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Northern Ontario Water Resources Studies

Summary Report on Engineering Feasibility and Cost Investigations

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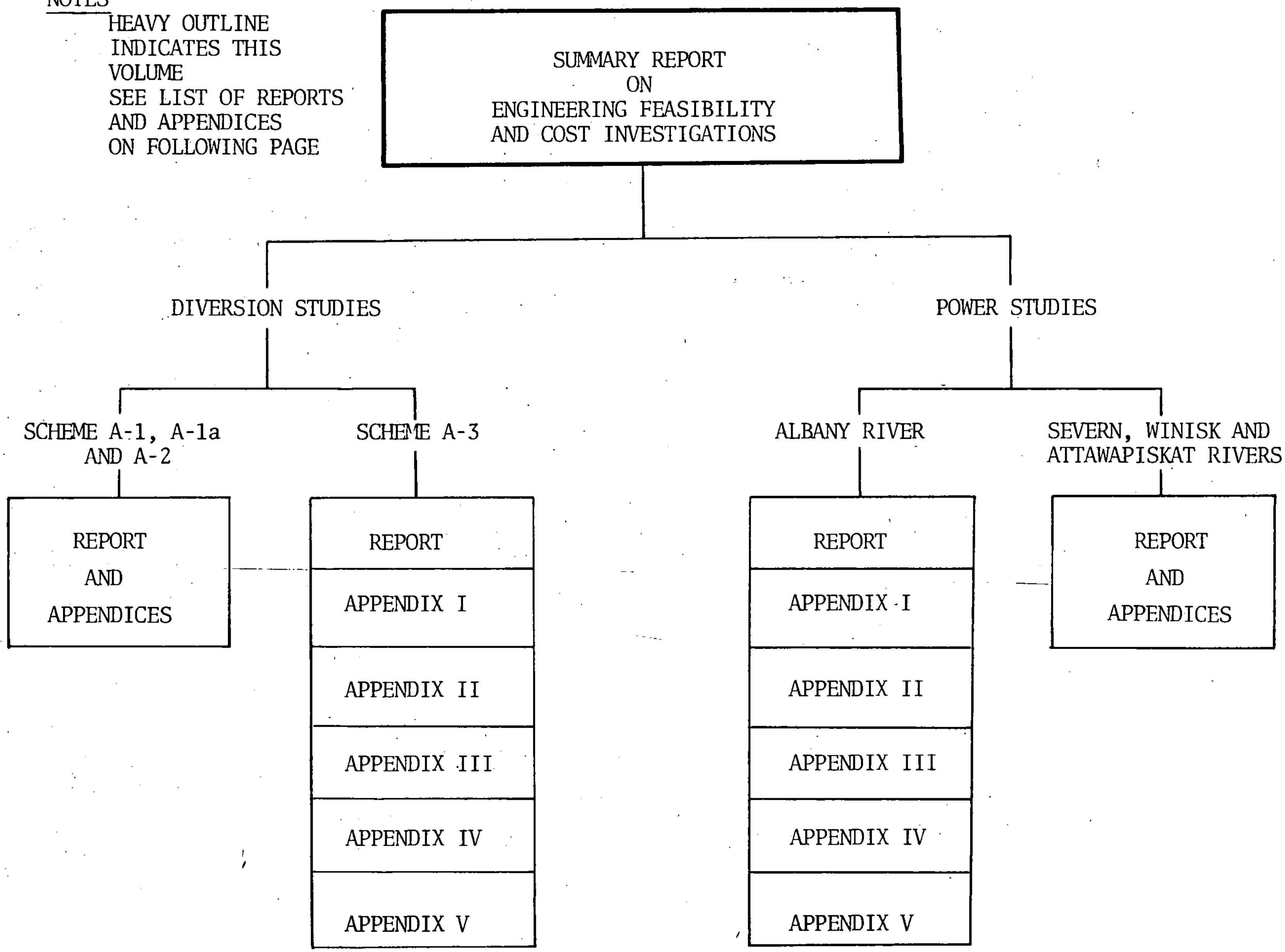

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Foreword

The Prime Minister of Canada and the Premier of Ontario announced in August, 1965, that agreement had been reached between their respective governments on the undertaking of studies of Ontario's northern water resources and related economic development. The announcement was made in simultaneous press releases which specified a general procedure for the studies. The press releases indicated that studies would be undertaken and financed separately by Canada and Ontario and would be co-ordinated by a committee representing both governments. This Co-ordinating Committee would arrange the complete exchange of all information gathered in the studies and insure against the duplication of effort by federal and provincial agencies involved.

The Co-ordinating Committee, consisting of three members appointed by the provincial government and three appointed by the federal government, held preliminary meetings in December, 1965, and February, 1966 to reach agreement on its own terms of reference; to prepare a statement of objectives for the studies and to co-ordinate arrangements for studies required to meet the objectives of the federal and provincial agencies.

Terms of reference agreed upon by the Committee were as follows:

(a) To ensure co-ordination in the arrangement of studies to avoid omissions, overlapping or duplication.

(b) To facilitate the exchange of data and the results of studies. It is the Committee's view that this includes an opportunity to review and comment on drafts of final reports.

(c) To report to the respective governments on the progress of studies at intervals of six months, (May and November).

The Committee's statement of objective for the studies reads as follows:

"With respect to waters draining into James Bay and Hudson Bay in Ontario, to assess the quantity and quality of water resources for all purposes; to determine present and future requirements for such waters; and to assess alternative possibilities for the utilization of such waters locally or elsewhere through diversions."

Hydrologic and water quality studies were the responsibility of the Ontario Water Resources Commission which now forms a part of the Ontario Ministry of the Environment. The Engineering Division, which now provides water resources engineering support to the Federal Department of the Environment, was responsible for engineering feasibility and cost studies required for an assessment of various possibilities for water resources development. The Committee decided that socio-economic studies related to Ontario's northern water resources would be carried out by a provincial planning group which is now in the Ontario Ministry of Treasury, Economics and Intergovernmental Affairs, and a federal group now in the Federal Department of the Environment. It was intended that the provincial group would study items of mainly provincial concern while any studies by the federal group would be limited to matters of mainly national and international concern. The two groups set up a sub-committee to facilitate co-ordination and the exchange of information in the socio-economic studies.

The Co-ordinating Committee agreed that the report, on northern Ontario water resources would include a statement on socio-economic aspects of the work. The Committee agreed that, in view of the inventory nature of the studies and in view of the fact that neither of the governments concerned has indicated that large scale development of Ontario's northern water resources is imminent or urgent, detailed socio-economic studies for all development possibilities could not be justified. If, when results of the current studies have been reviewed, it appears that one or more possibilities are of sufficient interest to warrant more detailed investigation, this further work would include environmental studies.

Northern Ontario Water Resources Studies

Summary Report on Engineering Feasibility and Cost Investigations

Chapter I

Introduction

1.1 General

This report presents a summary of the results of field and office engineering investigations carried out by the Federal Government under a 1965 agreement with Ontario for studies of the province's northern water resources and related economic development. Other work by federal and provincial agencies under the 1965 agreement includes hydrologic, water quality and socio-economic studies. Information collected in these studies is of an inventory nature intended to contribute to a basis for future government policies on the water resources concerned. Study results may also be used to assess the scope of environmental investigations which will be required before any proposal for the development of these water resources can be considered.

1.2 General Description of the Work

Work began with a preliminary map study and field reconnaissance in August and September, 1965. A small field party carried out topographic site surveys, barometric levelling and reconnaissance surveys during the 1966 field season. More detailed investigations during the 1967, 1968 and 1969 field seasons consisted of topographic site surveys; level surveys to provide ground control for air photo mapping and to tie in various sites to the Topographic Survey level grid in Northern Ontario;

and drilling, seismic and test pit explorations. These operations were supported and augmented by mapping and soils laboratory analysis carried out on a contract basis. Related office work included the processing, analysis and plotting of field data; the preliminary layout and design of structures; the calculation of construction quantities and costs, and the preparation of reports. Engineering consultants were retained to investigate, review and report on certain aspects of the work and to provide advice on field operations and the preliminary layout and design of structures.

Drainage areas concerned in the investigations include basins of the Severn, Winisk, Attawapiskat and Albany Rivers. Together, these basins occupy 135,500 square miles or nearly 33 per cent of the total area of Ontario. When the studies began, information on geology, topography, soil conditions, hydrology, etc., for most areas of Northern Ontario was either of a very general nature or non existent. For this reason, all information which was obtained during the engineering investigations and which was considered to be of potential value for future studies of any nature, has been included in detailed reports and appendices on the work.

The above-mentioned detailed reports and appendices are listed at the beginning of the present volume and a limited number of copies have been prepared by the Water Planning and Management Branch of the Department of the Environment. The cost of reproducing this large quantity of material for public distribution would not be justified so that, as an alternative, copies presently available may be placed at selected locations for public viewing.

Chapter II

Investigation Planning

2.1 Requirement for Federal-Provincial Studies

Factors chiefly responsible for the 1965 decision of Canada and Ontario to proceed with studies of Ontario's northern water resources were:

(i) Interest in northern development had been steadily growing in Canada.

(ii) Generally, low runoff conditions occurred in many parts of Canada during the period from about 1960 to 1964. The resulting drop in lake levels and river flows worked hardships on a broad spectrum of individuals and groups including industries and municipalities; lake shore property owners; summer resort operators; the shipping industry, and organizations responsible for the generation of electrical energy.

Because of factors mentioned under (i) and (ii) above, the Federal Government was being urged by concerned individuals and organizations to enunciate a definitive national policy on water resources. Information for use in formulating such a policy was lacking for Canada's northern territories and for large areas of the provinces. For example, discharge records were not available for three major rivers, (Severn, Winisk and Attawapiskat) in Northern Ontario. Provincial needs for water resources data equal or exceed federal needs in many instances so that a federal-provincial agreement was seen as the most equitable means of obtaining the required information.

2.2 Factors Considered in Planning the Engineering Studies

In accordance with the Co-ordinating Committee's statement of objective for Northern Ontario Water Resources Studies, the engineering investigations were intended to provide information for an assessment of "alternative possibilities for the utilization of such waters locally, or elsewhere through diversions". Local utilization of water was given general consideration in office studies and field reconnaissance surveys although development possibilities related specifically to local water uses were not investigated. Present local uses of water include fishing, transportation, recreation and domestic water supplies, while small hydro power installations have been made in the past in connection with mining operations. Small hydro installations such as those which once provided power for mining developments at Pickle Lake, North Spirit Lake and Lingman Lake, and which are now abandoned, may be required to develop future mineral discoveries. Such stations may also eventually replace diesel power units now being used at larger settlements in Northern Ontario. Fish production may be improved by re-stocking a number of lakes and rivers while the tourist trade might be increased by clearing and marking old portage trails; rebuilding abandoned marine railways which once carried small boats between a number of lakes and river channels; building small dams to regulate water levels in certain lakes, and by improving camp sites. Opportunities for such projects are numerous throughout the Canadian Shield which occupies a large portion of Northern Ontario, and their development need not be preceded by extensive engineering investigations.

Development of Ontario's northern water resources for utilization elsewhere may be accomplished by (a) the installation of hydro power plants on northern rivers and the construction of transmission lines to export the energy to markets in Southern Ontario, or (b) the diversion of water to Lake Winnipeg or the Great Lakes for development of power at new and existing hydro plants and to alleviate low water level conditions during dry periods. It is pointed out, however, that such diversions would have to be reduced or discontinued during periods of generally high water levels. The cost of these diversions would, therefore depend on:

(a) the extent of required alleviation measures consequential to environmental changes resulting from the diversion,

(b) the capital and annual costs of diversion work,

(c) the frequency with which diversion flows would have to be reduced or discontinued, and

(d) the value of foregone power benefits in river basins from which diversions might be made.

Obviously, condition (c) would also affect the dependability and cost of power produced from the diverted water, particularly along diversion routes.

The scale of existing diversions from Lake St. Joseph in the Albany River headwaters to Lac Seul in the Winnipeg River and Lake Winnipeg system and from upper Albany River tributaries to Lake Superior is such that they have had little effect on water levels in the large receiving lakes. Diversion flows have occasionally been reduced or discontinued, however, owing to high water level conditions in these lakes. At the same time, these diversions have been extremely advantageous to Ontario by virtue of the low cost power they have produced at plants located near load centers. However, if diversions to the Great Lakes were increased to a point where they would be effective in lake level regulation, say 40,000 to 50,000 cfs, it is unlikely that they could be fully utilized more often then about one year in ten. This is consistent with results of calculations made by the International Great Lakes Levels Board whose report to the International Joint Commission is scheduled for completion late in 1973. An indiscriminate use of large diversion flows would lead to excessively high lake levels which could be more devastating than low levels which have occurred in the past.

Few guidelines were available for the selection of diversion possibilities to be investigated. There were no reliable estimates of the monetary values of benefits which might be derived from energy generation or regulation of the Great Lakes levels so that diversion costs could not be used as a limiting factor. Agencies responsible for economic studies indicated that, for the purpose of their investigations, it would be desirable to have cost estimates for a variety of diversion projects providing the widest possible range in diversion flows.

Investigations of power development possibilities were assumed to warrant at least equal consideration with diversions because:

(i) The value of foregone power benefits should be assessed as one of the major costs of diversion.

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*Water levels in Lakes Superior and Ontario are already controlled while Lake Erie levels are affected by outflows from Lake Huron.

(ii) Development of power in Northern Ontario would be a natural alternative to diversions and could be complementary or alternative to developments such as tourism and commercial fishing.

(iii) Man's reluctance to accept socio-economic changes accompanying the production of power was beginning to restrict the development of power sites in densely populated areas, the construction of nuclear power plans, and the use of fossil fuels having a high sulphur content. These conditions were aggravated by continuing annual increases of 6 to 10 per cent or more in energy demands in industrialized countries with little prospect in site for the perfection and widespread use of a radically improved method of power production within the next 20 to 30 years. It was considered that this combination of conditions could substantially improve the general desirability of water power development in remote northern areas of Canada over the next few years.

Preliminary map studies of the Severn, Winisk, Attawapiskat, Albany and Moose River basins, completed in 1966, provided the information itemized below. A discussion of investigation planning on each item is included:

(a) Water power development in the Moose River basin was already well advanced and the more important undeveloped sites had received preliminary consideration. Thus, there was no further need for power site investigations in the basin, and, because the water resources were already beneficially committed to power production, any consideration of diversion alternatives was impracticable.

(b) With regard to the remaining four major drainage basins occupied by the Severn, Winisk, Attawapiskat and Albany Rivers, the Albany basin would hold the key to any future large scale development of Ontario's northern water resources for a number of reasons, the more important of which are:

(i) It extends from James Bay to within about 115 miles of the Manitoba boundary and separates the remaining three basins from potential markets for water or electrical energy to the south.

(ii) It contains approximately 39 per cent of the total area drained by the four major rivers and produces 45 per cent of the estimated total runoff.

(iii) The physiography of Northwestern Ontario favours southeasterly diversions to the Albany River from the remaining three basins while affording little opportunity for northward diversions from the Albany River.

For these reasons it was concluded that a major portion of the engineering feasibility investigations should be devoted to the Albany River basin.

(c) The four northern Ontario rivers in the study area have numerous rapids and low falls in their upper reaches but, in the lower 150 to 200 miles of channel, where higher flows occur, gradients are remarkably uniform, averaging from $2\frac{1}{2}$ to

3 feet per mile. The natural concentration of flow or fall in any of these channels is insufficient to provide a particularly attractive development possibility for the large scale export of either water or electrical energy. In the upper Albany River drainage system, where smaller schemes could be developed at low cost, three projects, consisting of the Lake St. Joseph, Ogoki and Long Lake diversions, have already been completed. These three diversions affect a total drainage area of nearly 12,000 square miles and the mean diversion flow from this area in the 10-year period between January 1, 1961 to December 31, 1970 was 8,640 cfs.

In planning the engineering investigations, it was assumed that existing diversions could be modified if and when such a course was considered beneficial. Also, it was concluded that the investigation of possible diversions from the Severn, Winisk and Attawapiskat Rivers to the Albany River to enhance the development potential of the latter should be considered an essential part of the engineering studies while only cursory consideration need be given to the power potential of the former three streams.

(d) Owing to the increasing use of the Great Lakes for shipping and to continuing growth in population and industries in lake shore areas, it was obvious that potential damages from low lake levels would continue to increase. The two widely advocated methods of regulating lake levels were:

1. Construction of regulating works in outlet channels from lakes Huron and Erie.

2. Diversion to the Great Lakes of water from adjacent drainage basins.

An investigation of the feasibility and cost of providing the required regulating works was undertaken by the International Joint Commission as part of a study of measures further to regulate the levels of the Great Lakes. Previous studies by the U.S. Corps of Engineers indicated that the cost of these works might be higher than could be justified through benefit-cost studies. It was therefore considered possible that demands for additional diversions to the Great Lakes from Ontario's northern rivers could substantially increase when low lake levels recur in the future. A satisfactory answer to these demands cannot be provided without reasonably firm estimates of the amounts of water obtainable through diversions, the cost of making these diversions, the added cost of diversions in the way of foregone power benefits and the effect of changes in drainage patterns and flows on socio-economic conditions in areas affected.

In view of the factors discussed above, together with the scarcity of detailed information on geology and topography in the study area, it was concluded that estimates sufficiently detailed to satisfy the requirement would, of necessity, involve drilling and seismic subsurface investigations in addition to reconnaissance and mapping. Engineering investigations, therefore, generally included drilling and seismic work in areas heavily mantled with glacial deposits, and in areas with paleozoic sedimentary bedrock which, as a foundation material, is much less reliable than precambrian rock.

2.3 Schemes Selected for Investigation

Schemes selected for consideration in the engineering feasibility investigations were divided into the following categories;

(a) Possibilities for Diversions to the Great Lakes

(i) Gravity Diversions

(ii) Pumped Diversions

(b) Possibilities for Gravity Diversions to Lake Winnipeg.

(c) Possibilities for Diversions to the Albany River's Main Channel.

(d) Assessment of the Albany River's Power Potential.

(e) Assessment of Power Development Possibilities on the Severn, Winisk and Attawapiskat Rivers.

Investigations carried out for development possibilities in each of these categories are described in the following chapters.

2.4 Mapping and Field Work

Plates Nos. 1, 2 and 3 provide a summary of field work and mapping completed in connection with engineering feasibility and cost studies of water resources development possibilities in northern Ontario. Plate No. 1 indicates areas covered by aerial photography along middle and lower reaches of the Severn, Winisk, Attawapiskat and Albany Rivers; in scattered small areas throughout the headwaters of these rivers and along possible diversion routes. Plate No. 1 also indicates that about half of the area photographed, including the Albany River from James Bay to Eskakwa Falls, was controlled, for mapping purposes, by the APR (Air Profile Recorder) method. This control was used for mapping in the Upper

Kenogami River Basin; at the Frenchman, Washi, Kagiami and Martin power sites on the Albany River and for most mapping along a diversion route between Winisk Lake and the Albany River (see Plates Nos. 2 and 11). Results obtained from APR work were not considered sufficiently accurate for the 10-foot contour interval used in mapping. These contours should therefore, be treated as form lines. Control for all other mapping indicated on plate No. 2 was provided by either ground surveys, altimetry, or an airborne control survey method. Most sites controlled by any one of the latter three methods were investigated in the field. Plate No. 3 indicates where field operations were carried out together with the extent of seismic and drilling work completed at each location.

Chapter III

Investigations of Possibilities for Diversions to the Great Lakes

3.1 General

This chapter outlines the field and office investigations of possible gravity and pumped diversions from Northern Ontario to the Great Lakes. Investigations of schemes for pumped diversions did not proceed beyond the preliminary map studies of various routes reported in this chapter. Detailed descriptions of investigations of gravity diversion possibilities, together with investigation results, are described in:

(i) Report on Upper Albany River Diversion Possibilities, Schemes A-1, A-1a and A-2.

(ii) Report on Diversion Scheme A-3.

3.2 Gravity Diversions

(1) Scheme A-1, shown on Plate No. 4, would divert water eastward from Pashkokogan Lake through headwaters of the Misehkow River to the Ogoki River basin. There would be a drainage area of 1,005 square miles within the scheme which would produce an estimated long-term average flow of 870 cfs. Structures required would include:

(a) A block dam on the Pashkokogan River below Pashkokogan Lake.

(b) Excavated channels to drain Pashkokogan Lake eastward through Greenbush and Metig Lakes in the Misehkow River basin.

(c) A block dam on the Misehkow River to divert water southward into Davies Lake.

(d) An excavated channel to drain Davies Lake eastward into headwaters of the Ogoki River.

Field work, which was carried out for this scheme in 1966, consisted of transit-stadia surveys at sites of the Pashkokogan and Misehkow River Dams and along the diversion route between Davies Lake and the Ogoki River basin. Level lines were run between Pashkokogan and Greenbush Lakes and at a channel improvement site between Greenbush and Metig Lakes. A level line was extended from a Geodetic Survey of Canada bench mark at Rat Rapids to Pashkokogan Lake and levels at all structure sites were related to Pashkokogan Lake through water transfers. Survey data were used to prepare site plans which, in turn, were used in the preparation of preliminary design drawings, construction quantities and costs for all Scheme A-1 structures.

Cost studies were also made for a Scheme A-1 modification which would provide a spillway at Misehkow Dam for releasing flood flows to the Misehkow River. This modification could be used, if necessary, to reduce flood levels at Ogoki Reservoir and Waboose Dam on the Ogoki River, and would divert an estimated long-term average flow of 700 cfs.

(2) Scheme A-2 would divert water from the Albany River near the head of Kagami Island and route it into the Ogoki River at Whitewater Lake as indicated on Plate No. 4. The scheme would encompass a drainage area of some 6,000 square miles with an estimated long-term average runoff of 5,100 cfs. A maximum diversion capacity of 5,000 cfs was assumed for the scheme even though there would not be sufficient reservoir capacity to maintain this flow over dry periods. The long-term mean

diversion yield from Scheme A-2 has been estimated at 4,300 cfs. Diversion structures required are listed below and their locations are indicated on Plate No. 4.

(a) A control dam with spillway sluices on the Albany River north channel at Kagami Island.

(b) A block dam on the Albany River south channel at Kagami Island.

(c) A block dam on the Misehkow River below Coles Lake.

(d) Excavated channels as required to convey water from the Albany River southeastward to Dawn Creek, a tributary of the Ogoki River emptying into Whitewater Lake.

Scheme A-2 was investigated some years ago by the Hydro-Electric Power Commission of Ontario. The Commission prepared a report on that investigation for the Federal Engineering Division on a consulting basis. Information obtained by Ontario Hydro for the preliminary layout, design and costing of structures included topographic field surveys made in 1933, 1937 and 1938 along the channel north of Kagami Island; preliminary topography and spot elevations obtained by photogrammetric methods, and the results of a 1952 geological reconnaissance.

At Ogoki Reservoir, downstream from Whitewater Lake, Scheme A-2 water would be channelled southward to Lake Superior via a modified version of the existing Ogoki diversion system. Modifications required to accommodate the 5,000 cfs flow increase would be as listed below.

(a) Channel excavation near Summit Control Dam at the outlet from Mojikit Lake to the Little Jackfish River.

(b) Extension of a concrete retaining wall at the CNR bridge at

Little Jackfish River.

(c) Channel excavation at the outlet of Lake Nipigon to the Black Sturgeon River and replacement of the existing block dam with a concrete control structure.

(d) Replacement of the existing Split Rapids Dam with a control structure which would carry a roadway across Black Sturgeon River.

(e) Replacement of Dolan Dam with a concrete control structure carrying a two-lane roadway bridge.

(f) Removal of the existing Twin Rapids Dam.

(g) Replacement of a timber bridge about 15 miles upstream from Twin Rapids Dam with a single-lane Bailey bridge

(h) Bank protection works at a number of locations downstream from Twin Rapids Dam.

(3) Scheme A-3, shown on Plate No. 6, would utilize the Agutua glacial moraine as a barrier to divert headwaters of the Winisk, Attawapiskat and Albany Rivers into the Ogoki River at Whiteclay Lake. From the vicinity of Ogoki Reservoir, the Agutua extends northwestward across most of northern Ontario. The diversion would be accomplished by closing breaches in the moraine ridge formed by streams flowing in a northeasterly direction. Storage for regulating diversion flows could be provided by the existing Lake St. Joseph reservoir and two new reservoirs ponded along the westerly side of the moraine ridge. The scheme, at its maximum development, would control a drainage area of nearly 13,360 square miles with an estimated long-term average runoff of

10,550 cfs. Water released at spillways in order to limit high water levels in reservoirs during flood periods would amount to an average flow of about 200 cfs. The estimated long-term average diversion yield from Scheme A-3 is, therefore, 10,350 cfs. The locations of structures required along the Agutua moraine are shown on Plate No. 6, and include:

(a) A dam and spillway on the Pipestone River.

(b) A block dam on the Pineimuta River.

(c) An excavated channel (Bugbee Channel) south of the Pineimuta dam.

(d) A control structure (Keech Control) on the Spruce River north of the Otoskwin River to form a reservoir extending to the Pipestone River.

(e) A dam with outlet works on the Otoskwin River.

(f) An excavated channel (Monmonawson Channel) between the Otoskwin and Trading Rivers.

(g) A block dam on the Trading River.

(h) A dyke (Etowamami Dyke) on low ground south of the Trading River.

(i) A dam with outlet works on the Albany River.

(j) A dyke (Ficht Dyke) on low ground north of the Attwood River.

(k) A dam with spillway on the Attwood River.

(l) A channel (South Channel) through the height of land between the Attwood and Ogoki River basins.

(m) A control structure (South Control) at the height of land between the Attwood and Ogoki River basins to regulate diversion flow from a reservoir extending northward to the Otoskwin River.

Other work would consist of the reconstruction of control dams at the east end of Lake St. Joseph Reservoir and the relocation of a section of Highway No. 808 north of Pickle Lake.

Most field investigations for Scheme A-3 were carried out in 1967 although the work was started in 1966 and completed in 1968. Field operations consisted of drilling and seismic explorations, test pit excavations plus topographic surveys at sites of major structures. A level line was run between the Pipestone River and the north boundary of the Ogoki River basin, and water levels and soundings were taken at river crossings.

Topographic site plans, together with preliminary layout and design drawings for structures, were prepared for all structure sites. These drawings were used in estimating construction quantities and costs. Results of this work are provided in "Report on Diversion Scheme A-3" and in appendices accompanying that report.

Improvements and modifications required in the Ogoki diversion system to pass a 10,000-cfs increase in flow to Lake Superior would form part of Scheme A-3. Work involved is described in "Report on Diversion Scheme A-3" and would be similar to that discussed previously under Scheme A-2.

3.3 Pumped Diversions (Reference Plate No. 7)

A rough cost comparison between gravity and pumped diversion possibilities was made before Gravity Scheme A-3 was selected for field investigation. This was done to obtain an indication of the most economical method for diverting a flow of 10,000 cfs from the Albany

River to the Great Lakes. The comparison showed that the unit cost of water diverted by the lowest cost pumping scheme would be of the same order of magnitude as that diverted by Scheme A-3. The gravity scheme was selected for field investigation because (a) its operation would be the more reliable, and (b) a pumping scheme would utilize a large block of power which a gravity scheme could make available for other purposes.

For reasons stated under (a) and (b) above, it appears that pumping from the Albany River to the Great Lakes should only be considered in order to obtain a diversion flow appreciably greater than that which could be provided through a gravity diversion. A flow of this nature, sufficiently reliable for a pumping scheme, would have to be obtained downstream along the Albany River from: (a) below the mouth of the Kenogami river, (b) just above the mouth of the Ogoki River where inflow could be provided by a gravity diversion from the Attawapiskat and Winisk Rivers, or a combination of both (a) and (b). At least one of these water supply alternatives was assumed for each of the pumped diversion possibilities discussed below.

1. <u>The Opichuan Pumped Diversion</u> route, shown on Plate No. 7, would extend upstream along the Albany River from a point near the mouth of the Ogoki River to the mouth of the Opichuan River. The route would ascend the Opichuan River to Kagianagami Lake and thence southward to the Ogoki River below Waboose Dam. A profile along this route, shown on Plate No. 8, indicates that structures required would be approximately as listed below:

(a) Five dams, four of which would be provided with pumping plants, on the Albany River.

(b) Three dams with pumping plants on the Opichuan River.

(c) A dam on the Ogoki downstream from Ogoki Reservoir to prevent impounded water from flowing down the Ogoki River.

(d) A pumping plant at Waboose Dam.

2. The Ogoki Pumped Diversion route, indicated on Plate No. 7, would follow the Ogoki River from its confluence with the Albany River to Ogoki Reservoir. A preliminary estimate of structures required along the route is shown graphically by the profile on Plate No. 9. These include one dam on the Albany River, eighteen dams with pumping plants on the Ogoki River plus a pumping plant at the existing Waboose Dam.

3. The Pagwachuan Pumped Diversion route, shown on Plate No. 7, would extend from the Albany River upstream along the Kenogami, Pagwachuan and Osawin Rivers to a point some 10 miles northeast of the village of Hillsport on the C.N.R. main line. From there, the route would descend to Lake Superior via the White Otter and Pic Rivers. The profile of this route, shown on Plate No. 10, indicates the following structures:

(a) A dam on the Albany River below the mouth of the Kenogami River.

(b) Two dams with pumping plants on the Kenogami River.

(c) Three dams with pumping plants on the Pagwachuan River.

(d) One dam with pumping plant on the Osawin River.

(e) An excavated channel through the height of land between the Osawin and White Otter River basins.

Rough estimates of the static pumping head or lift, flow available for pumping, and pumping power requirements relating to diversion routes discussed in this section are tabulated below:

Diversion Route	Static Lift (Feet)	Flow Available for Pumping (cfs)	Pumping Power Required (Mw)
Opichuan	500	20,000	1,300
Ogoki	530	20,000	1,400
Pagwachuan	700	40,000	3,600

Construction, operation and maintenance costs of pumping plants required for these diversions, and of generating stations required to provide pumping power, would be extremely high. It was decided, therefore, that no further consideration should be given to such schemes because there was no assurance that benefits could justify the costs.

Chapter IV

Investigations of Possible Gravity Diversions to Lake Winnipeg

4.1 General

Results of a 1966 preliminary map study of western headwaters of the James Bay-Hudson Bay basin indicated few opportunities for gravity diversions to Lake Winnipeg. The most extensive of these is the existing Lake St. Joseph diversion at Root Portage. Only two additional diversion possibilities, shown on Plates Nos. 4 and 11, were considered to be of significance for purposes of the current investigations. These are discussed briefly below.

Reports referred to in this and succeeding chapters were prepared as part of the engineering studies and are listed at the beginning of the present volume.

4.2 Discussion of Diversion Possibilities

1. Scheme A-1a diversion from Pashkokogan Lake to Lake St. Joseph is described in the report titled "Upper Albany River Diversion Possibilities". This scheme would divert Pashkokogan Lake outflows to Lake St. Joseph where they could be routed via Root Portage to the Winnipeg River system. Runoff from an area of some 894 square miles would be controlled by this scheme which would yield an estimated average diversion flow of 500 cfs to the Winnipeg River system. Structures required would include:

(a) A control dam on the Pashkokogan River below Pashkokogan Lake

(b) Minor channel excavations at two locations on the diversion route between Pashkokogan Lake and Lake St. Joseph, as shown on Plate No. 4.

Engineering investigations for this scheme were carried out by Ontario Hydro during the period from 1936 to 1958 and included topographic field surveys plus office map and geological studies. Results of these investigations, including estimates of construction quantities and costs, were provided by Ontario Hydro on a consulting basis for use in the current series of reports.

2. Scheme B-1 would divert water from southwestern tributaries of the Severn River to Lake Winnipeg via the Poplar River, as indicated on Plate No. 11. Approximately 2,970 square miles, including areas draining into Deer Lake and the upper Cobham River, would be involved. This area would yield an estimated average runoff of 1,390 cfs. Structures required for the scheme, as determined from available topographic maps, are listed below:

(a) A block dam on the Severn River at the outlet of Deer Lake.

(b) A block dam on the Cobham River southeast of Hudwin Lake.

As previously stated, this scheme was not investigated in the field, and no preliminary designs or estimates were made for structures involved. Owing to extremely flat slopes in drainage areas along the Ontario-Manitoba boundary, such an investigation would be very costly without better topographic maps than those presently available.

Chapter V

Possibilities for Diversions to the Albany River's Main Channel

5.1 General

Possibilities for diversions into the Albany River's main channel were considered in connection with studies of the power potential of that channel. Preliminary map studies indicated that flow in middle reaches of the main channel might be augmented through diversions from larger tributaries within the basin. Water so diverted would enter the main channel at a considerably higher elevation than the mouth of the tributary concerned. Diversion possibilities of this nature considered in the present investigations were:

(1) The Whiteclay Diversion from the Ogoki River.

(2) The Little Current Diversion from headwaters of the Kenogami River.

One possibility was considered for a diversion to the Albany River from other major rivers in Northern Ontario. This diversion was originally designated "Scheme B-2" and involved upper basins of the Severn, Winisk and Attawapiskat Rivers. As the investigation proceeded, it was found that a major diversion from the Severn River would be impracticable from an engineering point of view. The scheme was then limited to the Winisk and Attawapiskat River basins and its designation was changed to "Winisk-Attawapiskat Diversion".

Locations of diversion schemes mentioned above are shown on Plate No. 11. Details of field investigations carried out for the

Whiteclay and Winisk-Attawapiskat diversions are contained in Appendix II, Volume II, of "Report on Assessment of Albany River Power Potential".

5.2 Diversion Possibilities Within the Albany River Basin

(1) The Whiteclay Diversion would route water northward from the Ogoki River at Whiteclay Lake to the Albany River via the Shabuskwia River. There is a drainage area of 4,995 square miles in the Ogoki River basin above the point of diversion with an estimated average runoff of 4,410 cfs. An additional 102 square miles of drainage with an estimated average runoff of 90 cfs would be intercepted along the diversion route in the Attwood River basin which lies between the Ogoki and Albany Rivers. Diversion structures required would consist of:

(a) A control dam on the Ogoki River at the outlet of Whiteclay Lake.

(b) An excavated channel at the height of land between the Ogoki and Attwood Rivers.

(c) A dam on the Attwood River between Musgrave and Kilbarry Lakes. A block dam at this location was assumed for the purpose of this investigation although a spillway could be constructed here to bypass floodwaters from the upper Albany River basin.

(d) A channel excavation through the height of land between Musgrave and Shabuskwia Lakes in the Attwood and Albany River basins respectively.

Field investigations at structure sites for the Whiteclay diversion were carried out in 1967 and 1968, and consisted of:

(i) Levelling along the diversion route.

(ii) Seismic and drilling explorations at the Attwood River dam site and at the channel site between the Ogoki and Attwood Rivers.

(iii) A topographic survey of Whiteclay dam site and delineation of areas of bedrock outcrop at the site.

Site plans were produced for all structures and these were used in the preparation of layout and design drawings together with estimates of construction quantities and costs.

(2) The Little Current Diversion would involve an area lying northeast of Lake Nipigon and drained by the Little Current River, a tributary of the Kenogami River. The outlets from a series of lakes drained by the Little Current River would be blocked to form a continuous reservoir. This reservoir would be drained to the northeast across the Ogoki River to Kagianagami Lake which drains to the Albany River via the Opichuan River. The scheme would control runoff from some 1,750 square miles in the Kenogami River basin plus about 1,200 square miles in the Ogoki River basin below Whiteclay Lake. These areas yield an estimated average flow of 2,640 cfs.

Structures required for the scheme would include low dams and dykes on the Esnagami, Little Current, Kapikotongwa and Ogoki Rivers and on Meta Creek. Excavated channels would be required at drainage divides between the Kenogami and Ogoki River basins and between the Ogoki and Opichuan River basins.

Maps, produced at a scale of 1:12,000, with a contour interval of 10 feet, were used to prepare preliminary layout drawings for structures mentioned above. These drawings were used to prepare order-of-magnitude estimates of construction quantities and costs. No field investigations were carried out for this scheme and it was not considered to form part of the Albany River power development arrangement for which estimates are provided in Table No. 2 of this report.

5.3 The Winisk-Attawapiskat Diversion

This diversion possibility would divert water from Winisk Lake and the Attawapiskat River to the Albany River near Longitude 86° 15', as indicated on Plate No. 11. This scheme would control flow from a drainage area of 20,477 square miles with an estimated average runoff of 17,550 cfs. Diversion structures required would include:

(a) A control dam at the outlet of Winisk Lake.

(b) A regulating structure plus dyking and channel excavations as required to direct flow southeastward from Winisk Lake to the Attawapiskat River.

(c) A control structure plus dyking and channel excavations as required to direct flow southward from the Attawapiskat to the Albany River.

The scheme would also require storage dams for the regulation of diversion flows. It is assumed that two of these would be provided, one at Kanuchuan Rapids on the Winisk River, and the other on the Attawapiskat River at the outlet of Attawapiskat Lake.

Engineering investigations for this scheme were carried out under the direction of federal personnel in 1968. The work included drilling and seismic explorations at the more important dam and channel sites, levelling and site surveys. A wide strip of terrain along the diversion route was mapped on a contract basis at a scale of 1:12,000 with a contour interval of 10 feet. A materials investigation, including the probing of muskegs, was carried out along the diversion route in 1970. Related office work included the preparation of site plans, layout and design drawings and estimates of construction quantities and costs. Results of this work are presented in appendices to "Report on Assessment of Albany River Power Potential".

Chapter VI

Assessment of the Albany River's Power Potential

6.1 General

Rather detailed investigations were made of the engineering feasibility and cost of power development possibilities on the Albany River. These investigations were part of the overall engineering study of water resources development possibilities in northern Ontario and were not intended to overlap water power inventory studies by the Hydro-Electric Power Commission of Ontario. The Commission made a preliminary survey of a 125 mile reach of the Albany River below Rat Rapids in 1952 and carried out tentative studies of power development possibilities on main channels of the Attawapiskat, Winisk and Severn Rivers in the mid-1960's. The conclusion drawn from this work was that, at the time of these studies, development of power on these rivers was uneconomic.

No attempt was made in the present investigations to relate power development possibilities with Ontario Hydro load characteristics or requirements and no transmission linkages to the Ontario Hydro power grid were considered.

6.2 Assessment of Power Potential (Reference Plate No. 11)

The Albany River power study consisted essentially of investigating effects on the river's power potential of various assumed conditions with respect to diversions. Conditions considered included the existing Ogoki and Lake St. Joseph diversions, plus the three diversion possibilities discussed in the previous chapter. By selecting combinations of these diversion conditions as indicated in tabular form on the following page, eight power schemes designated 1a, 2a, 3a, 4a, 1b, 2b, 3b and 4b were formulated for investigation. One of these (3b) was chosen for detailed study as the basic power scheme. Preparation of preliminary layout and design drawings were carried out for this scheme, together with estimates of construction quantities and costs. The remaining seven schemes were considered in sufficient detail to determine roughly the effect on power availability and cost of variations in the water supply. Results of the work are provided in "Report on Assessment of Albany River Power Potential", Appendix IV "Power Study", and Appendix V, "Project Designs, Descriptions and Cost Estimates", Volumes I and II. Diversion conditions considered in the investigations for each power scheme were as indicated in the following tabulation:

	Power Scheme Designation (Read Down)							
Assumed Diversion Condition	1a	2a	3a	4a	1b	2b	3b	4b
Existing	x				x			
Lake St. Joseph - Discontinued		x	x	x		x	x	x
Ogoki - to Albany River			x	x			x	x
Little Current - to Albany River				x				x
Winisk-Attawapiskat - to Albany River					x	x	x	x

Results of map studies and field investigations indicated that 15 power dams would be required on the Albany River to utilize virtually the entire head, or difference in elevation between Rat Rapids and James Bay. A preliminary selection of sites for these dams is shown in plan on Plate No. 11 and in profile on Plate No. 12. These sites are named below in their order of location from upstream to downstream. The extent of field investigations at each site is also indicated.

Site Name	Drilling and Sampling	Test Pit Samples	Seismic Profiles	Topographic Survey
Achapi	No	No	No	Yes
Eskakwa	Yes	Yes	Yes	Yes
Miminiska	No	No	No	Yes
Frenchman	No	No	No	No
Washi	No	No	No	No
Kagiami	No	No	No	No
Martin	No	No	No	No
Nottik	No	No	No	No
Buffaloskin	Yes	Yes	Yes	Yes
Wabimeig	Yes	Yes	Yes	Yes
Chard	Yes	Yes	Yes	Yes
Hat	Yes	Yes	Yes	Yes
Blackbear	Yes	Yes	Yes	Yes
Biglow	Yes	Yes	Yes	Yes
Stooping	Yes	Yes	Yes	Yes

Field investigation results are provided in "Report on Assessment of Albany River Power Potential", Appendix II, "Subsurface and Materials Data", Volumes I to VII, and Appendix III, "Surveys and Mapping".

Chapter VII

Assessment of Power Development Possibilities on the Severn, Winisk and Attawapiskat Rivers

7.1 General

Investigations of the Severn, Winisk and Attawapiskat Rivers were made primarily to obtain a preliminary estimate of the power development potential of those streams. Engineering feasibility and cost studies were not involved. Results of the investigations provide an indication of the magnitude of foregone power benefits which, in an economic analysis, would have to be charged against possible diversions of the waters concerned. They also provide information which would be useful in planning possible future developments on the rivers and in studying the environmental impact of any such development.

The work consisted of a study of the power potential of each river concerned plus an airphoto interpretation of geology and surficial features which would affect, or be affected by, power development.

7.2 Assessment of Power Potential

An assessment of power potential was made for main channels of the Severn River between Hudson Bay and Sandy Lake; the Winisk River between Hudson Bay and Wunnummin Lake, and the Attawapiskat River between James Bay and Attawapiskat Lake. The effects on this power potential of two different diversion possibilities were also given preliminary consideration.

The assessment procedure used was as follows:

(a) Preliminary map and airphoto investigations were used to make a tentative selection of power sites along each river channel as required for virtually full development of the available head. An arbitrary limitation on this development was imposed by requiring that no individual site should provide a static head of less than 40 feet.

(b) A computer program was used to obtain a 50-year period of synthetic monthly mean flows at each power site selected.

(c) Computer programming was used to produce a residual mass curve of total energy in kilowatt-months on each stream. These curves, shown on Plate No. 13, represent the monthly energy which could be produced on each stream assuming sufficient plant capacity at each site to utilize the maximum flow at that site. The curves also indicate the mean power which might be produced on each stream over a 50-year period and the power available over a critical low flow period of 2 years.

In addition to the river channels discussed above, the power potentials of two diversion possibilities were assessed. One of these would route flow from the Attawapiskat and Winisk Rivers into lower reaches of the Severn River while the other would route waters of the Severn and Attawapiskat Rivers into lower reaches of the Winisk River.

Details of the investigations of power potential are described in Section I of "Report on Assessment of Power Potential of Severn, Winisk and Attawapiskat Rivers".

7.3 Airphoto and Map Study

A preliminary airphoto and map study of the Severn, Winisk and Attawapiskat Rivers' channels, and some possible diversion routes, was made by Dr. J.D. Mollard on a consulting basis. The report on this work is contained in Section II of "Report on Assessment of Power Potential of Severn, Winisk and Attawapiskat Rivers". Materials provided for Dr. Mollard's study by the Engineering Division included maps, airphotos and airphoto mosaics indicating the tentative selection of power sites used in studies of power potential. The report divides the river channels into short sections for discussion purposes although it makes reference to the power sites mentioned above to more clearly designate the locations of river sections. Features discussed in the report, and indicated, where possible, on maps in accompanying appendices, are:

(i) Surficial Geology
(ii) Bedrock Geology
(iii) Foundations below Water Development Structures
(iv) Excavation and Foundation Preparation Problems
(v) Fill, Borrow and Concrete Aggregate Materials
(vi) Accessibility
(vii) Cultural Features
(viii) Flooded Vegetation and Clearing Requirements
(ix) Additional Comments Related to Terrain Conditions.

The maps also indicate distances along river channels (measured from the river's mouth) at 10-mile intervals, and the locations of bench marks on the topographic survey traverse.

Chapter VII

Conclusions

8.1 General

Conclusions discussed below are based on the results of engineering feasibility and cost studies alone. It is recognized that deductions which may be drawn from the results of environmental and/or economic studies could sustain, modify, or completely differ from, these conclusions. Figures representing costs, flows, power potential, etc., in the conclusions have been taken from Tables No. 1 and 2, Pages 38 and 39. Cost figures are based on 1968 price levels and an interest rate of 5 per cent.

(1) Possibilities for Gravity Diversions to the Great Lakes

Results of engineering feasibility investigations indicate that the maximum gravity diversion (in addition to existing diversions) to the Great Lakes from Ontario's northern drainage would average about 10,350 cfs. The annual cost of this diversion (Scheme A-3) would be of the order of $19.4 million or $1,880.00 per cfs. An alternate diversion possibility (Scheme A-2) could divert 4,330 cfs of this water at an estimated annual cost of roughly $1.7 million, or $400.00 per cfs. In effect, the additional 6,020 cfs per year supplied by Scheme A-3 would cost some $17.7 million or nearly $3,000.00 per cfs.

Cost figures, quoted above do not include the estimated value of power benefits creditable to the existing Lake St. Joseph diversion. This diversion would have to be discontinued if either Scheme A-2 or Scheme A-3 were developed.

(2) Possibilities for Pumped Diversions to the Great Lakes

A water diversion from the James Bay - Hudson Bay basin in Ontario to the Great Lakes in sufficient quantity (40,000 to 50,000 cfs) to be effective in lake level regulation would necessitate pumping from the Albany River. The cost of power alone for such a scheme, assuming 70 per cent pump efficiency and power obtainable at 7 mills per KWH, would range up to approximately $5,000.00 per cfs per year. This cost is more than 10 times greater than that for gravity diversion Scheme A-2 which was given preliminary consideration by Ontario Hydro. For this reason it was concluded that further expenditures on studies of pumping schemes could not be justified at this time.

(3) Assessment of Albany River Power Potential

An average output of 2,141,440 kw. with an installed capacity of 3,064,800 kw. and a load factor of 60 per cent has been estimated for a basic scheme of power development on the Albany River. Using 1968 price levels and an interest rate of 5 per cent, the cost, based on installed capacity, has been estimated at $682 per kw. The average energy cost has been estimated at 6.79 mills per kwh. at site. Increases in construction costs and interest rates since 1968 could escalate this estimate by perhaps 4 to 5 mills per kwh. It must be pointed out also that the estimate was prepared on the assumption that two existing water diversions from the Albany River would be discontinued. These diversions are producing low cost power at generating stations located near load centers. Results of the current studies have indicated that the water involved could produce more power for Ontario if returned to the Albany River, but at a considerably increased cost. This increase in power cost would be charged against the Albany River Power Development in an economic analysis.

On the other hand, the estimate includes costs for a number of low head plants which would be expensive to develop. Consideration of the lower cost sites only, and use of a lower load factor, could possibly result in a sufficiently attractive estimate to justify further investigation.

(4) Assessment of Power Potential of Severn, Winisk and Attawapiskat Rivers

There are no particularly significant concentrations of power potential on channels of the Severn, Winisk and Attawapiskat Rivers. Results of preliminary investigations indicate few good power sites on the three rivers. Access to these would be difficult and development would be costly with lengthy transmission linkages to existing power grids. For these reasons, it seems certain that any future interest in power projects in the area concerned will be of a local nature only.

TABLE NO. 1

DIVERSION POSSIBILITIES - ESTIMATED FLOWS AND UNIT COSTS

TABLE NO. 1

DIVERSION			AVERAGE DIVERSION FLOW CFS	UNIT COST PER CFS - YEAR (5% INTEREST)
SCHEME	FROM	TO		$
Possibilities for Diversions to the Great Lakes				
A-1	Pashkokogan Lake and Misehkow River headwaters	Ogoki River above Ogoki Reservoir	870	383
A-1	Alternative with spillway discharging floods down Misehkow River		700	570
A-2	Albany River at Kagami Island	Ogoki River above Ogoki Reservoir	4,330	397
A-3	Albany-Otoskwin, Pipestone, Pineimuta, Spruce Rivers and Lake St. Joseph	Ogoki River above Ogoki Reservoir	10,350	1,880
Possibilities for Diversions to Lake Winnipeg				
A-1a	Pashkokogan Lake	Lake St. Joseph and Lake Winnipeg	500	226
B-1	Cobham River	Lake Winnipeg	1,390	-
Possibilities for Diversions to the Albany River's Main Channel				
W-A	Upper Winisk and Attawapiskat Rivers	Albany River above mouth of Ogoki River	14,550	1,526
Whiteclay	Ogoki River at Whiteclay Lake	Albany River above Eskakwa Fall	4,410	549
Little Current	Kenogami River headwaters and Ogoki Reservoir	Albany River by Opichuan River	2,640	1,181

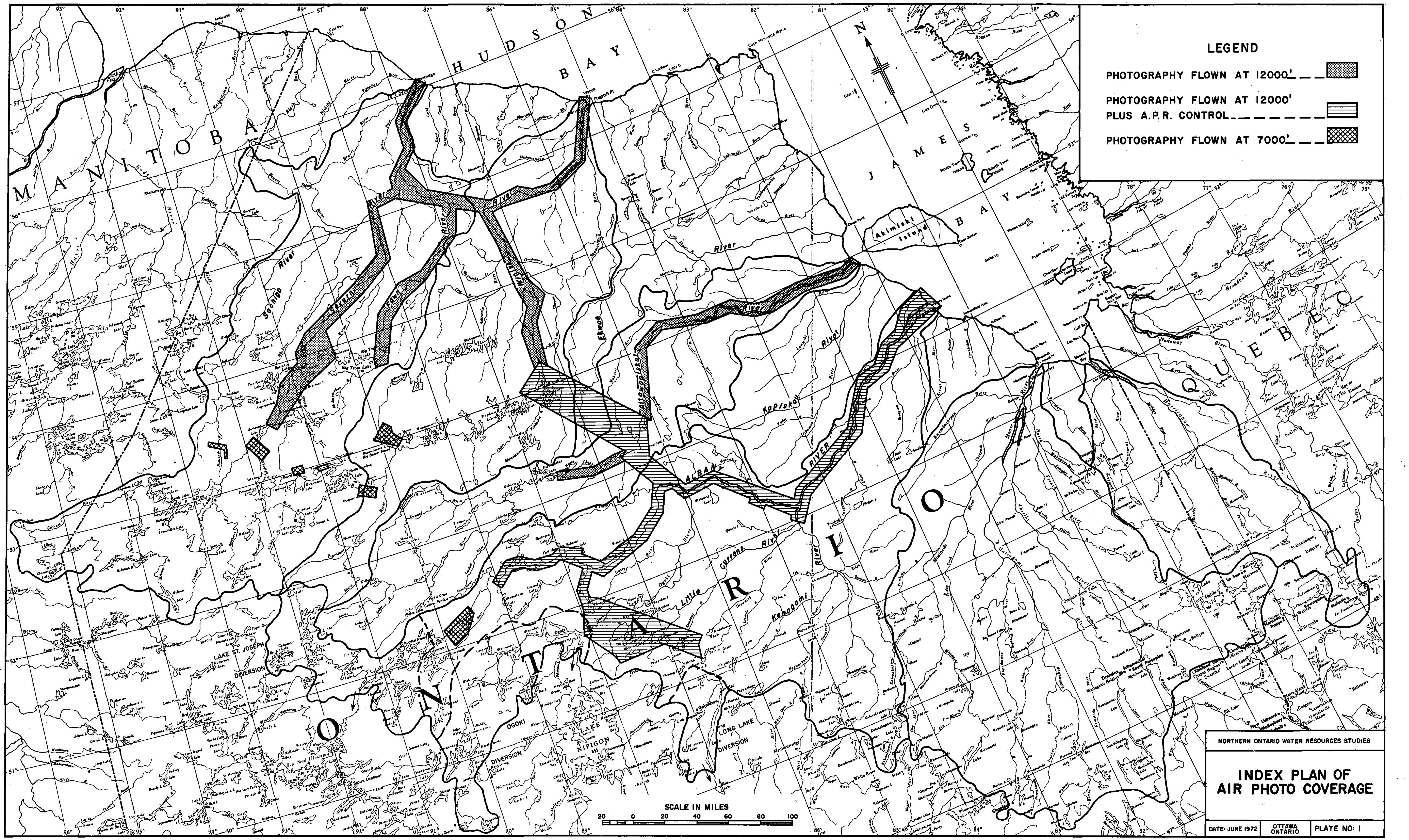
SUMMARY OF POWER, ENERGY AND COST ESTIMATES

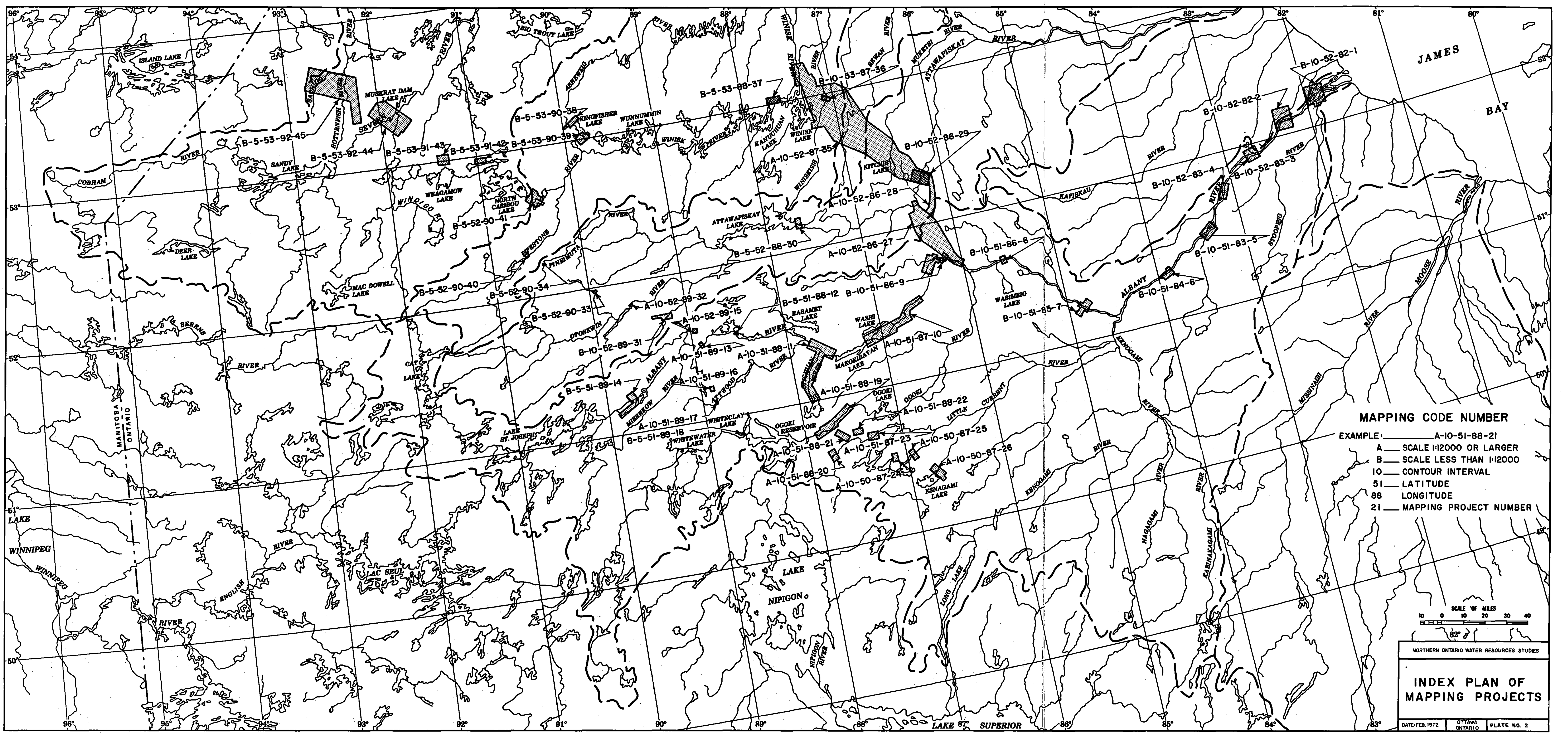
TABLE NO. 2

ESTIMATED POWER POTENTIAL			ESTIMATED QUANTITIES AND COSTS			
			POWER		ENERGY	
			ASSUMED INSTALLATION			
RIVER	SCHEME ARRANGEMENT	ESTIMATED AVE. POWER KILOWATTS	INSTALLED KILOWATTS	COST PER INSTALLED KW (5% INTEREST)	ANNUAL AVE. ENERGY K.W.H.	**COST AVE. ENERGY (5% INTEREST)
				$		MILLS/K.W.H.
ALBANY	*BASIC	2,141,440	3,064,800	682	18.76 BILLION	6.79
ATTAWAPISKAT	TOTAL RIVER	581,000	-	-	-	-
WINISK	TOTAL RIVER	614,000	-	-	-	-
SEVERN	TOTAL RIVER	1,051,000	-	-	-	-

* Lake St. Joseph diversion discontinued
Ogoki River at Whiteclay Lake diverted to the Albany River
Winisk and Attawapiskat Rivers diverted to the Albany River

** Energy cost at site based on 1968 prices. Price increases to 1972 could increase at site energy costs by 4 to 5 mills/K.W.H.


LEGEND
PHOTOGRAPHY FLOWN AT 12000'
PHOTOGRAPHY FLOWN AT 12000' PLUS A.P.R. CONTROL
PHOTOGRAPHY FLOWN AT 7000'
HUDSON BAY
JAMES BAY
MANITOBA
ONTARIO
QUEBEC
Akimiski Island
ALBANY RIVER
Little Current River
Kenogami River
Kapiskau River
Attawapiskat River
Ekwan River
Winisk River
Fawn River
Severn River
Sachigo River
LAKE ST JOSEPH DIVERSION
OGOKI DIVERSION
LAKE NIPIGON
LONG LAKE DIVERSION
SCALE IN MILES
20 0 20 40 60 80 100
NORTHERN ONTARIO WATER RESOURCES STUDIES
INDEX PLAN OF AIR PHOTO COVERAGE
DATE: JUNE 1972
OTTAWA ONTARIO
PLATE NO: 1



MAPPING CODE NUMBER
EXAMPLE: A-10-51-88-21
A SCALE 1:12000 OR LARGER
B SCALE LESS THAN 1:12000
10 CONTOUR INTERVAL
51 LATITUDE
88 LONGITUDE
21 MAPPING PROJECT NUMBER
SCALE OF MILES
10 0 10 20 30 40
NORTHERN ONTARIO WATER RESOURCES STUDIES
INDEX PLAN OF MAPPING PROJECTS
DATE: FEB. 1972
OTTAWA ONTARIO
PLATE NO. 2
JAMES BAY
LAKE WINNIPEG
LAKE NIPIGON
LAKE SUPERIOR
MANITOBA
ONTARIO
B-10-53-87-36
B-5-53-88-37
B-5-53-90-38
B-5-53-90-39
B-5-53-91-42
B-5-53-91-43
B-5-53-92-44
B-5-53-92-45
B-10-52-86-29
A-10-52-87-35
A-10-52-86-28
A-10-52-86-27
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B-5-52-90-40
B-5-52-90-34
B-5-52-90-33
A-10-52-89-32
A-10-52-89-15
B-10-52-89-31
B-5-51-88-12
B-10-51-86-9
B-10-51-86-8
A-10-51-89-13
A-10-51-88-11
A-10-51-87-10
A-10-51-89-16
B-5-51-89-14
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A-10-51-89-17
B-5-51-89-18
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A-10-51-87-23
A-10-50-87-25
A-10-50-87-26
A-10-51-88-20
A-10-50-87-24
B-10-52-82-1
B-10-52-82-2
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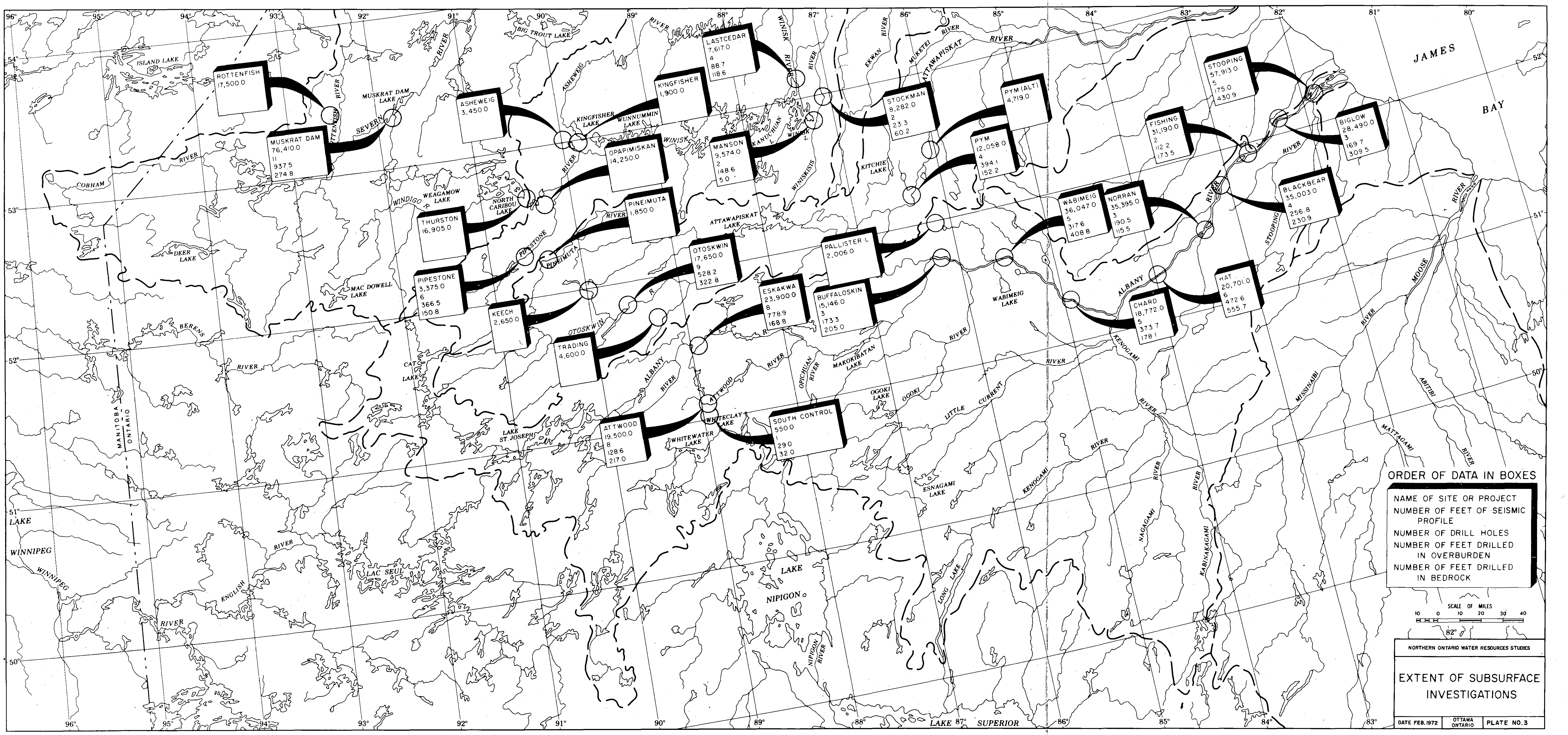
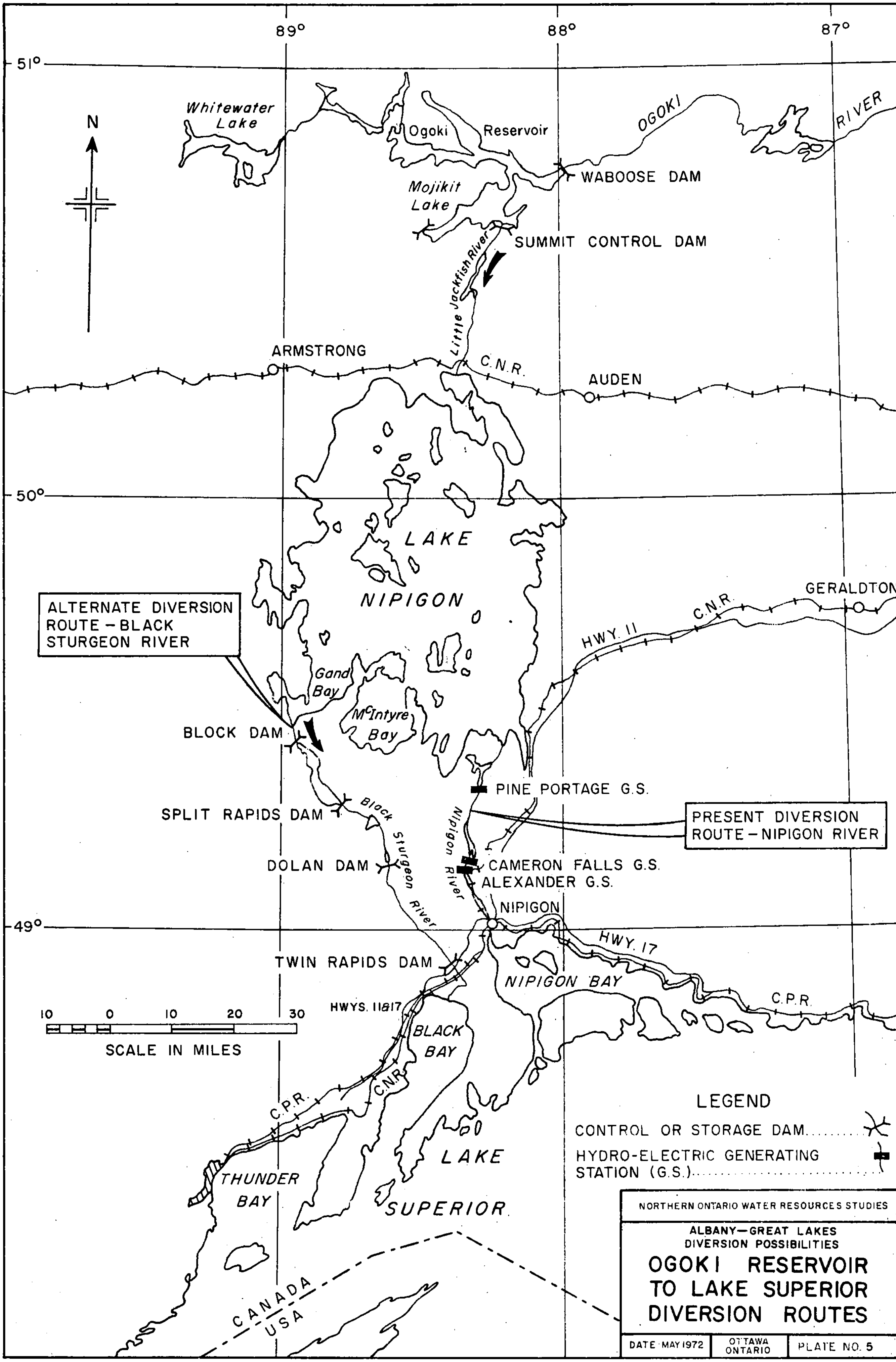
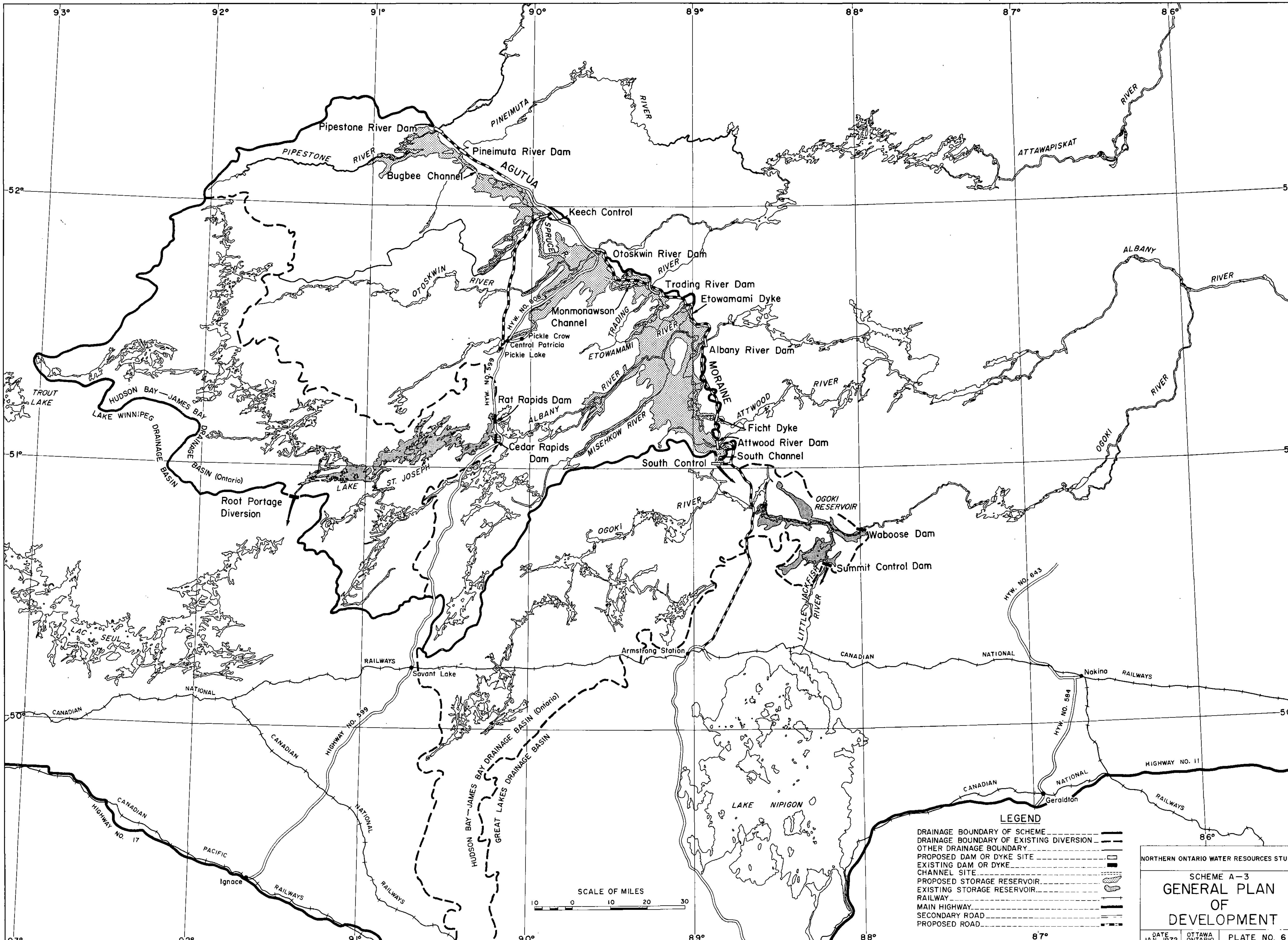
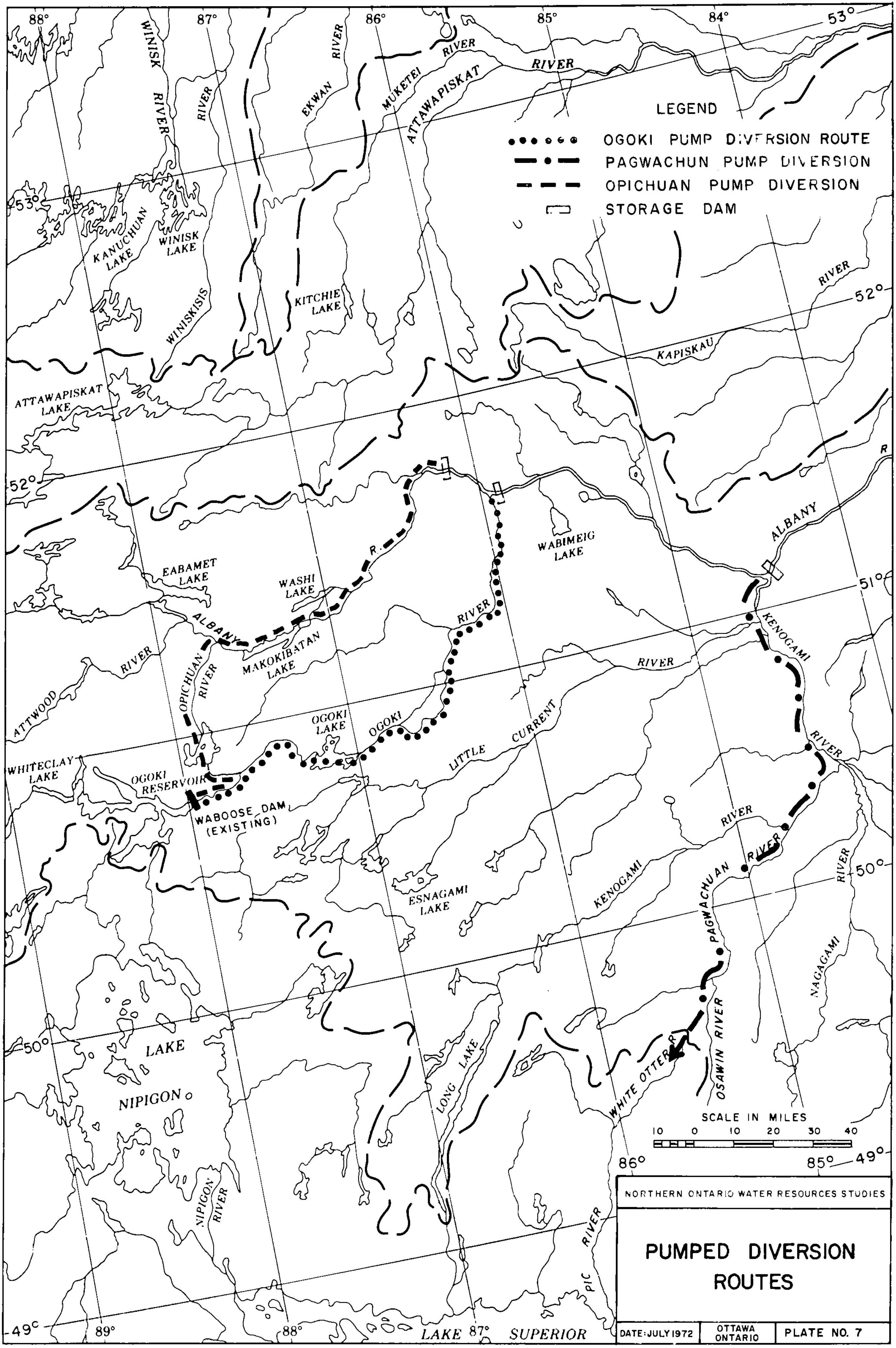

JAMES BAY
ROTTENFISH 17,500.0
MUSKRAT DAM 76,410.0 11 937.5 274.8
ASHEWEIG 3,450.0
KINGFISHER 1,900.0
LASTCEDAR 7,617.0 4 88.7 118.6
OPAPIMISKAN 14,250.0
MANSON 9,574.0 2 148.6 5.0
STOCKMAN 8,282.0 2 23.3 60.2
PYM (ALT) 4,719.0
PYM 12,058.0 4 394.1 152.2
STOOPING 57,913.0 5 175.0 430.9
FISHING 31,190.0 2 112.2 173.5
BIGLOW 28,490.0 3 169.7 309.5
BLACKBEAR 35,003.0 4 256.8 230.9
WABIMEIG 36,047.0 5 317.6 408.8
NORRAN 35,395.0 3 190.5 115.5
THURSTON 16,905.0
PINEIMUTA 1,850.0
PIPESTONE 3,375.0 6 366.5 150.8
KEECH 2,650.0
OTOSKWIN 17,650.0 9 528.2 322.8
PALLISTER L 2,006.0
ESKAKWA 23,900.0 8 778.9 168.8
BUFFALOSKIN 15,146.0 3 173.3 205.0
TRADING 4,600.0
HAT 20,701.0 6 472.6 555.7
CHARD 18,772.0 5 373.7 178.1
ATTWOOD 19,500.0 8 128.6 217.0
SOUTH CONTROL 550.0 1 29.0 32.0
ORDER OF DATA IN BOXES
NAME OF SITE OR PROJECT
NUMBER OF FEET OF SEISMIC PROFILE
NUMBER OF DRILL HOLES
NUMBER OF FEET DRILLED IN OVERBURDEN
NUMBER OF FEET DRILLED IN BEDROCK
SCALE OF MILES
10 0 10 20 30 40
NORTHERN ONTARIO WATER RESOURCES STUDIES
EXTENT OF SUBSURFACE INVESTIGATIONS
DATE FEB. 1972
OTTAWA ONTARIO
PLATE NO. 3

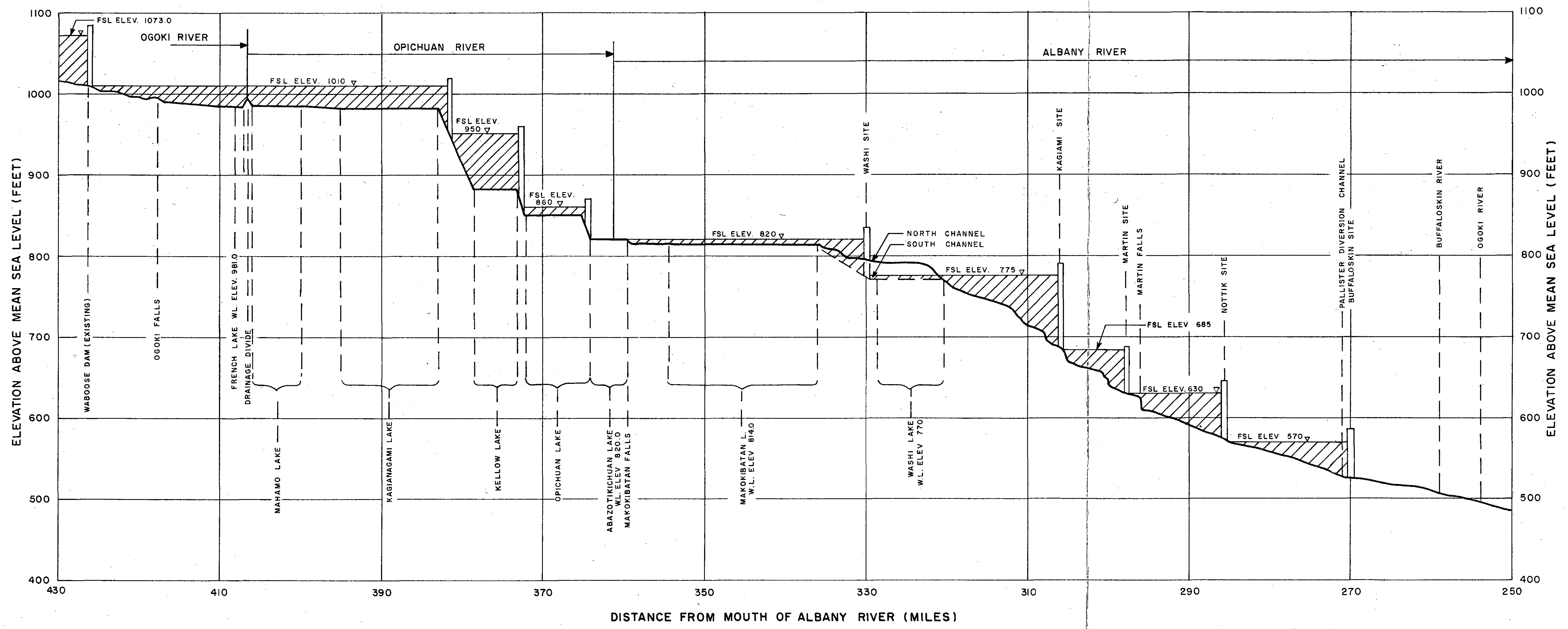

RAT RAPIDS DAM (EXISTING)
CEDAR RAPIDS DAM (EXISTING)
DIVERSION CHANNEL SCHEME A-1a
DIVERSION CHANNEL SCHEME A-1a
PASHKOKOGAN RIVER DAM
SCHEME A-1 BLOCK DAM
SCHEME A-1a CONTROL DAM
ROOT PORTAGE DIVERSION CONTROL DAM (EXISTING)
GREENBUSH DIVERSION CHANNEL SCHEME A-1
METIG DIVERSION CHANNEL SCHEME A-1
CONTROL CHANNEL SCHEME A-2
CONTROL DAM SCHEME A-2
BLOCK DAM SCHEME A-2
DIVERSION CHANNEL SCHEME A-2
DIVERSION CHANNEL AND BLOCK DAMS SCHEME A-2
DIVERSION CHANNEL SCHEME A-2
MISEHKOW RIVER DAM
SCHEME A-1 BLOCK DAM
SCHEME A-1 ALTERNATIVE-CONTROL DAM
MUSKIGA CHANNEL AND CONTROL STRUCTURE SCHEME A-1
OTOSKWIN RIVER SCHEME A-2 DRAINAGE BASIN
LAKE WINNIPEG DRAINAGE BASIN
LAKE ST. JOSEPH
SCHEME A-1 DRAINAGE BASIN
SCHEME A-1a DRAINAGE BASIN
SCHEME A-2 DRAINAGE BASIN
OGOKI RIVER DRAINAGE BASIN
ALBANY RIVER DRAINAGE BASIN
LAKE ST. JOSEPH DRAINAGE BASIN
PASHKOKOGAN DRAINAGE BASIN
MAIN CHANNEL
SOUTH CHANNEL
ALBANY
OGOKI
WHITEWATER LAKE
HWY 599
51°15'
51°00'
50°45'
91°00'
90°00'
89°00'
4 0 4 8 12
SCALE IN MILES
NORTHERN ONTARIO WATER RESOURCES STUDIES
UPPER ALBANY RIVER DIVERSION POSSIBILITIES
GRAVITY DIVERSION SCHEMES A-1, A-1a and A-2
DATE- MAY, 1972
OTTAWA ONTARIO
PLATE NO. 4


89°
88°
87°
51°
50°
49°
N
Whitewater Lake
Ogoki
Reservoir
OGOKI
RIVER
WABOOSE DAM
Mojikit Lake
SUMMIT CONTROL DAM
Little Jackfish River
ARMSTRONG
C.N.R.
AUDEN
LAKE
NIPIGON
GERALDTON
C.N.R.
HWY. 11
ALTERNATE DIVERSION ROUTE – BLACK STURGEON RIVER
Gand Bay
McIntyre Bay
BLOCK DAM
PINE PORTAGE G.S.
SPLIT RAPIDS DAM
Black Sturgeon River
Nipigon River
PRESENT DIVERSION ROUTE – NIPIGON RIVER
DOLAN DAM
CAMERON FALLS G.S.
ALEXANDER G.S.
NIPIGON
HWY. 17
TWIN RAPIDS DAM
NIPIGON BAY
HWYS. 11&17
C.P.R.
10 0 10 20 30
SCALE IN MILES
BLACK BAY
C.P.R.
C.N.R.
LEGEND
CONTROL OR STORAGE DAM
HYDRO-ELECTRIC GENERATING STATION (G.S.)
THUNDER BAY
LAKE
SUPERIOR
CANADA
USA
NORTHERN ONTARIO WATER RESOURCES STUDIES
ALBANY—GREAT LAKES DIVERSION POSSIBILITIES
OGOKI RESERVOIR TO LAKE SUPERIOR DIVERSION ROUTES
DATE MAY 1972
OTTAWA ONTARIO
PLATE NO. 5



Pipestone River Dam
Pineimuta River Dam
Bugbee Channel
AGUTUA
Keech Control
SPRUCE R.
Otoskwin River Dam
Trading River Dam
Etowamami Dyke
Monmonawson Channel
Pickle Crow
Central Patricia
Pickle Lake
Albany River Dam
MORAINE
Rat Rapids Dam
Cedar Rapids Dam
Ficht Dyke
Attwood River Dam
South Channel
South Control
Root Portage Diversion
OGOKI RESERVOIR
Waboose Dam
Summit Control Dam
PIPESTONE RIVER
PINEIMUTA RIVER
ATTAWAPISKAT RIVER
OTOSKWIN RIVER
TRADING RIVER
ETOWAMAMI RIVER
ALBANY RIVER
MISEHKOW RIVER
ATTWOOD RIVER
OGOKI RIVER
LITTLE JACKFISH RIVER
LAKE ST. JOSEPH
TROUT LAKE
LAC SEUL
LAKE NIPIGON
HUDSON BAY—JAMES BAY LAKE WINNIPEG DRAINAGE BASIN (Ontario)
HUDSON BAY—JAMES BAY DRAINAGE BASIN (Ontario)
GREAT LAKES DRAINAGE BASIN
HYW. NO. 808
HYW. NO. 599
HIGHWAY NO. 599
HYW. NO. 643
HYW. NO. 584
HIGHWAY NO. 11
HIGHWAY NO. 17
CANADIAN NATIONAL RAILWAYS
CANADIAN PACIFIC RAILWAYS
Armstrong Station
Savant Lake
Nakina
Geraldton
Ignace
93°
92°
91°
90°
89°
88°
87°
86°
52°
51°
50°
SCALE OF MILES
10 0 10 20 30
LEGEND
DRAINAGE BOUNDARY OF SCHEME
DRAINAGE BOUNDARY OF EXISTING DIVERSION
OTHER DRAINAGE BOUNDARY
PROPOSED DAM OR DYKE SITE
EXISTING DAM OR DYKE
CHANNEL SITE
PROPOSED STORAGE RESERVOIR
EXISTING STORAGE RESERVOIR
RAILWAY
MAIN HIGHWAY
SECONDARY ROAD
PROPOSED ROAD
NORTHERN ONTARIO WATER RESOURCES STUDIES
SCHEME A–3
GENERAL PLAN OF DEVELOPMENT
DATE JAN., 1972
OTTAWA ONTARIO
PLATE NO. 6


LEGEND
OGOKI PUMP DIVERSION ROUTE
PAGWACHUN PUMP DIVERSION
OPICHUAN PUMP DIVERSION
STORAGE DAM
WINISK RIVER
EKWAN RIVER
MUKETEI RIVER
ATTAWAPISKAT RIVER
KANUCHUAN LAKE
WINISK LAKE
WINISKISIS
KITCHIE LAKE
KAPISKAU RIVER
ATTAWAPISKAT LAKE
ALBANY
WABIMEIG LAKE
EABAMET LAKE
WASHI LAKE
MAKOKIBATAN LAKE
OPICHUAN RIVER
ATTWOOD RIVER
OGOKI LAKE
OGOKI RIVER
LITTLE CURRENT RIVER
KENOGAMI RIVER
WHITECLAY LAKE
OGOKI RESERVOIR
WABOOSE DAM (EXISTING)
ESNAGAMI LAKE
PAGWACHUAN RIVER
NAGAGAMI RIVER
OSAWIN RIVER
WHITE OTTER R.
LONG LAKE
LAKE NIPIGON
NIPIGON RIVER
PIC RIVER
LAKE SUPERIOR
SCALE IN MILES
10 0 10 20 30 40
NORTHERN ONTARIO WATER RESOURCES STUDIES
PUMPED DIVERSION ROUTES
DATE: JULY 1972
OTTAWA ONTARIO
PLATE NO. 7

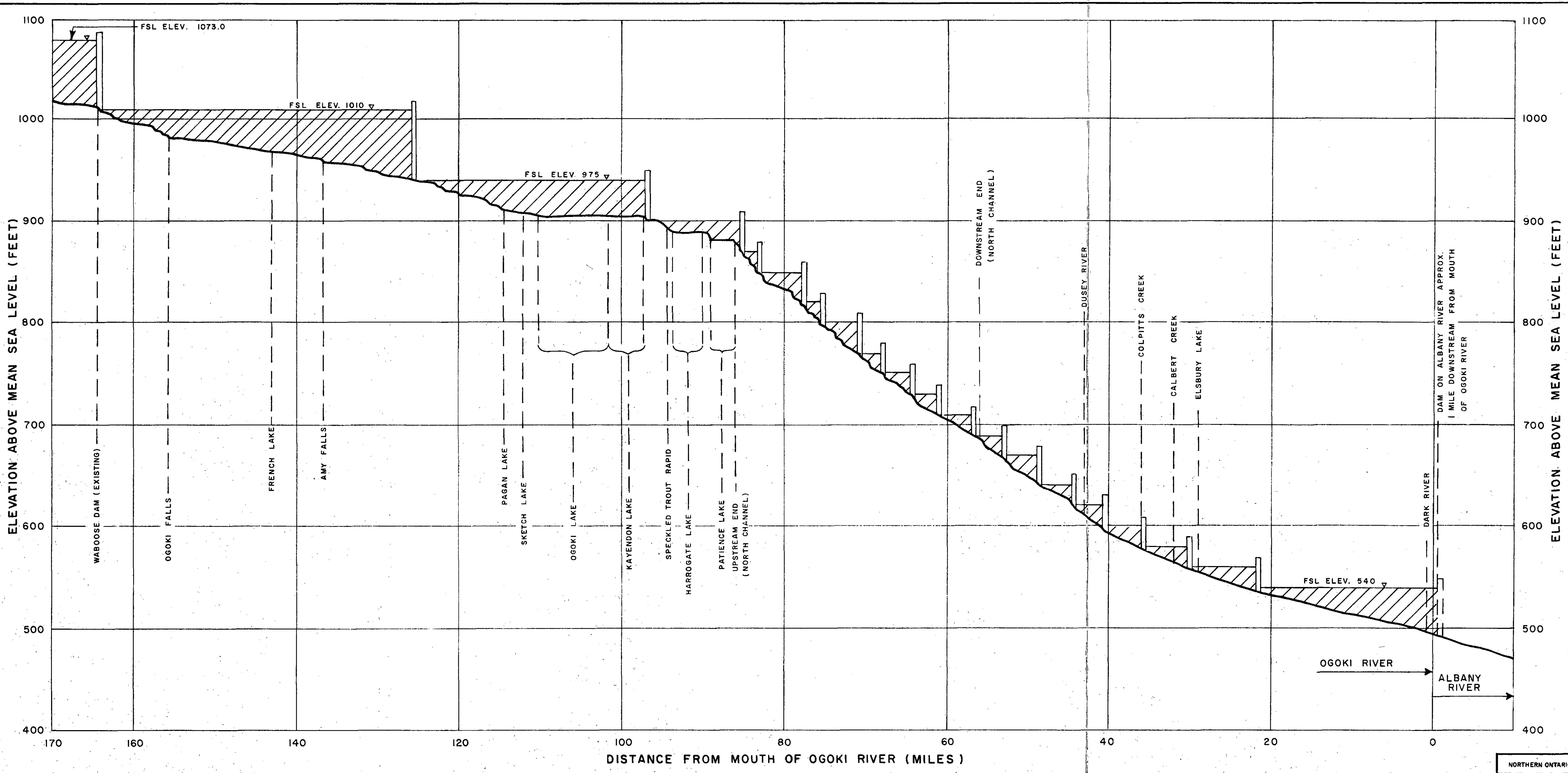


NORTHERN ONTARIO WATER RESOURCES STUDIES

ALBANY—GREAT LAKES
PUMPED DIVERSION POSSIBILITIES

PROFILE OF OPICHUAN ROUTE

DATE: MAY 1972	OTTAWA ONTARIO	PLATE NO. 8

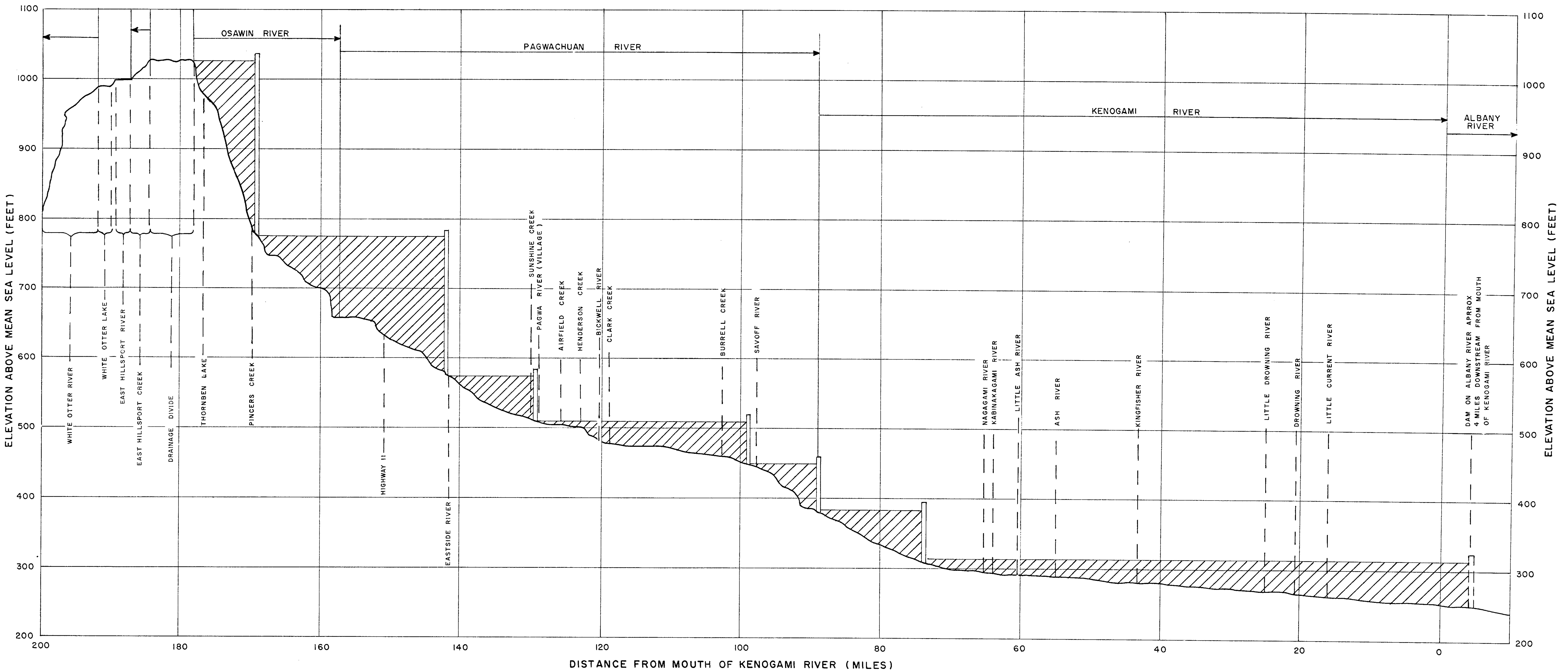


NORTHERN ONTARIO WATER RESOURCES STUDIES

ALBANY — GREAT LAKES
PUMPED DIVERSION POSSIBILITIES

PROFILE OF
OGOKI ROUTE

DATE: MAY 1972 | OTTAWA ONTARIO | PLATE NO. 9

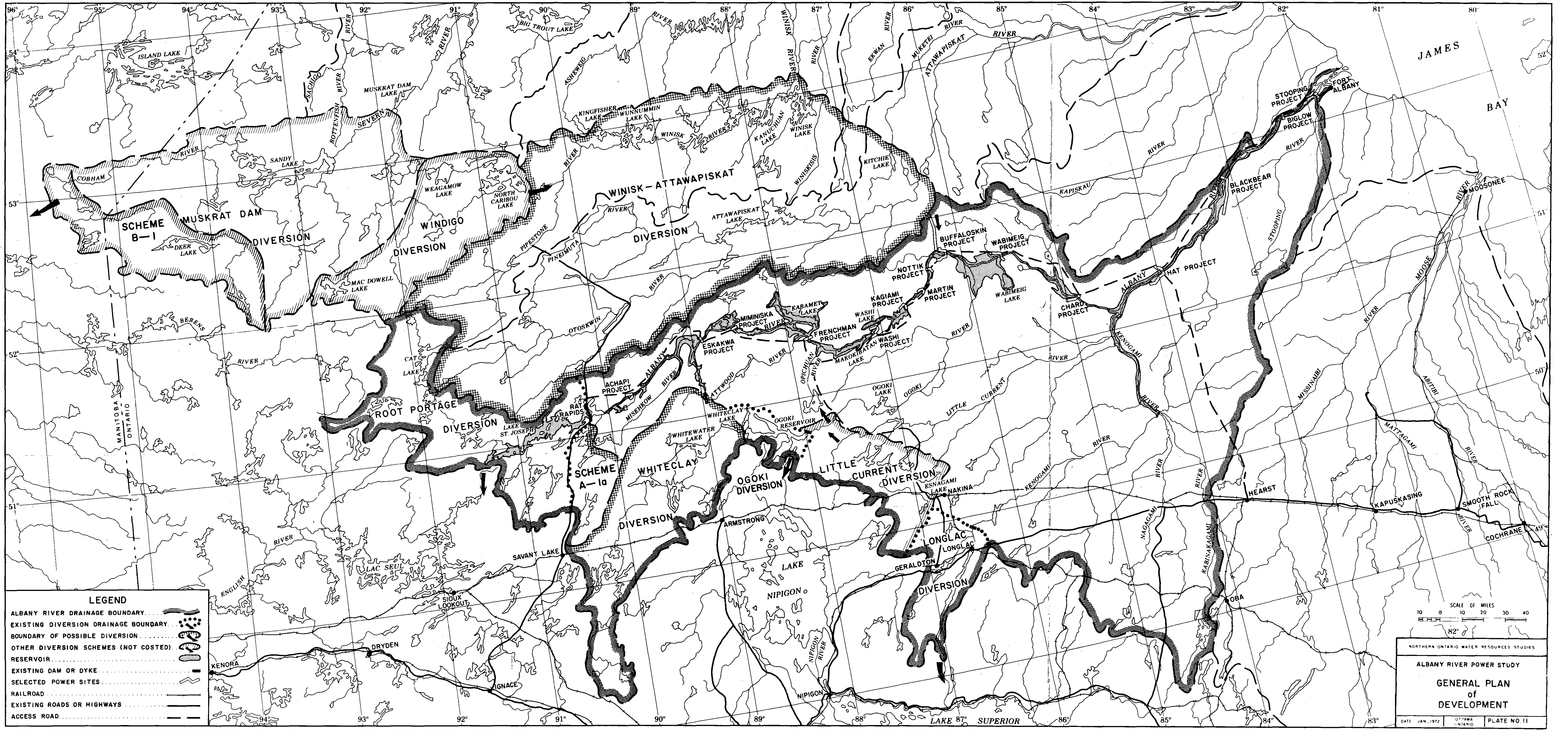


NORTHERN ONTARIO WATER RESOURCES STUDIES

ALBANY — GREAT LAKES PUMPED DIVERSION POSSIBILITIES

PROFILE OF PAGWACHUAN ROUTE

DATE: MAY 1972 | OTTAWA ONTARIO | PLATE NO. 10



LEGEND
ALBANY RIVER DRAINAGE BOUNDARY
EXISTING DIVERSION DRAINAGE BOUNDARY
BOUNDARY OF POSSIBLE DIVERSION
OTHER DIVERSION SCHEMES (NOT COSTED)
RESERVOIR
EXISTING DAM OR DYKE
SELECTED POWER SITES
RAILROAD
EXISTING ROADS OR HIGHWAYS
ACCESS ROAD
NORTHERN ONTARIO WATER RESOURCES STUDIES
ALBANY RIVER POWER STUDY
GENERAL PLAN of DEVELOPMENT
DATE JAN, 1972
OTTAWA ONTARIO
PLATE NO. 11
SCALE OF MILES
10 0 10 20 30 40
JAMES BAY
SCHEME B—I
MUSKRAT DAM DIVERSION
WINDIGO DIVERSION
WINISK—ATTAWAPISKAT DIVERSION
ROOT PORTAGE DIVERSION
SCHEME A—Ia
WHITECLAY DIVERSION
OGOKI DIVERSION
LITTLE CURRENT DIVERSION
LONGLAC DIVERSION
STOOPING PROJECT
BIGLOW PROJECT
BLACKBEAR PROJECT
HAT PROJECT
CHARD PROJECT
BUFFALOSKIN PROJECT
WABIMEIG PROJECT
NOTTIK PROJECT
MARTIN PROJECT
KAGIAMI PROJECT
FRENCHMAN PROJECT
MIMINISKA PROJECT
ESKAKWA PROJECT
ACHAPI PROJECT
RAT RAPIDS
FORT ALBANY
MOOSONEE
HEARST
KAPUSKASING
SMOOTH ROCK FALL
COCHRANE
NAKINA
GERALDTON
LONGLAC
ARMSTRONG
SAVANT LAKE
SIOUX LOOKOUT
DRYDEN
KENORA
IGNACE
NIPIGON
OBA
LAKE NIPIGON
LAKE SUPERIOR
LAC SEUL
MANITOBA
ONTARIO
ALBANY RIVER
KENOGAMI RIVER
MOOSE RIVER
ATTAWAPISKAT RIVER
WINISK RIVER
SEVERN RIVER
OGOKI RESERVOIR

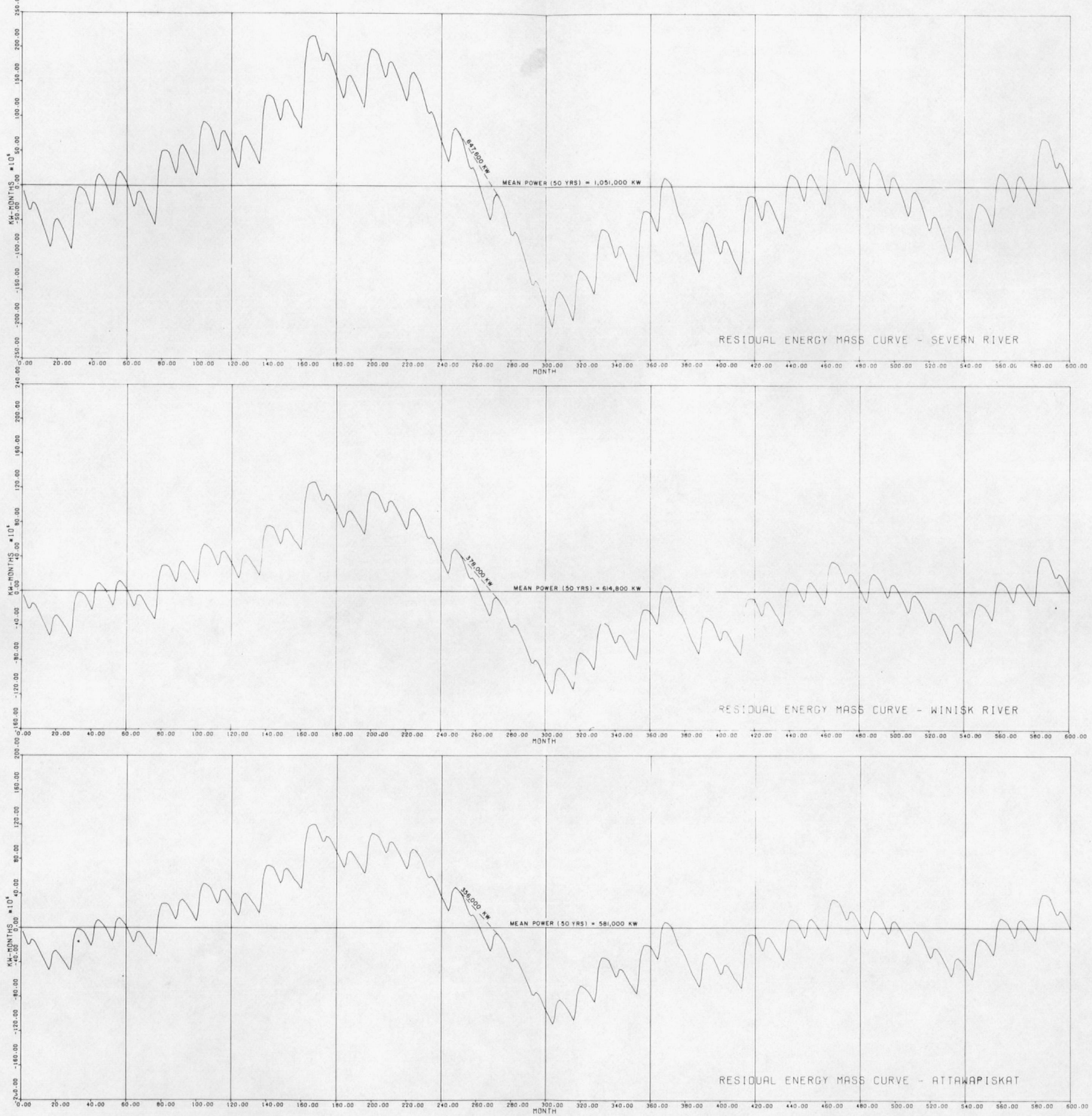
NORTHERN ONTARIO WATER RESOURCES STUDIES

ALBANY RIVER POWER STUDY

ALBANY RIVER PROFILE

SHOWING POWER DEVELOPMENT PROJECTS

DATE JAN. 1972	OTTAWA ONTARIO	PLATE NO. 12



NORTHERN ONTARIO WATER RESOURCES STUDIES

POWER POTENTIAL
SEVERN, WINISK AND ATTAWAPISKAT RIVERS

RESIDUAL ENERGY MASS CURVES

DATE: JAN. 1970	OTTAWA ONTARIO	PLATE NO. 13

Date Due
