THE PEACE & LIARD RIVER BASINS IN BRITISH COLUMBIA:

SURVEY OF RESOURCE DEVELOPMENT & ENVIRONMENTAL IMPLICATIONS

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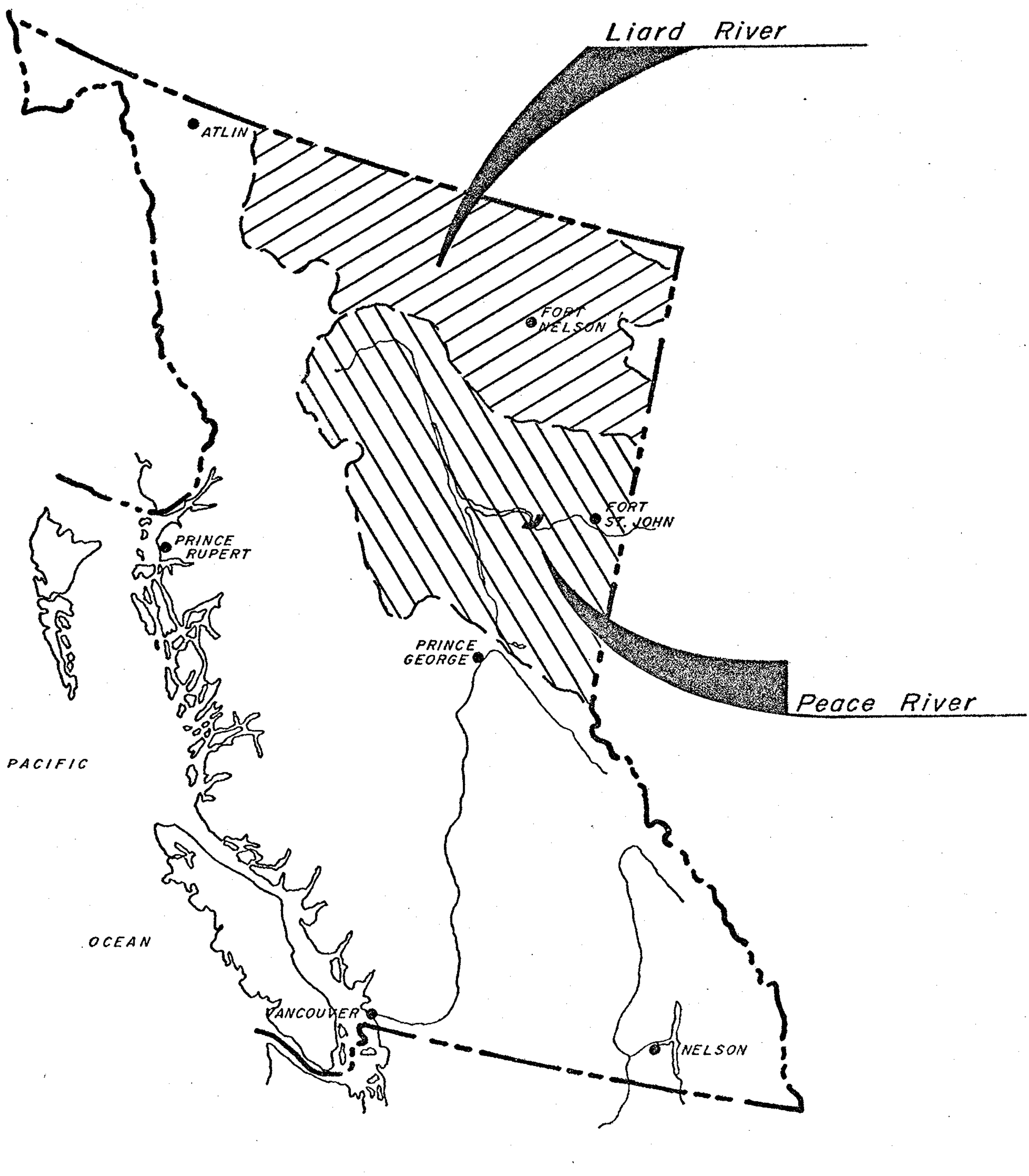
PEACE AND LIARD RIVER BASINS KEY MAP



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INTRODUCTION

This paper is a survey of resource and industrial development in the Peace and Liard River Basins of British Columbia and the possible water management and quality implications of such development. Areas of discussion include: geography, hydroelectric development, forestry, mining, petroleum and gas, agriculture, outdoor recreation and the environmental implications of development. For each resource, present activity is documented, future development is discussed and except for agriculture and outdoor recreation, water management and quality implications are reviewed.

Concrete data were difficult and in some cases impossible to obtain; thus data are in many cases neither complete nor up-to-date. This is especially true for the discussions on water management and quality considerations; except for municipalities and townships (see Appendix), water use and pollution control data were not available. In order to discuss the environmental consequences of development activity, data for similar activities in other areas are used to indicate approximate water demands, waste loads and volumes and other environmental factors.

The Peace and Liard Basins make up almost the entire B.C. portion of the Mackenzie River Basin and as such are areas which will undoubtedly come under closer scrutiny in the near future due to considerable federal-provincial interest in this basin. Indeed, this paper was written in part to supply resource information to the Mackenzie Basin Intergovernmental Liaison Committee. In another light, however, this survey was also conceived of as an example of the type of study that should be carried out by Water Planning and Management Branch, Pacific Region, throughout its geographic area of responsibility so that management can become aware of areas of possible present or future environmental stress. Surveys of this type are therefore management tools in that they may focus attention on areas not presently under in-depth study and thus may aid in the development of priorities and plans for future management action.

The reader will become aware that the various sections on resource and industrial development are not balanced in terms of length or depth of discussion. Thus, the section on mining is longer and more detailed than the section on forestry and the sections on agriculture and outdoor recreation are extremely brief. This was done for two reasons. First, in terms of future development, mining and forestry will be the resource sectors coming under the heaviest development. Secondly in past studies, forestry has received the most attention and so the extra detail on mining is merely to remind the reader of its importance and to outline environmental problems with which the reader may not be familiar.

GEOGRAPHY OF THE BASIN

Liard River Basin

The Liard River rises in the Pelly and Logan Mountains in the south-central Yukon, flows southeastward through the Liard Plain for about 180 miles, then turns northeast. As it flows the 120 miles to the B.C. - N.W.T. boundary, it gradually drops to the Fort Nelson Lowlands. Within the N.W.T. it follows the border between the Interior Plains and the Franklin Mountains until it joins the MacKenzie River at Fort Simpson. At its mouth, the Liard has a drainage area of approximately 105,000 square miles (54,000 sq.mi. in B.C.; 24,000 sq.mi. in the N.W.T.; 23,700 sq.mi. in the Yukon; and 3,300 sq.mi. in Alberta).

Within B.C., the main tributaries entering from the north are the Hyland, Coal, Smith, Grayling and Beaver Rivers. These tributaries rise in the Yukon and drain portions of the Liard Plain and Liard Plateau. South of the Liard River, the topography is more varied with the Liard Plain bounded by the Cassair Mountains to the south and west and the Rocky Mountains and Fort Nelson Lowlands to the east. The central portion of the Cassiar Mountains is drained by the Dease River which rises on the Stickine Plateau to the west, cuts through the Cassiar Mountains and joins the Liard near Lower Post.

The southeastern slopes of the Cassiar Mountains and the western slopes of the Rockies are drained by the Kechika River which flows northward in the Rocky Mountain Trench to join the Liard. The western slopes of the Rockies are drained by the Toad and by the western tributaries of the Fort Nelson River which meanders north across the Fort Nelson Lowlands before joing the Liard.

The precipitation pattern over the Liard Basin is poorly defined but appears to be relatively uniform and fairly low, in the order of 20 inches per year. The flow records on the Liard also indicate a fairly uniform runoff of about 1 cfs/sq.mi. through the Basin.

Peace River Basin

The Peace River Basin covers a 46,900 sq.mi. area. The Peace is formed by the junction of the Finlay and Parsnip Rivers which occupy about 350 miles of the Rocky Mountain Trench. The Finlay flows southeast and occupies that portion of the Trench from Sifton Pass (which forms the divide between the catchments of the Peace and Liard Basins) to Williston Lake. The Parsnip flows northwest and with its tributaries occupies the portion north of Arctic Lake (at the divide between the Peace and Fraser Basins) which is about 60 miles northeast of Prince George.

The Finlay and Parsnip join near Finlay Forks to form the Peace. The Peace flows eastward, cutting through the Rockies and reaching the foothill country just west of Hudson Hope. In the eastern foothills, the Peace cuts the 15 mile long Peace River Canyon; at the head of the canyon is the W.A.C. Bennett Dam which forms Williston Lake.

Williston Lake is a T-shaped reservoir extending from the dam about 70 miles back to Finlay Forks and from there about 80 miles north and south along the Finlay and Parsnip Valleys. With approximately 32 million acre-feet of live storage and an average annual inflow of about 36,400 cfs, it provides considerable regulation of the river downstream.

The Halfway River from the north and the Pine and Moberly Rivers from the south drain the eastern slopes of the Rocky Mountains. Precipitation in this area does not show the rapid decrease with distance from the mountains as exhibited in the coast ranges. Annual precipitation is about 20 inches per year, except for a small portion of the southern area in the Rockies which has precipitation approaching 60 inches.

POSSIBLE HYDRO-POWER DEVELOPMENT SITES

Liard Basin

Site G*, 80 miles downstream of the Yukon border lies on the Liard plain, while Site E, 75 miles downstream of Site G, is located within the Grand Canyon of the Liard near its upstream end. Site A, 80 miles downstream of Site E, lies to the east of the Rocky Mountain foothills on the interior plains. These 3 projects would develop 1140 ft. of head from elevation 2050 to elevation 910.

The dam at Site G would create a reservoir 100 ft. deep at the Yukon border. Additional height would cause extensive flooding near the settlement of Watson Lake. The development of Sites E and G would involve relocation of about 160 miles of the Alaska Highway. The reservoir for Site E would inundate the Liard Hotsprings Provincial Park.

Peace Basin

The existing W.A.C. Bennett Dam, located where the Peace flows out of the Rocky Mountains, has created Williston Lake storage reservoir, supplying water to the G.H. Shrum powerplant, which, when completed, will have a generating capacity of 2430 Mw. Between the dam and the Alberta border, the river drops 400 ft. in a distance of 100 miles; all of this head would be developed by projects at Sites 1,C and E, located 14, 60 and 100 miles downstream of the dam.

The amount of agricultural land that would be flooded by construction at Site 1 is negligible. Between Site 1 and the Alberta border some valley land has been developed for agriculture.

The McGregor Diversion project would divert water from the Fraser drainage to the headwaters of the Parsnip River, providing more flow at the existing and proposed plants on the Peace River. One precaution to be observed if the McGregor were diverted to the Peace would be to leave adequate impediments in the diversion channel to prevent the introduction of northern pike from the Arctic watershed to the Pacific watershed.

The average streamflow of the McGregor at the damsite is 7,650 cfs. If diverted to the Peace, it would increase the average annual energy production at the existing G.M. Shrum powerplant by 290 Mw. If the projects at Sites 1, C and E were later added, the McGregor Diversion would increase the total average annual energy production in B.C. by 485 Mw.

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*Note: Figures 1-4 & Table 1 describe the various hydroelectric site possibilities. Data & Figures in this section are from Montreal Engineering Co.Ltd. (1972a).

Fig. 1 LIARD BASIN

POTENTIAL HYDROELECTRIC SITES

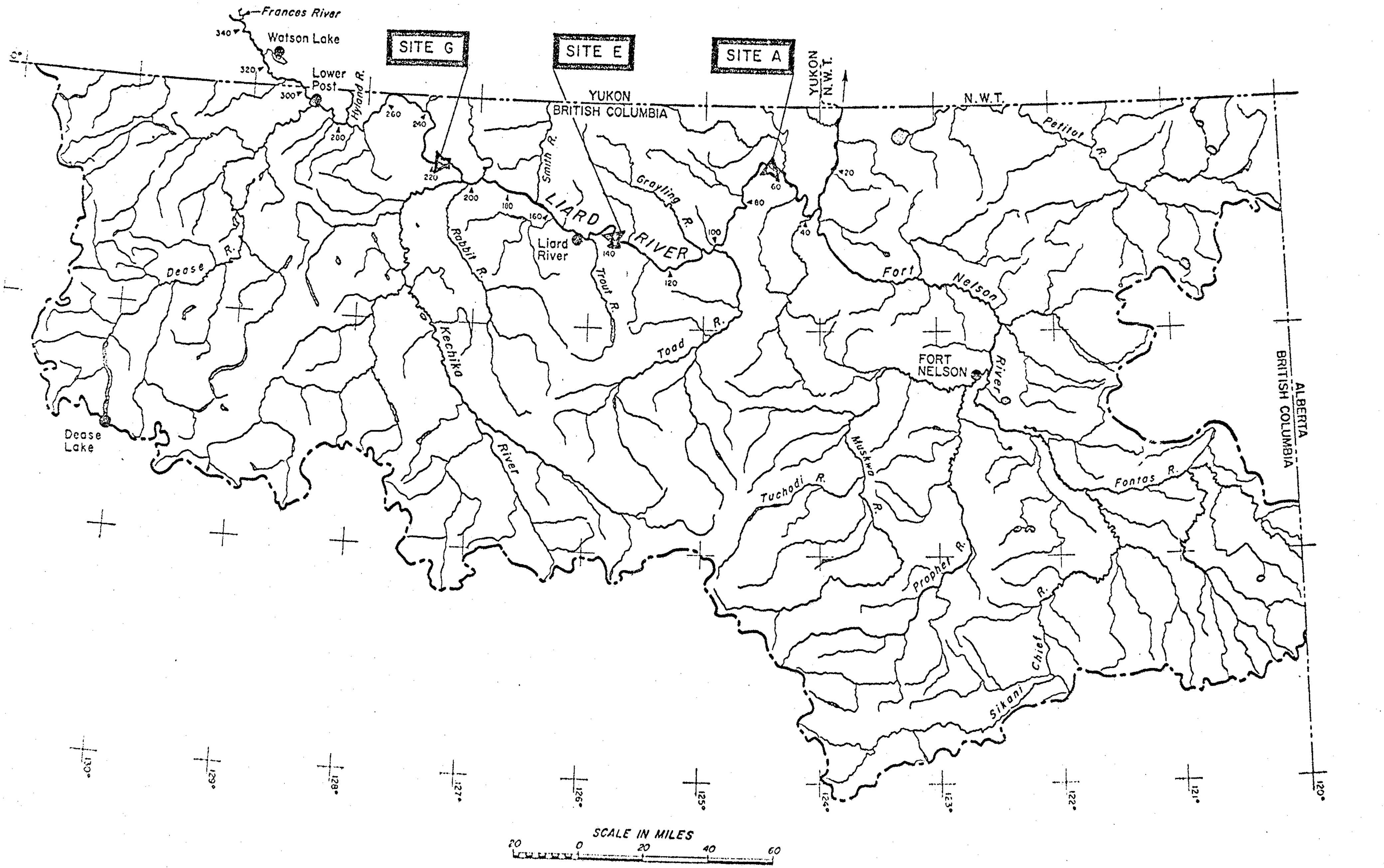
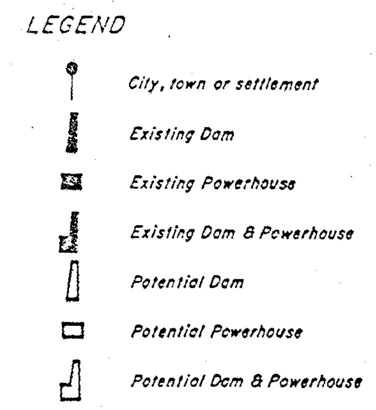
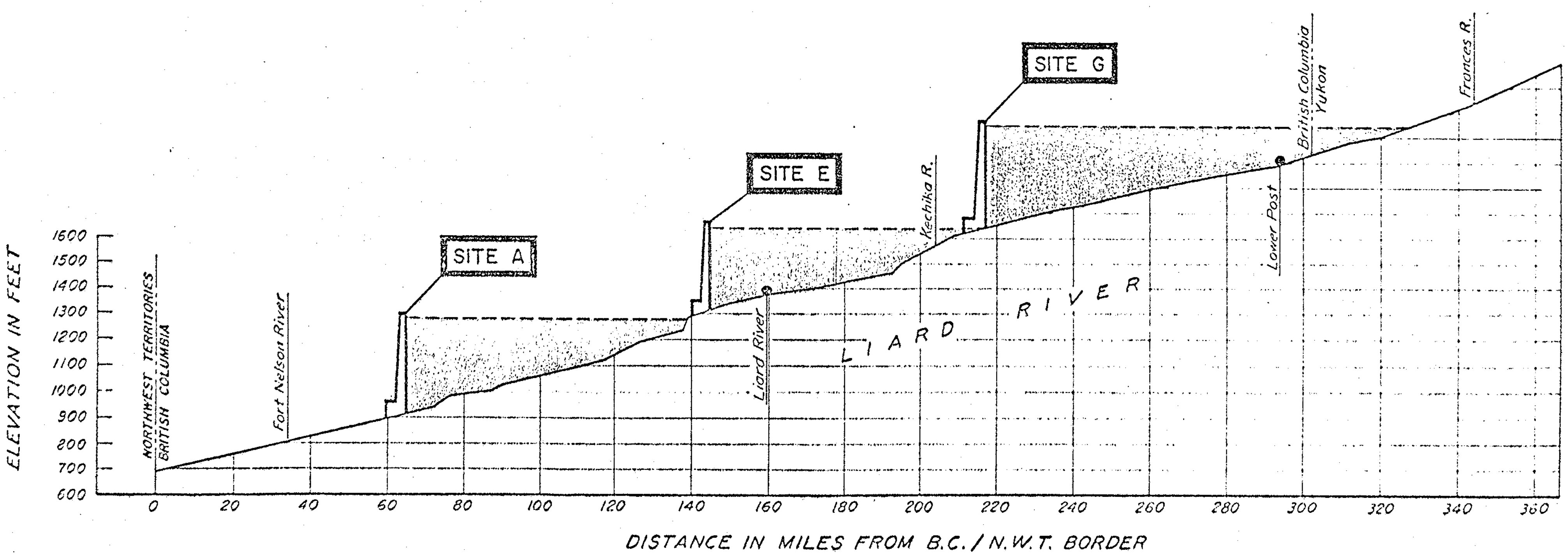


FIG. 2 LIARD BASIN - RIVER PROFILES
(source - Montreal Eng. Co. Ltd. 1972A)





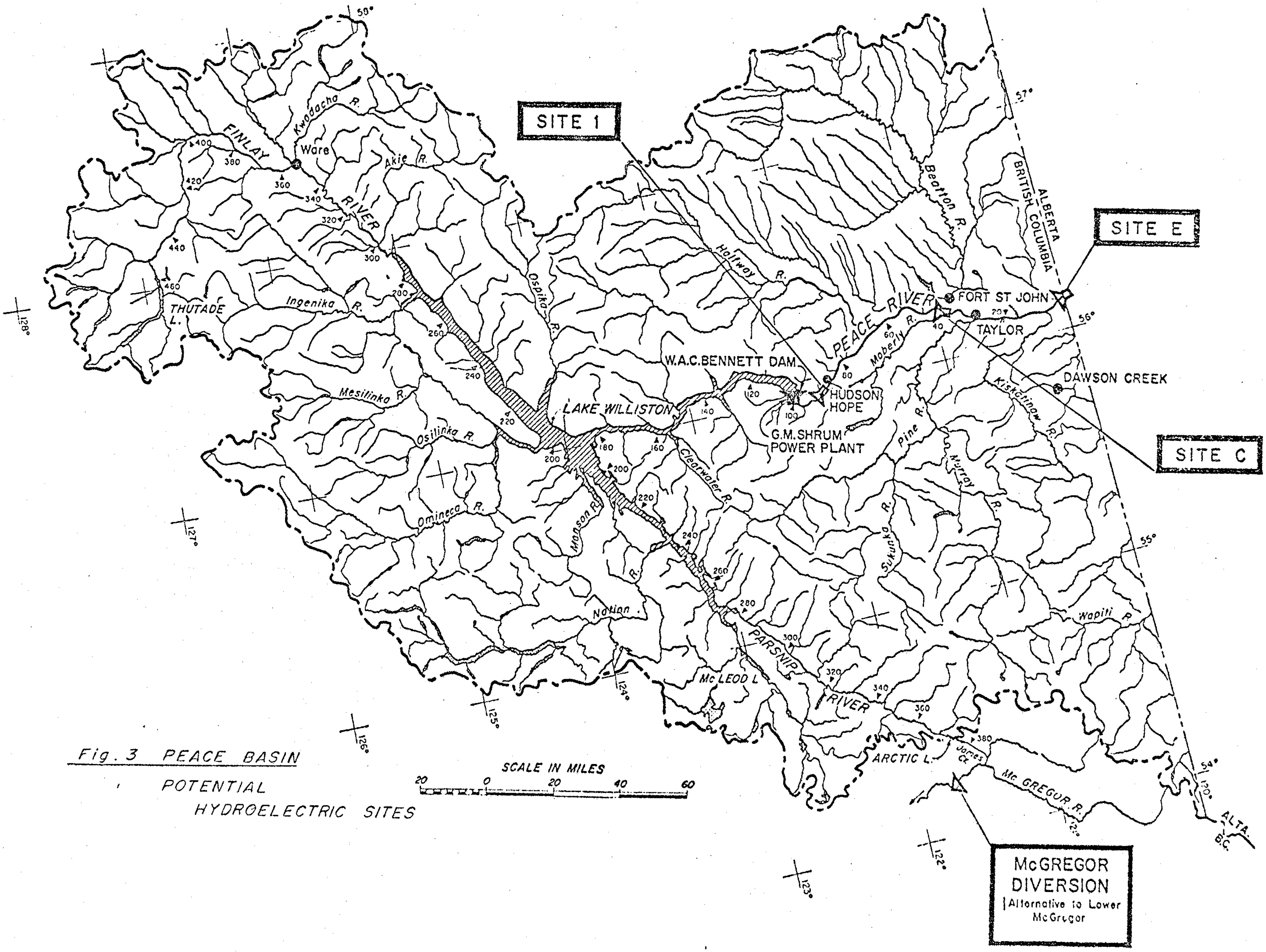


Fig. 3 PEACE BASIN
POTENTIAL HYDROELECTRIC SITES

FIG. 4 PEACE BASIN - RIVER PROFILES
(source - Montreal Eng. Co. Ltd. 1972A)

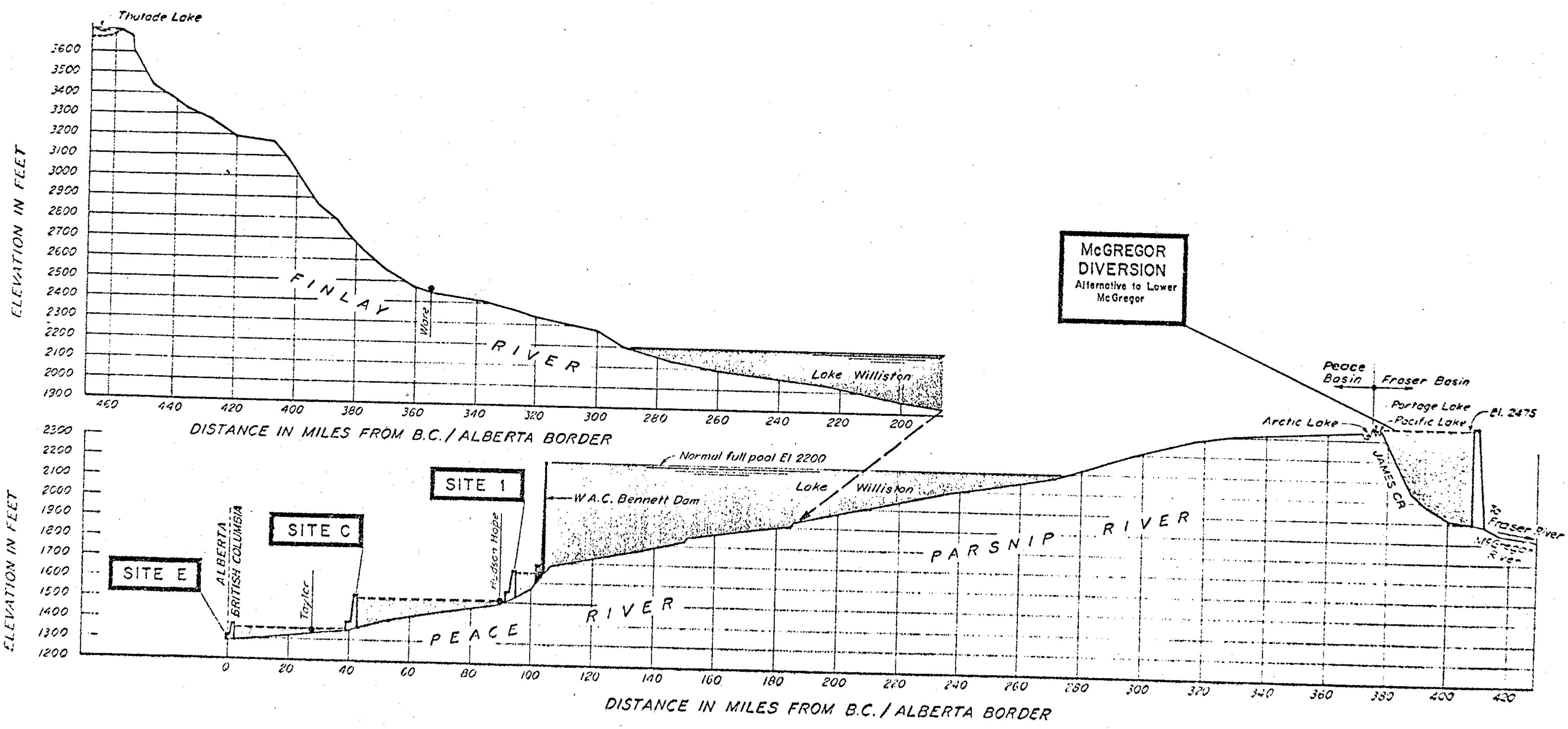


Table 1

Possible Hydro-Power Sites

Site	Height of Dam (ft.)	No. of Units	Spillway (cfs)	Storage (Acre-ft.)	Max. Capacity (Mw)	Cost of Capacity ($/kw)	Cost of At-Site Energy (mills/kwh)
Liard Site A	400	6	810,000	1.0 million	1518	329	3.4
E	450	6	685,000	5.15 "	1416	352	4.2
G	500	4	500,000	14.1 "	912	435	4.7
Peace Site E	130	6	850,000	(pondage)	550	515	5.7
C	200	4	490,000	(pondage)	800	391	5.2
1	165	4	363,000	(pondage)	700	256	4.1
McGregor Diversion					n.a.	n.a.	1.8*
G.M. Shrum Unit 10					300	39	n.a.

* if constructed after Sites E, C and 1 were developed.

Source: Montreal Engineering Co. Ltd. (1972a)

Forestry

The Resource

Productive forest land accounts for 3/4 of the entire area of the Peace River region; this is 29% of total B.C. forest land.

Spruce is the predominant species, accounting for 59% of the mature timber volume & 58% of the immature timber volume. Spruce is the most important species in Canada for the forest industry as it yields excellent quality pulp and paper.

Lodgepole pine accounts for 18% of the mature volume and 28% of the immature volume. This lumber is also desirable for pulp and paper.

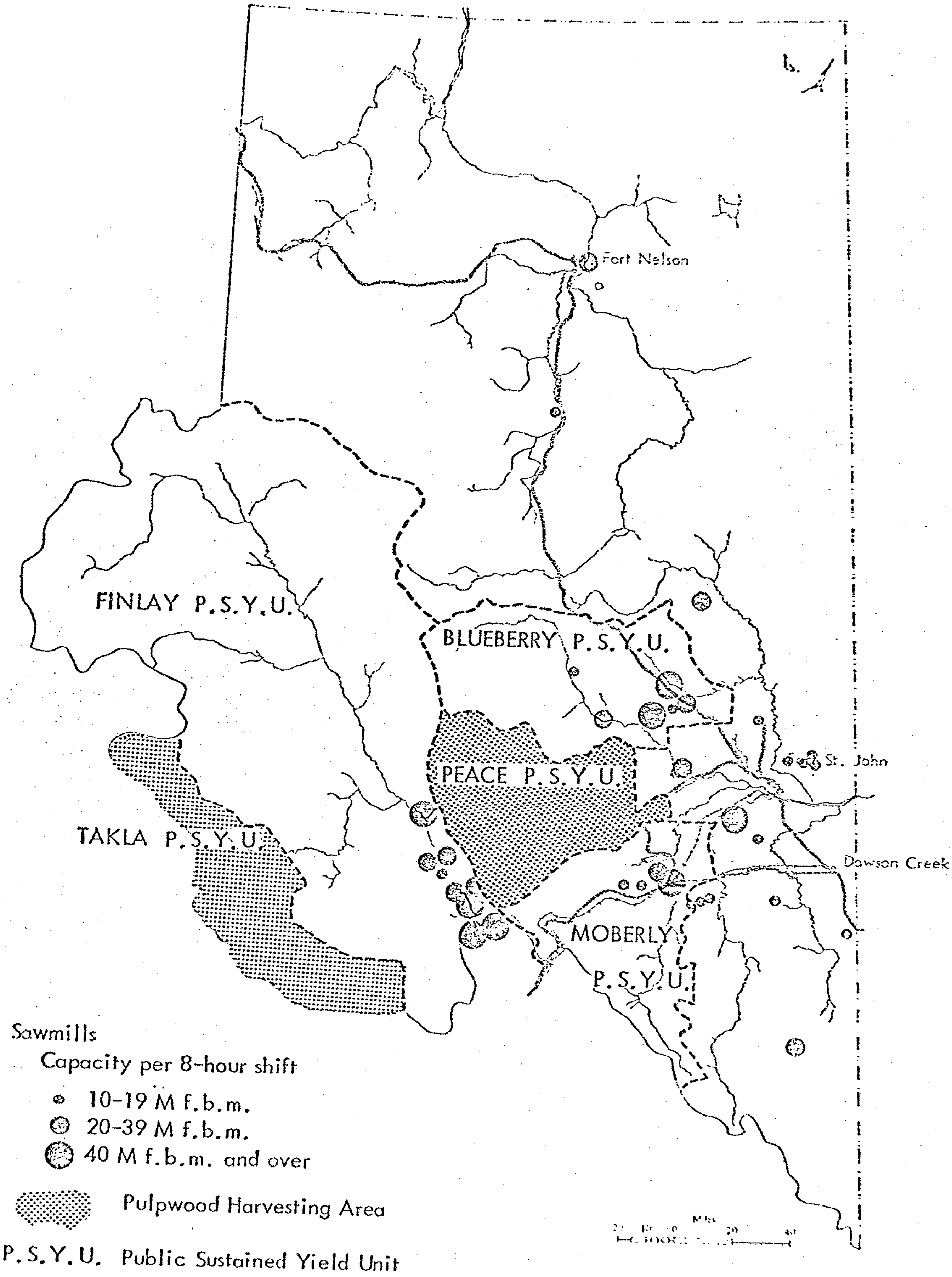
Poplar (cottonwood and aspen) accounts for 12.6% of the mature volume and 9% of the immature volume. At present, the main value of this species is in its aesthetic appeal, although a small volume is used in plywood and particle board; the low density of the wood means poor pulp yields.

Activity

The majority of forestry activities in the region have been concentrated in the southern parts, although potential exists throughout the area. There are 5 approved Public Sustained Yield Units (PSYU's), 5 proposed PSYU's and one regulated unit in the area, containing 12.4 million acres of mature and 21.7 million acres of immature timber. A PSYU is a unit of Crown Land, under provincial jurisdiction, for which the B.C. Forest Service has calculated the annual cut that can be sustained at the current standard of utilization. Cutting rights to the annual harvest are sold to the established industry through the medium of timber licences.

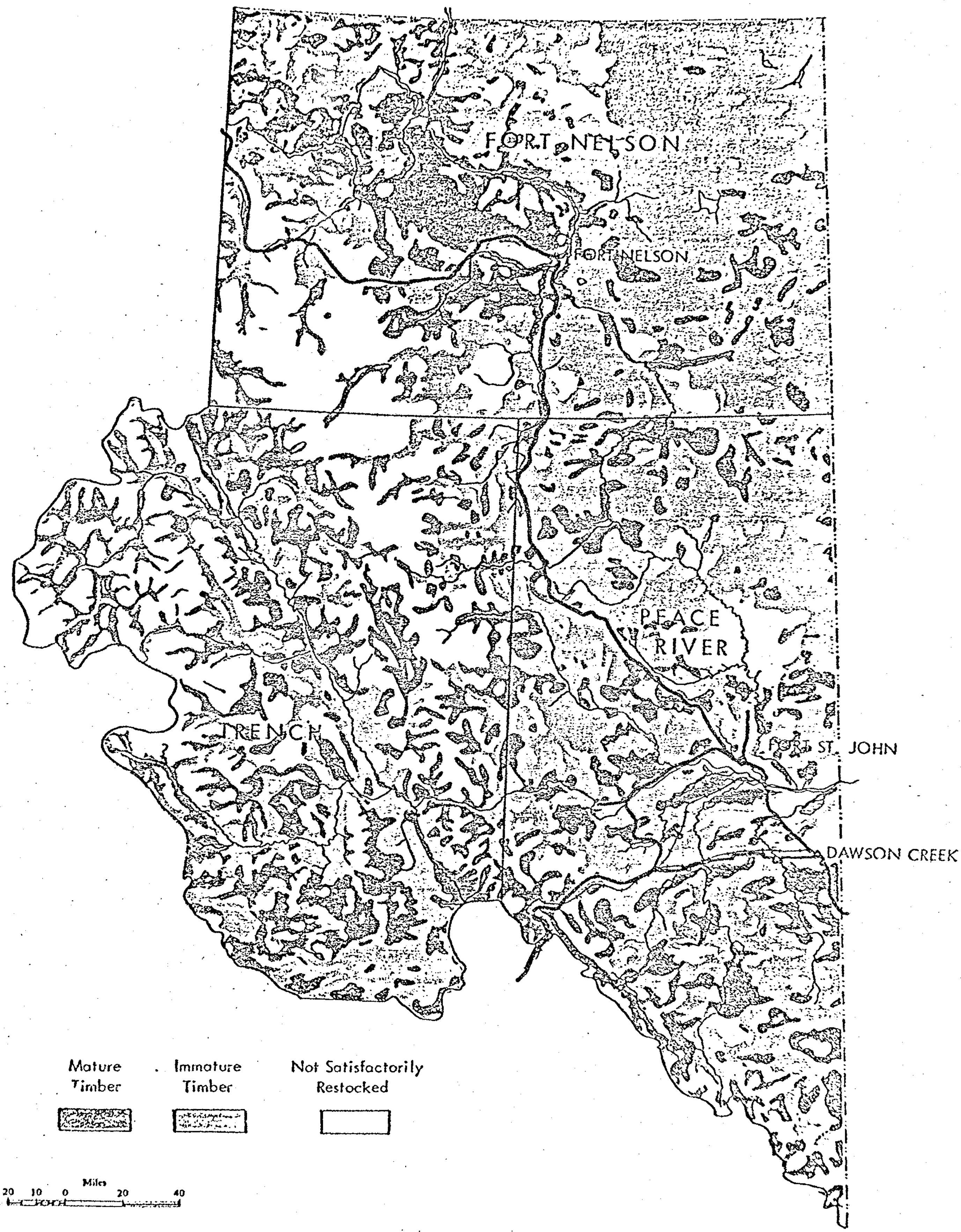
Table 2 indicates there is an annual allowable cut of 474,650 MCF of timber in the approved and proposed PSYU's and the regulated unit. The 1968 committed cut was 114,324 MCF and the actual cut 50,312 MCF. Adjusting to full cutting of the committed volumes in the units, plus the actual cuts in those units where there were no committments but where cuts were made, the potential additional cut is 354,040 MCF. Using the average B.C. interior conversion factor of 5.75 Mfbm per MCF, this represents 1,983,980 Mfbm of lumber production potential.

FIGURE 5
FOREST LAND MANAGEMENT STATUS



Source – Gray and Uegama (1969)

FIGURE 6
FOREST COVER MAP



Source - Gray and Uegama (1969)

Table 2

Peace River Region

Annual Cuts, Lumber Production, Sawmills - 1968

	Allowable Annual Cut (MCF)	Committed Cut (MCF)	Actual Cut (MCF)	Lumber Production (Mfbm)	No. of Operating Sawmills
Approved PSYU's*					
Blueberry	30,550	5,000	4,962	11,710	6
Finlay	121,200	100,000	25,601	123,000	7
Moberly	25,600	5,400	4,193	51,131	10
Peace	17,000	-	7,912	3,722	3
Wapiti	32,200	3,924	1,270	4,002	3
Proposed PSYU's*					
Fontas	24,000	-	-	-	-
Fort Nelson	40,000	-	1,289	9,450	7
Kotcho	44,100	-	-	-	-
Liard	76,000	-	-	-	-
Sikanni	37,000	-	415	1,500	2
Regulated Unit					
Dawson Creek	27,000	-	4,670	31,436	35
TOTAL	474,650	114,324	50,312	235,951	73

* Public Sustained Yield Unit

Saw and Pulp Mills

The number and PSYU location of sawmills in the area are shown in Table 2. Until recently, there were no pulp mills in the region. Since 1970, however, 2 mills have been built and are in production and at least one other possible site is being investigated.

B.C. Forest Products has a $90 million complex at Mackenzie which includes a kraft pulp mill, 2 sawmills and a veneer and plywood plant. The pulp mill has a capacity of 500 tons per day and the sawmill a capacity of 120 Mfbm per year.

Finlay Forest Industries Ltd. has a $25 million saw-pulp mill also at Mackenzie. The pulp mills is a refiner-groundwood mill (mechanical rather than chemical process) with a capacity of 320 tons of pulp per day for news-print; the sawmill has a capacity of 150 Mfbm per year.

Peace River Forest Products is investigating the possibility of con-structing a mill complex at Taylor which may include a sawmill, plywood mill, hardboard plant and pulp mill.

Future

The development of the logging industry in this region is contingent upon the growth of forest-oriented processing and manufacturing operations. These operations are affected by 5 factors: (1) Licencing requirements such as timber harvesting rights; (2) major financing; (3) relative quality of timber in terms of size (smaller diameter than coastal timber), growth rate (longer than in most other areas), short logging season (the 4 month winter freeze-up only - bog and muskeg limit logging the rest of the year) and species mix (large quantities of poplar); (4) distance from ports or markets; (5) absence of rail transport to some areas (e.g., north of Fort St. John).

Water Management & Quality Considerations

a. Logging Operations

Logging operations frequently result in serious degradation of water quality. The operations may result in sediment loading in streams due to erosion, in heating of stream waters and in the leaching of organic products into the stream.

The most serious impact on stream water quality is the greatly increased sediment load caused by erosion of the soils from the surface of logged-over areas and from logging roads. In studies done in the U.S. Pacific Northwest, under natural conditions sediment loads in streams measured 10 ppm or less, whereas suspended sediment concentrations in a stream immediately downstream from an improperly logged area exceeded 70,000 ppm. Thus, in a logging region, many streams polluted with heavy sediment loads may cause similar problems in the rivers into which they drain.

Heavy sediment loads in streams may destroy fish populations by silting over spawning beds and smothering eggs and fry; may bury food supplies for fish and wildlife; may disrupt sports fisheries; and may increase costs of water treatment and cause excess wear on turbines, pumps, etc. As well, soil losses from harvested areas may decrease the capability of the land to produce harvestable trees.

Logging of all trees to the stream's edge exposes the stream to the full impact of the sun's heat. This can increase water temperatures by as much as 10° - 15° F., depending on stream flow and volume. This thermal pollution may cause damage to fish populations, especially cold water fisheries.

Improper logging operations leave organic debris and litter in and adjacent to stream channels. As these organic materials, in contact with surface and percolating waters, go through the process of decomposition, measurable increases in dissolved chemicals and plant nutrients occur in the streams; of particular concern are the wood sugar products readily released by leaching. These chemicals and nutrients may lead to the growth of bacterial slimes and algae and to decreases in the amount of dissolved oxygen in the waters.

b. Pulp Mill Water Use

Kraft mills of recent technology use about 40,000 gallons of water per ton of production. The amount of water reuse affects the fresh water demand. The extent to which reuse is practiced depends upon the build-up of undesirable conditions in the system, such as temperature rise, slime and fungi growth, the increase in dissolved solids, corrosion acceleration and fouling.

c. Pulp Mill Wastes

Wood preparation for the pulping process produces, through hydraulic debarking, losses into the water of sawdust, fines, fibres, bark and dirt, as well as untreated debarker effluent containing highly toxic resin acids.

Refiner-groundwood pulping (such as at the Finlay Forest Products Mill at Mackenzie) is a non-chemical process producing pulp for newsprint. Although waste production is relatively low, a considerable amount of small fibres can be released and resinous wood constituents are leached during processing. Substances in the wastes include: particulate effluent of screening rejects, wood fibres and cellulose fines; resin acids, which are greatly determined by the type of wood processed (coniferous species have the highest amounts); and zinc hydrosulphite, which is often used for bleaching (significant concentrations of zinc may be found in the effluent).

Kraft pulping involves digestion of the wood in an alkaline mixture of sodium salts (mostly sulphide and hydroxide). In the digestion process, about 52% of the wood is solubilized, but the process includes a recovery system, thereby decreasing water pollution hazards. However, serious air pollution problems can occur due to sulphide use. Kraft process wastes include sulphides, mercaptans, lignin derivatives, resin acids and fatty acids (or their salts).

Thus, pulp mill wastes result in three types of pollutants: suspended solids, toxic chemicals and BOD-producing nutrients. Table 3 indicates typical effluent loads for a 500 ton per day kraft mill of recent technology (such as the B.C. Forest Products Mill at Mackenzie), for the groundwood pulping process and for wood preparation.

Table 3 Pulp Mill Waste Loads and Volumes

	Suspended Solids (lbs./ton)	BOD5 (lbs./ton)	Volume (gal./ton)
Wood Preparation	2	1	1,700
Kraft Pulping	20 - 30	25 - 50	15,000 - 35,000
Groundwood Pulping	40 - 80	15 - 25	4,000 - 10,000
Bleaching	6 - 35	12 - 200	15,000 - 60,000

Source: D. Jones (1966)

Mining

Minerals

At present, there are only two producing mines in northeastern B.C.: Cassiar Asbestos at Cassiar and Consolidated Churchill Copper at Delano Creek. The Cassiar mine has an operating capacity of 2,000 tons per day. Recent drilling has assured at least another 20 years of open-pit life; $8 million will be spent to update waste removal equipment, ore delivery system, concentrator and tailings disposal conveyors. Cassiar has also found indications of further substantial asbestos reserves at depth and although further drilling is required, the potential is believed significant.

The Consolidated Churchill Copper mine at Delano Creek (80 miles west of Fort Nelson) has a daily capacity of 500 tons of very high grade copper ore (3.9% copper). Only a few miles from the mine site, Davis Keays Mining Co. will be placing their copper mine in production, with the ore to be milled at the Consolidated Churchill Copper mill.

Exploration and development seem to be stalled at the present time, due (according to the mining industry) to provincial taxation policies. Nevertheless, many claims have been surveyed and drilled in the past few years and several areas will see rapid development as soon as the present state of flux is ended. The most important areas appear to be: Robb Lake (lead-zinc), Dease Lake (copper-molybdenum-tungsten) and the Omineca region (copper-molybdenum, lead-zinc-silver). Areas of interest are indicated in Figures 7 & 8.

Activity in the Robb Lake area (at the head of the Halfway River) is being led by more than half a dozen large companies. The discovery of lead-zinc mineralization in this area was made in 1971; the extensive properties are being thoroughly explored and at least 41,000 ft. of drilling has been accomplished with very encouraging results.

In the Dease Lake area, drilling and survey work are being carried out on asbestos showings and copper properties. Tormex Resources - Tournigan Mining are conducting drilling and survey work on their Snow Peak copper-molybdenum-tungsten properties 16 miles west of Dease Lake; the surveys have thus far resulted in 3 coincident copper-molybdenum anomalies, the largest of which peaks at +4000 ppm molybdenum and +2000 ppm copper. The planned Dease Lake railhead of B.C. Railway will undoubtedly open up that area to extensive exploration and to mine and mill production.

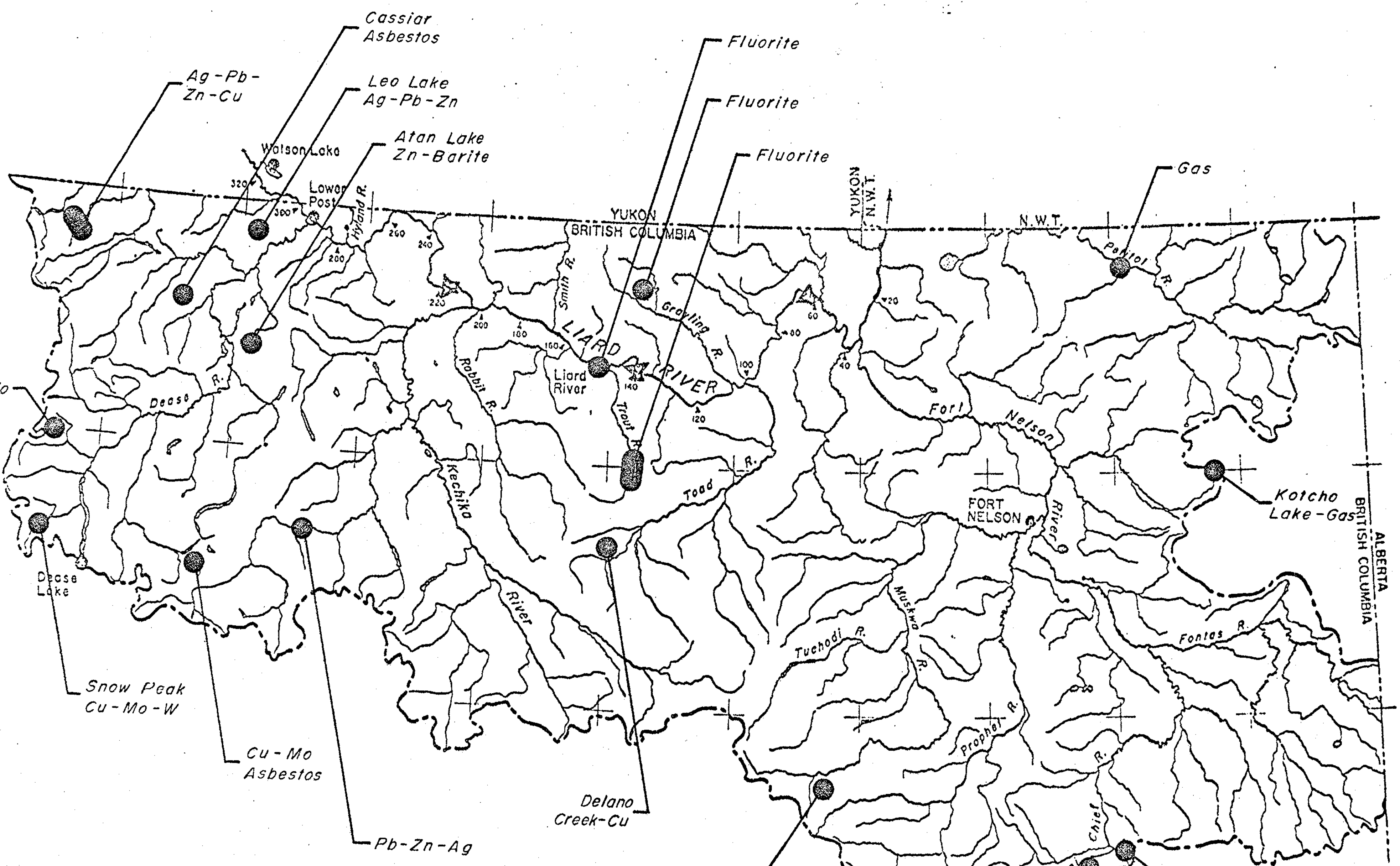


Fig.7 LIARD RIVER BASIN

MINERAL & GAS EXPLORATION & DEVELOPMENT

(approximate locations)

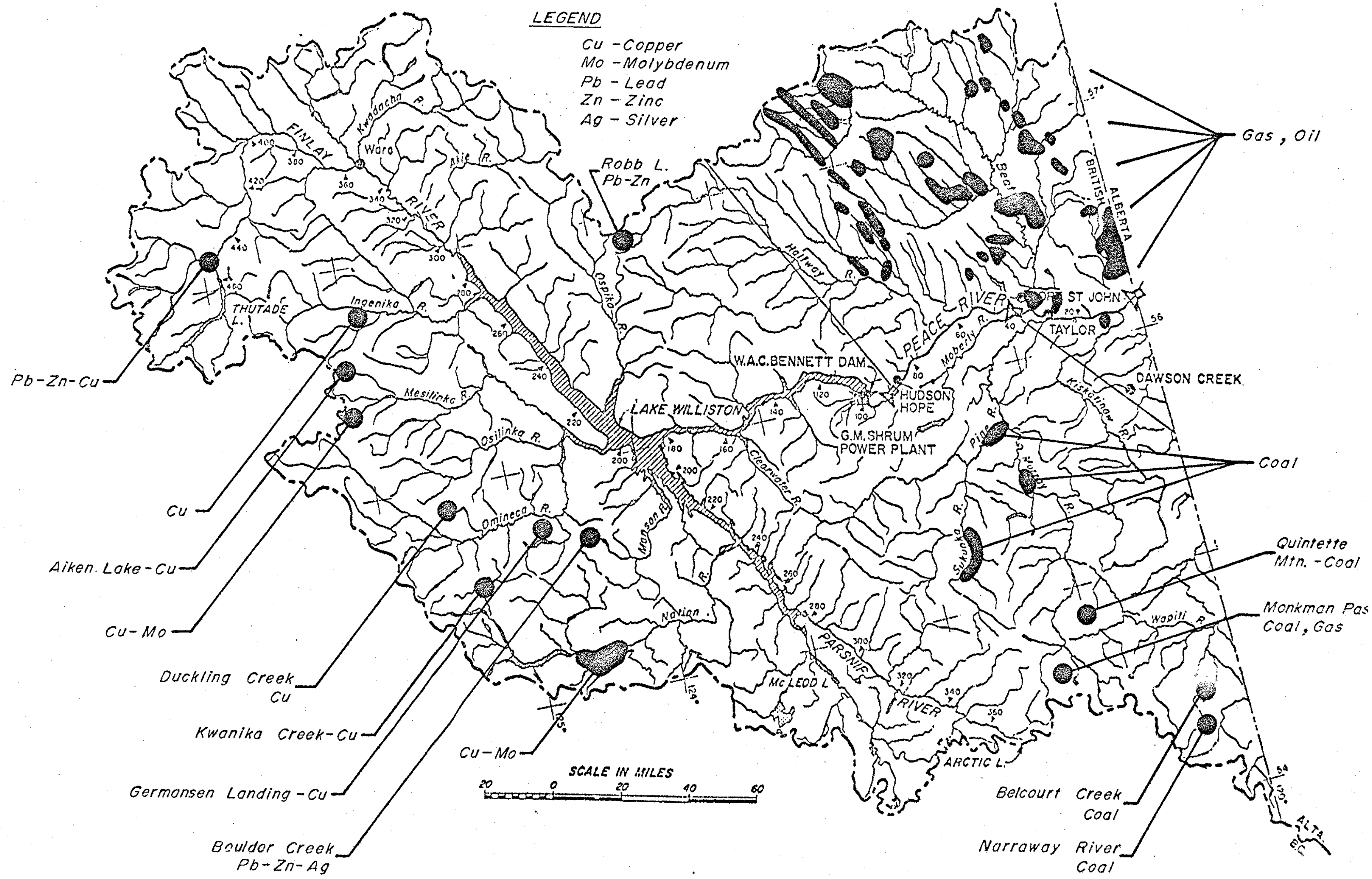
Legend

Cu - Copper
Mo - Molybdenum
Pb - Lead
Zn - Zinc
Ag - Silver
W - Tungsten

Fig. 8 PEACE RIVER BASIN

MINERAL, OIL & GAS EXPLORATION & DEVELOPMENT

(approximate locations)



In the Omineca region, activity is proceeding on large scale copper-molybdenum properties as well as several lead-zinc claims. Among the most important sites are Kwanika Creek, Duckling Creek, Boulder Creek and Chuchi and Witch Lakes on the Nation River. Other areas of exploration activity are Germansen Landing, Aiken Lake and the Ingenika River.

While the above are the sites of major efforts, active exploration is ongoing in other areas of the basins. Fosco Mining has completed 1,700 ft. of underground development work on its Leo Lake property (west of Lower Post); activities have established 111,000 tons of silver-lead-zinc ore with recoverable values of silver of 24 oz. per ton and lead-zinc of 12%. Further development is expected to establish an additional 280,000 tons of ore of comparable grade; mining and concentrator operating are expected to commence shortly.

At Atan Lake, south of Lower Post, Tournigan Mining is proceeding with large scale development on its zinc-barite property. The highest grade section encountered runs 17% zinc. The construction of a barite mill to process and package ground barite for the oil drilling industry is contemplated for the near future. At Redfern Lake (on the Besa River), several companies are conducting mapping and geological surveys to determine the extent of lead-zinc mineralization, with results so far encouraging. Fluorite deposits are the subject of exploration activity in the Liard Hot Springs - Muncho Lake area.

Geologists also speculate that huge mineral resources exist in the area that have yet to be discovered. A series of maps produced by the Canada Dept. of Energy, Mines and Resources (Barry and Freyman, 1970) on the undiscovered major areas of mineral endowment of the Canadian northwest indicate: tungsten and asbestos in the Dease Lake area; iron deposits north of the Peace River and south of Dawson Creek; gold and silver in the Omineca and Dease Lake areas; nickel in the Omineca area and southeast of Dease Lake; molybdenum around the Dease River; lead-zinc in a wide band running north and south from the Yukon to Prince George and west from Williston Lake; and copper in the Omineca area. These predictions express the judgement of a panel of geologists who were requested to disregard known deposits.

Coal

As current upward trends in energy resource prices continue, coal exploration and development is increasing rapidly. A wide belt of coal runs northwest from the Smokey River area in Alberta; the ultimate distance that this belt extends is not known, although there have been a few reports of coal being found on the Halfway, Sikanni Chief and Minakee Rivers. The coal, with few exceptions, is low and medium volatile bituminous and invariably has a low sulphur content. Coals of excellent coking quality have been found at various localities, but certainly not all the coal is of this quality. Lignite coals occur along the Upper Liard River on the Yukon side of the B.C.-Yukon border.

Coal occurrences have been noted in the vicinity of the Narraway River and Belcourt Creek. Thick seams, ranging from 10-25 ft. occur between the Kakwa and Murray Rivers, and at Quintette Mountain; 20 ft. thick seams are present on the north side of the Pine River. Extensive survey work is ongoing in the Monkman Pass area.

The most important area at the present centres on the Sukunka River. At one property owned by Brameda Resources, 50,000 tons were extracted to September, 1973 and test results proved the quality to be of a very high order for metallurgical coke production. Another deposit has been drill-indicated near the W.A.C. Bennett Dam and investigations are underway on the eastern shores of Williston Lake.

Water Management and Quality Considerations

a. Water Use

Normally, about 40 U.S. gallons of process water are required to produce one pound of blister copper. About 90% of this process water is used in the milling process and only about 1% in mining operations. As a general rule, one ton of water is required for each ton of copper ore milled, when maximum water economy and reclamation are utilized. In a new mining operation, however, until the tailing pond is built up to contain sufficient water for reclamation, all of the water supply must come from fresh water. Also, where multi-mineralized ores are milled, it may not be feasible to practice full water reclamation due to the reagents used in the flotation process.

Table 4 illustrates process water requirements for several B.C. mines and mills. As may be noted, average annual amounts of precipitation influence the degree to which water is reclaimed and recycled. Table 5 gives data on several mines in northeastern New Brunswick, including process water data.

Table 4 Process Water Requirements for Selected B.C. Mines & Mills

Type	Amount Mined (tpd)	Amount Milled (tpd)	Annual Precipitation (inches)	Internal Recycling	Fresh Water Make-up (gpm/1000 Tons Milled)	Reclaimed Tailing Wa[ter] Volume (gpm/1000 Tons Milled)	Reclaimed Tailing Wa[ter] % of Tailing (%)
Cu-Mo	72,000	25,000	10 - 15	Yes	67	330	83
Cu	12,400	2,400	20	Yes	110	210	65
Cu-Mo	48,000	24,000	20	Yes	30	420	87
Coal	20,000	14,000	20	Yes	57	45	100
Coal	18,000	12,900	41	Yes	72	610	100
Pb-Zn	800	800	20 - 30	No	650	0	0
Pb-Zn	700	700	30	No	350	0	0
Ag-Pb-Zn	170	120	20 - 30	No	520	0	0

Source: Ker (1974)

b. Mining Wastes

There are three main sources of water contamination at mine-mill developments: mine water, process water effluent and contaminated surface drainage.

Mine water has several sources. Groundwater seepage through mines may be serious, given substantial flows. Local groundwater patterns may be changed significantly by both underground and open pit mines which create a natural sump drawing down the groundwater profile. A second source is clean water use: normal mining practice usually entails piping clean water into a mine for use in drilling operations, dust suppression and for sanitary purposes. A third source is hydraulic backfill operations, where mill tailings may be used as the backfill material; water draining from the fill must then be collected and treated. A fourth source is surface drainage into or through open pits. The mine water is contaminated by contact with the mineral bearing ores in the mines and in the case of backfill, by process water effluent.

Table 5

Characteristics of Mines in Northeastern New Brunswick

Mine	Description		Process Water			Mine Water	Surface Drainage	Waste Treatment		
	Type	Capacity (tpd)	Total (gpm)	Recycle (%)	Fresh Water Make up (gpm)	Avg. (gpm)	Avg. Flow (gpm)	Avg. Vol. Treated (gpm)	Avg. Net Vol. (gpm)	Net Unit Effluent (gal/ton)
Anaconda-Caribou	Cu	Mined: 1000 Milled: 1000	400	67	120	100	103	580	308	443
Brunswick #12	Pb-Zn-Cu	Mined: 6500 Milled: 10000	3600	70	1100	250	678	4313	1819	262
Brunswick #6	Pb-Zn-Cu	Mined: 3500	-	Not Applicable	-	165	346	511	559	230
Heath Steele	Cu-Pb-Zn-Ag	Mined: 3000 Milled: 3000	2500	34	1650	580	1036	3200	3200	1493

Source: Montreal Engineering Co. Ltd. (1972)

Process waters are those waters used mainly in the milling process. The most common method of concentrating base metal ores is differential flotation. The milling process results in effluents high in dissolved metals (metal recovery efficiencies are often in the order of 85 - 95%), contains in the order of 80 - 90% of the solid material processed (tailings) and may be chemically complex depending on the types of process reagents used.

Typical reagents used in flotation processes for the separation of ores include:

copper ores - lime, sodium cyanide
lead ores - cyanide
zinc ores - copper sulphate
copper zinc ores - lime, soda ash, sodium sulphite, sulphur dioxide, cyanide, copper sulphate
lead-zinc ores - zinc sulphate, cyanide
copper-lead-zinc ores - zinc sulphate, cyanide, sodium sulphite, sulphur dioxide

The key waste management implications of the milling processes are the treatability of the effluent and the degree to which it can be minimized by recycling water to the process within the mill or by reclaiming water after treatment. Present technologies enable use of recycle ratios of 80 - 90% of process requirements.

Contaminated surface drainage occurs where sulphide bearing rock is exposed to water and air, causing oxidation and generation of acids, which in turn leaches metals from exposed rock or particle surfaces. Contaminated surface drainage is therefore highly acid with heavy metal concentrations. Potential sources of contaminated surface drainage include areas of the mine site around ore handling facilities, mill and concentrator, haul roads, ore storage and waste rock piles.

Another potential source of water pollution is in the disposal of the mill tailings. Generally, tailings are stored in ponds, contained by dams. The tailings settle and the water may then be reclaimed for the milling process or may be discharged after treatment. Tailing pond disposal may have serious effects: there is a strong possibility of contamination of neighbouring streams by seepage from the pond and there is the potential risk of large scale release of slimes in the event of a structural failure of the dam.

Underwater tailing disposal is also a possibility. The amount of ecological damage caused by such disposal depends upon the depth of the body of water (usually a lake) and the depth at which the tailings are discharged. The major problems associated with underwater disposal are turbidity and silting.

Table 5 gives water use and effluent data for copper, lead and zinc mining and milling operations in New Brunswick.

Oil and Gas

In 1956, there were 9 producing oil wells and 3 producing gas wells in the Peace River Region. In 1973, crude oil output from 542 of 693 producible wells was 21.2 million barrels (valued at $68.3 million); natural gas output from 325 of 858 producible wells was 462 billion cubic ft. (valued at $46.7 million); butane and propane output was 2.5 million barrels (valued at $1.1 million). Figures 7 & 8 indicate areas of oil and gas exploration and development.

The oil fields are centered around Fort St. John. The fields are served by pipelines which carry the product to Taylor, the processing centre of the region. At Taylor, Pacific Petroleum Ltd. operates a refinery with a crude-oil capacity of 8,500 barrels per day, storage capacity of 700,000 barrels and cracking capacity of 3000 barrels per day. A 12 inch, 505 mile pipeline carries crude oil from Taylor to Kamloops.

The natural gas industry covers a much greater portion of the region; although most of the fields are around Fort St. John, there is increasing activity around Fort Nelson (Clarke Lake, Kotcho Lake, Petitot River). Pacific Petroleum operates a gas processing plant with 435 and 400 Mscf in and out capacities in Taylor; Westcoast Transmission has a smaller (200 and 170 Mscf in and out) plant at Clarke Lake south of Fort Nelson which is being expanded by approximately 30%. Gas Trunk Line of British Columbia Ltd. (10 Mscf in and 9.5 Mscf out) and Imperial Oil Ltd. (17 Mscf in and 15 Mscf out) have plants at the giant Boundary Field near the Alberta border. Pipelines carry the natural gas south to Vancouver and the U.S.

Sulphur is also produced at a natural gas scrubbing plant at Taylor; Westcoast Transmission is reportedly planning to establish a similar plant at Clarke Lake.

Petrochemical production is not likely in the region because of the large size of economic plant, distance to market and associated operations being required nearby.

Waste Management and Quality Considerations

a. Refinery Water Use

Modern refinery processes are complicated and varied and thus water use varies greatly from refinery to refinery. In the U.S., an average of 468 gallons (U.S.) of water is required to refine a barrel of crude oil; the median figure is 95 gallons.

Cooling water accounts for 91% of modern refinery water requirements. Refineries with recirculating cooling systems circulate about twice as much cooling water but need 25 times less make-up water as refineries using once-through cooling systems. A typical 50,000 barrel per day refinery generates more than 1,000 million Btu per hour and about 50% of this heat is removed by water; allowing for other water uses and assuming a 30°F temperature rise in the cooling water, it is estimated that the refinery would require about 40,000 gallons of water per minute to remove this amount of heat.

Only 6.1% of water withdrawn is used for process water, and based on gross water used, process waters constitute only 1.4% of total water used. Process water reuse is probably insignificant.

b. Petroleum Wastes

Aqueous wastes from the production, transportation and refining of petroleum are important contributors to water pollution.

Considerable quantities of concentrated salt brine may be produced from the well with the crude oil. This brine is separated by heating, settling and use of emulsion breakers. The separated brine is usually treated and returned to the ground through a disposal well. Quantities of the separated brines may however be dissolved in drainage waters and the brines can increase the salinity of both surface streams and groundwater.

As more than 90% of refinery water use is devoted to cooling, thermal pollution of receiving streams may result from the discharge of large quantities of cooling waters. When cooling water is circulated through cooling towers, organic growths of algae and slimes are encountered on the cooling surfaces; to prevent resultant undue loss of heat exchange, chemicals are used to remove these growths. Chlorine, copper sulphate or other biocides may be used and must be carefully controlled to protect the quality of the receiving stream.

Small concentrations of water soluble chemicals other than hydrocarbons occur naturally in crude petroleum, are formed during refinery processes or are used as heating agents. In sufficient quantities, these chemicals can cause tainting, turbidity, toxicity and oxygen depletion in receiving waters.

Dust and eroded silt from working areas, coke dust, spent catalysts and a variety of solid treating residues are also sources of solids entering waters, causing sedimentation and turbidity.

Agriculture

Farming is a major industry in the southern part of the Peace River region, stretching from Chetwynd and Hudson's Hope in the west to the Alberta border. The land is flat with forest cover and numerous rivers. The eastern half of this area is part of the great plains of the Prairies.

The soil is reasonably rich, summer days are long and the light precipitation is greatest during the summer growing months; this is the largest area of arable land in B.C. A soil survey in 1965 of over 4 million acres in the southwest of the region indicated soil ratings as follows:

excellent for cultivated crops	- 233,000 acres
good to very good	- 362,000 "
fairly good to good	- 1,602,000 "
fair to fairly good	- 428,000 "
TOTAL	2,625,000 acres

There is also an estimated 1 to 1.5 million acres of arable land in the Fort Nelson area; however cover, clearing and development costs are double those in the southern Peace area and bog and muskeg access road building difficult.

Land use in the Peace River region in 1965 was:

land under crops	-	398,000 acres
summer fallow	-	96,000 "
improved pasture	-	42,000 "
other	-	31,000 "
irrigated		320 "
TOTAL		567,320 acres

Table 6

Agricultural Production

Grain Crops (1971)	Acres in 000's
Wheat	91
Barley	176
Oats	69
Mixed Grains	2
Rapeseed	19
Total	357

Forage Crops (1968)	Acres in 000's
Creeping Red Fescue	19
Alsike Clover	9
Red Clover	7
Sweet Clover	3
Alfalfa	2
Other	2
Total	42

Livestock in Census Division 10 (1966)	000's
Beef Cattle	31
Dairy Cattle	2
Swine	6
Sheep	6
Horses and Ponies	4

Horticulture (1965)	Acres
Potatoes	185
Cabbage	10
Turnips	17
Total	212

Potential

The potential for agricultural expansion in this region is great. Much good quality land is still available and the markets locally, in the rest of B.C., and in Alaska, are wide open.

Grain and forage crop production could increase tremendously. The region's high quality seed production, availability of land and the desirability of rotating forage crops with grains rather than the traditional practice of summer fallow make increased production both possible and desirable.

The Peace region is also ideal for expanded beef cattle production to meet ever-increasing provincial needs. Among the factors presently holding back increased production are the lack of large areas of community grazing pasture and the extremely long winter feeding period; this latter factor presents problems of providing shelter and feed and the difficulty of maintaining weight gains under extremely cold conditions. These problems also hold true for the dairy industry. Potential for expansion of swine and poultry production is also large, as present output fails to meet even local requirements.

The majority of the land suitable for horticulture is on the river flats along the Peace River. Now that the Bennett Dam has regulated water levels and thus eliminated flooding, horticulture will expand rapidly. One advantage of the area is the availability of inexpensive natural gas for hot-houses.

The Peace River region is also one of the finest honey producing areas in Canada. Quality is very high and yields are up to 50% above the national average - probably due to ideal weather and large acreages of seed crops; this suggests development of a specialty market.

Outdoor Recreation

Hunting

The Peace River - Liard Region offers hunters an exciting variety of game animals and birds. Generally speaking, moose can be found in the marshlands of the Peace River Region; black bear and mule deer throughout the region; grizzly bear, sheep and goat in the mountains; caribou in the wooded plateaus and alpine meadows north of the Sikanni Chief; waterfowl on the migration routes in the eastern section of the Region; and grouse, west of Dawson Creek. Unfortunately, the Finlay-Parsnip-Peace River Valleys, one of the best moose ranges in B.C., was flooded by Williston Lake.

Some of the more productive areas include the Sukunka River area, which is excellent for moose, good for mule deer and fair for elk, black and grizzly bear. A 4 to 5 hour hike up Bull Moose Mountain (east of the Sukunka) takes the hunter into one of the few mountain goat ranges which may be reached without using pack horses. Unfortunately, this area around the Sukunka is the scene of increasing activity for coal mining and development. The effects of this industry on the animals is yet to be seen.

The lateral roads on either side of the Hart Highway between Chetwynd and Dawson Creek lead to productive moose and mule deer areas. The country east and west of Mile 80 to Mile 200 on the Alaska Highway offers outstanding hunting for moose and caribou. Mule deer are found in abundant numbers along both sides of the Alaska Highway from Dawson Creek to Beatton River. Some excellent sheep and caribou country is located north of Muncho Lake Provincial Park.

Fishing

Although anglers frequently report excellent catches during the summer months, fishing in the Peace River Region is not as extensively developed as is the hunting. Access to fishing areas is usually limited and the tourist frequently is confined to rivers and lakes situated near the highways. In order to reach many of the more productive sites, aircraft, riverboats or pack horses are required. The scarcity of available lakes, as compared to the Caribou, for instance, has reduced the tourist fishing potential. Table 7 gives a general indication of sports fish resources of the region.

Table 7 Angling in the Peace River - Liard River

	Lake Trout	Rainbow Trout	Dolly Varden	Grayling	Whitefish	Jackfish	Perch
Dawson Creek Area							
Moberly Lake	x						
One Island Lake		x					
Pine River			x	x	x		
Swan Lake						x	x
Fort St. John Area							
Charlie Lake						x	
Chinaman Lake		x					
Clearwater Creek		x	x	x			
Haddon Lake						x	
Halfway River		x	x				
McDonnell River			x	x			
Peace River		x	x				
Racing River							
Sikanni River			x	x			
Tetsa River				x			
Grayling River				x			
Jackfish Creek				x			
Kluachesi Lake	x		x	x			
Tetsa Lake			x	x			
Toad River			x	x			
Tuchadi Lake	x						
Lower Post Area							
Liard River			x	x			
Muncho Lake	x			x	x		

Table 8

Provincial Parks

Park	Location	Acreage	Class	Facilities
Pearce Island	Near Taylor	102	C	
Moberly Lake	North west of Chetwynd			30 camping units, boat launch
Swan Lake	South of Pouce Coupe	166	C	
Kiskatinaw	North of Dawson Creek	143	A	26 camping units
Beatton	On Charlie Lake			
Charlie Lake	On Charlie Lake			20 camping units, boat launch
Fort Nelson Centennial	Fort Nelson	13	C	
Kledo Creek	West of Fort Nelson	14	A	15 camping units
Stone Mountain	Surrounding Summit Lake	64,000	B	
Muncho Lake	Surrounding Muncho Lake	218,600	B	
Liard River Hotsprings	Near Liard River	1,650	Special Interest	21 camping units

Conclusions

The early post-war agricultural economy of this region has swung over in the last 10 years to natural gas, crude oil and forestry. The next 10 years will see further fossil fuel and forestry development as well as considerable expansion of mining activity.

More complete utilization of the extensive forest resources is underway. Rail access to Fort Nelson may lead to a pulp mill complex there. Chips for sawmills in the Peace River area are destined for Mackenzie. Timber in the upper portion of Williston Lake is also being harvested.

Coal deposits in the Rocky Mountain foothills are being developed, especially along the Sukunka River south of Chetwynd. Potential mines are being studied intensively, especially copper, lead and zinc west of Williston Lake and in the Dease Lake area.

Oil and gas exploration continues and will undoubtedly result in other producing fields and more pipeline capacity.

As the previous sections indicate, this development could have profound environmental implications. Given present trends in resource development, the Williston Lake and Peace River regions seem likely to become areas of environmental stress.

Williston Lake is becoming the centre of a quickly developing region. Forestry activities are rapidly expanding in the Finlay PSYU surrounding the lake. Logging, as discussed in a previous section, leads to increased stream sediment loads, increased water temperatures due to loss of shade over streams and leaching of organic products reducing dissolved oxygen content in streams. Williston Lake is also being used for log transport to the mills at Mackenzie. Log transport increases lake sediment loads as well as increasing oxygen depleting organic wastes. The pulp mills at Mackenzie cause increases in suspended solids (from wood preparation and pulping processes), dissolved solids, toxic chemicals and BOD-producing nutrients.

Exploration activities for lode minerals in the Omineca region will soon lead to mining and milling operations on the tributaries to Williston Lake. These tributaries (the Ingenika, Finlay, Mesilinka, Osilinka, Omineca, Manson and Nation Rivers) will receive mine and mill effluents in the form of toxic mine drainage, metal concentrations (lead, zinc, copper) and possibly cyanide (used as a flotation process reagent). Coal mining exploration activity along the eastern shores of the lake will add yet more sediment loading and surface acid drainage.

It is unlikely that the flow of such wastes in the tributary rivers will not disturb the ecology of Williston Lake. At present, the area is scarcely populated and the tourist potential of the lake is still that: potential. However, with increases in tourism in the area, conflicts are bound to arise as recreationists recognize the harmful effects of the wastes on Williston Lake. As well, increased sedimentation may cause excess wear on the powerplant turbines at the G.H. Shrum powerplant and on possible downstream sites.

The waters of Williston Lake flow into the Peace River, past the W.A.C. Bennett Dam. The Peace will also be under environmental stress. The B.C. Energy Board has presented plans for possible development of Sites 1, C and E on the Peace River, flooding low-lying parts of the valley to the Alberta border. Although the consultant's report to the Energy Board discounted the agricultural value of the floodable land, agriculture sources indicate that the river flats are highly suitable for horticulture.

Agriculture itself is a source of potential environmental degradation. Practices related to livestock operations contribute appreciably to the quantity of nutrients entering a river system through surface runoff. These practices include stock watering in streams, disposal of animal wastes in land sloping towards streams and cultivation of slopes adjacent to streams. Considerable growth in the beef cattle industry is expected in the Peace River area and so nutrient loading may become a problem in the near future.

The Peace River will have further quality stresses from resource and industrial development. Coal mining on the tributaries from the south (Sukunka, Pine, Murray) will doubtless affect water quality through increased sediment loads and acid mine drainage. Industrial development at Taylor will also affect river quality. Taylor is presently the site of a refinery with corresponding high water use, thermal pollution, increased sediment loads and BOD producing nutrient wastes. Combined with possible poor water quality originating in Williston Lake, the Peace River water quality may become a problem, especially as an interprovincial river draining into the already troubled Peace-Athabasca Delta.

Water quality degradation would appear to be a most likely outcome of these development trends. In terms of water quantity, no supply problems are evident at present. Present demands are limited to domestic water use for a number of small communities and to industrial use for 2 pulp mills, an oil refinery and other small installations. Sufficient quantity also exists for possible hydroelectric power generating facilities on the Peace and Liard Rivers and diversion of McGregor River water into the Peace system to provide added flow for existing and proposed plants is under consideration.

The lack of data leaves many questions to be answered concerning the capability of the region's water resources to accommodate future water demands: for example, are flows in the headwaters of the Finlay, Meslinka, Nation, Dease, Halfway and other rivers, where mining and milling operations are likely to develop, sufficient to supply water to and assimilate wastes from these operations? Are flows in the Peace at Taylor sufficient to absorb thermal pollution from more than the present single refinery? In low flow years, will Williston Lake be drawn down to a point endangering log transportation, waste water outfalls from pulp mills at Mackenzie, recreation and other uses? Will water use deprive fish populations of necessary flow or wildlife populations of required marshlands?

The lack of such concrete baseline data concerning resources, resource-use and development trends in the Peace-Liard region presents definite limits to the identification of present and future areas of environmental stress and of the exact nature of these stresses. Such identification is instrumental to water resource planners as a guide to areas of possible management consideration and action.

It is therefore recommended that an inventory of the quantity and quality of the water resources and of the characteristics of related resources of the area be undertaken. Such an inventory would include data of the following nature:

hydrologic data: precipitation
runoff characteristics & sedimentation
flow frequencies
groundwater resources

water quality data: dissolved oxygen
mineralization
acidity
temperature
turbidity

current and planned water use

biological resources

related land use.

Data on precipitation, runoff characteristics and sedimentation are necessary to study the rates of erosion from forested and cultivated areas and the consequent effects on receiving waters; to judge the probable levels of drainage from mining areas and tailing ponds; to predict possible levels of water recycling in industrial operations, especially milling operations. From data on present sediment loads, we may predict the effects of incremental increases of such loads on powerplant turbine efficiency, on fish populations, on municipal water supply treatment costs, on suitability of raw water for industrial use.

Flow frequency data will determine if flow is sufficient to satisfy future demands, whether waters have sufficient capacity to assimilate probable levels of waste discharges (including thermal) and whether waters can satisfy demands in low flow periods. Study of the region's groundwater resources will allow managers to pinpoint areas where mining activities might seriously affect groundwater patterns or groundwater quality.

Data on the water quality parameters mentioned above are necessary to judge the possible effects of industrial activities. Nutrient loadings from forestry and pulpmill operations will lead to decreased levels of dissolved oxygen in rivers and lakes. Mining and milling operations will lead to copper, lead and zinc loadings to streams and rivers. Present acidity levels in receiving waters will determine the consequences of acid mine drainage.

Data on present and predicted water use in conjunction with hydrologic and water quality data, information on fish and other biological resources and information on related land use and practices will allow analysis of the capability of the resources to meet current and projected needs and will thus reveal the extent and magnitude of unsatisfied demands for specific quantities and qualities of water. From such an analysis, problems likely to impede the attainment of desired levels of regional economic growth, social betterment and preservation and enhancement of the natural environment can be identified. Problems may include conflicts in resource use, physical constraints limiting resource use, or other limitations.

Should the Peace-Liard River Basins receive priority from water resource managers (perhaps due to interest in the Mackenzie Basin), all of the types of data discussed above will be required for thorough investigation of the region. Whether or not the region receives that degree of attention, data gathering activities should still be encouraged in the two areas most likely to experience environmental stress: Williston Lake and the Peace River. The types of data most urgently required are water quality and quantity data on Williston Lake, the Omineca River, Mesilinka River and Nation River; and on the Peace River, Sukunka River and Halfway River. Special interest should be paid to areas of present and planned mining and forestry activities.

Whether or not development in the Peace-Liard region leads to environmental problems of sufficient magnitude to warrant large scale federal initiatives in the region, the possibilities of environmental stress combined with the complications of interprovincial jurisdictions and sensibilities due to the transboundary nature of the Peace and Liard Rivers, indicate that data gathering activities are called for in order that management may be aware of the situation and can thus be prepared to either take the lead in detailed study or provide guidance and input into programs initiated by other agencies.

Water Supply and Pollution Control

	Chetwynd	Dawson Creek	Fort Nelson	Fort St.John	Taylor	Hudson's Hope	Pouce Coupe
Population (1971)	1,260	11,885	2,290	8,260	605	1,745	600
Water Supply							
Raw Water: PH	n.a.	7.8	n.a.	7.3	n.a.	n.a.	n.a.
Hardness (mg/1)	"	160	"	72.6	"	"	"
Turbidity (JTU)	"	60	"	0.5	"	"	"
Color (Hazen Units)	"	n.a.		5	"	"	"
Source	River	River	"	Lake	River	"	"
Pumpage (gal.per minute)	175	1,400	250-270	850	130	410	184
Type of Treatment	A*	A,B,C*	A*	A,B,C*	A,B*	A*	A*
Plant Design Capacity (MGD)	0.5	2.2	n.a.	0.8	n.a.	n.a.	n.a.
Storage Capacity (MG)	0.1	8.5	48.0	1.5	0.3	0.1	6.0
Miles of Mains	6.3	59.8	25.0	28.8	4.1	5.3	3.3
Cost per 1000 gals ($)	n.a.	0.30	n.a.	0.80	n.a.	n.a.	n.a.
Pollution Control							
Avg. Daily Flow (MGD)	0.1	0.6	0.2	n.a.	n.a.	n.a.	n.a.
Degree of Treatment	Secondary	Secondary	Primary	Primary	"	"	"
Plant Design Capacity (MGD)	n.a.	1.5	0.2	n.a.	"	"	"
Plant Influent: BOD	"	240	n.a.	"	"	"	"
Plant Influent: SS	"	290	"	"	"	"	"
Plant Effluent: BOD	"	40	"	"	"	"	"
Plant Effluent: SS	"	80	"	"	"	"	"
Type of Treatment	D,E*	E,F*	E,G*	"	G*	D*	G*
Sanitary Sewers (miles)	6.1	40.6	25.0	25.1	2.5	5.2	2.4
Storm Sewers (miles)	0.4	13.5	2.5	1.7	n.a.	1.3	0.1

* A - Chlorination
B - Filtration
C - Flocculation
D - Aerated Lagoon
E - Anaerobic Lagoon
F - Algae Lagoon
G - Septic Tank

Sources: Water and Pollution Control (1974)
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