A Twenty-Five Year Scenario of Anticipated Resource Developments that may have an Impact on Fish and Fish Habitat in the Prairie Provinces and the Northwest Territories

D.G.Wright

Western Region
Fisheries and Marine Service
Department of Fisheries and the Environment
Winnipeg, Manitoba R3T 2N6

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A TWENTY-FIVE YEAR SCENARIO OF ANTICIPATED RESOURCE DEVELOPMENTS THAT MAY HAVE AN IMPACT ON FISH AND FISH HABITAT IN THE PRAIRIE PROVINCES AND THE NORTHWEST TERRITORIES

by

D. G. Wright

Western Region

Fisheries and Marine Service

Department of Fisheries and the Environment

Winnipeg, Manitoba R3T 2N6

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There will be considerable development of the resources of the three prairie provinces and the Northwest Territories over the next 25 years. Because of the responsibility of the Department of Fisheries and Oceans to protect fish and fish habitats from man-induced disturbances there is an ongoing need to match development scenarios with both baseline inventory and industrial process oriented aquatic research. As a first step in the process, a long-range scenario of anticipated developments in the energy resources (frontier hydrocarbon exploration, production and transportation, non-conventional hydrocarbons, coal and hydroelectric potential) and mining (base metals, precious metals and uranium) sectors has been prepared. Projects with a significant potential for adverse impact on fish and their habitats include: production and transportation of hydrocarbons from the Beaufort Sea and Sverdrup Basin; production of synthetic oil from the bituminous sands of Alberta and Saskatchewan; uranium development in northern Saskatchewan; metal mining in the Mackenzie Mountains and Bear-Slave structural provinces, and development of the hydroelectric potential of the Mackenzie and Churchill river basins.

Key words: Alberta; Saskatchewan; Manitoba; oil industry; gas; pipelines; mining; coal mining; uranium; hydroelectric.

RESUME

Wright, D. G. 1980. A twenty-five year scenario of anticipated developments that may have an impact on fish and fish habitat in the prairie provinces and the Northwest Territories. Can. Fish. Mar. Serv. MS Rep. 1546: iv + 31 p.

Au cours des 25 prochaines années, on assistera à une mise en valeur considérable des ressources des Prairies et des Territoires du Nord-Ouest. Comme il incombe au ministère des Pêches et des Océans de proteger le poisson et son habitat contre les perturbations anthropiques, il faut désormais envisager cette mise en valeur en tenant compte des recherches aquatiques orientées vers les processus industriels et les inventaires de base. Dans un premier temps on a préparé un scénario à long terme de la valorisation des ressources énergétiques (recherche, production et transport d'hydrocarbures dans le Nord, potentiel hydro-électrique, houillier et d'hydrocarbures tirés de nouvelles sources) et dans les secteurs d'exploitation minière (métaux communs, précieux et uranium). Parmi les projets qui menaceront vraisemblablement le poisson et son habitat, notons la production et le transport d'hydrocarbures de la Beaufort Sea et du Sverdrup Basin, la production de pétrole synthétique tiré des sables bitumineux de l'Alberta et de la Saskatchewan, l'exploitation des gisements d'uranium dans le nord de la Saskatchewan, l'extraction des métaux dans les monts Mackenzie et les régions structurales de Bear-Slave et l'exploitation du potentiel hydro-électrique des bassins Mackenzie et Churchill.

Mots-clés: Alberta; Saskatchewan; Manitoba; industrie houille; gaz; pipelines; exploitation minière; charbonnage; uranium; hydro-électricité.

INTRODUCTION

Over the next 25 years there will be significant development of the natural resources of Canada's three prairie provinces and the Northwest Territories (the Western Region of the Department of Fisheries and Oceans (DFO)). Because of this department's responsibility to protect fish and fish habitat from man-induced disturbances, there is a need for DFO to relate its baseline inventory and process-related research programs to anticipated developments in the region.

These programs are to be undertaken as ongoing activities within the resources allocated to this department (and region). Due to the limited resources, both financial and personnel, allocated to this region, it is necessary to establish long-range strategies for baseline studies and research. A necessary first step in this process is the development of a scenario which reflects areas of potential resource development. The following scenario is a projection of anticipated developments for each of the major resource areas or industries within the provinces of Alberta, Saskatchewan and Manitoba and the Northwest Territories.

It should be noted that this report is intended primarily as a planning document within DFO Western Region and is the author's interpretation of the best available information at the time of writing. The scenario is intentionally biased towards fisheries concerns and is not intended as an exhaustive treatment of the subject.

DISCUSSION

FRONTIER HYDROCARBONS

Exploration has commenced or is planned for the near future in all of the frontier areas such as the Beaufort Sea, Sverdrup Basin, Lancaster Sound, Baffin Bay and Davis Strait and the Mackenzie Delta (Fig. 1). Prediction of the level of activity beyond what is already committed is impossible at this time.

Production of frontier hydrocarbon reserves at present comes from the Pointed Mountain and Kotaneelee gas fields on the NWT/Yukon/B.C. border and from the Norman Wells oil pool. The Norman Wells area has produced over 1.9 x 10^6 m^3 (11.9 x 10^7 bbls) of oil since its discovery in 1923. A re-evaluation of this reservoir's potential undertaken during the winter of 1978-79 by Esso Resources Canada Ltd. (Esso) has increased estimated reserves to 17 x 10^6 m^3 (600 x 10^6 bbls) of oil, of which 7 x 10^6 m^3 (250 x 10^6 bbls) may be recoverable by water flooding. The new status of the field may warrant the construction of a 30 cm diameter pipeline south to Zama Lake, Alberta (Oilweek 1979c).

Exploration activity in the Mackenzie Delta has diminished considerably since the early 1970's, as most of the potential geological structures have been tested. Esso, currently the only operator in the area, is complementing a program of exploration of the near-shore Beaufort Sea with some land work in the Mackenzie Delta. Esso probably will construct, and drill from, one or two artificial islands per year for the next five years. Beyond this period it is impossible to predict the level of activity. Should either the Dempster Highway Pipeline proposal or the Polar Gas "y-line" proposal be accepted by the National Energy Board, exploratory, delineation and production drilling in the Mackenzie Delta and near-shore Beaufort Sea would be greatly stimulated.

In the offshore waters of the Beaufort Sea, detailed geophysical exploration of the approximately 38,500 ha (95,000 acres) under exploration permit to Dome Petroleum Ltd. (Dome) has revealed the presence of more than 40 extremely large geological structures of the type known to contain hydrocarbon reservoirs in other parts of the world. A similar number of structures are believed to be scattered under the Beaufort Sea in areas under exploration permits held by other companies. Although neither Dome nor their drilling subsidiary Canadian Marine Drilling Ltd. (Canmar) has released detailed results of their drilling programs; the results to date have been sufficiently encouraging for the company to enter into the early stages of design and planning for production and transportation facilities. Dome estimates production of 32 x 10^3 m^3 (200,000 bbls) of oil and 2.83 x 10^7 m^3 (1 x 10^9 ft^3) of gas per day by 1985, increasing to 1.43 x 10^5 m^3 of oil and 7.75 x 10^7 m^3 of gas per day by 1990 (Northern Miner 1978a).

For shallow waters up to 25 m, artificial islands would most likely be used as production platforms. Esso has developed a concept known as a caisson retained island. This structure will comprise eight trapezoid-shaped steel caissons with an elevation of 15 m and a diameter of 91 m. The caissons will be linked together and floated onto a dredged base island and sunk. The annulus so formed would then be filled with dredged material. For water depths up to 76 m Dome has proposed the Arctic Production Monopod (APM). The APM would be comprised of three basic components: a doughnut shaped base, a bottle-shaped superstructure and a jack-up deck. It is assumed that this design will allow for fabrication in the south with assembly of the components at a sheltered deepwater staging site in the Beaufort Sea area (Offshore Services 1979).

In the Sverdrup Basin of the high Arctic islands, most of the on-land structures have been drilled and tested. Exploration of offshore structures is now proceeding. To date some 3.4 x 10^{11} m^3 of proven recoverable reserves of natural gas have been delineated. In addition to this, Panarctic Oils Ltd. and Petro Canada recently announced the discovery of gas at a large offshore structure, Whitefish H-63. Although the structure has not been fully tested, seismic and geological evidence support an approximate reservoir estimate of 1.41 x 10^{11} m^3 of gas, which would make this one of the largest fields discovered in Canada. In order for a pipeline project to be economically viable 5.7 x 10^{11} m^3 of gas need to be proven from the whole basin.

Exploration of eastern Arctic offshore sedimentary basins commenced in July 1979 with the drilling of two wells in the south Davis Strait area by Esso and Aquitaine Petroleum of

Canada Ltd. The current exploratory drilling program is planned to last two to three years, after which there will be an evaluation of the results and a decision made as to whether or not to continue with forther work. Norlands Petroleum Ltd. and Petro Canada may commence drilling in Lancaster Sound and Baffin Bay within the next two to three years. The program will involve the drilling of several wells to evaluate the large geological structures in the area. The size of the program has not yet been announced.

HYDROCARBON DELIVERY SYSTEMS

Gas pipelines

Although there are several proposals to bring Arctic frontier hydrocarbon resources to southern markets, the Alaska Highway Gas Pipeline (Fig. 2) is the only project which has received Canadian government approval. A starting date for construction of the pipeline has not been announced. This pipeline will transmit natural gas from the Prudhoe Bay area on the north slope of Alaska to markets in the lower 4B United States. The pipeline will follow the right-of-way of the Alyeska Pipeline from Prudhoe Bay to Fairbanks and from there will parallel the Alaska Highway to about Grande Prairie, Alberta and thence along existing pipeline rights-of-way to the international border at Kingsgate, B.C. and Monchy, Saskatchewan.

Apart from the Alaska Highway Gas Pipeline, the pipeline scenario appears to be very confused. As part of the terms and conditions for approval of the Alaska Highway Pipeline, the proponent of the Canadian segment, Foothills Pipe Lines (Yukon) Ltd. (Foothills), a subsidiary of Alberta Gas Trunk Line Co. Ltd. (AGTL), was required by the National Energy Board (NEB) to prepare and submit an application by July 1, 1979, for the construction of a pipeline along the Dempster Highway right-of-way from the Mackenzie Delta/Beaufort Sea and connecting to the Alaska Highway Pipeline at Whitehorse.

Although Foothills was committed to the preparation of an application for the Dempster Highway Pipeline, neither Foothills nor AGTL has renounced their preference for a pipeline down the Mackenzie Valley. Indeed, Mr. Justice Thomas Berger in his report to Parliament of the findings of the Mackenzie Valley Pipeline Inquiry, concluded that it was feasible, from an environmental point of view, to build a pipeline and to establish an energy corridor along the Mackenzie Valley but recommended that the pipeline be postponed for ten years to permit the settlement of native claims, for new programs and new institutions to be established and to determine the full extent of oil and gas reserves in the Mackenzie Delta and Beaufort Sea (Berger 1977). To this end, Dome Petroleum Ltd. and AGTL have had recent discussions on the feasibility of reviving the Mackenzie Valley Pipeline proposal (Oilweek 1979a).

The gas pipeline scenario is further complicated by the recent withdrawal of an application by the Polar Gas consortium to construct a pipeline from the Arctic Islands, along the west coast of Hudson Bay to interconnection with the Trans-Canada Pipeline at Longlac (Fig. 2). Polar Gas has announced its intention to file an application with the National Energy Board in early 19B0 for a Y-shaped pipeline that would connect both Arctic Islands and Mackenzie Delta/Beaufort Sea reserves to southern markets. The exact routing for such a pipeline has not been decided but both a Mackenzie Valley routing and a Coppermine south-east to Longlac routing are being considered. It is most likely that the Polar Gas and Dempster Highway projects will be reviewed in competitive hearings. Because of the current surplus of natural gas from reserves in southern Canada, domestic markets will not be able to absorb frontier gas reserves until late in the 1990's. Foothills estimates that the Dempster Pipeline could begin tranporting 2.27 x 10^7 m^3/d (B.0 x 10^8 ft^3/d) by 19B7 and 3.4 x 10^7 m^3/d (2 x 10^9 ft^3/d) by 19BB, while Polar Gas estimates that 11.3 m^3/d (4 x 10^9 ft^3/d) could begin to flow by 1990.

In my opinion, the Polar Gas application will be accepted over the Dempster Highway Pipeline application and a routing along the Mackenzie Valley will be chosen. It would make much more sense, economically, to construct one pipeline to transport both Mackenzie Delta/Beaufort Sea and Arctic Islands gas rather than two separate pipelines. The National Energy Board (1977) stated that if Beaufort Sea/Mackenzie Delta reserves were no greater than 4.3 x 10^{11} m^3 (15 x 10^{12} ft^3) it would be more economical to connect the gas via Dempster Highway Pipeline. However, if reserves in excess of this figure were present, a Mackenzie Valley route would be more advantageous.

Oil pipelines

As was noted previously, Esso has re-evaluated the Norman Wells oil field with the drilling of three wells from ice pads in the Mackenzie River and several on-shore wells to facilitate water-flooding. The field, first discovered in 1923, has been producing oil at the rate of 477 m^3 (3000 bbl) per day to supply the Norman Wells refinery. Esso how estimates the field to contain 17 x 10^6 m^3 (600 x 10^6 bbls) of oil, or approximately 10% of proven national reserves (Oilweek 1979c). Esso is currently studying the feasibility of a pipeline along the Mackenzie Valley to link up with existing pipelines at Zama Lake, Alberta. Probably the company will submit an application for permission to construct a 30 cm diameter pipeline to the National Energy Board early in 19B0.

There are several proposals under consideration to make Alaskan oil more available to markets in the eastern and mid-western United States. These include: 1) a tanker route from Valdez Alaska to Low Point, Washington and eitner a new pipeline to the mid-west or a reversal of flow in the existing Trans Mountain Pipeline to Edmonton; 2) a marine terminal at Skagway Alaska and a pipeline from there to Whitehorse and thence along the Alaska Highway right-of-way to Keg River Alberta, and 3) a pipeline from the Alyeska Pipeline at Delta Junction Alaska to Keg River Alberta via the Alaska Highway right-of-way. If either of the latter two proposals are accepted, this would enhance the probability of an oil pipeline from the Mackenzie Delta-Beaufort Sea area along the Dempster Highway right-of-way.

Ice-strengthened oil tankers

As was stated previously, Dome remains confident that the company can achieve partial production of oil from the Beaufort Sea by the year 1985. Initially, the company foresees the use of Arctic class 10 200,000 DWT oil tankers supported by an Arctic class 10 ice-breaker to move oil from the Beaufort Sea to southern markets either around Alaska or through the Northwest Passage. The Arctic class 10 tanker would be able to move through 10 ft (3 m) of ice at a continuous rate of 3 knots. A propulsive force of at least 150,000 hp would be required to do so. Some of the technological features that would be incorporated into the design include:

1) A ship hull about 10 times stronger than that of a conventional tanker;

2) A double hull so that no oil is in contact with the outer hull and a pumping system which would enable oil to be pumped from damaged tanks to undamaged sections of the hull, and

3) A sophisticated satellite informational and navigation system to provide the ship with ship traffic, ice conditions and high precision navigation.

Prior to tanker loading, produced oil would be stored in the base of the production platform. Six tankers each with a capacity of 159,000 m^3 (1×10^6 bbls) of oil would be required for each 10,000 m^3 per day of field production.

Liquefied natural gas (LNG)

A proposal has been made by Petro Canada to liquify natural gas from the Hecla and Drake fields on Melville Island at a barge mounted facility at Bridport Inlet for trans-shipment by tanker to east coast ports. The project, known as the Arctic Pilot Project, is currently under review by the National Energy Board and the Environmental Assessment and Review Process (EARP). The initial system under consideration is for a barge mounted facility to liquify 7.08×10^6 m^3 of gas per day for trans-shipment via two Arctic class seven 125,000/150,000 m^3 LNG tankers or barges. It should be stressed that this is only a pilot scale operation and that a full scale operation could involve considerably more ships and liquification facilities and could exploit other high Arctic gas fields such as Wallis, Thor, King Christian and Jackson Bay (Fig. 1). Petro Canada anticipates that the system will be in operation by 1985 (Offshore Services 1979).

Development scenario

In light of the fact that it will be possible to undertake only one major pipeline project at a time due to both a shortage of skilled workers and a shortage of working capital, the following scenario of pipeline construction is based on the author's interpretation of the situation.

The National Energy Board may authorize an increase in the volume of natural gas exported to the United States. Anticipatory building of the southern section of the Alaska Highway Pipeline, in advance of deliveries of gas from Alaska could begin as soon as 1980 or 1981. In the event that the United States government gives approval to either the Skagway-Keg River or the Delta Junction-Keg River pipeline proposal over the competing "all-American" route, construction of the project could begin in mid-1981 with completion by mid-1983. The northern portion of the Alaska Highway Pipeline would be constructed in the period 1984-1986. A small diameter pipeline from Norman Wells to Zama Lake will most likely be constructed in the 1981-1983 period. As production of oil from the Beaufort Sea increases, the construction of a pipeline would become more economically viable than increasing the size of the tanker fleet. Construction of an oil pipeline along the Mackenzie Valley would likely take 2-3 years and would come on-stream in 1988 or 1989. A gas pipeline to transport both high Arctic Islands and Beaufort Sea gas could then begin. The route to be chosen would either be a modified Dempster Highway pipeline or Mackenzie Valley Polar Gas "Y"-pipeline. Construction of this pipeline could be completed by 1992. The construction of the gas gathering system and pipeline from the Hecla and Drake gas fields on the Sabine Peninsula of Melville Island to Bridport Inlet could commence in 1983.

NON-CONVENTIONAL HYDROCARBONS - HEAVY OILS AND OIL SANDS

Despite recent significant conventional oil discoveries and the indication of large reserves in the Beaufort Sea and other frontier areas, a considerable portion of Canada's future petroleum needs will be derived from the abundant bituminous sands and heavy oil deposits in Alberta and Saskatchewan.

The non-conventional hydrocarbon reserves of Alberta and Saskatchewan are enormous. The heavy oil deposits and oil sands are estimated to contain 1.6×10^{11} m^3 (1×10^{12} bbls) of oil in place (Gander and Belaire 1978). Of this, only 10 or 20 percent or 3.2×10^{10} m^3 (200 billion bbls) technically might be recoverable over the next 50 years.

The four major oil sands deposits in Alberta cover an area of more than 4.9×10^6 ha in the Athabasca, Wabasca, Peace River and Cold Lake areas (Fig. 3). The Lloydminster heavy oil region on the Alberta-Saskatchewan border covers an estimated 1.7×10^6 ha with some 2.5×10^{12} m^3 of oil in place.

The Athabasca sands are at shallower depths than the other deposits and contain all of the reserves recoverable by surface mining techniques. The deposit covers an area of 2.3×10^6 ha with estimated reserves of 1.0×10^{11} m^3 in place. About 8.5% of the area - 1.9×10^5 ha, has overburden less than 45 m thick from which the sands can be surface mined. There are 3.5×10^5 ha with overburden ranging from 45 to 150 m for which no recovery technology has been developed, while the remaining 1.8×10^6 ha have overburden of more than 150 m and can be exploited by *in situ* recovery.

The Cold Lake region is estimated to contain 2.6×10^{10} m^3 of oil in place within an area of

1×10^6 ha, while the Peace River deposit covering approximately 5×10^5 ha is estimated to contain reserves of 8×10^9 m^3 in place. Wabasca has an estimated 6×10^9 m^3 in place in an area of 5×10^5 ha.

The Great Canadian Oil Sands (GCOS) and Syncrude facilities are currently the only full scale production facilities operating in the oil sands area. GCOS is currently producing approximately 7.9×10^3 m^3 of synthetic crude oil per day and has an application before the Alberta Energy Resources Conservation Board to increase production to 10.3×10^3 m^3 per day by 1981. The Syncrude facility came on line in August, 1978 and is currently producing 7.9×10^3 m^3 of synthetic crude oil per day. During the next few months mining, extraction and processing components will be "de-bugged" to raise output to the design capacity of 16.4×10^3 m^3 per day. However, to meet the Federal Department of Energy, Mines and Resources recommendation of a more than 50% increase over current levels of production to 3.97 x 10 m of oil per day by the year 2000 and to maintain that level to 2025, at least 14 surface mining *in situ* oil sands and *in situ* heavy oil production units will be required (Gander and Belaire 1978).

At present, only one consortium, the Alsands Project Group, is planning the construction of a surface mining and extraction facility. An application to construct and operate a 22×10^3 m^3 per day synthetic crude facility on the east side of the Athabasca River 100 km north of Fort McMurray has been approved by the Alberta Energy Resources Conservation Board (AERCB). The project will cost some $4.9 billion to achieve production in 1986. Plant site clearing and drainage will commence in late 1979.

Esso Resources had received approval from the AERCB to construct an *in situ* recovery facility in the Cold Lake Clearwater oil sands deposit. The scheme, estimated to cost $4 billion includes production facilities to recover 25.5×10^3 m^3 of bitumen per day by an *in situ* process of steam injection. Up to 1800 wells would be drilled to the heavy oil sands at the 460 m level. Bitumen recovered would be upgraded by the "Flexicoking" process followed by secondary treatment and would result in the production of 18.1×10^3 m^3 of synthetic crude oil per day.

A group of some 20 companies headed by Pacific Petroleums Ltd. (Petro Canada) has completed a feasibility study on a 15.9×10^3 m^3 facility in the Lloydminster heavy oil deposit. A similar scheme is being developed by a consortium headed by Husky Oil Ltd. The status of this proposal is unknown due to the change in ownership of Husky Oil Ltd.

A considerable number of *in situ* recovery research projects are currently underway in all of the oil sands and heavy oil areas.

The majority of these projects involve steam injection to reduce the viscosity of the bitumen or the heavy oil so that it may be pumped to the surface. Natural gas is sometimes also injected into the formation to increase pressure and induce the wells to flow. Another method currently under investigation is forward combustion. In this study, air is injected into the formation and the bitumen is burned in place. The resulting heat decreases the viscosity of the surrounding bitumen and steam, derived from the associated water, supplies the driving energy. Several groups are investigating a combination of dry combustion and steam stimulation while other companies are experimenting with *in situ* caustic or solvent extraction processes. A more complete description of these projects is contained in Oilweek (1979b).

MINING

Coal

Coal production in the western region presently amounts to approximately 17.6×10^6 tonnes per year, of both thermal and metallurgical coal. The locations of these mines are shown in Fig. 4 and information on each is listed in Table 1.

It is anticipated that there will be a considerable increase in coal production and consumption in the next 35 years. Gander and Belaire (1978) recommend that an indicative target of increased coal production should be a five-fold increase by the year 2000 and a further doubling of production by the year 2025. The principal expansion in coal mining is expected to take place in Alberta (plains, foothills and mountains), British Columbia (Crow's Nest Basin, Hat Creek) and in Saskatchewan. Areas favourable for the development of new coal mines are shown in Fig. 4.

Two potential new, energy-related uses for coal could be the production of high pressure steam and hydrogen for *in situ* recovery of oil from the tar sands and from heavy oil deposits. Esso Resources Ltd. suggest that the entire output of the proposed Judy Creek mine could be used for steam generation at the proposed Cold Lake heavy oil recovery project. Coal could also be used for the production of substitute natural gas (SNG). However this is not likely to occur for several decades due to the availability of lower cost conventional and frontier natural gas reserves. In addition to the above, industrial use of coal could increase substantially as a partial substitute of coal for oil and natural gas in process heat or as feedstock for the manufacture of petro-chemicals. Coal can also be expected to replace some oil in thermal electric generation, particularly in Ontario.

By nature of mine locations and principal markets, long distance haulage is necessary. Rail and ship transport are the predominant methods at present. For example a coal handling facility designed to provide an initial throughput capacity of 4.0×10^6 tonnes of coal per year recently commenced operations in Thunder Bay. Output from the Luscar-Sterco mine at Coal Valley Alberta and from the Byron Creek mine at Corbin British Columbia is shipped by 98-105 car unit trains to the Thunder Bay terminal for transshipment by bulk lake carriers to Ontario Hydro's Nanticoke Generating Station on Lake Erie. Coal slurry pipelines are expected to be economical when large quantities of coal (e.g. in excess of 10×10^6 tonnes per year) are moved over intermediate distances (e.g. from mines in the mountains or foothills areas to the tar sands and heavy oil areas).

Uranium

World-wide demand for uranium will increase ten-fold to about 200,000 tonnes per year (Gander and Belaire 1978). A considerable portion of the increased demand will be met by production from the prairie provinces and the Northwest Territories.

At present, uranium production in the region is confined to northern Saskatchewan. Areas with identified uranium resources are shown in Fig. 5, while areas foavourable for the occurrence of uranium deposits are shown in Fig. 6.

Present production: Eldorado Nuclear Ltd. has operated underground mines near Uranium City since 1953 and is in the process of expanding production to 637 tonnes per year by the end of 1981. The Gulf Minerals/Uranerz Canada joint venture at Rabbit Lake commenced production in 1975. The open-pit mine and 1,500 tonnes of ore per day mill is designed to produce some 1,730 tonnes U per year. In addition to the main deposit at Rabbit Lake, three nearby deposits, one at Collins Bay, 11 km north of Rabbit Lake and the Raven and Horseshoe deposits some 5.5 km southwest of Rabbit Lake (Fig. 7) will extend the operating life of the mill.

Mines under development: Following the release of the report of the Cluff Lake Board of Inquiry (1978), the government of Saskatchewan announced that Phase I of the Cluff Lake (Fig. 7) project could proceed subject to strict health, safety and environmental regulations and agreed in principle to a general expansion of the uranium industry in that province. The Cluff Lake mine is expected to be operational by mid-1980 with an initial rate of production of 900 tonnes U per year from the extremely rich "D" ore-body. This will increase by 1983 to 1400 tonnes U per year with development of the larger but lower grade "N" and "Claude" ore bodies.

At Key Lake Saskatchewan (Fig. 3), Uranerz Exploration and Mining Ltd. is conducting feasibility, engineering and environmental studies of the Gaertner and Deilmann uranium-nickel deposits. The mine is slated to be in operation by 1984 with an annual production of up to 2,100 tonnes U per year. The operation would involve draining several lakes overlaying the two main orebodies and mining the deposits by open pit methods.

Esso Minerals Canada Ltd. announced the discovery of a large deposit at Midwest Lake (Fig. 3) in February 1978. On the basis of preliminary information the deposit has been conservatively estimated to contain 3.7 x 10^4 tonnes U with the probability that the deposit contains in excess of 7.7 x 10^4 tonnes U in addition to important quantities of cobalt, nickel and silver. Production is scheduled to begin in 1984. Regulatory approvals to determine when and at what rate the operation will be brought into production have not yet been received. Because of the (unusually) high grade of the Midwest Lake ore, the project will be subject to extremely stringent controls.

A facility to recover 36 tonnes U per year is planned to be built at the Western Cooperative Fertilizers Ltd. (WCFL) phosphoric acid fertilizer plant near Calgary. A second recovery facility has been proposed at WCFL's Medicine Hat Alberta fertilizer plant. In both facilities the uranium is recovered as a by-product of phosphate fertilizer production.

Exploration: There is a high level of uranium exploration throughout the western region. Significant deposits have been found in the Dismal Lakes area west of Coppermine and in the Amer Lake-Schultz area west of Baker Lake in the Northwest Territories (Fig. 7). Exploration is taking place throughout the west-Bear structural province (Fig. 10) and in a broad arc to the south of the Thelon Game Sanctuary. Increased exploration in Nunatsiaq (Keewatin District) is anticipated following a one year ban on exploration imposed by the Department of Indian and Northern Affairs at the request of native peoples of the Baker Lake area.

Northern Saskatchewan, including the Athabasca Basin and the Wollaston Fold Belt (Fig. 7) is recognized as the single most important uranium area discovered in the world to date (Northern Miner 1978b). Currently, some 150 companies are exploring for uranium in this area. As an indication of the area's potential, discoveries made to date in the Athabasca Basin have an average grade of 15 kg U_3O_8/tonne for commercial uranium deposits. Since the Wollaston Fold Belt continues into northwestern Manitoba and south-eastern Nunatsiaq there is a high probability that uranium prospects will be discovered in these areas as well.

Base metals - precious metals

There are a great many mining operations in production or under development in the region. The locations of these mines are shown in Fig. 8 while details as to ownership, reserves and production rates are given in Table 2. Of more importance for the purposes of this scenario are those ore bodies that have not yet been brought into production but are economically exploitable at the present time or are within reach of becoming so by the year 2000. The locations of these deposits are shown in Fig. 9 and details on each of these are given in Table 3.

Although proven ore bodies are of interest for the purposes of undertaking site specific environmental impact assessments or long-term surveillance and monitoring programs, of far greater importance for the purposes of this report are those areas which have a high probability for the discovery of new exploitable ore bodies.

In order to predict areas where new mineral deposits may be discovered and developed it is necessary first to examine the existing development. Many of the major mining areas in Canada are located near or along the boundaries of suture zones of the structural provinces that comprise the Canadian Shield (Fig. 10). For example: the rich iron ore deposits in the Labrador Trough lie along the boundary of the Churchill and Superior structural provinces; the Sudbury nickel belt is located near the junctions of the Southern, Grenville and Superior provinces, and the nickel deposits at and near Thompson are in the transition between the Churchill and Superior provinces.

If the hypothesis that major mineralizations are located along the suture zones between geological provinces is correct, then a high potential for discovery of exploitable ore bodies exists along the transition zones between the Bear and Slave and the Slave and Churchill or the Churchill and Superior provinces. Already several large, but as yet unexploited, deposits have been discoveres in these areas (Fig. 9, Table 3). These include: Izok Lake (10); Contwoyto Lake (13); Takiyuak Lake (11); Hackett River (14): High Lake (3); and Wreck Lake (2).

Similarly, many major mineralizations occur in a class of geological formations collectively referred to as 'greenstones'. Examples of these are: the rich deposits of gold, silver, nickel, copper and zinc in the Timmins, Kirkland Lake, Rouyn-Noranda and Chibougomau areas; the Red Lake area gold deposits; the Thompson nickel deposits; the Yellowknife area gold deposits; and the Selco "B" zone prospect of O'Brien Gold Mines Ltd. (28) in Nunatsiaq. Extensive greenstone belts are located throughout the region (Fig. 10) and many more prospects will ultimately be discovered.

The Cordilleran Orogen in the Northwest Territories and Yukon contains many known mines/deposits. These include: Cantung, Howard's Pass, Redstone, Prairie Creek and Snake River. Due to the relative inacessability of this area, extensive exploration has not been undertaken in detail. Experts from EM&R (S. Hamilton, pers. comm.) speculate that this area is perhaps the most prospective area for the discovery and development of new copper-lead-zinc deposits in Canada.

Iron ore

Although iron ore resources in the region are very large, it is unlikely that any of the deposits will be developed before the year 2000. The location of these deposits are shown in Fig. 11.

The Mary River iron deposit, 160 km southwest of Pond Inlet on northern Baffin Island, is one of the richest deposits of iron ore in the world. There are four main deposits, the largest of which contains approximately 120 x 10^6 tonnes of ore grading at 68.13% iron. The short shipping season and abundant supplies of lower cost ore elsewhere preclude development of the resource before the year 2000 to meet Canadian demands. The deposit could be developed for export markets in Europe.

The Snake River or Crest iron deposit on the Yukon/NWT border is one of the world's larger reserves of medium grade iron ore. Potential reserves are estimated at between 10 and 30 x 10^9 tonnes of hematite, with an iron content of 45%. The major obstacles to development of these reserves are the lack of an economical source of energy and the need for a 1000 km extension of the railway to transport ore to the nearest coastal port at Skagway, Alaska.

Mineralogical problems and/or the need for underground mining precludes the development of the Clear Hills (Peace River), Choiceland and Neepawa iron ore deposits. Iron ore needs for the Interprovincial Steel Corporation steel mill at Regina and the Stelco facility at Edmonton can be met by production from existing and potential developments in northwestern Ontario.

Because of the lower grades, smaller size and transportation problems of the other deposits shown on Fig. 11 it is highly unlikely that these will be brought into production in the foreseeable future.

ELECTRICAL ENERGY

A scenario of anticipated electrical energy projects is difficult to procure at this time. Electrical utilities usually plan for expansion of generating capacity at rate of growth of six to seven percent a year. At present several of the utilities have a surplus of generating capacity and power is exported to neighboring utilities or to the United States. Due to the long lead-time required for the design and construction of major power projects, the present surplus of generating capacity can be considered to be only temporary.

The rate of growth of electrical capacity will need to be increased rapidly in order to substitute electrical energy for fossil fuels for space and water heating. The Department of Energy Mines and Resources (Gander and Belaire 1978) foresees the need to increase generating capacity nearly four-fold between now and the year 2000 and to increase it by one-third again between 2000 and 2025. The share of electricity in Canada's total primary energy supply would increase from about one-third at present to one-half by the year 2000 and would continue to increase at least until 2025.

Increased electrical energy demands in Manitoba will probably be met by development of the hydro-electric potential of the Churchill-Nelson River system. A total of 14 sites have been identified by Manitoba Hydro to harness the Nelson River and the diverted flow of the Churchill River (Fig. 12, Table 4). Four of the stations, Kelsey, Kettle Rapids, Long Spruce and Jenpeg are in operation and work on a fifth site, Limestone, is scheduled to resume in 1983 with 1987 as a target date for completion. As electrical loads increase, it is most probable that the smaller sites on the Burntwood and Rat rivers (Churchill River Diversion) will be developed before the larger and more expensive sites on the main stem of the Nelson River, A schedule for development of these sites has not been announced.

Should construction costs escalate to a point at which continued development of hydro-electric resources becomes uneconomical, Manitoba Hydro may develop coal-fired thermal electric or nuclear electric generating facilities. Manitoba Hydro has undertaken initial planning for a nuclear facility and has chosen a site on the Winnipeg River near the MacArthur Falls as the prime location with alternate sites on the east side of Lake Winnipeg near the Black River Indian Reserve and 25 km northwest of Selkirk. The Black River site would utilize a once-through cooling system while the other two sites would utilize a closed-circuit cooling pond.

Fourteen potential hydro-electric sites have been identified in Saskatchewan, eleven sites on the Saskatchewan River and three on the Churchill River. Only two of these major sites, Nipawin on the Saskatchewan River and Wintego Rapids on the Churchill River, are considered to be viable before the year 2000. Smaller generating stations at or near developing uranium mines could be built to supply the power demands of these site specific load centres. Expansion of Saskatchewan's electrical energy needs probably will come from development or expansion of thermal generating facilities in the Estevan-Bienfait and Poplar River areas.

Alberta's five main river basins (Athabasca, North Saskatchewan, Peace, Slave and South Saskatchewan) have an untimate hydro-electric power potential of some 1850 MW. However only the Mountain Rapids site on the Slave River near the NWT/Alberta Border is being actively considered at the present time. Additional power demand could be met by development or expansion of fossil fuel thermal generating facilities or by interconnection with other provincial hydro utilities having a surplus of electrical capacity.

Many potential hydro-electric sites have been identified in the Northwest Territories (Fig. 13, Table 5), but development of these will depend on the demand for electrical energy. A site on the Talston River near the existing Twin Gorge facility may be developed to meet increasing demands of the Pine Point area mines and by the town of Hay River. Development of the upper Snare River either above or below Indin Lake could meet increased demands in the Yellowknife area. The development of uranium resources in the Baker Lake area may necessitate the construction of hydro-electric facilities in the Thelon-Dubawnt-Kazan river basins.

TIMETABLE FOR DEVELOPMENT

In order to assist with the planning of baseline inventory programs or process related research, Table 6 summarizes and provides a timetable for major developments that may be expected in the three prairie provinces and the Northwest Territories in the next 25 years. This timetable is based on the best information available to the analyst at the time of writing. However, changes in energy development technology, the failure of frontier areas to contain commercial quantities of hydrocarbons, changes in metal prices or the development of new transportation corridors will subject this timetable to continuous revision. It is a realistic scenario based on current information.

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Table 1. Principal coal mines in the prairie provinces.

Map Number	Mine	Owner	Output (tonnes)	Remarks
1	Grand Cache	McIntyre Mines Ltd.	1.6 million	potential reserves of over 1.5 billion tonnes of high grade coking coal. surface mining and underground operation.
2	Wabamun-Whitewood Mine Highvale Mine	Manalta Coal Ltd.	1.36 million 6 million	strip mines. output used for thermal power generation.
3	Hinton (Cardinal Rose)	Cardinal River Coals Ltd. (Luscar Ltd.)	1.55 million	surface mine. production of bituminous coal exported to Japan for coking.
4	Egg Lake-Morinville	Egg Lake Coal Col Ltd.	20 thousand	
5	Forestburg-Diplomat Mine	Forestburg Collieries Ltd.	1 million	surface operation sub-bituminous coal production used primarily by Alberta Power Ltd. Battle River Generating Station.
6	Canmore	Canmore Mines Ltd.	90 thousand	underground and surface operation producing semi-anthracite and low volatile bituminous coal for export to Japan for coking.
7	East Coulee-Atlas Mine	Century Coals Ltd.	40 thousand	underground operation produces sub-bituminous coal for thermal power generation.
8	Sheerness-Roslyn Mine	Manalta Coal Ltd.	600 thousand	surface mine producing sub-bituminous coal for thermal power generation.
9	Vicary Creek, Tent Mountain	Coleman Collieries Ltd.	1.4 million	underground mine, exporting metallurgical grade bituminous coal to Japan, operation due to close in 1980.
10	Judy Creek (proposed)	Imperial Oil	2.3 million	surface mine - output to be used at Cold Lake Heavy Oil Recovery Project.
11	Coal Valley	Luscar Sterco Ltd.	2 million	production of high volatile bituminous coal has been contracted to Ontario Hydro.
12	Bienfait	Manitoba & Saskatchewan Coal Co. Ltd. (Luscar Ltd.)	650 - 800 thousand	surface mine produces lignite for thermal power generation.
13	Boundary Dam Mine	Manitoba & Saskatchewan Coal Co. Ltd. (Luscar Ltd.)	1.5 million	surface mine produces lignite for use at Boundary Dam Power Station.
14	Klimax Mine	Manalta Coal Co. Ltd.	0.8 million	surface mine produces lignite.
15	Utility Mine	Utility Coals Ltd. (Manalta)	2.2 million	surface mine produces lignite for thermal power generation.
16	Boundary Mine	Saskatchewan Power Corp.	350 thousand	output of lignite used at Saskatchewan Power's Boundary Dam Power Station.
17	Willow Bunch -under development	Saskatchewan Power Corp.	1.4 million	output to be used at Poplar River Power Station near Coronach.

Table 2. Mines (other than uranium) in production or currently under development in the prairie provinces and the Northwest Territories.

Map Number	Mine	Owner	Remarks
1	Nanisivik	Nanisivik Mines Ltd.	reserves as of January 1, 1978 6,353,000 tonnes. grading 13.48% Zn, 1.45% Pb.
2	Echo Bay-Port Radium	Echo Bay Mines Ltd. (I.U. International Corp. of Philadelphia)	silver, copper producer. No data as to reserves or grades.
3	Silver Bear Mine	Terra Mining and Exploration Ltd.	silver producer south of Port Radium - 200 tonne per day mill. no information on reserves or grades.
4	Northrim	Northrim Mines Ltd.	production suspended following fire in May 1978. estimated silver grade is 1875 mg/kg.
5	Giant Yellowknife-Lolor - Supercrest	Giant Yellowknife Mines Ltd.	3 open pits and underground workings 1100 tonne per day mill. reserves as of January 1978 913,000 tonnes. grading 10.6 mg/kg gold.
6	Con - Rycon	Cominico Ltd.	mine equipped with 590 tonne/day mill. reserves as of January 1, 1978 estimated 1,600,000 tonnes grading at 17.8 mg/kg gold.
7	Mactung	Amax Northwest Mining Co. Ltd.	mine is currently under development. reserves in excess of 25 million tonnes averaging 0.90% tungsten.
8	Pine Point	Pine Point Mines Ltd.	open pit lead-zinc operation. equipped with 9000 tonne per day concentrator. reserves in excess of 34 million tonnes grading 2.1% lead, 5.3% zinc.
9	Cantung	Canada Tungsten Mining Corp. Ltd.	production to be expanded to 900 tonnes per day by mid-1979. reserves estimated in excess of 4 million tonnes grading 1.55% tungstite (WO_3).
10	Ruttan Lake	Sherritt-Gordon Mines Ltd.	9,000 tonne per day concentrator. reserves as of January 1, 1978 were 27 million tonnes grading 1.74% copper and 1.25% zinc. originally an open pit mine. underground production to start in 1979.
10	Fox Lake	Sherritt-Gordon Mines Ltd.	underground operation equipped with 2700 tonne per day concentrator. reserves as of January 1, 197B were in excess of 6 million tonnes grading 1.83% copper and 2.12% zinc.
11	T1 T3 Birchtree Pipe Lake	Inco Ltd.	Inco has longterm mining rights on an area 125 km long and up to 15 km wide in Mystery-Moak-Thompson area of Northern Manitoba. no data as to reserves, rate of production or grade.
12	Flin Flon North Main South Main	Hudson Bay Mining and Smelting Co.	reserves of 893,000 tonnes grading 2.41% copper, 2.1% zinc, 17.2 mg/kg silver, 1.66 mg/kg gold. 6600 tonne per day concentrator, smelter and refinery.
	Flin Flon White Lake	Hudson Bay Mining and Smelting Co.	reserves 175,600 tonnes grading at 1.82% copper, 5.2% zinc, 25.3 mg/kg silver, 0.66mg/kg gold.
	Flin Flon Centennial	Hudson Bay Mining and Smelting Co.	1,470,000 tonnes reserves grading 1.63% copper, 2.7% zinc, 23.1 mg/kg silver, 1.6 mg/kg gold.

Table 2. Continued.

Map Number	Mine	Owner	Remarks
12	Flin Flon Westarm	Hudson Bay Mining and Smelting Co.	940,000 tonnes reserves grading 3.85% copper, 0.9% zinc 13.4 mg/kg silver, 1.19 mg/kg gold.
13	Snow Lake-Ghost Lake	Hudson Bay Mining and Smelting Co.	reserves 72,500 tonnes grading at 1.59% copper, 9.7% zinc, 0.3% lead, 28.88 mg/kg silver, 0.63 mg/kg gold.
	Snow Lake-Chisel Lake	Hudson Bay Mining and Smelting Co.	reserves 2,465,000 tonnes grading at 0.33% copper, 10.9% zinc, 1.0% lead, 41.6 mg/kg silver, 1.53 mg/kg gold.
	Snow Lake-Anderson Lake	Hudson Bay Mining and Smelting Co.	reserves 224,300 tonnes grading at 0.86% copper, 7.0% zinc, 45 mg/kg silver, 1.41 mg/kg gold.
	Snow Lake-Stall Lake	Hudson Bay Mining and Smelting Co.	reserves 1,774,000 tonnes grading at 3.76% copper, 0.1% zinc, 5.3 mg/kg silver, 0.44 mg/kg gold.
	Snow Lake-Osborne Lake	Hudson Bay Mining and Smelting Co.	reserves 3,250,000 tonnes grading at 4.16% copper, 0.5% zinc, 5.9 mg/kg silver, 0.09 mg/kg gold.
14	Bernic Lake	Tantalum Mining Corp./ Canada Ltd.	tantalum - lithium - cesium producer equipped with 650 tonne per day mill. no information as to grades or reserves.

Table 3. Potential mineral developments in the prairie provinces and the Northwest Territories.

Map Number	Prospect	Location	NTS	Owner	Remarks
1	Polaris Eclipse	75° 23' 42"/96° 56' 75° 32' 30"/96° 09'	63 H/8 63 H/9	Arvik Mines Ltd. Arvik Mines Ltd.	25 million tonnes at 14.1% Zn, 4.3% Pb. 1 million tonnes at 12.43% Zn, 2.18% Pb. 250 thousand tonnes at 3.6% Zn, 0.05% Pb. 240 thousand tonnes at 3.45% Zn, 2.19% Pb.
2	Wreck Lake #47 Zone	67° 24'/116° 23'	86 N/8	Coppermine River Ltd.	3.75 million tonnes at 3.07% Cu.
3	High Lake	67° 22' 45"/110° 51' 19"	76 M/7	Kennarctic Exploration Ltd.	4.72 million tonnes at 2.46% Zn, 3.53% Cu, 7.2 ppm Au. Minor Ag, Pb.
4	Echo Bay	66° 05' 30"/117° 59' 50"	86 K/4	Echo Bay Mines Ltd.	N/A - recovery of Ag/U from tailings of previous operation.
5	G W Group	66° 26' 43"/117° 31' 25"	86 K/5	Westfield Minerals Ltd.	90,000 tonnes at 8.4% Cu plus U could be be open pit operation.
6	Eldorado Port Radium	66° 05'/118° 01' 30"	86 L/1	Eldorado Nuclear Ltd.	18,000 tonnes at 15% Cu - high grade Cu pod in old workings of Port Radium mine.
7	Contact Lake	65° 59' 37"/117° 48'	86 F/13	Ulster Petroleum Ltd.	18,000 tonnes at 1359 mg/kg Ag, .33% U_3O_8
8	Silver Bay (White Eagle)	65° 35' 42"/117° 59' 30"	86 F/12	Camsell Holdings Ltd.	21,000 tonnes at 3406 mg/kg Ag plus Bi, Co, Ni, U, Pb. Deposit to be developed by Northrim Mines Ltd.
9	Caesar Silver (Norex)	63° 35' 06"/117° 57' 30"	86 F/12	Terra Mining and Development	13,000 tonnes at 4656 mg/kg Ag, 0.1 - 1% Bi. Small but very rich deposit is located south of the Terra Mine.
10	Izok Lake	65° 38' 00"/112° 47' 45"	86 H/10	Texas Gulf Inc.	12 million tonnes at 2.82% Cu, 13.7% Zn, 1.42% Pb, 64 mg/kg Ag. Three shallow zones-potential open pit.
11	Takiyuak Lake No. 10	66° 04' 40"/112° 45' 00"	86 I/2	Texas Gulf Inc.	500,000 tonnes at 5% Cu, 3.5% Zn, 31 mg/kg Ag.
	Takiyuak Lake No. 41	66° 03' 30"/112° 42' 00"	86 I/2	Texas Gulf Inc.	320,000 tonnes at 1.57% Cu, 4.12% Zn, 16 mg/kg Ag.
12	Bear Twit	65° 38' 00"/112° 47' 45"	106 A/3	Bethlehem Copper Co.	10 million tonnes at 8% Pb - Zn.
13	Contwoyto Lake	65° 45' 52"/111° 13' 35"	76 E/14,11	Canadian Nickle Co. (Inco)	1 million tonnes at 23.4 mg/kg Au or several million tonnes at 9.4 mg/kg Au.
14	Hackett River	65° 55'/108° 22'	76 F/16	Bathhurst Norsemines Ltd./ Cominco Ltd.	'A' Zone 4 million tonnes at 7.07% Zn, 1.06% Pb, 0.45% Cu, 168 mg/kg Ag, 0.41 mg/kg Au. Cleaver Zone 4 million tonnes at 8.16% Zn, 1.18% Pb, 0.45% Cu, 222 mg/kg Ag, 0.22 mg/kg Au. Cleaver Low Grade 4 million tonnes at 1.08% Zn, 0.84% Pb, 0.45% Cu, 30.3 mg/kg Ag, 0.22 mg/kg Au.

Table 3. Continued.

Map Number	Prospect	Location	NTS	Owner	Remarks
14	Hackett River	65° 55'/108° 22'	76 F/16	Bathhurst Noresmines Ltd. Cominco Ltd.	Boot Zone 5 million tonnes at 4.97% Zn, 0.99% Pb, 0.29% Cu, 183 mg/kg Ag, 0.43 mg/kg Au, plus 2 million tonnes at lower grade. Total for all Hackett River area zones is 21.5 million tonnes at 5% Zn, 1% Pb, 125 mg/kg Ag.
15	G I Group	64° 22' 42"/115° 06' 30"	86 B/6	Johnsby Mines Ltd.	Colomac Dyke 15 million tonnes at 2.5 mg/kg Au. Goldcrest Dyke 1.15 million tonnes at 4.5 mg/kg Au.
16	Mactung	65° 17' 15"/130° 08' 45"	105 O/8	Amax Northwest Mining Co. Ltd.	30 million tonnes at 0.9% WO_3 - proceeding with development.
17	Tom Group	63° 10'/130° 09'	105 D/1	Hudson Bay Exploration and Development (HBM&S)	7.8 million tonnes at 8.1% Pb, 8.4% Zn, 86 mg/kg Ag, on NWT/Yukon border near Canol Road.
18	Howard's Pass	62° 27'/129° 11'	105 I/6	Canex Placer Ltd.	300 million tonnes at 5 - 10% Pb, Zn, development is proceeding.
19	Lened	62° 22'/128° 38'	105 I/6	Union Carbide	tungsten deposit - details unknown.
20	Redstone	62° 41'/126° 38'	95 L/10	Redstone Resources Ltd.	tonnages not available - widespread mineralization with Cu values 2.96 - 4.94% with some Ag and Co - 150 km west of Wrigley.
21	Prairie Creek	61° 33' 35"/124° 47' 30"	95 F/10	Cadillac Exploration Co.	1.9 million tonnes at 10.9% Pb, 13.5% Zn, 0.52% Cu, 183 mg/kg Ag, 0.43 mg/kg Au.
22	Deloro (Snare River)	63° 21' 10"/116° 18' 20"	85 N/8	Anglo United Development Co.	40,000 tonnes at 14.3 mg/kg Au - near Snare Forks Hydro plant.
23	Giaque Lake	63° 08' 45"/113° 54'	85 P/4	Bruce-Avis Group	100,000 tonnes at 19.3 mg/kg Au - 3 km S of Discovery Mine, 80 km N of Yellowknife.
24	Crestaurum	62° 35'/114° 21' 10"	85 J/9	Northbelt Yellowknife Mines Ltd.	100,000 tonnes at 17.2 mg/kg Au - near Ryan Lake 15 km N of Yellowknife, 8 km N of Giant Yellowknife.
25	Ann	62° 28'/113° 25' 25"	85 I/6	Unknown	10 million tonnes at 1.6% LiO_2.
26	Kennedy Lake B B Zone	63° 02' 44"/110° 57' 16"	75 M/2	Indian Mountain Metal Mines Ltd.	65,000 tonnes at 6% Zn, 1% Pb, 155 mg/kg Ag. 1 million tonnes at 10% Zn 1% Pb, 94 mg/kg Ag.
	Voo Copper Zone	63° 01' 57"/110° 57' 48"			1.5 million tonnes at 0.62% Cu. 15 km N of McLeod Bay, Great Slave Lake, 200 km E of Yellowknife.
27	X - 25	60° 44' 15"/115° 03' 15"	85 B/11	Western Mines Ltd./ Dupont of Canada Explorations Ltd.	2.5 million tonnes at 4.1% Pb, 11.9% Zn - adjoins Pine Point Mine, decision on development schedule by end of 1979.

Table 3. Continued.

Map Number	Prospect	Location	NTS	Owner	Remarks
28	Selco B Zone	61° 17'/98°30'	65 G/8,7	O'Brien Gold Mines Ltd.	270,000 tonnes at 23 mg/kg Au, property at Cullaton Lake, 2 km N of Kognak River.
29	Lynn Lake (Agassiz)	56° 55/100° 55'	64 C/15	Agassiz Resources Ltd.	1.4 million tonnes indicated +650,000 tonnes inferred at 10mg/kg Au, 37.2 mg/kg Ag, company presently seeking financing.
30	McKenzie Peg	56° 07' 30"/103° 42' 00"	64 D/4	Bison Petroleums & Minerals Ltd.	4 million tonnes at 4.43% Zn, 0.64% Cu.
31	Nemeiben Lake	55° 19'/105° 10'	73 P/6	Aberdeen Minerals/Cadillac Explorations	2.1 million tonnes at 0.35% Cu, 0.61% Ni, 5 million tonnes at 0.34% Ni, 0.18% Cu, 7.2 million tonnes at 0.15% Cu, 0.23% Ni.
32	La Ronge	55° 24' 30"/104° 27' 30"	73 P/8	Drope Lake Metals & Holdings Ltd.	8.5 million tonnes at 0.083% U_3O_8 all available for open pit mining.
33	Schotts Lake	55° 05' 45"/102° 13' 35"	63 M/1	Stall Lake Mines Ltd./ Scope Resources Ltd.	2 million tonnes at 0.61% Cu, 1.35% Zn plus minor Ag and Au values, 40 km NW of Flin Flon.
34	Quandt Group	55° 14' 17"/102° 45' 05"	63 L/10	Western Nuclear Inc./ Share Mines & Oils Ltd.	800,000 tonnes at 2.16% Cu, 1.77% Zn, 6.3 mg/kg Ag.
35	Vamp Lake	54° 56' 13"/101° 10' 20"	63 K/14	Hudvam Mines Ltd.	455,000 tonnes at 1.65% Zn, 1.1% Cu, 2.5 mg/kg Au, 15 mg/kg Ag, within 3 km of Lynn Lake branch of CNR. Company controlled by HBM&S, development depends on HBM&S priorities.
35	Vamp Lake	Unknown	u/k	Cerro Corp./Guggenheim Exploration Co. Ltd.	410,000 tonnes at 3% Cu.
35	Jungle Lake	55° 11"/100° 58'	63 N/2	Hudson Bay Mining & Smelting Co. Ltd.	3.4 million tonnes at 1.12% Cu, 1.1% Zn.
35	Bob Lake	55° 09' 30"/101° 02' 30"	63 N/3	Sherritt Gordon Mines Ltd.	2.2 million tonnes at 1.18% Zn, 1.33% Cu, 8.4 mg/kg Ag.
36	Stall Lake	54° 51' 18"/99° 55' 10"	63 J/13	Stall Lakes Mines Ltd. Falconbridge Nickel Mines Ltd.	609,000 tonnes at 5.38% Cu, 2.28% Zn.
36	Reed Lake	54° 34' 30"/100° 24'	63 K/9	Freeport Canadian Ltd./ Beth-Canada Mining Co.	in excess of 1 million tonnes at 2% Cu, 4% Zn.
36	Reed Lake	54° 38' 12"/100° 32' 54"	63 K/10	Hudson Bay Mining & Smelting Co. Ltd.	1 million tonnes at 2.18% Cu - underlies Reed Lake. Development depends on priorities of HBM&S.
36	Rail Lake	54° 44' 30"/100° 35' 25"	63 K/10	Hudson Bay Mining & Smelting Co. Ltd.	295,000 tonnes at 3.0% Cu, .7% Zn.
36	Nor Acme	54° 53' 10"/100° 101' 20"	63 K/16	Nor-Acme Gold Mines Ltd.	180,000 tonnes at 5.71 mg/kg Au plus 227,000 tonnes at 8.75 mg/kg Au in tailings of old mine.

Table 3. Continued.

Map Number	Prospect	Location	NTS	Owner	Remarks
37	G R 34	160 km SW of Wabowden	63 J/13	Amax Exploration Inc.	6.6 million tonnes at 1.33% Ni.
37	Bowden Lake	54° 55' 40"/98° 28' 30"	63 J/15	Falconbridge Nickel Mines Ltd.	72.7 million tonnes at 0.04% Cu, 0.6% Ni.
37	Bucko Deposit	54° 55' 40"/98° 28' 30"	63 J/15	Falconbridge Nickel Mines Ltd.	27.2 million tonnes at 0.04% Cu, .78% Ni.
38	Chrome Group	50° 27' 3B"/95° 33' 58"	52 L/5	A. O. Zeemel	1.1 million tonnes at 18.2% Cr_2O_3.
38	Page Group	50° 29'/95° 30'	52 L/5	Manitoba Chromium	795,000 tonnes at 25.2% Cr_2O_3.
38	Euclid Lake	50° 34' 18"/95° 22' 12"	52 L/11	Strannar Mines Ltd.	10 million tonnes at 4.6% Cr_2O_3 plus 614,000 tonnes at 6.7% Cr_2O_3.
3B	San Antonio Mine	51° 01' 22"/95° 40' 41"	52 M/4	New Forty Four Mines Ltd.	7.2 million tonnes at 3.75 mg/kg Au - was a producing mine from 1932-6B.
39	Hambone	55° 17' 30"/9B° 20' 25"	63 O/8	INCO	3.2B million tonnes at 0.81% Ni and 1.1 million tonnes at 1.1% Ni - Thompson Area.
39	Mystery Lake South	55° 49' 15"/97° 45' 45"	63 P/13	INCO	227 million tonnes at 0.6% Ni - Thompson Area.

Table 4. Hydroelectric potential of the Nelson River with Churchill River Diversion and Lake Winnipeg Regulation.

Site	Potential in kilowatts	In Service
Upper Nelson River		
Jenpeg	168,000	1977
Bladder Rapids	565,000	-
Kelsey	224,000	1960
	957,000	
Lower Nelson River		
Upper Gull	565,000	-
Lower Gull	560,000	-
Kettle	1,272,000	1974
Longspruce	980,000	1977
Limestone	1,100,000	1987
Conawapa	1,100,000	-
Gillam Island	1,000,000	-
	6,577,000	
Burntwood River		
Notigi	90,000	-
Early Morning	100,000	-
Wuskwatim	156,000	-
Kepuche	156,000	-
Manasan	82,000	-
First Rapids	166,000	-
	750,000	
	8,284,000	

Table 5. Existing and potential hydro-electric generating facilities in the Northwest Territories.

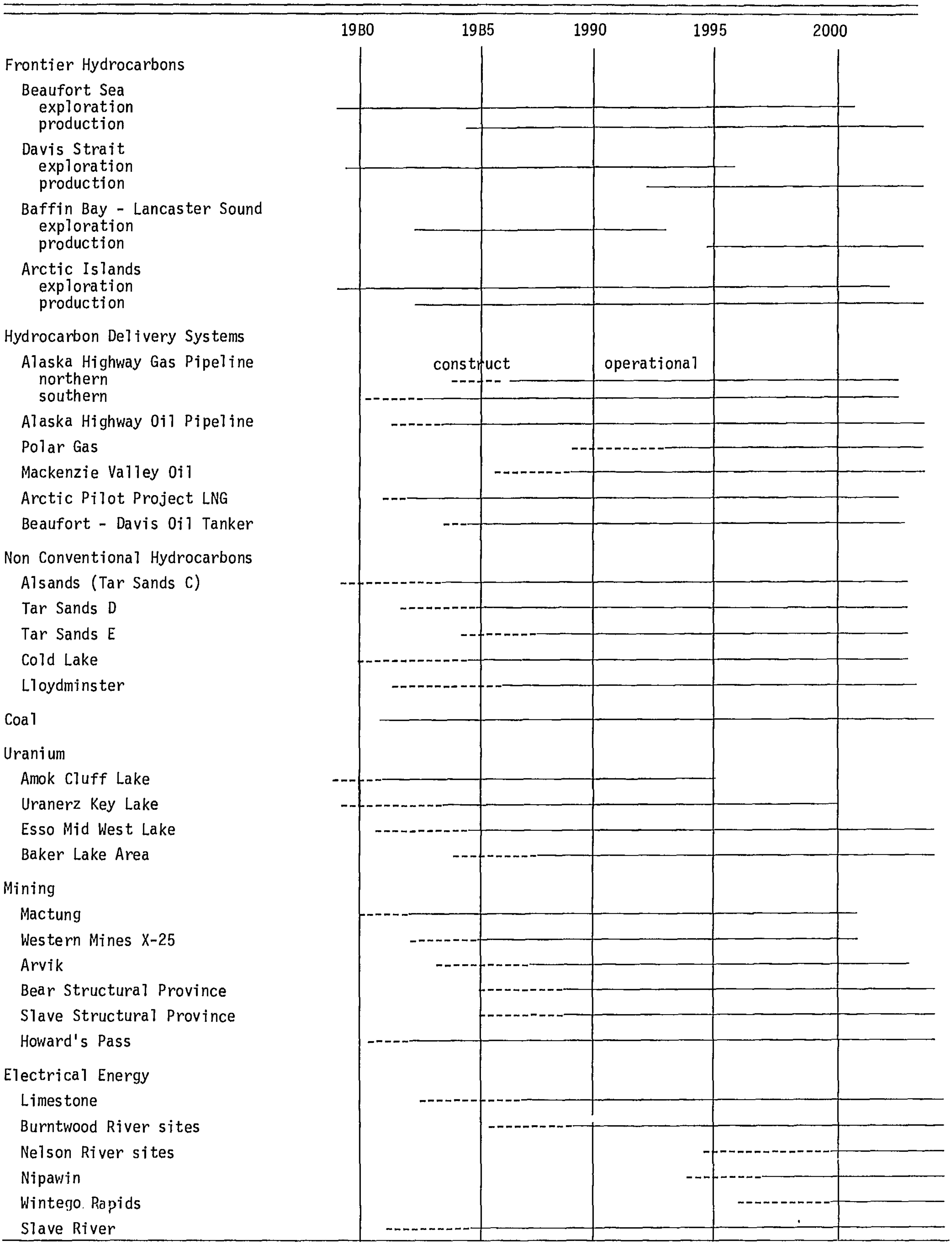
Potential	Site	River	Capacity (MW)
1	Baker Lake	Kazan River	115
2	Kazan Falls	Kazan River	24.6
3	Thirty Mile Lake	Kazan River	flow control
4	Beverly Lake	Kazan River	50.6
5	Grant Lake	Kazan River	74.8
6	Dubawnt Lake	Kazan River	165.8
7	Upper Thelon	Thelon River	7.1
8	Muskox	Thelon River	7.2
9	Lower Muskox	Thelon River	73.4
10	Dickson Canyon	Hanbury River	56.5
11	Lockhart-Hanbury	Diversion Canal	flow augmentation
12	Ptarmigan Lake	Lockhart River	-
13	Anderson Falls	Lockhart River	52.4
14	Parry Falls	Lockhart River	50.8
15	Tyrell Falls	Lockhart River	62.5
16	Snow Drift River #1	Snow Drift River	9.8
17	Snow Drift River #2	Snow Drift River	-
18	Elizabeth Falls	Fond du Lac River	-
19	Slave	Slave River	-
20	Mountain Rapids	Slave River	1500
21	Kolethe Rapids	Thoa River	7.8
22	Nettell Falls	Thoa River	12.5
23	Othikethe	Talston River	5.8
24	Neude Rapids/Elsie Falls/ Twin Gorge #2	Talston River	62
25	Buffalo Lake	Buffalo River	-
26	Lady Evelyn Falls	Kakisa River	87
27	Upper Snare	Snare River	-
28	Indin Lake	Snare River	-
29	Snare Cascades	Snare River	-
30	Lac La Martre .	La Martre River	50
31	Fort Simpson	Liard River	-
32	Petitot Canyon	Petitot River	49.6
33	Wrigley	Mackenzie River	-
34	Lower Brackett	Great Bear River	240
35	Upper Brackett	Great Bear River	280
36	St. Charles Rapids	Great Bear River	126
37	Head of Rapids	Great Bear River	288
38	Wolverine Creek	Great Bear River	236
39	Ramparts	Mackenzie River	-
40	Site A	Liard River	1140
41	Site E	Liard River	915
42	Site G	Liard River	640

... continued

Table 5. Continued.

Existing	Site	River	Capacity (MW)
1	Waterloo Lake	Charlot River	20
2	Wellington Lake	Charlot River	
3	Twin Gorges	Talston River	18
4	Bluefish Lake	Yellowknife River	-
5	Snare Falls	Snare River	7
6	Snare Rapids	Snare River	7

Table 6. A timetable for major developments in the prairie provinces and the Northwest Territories.



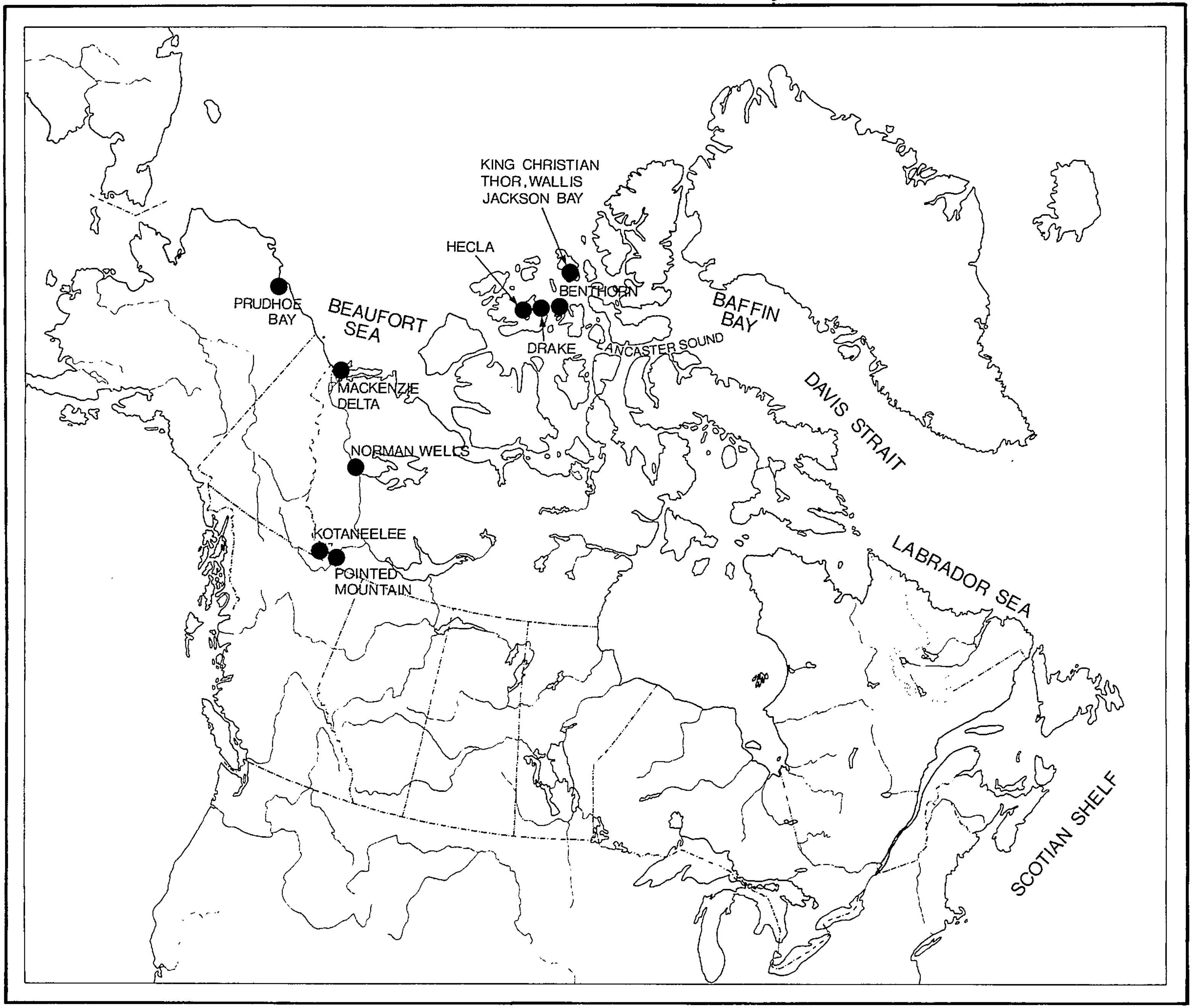


Fig. 1. Frontier hydrocarbon areas in Canada.

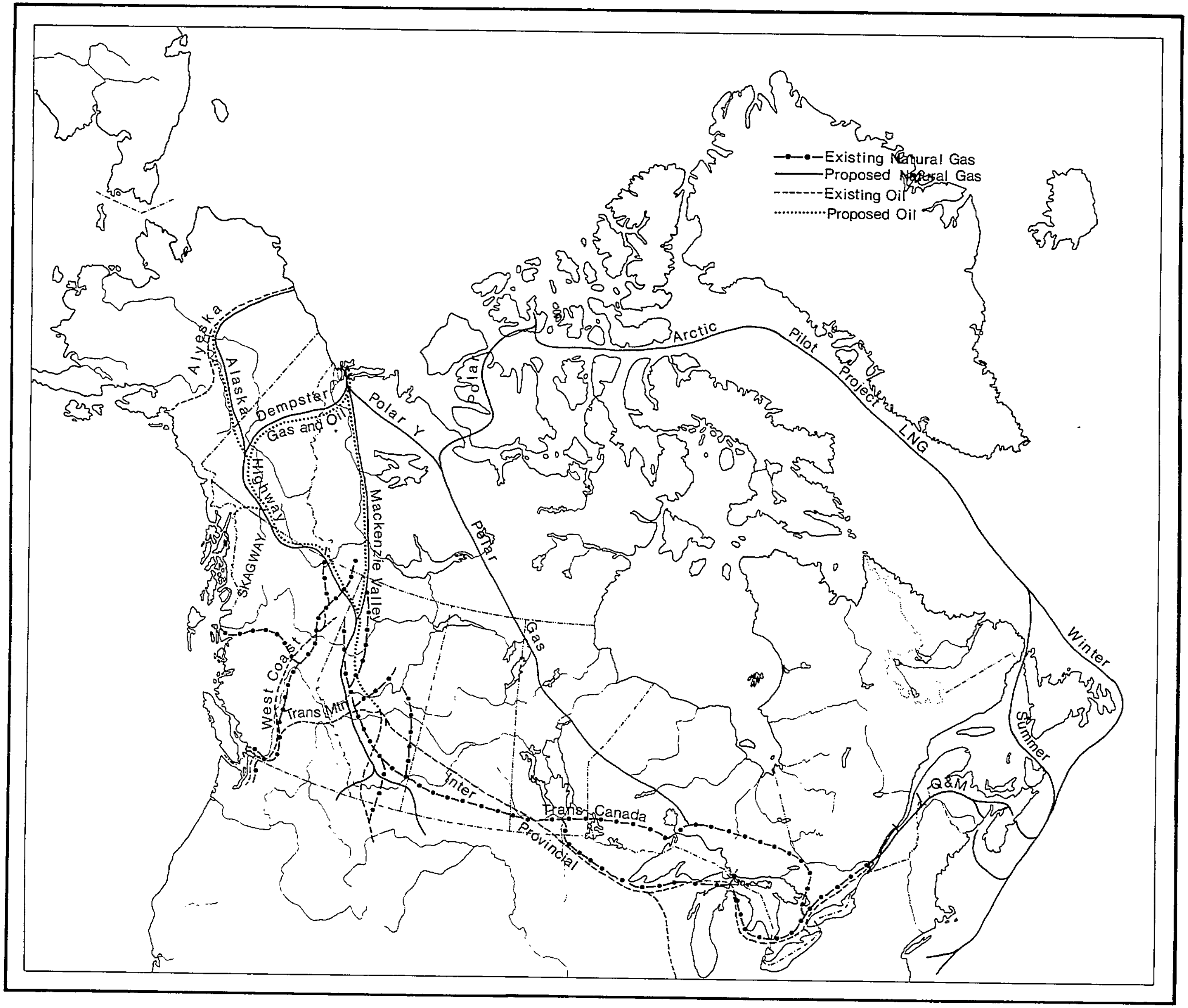


Fig. 2. Existing and proposed oil and gas delivery systems.

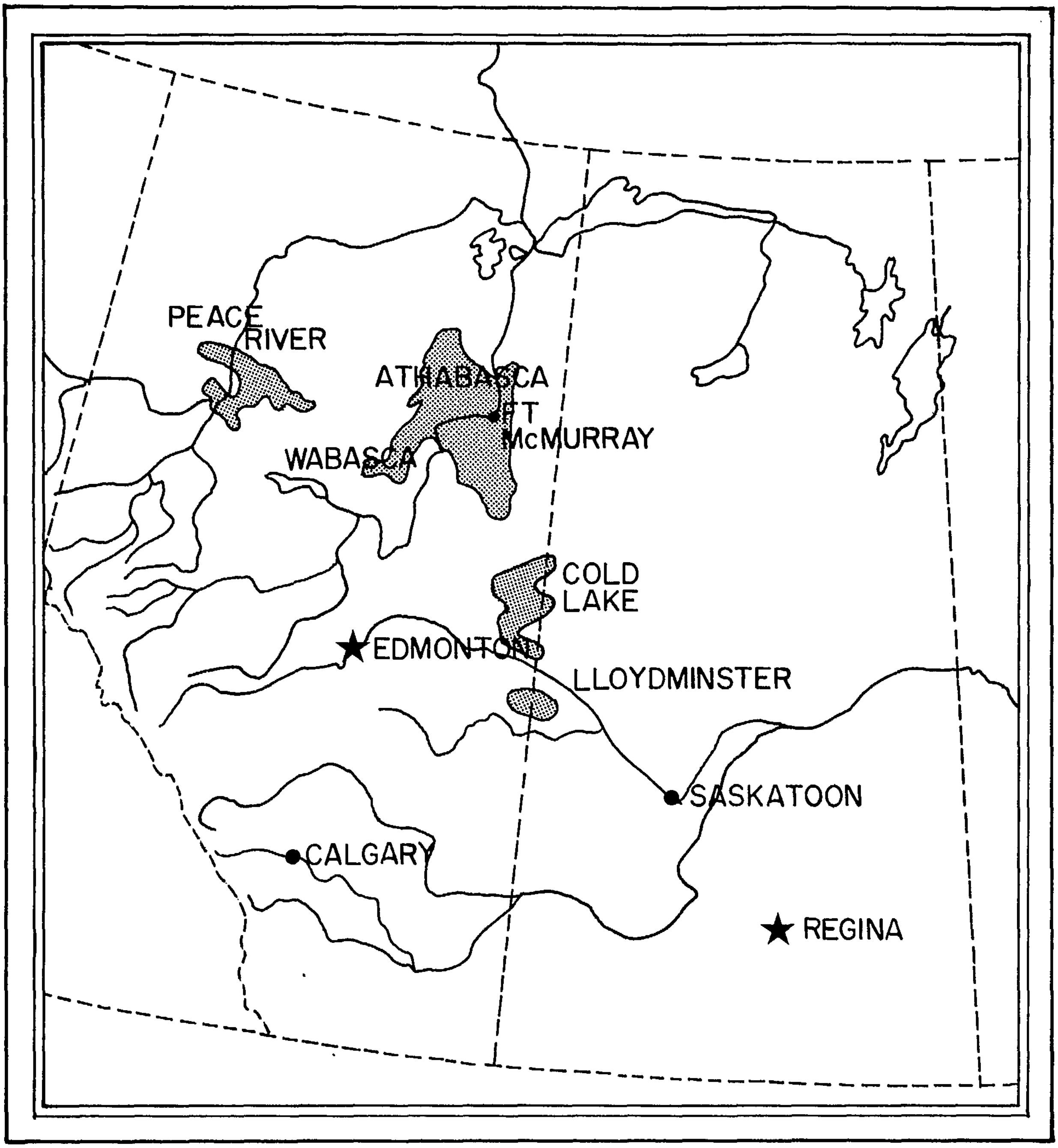


Fig. 3. Bituminous sands and heavy oil deposits in Western Canada.

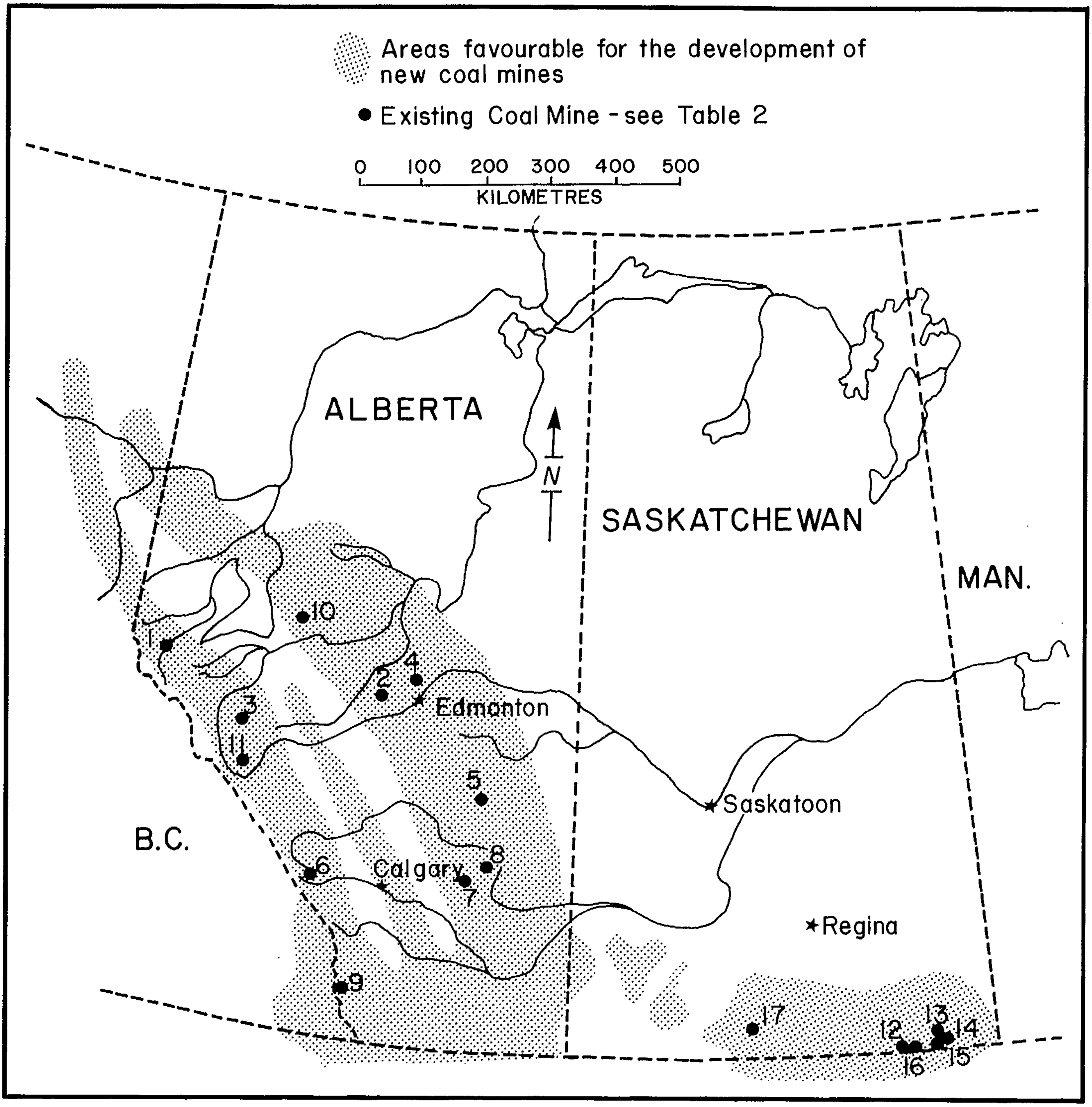


Fig. 4. Existing, developing and potential coal mines in Alberta and Saskatchewan.

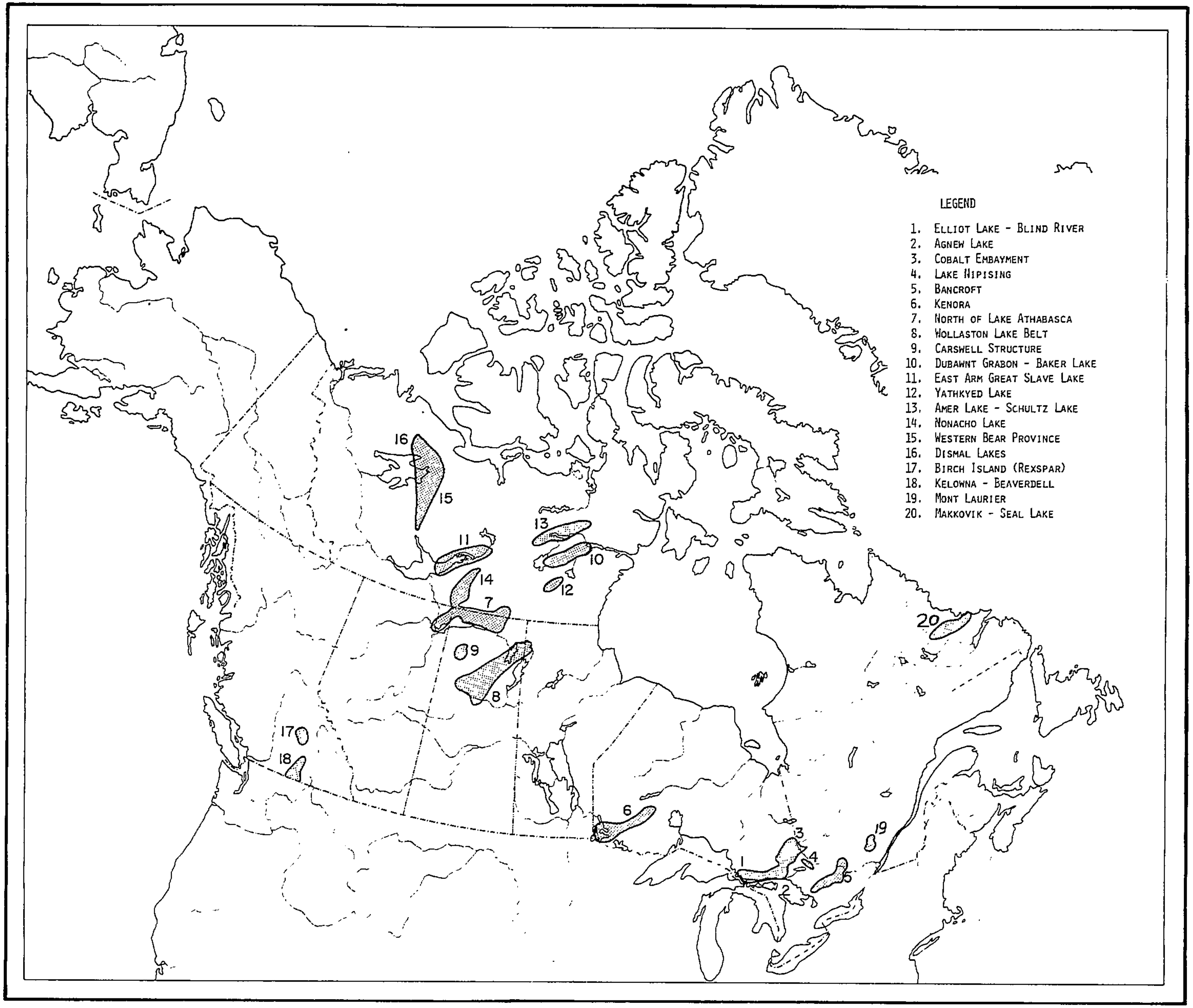


Fig. 5. Identified uranium resources in Canada.

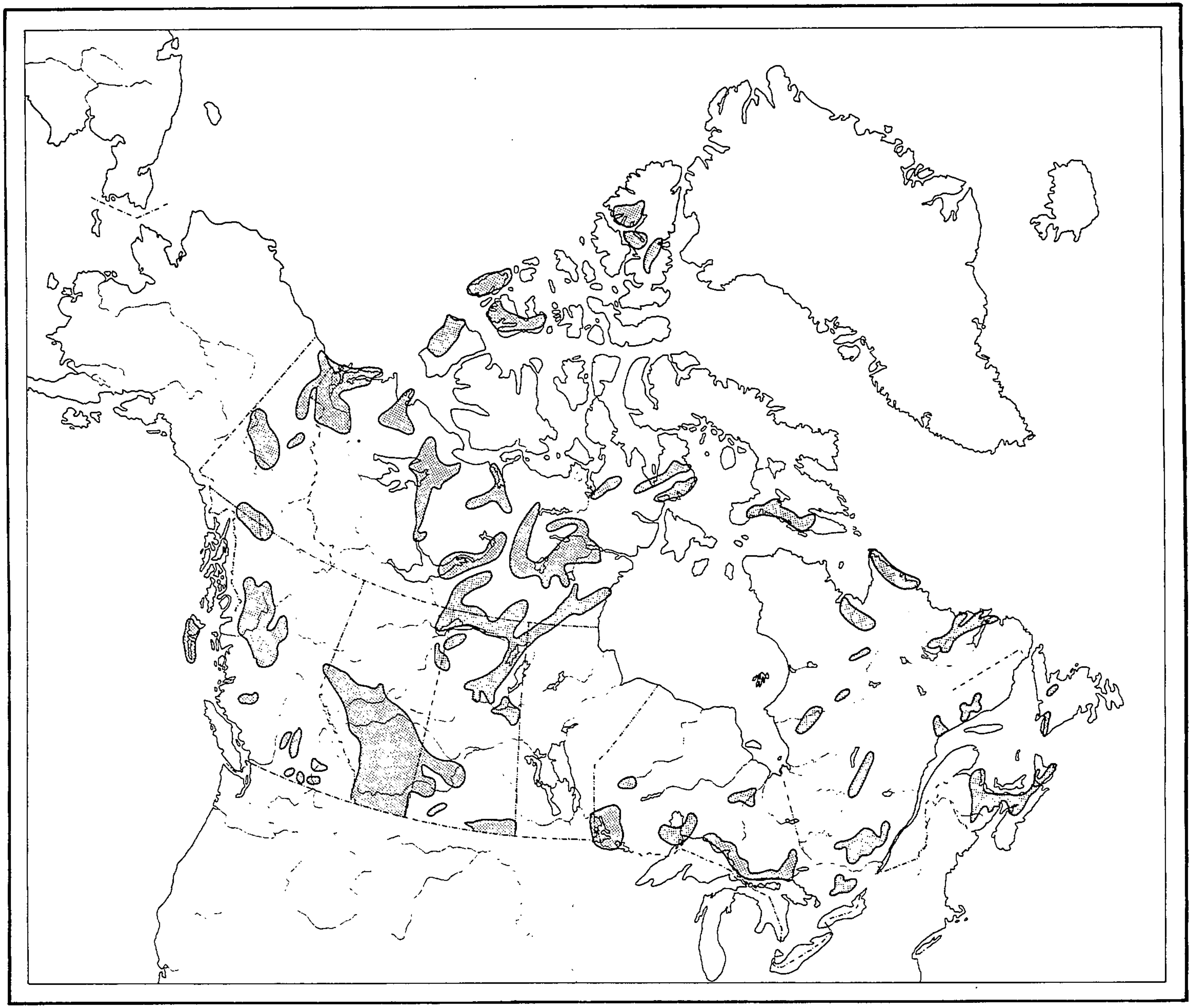


Fig. 6. Areas favourable for the occurrence of uranium resources in Canada.

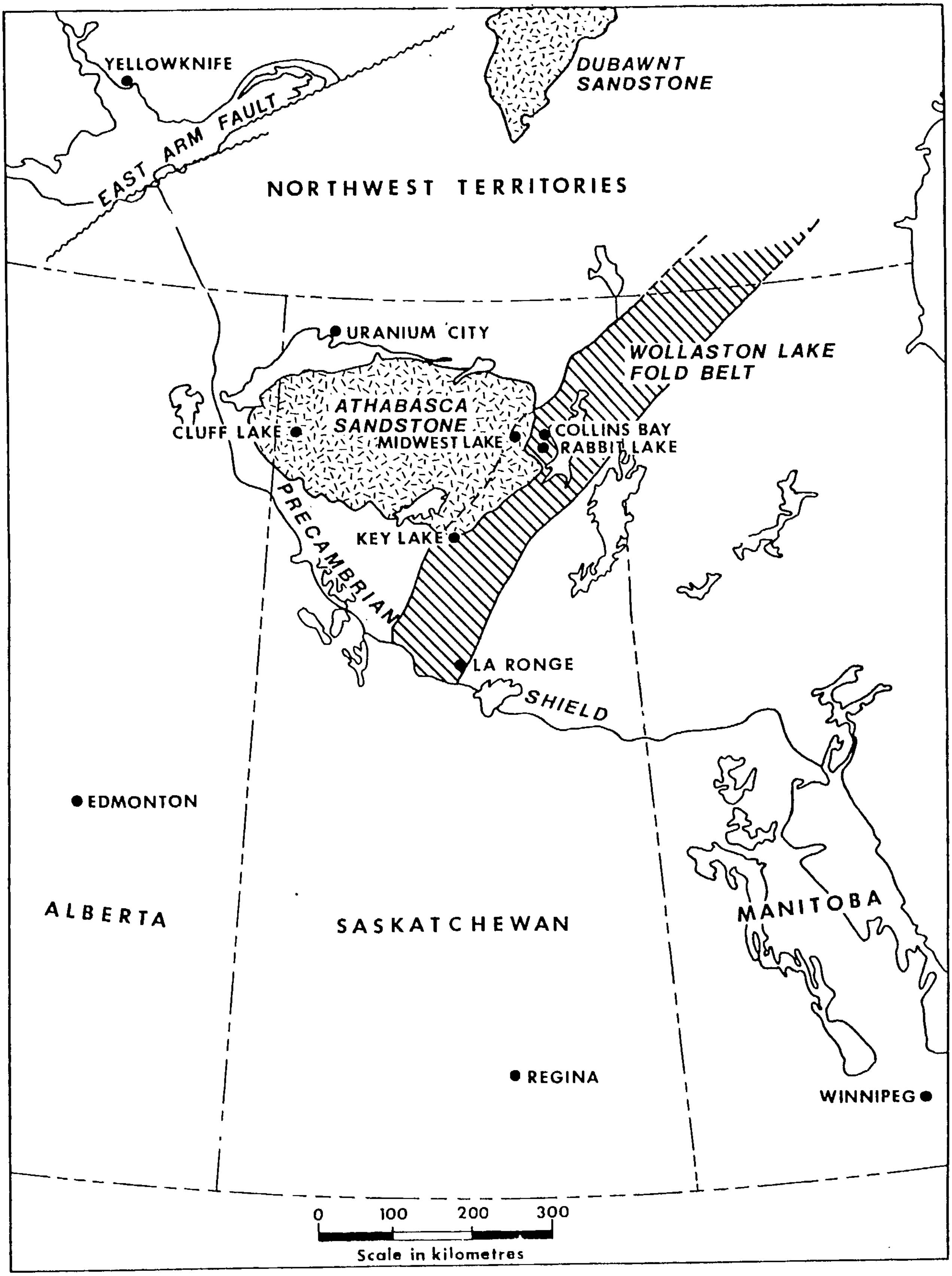


Fig. 7. Existing and developing uranium mines in northern Saskatchewan.

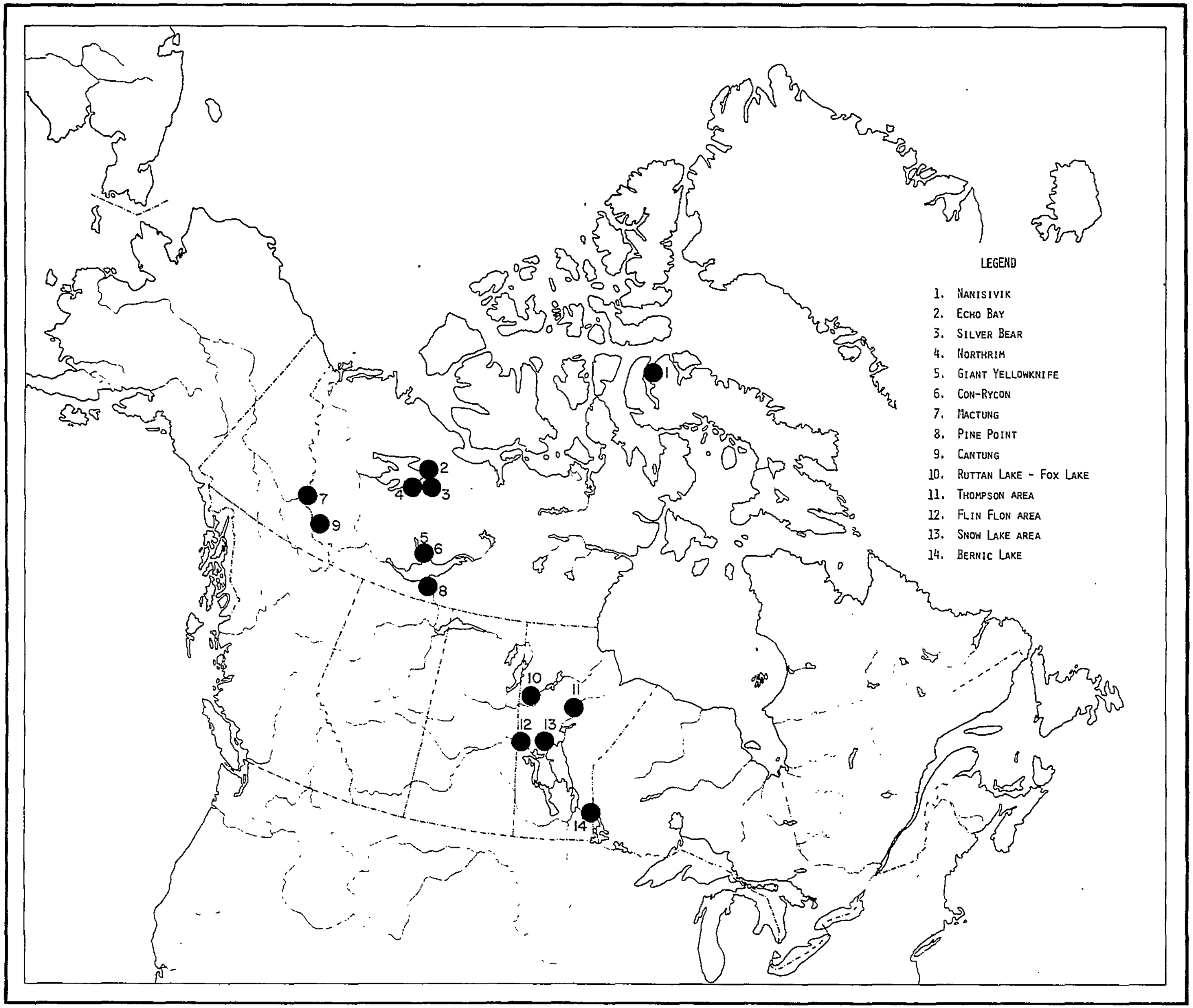


Fig. 8. Producing or developing mines, other than uranium, in the prairie provinces and the Northwest Territories.

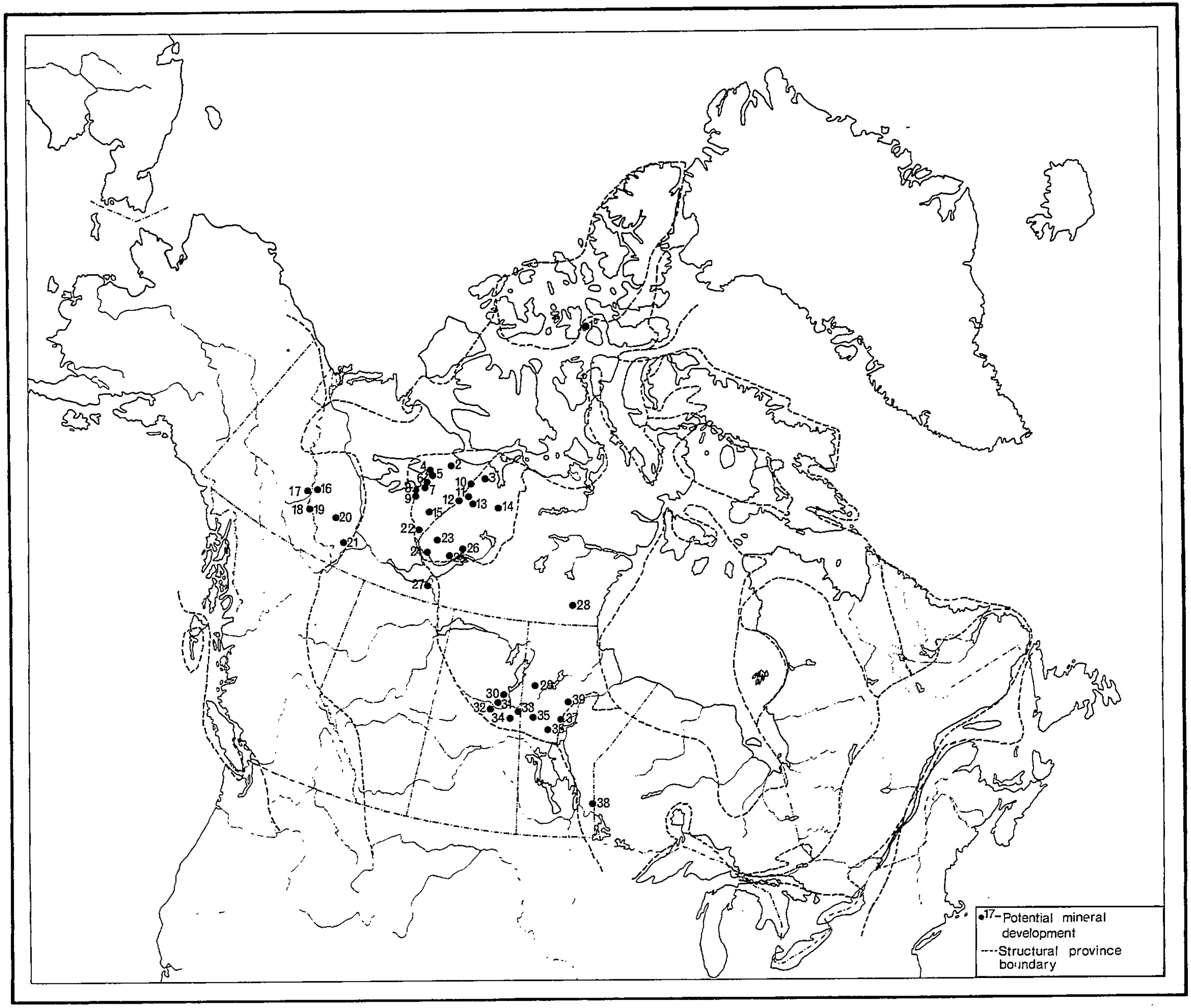


Fig. 9. Mineral deposits in the prairie provinces and the Northwest Territories that are economically exploitable at the present time or within reach of becoming so by the year 2000.

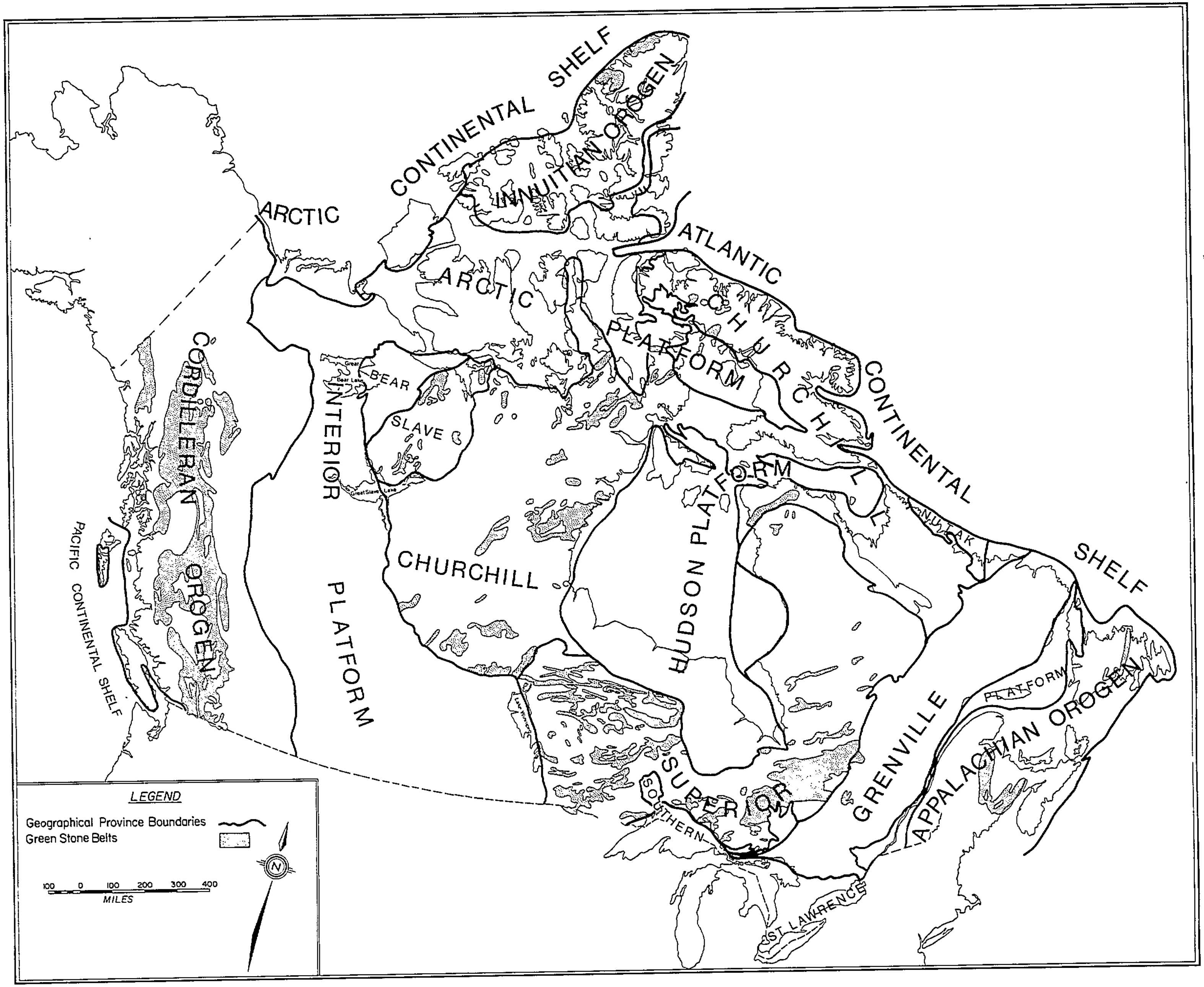


Fig. 10. Structural provinces and greenstone deposits in Canada.

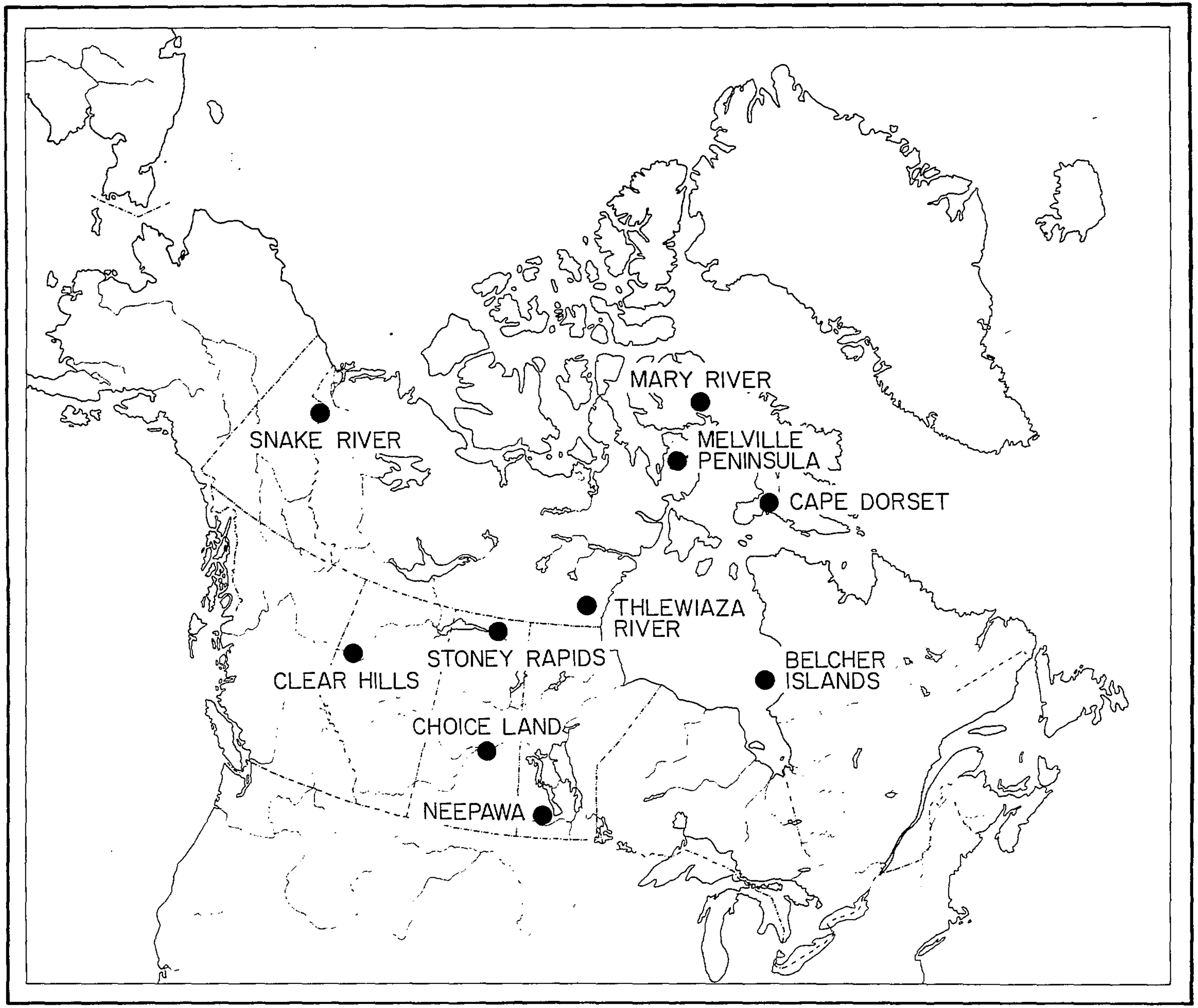


Fig. 11. Potential iron ore deposits in Canada.

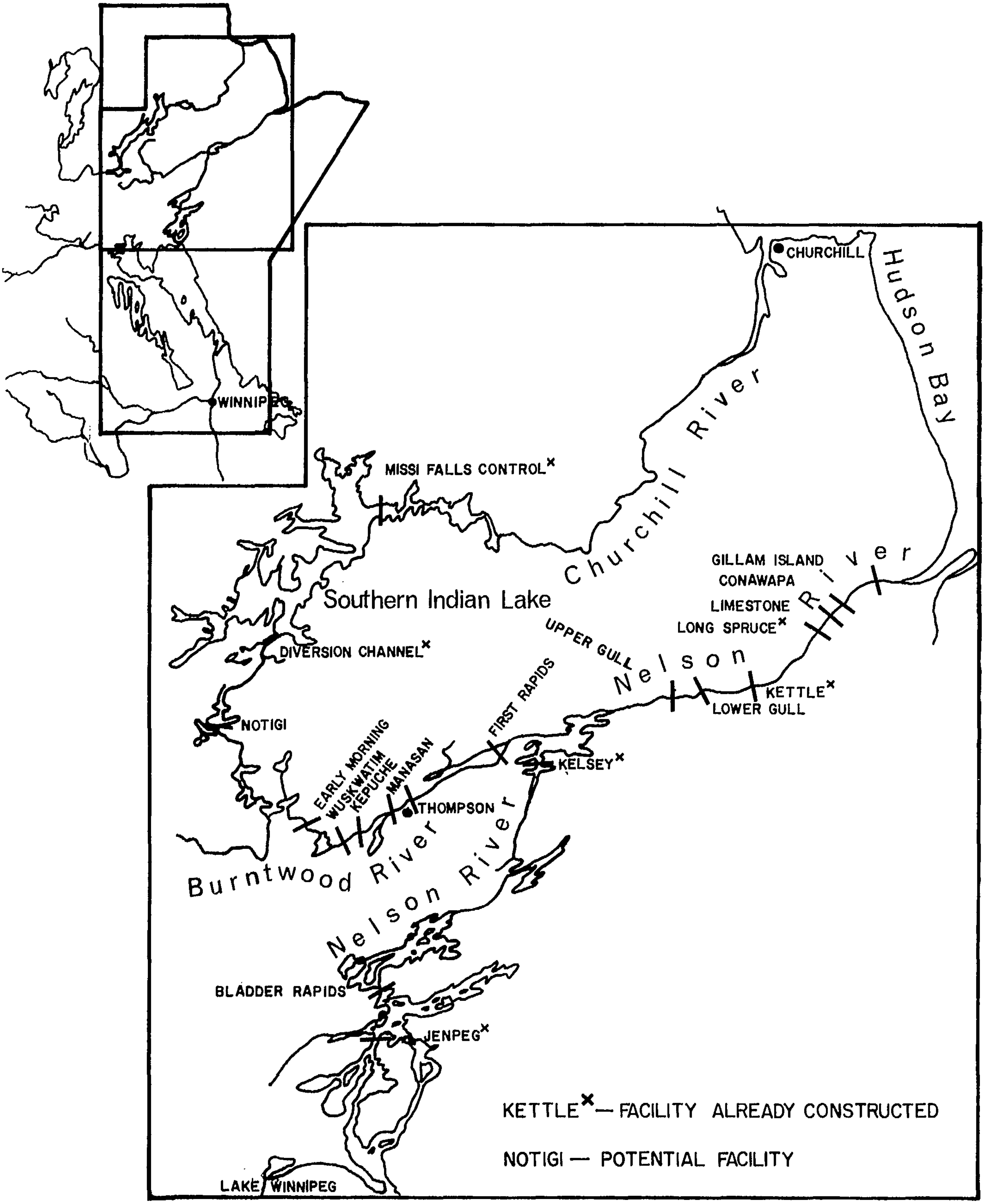


Fig. 12. Existing and potential hydroelectric sites on the Churchill-Nelson River system.

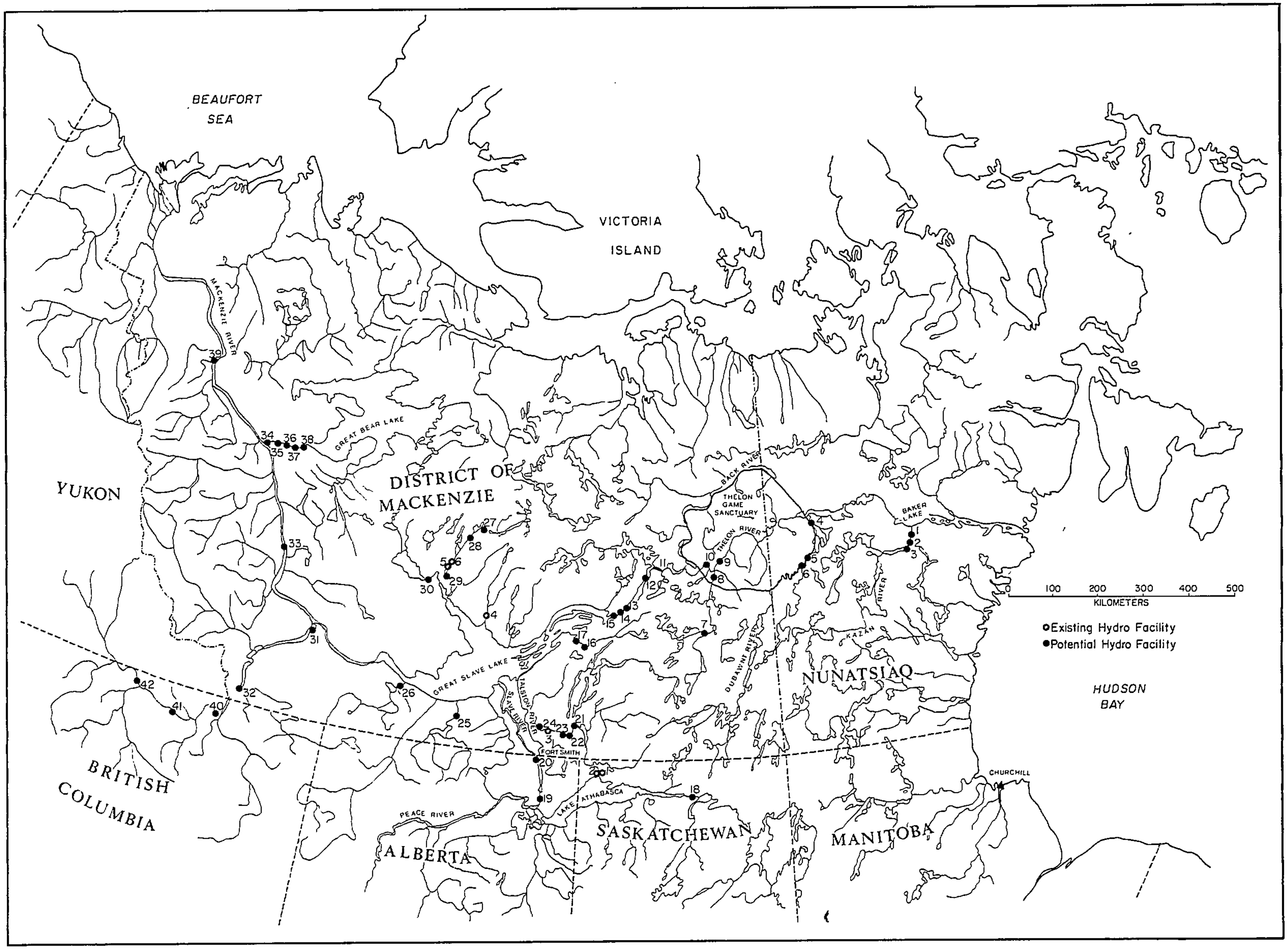


Fig. 13. Existing and potential hydro-electric sites in northern Canada.

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