles, the river is navigable by shallow draught vessels, except for two rapids located about three miles downstream of Glenwood. In addition, Gander Lake is over 30 miles long and the Northwest Gander River is navigable for 16 miles upstream of Gander Lake.

Pleasure boats presently use the river for sport fishing and transporting big game hunters. Recreational boating, which includes water skiing and sailing, is generally confined to Gander Lake.

19.2 Withdrawal Uses

Present withdrawal uses of the basin's water resources are limited to the domestic and minor industrial requirements of the small communities in the basin. The large drainage area of over 2,000 square miles provides ample flow for future industrial growth.

19.2.1 Agriculture

Agriculture does not contribute significantly to the economy of the basin as very little of the land is suited to cultivation. In 1965, only about 100 acres were in use for agricultural purposes. A significant demand of fresh water for agricultural purposes does not exist and is not likely to develop.

19.2.2 Population, Municipal Water Supply, and Waste Disposal

The population in the communities in the basin from 1951 to 1966 is shown in the following table. The square grid distribution of population in the basin for this period is shown in Figure 19-2.

	1951	1956	1961	1966
Benten	112	129	200	251
Clarke's Head	388	422	378	416
Georges Point**	173	189	207	230
Glenwood	689	792	1,130	1,000
Main Point**	70	114	122	195
Victoria Cove**	246	250	298	212
Wings Point**	127	131	142	195
Roger Cove**	107	-	-	-
Subtotal	1,912	2,027	2,477	2,499
Gander	3,780*	4,900*	5,725	7,183
Total Communities	5,692*	6,927*	8,202	9,682
Outside Communities	428	373	378	598
TOTAL BASIN	6,120*	7,300*	8,580	10,280

*Estimated.
**Located on Gander Bay.

There has been a steady growth in the population of the Gander basin since the 1951 Census. The largest concentration is in the town of Gander where 70 percent of the basin population was living in 1966. Another 24 percent of the population lived in the small communities for which individual census data was available. An estimated 6 percent of population lived in other small communities within the basin.

Gander obtains its water supply from Gander Lake through a system operated by the Department of Transport. The DOT owns the pumping station located on Gander Lake and the pipeline to the town boundary. The distribution system in the town is owned by the town of Gander. Gander pays the DOT $66,500 per year for the water supply, and the maintenance of the town mains and operating costs are about $27,000 per year. A $60 annual water rate charge per family is included in the general taxation charges. The town has about 1,450 dwellings.

The entire town is supplied by the community system, and groundwater sources are not used. The water supply is treated by chlorination. Information obtained from the community questionnaires on the consumption per capita from 1956 to date is outlined below as it represents one of the few communities on the Island where consumption data is available. The water supplied is metered by the DOT.

Year	Population	Average Daily Demand (gallons)	Average Daily Demand (gallons/capita)
1956	4,900*	400,000	82
1961	5,725	580,000	102
1966	7,183	750,000	104

At present, water pressure in many sections of the town is low and it is anticipated that the installation of a new water supply system, independent of the DOT system, will be given serious consideration in the near future.

* Estimated.

The entire community is serviced by a sanitary sewerage system. Wastewaters are treated by a package treatment plant with a capacity of one million gallons per day which was installed in 1966. The receiving body of water, Soulis Pond, eventually drains into Gander Lake upstream of the water supply intake.

The second largest community in the basin, Glenwood, which has a population of about 1,000, recently (1965) installed a community water supply and sewerage system which includes a package treatment plant. Gander River is the source of water, treatment of which is limited to chlorination. Treated wastewaters are discharged into the Gander River; the treatment plant has a capacity of 200,000 gallons of wastewater per day.

The remaining small communities, which have an average population of about 250, were not visited during the 1967 field survey due to time and budget limitations. However, based on data gathered in similar sized Island communities, it is considered likely that these small Gander basin communities generally have fresh water supplies of inadequate quantity and unsatisfactory quality.

None of the present communities imposes a significant pollution load on the river system which would adversely affect the water quality for other present resource users. However, treatment of the water may be required for future industrial or domestic users, depending on their particular needs.

The quantity of the resource is adequate for present-day domestic users utilizing the main river stem for a source; the minimum daily flow at the river mouth is about 100 cfs.

19.3 Present-Day Water Resource Problems

One of the problems existing in the basin is the fisheries log-driving conflict of interest. A program is presently under way to remove some of the abandoned logging dams that are obstacles to fish migration and to ensure that dams in use do not present obstacles to migrants.

In addition, the past use of the river for log driving and the existence of small sawmills in the basin has resulted in bark and sawdust being deposited on the river bottom which depletes bottom fauna populations and, hence, fish populations.

The Department of Fisheries believes that the Gander River system should be supporting a stock of salmon significantly larger than is now the case. Investigations are required to determine the reasons for the lower numbers and how to improve the situation. These investigations have not been possible because of priority given to other areas which have more critical problems at the present time.

It is considered that a potentially dangerous condition can exist when wastewater disposal systems utilized in small communities in the basin are improperly located near the potable water supply.

20 PLANNED AND FORECAST DEVELOPMENT

20.1 Non-withdrawal Uses

20.1.1 Fisheries

It is expected that the trend to increased sports fishing of Atlantic salmon stocks will continue. The river is already one of the best Atlantic salmon runs in North America. Future competition for the water resource will probably be limited to fisheries, log driving, recreational and domestic uses. Consequently, the river appears to be a particularly good choice for the preservation and the development of the Atlantic salmon resource.

20.1.2 Log Driving

Large-scale cutting in the basin has practically ceased and thus present-day log driving has diminished in proportion. However, it is expected that log driving will be reconsidered in the future when the area is again exploited by the mills for its forest resources.

Conflict in use with the fisheries in the basin will then re-occur to a greater extent than in the past since the fisheries resource will probably have grown and increased in relative importance. In addition, log driving will conflict with use of the river for boating and will make water skiing virtually impossible.

20.1.3 Recreation, Tourism, and Wildlife

The future development of recreation and tourism in the basin will be hindered to some extent by the relatively small basin population, the distance from larger population centres on the Island, and the competition from Terra Nova National Park which is between St. John's and Gander.

The fisheries resources of the basin could be promoted to attract more mainland visitors to the area. The fact that a large part of the river is navigable by pleasure craft adds to its potential use for sports fishing and recreational development. The location of the international airport in the basin is an asset for tourist promotion which could be exploited further.

In the future, it is expected that big game hunters will take advantage of the new north-south gravel highway located in the upper basin area. In addition, the new road will enable small pleasure craft to be taken into the upper basin and permit the hunters to cover a wider territory with more ease. Consequently, management of the big game species will have to adjust to the increased hunting pressures in the basin in the future.

20. 1. 4 Navigation

The length of the natural waterway existing in the Gander River basin is relatively large for the Island, and is capable of handling a much larger pleasure boat traffic than at present. Although no data are available on the trends of pleasure craft numbers over the years, it is expected that they will increase in proportion to the related tourist and recreational activities in the area. Increase of pleasure craft in the upper basin area is expected as hunters, fishermen, and recreation enthusiasts utilize the new gravel road in the upper basin and commence their boating activities from this newly opened-up area.

20. 2 Withdrawal Uses

20. 2. 1 Water Uses for Manufacturing

Future industrial development in the basin, with proper planning, could avoid conflicts with the existing fishery resource. Although the quality of water in the basin is of a high standard, some treatment may be required for specialized uses.

The minimum daily flow at the mouth is estimated to be over 100 cfs or 54 million gpd which would enable a large industrial use without any artificial storage facilities. However, the problem of wastewater disposal would require careful consideration. Problems of this nature would have to be examined in the light of the local conditions and industry characteristics, taking into account the large river potential for anadromous fish and recreation.

A proposal to establish Gander as an air freight marshalling centre is currently being promoted by the Gander Development Association. The proposal envisages trans-Atlantic jumbo freight jets discharging their cargo at Gander, for shipment throughout the continent by smaller aircraft. A feasibility study of the proposal, carried out with assistance from the Atlantic Development Board, was completed in February of 1967. Leading air cargo carriers consider the program realistic and practical although Gander has to be made a free trade zone before the airlines will support the plan.

As many as 200 men would be employed when the scheme is in full operation. The demand on the basin's water resource created by such a scheme is expected to be very low.

20.2.2 Population, Municipal Water Supply, and Waste Disposal

Based on past trends, the population of the Gander basin is projected to grow from its 1966 level of 10,280 to 11,840 by 1971; to 13,410 by 1976, and to 15,030 by 1981. The areal distribution of these projections are shown on Figure 20-1.

From the assumptions concerning future age structure distribution and labour force participation rates (Volume Three, Section 5), it is possible to make estimates of these characteristics for the Gander basin.

Size of Labour Force Age Group and Labour Force

	1971	1976	1981
Labour Force Age Group	5,580	6,300	7,090
Labour Force	2,560	3,100	3,545

The population projections and labour force estimates are based on the premise that there will be no major economic development occurring in the study basin over the forecast period which would require a net inward movement of population to satisfy a greatly increased demand for labour.

A 1981 basin population will have a water demand of about 2 million gpd or 3.7 cfs which could be readily met by the basin's surface supplies. However, it may be necessary in some cases to increase the capacity of existing community supply systems to serve the increasing population.

Fresh water supply and/or wastewater disposal facilities in the small Island communities are generally inadequate, and it is possible that future facilities for individual dwellings in the small communities in this basin will be improved if a survey reveals this to be feasible. The wastewater treatment facilities operated by the municipalities of Gander and Glenwood are more than adequate to meet the water quality requirements of the fisheries resource and other anticipated users; provided these facilities are expanded to treat increasing flows, they will continue to be adequate.

21 CONCLUSIONS AND RECOMMENDATIONS

21.1 Conclusions

a) The economic activity of the basin is related mainly to the transportation and service industries, and these do not create significant demands on the water resource. The most important municipal demand is that of the town of Gander.

b) One of the present day water resource problems in the basin is the conflict between the fisheries resource and the former log driving activities which occurred in the basin. A program is presently underway to eliminate these conflicts.

c) The Gander River is one of the best Atlantic salmon runs in North America, and it is well suited to salmon production. In addition, it has wildlife resources and related recreation and tourism potential. Consequently, it is considered that other basins would be more suited for industrial development. Under these circumstances future conflicts between fisheries and future water resource users are expected to be limited mainly to a possible revival of large scale log driving.

d) It is considered that a potentially dangerous situation can exist due to contamination of the water supply sources for the smaller communities in the basin where individual wastewater disposal systems are improperly located near the supply.

e) Pollution control in serviced centres has been well conceived and no significant water quality degradation is occurring from the municipal demand.

21.2 Recommendations

It is recommended that:

a) The development of the basin for use by anadromous and fresh water fish be continued since conflicts of interest with other users are minimal and will continue to be so in the future.

b) In addition to the development of the basin for fisheries, efforts should be continued to develop the area for recreation and tourism, taking advantage of the existing transportation network and water resources.

c) The quality of water for domestic purposes be monitored throughout the basin to identify all unsatisfactory sources and potential problem areas.

REFERENCES

1 Town of Gander Municipal Plan
Project Planning Associates Ltd., Toronto
85 pages.

2 Mineral Resources Development Province of Newfoundland and Labrador, Mineral Resources Division, Department of Mines and Technical Surveys, Ottawa, May 1966.

Cannot find any grounds for basic disagreement with recommendations. Price and Bowater might think otherwise but insofar as the population of the Island as a whole is concerned,) there is no argument.

29/10/68

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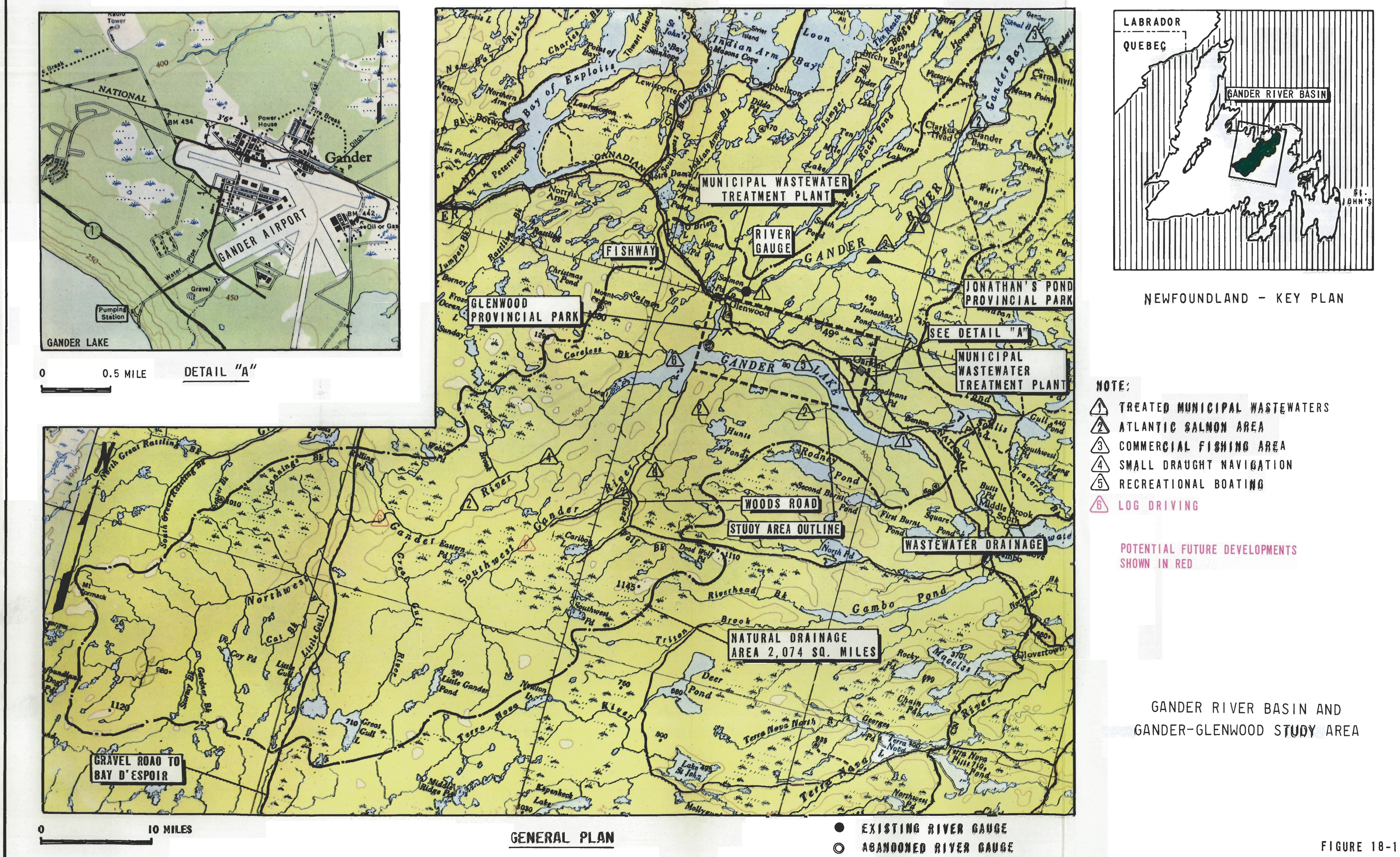
LIST OF FIGURES

PART V GANDER RIVER BASIN AND GANDER-GLENWOOD STUDY AREA

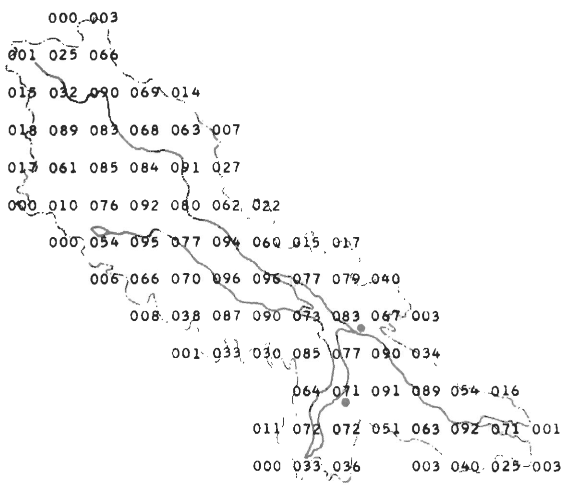
Figure



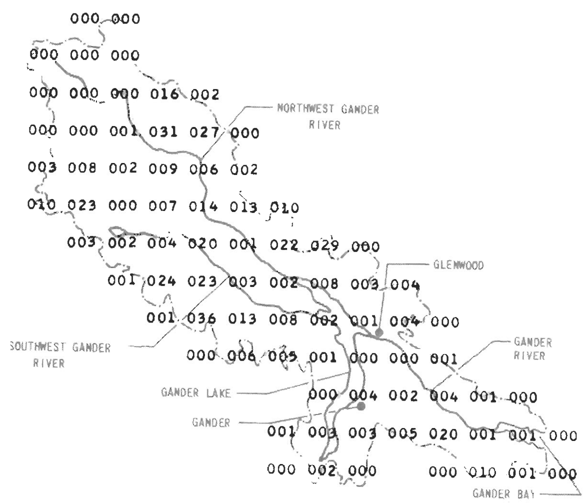
GANDER RIVER BASIN AND GANDER-GLENWOOD STUDY AREA

FIGURE 18-1

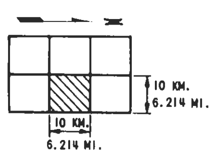
GANDER RIVER BASIN AND GANDER-GLENWOOD STUDY AREA SQUARE GRID DISTRIBUTION OF LAKES, BOGS, BARRENS AND FORESTS



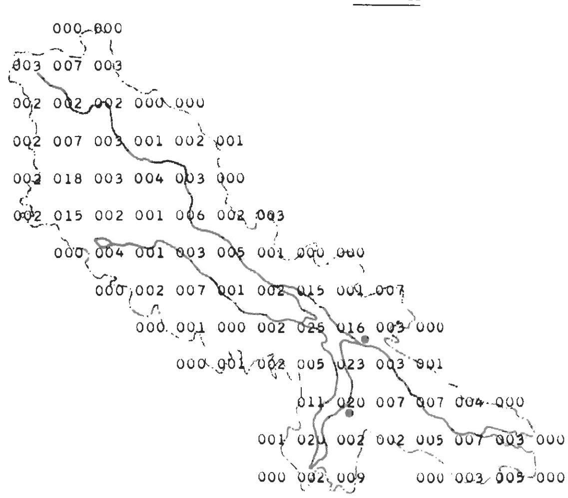
FOREST AREA – SQ.KM.



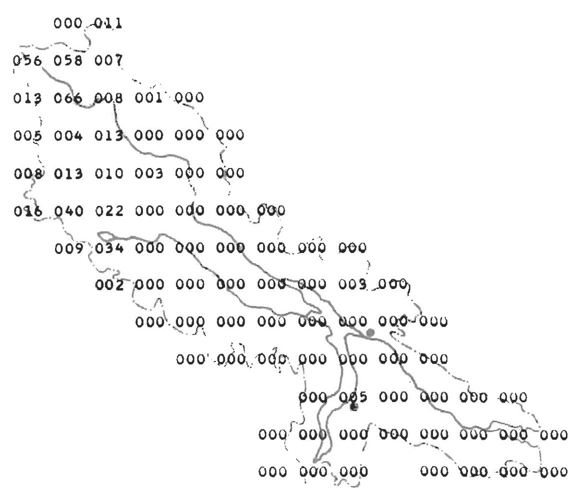
BOG AREA – SQ. KM.



GRID SCALE



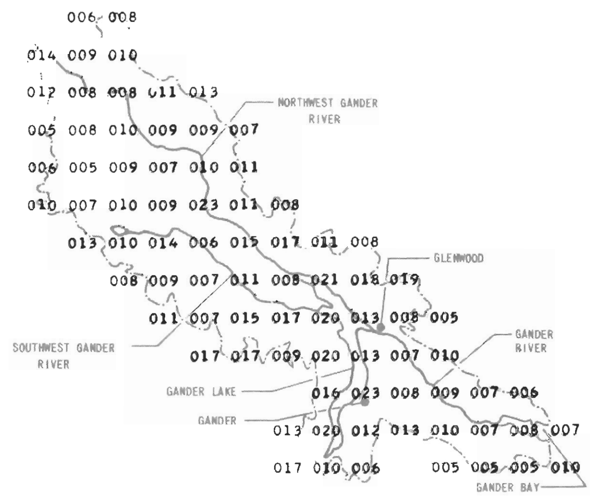
LAKE AREA – SQ.KM.



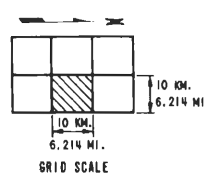
AREA OF BARREN – SQ.KM.

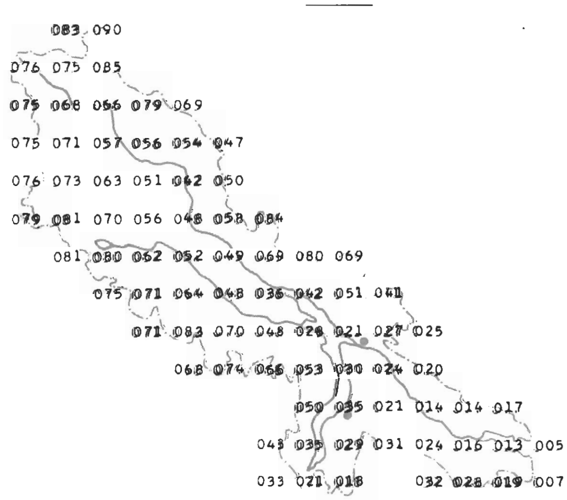
FIGURE 18-2

GANDER RIVER BASIN AND GANDER-GLENWOOD STUDY AREA
SQUARE GRID DISTRIBUTION OF LAND SURFACE SLOPE AND ELEVATION



SLOPE - TENTHS OF A PERCENT

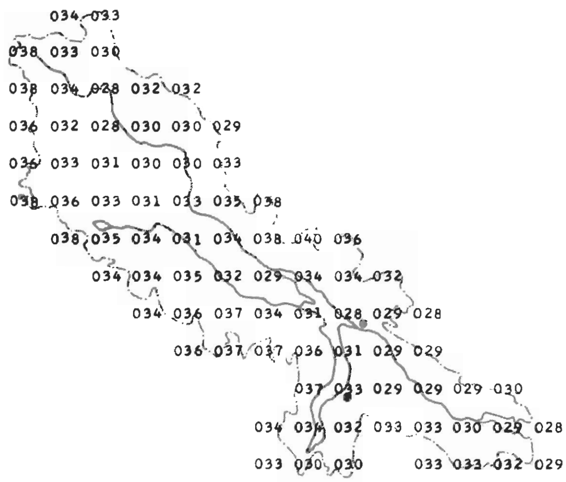




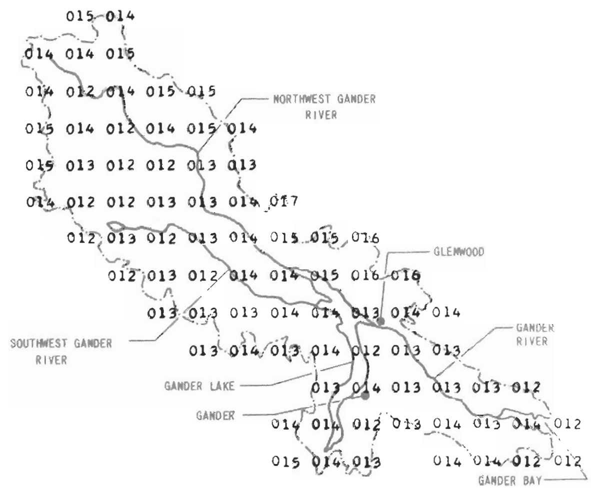
AVERAGE ELEVATION OF SQUARE
- TENS OF FEET

FIGURE 18-3

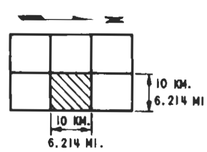
GANDER RIVER BASIN AND GANDER-GLENWOOD STUDY AREA SQUARE GRID DISTRIBUTION OF MEAN ANNUAL TEMPERATURE, PRECIPITATION, EVAPORATION AND RUNOFF



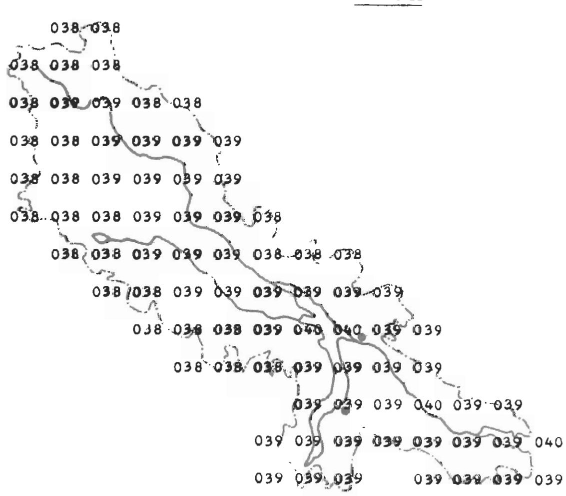
AVERAGE YEARLY RUNOFF
- INCHES OF WATER



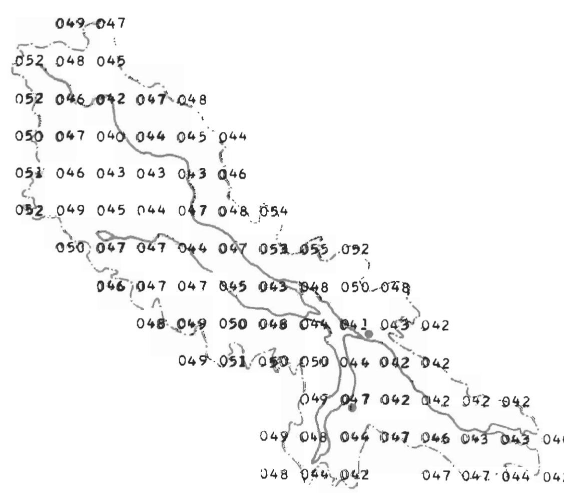
AVERAGE YEARLY EVAPORATION
- INCHES OF WATER



GRID SCALE



AVERAGE YEARLY TEMPERATURE
-DEGREES FAHRENHEIT.



AVERAGE YEARLY PRECIPITATION
- INCHES OF WATER

GANDER RIVER BASIN AND GANDER-GLENWOOD STUDY AREA
GROSS HYDRO ELECTRIC POTENTIAL ON GANDER RIVER

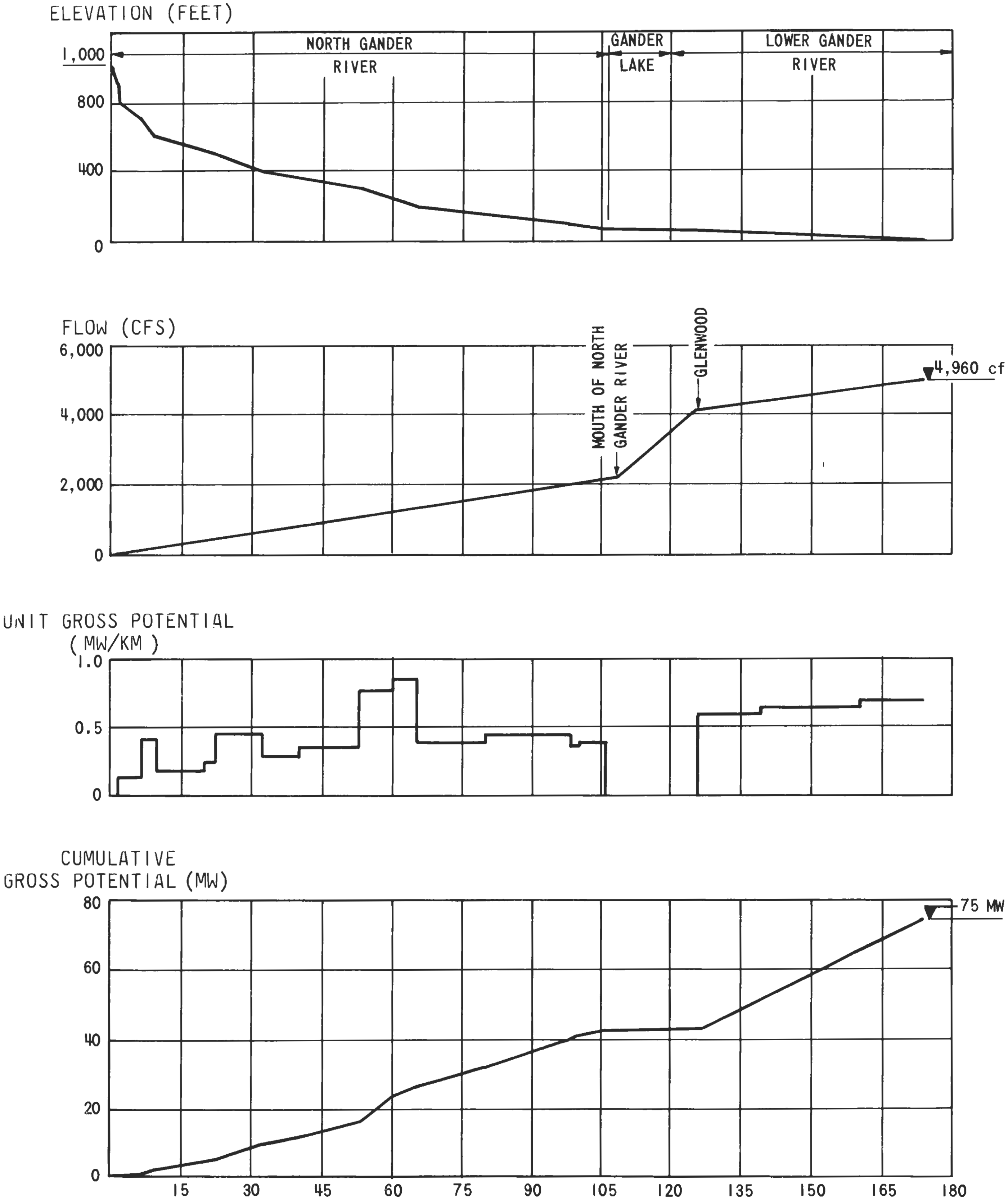


FIGURE 18-5

GANDER RIVER BASIN
ANNUAL ANGLERS CATCH
(SALMON AND GRILSE)

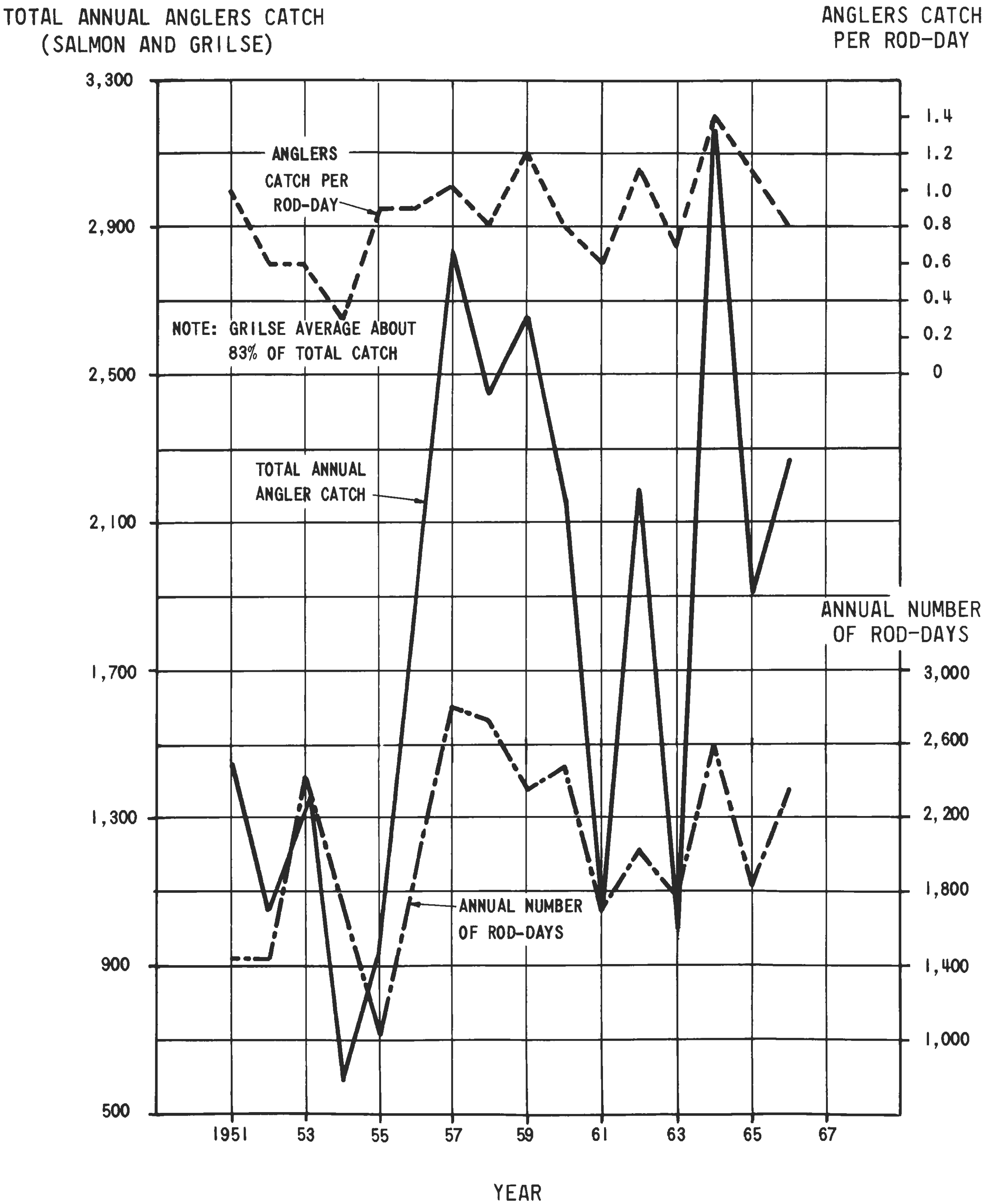
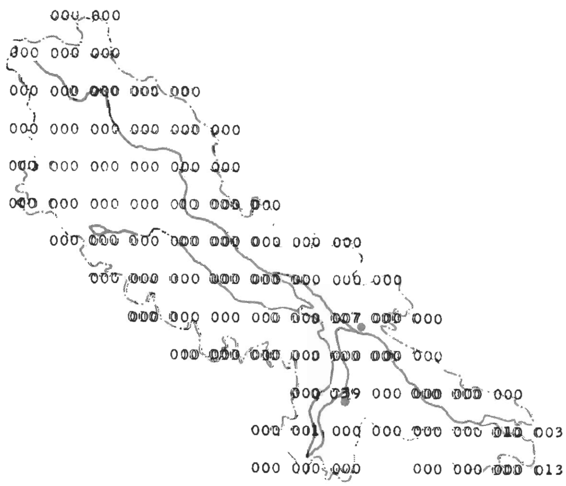


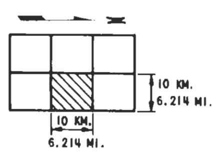
FIGURE 19-1

GANDER RIVER BASIN AND GANDER-GLENWOOD STUDY AREA
SQUARE GRID DISTRIBUTION OF RECORDED POPULATION 1951 - 1966

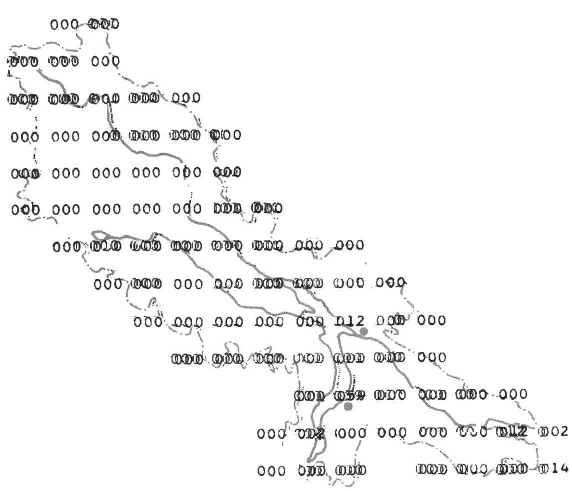


POPULATION 1951 - 100'S

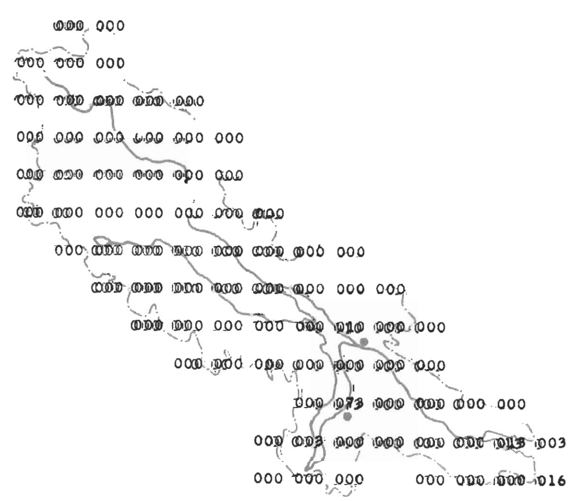
POPULATION 1956 - 100'S



GRID SCALE



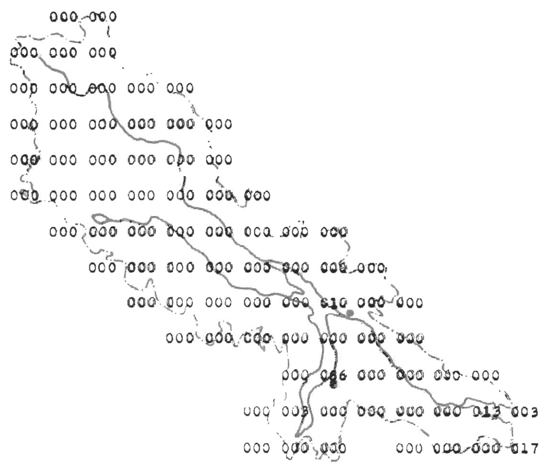
POPULATION 1961 - 100'S



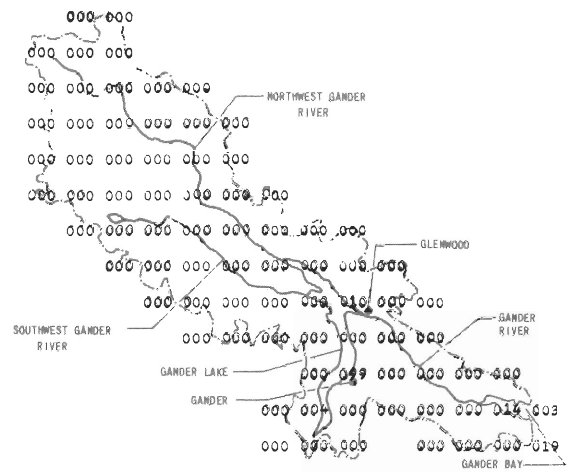
POPULATION 1966 - 100'S

FIGURE 19-2

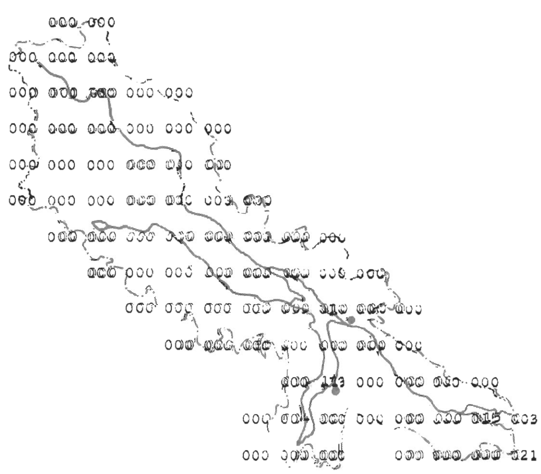
GANDER RIVER BASIN AND GANDER - GLENWOOD STUDY AREA
SQUARE GRID DISTRIBUTION OF POPULATION FORECAST 1971-1981



POPULATION 1971 - 100'S



POPULATION 1976 - 100'S



POPULATION 1981 - 100'S

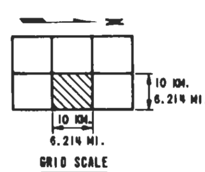


FIGURE 20-1

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PART V GANDER RIVER BASIN AND GANDER-GLENWOOD STUDY AREA

GANDER RIVER BASIN AND GANDER-GLENWOOD STUDY AREA

SUMMARY OF CLIMATIC CHARACTERISTICS

A ANNUAL MEANS

Precipitation (inches)	Air Temperature (deg F)	Potential Evaporation (inches)	Relative Humidity (percent)
45.9	38.8	18.7	84

B MEAN MONTHLY PRECIPITATION (inches)

Stations	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Glenwood	3.15	3.26	2.84	2.42	2.65	2.88	2.80	3.68	3.45	3.82	3.82	3.12	37.89
Gander Int. Airport	3.32	3.44	3.19	2.73	2.43	3.04	3.20	3.78	3.35	3.98	4.21	3.68	40.35
Basin Mean Synthesized	3.8	3.9	3.4	2.9	3.0	3.4	3.4	4.4	4.2	4.8	4.8	3.9	45.9

C MAXIMUM POSSIBLE STORM PRECIPITATION (inches)

Area (sq. mi)	Storm Duration (hours) 6	12	18	24	36	48	72
100	4.25	7.50	8.85	10.30	12.25	12.50	14.15
300	4.20	7.35	8.70	10.10	12.00	12.35	14.10
500	4.12	7.20	8.60	10.00	11.90	12.25	14.00
1000	4.00	7.00	8.40	9.80	11.60	12.00	13.60
2070	3.70	6.40	7.90	9.40	10.90	11.30	12.70

D MAXIMUM POSSIBLE SEASONAL SNOWFALL (inches of water equivalent): 45.0

E CRITICAL SEQUENCES FOR SNOW MELTING (degrees F)

Interval	Date: March 1	March 10	March 20	April 1	April 10	April 20	May 1	May 10	May 20
4 - day	40.0	42.5	45.5	49.5	53.0	57.0	61.0	64.5	69.0
8 - day	38.5	41.0	43.0	46.5	49.0	51.0	54.0	58.0	63.5
16 - day	35.0	36.5	38.0	41.5	44.0	47.5	51.0	54.0	55.5

F DROUGHT

Return Period	2.33-Year	5-Year	10-Year	20-Year	50-Year	100-Year
Length of Drought	13 days	16 days	19 days	23 days	27 days	30 days

TABLE 18-1

SUMMARY OF HYDROLOGIC CHARACTERISTICS
GANDER RIVER BASIN

I - SYNTHESIZED DATA

A. ANNUAL MEANS FOR THE TOTAL BASIN

FLOW (CFS)	RUNOFF (CFS/SQ.MI)	RUNOFF (INCHES)	ACTUAL EVAP. (INCHES)
4,960	2.4	32.4	13.4

B. MEAN MONTHLY FLOWS (Q) AND STANDARD DEVIATIONS (S) (CFS)

RIVER AND LOCATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
GANDER RIVER AT BIG CHUTE	Q	3520	3050	3100	6750	9910	3770	1960	2010	2150	2910	4970	4010	4010
	S	2440	1540	1960	2960	3450	1560	1030	1520	1500	1680	2200	1730	640
N.E. GANDER RIVER AT GANDER LAKE	Q	2170	1870	1700	3690	5020	1890	1150	1120	1230	1450	2800	2320	2200
	S	1250	920	1070	1390	1770	855	505	730	800	850	1190	930	335
	Q													
	S													

C. MAXIMUM FLOWS (CFS) AND FLOOD VOLUMES (CFS DAY) OBTAINED BY THE MAXIMIZATION PROCEDURE (INSTANTANEOUS PEAKS)

RIVER AND LOCATION	MAXIMIZED RAIN ON SNOW PACK		MAXIMIZED RAIN ONLY		SNOW PACK & AVERAGE RAIN	
	PEAK	VOLUME	PEAK	VOLUME	PEAK	VOLUME
GANDER RIVER AT BIG CHUTE	136,000	1,110,000	90,000	540,000	55,000	660,000

D. MAXIMUM FLOWS OBTAINED BY STATISTICAL ANALYSIS (CFS) (DAILY AVERAGES)

RIVER AND LOCATION	GENERATED BY SNOW MELT & RAIN		GENERATED BY RAIN ONLY	
	1/10000 YEARS	1/1000 YEARS	1/10000 YEARS	1/1000 YEARS
GANDER RIVER AT BIG CHUTE	56,800	47,100	31,400	25,400
N.E. GANDER RIVER AT GANDER LAKE	33,700	28,300	17,300	14,300

TABLE 18-2
Page 1 of 2

SUMMARY OF HYDROLOGIC CHARACTERISTICS
GANDER RIVER BASIN

E. MINIMUM FLOWS OBTAINED FROM RECESSION CURVES (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/10 YEARS	1/20 YEARS

F. MINIMUM FLOWS OBTAINED FROM STATISTICAL ANALYSIS (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/20 YEARS	1/100 YEARS
GANDER RIVER AT GANDER BAY	590	260	10	
GANDER RIVER AT BIG CHUTE	495	235	30	
N.E. GANDER RIVER AT GANDER LAKE	215	100	10	

G. FULL REGULATION STORAGE

RIVER AND STATION	STORAGE (CUBIC FEET x 10^9)
GANDER RIVER AT GANDER BAY	235
GANDER RIVER AT BIG CHUTE	185
N.E. GANDER RIVER AT GANDER LAKE	93.7

II - RECORDED DATA

H. MEAN MONTHLY AND ANNUAL FLOWS (CFS)

RIVER AND STATION	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
GANDER RIVER AT BIG CHUTE	19	4,030	3,120	3,420	7,560	9,260	3,660	1,820	1,710	1,700	2,520	4,770	4,600	4,010

I. EXTREMES RECORDED (CFS)

RIVER AND STATION	MAXIMUM FLOWS			MINIMUM FLOWS		
	FLOW	DATE	COMMENTS	FLOW	DATE	COMMENTS
GANDER RIVER AT BIG CHUTE	28,600 cfs	APR. 19 1964	DRAINAGE AREA = 1,690 SQ. MILES	93 cfs	SEPT. 24 1961	OCTOBER 1949 TO SEPTEMBER 1966

GANDER RIVER BASIN
AND
GANDER-GLENWOOD STUDY AREA

SUMMARY OF WATER QUALITY EXTRAPOLATIONS

Location	----- Effects of Characteristics on Use for -----								
	Fish			Pulp & Paper			Domestic and Raw Water		
	P	C	B	P	C	B	P	C	B
Mouth of Northwest Gander River	+	+	0	+	+	0	+	+	+
Mouth of Southwest Gander River	+	0	0	+	+	0	+	+	+
Gander Lake Outlet	+	+	-	+	+	0	+	+	+
Mouth of Gander River	+	0	0	+	+	0	+	+	+

NOTE

P = Physical Characteristics
C = Chemical Characteristics
B = Biological Characteristics
+
0 = Comparative Ratings
-

See Volume Two for description of Water Quality Extrapolations

TABLE 18-3

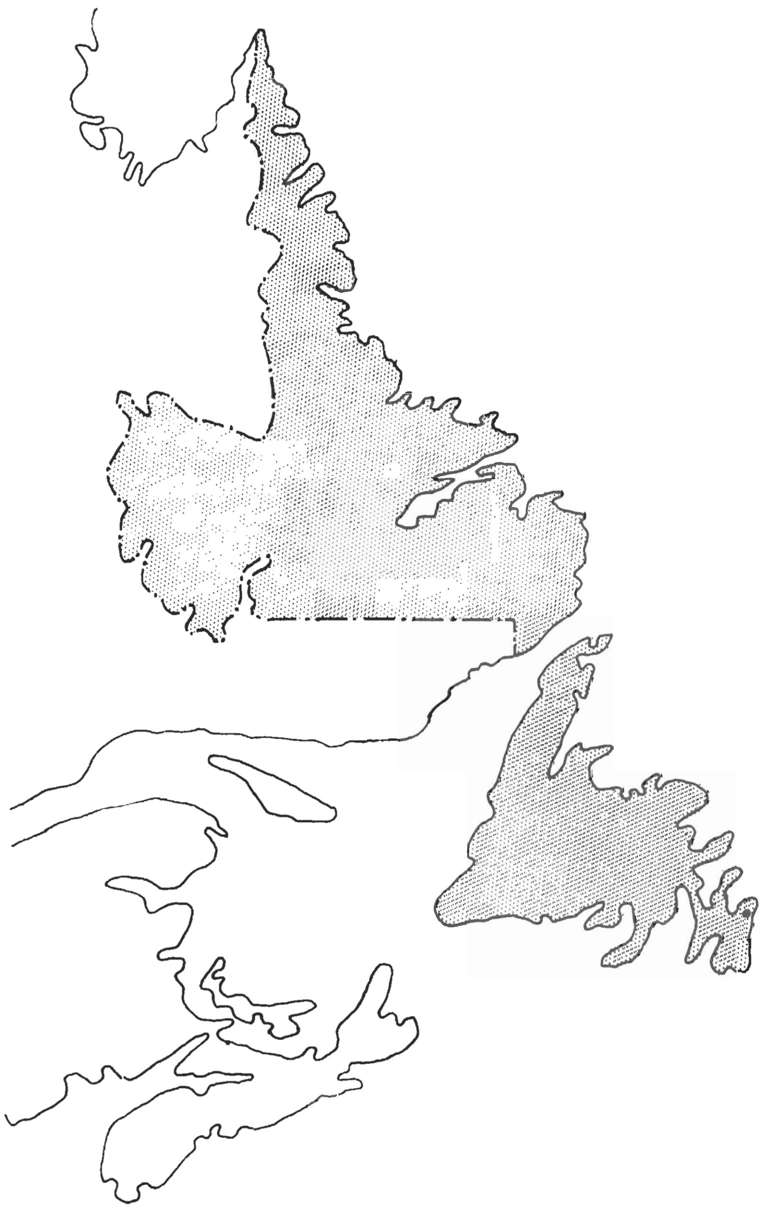
GANDER RIVER BASIN AND GANDER-GLENWOOD STUDY AREA

GROUNDWATER POTENTIAL

Hydrogeologic Unit	Mean Well Depth (bedrock)	Estimated Yield Range (gpm)	Percentage of Basin	Area in Basin (sq. mi)	Comments
Bedrock Units:					
R1	159	0 to 40	32.6	676	Includes some basic and ultra-basic rocks with poor quality water.
R4	113	1 to 20	19.9	412	
R6	127	1 to 20	47.5	986	
Surficial Units:					
S2		10 to 50	67.4	1400	
S3		5 to 50	27.2	563	
S4		50 to 1000	5.4	112	
S5		-	18.0	373	Poor quality water.

A detailed discussion of hydrogeology is given in Volume Two.

TABLE 18-4



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CAT ARM RIVER BASIN

PART VI - CAT ARM RIVER BASIN

This basin has been selected for detailed investigation because the potential hydro electric development, which is outlined in Volume Four, Section 1, compares favourably in many respects with the most attractive undeveloped hydro schemes remaining on the Island.

22 NATURAL CONDITIONS

The Cat Arm Basin is located on the east side of the Long Range Mountains in the Great Northern Peninsula as shown in Figure 22-1. The river presently drains into the Great Cat Arm which is a natural harbour extending inward from the coast line of White Bay.

The basin is presently isolated and uninhabited. The nearest road is approximately 20 miles south along the coast line at Jackson's Arm.

22.1 Physiographic Conditions

The Cat Arm River has a total natural drainage area of 330 square miles. The limits of the basin are shown in Figure 22-1.

The total natural drainage area includes about 21 square miles of lake surface area, 4 square miles of bog or marsh area, and 47 square miles of barrens, as measured on the 1:250,000 scale maps. The square grid distribution of lake, marsh, and barrens is shown in Figure 22-2.

There are no large lakes or ponds in the basin and none is named.

The hypsographic curve of the basin is given in Figure 1-4. The curve indicates the rapid rise in the elevation of the basin which results in an average elevation of greater than 1500 feet. The land surface slope and elevation distribution are shown in Figure 22-3.

There are no climatologic stations in or near the basin. The climatologic characteristics were synthesized by relating the available data at other stations with similar physiographic and hydrologic characteristics. The average annual temperature in the basin is estimated to be 34 degrees F, the average precipitation and evaporation is 81 inches per year and 13 inches per year respectively. The variation in mean annual temperature, precipitation, and evaporation in the basin is shown in Figure 22-4. The basin has one of the coolest climates on the Island and one of the highest precipitations. A summary of synthesized climatologic characteristics of the basin is shown on Table 22-1.

22. 2. Water Resources

22. 2. 1. Surface Water

Hydrologic data are not available from river gauges located in the basin. However, hydrologic characteristics have been derived from the available records from river gauges in the area combined with the generalized relationships developed in the computer study with meteorologic and physiographic factors. The areal distribution of mean annual runoff in the basin, as derived from these relationships is indicated on Figure 22-4. Table 22-2 is a summary of hydrologic characteristics of the basin.

The average annual runoff in the total basin is estimated to be 68 inches or 5.0 cfs per square mile. The average annual runoff of the 241 square miles which is contained in the proposed hydro development area is estimated to be 73 inches or about 5.4 cfs per square mile.

It is recognized that this derived runoff is high relative to the average runoff in other areas of the Island. However, it is not outside the range of recorded average runoff, as a gauged river on the Island has recorded a higher average. This is Isle aux Morts River on the south coast which has averaged 5.7 cfs per square mile in the four years of record available.

22. 2. 2 Fresh Water Fish

An obstruction at the mouth of the Cat Arm River where it cascades into the salt water of Great Cat Arm prevents access by anadromous fish to all upstream areas of the river. There is very little information available on other species of this area.

22.2.3 Hydro Power Potential

The main interest in the water resources of the basin lies in the undeveloped hydro electric potential which was described during the investigations for hydro power potential reported in Volume Four, Section 1.

As shown in Volume Four, the calculations for the hydro development were based on a conservative regulated flow of 3.0 cfs per square mile which anticipated a long term average flow of about 3.7 cfs per square mile. It was shown that the scheme has economic storage potential relative to the drainage area it would be required to regulate.

Consequently, the cost estimates are considered conservative as the regulated flow could well be over 4.0 cfs per square mile, with proportionate increases in the capacity and firm energy benefits. Confirmation of the synthesized flows with corresponding storage requirements and secondary energy benefits will have to await data obtained after the installation of a river gauge which is scheduled for the 1968 season.

The results of the Cat Arm River hydro development are summarized below at a 60 percent capacity factor:

Cat Arm River Development

Drainage Area		241 square miles
Total Regulated Flow		725 cfs
Full Supply Level		1280 feet
Low Supply Level		1249 feet
Tailwater Level		0 feet
Average Gross Head		1265 feet
Annual Firm Energy		554×10^6
Installed Capacity		160,000 hp
Total Project Cost	$37,465,000	
Capital Cost per Installed hp	$/hp	234
Cost of Firm Energy (at plant bus bar)		5.0 mills/kwh

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The gross river hydro-electric potential has been calculated and the results are shown on Figure 22-5.

22.3 Natural Resources

22.3.1 Forests

According to the 1:250,000 scale maps, there are 258 square miles of forested area in the basin. The square grid distribution of forested area is shown in Figure 22-2. Both Bowaters and Price have timber limits in the basin area. Although exploitation of the resource has not occurred in the basin to date, Bowaters expects to commence activities on the Main River basin in the 1968 to 1972 period. The Main River basin is located just south of the Cat Arm basin and road access is presently available to the mouth of the Main River.

A report [1] on the forest resources of the Great Northern Peninsula indicated that there are about 211,000 cords of inaccessible over mature timber stands in the Cat Arm basin which are owned by Bowaters. Development of the forest resources in the Great Northern Peninsula has not taken place to any great extent to date, as it is uneconomical at the present time for the woods industry to build roads and wharves in order to develop these areas. These inaccessible forest stands are being lost through decadence, insect infestation, and through loss of annual increment. As pointed out in the report on the forest utilization of the area, the greatest needs in the area are access roads and harbour facilities.

Consequently, the roads required in the construction of the Cat Arm Basin for access to the area would contribute significantly to the development of the area, and prevent the losses of the forest resource which is presently occurring. The recommended road access [1] for the eastern part of the Northern Peninsula extends from the existing road at Jackson's Arm on the southeast side of the Peninsula to the community of Williamsport. A total of about 63 miles of direct access roads is required. Although the Cat Arm hydro scheme would only finance about 25 miles of these roads, the contribution to the forest resource would be significant.

The east coast of the Peninsula contains two fine harbours, one of which is located at Great Cat Arm. Pulpwood from Great Cat Arm would likely be towed to Hampden, on the south tip of White Bay, thence hauled by truck and unloaded into the Humber River for transfer to the Corner Brook mill. It may prove feasible to transfer wood chips by pipeline from this basin to adjoining basins or to the Great Cat Arm harbour area.

22.3.3 Wildlife

The area came under two moose hunting zones in the 1967 season. However, due to access problems, hunting of big game animals does not occur extensively in the basin. Caribou do not frequent the area, but the other big game animal on the Island, the black bear, could adapt to the basin's environment. The hydro development, by providing access roads to the basin, will enable increased hunting in the area.

Although data are not available, it is assumed that the fur-bearing animals common to Newfoundland are generally represented in the basin.

23. CONCLUSIONS AND RECOMMENDATIONS

23.1 Conclusions

a) The Cat Arm River basin has attractive hydro-electric potential which is competitive with other undeveloped sites on the Island.

b) There is no present day development of the basin's resources and the basin is uninhabited. The construction roads required for the hydro development would give access to the forest and other resources in the area.

c) Conflicts of use between the potential hydro development and the fisheries resource are unlikely, as the fisheries resource in the basin is limited to fresh water species. Anadromous fish cannot pass a natural barrier located at the river mouth.

d) Conflicts may occur with the forestry resource if the hydro development takes place. Part of the timber area would be flooded and the river immediately downstream of the damsite would be less effective for future log driving schemes, as the flow would be diverted from the main stem to Devil Cove on White Bay. However, it is doubtful if the forestry resource in this general area could be economically developed without the access roads provided by the hydro scheme, and the losses created by a future hydro development by the flooding of the timber in the reservoir area would be regrettable, but undoubtedly justifiable in view of the benefits obtained.

23.2 Recommendations

a) In order to determine the actual runoff available to the proposed hydro development, it is essential that an automatic river gauge be installed near the proposed damsite and a recording rain gauge should be installed in a representative location in the basin. These recommendations were accepted by the Department of Energy, Mines and Resources in 1967, and the gauges are to be installed in 1968. Recommendations for future studies of the hydro development are included in Volume Four.

b) It is recommended that the potential hydro-electric development in this basin, which is outlined in detail in Volume Four, Section 1, be considered for future development and that more detailed studies be carried out to assess the basin's hydro-electric potential. These studies should be carried out in conjunction with a complete assessment of the resources to permit an integrated resource development of the area.

REFERENCES

R. 1 Black, W.A. - ARDA study 1043
Forest Utilization Great Northern Peninsula, Newfoundland. Geographical Branch Department of Mines and Technical Surveys, Ottawa, 1965, 66pp.

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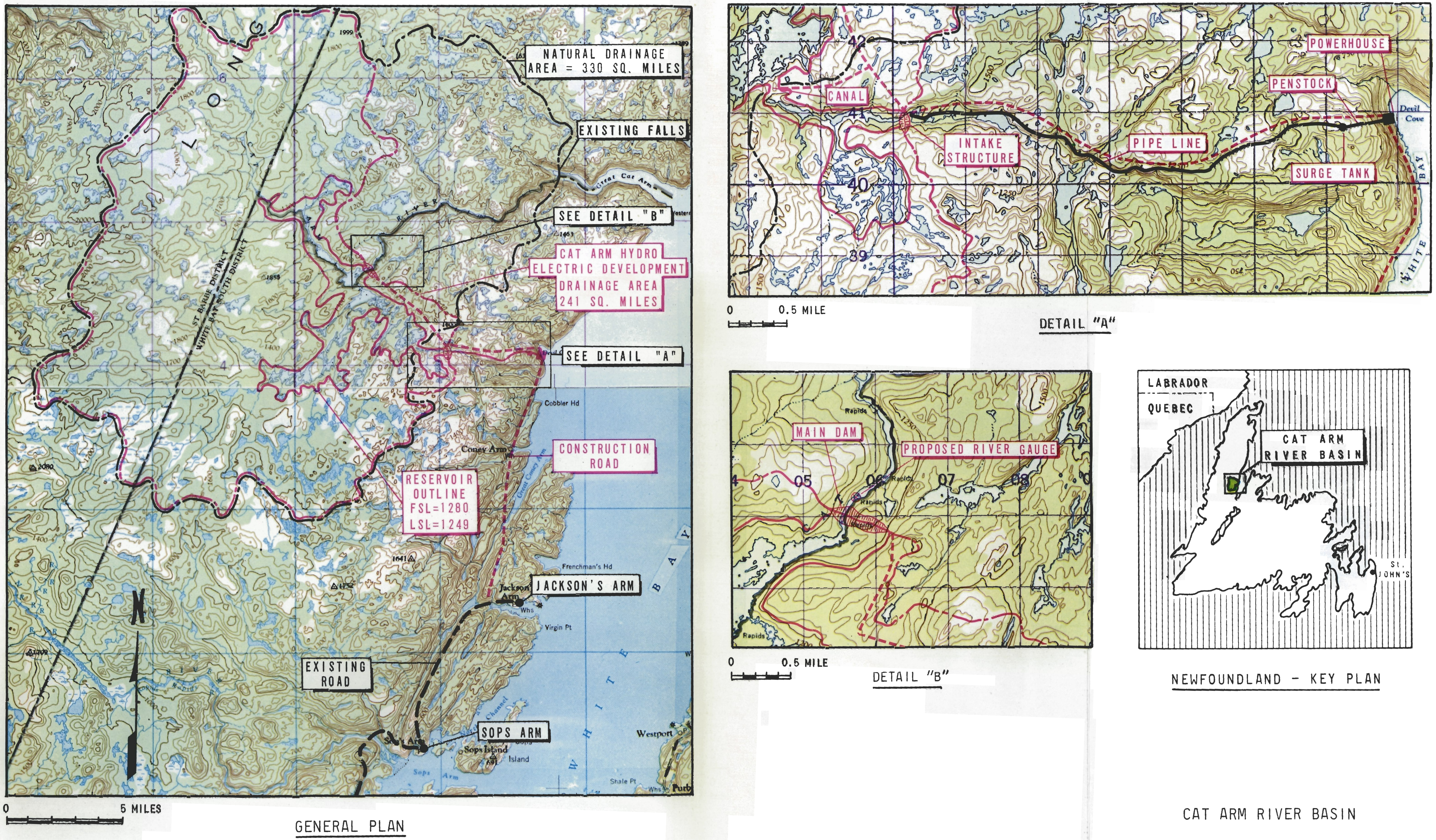
LIST OF FIGURES

PART VI CAT ARM RIVER BASIN

Figure

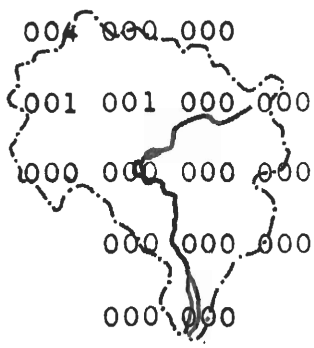


CAT ARM RIVER BASIN

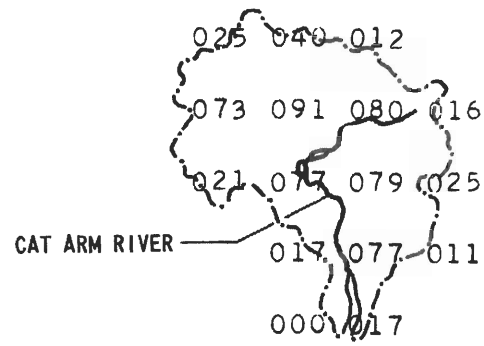
NOTE: POTENTIAL FUTURE DEVELOPMENT SHOWN IN RED

FIGURE 22-1

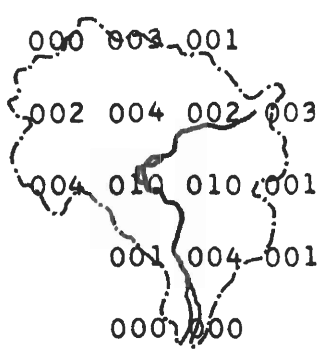
CAT ARM RIVER BASIN - SQUARE GRID DISTRIBUTION OF LAKES, BOGS, BARRENS AND FORESTS

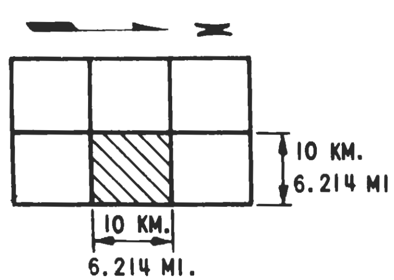


BOG AREA - SQ.KM.



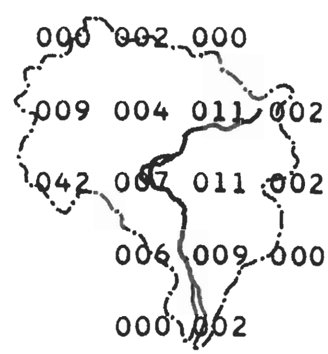
FOREST AREA - SQ.KM.





GRID SCALE

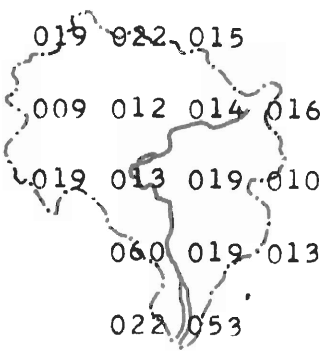
LAKE AREA - SQ.KM.



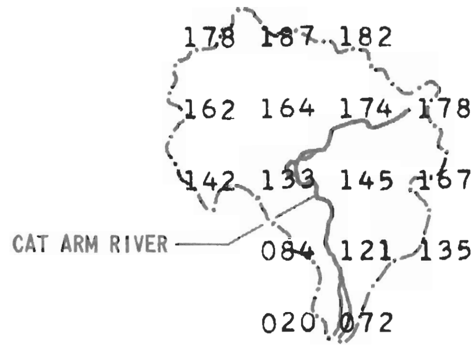
AREA OF BARREN - SQ.KM.

FIGURE 22-2

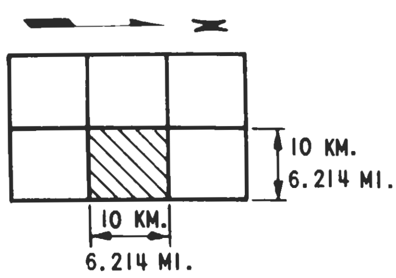
CAT ARM RIVER BASIN - SQUARE GRID DISTRIBUTION OF LAND SURFACE SLOPE AND ELEVATION



SLOPE - TENTHS OF A PERCENT



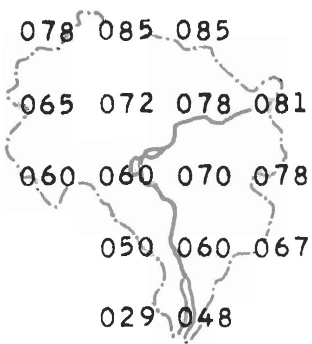
AVERAGE ELEVATION OF SQUARE - TENS OF FEET



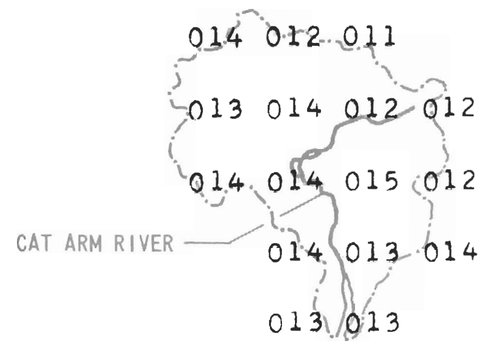
GRID SCALE

FIGURE 22-3

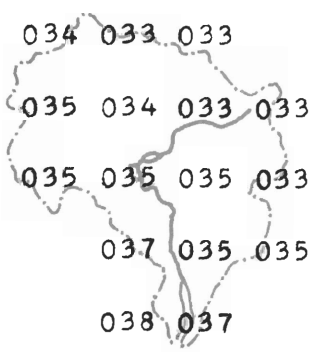
CAT ARM RIVER BASIN - SQUARE GRID DISTRIBUTION OF MEAN ANNUAL TEMPERATURE, PRECIPITATION, EVAPORATION AND RUNOFF



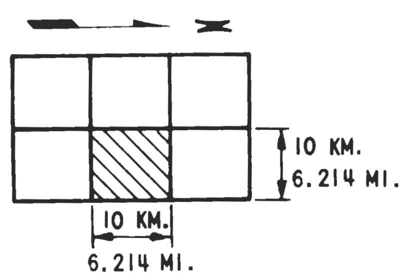
AVERAGE YEARLY RUNOFF
- INCHES OF WATER



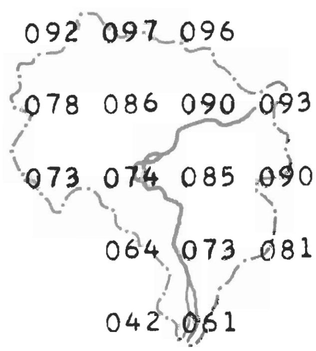
AVERAGE YEARLY EVAPORATION
- INCHES OF WATER



AVERAGE YEARLY TEMPERATURE
-DEGREES FAHRENHEIT



GRID SCALE



AVERAGE YEARLY PRECIPITATION
- INCHES OF WATER

FIGURE 22-4

CAT ARM RIVER BASIN
GROSS HYDRO ELECTRIC POTENTIAL
ON CAT ARM RIVER

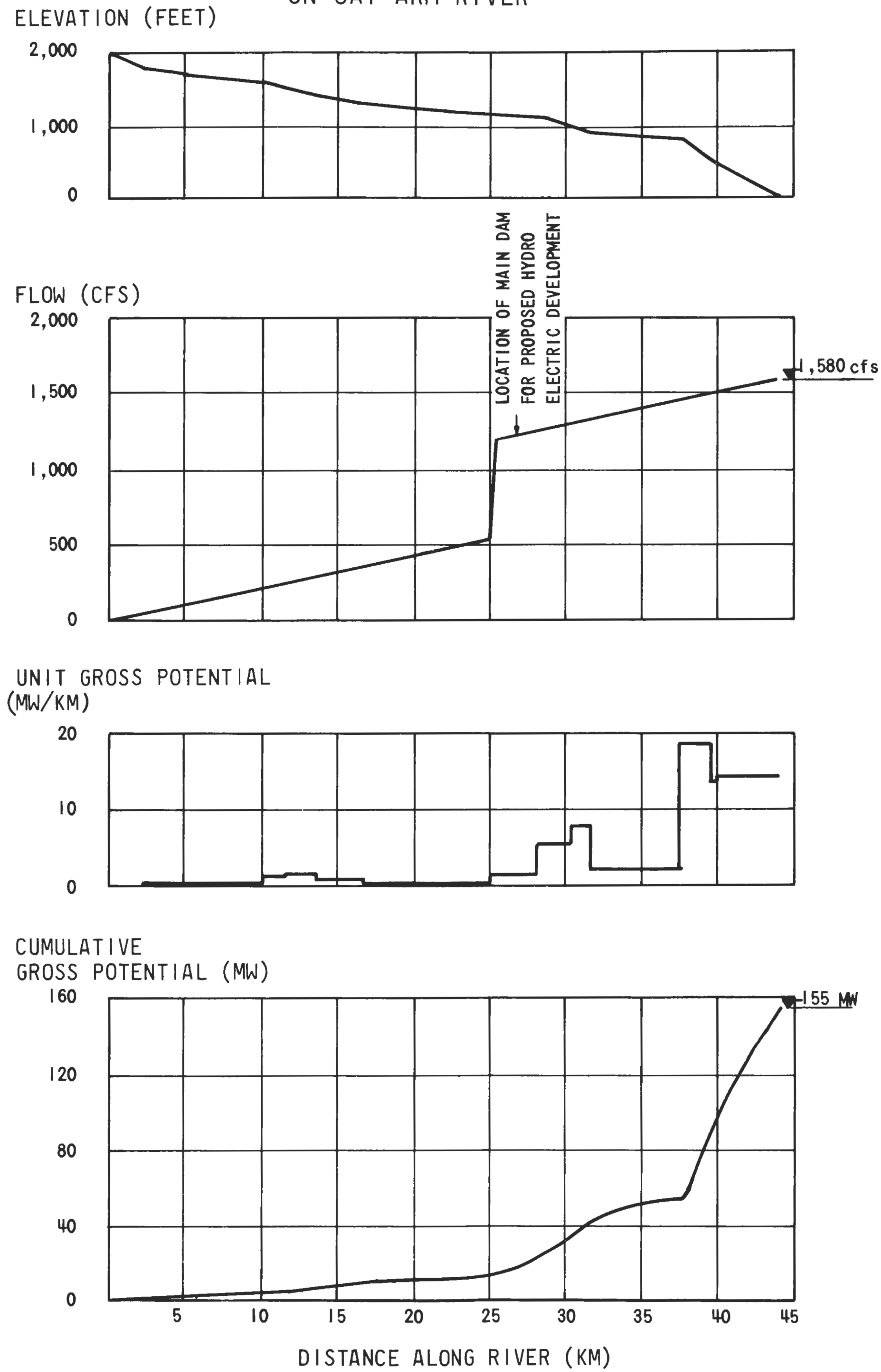


FIGURE 22-5

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LIST OF TABLES

PART VI CAT ARM RIVER BASIN

CAT ARM RIVER BASIN

SUMMARY OF CLIMATIC CHARACTERISTICS

A ANNUAL MEANS

Precipitation (inches)	Air Temperature (deg F)	Potential Evaporation (inches)	Relative Humidity (percent)
81.3	34.4	18	84

B MEAN MONTHLY PRECIPITATION (inches)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Basin Mean Synthesized	6.5	6.1	4.9	4.9	5.7	7.3	6.9	8.1	8.1	7.7	8.9	6.1	81.3

C MAXIMUM POSSIBLE STORM PRECIPITATION (inches)

Area (sq. mi)	Storm Duration (hours) 6	12	18	24	36	48	72
100	4.25	7.50	8.85	10.30	12.25	12.50	14.15
300	4.20	7.35	8.70	10.10	12.00	12.35	14.10
330	4.18	7.30	8.65	10.10	12.00	12.30	14.10

D MAXIMUM POSSIBLE SEASONAL SNOWFALL (inches of water equivalent) : 45.2

E CRITICAL SEQUENCES FOR SNOW MELTING (degrees F)

Interval	Date: March 1	March 10	March 20	April 1	April 10	April 20	May 1	May 10	May 20
4 - day	40.0	42.5	45.5	49.5	53.0	57.0	61.0	64.5	69.0
8 - day	38.5	41.0	43.0	46.5	49.0	51.0	54.0	58.0	63.5
16 - day	35.0	36.5	38.0	41.5	44.0	47.5	51.0	54.0	55.5

F DROUGHT

Return Period	2.33-Year	5-Year	10-Year	20-Year	50-Year	100-Year
Length of Drought	12 days	14 days	16 days	18 days	21 days	23 days

TABLE 22-1

SUMMARY OF HYDROLOGIC CHARACTERISTICS CAT ARM RIVER BASIN

I - SYNTHESIZED DATA

A. ANNUAL MEANS FOR THE TOTAL BASIN

FLOW (CFS)	RUNOFF (CFS/SQ.MI)	RUNOFF (INCHES)	ACTUAL EVAP. (INCHES)
1,650	5.0	68.0	13.3

B. MEAN MONTHLY FLOWS (Q) AND STANDARD DEVIATIONS (S) (CFS)

RIVER AND LOCATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
CAT ARM RIVER AT GREAT CAT ARM	Q		564			3880			742			1480		1625
	S		172			720			573			580		285
	Q													
	S													
	Q													
	S													

C. MAXIMUM FLOWS (CFS) AND FLOOD VOLUMES (CFS DAY) OBTAINED BY THE MAXIMIZATION PROCEDURE (INSTANTANEOUS PEAKS)

RIVER AND LOCATION	MAXIMIZED RAIN ON SNOW PACK		MAXIMIZED RAIN ONLY		SNOW PACK & AVERAGE RAIN	
	PEAK	VOLUME	PEAK	VOLUME	PEAK	VOLUME
CAT ARM RIVER AT GREAT CAT ARM	43,700	258,000	33,300	104,500	13,400	191,000

D. MAXIMUM FLOWS OBTAINED BY STATISTICAL ANALYSIS (CFS) (DAILY AVERAGES)

RIVER AND LOCATION	GENERATED BY SNOW MELT & RAIN		GENERATED BY RAIN ONLY	
	1/10000 YEARS	1/1000 YEARS	1/10000 YEARS	1/1000 YEARS
CAT ARM RIVER AT GREAT CAT ARM	31,200	24,900	32,000	25,300

TABLE 22-2

SUMMARY OF HYDROLOGIC CHARACTERISTICS
CAT ARM RIVER BASIN

E. MINIMUM FLOWS OBTAINED FROM RECESSION CURVES (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/10 YEARS	1/20 YEARS

F. MINIMUM FLOWS OBTAINED FROM STATISTICAL ANALYSIS (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/20 YEARS	1/100 YEARS
CAT ARM RIVER AT GREAT CAT ARM	110	60	14	

G. FULL REGULATION STORAGE

RIVER AND STATION	STORAGE (CUBIC FEET x 10^9)
CAT ARM RIVER AT GREAT CAT ARM	113.

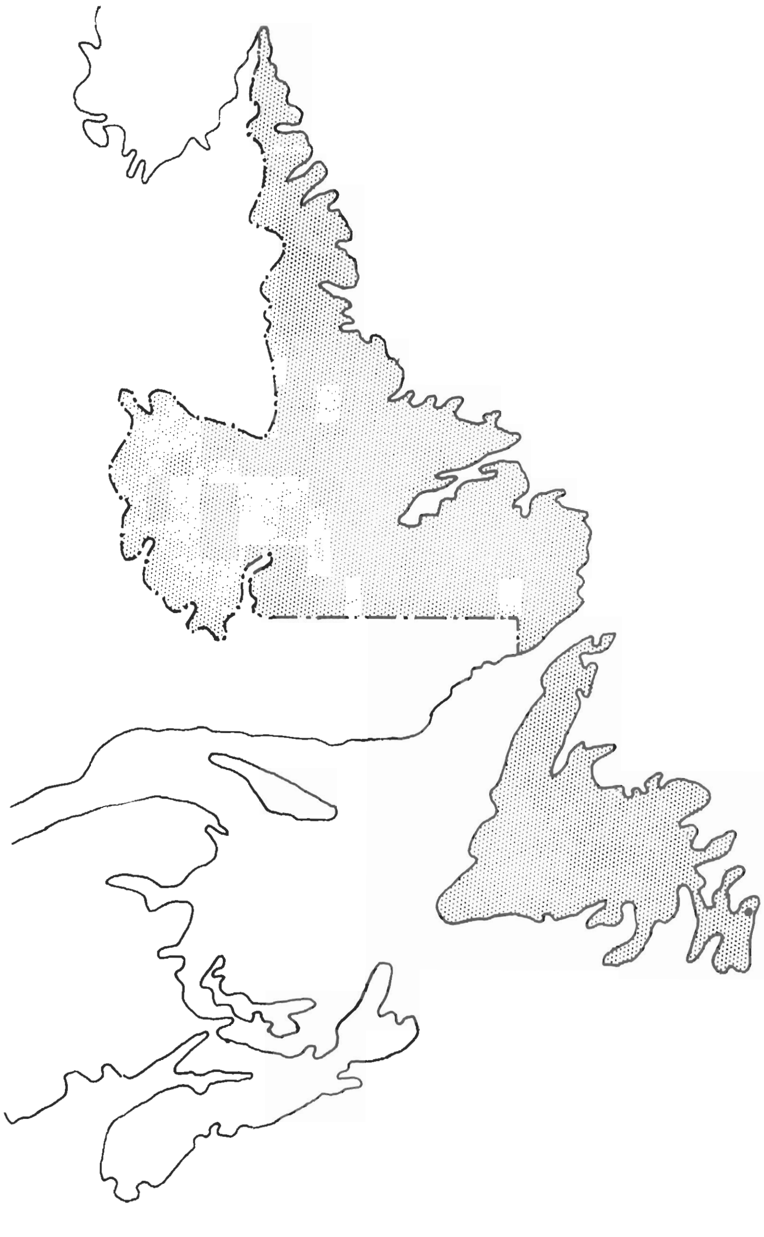
II - RECORDED DATA

H. MEAN MONTHLY AND ANNUAL FLOWS (CFS)

RIVER AND STATION	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE

I. EXTREMES RECORDED (CFS)

RIVER AND STATION	MAXIMUM FLOWS			MINIMUM FLOWS		
	FLOW	DATE	COMMENTS	FLOW	DATE	COMMENTS



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PIPERS HOLE RIVER BASIN

PART VII - PIPERS HOLE RIVER BASIN

24 NATURAL CONDITIONS

The Pipers Hole River flows into the head of Placentia Bay in the southeast part of the Island. The gravel highway which connects the Burin Peninsula to the Trans-Canada Highway crosses the river near its mouth about 20 miles west of the Trans-Canada Highway, in the vicinity of Come By Chance. The basin is uninhabited and road access is not provided to the interior.

24.1 Physiographic Conditions

The total drainage area of the basin, as outlined in Figure 24-1, is 320 square miles. The figure indicates the topography, roads, main lakes, and nearby communities in the area.

The drainage area includes 34 square miles of lakes, 68 square miles of bog, and 178 square miles of barrens according to the 1:250,000 scale Department of Mines and Technical Surveys' maps which were compiled in 1960. The square grid distribution of these areas are shown in Figure 24-2.

There are several large areas of standing water in the basin. These include Norsemen's Pond, Middle Pond, White Head Pond, and Island Pond West.

The hypsographic curve of the basin is shown in Figure 1-4. The square grid distribution of land surface slope and elevation throughout the basin are shown in Figure 24-3.

The bedrock of the area consists mainly of Pre-Cambrian, sedimentary and volcanic rocks which have undergone some metamorphism. The western part of the area is underlain by part of a major granitic intrusion. There is also one minor basic igneous intrusion. There is a cover of surficial materials over all the basin, mainly made up of ribbed moraine, with smaller areas of ground moraine and alluvium. The distribution of the surficial and bedrock materials is shown on the maps accompanying Volume Two of this report.

The variation of average annual temperature, precipitation, and evaporation in the basin is shown on Figure 24-4. The average annual basin temperature is 39 deg F, the average annual precipitation is 56 inches, and the average annual evaporation is 13 inches.

The climatic characteristics of the basin are summarized on Table 24-1.

24.2 Water Resources and Potential Uses

24.2.1 Surface Water

Hydrologic data on the basin are available from one river gauging station located near the river mouth. This station has been in operation since 1950 and records the natural runoff from 300 square miles of the drainage area.

The records from this station have been used together with the physiographic and meteorologic characteristics of the basin to obtain the areal distribution of average annual runoff as indicated on Figure 24-4. The average annual runoff for the entire basin is 43 inches per square mile. The main hydrologic characteristics of the basin are summarized on Table 24-2.

The flow regime was changed markedly by the fire that occurred from August to October of 1961, which covered a large portion of the basin area. As seen in Figure 24-5, the peak daily flow on the Pipers Hole River in the two-year period before the fire was about 10 cfs per square mile. In the two-year period after the fire, the peak daily floods reached levels of 33 to 43 cfs per square mile. The figure includes a hydrograph for the Bay Du Nord River for the same period. This river is located about 40 miles west of the Pipers Hole River and is an example of a gauged river basin which was untouched by fires during the 1959-64 period shown. In the two-year period prior to the fire, the river recorded a flow of about 9 cfs per square mile; after the fire a peak daily flow of 14 cfs per square mile occurred. Thus, it appears that the fire resulted in daily flood peaks of about 2.5 times that which would have occurred in the Pipers Hole River if the fire had not taken place. Practical consequences of this fire on flood peak increase are negligible in this instance because of the lack of habitation in the basin.

No evidence of soil erosion due to the fire is known to exist, although any increase in erosion would probably go unnoticed because of the isolation of the basin.

Low period flows in the Pipers Hole River were lower relative to the Bay Du Nord River after the fire than before. This is not evident from the correlation of the mean monthly flows shown in Figure 24-6, but becomes apparent when the 10-day average flows are plotted as shown in Figure 24-7.

The resulting increase in peak flows and reduction in low flows reflects the influence of forest management in water resources. The practical consequences of a forest fire on a basin utilized for water supply, hydro development, and the like, would depend on the capacity of the storage reservoirs available to the development.

Water quality extrapolations have been made for the basin and the surface water quality under natural conditions is expected to be slightly acidic and to have a pH of about 6.8, colour of approximately 50 units, turbidity of less than 5 units, and hardness of less than 10 ppm (as $CaCO_3$).

24.2.2 Groundwater

The distribution of the different surficial and bedrock hydrogeological units is shown in Volume Two. The surficial material covering most of the area is unit S3 consisting of ribbed moraine with a moderate groundwater potential. Most of the rest of the area is covered by S2 material which can also produce moderate yields. Near the mouth of the river, there are deposits of unit S4 material covering about 2 percent of the basin which has a high potential yield, and any small community established in the area could draw an adequate supply from one or two screened wells.

The bedrock unit underlying 59 percent of the area is unit R2 (mainly Pre-Cambrian sediments) consisting of rocks with low groundwater potential. Unit R1 (major igneous intrusions) underlies 27 percent of the basin and again has a low groundwater potential. Unit R3 (Pre-Cambrian volcanics), which underlies the remainder of the basin, also has a low potential, but is somewhat better than the other two. There may be some poor quality water produced from an isolated intrusion of basic igneous rock in the unit R1 material.

24.2.3 Hydro Power

The basin has been investigated for potential hydro-electric development by ShawMont Newfoundland Limited[1]. The development of a large block of power along the main stem itself together with diversions from adjacent watersheds is not economically feasible.

Investigations by ShawMont also revealed that development of a peaking plant utilizing only the direct runoff from the river would not be economically feasible. However, a part of the upper basin can be economically diverted to the proposed hydro plant on the Terra Nova River via the Northwest River. This diversion[2] is outlined in Part IV of this Volume on the Terra Nova River basin.

The gross river potential has been calculated and the results are shown on Figure 24-8. As shown, the potential of the main river is relatively low compared with other rivers on the Island.

24.2.4 Log Driving and Navigation

The potential for log driving on the river is limited to periods of high flow under natural conditions. Harvesting of the basin's timber resource will not occur in the immediate future because of the effects of the 1961 fire.

Navigation by small pleasure craft in other than high flow periods is not feasible on a large part of the main stem due to the presence of rapids and falls. The large ponds in the upper basin are suitable for small pleasure craft but are inaccessible by road.

24.3 Natural Resources

24.3.1 Forests

The basin area, prior to the fire in 1961, was covered with 40 square miles of forested land according to the 1:250,000 scale topographic maps. The distribution of forested areas in the basin is given in Figure 24-2.

24.3.2 Minerals

There is no known occurrence of metallic or non-metallic minerals of commercial significance in the basin area.

24.3.3 Agriculture

The potential for development of agriculture is low as very little land in the basin is suitable for cultivation.

25 PRESENT DAY DEVELOPMENT

The resources of the basin are used by a limited number of Atlantic salmon anglers and big game hunting enthusiasts.

25.1 Non-withdrawal Water Resource Uses

25.1.1 Fisheries

Information on the present-day fisheries resource in the basin has been obtained from the Department of Fisheries of Canada. The total length of the river is 160 miles of which 140 miles are classed as tributary streams. The main river is accessible to anadromous fish up to Mile 12, where there is an impassable falls. Downstream of this falls 37 miles of tributary streams are also available to anadromous fish. Theoretically, the main river stream and tributaries available should support about 7,000 Atlantic salmon.

However, the total present-day escapement is about 130 to 300 salmon. Consequently, the annual anglers' catch is also low. As shown in Figure 25-1, the average number of salmon angled per year is 24 during the 1951 to 1966 period.

Good runs of sea-run brook trout have been reported in the river, but no quantitative data are available. Resident brook trout are also reported to be plentiful.

There is no commercial fishery in the river and data are unavailable for the estuary.

25.1.2 Recreation, Tourism, and Wildlife

Present-day recreational facilities are non-existent and relatively few tourists are attracted to the basin due to the access problem and the existing state of the timber stands.

Data are not available on a basin basis on the annual number of hunters and big game animals taken from the basin. Caribou, black bear, and moose hunting areas cover a major portion of the basin. Access problems limit hunters from nearby communities to the lower basin area.

In addition to the big game animals in the basin, the area includes most of the small fur-bearing land mammals common to the Island.

26 PLANNED AND FORECAST DEVELOPMENT

26.1 Fisheries

Information on the planned and forecast development in the basin for the fisheries resource has been obtained from the Department of Fisheries of Canada.

The policy of the Department of Fisheries in this basin will be to take action to:

a) Preserve existing stocks of fish;

b) Maintain pollution levels at a minimum;

c) Undertake feasibility studies for development measures outlined below;

d) Proceed with development, if studies suggest that this is feasible, to provide more fish for the recreational needs of an expected increase in population in the Come By Chance area.

Development of Pipers Hole River will require construction of a fishway over the falls at Mile 12. In addition, it will be necessary to introduce hatchery stock both above and below the falls to bring the river to its full potential quickly.

The cost of the fishway construction, access, and hatchery stock is estimated by the Department of Fisheries to be $145,000. This expenditure would produce in the order of 9,000 salmon in the area upstream of the falls which has about eight miles of main river and 50 miles of tributary streams available for salmon production, and would bring the total river production potential to 16,000 salmon.

These development measures must be considered in conjunction with development of the nearby North Harbour and Come By Chance Rivers. The development of the Pipers Hole River will only be considered seriously by the Department of Fisheries if development procedures on the other two nearby rivers fail to provide enough fish to meet the recreational need of the expected increase in population in the Come By Chance area associated with the proposed industrial development.

27 CONCLUSIONS AND RECOMMENDATIONS

27.1 Conclusions

a) Recreational, hydro power, and mineral resources in the basin do not appear to have attractive development possibilities relative to other basins on the Island.

b) The only problems related to water resources in the basin are those connected with the forest management aspects of fire protection and soil erosion control, and those related to fish and wildlife conservation.

c) The proposed Terra Nova hydro-electric development includes a diversion of the upper Pipers Hole River, and this may affect fish and wildlife in the lower basin.

27.2 Recommendations

It is recommended that:

a) The Provincial Government in co-operation with interested Federal agencies should establish guidelines for forest management and fish and wildlife conservation in the basin;

b) The effects on the area downstream of the proposed diversion of the upper area of the Pipers Hole River be ascertained.

REFERENCES

ShawMont Newfoundland Limited, Report No SM-1-66 "Report on Studies of Hydro-Electric Potential in Central Newfoundland Part I General Appraisal", January 1966

ShawMont Newfoundland Limited, Report No SM-3-66, "Interim Report on the Terra Nova Development", June 1966

Fogwill, W. D., "Mines and Mineral Occurences Map of the Island of Newfoundland Information Circular No 11", Department of Mines, Agriculture and Resources, Mineral Resources Diversion, St. John's, Newfoundland, 1965

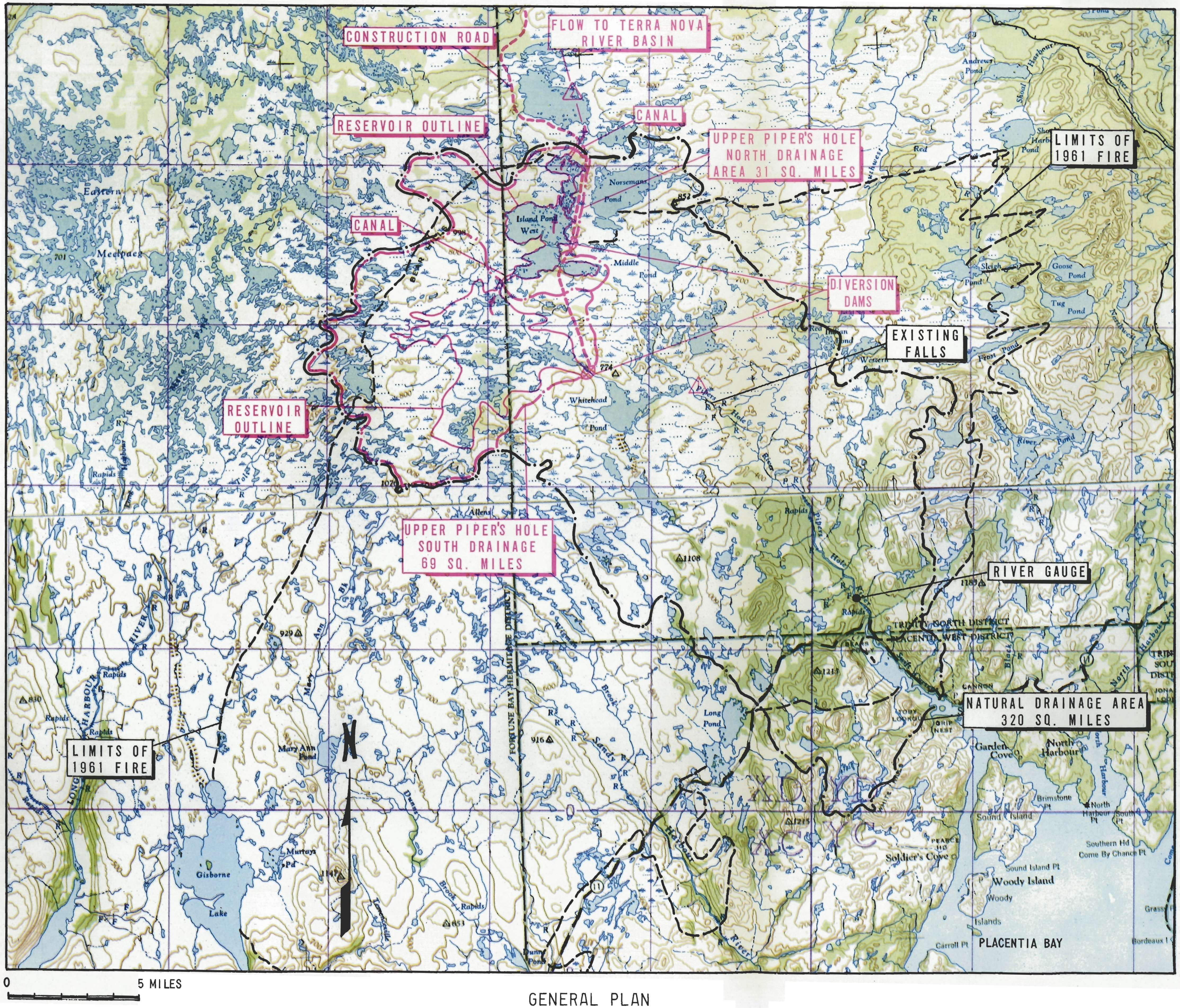
VOLUME SIX B

LIST OF FIGURES

PART VII PIPERS HOLE RIVER BASIN

Figure

The Shawinigan Engineering Company Limited
James F. MacLaren Limited



GENERAL PLAN

NEWFOUNDLAND - KEY PLAN

NOTE: POTENTIAL FUTURE DEVELOPMENTS SHOWN IN RED.

⚠1 ATLANTIC SALMON AREA UPSTREAM OF EXISTING FALLS.

⚠2 UPPER AREA DIVERSION TO TERRA NOVA HYDROELECTRIC DEVELOPMENT.

PIPER'S HOLE RIVER BASIN

FIGURE 24-1

PIPERS HOLE RIVER BASIN - SQUARE GRID DISTRIBUTION OF LAKES, BOGS, BARRENS AND FORESTS

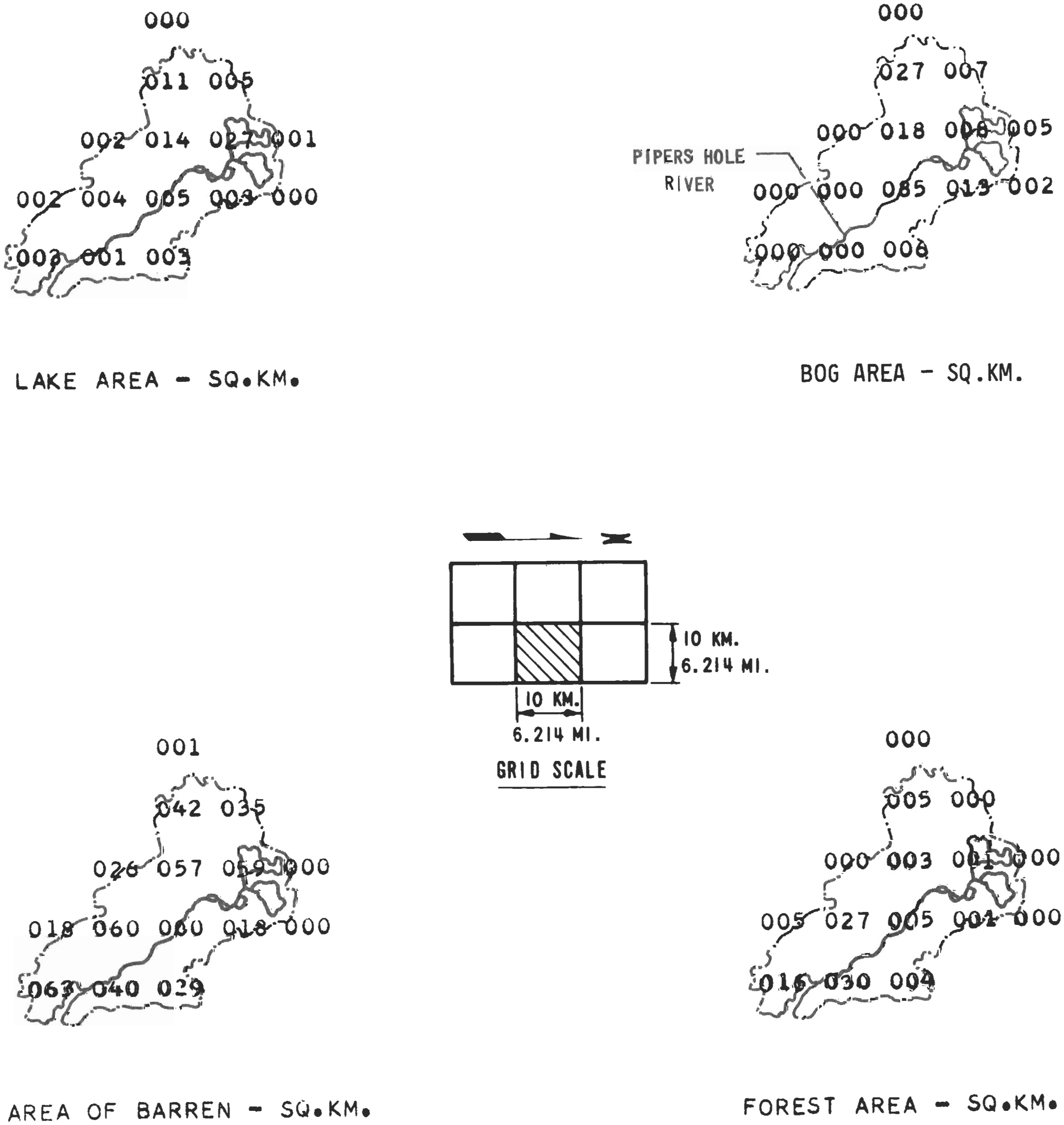
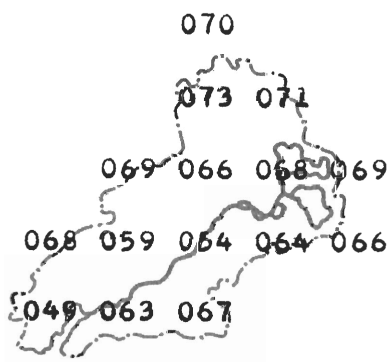
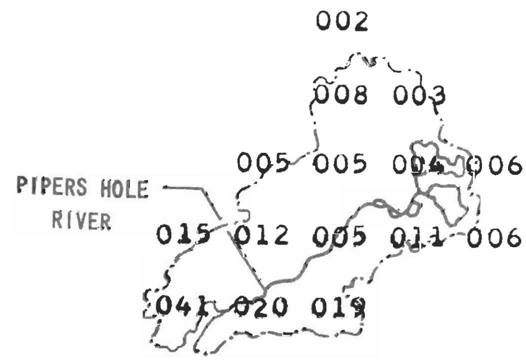


FIGURE 24-2

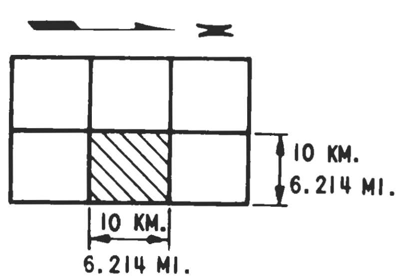
PIPERS HOLE RIVER BASIN - SQUARE GRID DISTRIBUTION OF LAND SURFACE SLOPE AND ELEVATION



AVERAGE ELEVATION OF SQUARE
- TENS OF FEET



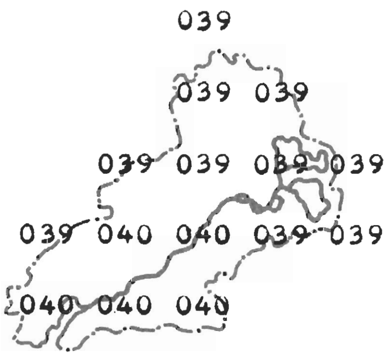
SLOPE - TENTHS OF A PERCENT



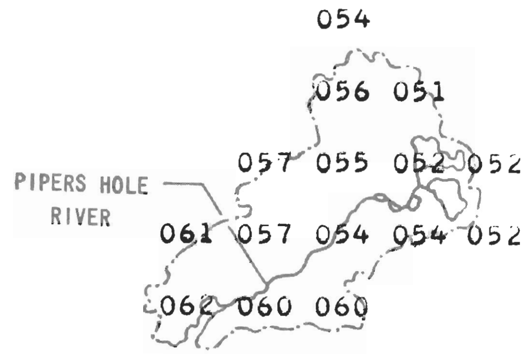
GRID SCALE

FIGURE 24-3

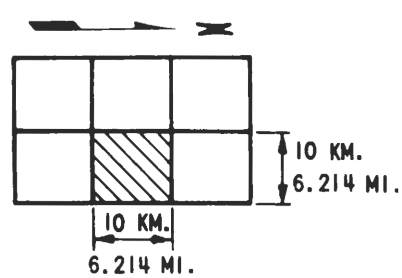
PIPERS HOLE RIVER BASIN - SQUARE GRID DISTRIBUTION OF MEAN ANNUAL TEMPERATURE, PRECIPITATION, EVAPORATION AND RUNOFF



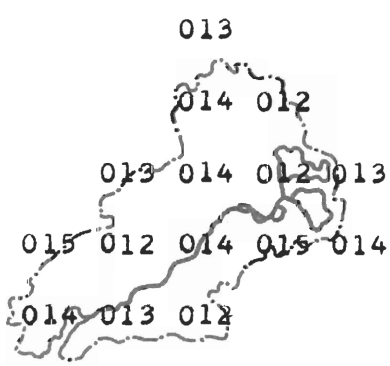
AVERAGE YEARLY TEMPERATURE -DEGREES FAHRENHEIT



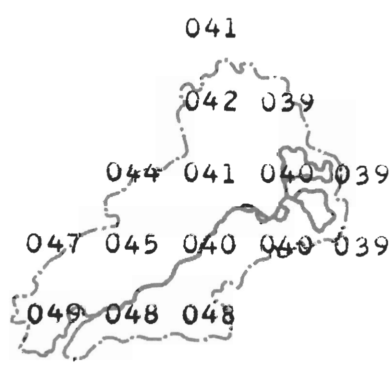
AVERAGE YEARLY PRECIPITATION - INCHES OF WATER



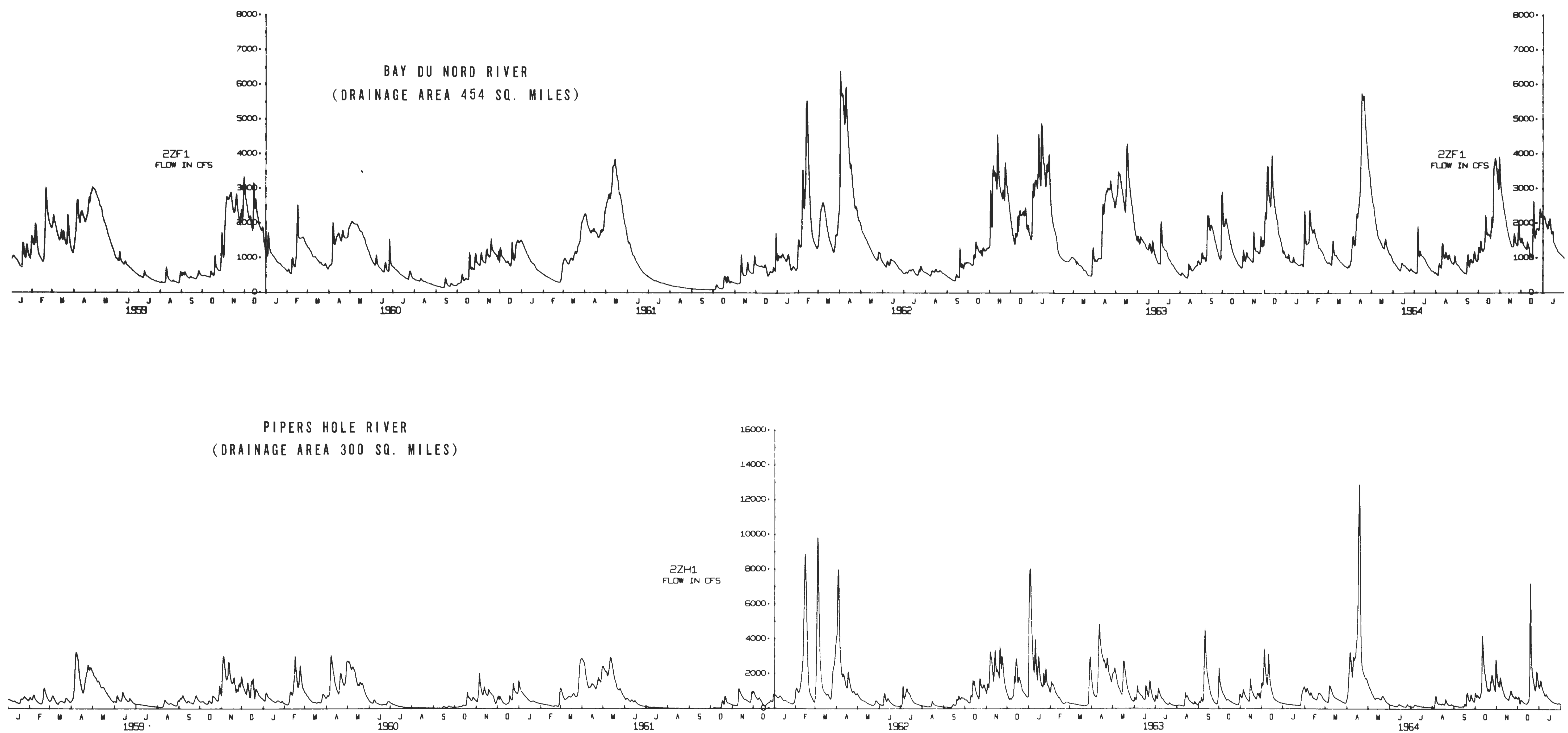
GRID SCALE



AVERAGE YEARLY EVAPORATION - INCHES OF WATER



AVERAGE YEARLY RUNOFF - INCHES OF WATER



MEAN DAILY FLOW HYDROGRAPH
PIPERS HOLE RIVER AND BAY DU NORD
RIVER 1959-64

FIGURE 24-5

CORRELATION OF MONTHLY AVERAGE FLOWS
PIPERS HOLE RIVER VS BAY DU NORD RIVER

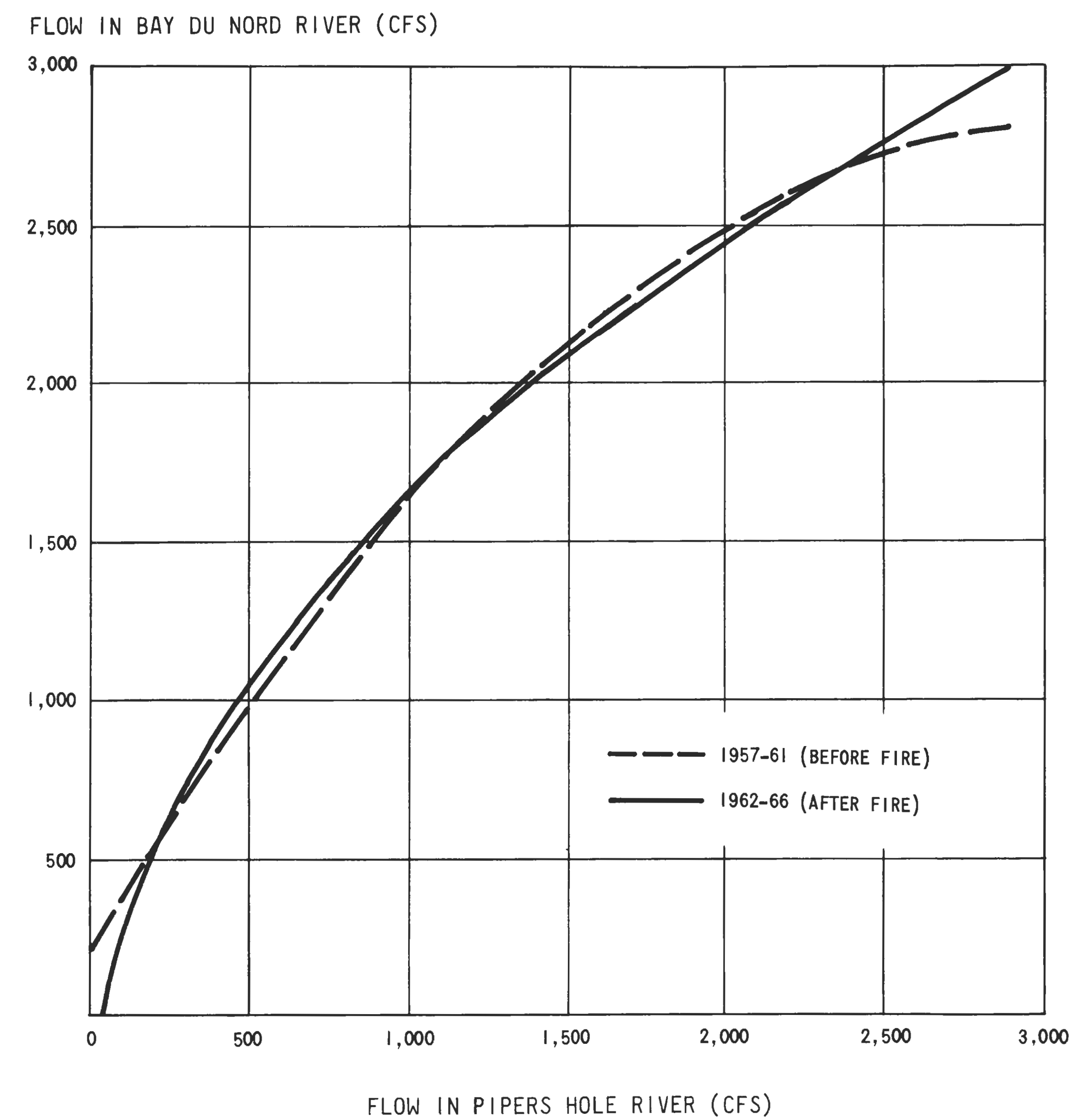


FIGURE 24-6

CORRELATION OF TEN DAY AVERAGE FLOWS
PIPERS HOLE RIVER VS BAY DU NORD RIVER

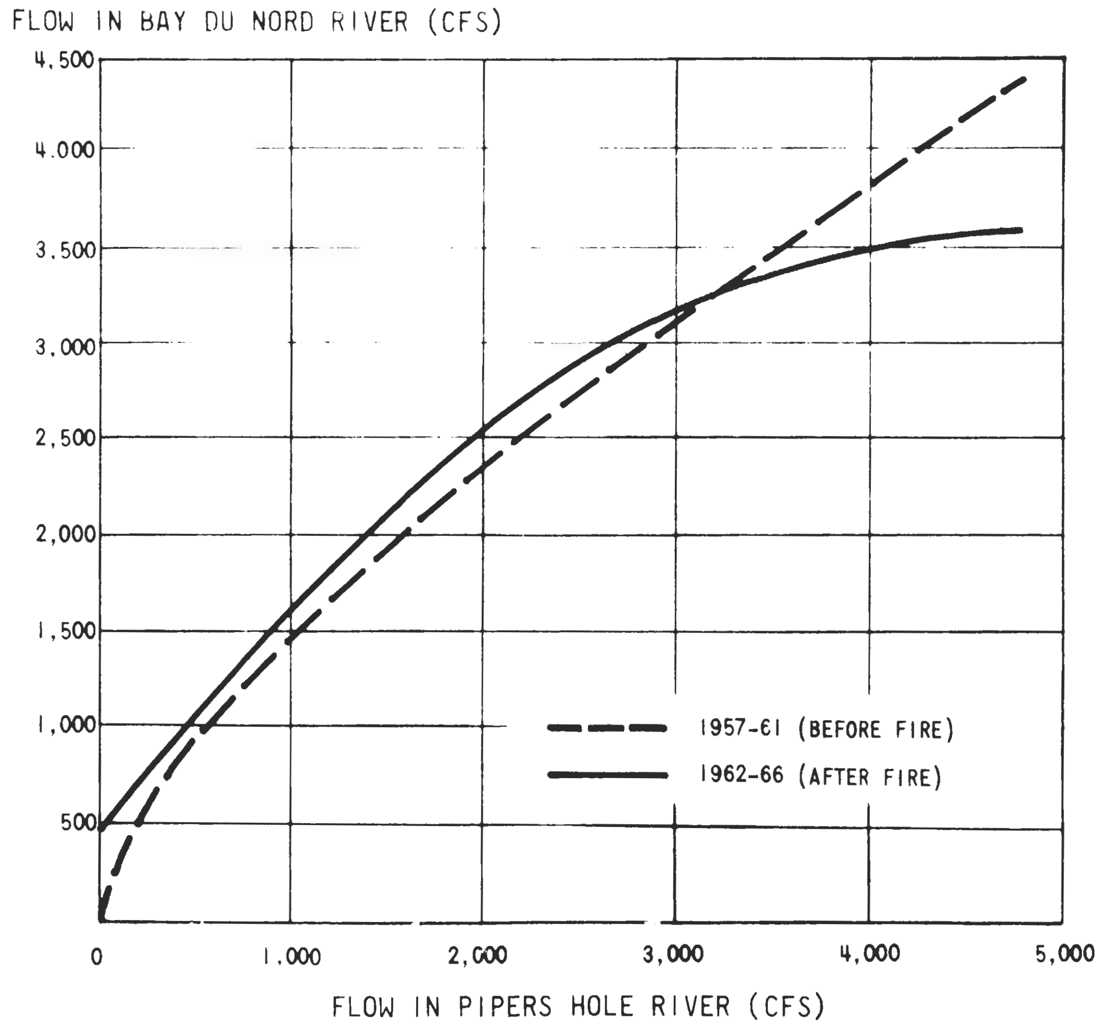


FIGURE 24-7

PIPERS HOLE RIVER BASIN
GROSS HYDRO ELECTRIC POTENTIAL
ON PIPERS HOLE RIVER

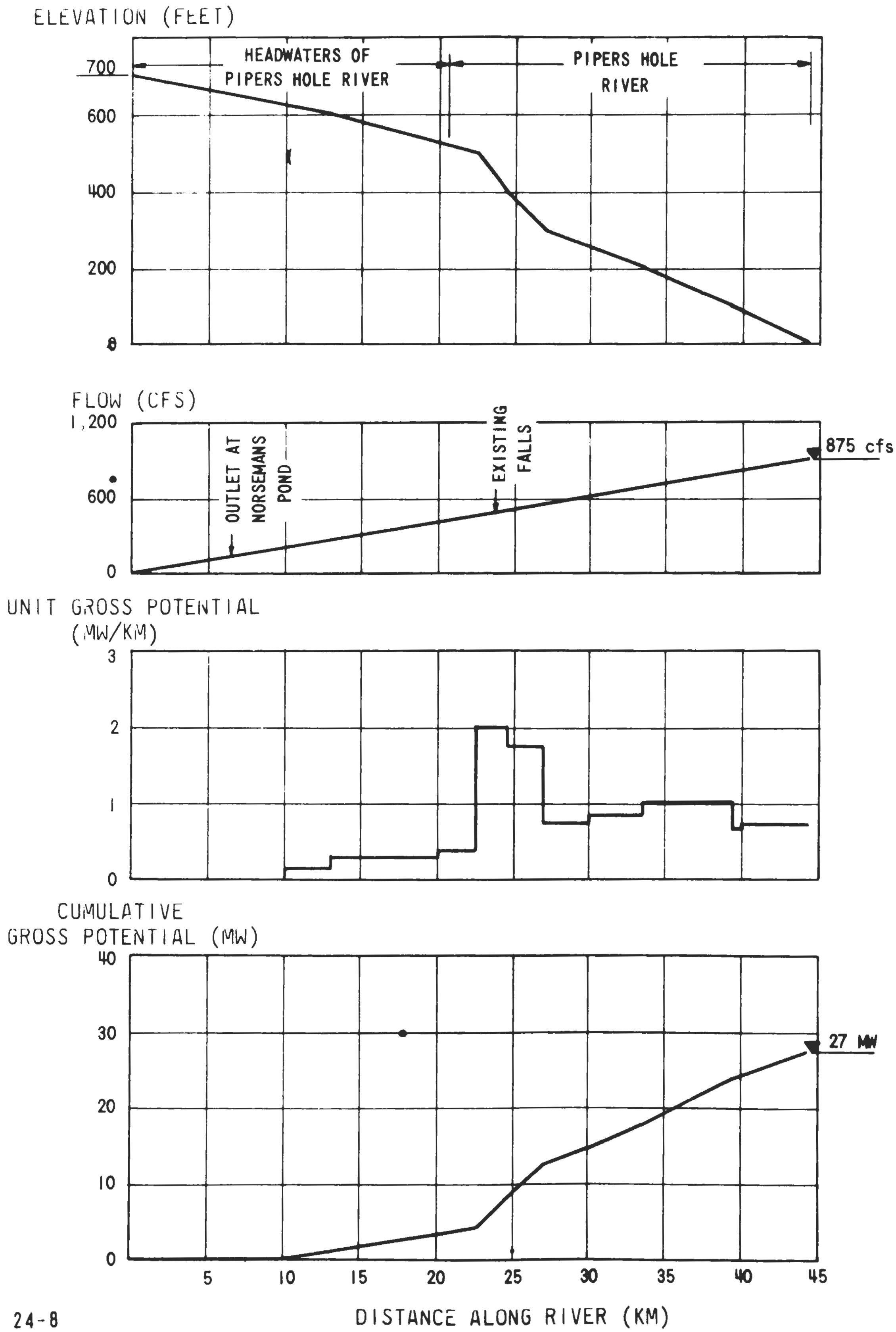


FIGURE 24-8

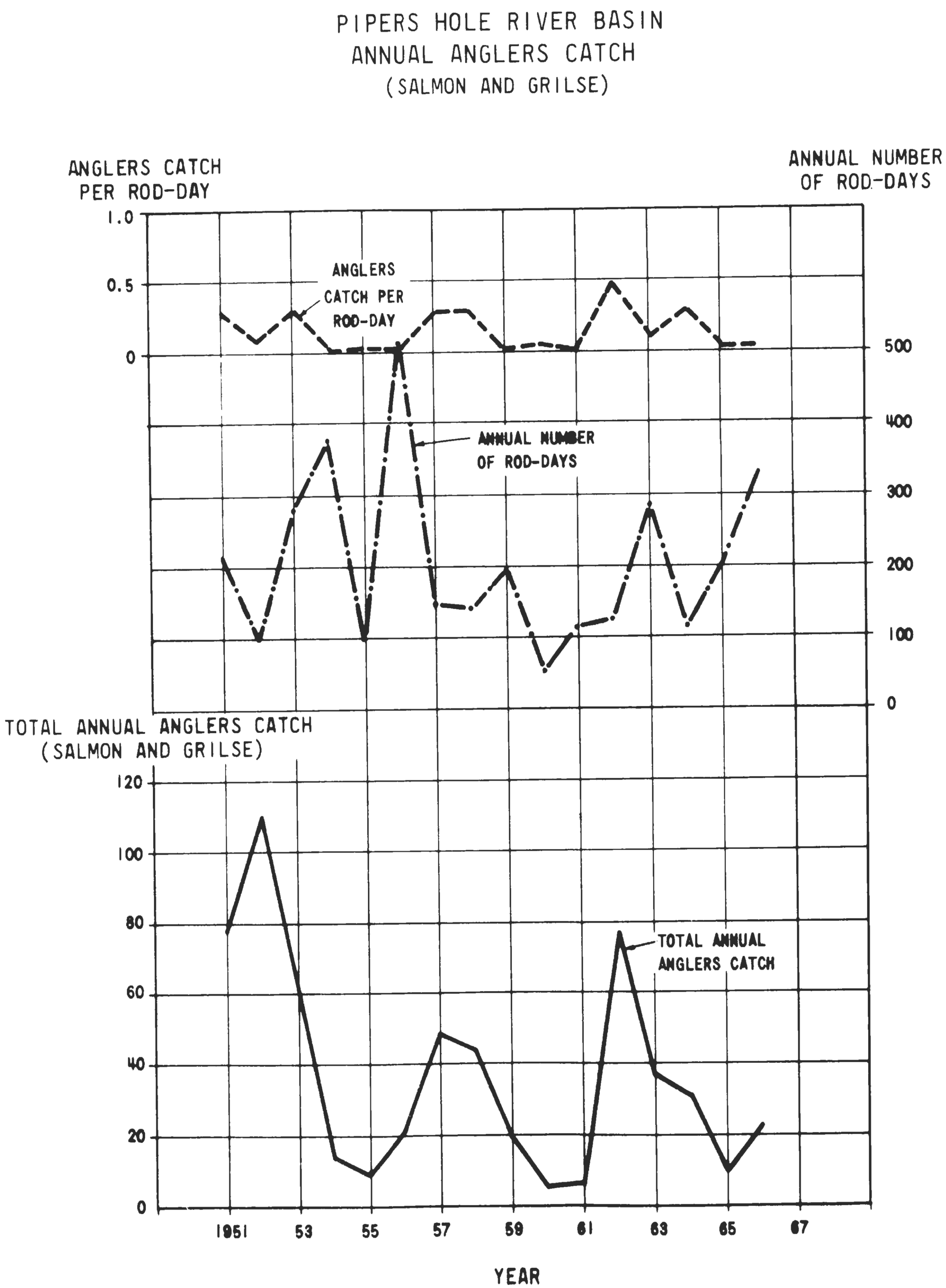

PIPERS HOLE RIVER BASIN
ANNUAL ANGLERS CATCH
(SALMON AND GRILSE)
ANGLERS CATCH PER ROD-DAY
ANNUAL NUMBER OF ROD-DAYS
1.0
0.5
0
ANGLERS CATCH PER ROD-DAY
ANNUAL NUMBER OF ROD-DAYS
500
400
300
200
100
0
TOTAL ANNUAL ANGLERS CATCH (SALMON AND GRILSE)
120
100
80
60
40
20
0
TOTAL ANNUAL ANGLERS CATCH
1951
53
55
57
59
61
63
65
67
YEAR

FIGURE 25-1

TABLE SIX B

LIST OF TABLES

PART VII PIPERS HOLE RIVER BASIN

Table

PIPERS HOLE RIVER BASIN

SUMMARY OF CLIMATIC CHARACTERISTICS

A ANNUAL MEANS

Precipitation (inches)	Air Temperature (deg F)	Potential Evaporation (inches)	Relative Humidity (percent)
56.3	39.2	19.5	83

B MEAN MONTHLY PRECIPITATION (inches)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Basin Mean Synthesized	5.3	5.2	3.9	3.7	3.6	3.9	4.2	4.6	4.5	5.3	6.5	5.6	56.3

C MAXIMUM POSSIBLE STORM PRECIPITATION (inches)

Area	Storm Duration (hours)						
(sq. mi)	6	12	18	24	36	48	72
100	4.85	7.30	8.85	10.20	12.10	12.50	14.20
300	4.75	7.25	8.70	10.10	12.00	12.40	14.05
320	4.75	7.25	8.70	10.10	12.00	12.40	14.05

D MAXIMUM POSSIBLE SEASONAL SNOWFALL (inches of water equivalent): 32.0

E CRITICAL SEQUENCES FOR SNOW MELTING (degrees F)

Interval	Date								
	March			April			May		
	1	10	20	1	10	20	1	10	20
4 - day	50.0	50.5	51.5	53.0	54.5	56.5	58.5	61.0	63.5
8 - day	46.0	47.5	48.5	49.7	50.7	52.6	55.0	56.5	59.5
16 - day	40.5	41.5	42.5	45.0	47.5	49.0	51.0	52.5	55.0

F DROUGHT

Return Period	2.33-Year	5-Year	10-Year	20-Year	50-Year	100-Year
Length of Drought	14 days	17 days	20 days	24 days	29 days	32 days

TABLE 24-1

SUMMARY OF HYDROLOGIC CHARACTERISTICS
PIPERS HOLE RIVER BASIN

I - SYNTHESIZED DATA

A. ANNUAL MEANS FOR THE TOTAL BASIN

FLOW (CFS)	RUNOFF (CFS/SQ.MI)	RUNOFF (INCHES)	ACTUAL EVAP. (INCHES)
905	3.2	43.0	13.2

B. MEAN MONTHLY FLOWS (Q) AND STANDARD DEVIATIONS (S) (CFS)

RIVER AND LOCATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
PIPERS HOLE RIVER AT MOTHERS BROOK	Q	1020	825	1050	1550	1490	750	415	385	465	790	1090	1000	905
	S	640	405	440	595	565	285	220	285	365	370	515	352	130
	Q													
	S													
	Q													
	S													

MONTHLY FLOWS CORRECTED BY THE RATIO 905/770 TO ACCOUNT FOR DIFFERENCE BETWEEN AVERAGE FLOW OBTAINED FROM THE RUNOFF DISTRIBUTION AND THE AVERAGE OF SYNTHESIZED MONTHLY FLOWS.

C. MAXIMUM FLOWS (CFS) AND FLOOD VOLUMES (CFS DAY) OBTAINED BY THE MAXIMIZATION PROCEDURE (INSTANTANEOUS PEAKS)

RIVER AND LOCATION	MAXIMIZED RAIN ON SNOW PACK		MAXIMIZED RAIN ONLY		SNOW PACK & AVERAGE RAIN	
	PEAK	VOLUME	PEAK	VOLUME	PEAK	VOLUME
PIPERS HOLE AT MOTHERS BROOK	44,000	159,000	35,000	99,000	11,400	75,000

D. MAXIMUM FLOWS OBTAINED BY STATISTICAL ANALYSIS (CFS) (DAILY AVERAGES)

RIVER AND LOCATION	GENERATED BY SNOW MELT & RAIN		GENERATED BY RAIN ONLY	
	1/10000 YEARS	1/1000 YEARS	1/10000 YEARS	1/1000 YEARS
PIPERS HOLE AT MOTHERS BROOK	15,500	12,600	11,700	9,350

SUMMARY OF HYDROLOGIC CHARACTERISTICS

PIPERS HOLE RIVER BASIN

E. MINIMUM FLOWS OBTAINED FROM RECESSION CURVES (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/10 YEARS	1/20 YEARS

F. MINIMUM FLOWS OBTAINED FROM STATISTICAL ANALYSIS (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/20 YEARS	1/100 YEARS
PIPERS HOLE AT MOTHERS BROOK	135	65	10	

G. FULL REGULATION STORAGE

RIVER AND STATION	STORAGE (CUBIC FEET x 10^9)
PIPERS HOLE RIVER AT MOTHERS BROOK	24.0

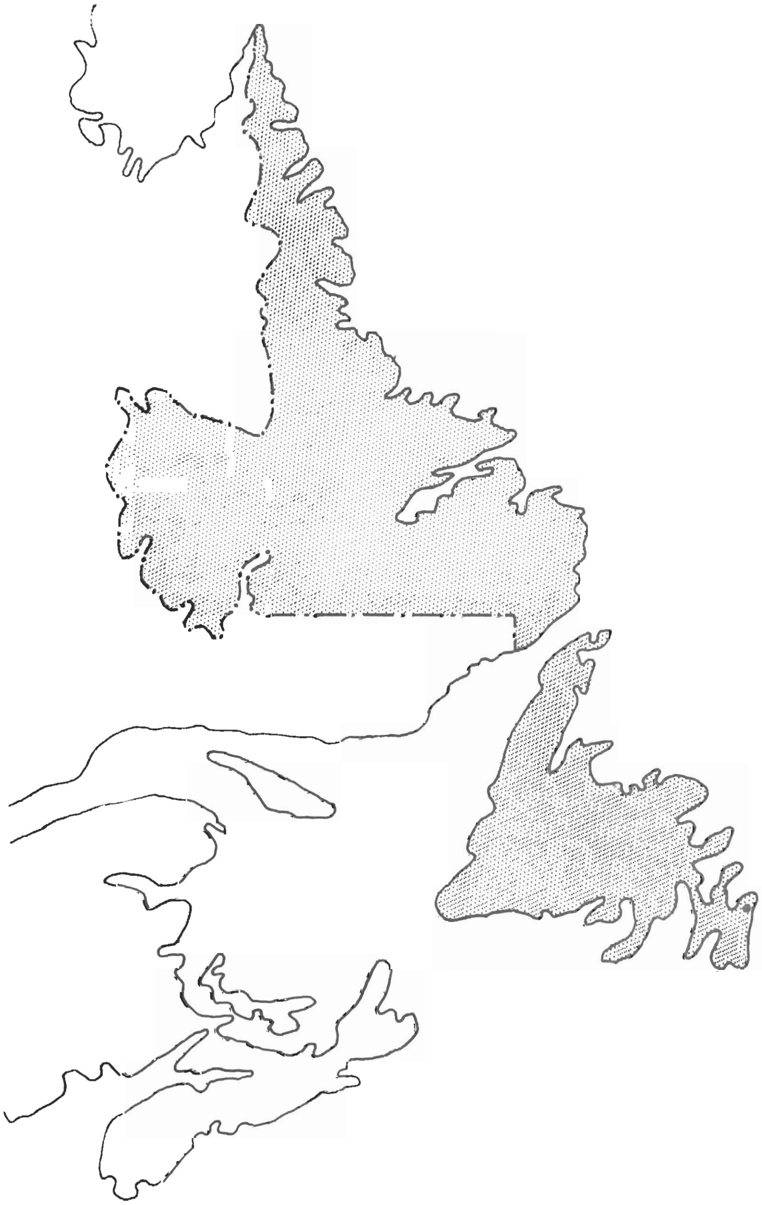
II - RECORDED DATA

H. MEAN MONTHLY AND ANNUAL FLOWS (CFS)

RIVER AND STATION	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
PIPERS HOLE RIVER AT MOTHERS BROOK	14	970	780	980	1790	910	515	315	295	450	725	1280	1080	840

I. EXTREMES RECORDED (CFS)

RIVER AND STATION	MAXIMUM FLOWS			MINIMUM FLOWS		
	FLOW	DATE	COMMENTS	FLOW	DATE	COMMENTS
PIPERS HOLE RIVER AT MOTHERS BROOK	13300 cfs	APRIL 18/64	DRAINAGE AREA= 300 SQ. MILES	3 cfs	SEPT. 24 AND 25 1961	PERIOD OF RECORD NOV. 1952 TO SEPT. 1966



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CHURCHILL RIVER BASIN AND
LABRADOR CITY STUDY AREA

PART VIII CHURCHILL RIVER BASIN AND LABRADOR CITY STUDY AREA

28 NATURAL CONDITIONS

The Churchill River basin in Labrador has a total drainage area of over 31,800 square miles, and is the largest basin in the Province (Figure 28-1) . Although the existence of the basin's mineral and water resources has been recognized for many years, actual development of these resources has only been initiated relatively recently.

The basin was opened up when the Quebec North Shore and Labrador Railway which runs from Sept Isles, Quebec on the St. Lawrence River to the large iron ore deposits in the interior was completed. Mining of these deposits commenced in the early 1960's and resulted in the establishment of the communities of Labrador City and Wabush.

The Churchill River is known as one of the truly great rivers of the world in terms of energy available from its water resources. Partial development occurred when two hydro plants were installed in the upper basin area. The river presently has the largest reserve of hydro power on the North American continent. Construction of a one billion dollar hydro-electric project at the Churchill Falls power site is presently under way.

Access to the basin is by air to Goose Bay, Twin Falls, or Labrador City, or by railway from Sept Isles, as shown in Figure 28-1 and Figure 28-3. An access road is presently under construction from Goose Bay near the river mouth to the Churchill Falls power site, a distance of about 180 miles. This road will join up to the existing 120-mile access road from the power site to Esker which is located on the rail line. The rail distance from Esker to Sept Isles is 286 miles.

28.1 Physiographic Conditions

The Churchill River rises in the central plateau of the Labrador coast and flows in an easterly direction into Lake Melville, an inlet which extends from the coast into the centre of Labrador.

The basin of the Upper Churchill River, which is the area upstream of Churchill Falls, lies in the central plateau at an average elevation of greater than 1500 feet. The principal rivers in this upper area are the Ashuanipi and Atikonak rivers. The plateau is a vast flat area with an abundance of large lakes. Here the gradient of the rivers is very gentle dropping about 325 feet in a 250-mile length. The Churchill River proper starts at the edge of the plateau where a series of rapids and the Churchill Falls drop the river in a distance of 16 miles to a channel over 1000 feet below. Downstream from the Falls the river drops about 400 feet in its 180 - mile course to tidewater, and occupies a pre-glacial valley some 600 to 800 feet below the level of the surrounding country. In this section, the river has a strong current marked by numerous rapids, but only one drop of consequence, about 50 to 70 feet at Muskrat Falls, which is 24 miles from the river mouth.

The total natural drainage area of the basin above the river mouth is about 31,800 square miles, or about 75 percent of the area of the entire Island of Newfoundland. This area includes 4950 square miles of lakes, 2095 square miles of bogs or marshes, and 540 square miles of barrens. The distribution of lake, bogs, and barrens throughout the basin is shown in Figures 28-5 to 28-7.

There are many large lakes in the basin. These include Wabush, Ashuanipi, Lobstick, Sandgirt, Gabbro, Ossokmanuan, and Lac Joseph in the upper basin and Minipi, Winokapau, and Gull lakes in the lower basin. The latter two are actually a widening of the main river stem. After the completion of the Churchill Falls power site, a man-made lake will raise the level of several existing lakes and will cover an area of approximately 2700 square miles. Details of this scheme are described in Section 30.1.1

The hypsographic curve of the basin is given in Figure 1-4, the land surface slope distribution is shown in Figure 28-8 and the elevation distribution in the basin is shown in Figure 28-9.

Most of the basin is underlaid by crystalline rocks of Pre-Cambrian age. The upper part includes the southern end of the Labrador trough, a belt of Pre-Cambrian sedimentary and volcanic rocks. The iron ore deposits, which have played an important part in the development of the area, are found in the deposits of the Labrador trough.

A large part of the basin is covered by glacial deposits of various types. The most widespread surficial material present is ground moraine which covers most of the upper part of the basin. There are also some areas of ribbed moraine, and numerous eskers, some of them extending for 50 miles or more. About 15 percent of the area has practically no surficial cover, with only thin patches of ground moraine on top of the bedrock.

Near the mouth of the river, in the vicinity of Lake Melville, there are extensive deposits of sand and gravel which are known to be several hundred feet thick in some areas.

The distribution of surficial material is shown on the map included with Volume Two of this report.

The variation in mean annual temperature, precipitation, and evaporation in the basin is shown in Figures 28-10 to 28-12. The mean annual temperature for the basin is 26 deg. F : the mean annual precipitation is about 33 inches; and evaporation has a mean annual value of 8 inches. The climate of Labrador is discussed in detail in Volume Two.

28.2 Water Resources and Potential Uses

28.2.1 Surface Water

Five river gauges have been established on the Churchill River basin. Three are still in operation and they are located at Muskrat Falls in the lower basin, at Flour Lake, and on the Unknown River at Lake 51 in the upper basin. These gauging stations have a drainage area of 30,400, 13,100, and 7700 square miles respectively. In addition, the two existing hydro power plants at Menihek Rapids on the Ashuanipi River and at Twin Falls on the Unknown (Atikonak) River provide daily outflow records. Their drainage areas are 7400 and 8800 square miles respectively.

The data at the hydro plants have been utilized for the estimation of the average annual flow. Generalized relationships with meteorologic and physiographic factors have been used to compute the areal distribution of average annual runoff in the basin (Figure 28-13). The mean annual runoff on the total natural drainage area is estimated to be 24 inches or 1.75 cfs per square mile. Hydrologic characteristics of the basin are summarized in Table 28-1.

The quality of the surface waters in the Churchill River basin are expected to conform to the general observations made in Volume Two, Section 28; that is the waters will be highly coloured, with low turbidity, very soft, low in dissolved solids, and with pH of slightly less than 7. The construction program of the hydro-electric development at Churchill Falls may substantially increase the river's turbidity and settleable solids content throughout the construction phase but in the long run little significant permanent change is expected to result from the installation of the storage dams and generating facilities.

28.2.2 Groundwater

Very little information is available on the groundwater potential of this basin. Excellent supplies of groundwater have been developed from the sand deposits in the Goose Bay area, but deposits of this type, unit SL4, occur over only a very small proportion of the basin. Most of the basin is covered by moraines belonging to hydrogeologic units SL2 and SL3, which are capable of producing moderate supplies of water only, and in some areas they may produce extremely low yields. The distribution of the surficial units is shown in Volume Two, and there is also a general discussion of the groundwater potential in the same volume.

The development of the iron ore mines in the basin has indicated that considerable quantities of groundwater can be obtained from the Pre-Cambrian sediments and volcanics of the Labrador trough. In the west of the basin, where the rocks are crystalline, the groundwater potential of the bedrock will be generally low except in highly fissured areas.

28.2.3 Hydro Power

The river has a vast hydro potential which when developed will be of significant benefit to the economy of Eastern Canada. The gross potential of the main river stem is shown in Figure 28-14. As shown, the largest potential site is that at Churchill Falls (formerly known as Hamilton or Grand Falls) which is presently being developed. The largest sites remaining are those at Gull Island and Muskrat Falls located in the lower basin. The gross potential of the river under natural conditions does not include the effect of the diversions which are included in the plans for the Churchill Falls power site. The Churchill Falls development is outlined in Section 30.1.1.

28.2.4 Fresh Water and Anadromous Fish

Only about 1.3 percent of the total drainage area is accessible to Atlantic salmon since Muskrat Falls prevents salmon movement upstream from this point. Downstream from Muskrat Falls, approximately 134 miles of main river and tributary streams are accessible to Atlantic salmon. The Department of Fisheries believe that this area has a potential salmon population considerably in excess of the present estimate of 1000 spawners or less.

The potential for commercial fisheries of lake trout and white fish in the basin area exceeds 2 million pounds per annum based on catches in similar waters in Northern Canada which produce about 1 pound per acre per annum of commercially-useful species.

The potential of the water resource for log driving and navigation are included in Section 30.

28.3 Natural Resources

The basin has a significant forest, mineral, and wildlife potential in addition to the water resource potential previously outlined.

28.3.1 Forests

The forested area of the Churchill basin covers 24,220 square miles or about 76 percent of the total basin area according to the available government maps of 1:250,000 scale. The areal distribution of the forests are shown in Figure 28-15.

The lower basin area has the greater density and the lower river valley has an excellent to good forest zone while the highlands of lower basin have a fair to marginal forest zone. The wooded areas in the central plateau are of poor quality.

28.3.2 Minerals

The basin is the site of extensive iron ore development. Concentrations of lead, zinc, and copper, which could be of significant proportions and have development potential, occur in the Menihek Lake area which is in the Upper Churchill basin. The geology and mineral potential of much of the basin is practically unknown, and sustained exploration may lead to successful development and production of mineral commodities[2].

28.3.3 Wildlife

Most of the 42 species of land mammals in Labrador are found in the Churchill Basin. The number of species of native mammals of Labrador surpass by three times the native species on the Island.[3] These include moose which are believed to be moving into eastern Labrador at this time. The wild mink of Labrador is one of the most valuable of all wild mink pelts and are trapped as are the red fox and arctic fox. Caribou have been important to Eskimos and Indians for many year.

The potential for agriculture in the basin is discussed in Section 30.2.2

29 PRESENT DAY DEVELOPMENT

29.1 Non - Withdrawal Water Demand and Supply

Present - day development in the basin is a result of a campaign which the Government of Newfoundland and Labrador initiated in 1953 to further the economic development of the Province on a broad scale by interesting private companies in its human and natural resources [4]. One result of these efforts was a resource development agreement arranged with a group of British companies. This led to the formation of the British Newfoundland Corporation Limited. Brinco, as the Company is commonly called, received certain rights and concessions relating to minerals, timber, and water power in specified areas of the Island and Labrador. These rights were subject to undertakings to spend money on the exploration and development of these resources. Under its principal agreement with the Provincial Government, Brinco became a custodian of the Churchill River [4].

Detailed exploration of the iron ore deposits in the upper basin of the Carol Lake-Wabush Lake area began in 1956 by the Iron Ore Company of Canada. Mine development and plant construction commenced in 1959 and production started in 1962. The power requirements for these mines have been developed in the upper basin area by Brinco. A separate power development company now known as the Churchill Falls (Labrador) Corporation, was formed to develop the Upper Churchill River basin. The Company has a 99-year lease on this catchment area from the Government of Newfoundland.

29.1.1 Hydro Power Development

The mining developments in the upper basin have utilized the power available from the plant owned by Twin Falls Power Corporation Limited.

The Twin Falls generating station which went into production in 1962 is located on the Unknown River at 53 deg. 30' north latitude and 64 deg. 30' west longitude. As shown on Figure 28-4, it is some 12 miles southwest of Churchill Falls and 250 miles north of Sept Isles on the Gulf of St. Lawrence.

The natural topography at the site is well suited for hydro-electric development [5]. In a three - mile stretch of the river the drop is more than 400 feet. Running roughly parallel to the river is a gorge, the bed of which, at the upper end, is 300 feet below the normal water level above the falls. The general scheme of development was to divert the river from the plateau level through a canal and penstocks to powerhouse on the floor of this gorge.

The Churchill River plateau on which the site is situated contains little topography above elevation 2500 which accounts for the many lakes and marshy ground existing over the approximate 8800 square miles of drainage area which now supplies water to the Unknown River.

The powerhouse is located at the bottom of the dry gorge which runs parallel to the Unknown River. Initially, it contained two vertical shaft Francis type turbines each nominally rated at 60,000 HP. under 290 feet net head. The powerhouse was designed to allow extension to accommodate additional units and additional tailrace improvement to increase the head. Final expansion of the plant was completed in 1968 bringing the capacity of the five units to 358,000 horsepower.

The plant supplies power to the Iron Ore Company and the Wabush Iron Company at Wabush Lake and 110 miles of 230 kv transmission lines were required to connect the site to the mine.

After development at Churchill Falls is completed, Twin Falls will only be used during high flood periods as the flow which is presently utilized will pass through a much larger head at Churchill Falls and the Wabush mining area load will be supplied by the new power plant. About 2 billion kwh will be supplied by the Churchill Falls plant to honour Twin Falls power commitments to the iron ore operations at Wabush and Labrador City after the over $60 million Twin Falls plant is demoted to reserve status[11].

The other hydro-electric plant presently operating in Labrador is located in the upper basin and is owned by the Iron Ore Company of Canada[6]. This plant has been in operation since 1954 and it supplies the power requirements of the iron ore mine at Schefferville which is located to the north just outside of the basin area. The plant is at the outlet of Menihek Lake which is fed by the Ashuanipi River, one of the Churchill River's two main tributaries.

The rated head of the plant is small being about 35 feet, but the drainage area is 7400 square miles. The first unit was installed in 1954 and subsequent expansion took place in 1960. Three units are now installed and the total capacity of the units is 25,500 horsepower.

The main features of the hydro developments of Twin Falls and Menihek are summarized below:

Development	Menihek	Twin Falls
River	Ashuanipi	Unknown
Square Miles	7,400	8,800
Year Installed - First Unit	1954	1962
- Latest Unit	1960	1968
Number of Units	3	5
Owner	I0Co	TFPCo
Rated Head	2-34 feet	300 feet
	1-40 feet	
Total Installed Turbine Capacity	25,500 HP	358,000 HP

29.1.2 Fisheries

Information on the present-day fisheries resource has been provided by the Department of Fisheries of Canada.

29.1.2.1 Sports Fishery

At least 17 species of fish are found in the Churchill River system. These are: Atlantic salmon and eastern brook trout (both resident and anadromous varieties), Arctic char, (anadromous and resident forms), lake white fish, round white fish, smelt, four species of suckers, northern pike, lake chub, barbot, three species of sticklebacks, and lake trout.

Sport fishing is limited throughout the system principally to "fly-in" tourists and to American Armed Forces camp occupants. The resident population of Happy Valley and Goose Bay maintain an active sport fishery in the section below and immediately above Muskrat Falls.

At the present time, with possible minor exceptions in the area of "fly-in" camps, the resident fresh water species are receiving little exploitation, However, both resident and brook trout are fished by Indians and Eskimos with gill nets in the Traverspine and McKenzie Rivers, tributaries to the Churchill River downstream from Muskrat Falls. Trout are abundant in most waters and are the preferred game fish of the area.

There is insufficient information on the remaining species to indicate population levels, but it is known that lake trout and white fish are common in the lakes of the system. The level of abundancy of these species is not known by the Department of Fisheries , but their productivity level could be comparable to similar waters in other parts of northern Canada.

The boundaries of the Labrador City study area contain about 180 square miles of lakes and ponds. This includes 28 bodies of standing water, the two largest being Wabush Lake and Shabogamo Lake with areas of 44 and 83 square miles respectively.

The mining towns of Wabush and Labrador City are located near the shores of Wabush Lake. The combined population of the two centres is about 10,000. The many lakes and ponds of the area are the prime recreation area for boating and angling. Angling is particularly popular since many waters are still supporting relatively unexploited stocks. Brook trout up to 7 pounds have been taken, and 4 pound fish are not uncommon; lake trout up to 30 pounds have been angled. Good ouananiche fishing is also reported.

Angling statistics in the study area are available for 1967 only. In that year anglers fishing an estimated 7000 rod-days caught 6075 speckled trout, 325 lake white fish, 590 northern pike, 1475 lake trout, and 1060 lake landlocked Atlantic salmon. These statistics represent the catch by Wabush and Labrador City residents fishing in Wabush, Shabogamo, Julian, and Javelin Lakes. Although one season's records cannot be used to estimate population levels, the 1967 catch record would indicate that these waters are probably underfished.

Such small samples as have been examined by the Department of Fisheries of Canada of major species from lakes in that area are inadequate to base firm statements as to the "condition" of these populations but it would appear, as might be expected, that they are somewhat more slow growing than populations from more southern waters.

Two mining companies, Wabush Mines and Iron Ore Company of Canada, operate open pit iron mines in the area. Wabush Mines discharges tailings into Flora Lake which, by agreement with the Department of Fisheries, has been set aside as a tailings disposal area. Flora Lake has an area of some 3330 acres and the lake basin which has a 5820 acre area will eventually be filled with these tailings. Use of Flora Lake, and eventually the whole basin, for this purpose was approved by the Department of Fisheries to prevent indiscriminate spread of these tailings throughout downstream water systems of the area.

The Iron Ore Company of Canada, the second large mining operation in the area, deposits several million tons of iron tailings annually directly into Wabush Lake. This action, too, was originally approved by the Department of Fisheries on the basis of assurance that these tailings would settle out rapidly and would cause only very localized pollution. It soon became obvious that the finer fractions of these tailings spread throughout the lake and sometimes into adjoining Shabogamo Lake. Some attempt is being made to control this pollution by partial dyking of the tailings area, but to date it has not been particularly effective. Efforts to improve the situation continue.

A combined survey by the Department of Fisheries and the Fisheries Research Board of Canada in 1966 indicated no direct toxic or other effects from the deposits on the fish themselves but doubtless, in time, their settling out will destroy spawning areas and the fish food producing capacity of the lake. It does not appear that present policies and attitudes will enable this source of pollution to be stemmed.

The mining companies carry out annual black fly control procedures by spraying and larvaciding with DDT. No extensive evaluation of the effect of this operation on fish populations has been conducted.

At present there are no other known pollution problems in the waters of the Churchill River drainage basin.

29.1.2.2. Commercial Fishery

A small commercial fishery exists on the lakes to the north-east of Labrador City near the provincial boundary. No details are available on the quantity of the annual catch.

29.1.3 Recreation, Tourism, and Wildlife

When evaluating the tourist development, it must be remembered that the basin was a completely uninhabited wilderness a little more than a decade ago, and that the tourist industry has not had sufficient time to develop appreciably. Only recently have visitors been permitted to fly to the Churchill basin without written proof of confirmed accommodation. The vast natural basin area of 31,300 square miles is still relatively isolated from the outside world and has a frontier atmosphere despite the modern towns which have sprung up with the mining developments.

The vacation attractions to tourists in the Churchill basin centre around the excellent trout fishing found in the virgin lakes of the interior. Limited hunting for woodland caribou is available in the western or upper basin area.

Access to the basin from large population centres to the south is still a problem - and the few tourists who come to the area generally use air transport. Local recreation facilities have been established for the employees of the mines at Wabush and Labrador City.

29.2 Withdrawal Water Demand and Supply

Withdrawal uses of the water resources are limited to water required in the iron ore mining operations and the municipal water supply and waste disposal for the towns which have developed in the upper basin area and the towns near the river mouth.

29.2.1 Mining

The Iron Ore Company of Canada (IOCo) and Wabush Mines located as shown in Figure 29-1 are the two mining companies operating open pit iron mines and beneficiating plants in Western Labrador [7]. Production data and information on town and plant location are summarized below.

Mining Company	Iron Ore Company of Canada	Wabush Mines Limited
Start of production	1962	1964
Annual Production		
Crude ore	17,200,000 long tons	14,000,000 long tons
Concentrate	8,000,000 long tons	5,500,000 long tons
Pellets produced from concentrate	5,500,000 long tons	4,900,000 long tons
Location		
Mine and town	Labrador City	Wabush
Population	6000	2100
Concentrator	Labrador City	Wabush
Pellet Plant	Labrador City	Pointe Noire, Que.
Port	Sept Iles, Que	Pointe Noire, Que.

The waste products from these iron ore mining operations originate from two main sources. One source is the surface and underground water from the open pit mines which is collected in sumps from where it is pumped into an existing drainage system. Pollution from this source will increase as the mines enlarge, and monitoring of this pollution source may be required.

The major threat of pollution from the mining operation occurs from the disposal of waste materials following the processing of crude ore in beneficiating and pelletizing plants.

Figure 29-2 presents in plan the plant, tailings disposal area, and discharge system for both the Iron Ore Company and Wabush mines. Table 29-1 presents a simplified mining and concentrating flow sheet for each company.

The Iron Ore Company operation started in 1962, and has resulted in the disposal, to the end of 1967, of about 43 million long tons of tailings at an average annual rate of seven million long tons.

Process water is required 7 days a week since the operation is continuous. It is obtained from the south end of Wabush Lake and is pumped to a 2,000,000 gallon tank from which it is gravity fed to the concentrator and pellet plant. Reclaim systems are used in both plants to conserve water.

Waste water being discharged into Wabush Lake comes from two sources:

Concentrator discharge - comprising coarse and fine tailings together with scrubber slimes (26,000 gpm).

Pellet plant discharge - comprising cooling water from the induration machines together with some thickener overflow water (5,500 gpm).

The concentrator tailings at 20 percent solids containing quartz particles, iron oxides in the form of hematite and magnetite, and calcium /magnesium and iron carbonates, are carried in a semi-circular 9 foot diameter rubber - lined flume to a tailings pumphouse on the west shore of Wabush Lake.

Pumps deliver the tailings to the disposal area in the lake. Mobile cyclones are being used to construct two dykes which serve to protect rail access on the west side and the emergency disposal area to the south. The material so delivered settles rapidly and the waste water flows into the lake and follows the drainage pattern as indicated on Figure 29-2. Wabush Lake drains into Shabogamo Lake, which discharges into the Ashuanipi River. After flowing north through Menihek Lakes drainage follows a southeasterly course through the Lobstick Lake area, where it discharges into the Churchill River and thence to the Atlantic Ocean at Hamilton Inlet. The total distance is approximately 750 miles. While the majority of the material delivered to the lake settles rapidly, some colloidal material held in suspension has resulted in the discolouration of the lake water.

A research program was started in 1963 to investigate the possibility of pollution of the drainage system resulting from plant effluents. Chemical tests were originally carried out on surface water samples from Wabush Lake, taken close to and downstream from the plant effluents. In the summer of 1965, the Federal Department of Fisheries, in conjunction with IOCo. conducted a preliminary survey in the area to obtain a general knowledge of the lake conditions. The primary purpose of this survey was to determine the effect of waste disposal on the aquatic life.

Included was a water quality study, bioassay tests on the effect of mine waste on fish, benthic fauna survey, and fish population analysis.

A review of the data available from the 1965 survey shows general agreement with the results of previous IOCo. surveys. Conclusions that can be broadly drawn from these studies are as follows:

a) The effect of entering waste waters from the concentrator is clearly evident from an increase in mineral content both from iron and manganese analysis and specific conductance measurements. The waste water, however, cannot be considered highly mineralized as samples taken 10 miles downstream give comparable results to those obtained above the plant effluents.

b) Calcium/magnesium and iron carbonates contained in the waste waters result in an increase in total hardness which is evident for the entire length of Wabush Lake.

c) Turbidity increases in the general area of the discharge but reverts to a low level approximately five miles downstream.

The results in ppm. of some of the surface samples taken during the 1965 survey are given below. Sample locations are noted on the drainage system plan Figure 29-2.

Sample Location	I	2	3	4
Colour (Hazen Units)	45.00	25.0	35.0	25.0
Turbidity (Jackson Units)	1.00	3.0	2.0	1.0
Total Iron	0.18	0.57	0.27	0.10
Manganese	0.04	0.31	0.14	0.07
Hardness	22.80	40.7	37.6	37.5

The pellet plant discharge was found to be unsatisfactory according to the paper by Dr. W. R. Horn. Flocculating agents to reduce the turbidity were used with varying degrees of success. A change in plant design, using two 150 foot diameter thickeners in place of 32 foot diameter fines thickener, has resulted in a waste discharge of acceptable quality. In 1966 a magnetic separation plant was commissioned which recovers about 700,000 long tons per year of magnetic concentrate by processing the concentrator tailings. Inasmuch as the process requires further grinding of the original tailings material, it results in the increase of material of colloidal size being discharged into the lake.

In conjunction with other mining companies in the area and with Federal and Provincial authorities, IOCo. intends to continue to carry out studies which evaluate the effects of waste disposal. However, as mentioned in the previous section on Fisheries, this source of pollution remains unstemmed.

Operations began at the Wabush Mines in late 1964. The designed operation of the concentrating plant at the Wabush Mines (Scully Mine) requires new process water make-up from Little Wabush Lake. This is pumped to the plant at an average rate of 8700 gpm.

After the beneficiation process, the tailings are thickened in a 280 foot diameter thickener and, to conserve water, the overflow is reused in the plant at the rate of 50,000 gpm. Total tailings from the plant are pumped approximately 3 miles to the final disposal area at 40 percent solids, with a water rate of 7090 gpm.

The disposal area, which was designed with the approval of Provincial and Federal authorities, will receive 8,500,000 long tons per year of tailings, with provision for increases above this figure.

Generally, the area provides for deposition of the tailings from the pump lines onto land adjacent to the west side of Flora Lake. The discharge lines are raised and extended periodically as the volume of deposited tailings increases. Ultimately, this will raise the level of the land disposal area to about 80 feet above Flora Lake.

The area is bounded on the west side by impounding dams to prevent flow of material to other lakes in the area. The finer sizes of the tailings from the pump lines flow down the east side of the land deposition area into Flora Lake.

These finer sizes settle in Flora Lake and the clear water then flows into Wabush Lake via the Flora River as outlined in Figure 29-2.

In the distant future, when tailings volume becomes much greater and results in a diminished settling area in Flora Lake, provision in the design allows for complete isolation of the area by dam construction at the north and south ends of Flora Lake.

The Scully Mine does not pelletize locally; the concentrated ore is shipped by rail to Point Noire, Quebec for pelletizing.

29.2.2 Population, Municipal Water Supply, and Wastewater Disposal

All significant population concentrations in Labrador are located in the Churchill River basin. In 1966 the populations of Wabush, Labrador City, Happy Valley, Goose Bay and Twin Falls accounted for approximately 70 percent of the 21,157 persons living in Labrador. In addition to the populations recorded in the 1966 Census there was an estimated population of 7,300 living on the U. S. Air Force Base at Goose Bay. The rest of the population lived in 30 communities which lay outside the river basin. Most of these communities are scattered along the coast line from Forteau in the south to Cape Chidley in the north.

Only Labrador City and Wabush are significant municipal users of water in the upper part of the Churchill River basin. Both of these municipalities are local improvement districts formed to house the employees and dependents of the two mining companies. In 1966 the estimated population of Labrador City constructed by the Iron Ore Company of Canada, was 7500 persons; the estimated 1966 population of Wabusn associated with Wabush Mines, was 2600 persons.

Labrador City utilizes nearby Beverley Lake as its water supply source; the drainage area of this lake is more than adequate to meet the present average daily demands of 600,000 gallons. The water from Beverley Lake is of good quality, having a colour of 5 units, a pH of 6.4, turbidity of 1 unit, and a total hardness of 44 ppm. Treatment of the water is limited to chlorination and fluoridation. The whole of Labrador City is served by a water distribution system which, although constructed by the mining company, is leased to and operated by the municipality. There are no industrial consumers connected to the system and the consumption, with the exception of certain commercial uses, is residential in nature.

All municipal wastewaters from Labrador City are treated by means of sewage treatment plant utilizing the activated sludge process. Effluent from the treatment plant is chlorinated before discharge into Little Wabush Lake. The rated capacity of the treatment plant is 333,000 gallons per day. No data are available as to the efficiency of treatment by the plant.

The municipality of Wabush takes its water from Wahnahnish Lake which is adequate for the present and forecast water demands. Although no chemical analyses of the water are available, its quality appears to be excellent. The municipality is completely residential and is entirely served by a water distribution system. Consumption is estimated at 50,000 gallons per day by municipal officials. This averages only 21 gallons per capita per day and appears to be an erroneous estimate.

Wastewaters from the municipality are treated by a primary sewage treatment plant and the effluent is chlorinated prior to discharge into Jean Lake.

The two communities in the lower basin, Happy Valley and Goose Bay, are located near the river mouth and are about three miles apart as shown in Figure 28-2.

A striking physical feature of this area is the sand overburden which extends for miles around the townsites and up the Churchill River valley. The sand has created problems in the water supply systems serving the communities.

There are three separate water supply and sewage disposal systems in the area: one is for the town of Happy Valley, and the other two are for the Royal Canadian Air Force and the United States Air Force personnel at Goose Bay.

The town of Happy Valley, which has had a municipal government since 1966, uses the Churchill River as a source of water supply and as a receiving body for the raw sewage. The town water and sewer system is less than four years old. Water is pumped from the river to the town from a plant which was commissioned in 1966. Numerous problems have occurred because of sand entering the supply system at the pumping plant.

The capacity of the system is about 0.5 million gallons per day, and it serves 8 00 of the 875 dwellings. The peak daily demand has been recorded at 400,000 gallons and the peak hourly demand at 27,000 gallons.

Sewers, connected to 800 of the dwellings, carry the untreated sewage to the river. In addition, individual septic tanks are utilized by about 20 dwellings. The town is experiencing blockages and freezing of the sewer system and these problems are being investigated by a consultant engaged by the municipal government. Inadequate cover and grade are probably the main causes of these operating difficulties.

There are two small industries within the community - a dry cleaning establishment and a dairy. The latter had to resort to its own ground supply system, using well points because of the sand deposits from the municipal system which were collected in milk containers.

The population of Happy Valley increased from 1,145 in 1956 to 2,861 in 1961, and presently has over 6,000 inhabitants. A flat rate of $8 per month charged to each dwelling served by the water and sewage utility is subsidized by the Provincial government making the actual cost to the inhabitants $6.40 per month.

The RCAF constructed a pumping station in 1943 on the Churchill River. Owing to the reduction in the RCAF staff now stationed at Goose Bay, the Department of Transport took over operation of the pumping station in July, 1967, to supply the remaining RCAF and British RAF personnel on the Canadian base. This pumping station has three rapid sand filters with back washing apparatus.

The capacity of this water supply system is rated at 780,000 gallons per day. The water is pumped to a reservoir system which has a 720,000 gallon capacity. The system services a present day population of about 2200 persons and operating expenses for 1966 were about $34,000.

Water quality samples taken for a 10 - year period have shown no coliform organisms present in the water.

The water supply source for the USAF area of the Base is Spring Gulch. At Spring Gulch a dam has been constructed to form a reservoir of the natural spring water and watershed runoff. (Figure 28-2) Although the capacity of the supply is not definitely known, it has been estimated at 2 million gpd. This rate of pumping has been maintained for an 8-day period without any drawdown in the reservoir level.

From Spring Gulch the water is pumped to 2 underground reservoirs located in the main base cantonment areas. The reservoirs have capacities of 200,000 and 500,000 gallons.

The reservoir pumping station draws the water from the underground reservoirs and pumps it into the distribution system. This facility is identical to the Spring Gulch pumping station.

Analysis of the Spring Gulch water shows that no treatment is required. A chlorine residual is maintained in the domestic water by a proportioning type chlorinator located within the Spring Gulch pumping station.

Water for the outlying areas is hauled to the sites by water trucks. The USAF and RCAF water systems are interconnected by a 10-inch loop which runs through the USAF cantonment area and ties into the Canadian system. This loop provides water to both areas in the event of the failure of either the USAF or Canadian pumping stations.

The capital costs of the pumping plant treatment plant and the transmission and distribution system for the USAF base amounts to $2.6 million. Operating expenses of the system were not readily available.

Sewerage from the Air Force systems is not treated.

A camp site to accommodate the first workers at the Churchill Falls project was set up in 1966. Through 1967 the townsite was expanded to include a bank, school, mess hall, pub, communications centres, and the like. In the spring of 1968, a start was made on a permanent community which will house more than 1000 people who will remain at the townsite after construction finishes [11]. Information on the water and sewer facilities for this new townsite was not available up to the time of preparation of this report.

30 PLANNED AND FORECAST DEVELOPMENT

30.1 Non-Withdrawal Uses

30.1.1 Hydro Power Development

The massive size and remote location of Churchill Falls, prevented serious consideration of power development until the early 1950s [4]. The true potential of the Falls came to light only after intensive field work and comprehensive engineering studies undertaken by The Shawinigan Engineering Company Limited and Montreal Engineering Company Limited for British Newfoundland Corporation Limited in the period 1954 to 1958 [8,9].

Several events in the last eight years have made the development of Churchill Falls a much more practical reality. The four principal events are as follows [4].

a) The opening up of the interior of Labrador to tap the rich iron ore deposits in that area;

b) The rapid advance in the technology of high voltage transmission;

c) The increase in demand for electrical energy in the eastern Canadian provinces;

d) The new policy of the Government of Canada which permits the export of large blocks of electrical energy.

Churchill Falls (Labrador) Corporation which is 72 percent owned by the British Newfoundland Corporation, is the company directly responsible for the development of the Churchill Falls power project.

The power project started in earnest almost immediately after the signing of a letter of intent in October 1966. In it Hydro-Quebec agreed to purchase almost all of Churchill Falls power in excess of a small amount (2.37 billion kwh) going to Newfoundland. Delivery to Quebec is to begin in 1972 [11].

For the Churchill Falls project, as presently envisaged, [10] a storage reservoir to regulate river flow will be formed by raising the levels of existing large lakes in the Labrador plateau as shown in Figure 28-4.

This will be accomplished by constructing a series of dykes at low points along the rims of the lakes. The storage reservoir will discharge through a control structure to the Churchill River. The regulated flow of the river will be diverted by a gated spillway structure and excavated channels to a forebay reservoir which will be formed by the construction of dykes along the south rim of a valley lying in an east-west direction parallel to the Churchill River.

The power installations will be located at the east end of the forebay. The powerhouse will be underground, and the transformers and switching station will be located above the powerhouse about one mile from the river.

The principal characteristics of the power site are given below.

Reservoir

Surface Area	2,600 sq. miles
Live Storage	1,120 bcf
Maximum Level Range	25 feet
Dykes - Total Length	30 miles
Range of Heights	10 to 50 ft.
Total Fill Volume	10,000,000 cu. yds.
Channel Excavation	1,500,000 cu. yds.
Central Structure Concrete	34,000 cu. yds.

Forebay

Surface Area	73 sq. miles
Dykes - Total Length	12 miles
Range of Heights	10 to 106 ft.
Total Volume of Fill	10,000,000 cu yds.
Channel Excavation	4,750,000 cu. yds.
Spillway Concrete	18,000 cu. yds.

Power Installations

Gross Head	1,061 ft
Regulated Outflow	49,000 cfs
Capacity Factor [13]	75 percent
Total Rated Plant Capacity [13]	5,225,000 kw
Annual Firm Energy (Generator terminals)	34,000,000 kw hrs

Generating Units

Number [13]	11
Rated Net Head [13]	1025 ft.
Turbine Rating (Full Gate)	648,000 H.P. (modified Francis)

Penstocks

Number [13]	11
Length	1,394 ft.
Internal Diameter	20 ft. 0 in. to 12 ft. 2 in.
Total Underground Rock Excavation	2,340,000 cu. yds.
Total Power Installation Concrete	340,000 cu. yds.

The total cost of this venture, with associated transmission facilities will exceed one billion dollars [13].

In order to put this massive project into proper perspective it should be noted that the reservoir surface area of 2600 square miles is almost half the area of Lake Ontario. The 34 billion kilowatt hours per annum which will be produced at the plant busbar can be compared to the total production of hydro energy in Ontario which was less than 33 billion kwh in 1964.

The location of the dykes forming the various reservoirs in the development described below are shown in Figure 28-4. The Julian River dykes will divert the runoff from this river to the Gabbro-Ossokmanuan reservoir. The Ossokmanuan control structure and dykes divert the headwaters of the Unknown River and raise the existing reservoir of the Twin Falls project to a maximum elevation of 1555 feet. A drawdown of 15 feet on this reservoir provides an estimated storage of 100 bcf. A control structure located at the outlet of Gabbro Lake will regulate flows from this reservoir and divert them to the Sandgirt Lobstick-Michikamau Reservoir which will have a maximum level of 1526 feet and provide the remaining storage of 1020 bcf. The Freemont Lake dykes cut off the present outflow from Michikamau Lake to the Naskaupi River diverting it to the Churchill basin. The Sail Lake dykes divert part of the headwaters of the Canairiktok River to the Churchill basin. A channel will be excavated through to the low ridge separating the existing Michikamau and Lobstick lakes.

The Naskaupi and Canairiktok River diversions shown on Figure 28-4 will be about 4380 square miles or 35 percent of the combined natural drainage area of 12,400 square miles of these two rivers which are not a natural part of the Churchill River drainage.

About 360 square miles of the Julian River, a small tributary of the lower Churchill basin, will be diverted into the Upper Churchill basin as shown in Figure 28-4.

The control structure at the outlet of the Sandgirt-Lobstick Lake will regulate the discharge of the Churchill River as required for power generation. A spillway structure and adjoining dykes will be constructed about 5 miles upstream of the Falls to divert this regulated discharge to the powerhouse forebay. The maximum water elevation in the forebay is 1455 feet with a maximum drawdown of 10 feet. Channels will be excavated through the low ridges between the Churchill River and the forebay reservoir which will be formed by a series of dykes along the south rim of the valley lying in an east-west direction parallel to the Churchill River between the Falls and the North River.

In addition to the Churchill Falls power site, downstream sites at Gull Island and Muskrat Falls would add approximately three million horsepower to the six million which can be generated at the Falls site.[10] The total energy potential of the Churchill River is about 50 billion kwh per annum[4]. A two-stage development of the 394 feet of head available in the lower Churchill basin is envisaged. The location of power sites at Gull Island and Muskrat Falls which have been picked out for possible future development are shown in Figure 28-4.

The Churchill Falls development will provide about 2 billion kwh for the mines at Wabush and Labrador City. In the lower basin, at Goose Bay, electrical needs are supplied by diesel generation owned and operated individually by the RCAF and USAF. At the nearby community of Happy Valley, electricity has been generated by the municipality with its own diesels since 1958.

Great dissatisfaction has been expressed by the residents of Happy Valley at the high cost of electricity in the area[12]. It is unlikely that the residents of this community in the lower Churchill Basin will receive energy from the Churchill Falls site since the amount of energy available to the Island of Newfoundland from this site (2. 37 billion kwh) must be transmitted a long distance.

Residents of the Happy Valley-Goose Bay area may have to rely on the lower Churchill hydro site for an economical power source or the community may be able to utilize power developed primarily for the proposed chip mill in the area. Preliminary investigations are currently under way for the development of a 10Mw hydro plant for use by the chip mill which is scheduled for the early 1970's. The chip mill is to supply wood chips for the future mills at Stephenville and Come By Chance.

30.1.2 Fisheries

The policy of the Department of Fisheries for the fishery resources in this basin is based on the following premises:

a) The desirability of protecting the limited anadromous fish resources in the lower Churchill River and, if possible, expanding its base by constructing fish passage facilities over Muskrat Falls in conjunction with its development for hydro power, if examination indicates this procedure to be biologically and economically justified.

b) A long-term policy will look toward the feasibility of establishing viable commercial fisheries in the larger waters of the basin to exploit a resource of resident freshwater species, particularly lake trout and white fish which is presently going to waste.

c) The Departmental policy will be to control as far as possible unnecessary pollution caused by existing industry or new industry which may be developed in the future.

There is a distinct possibility of developing commercial fisheries for lake trout and white fish in major lakes and in the main hydro reservoir for the Churchill Falls Development. This reservoir, when stabilized, should have an interesting commercial fisheries potential. One of the main problems presently facing the development of a commercial fishery in the basin is in the development of a market for the product rather than the developing the stocks themselves. Increased mining pollution could have adverse effects on future commercial fisheries in the major lakes downstream of the IOCo mine.

The fresh water species in the basin are receiving almost no exploitation at this time. There appears to be no good reason why future recreational fishing cannot be greatly increased.

30.1.3 Log Driving

The access road which parallels a good part of the river from Goose Bay to Churchill Falls enhances the possibility of harvesting the forest resources in the basin. The potential for log driving in the main river stem under natural flow conditions is good due to the large flows available. The regulated outflow of about 49,000 cfs from the Churchill Falls plant will probably permit log driving in the lower main stem without the use of small dams to augment low flows.

30.1.4 Recreation, Tourism, and Wildlife

By 1972, an investment exceeding $ 1 billion will have been made to enable the basin's rich mineral resources and low cost electrical energy to flow to the markets of the world. The tourism potential of the basin will be greatly enhanced by the necessary road, rail, airport, and community facilities which will have helped to open up the interior of the basin.

Despite these remarkable developments in the basin in such a short period, it is doubtful that the area will develop a significant tourist trade in the study period, that is, up to 1981. This is due to the remoteness and sparse settlement in this vast basin area and to some extent the climatic conditions.

It should be noted that the hydro development, while opening up the interior of the basin, has at the same time removed what is probably the most impressive and valuable natural attraction to tourism - that of Churchill Falls itself. It is conceivable, when one reviews the remarkable developments that are presently under way in the basin, that in the years beyond 1981 flow releases from the forebay spillway will be required during certain periods to provide tourists with a view of the Falls.

30.1.5 Navigation

The possibility of commercial navigation in the river will also be enhanced by the increase in the low flows due to the storages available upstream of the Churchill Falls plant, however, the navigation season is likely to be less than six months. Provided future navigation warrants the expenditure, by-pass facilities at the lower falls would open up many miles of the river upstream. The actual length of river made available to navigation depends on the elevation of the reservoir created by the future power dam at Muskrat Falls. Expenditures for navigation facilities on the river could very well depend on the location of new mining developments in the area upstream of Muskrat Falls.

30.2 Withdrawal Uses

30.2.1 Mining

The Iron Ore Company of Canada in 1968 will be commissioning an additional concentrator facility bringing the total capacity to 10,000,000 long tons of concentrated ore per year. Water consumption for concentrating and pelletizing this additional ore will be 26 million gpd making the total water requirements of this mining complex approximately 50 million gpd. All water requirements will be met from Wabush Lake which will continue to receive all wastewaters.

Expansion of the capacity of Wabush Mines is planned but the magnitude and timing of such expansion is not known. Any expansion is probably limited at present by the fact that virtually no surplus power is available from the Twin Falls development.

A power shortage in the upper basin may develop and inhibit significant expansion of the mining development in the years 1969 to 1972 since additional power for the mines in the area will not be available from the Churchill Falls site before 1972. Water requirements for the expanded operation can be easily obtained from the present source, Little Wabush Lake. No doubt Flora Lake will continue to be the receiving body for wastewaters from the mining complex although complete isolation of the area will be required.

30.2.2 Agriculture

The future for agriculture in the area is difficult to assess because of the potential of the land for cultivation has not been studied. However, land is probably unsuitable for agriculture in the upper basin because of the high proportion of swamp, lakes, and land covered with boulders (Figures 28-5 to 28 -7) [5].

The lower basin may be better suited to agriculture but the remoteness of the area will probably eliminate significant agriculture development in the foreseeable future.

30.2.3 Population and Municipal Water Supply and Wastewater Disposal

For purposes of this section a population by 1981 of 63,100 was projected for Labrador (Volume Three, Section 21). The population of the communities which lie outside the Churchill River basin were assumed to remain relatively static over the forecast period which resulted in a population project for the basin of an estimated 54,000, a substantial increase from the 1966 level of 14,400 persons (excluding USAF personnel).

While this forecast is optimistic, it is not without rational basis. Considering first the total population of Labrador, the projected figure of 63,100 reflects a considerable moderation in the growth rate which took place between 1961 and 1966. Had this rate been projected to 1981, the population would have been estimated at approximately 86,000.

The second assumption which provides a basis for the projection, and which is confined to the river basin projection, is the fact that a shift will take place in the household structure. In 1966 disposable income per household was $15,930 compared to the Provincial average of

$6,320. This relationship indicates that a large proportion of households do not include dependents, and should not be confused with family units. Development of infrastructure in the basin will not only create jobs but may well encourage a less transient labour force structure. In effect the population projection assumes a movement of dependents into the river basin. Further, the forecast implies a growth in the mining sector and the establishment of a primary forest industry which will be reflected in an increased employment. The primary forestry activity will support a chip mill at Happy Valley.

Finally it is assumed that no major change will take place in the employment generated by the U.S. Air Force Base at Goose Bay which has an on-base population of approximately 7300. The closure of this base would require a downward adjustment in the population projection of between 5000 and 10,000 people in addition to the American personnel withdrawn.

As an order of magnitude indication of areal distribution, it is considered that the 1981 population of the upper basin will be about 30,000 while the lower basin will support a population of about 25,000 or about 32,000 including Americans living on base.

Increasing population will create pressures on the water resource for recreational use; this demand can be met quite easily by the numerous lakes and river systems in the immediate area of Labrador City and Wabush. It will be necessary, however, to ensure that the drainage areas of Beverley Lake and Wahnahnish Lake, the sources of water for Labrador City and Wabush, are not utilized for recreational pursuits; or if they are, that such use is carefully controlled in order to maintain the bacteriological quality of these waters.

Modifications to the water and sewer system in the community of Happy Valley are required. A total of about $250,000 may be required to modify the sewerage system, and another $200,000 may be required to include sand filters in the pumping plant according to information received from the municipal authorities.

About 4500 men are expected to be employed directly at various construction sites in the Churchill Falls area by 1970 at the peak of activity. Total population at the project townsite will then be about 7000 persons. After 1974, at the completion of construction, the permanent townsite is expected to have a population of 1000 [11]. The surface water supplies in the area are capable of providing the water demands from this new townsite.

31 CONCLUSIONS AND RECOMMENDATIONS

31.1 Conclusions

a) The most important use of the water resources of the basin is hydro power. Significant development of forest exploitation in the area can be expected by 1981, and it is expected that a proportion of the logs may have to be transported by log driving.

b) There is a significant potential for resident fresh water fish which can be used for attracting tourists or even for developing a commercial inland fishery. There is a possibility of increasing the present Atlantic salmon fish run, if facilities are provided to overcome the natural barrier at Muskrat Falls.

c) Iron ore mining and beneficiation is the major present day economic activity in the basin. It will undoubtedly expand further and thus require increased development of hydro-electric power. There are no problems in supplying the water required for this mining activity. However, the wastes it generates have polluted the waters of two lakes and may generate further pollution in other bodies of water, especially with further mining development. If other types of ore should be exploited, similar water quality problems might be expected.

d) The major degradation in water quality from the mining demand eventually can materially reduce the fisheries and tourism potential. To control this consumptive use to even the minimum level today would require an investment of wastewater in the order of $11,000,000, with an annual operating cost of $400,000. It should be pointed out that, because of the toxic aspects of this consumptive use, quality recovery through treatment may in a few years be impossible.

e) The population of the basin will expand rapidly in the next decade if the forecast development in hydro-electric power, mining, forestry, and related activities materializes. However, water supply and sewage disposal problems related to population increase will not be significant from the viewpoint of water resources and practice to date has been to keep them under reasonable control through the installation of primary-type waste-water treatment plants. No treatment facility exists at Happy Valley nor in either of the Goose Bay systems. An estimated capital investment in the order of $3,100,000 would be required in these instances to control quality reduction of the resource to an acceptable level in the future. The annual operation and maintenance costs of such facilities are estimated to be $65,000.

f) Complex conflicts of interest may develop between the different water resources users in the basin, although some community of interest may also develop.

The most significant conflict of interest which may develop in the Churchill River basin is between mining and/or log driving on the one hand and fisheries on the other. This conflict of interest already exists in the upper portion of the basin.

The most important community of interest may develop between hydro-electric energy production and log driving, since the regulated flow of hydro-electric plants could be useful for log driving in the lower river channel.

Although hydro-electric power may have a negative effect on tourism due to the disappearance of the Churchill Falls, it will also have a positive effect since many tourists will be interested in visiting the impressive hydro-electric facilities, and the regulated flows may enhance the possibilities of using pleasure craft downstream along the main river stem.

31.2 Recommendations

a) While the development of the basin's resources is already proceeding apace, the complex nature of the water related development problems must be recognized. A comprehensive review of all natural resources in the basin, especially in the field of hydro-electric energy, minerals, forestry, and fishery is recommended to obtain a complete picture of the development possibilities and problems and to enable harmonious development of these resources.

Such a review would of necessity require the co-operation of the various private interests working in the basin and the disclosure of basic information which has not yet been made available to the planning agencies of Government.

b) The multiple inter-relationships which exist in the development of the basin from the common use of hydro-electric power and other water resources indicate that the best solution for planning, solving conflicts of interest, and taking advantage of community of interests would be through development of a comprehensive water resources management plan for the basin. It is recommended that this be given a high Provincial priority. Agreed

c) Even before a comphehensive management plan has been developed for the basin, potential conflicts of water use must be recognized; and it is recommended that approval be given only to those developments which are not subject to major controversy or to significant modification following completion of a water management study. Whenever possible, without significant increase in cost, provisions for the possibility of satisfying requirements for other water users should be included in the projects (fish passage facilities, water releases at diverted rivers to satisfy fishing or log driving requirements).

d) The re-examination of the tailings disposal system by the iron ore industry with a view to reducing pollution of the Churchill River headwaters is recommended since the future use of area for fisheries and recreation and tourism may be seriously affected by this pollution. Consideration should be given in this re-examination to the fact that the toxic aspects of these wastes may destroy the enviroment of the resource beyond recovery, if not soon controlled.

Disappointing in that a stronger recommendation re wastewater treatment is not forthcoming ((d) R) vs ((d) C) with respect to mining interests

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LIST OF FIGURES

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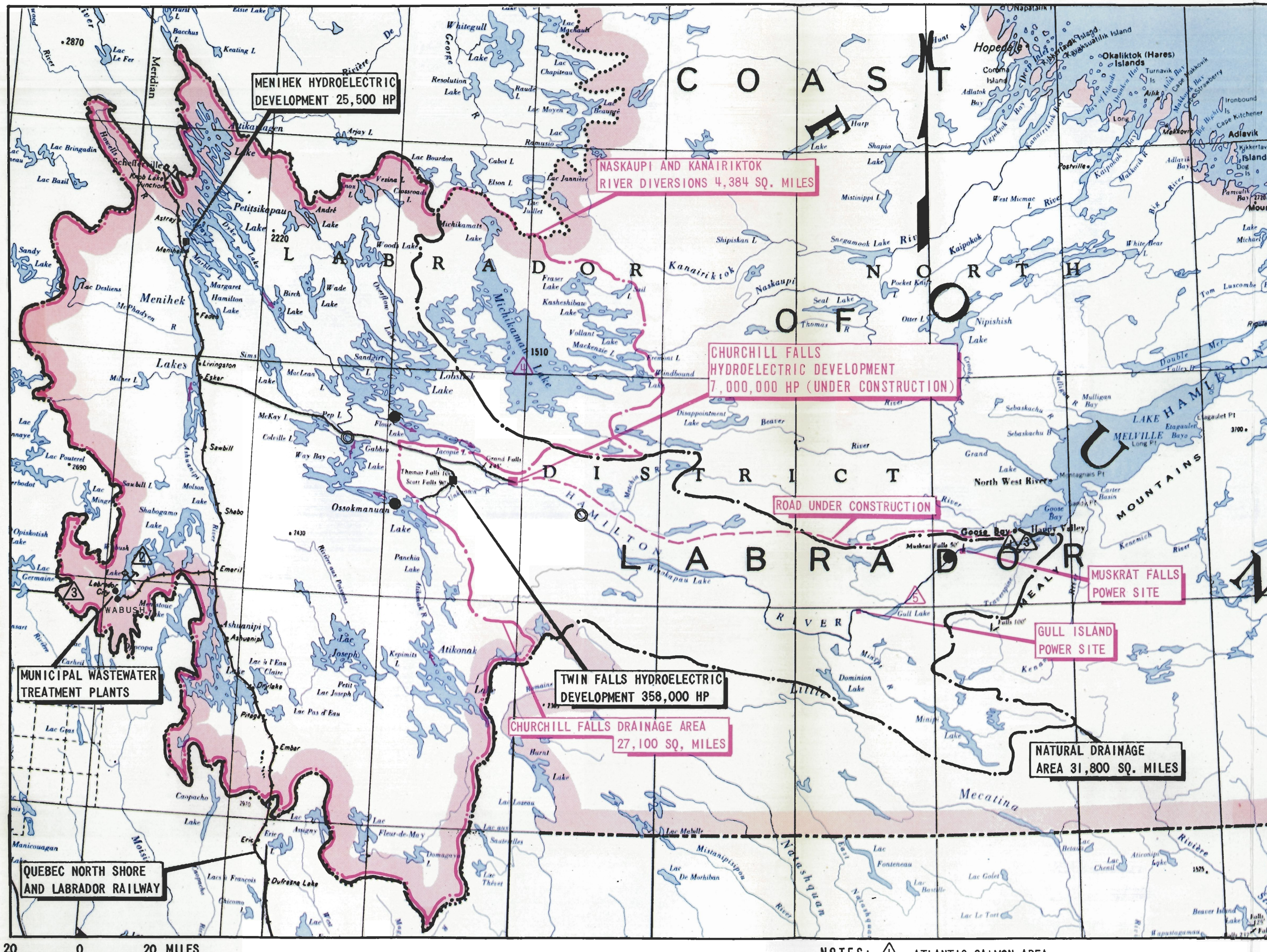
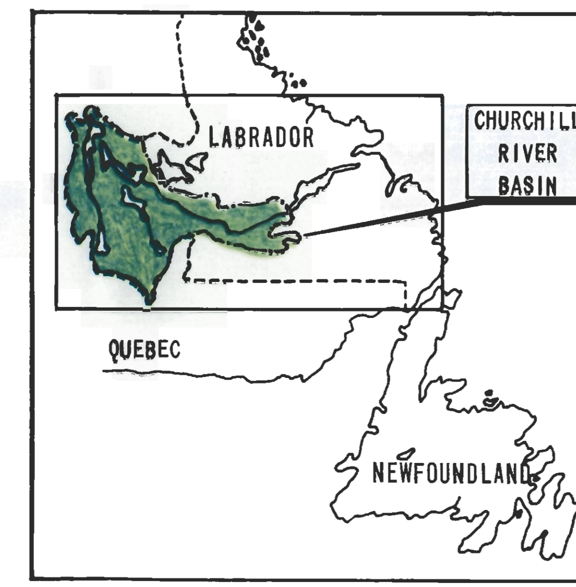


GENERAL PLAN



KEY PLAN

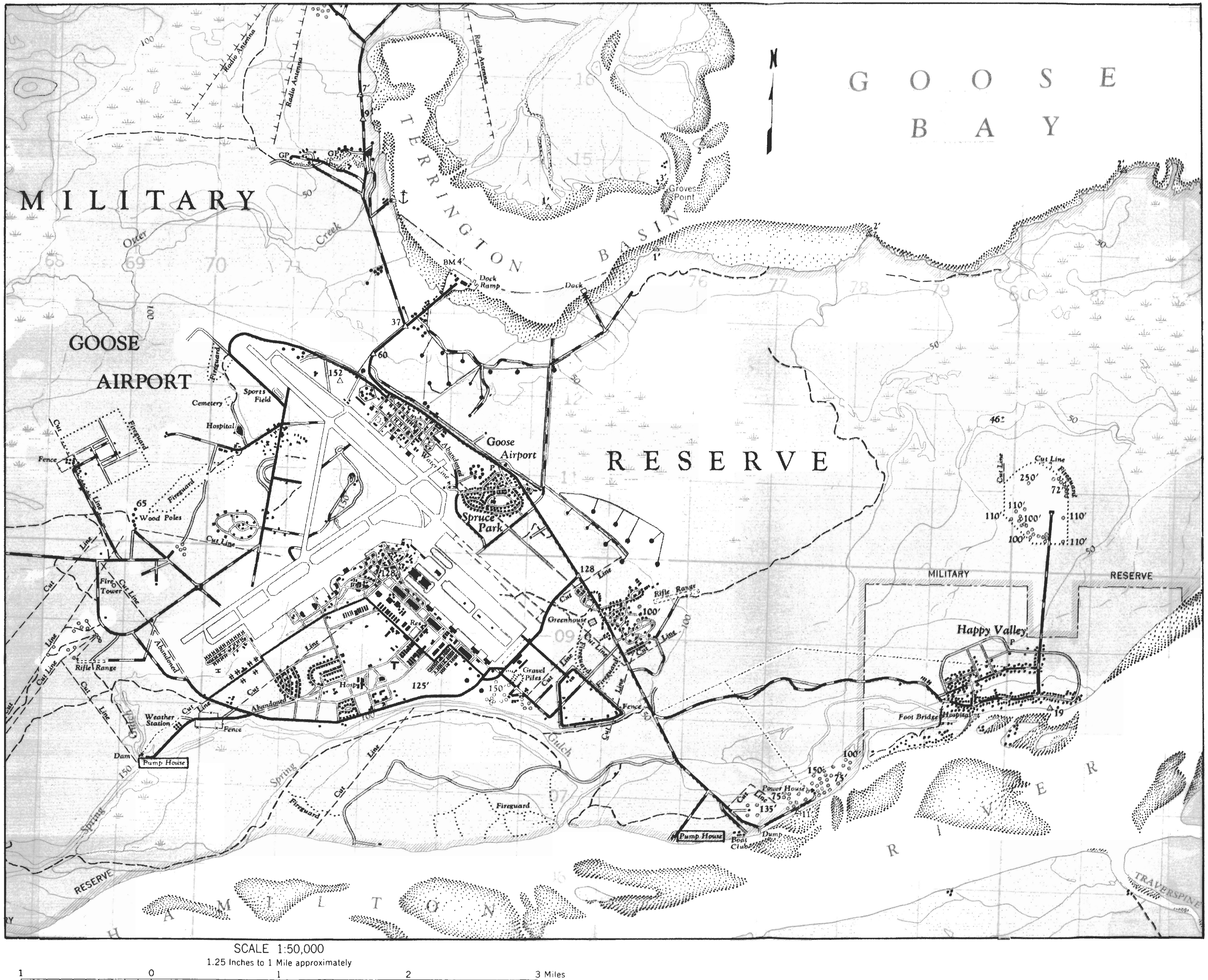
NOTES: 1) FOR CLARITY OF PRESENTATION FUTURE POWER STRUCTURES AND RESERVOIR OUTLINES NOT SHOWN

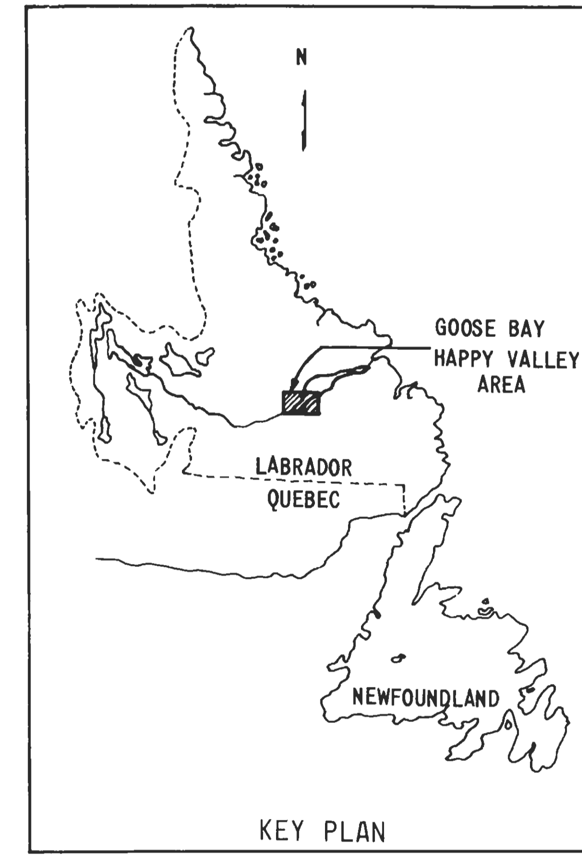
2) POTENTIAL FUTURE DEVELOPMENTS AND PROJECTS UNDER CONSTRUCTION SHOWN IN RED

NOTES:
1. ATLANTIC SALMON AREA
2. MINING POLLUTION
3. MUNICIPAL WATER SUPPLY AND WASTEWATER DISPOSAL SYSTEMS
4. COMMERCIAL FRESH WATER FISHING AREA
5. LOG DRIVING

CHURCHILL RIVER BASIN AND LABRADOR CITY STUDY AREA

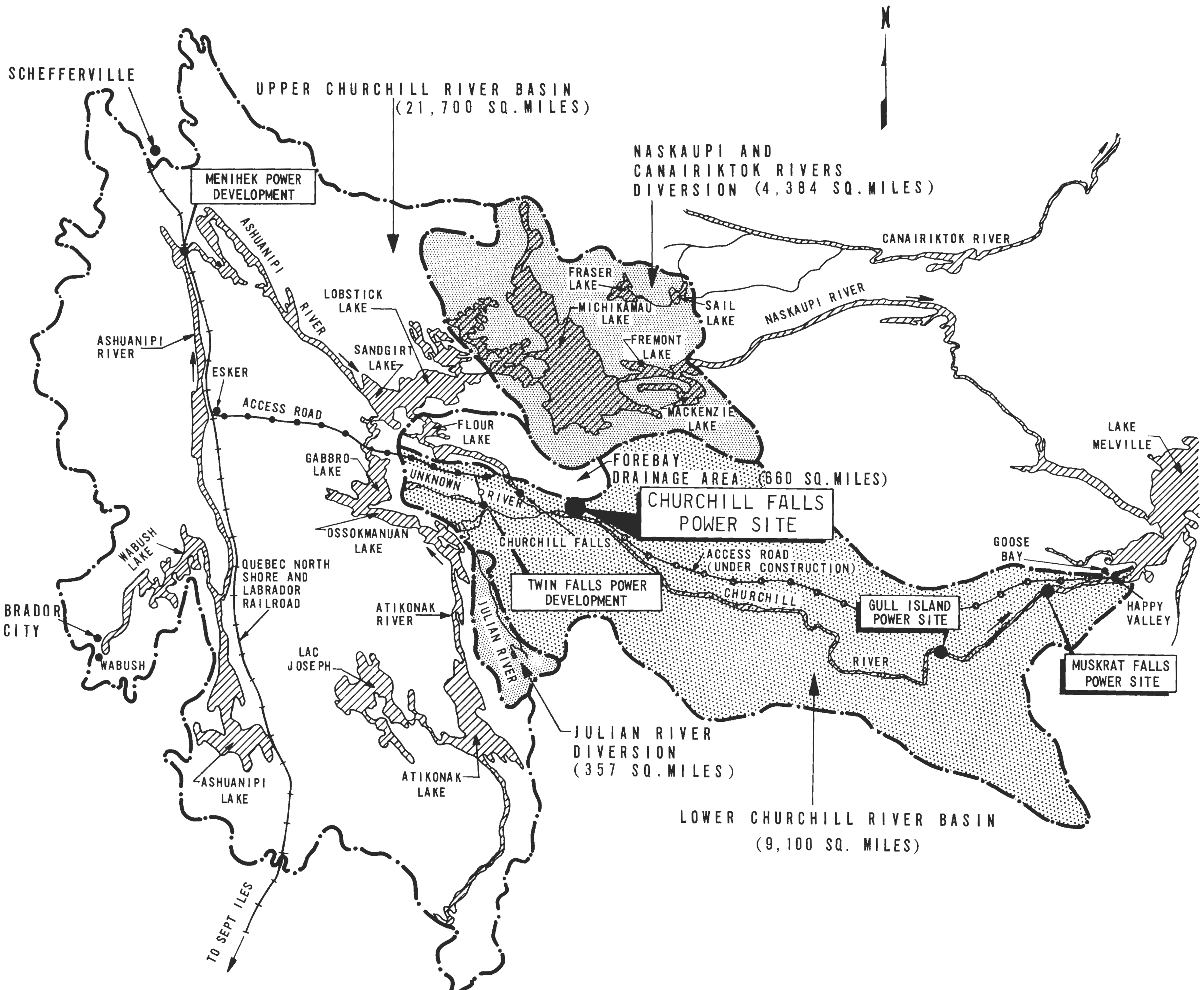
FIGURE 28-1





PLAN OF HAPPY VALLEY AND GOOSE BAY AREA

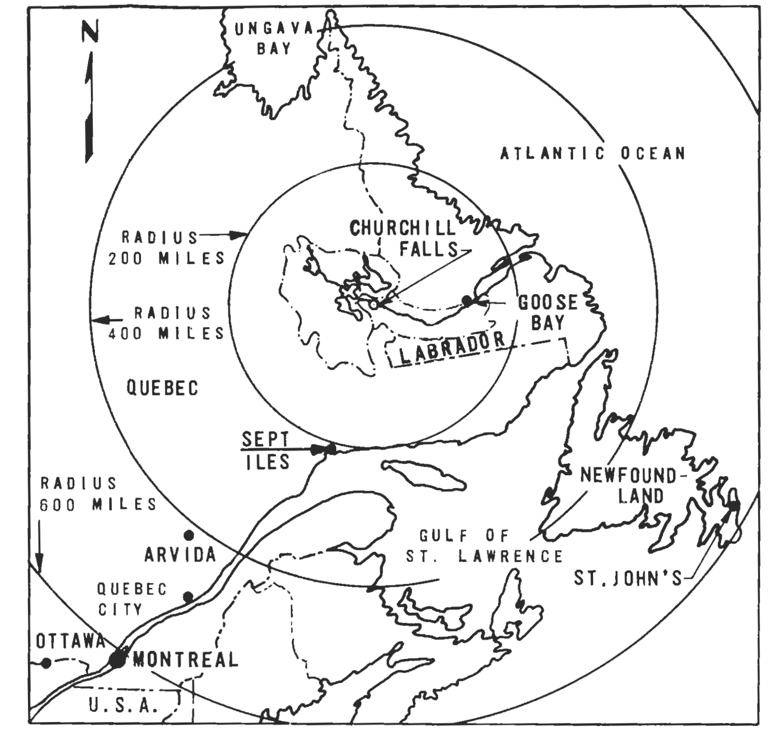
FIGURE 28-2



SCALE 20 0 20 40 60 MILES

NOTE:

1. FOR CLARITY OF PRESENTATION ONLY MAJOR LAKES AND RIVERS ARE SHOWN
2. BASIC DATA OBTAINED FROM ACRES CANADIAN BECHTEL JULY 1964 REPORT ON HAMILTON FALLS POWER PROJECT



KEY PLAN

SCALE 200 0 200 400 MILES

CHURCHILL RIVER BASIN
AND LABRADOR CITY STUDY AREA

CHURCHILL FALLS DEVELOPMENT
MAP OF DRAINAGE AREAS

FIGURE 28-3

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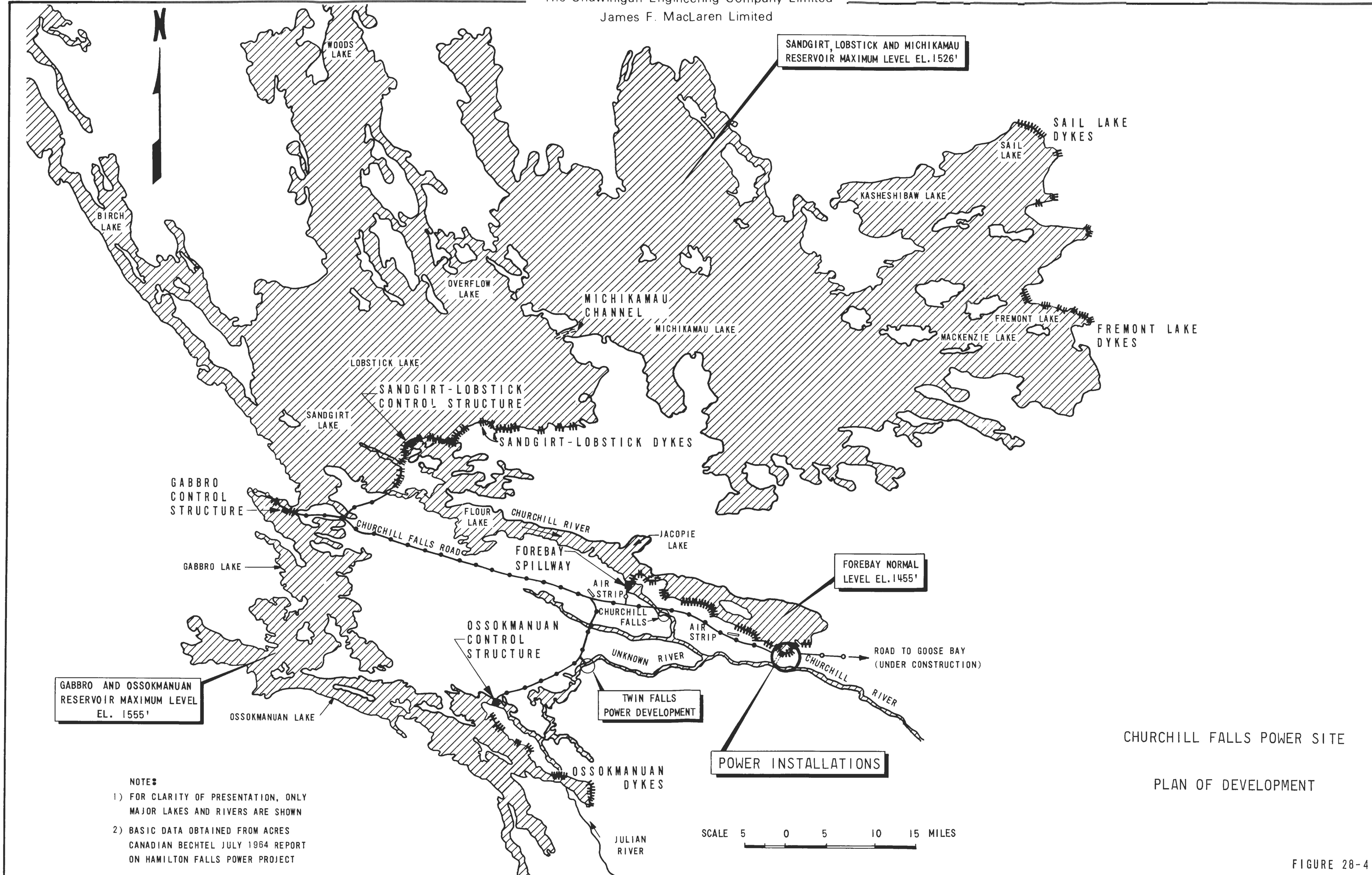

CHURCHILL FALLS POWER SITE

PLAN OF DEVELOPMENT

FIGURE 28-4

CHURCHILL RIVER BASIN AND
LABRADOR CITY STUDY AREA
SQUARE GRID DISTRIBUTION OF LAKES

FIGURE 28-5

CHURCHILL RIVER BASIN AND
LABRADOR CITY STUDY AREA
SQUARE GRID DISTRIBUTION OF BOGS
AND SWAMPS

FIGURE 28-6

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CHURCHILL RIVER BASIN AND
LABRADOR CITY STUDY AREA
SQUARE GRID DISTRIBUTION OF BARRENS

FIGURE 28-7

CHURCHILL RIVER BASIN AND
LABRADOR CITY STUDY AREA
SQUARE GRID DISTRIBUTION OF
LAND SURFACE SLOPE

FIGURE 28-8

CHURCHILL RIVER BASIN AND
LABRADOR CITY STUDY AREA
SQUARE GRID DISTRIBUTION OF ELEVATION

FIGURE 28-9

CHURCHILL RIVER BASIN AND
LABRADOR CITY STUDY AREA
SQUARE GRID DISTRIBUTION OF
MEAN ANNUAL TEMPERATURE

FIGURE 28-10

CHURCHILL RIVER BASIN AND
LABRADOR CITY STUDY AREA
SQUARE GRID DISTRIBUTION OF
MEAN ANNUAL PRECIPITATION

FIGURE 28-11

CHURCHILL RIVER BASIN AND
LABRADOR CITY STUDY AREA
SQUARE GRID DISTRIBUTION OF
MEAN ANNUAL EVAPORATION

FIGURE 28-12

CHURCHILL RIVER BASIN AND
LABRADOR CITY STUDY AREA
SQUARE GRID DISTRIBUTION OF
MEAN ANNUAL RUNOFF

FIGURE 28-13

CHURCHILL RIVER BASIN AND LABRADOR CITY STUDY AREA
GROSS HYDRO ELECTRIC POTENTIAL ON CHURCHILL RIVER

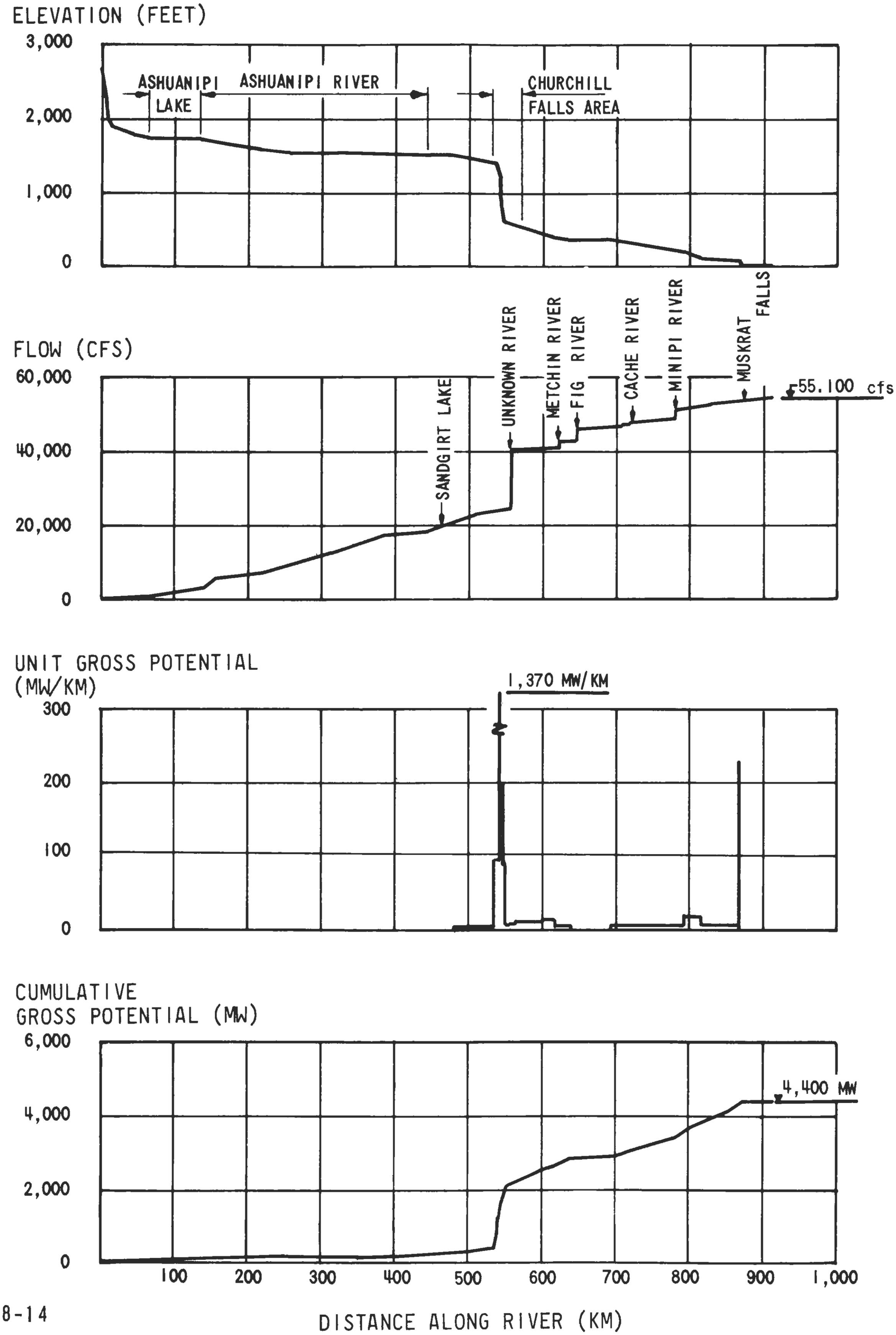

FIGURE 28-14

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CHURCHILL RIVER BASIN AND
LABRADOR CITY STUDY AREA
SQUARE GRID DISTRIBUTION OF FORESTS

FIGURE 28-15

CHURCHILL RIVER BASIN AND LABRADOR CITY STUDY AREA LOCATION OF MINING DISTRICTS AND FORESTED AREAS

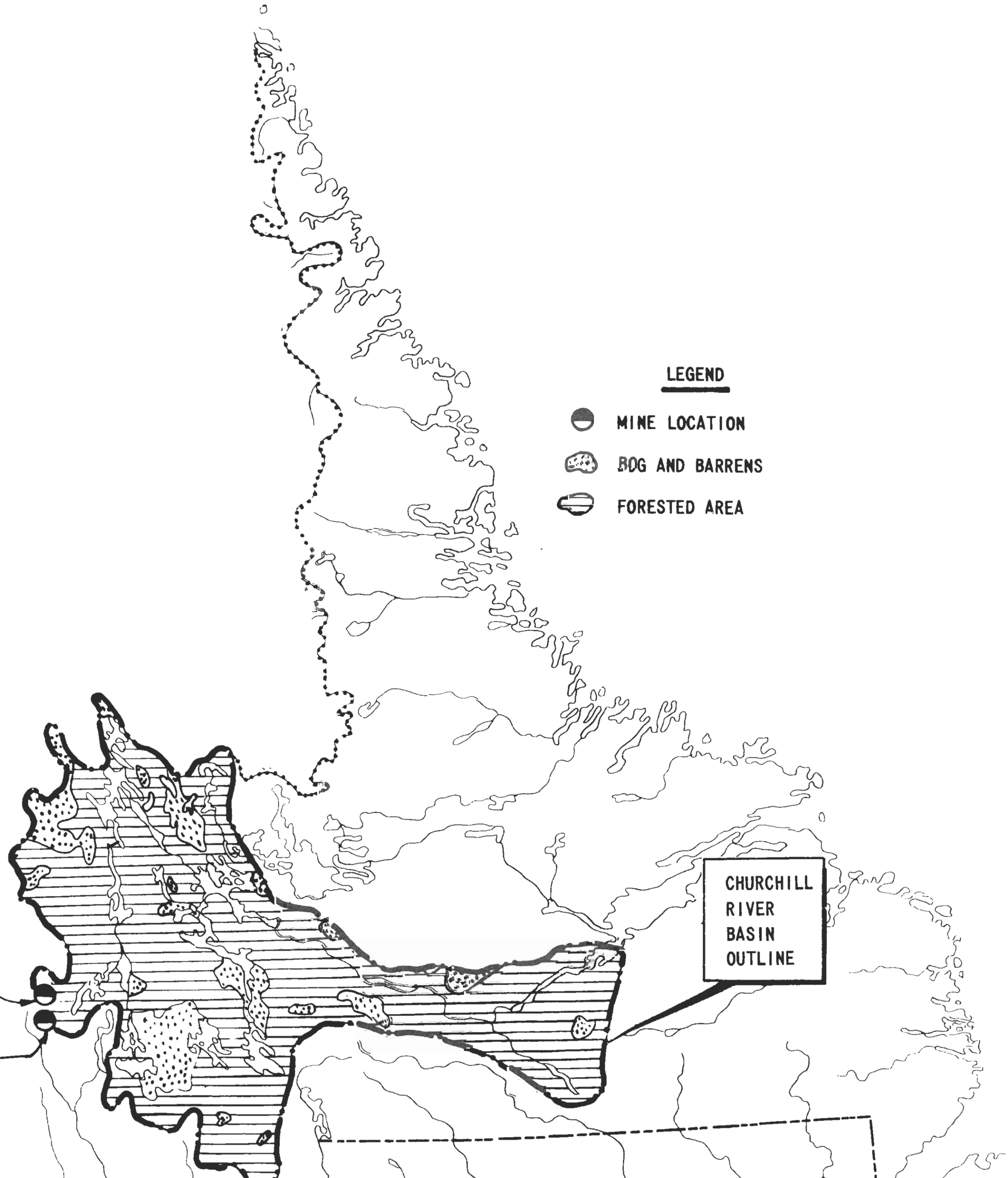
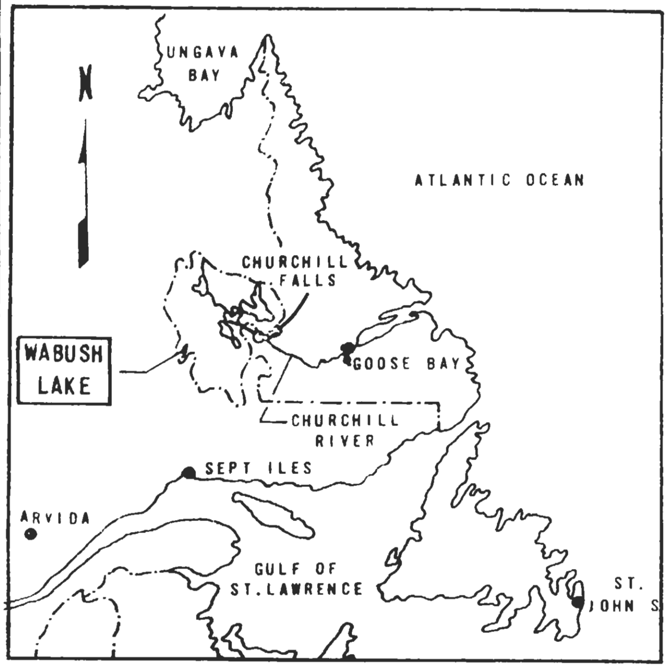
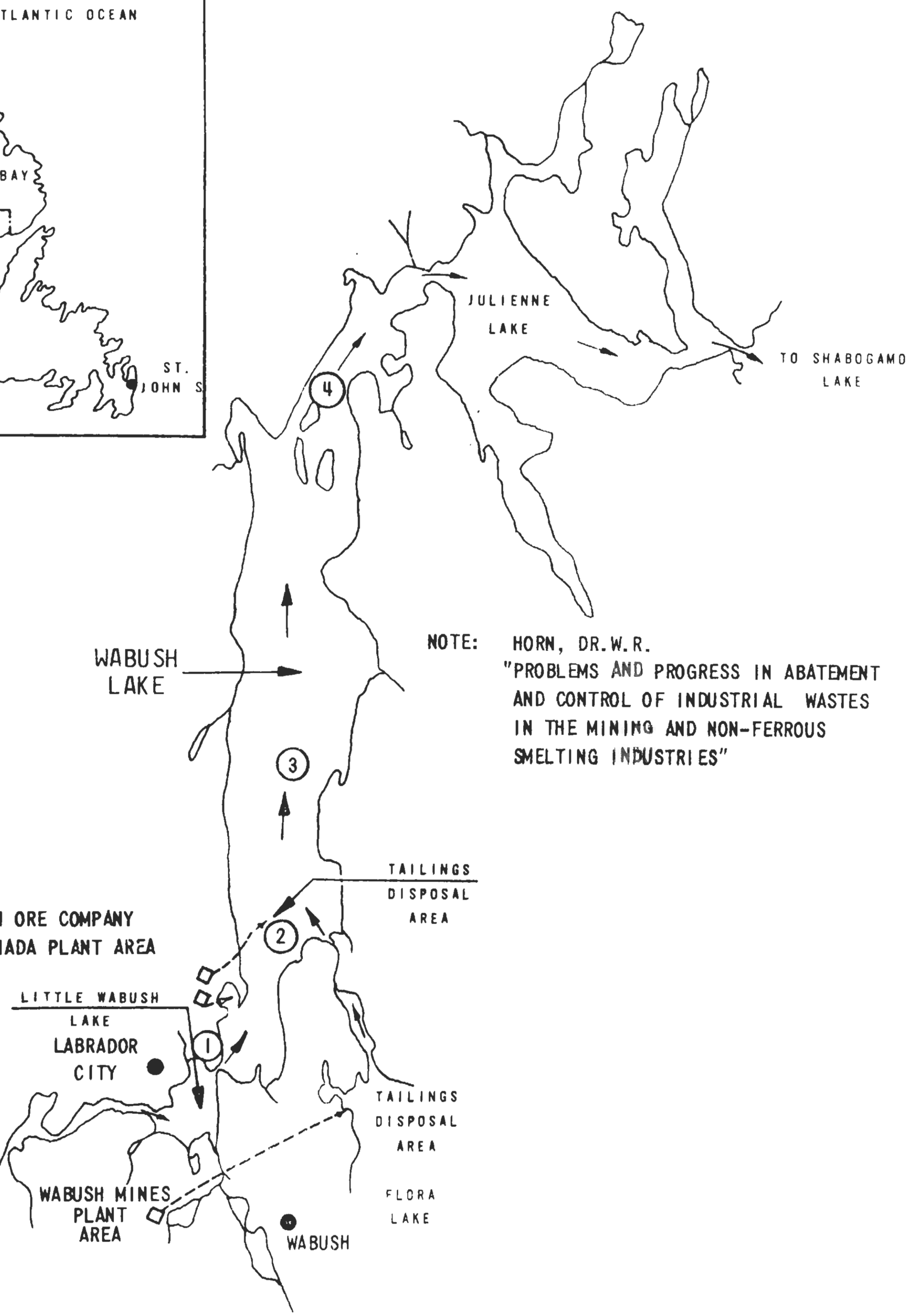


FIGURE 29-1

CHURCHILL RIVER BASIN AND LABRADOR CITY STUDY AREA
WASTEWATER DRAINAGE SYSTEM
IRON ORE COMPANY OF CANADA AND WABUSH MINES



KEY PLAN



LEGEND

(1) TO (4) WATER SAMPLE LOCATIONS

NOTE: HORN, DR. W. R.
"PROBLEMS AND PROGRESS IN ABATEMENT AND CONTROL OF INDUSTRIAL WASTES IN THE MINING AND NON-FERROUS SMELTING INDUSTRIES"

FIGURE 29-2

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LIST OF TABLES

PART VIII CHURCHILL RIVER BASIN AND LABRADOR CITY STUDY AREA

Table

SUMMARY OF HYDROLOGIC CHARACTERISTICS
CHURCHILL RIVER BASIN

I - SYNTHESIZED DATA

A. ANNUAL MEANS FOR THE TOTAL BASIN

FLOW (CFS)	RUNOFF (CFS/SQ.MI)	RUNOFF (INCHES)	ACTUAL EVAP. (INCHES)
55,800	1.8	23.8	8.2

B. MEAN MONTHLY FLOWS (Q) AND STANDARD DEVIATIONS (S) (CFS)

RIVER AND LOCATION		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
	Q													
	S													
	Q													
	S													
	Q													
	S													

C. MAXIMUM FLOWS (CFS) AND FLOOD VOLUMES (CFS DAY) OBTAINED BY THE MAXIMIZATION PROCEDURE (INSTANTANEOUS PEAKS)

RIVER AND LOCATION	MAXIMIZED RAIN ON SNOW PACK		MAXIMIZED RAIN ONLY		SNOW PACK & AVERAGE RAIN	
	PEAK	VOLUME	PEAK	VOLUME	PEAK	VOLUME

D. MAXIMUM FLOWS OBTAINED BY STATISTICAL ANALYSIS (CFS) (DAILY AVERAGES)

RIVER AND LOCATION	GENERATED BY SNOW MELT & RAIN		GENERATED BY RAIN ONLY	
	1/10000 YEARS	1/1000 YEARS	1/10000 YEARS	1/1000 YEARS

SUMMARY OF HYDROLOGIC CHARACTERISTICS
CHURCHILL RIVER BASIN

E. MINIMUM FLOWS OBTAINED FROM RECESSION CURVES (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/10 YEARS	1/20 YEARS

F. MINIMUM FLOWS OBTAINED FROM STATISTICAL ANALYSIS (CFS)

RIVER AND LOCATION	1/2 YEARS	1/5 YEARS	1/20 YEARS	1/100 YEARS

G. FULL REGULATION STORAGE

RIVER AND STATION	STORAGE (CUBIC FEET x 10^9)

II - RECORDED DATA

H. MEAN MONTHLY AND ANNUAL FLOWS (CFS)

RIVER AND STATION	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVGE
ASHUANIPI RIVER AT MENIHEK RAPIDS	13	5430	5040	4680	4680	18900	39900	22900	17100	16200	15000	10100	6990	13900
CHURCHILL RIVER AT FLOUR LAKE	12	11700	9080	7500	7040	17700	73200	59700	37100	31700	29300	23300	16100	26950
CHURCHILL RIVER AT MUSKRAT FALLS	14	23300	18600	16000	15600	62180	147700	169000	72300	63600	58500	46700	30800	60400

I. EXTREMES RECORDED (CFS)

RIVER AND STATION	MAXIMUM FLOWS			MINIMUM FLOWS		
	FLOW	DATE	COMMENTS	FLOW	DATE	COMMENTS
CHURCHILL R. AT FLOUR LAKE	107,000 CFS	JUNE 15 1958	DRAINAGE AREA = 13,100 SQ.MILES	4750 CFS	APR 21 TO 30, 1962	PERIOD OF RECORD MAY 1955 TO SEPT. 1966
CHURCHILL R. AT MUSKRAT FALLS	241,000 CFS	JUNE 27 1957	DRAINAGE AREA = 30,400 SQ.MILES	8950 CFS	MAR 27 TO APR 5/57	PERIOD OF RECORD JULY TO SEPT. 1948 AND OCT. 1953 TO SEPT. 66

CHURCHILL RIVER BASIN AND LABRADOR CITY STUDY AREA

MINING AND CONCENTRATING FLOWSHEET

		Iron Ore Company of Canada	Wabush Mines Limited
MINING	Drilling	Rotary drills Jet piercers	Rotary drills
	Blasting	Slurried explosives	ANFO explosives Slurried explosives
	Loading	10 cu. yd shovels	8 cu. yd shovels
	Truck hauling	100 ton trailer units	55 long ton trucks
	Train hauling	6 mile automated railroad	-------
CONCENTRATOR	Primary crushing	Gyratory crusher	Gyratory crusher
	Grinding	Dry autogenous	Wet autogenous
	Processing	Spirals	Spirals
		Spirals → Concentrate Spirals → Magnetic separation → Concentrate, Tailings	Spirals → Hi-tension separation → Concentrate Spirals → Sizing cyclones → Magnetic separation → Concentrate, Tailings

Source: Horn, Dr. W. R.,
"Problems and Progress in Abatement and Control of Industrial Wastes in the Mining and Non-ferrous Smelting Industries".

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