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MINERAL RESOURCES DIVISION
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SAND AND GRAVEL STUDY 1985
Transportation Corridors and Populated Areas

By Z.D. Hora

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

INTRODUCTION

This report completes the basic inventory of the construction aggregate resource in British Columbia. The information for the Lower Mainland has already been published in the Sand and Gravel Study 1980 - Paper 1980-10, by Z.D. Hora and F.C. Basham, which covers the transportation corridors and populated areas of the mainland. A similar inventory for Vancouver Island was deemed unnecessary, because the whole area of the island is covered by 1:50 000 landform maps outlining where granular units can be readily identified.

CIRCUMSTANCES OF THE STUDY

The inventory of aggregate resources in British Columbia was initiated in 1978, when the Ministry of Energy, Mines and Petroleum Resources began to analyse the supply-demand situation and the availability of the resource in the Lower Mainland and Greater Vancouver area. The results of this study were published in June 1981. The province-wide development of official settlement plans, in progress during the late 1970s and early 1980s, required basic information on the distribution of non-renewable resources, in order to prevent the sterilization of undeveloped sand and gravel deposits by inappropriate zoning. The next logical step after completing the Lower Mainland study was to proceed with an aggregate resources inventory in other populated areas and transportation corridors throughout the province. This report summarizes the results of this work carried out during 1980-1982.

COMMODITY DESCRIPTION AND USE

Sand and gravel are the main sources of fine and coarse construction aggregate. Petrological and mineralogical composition of individual rock particles plays a major role in determining industrial uses and the quality of aggregate. These are important factors in the evaluation of deposits across the province. The composition of gravels in the Lower Mainland is generally quite uniform due to a geologically similar source areas, and does not present a major concern. However, the diversity of British Columbia geology makes the quality of available aggregate variable from region to region. Even though the quality of cement manufactured in the province does not pose an alkali-reaction problem as in some other parts of North America (CANMET, personal communication, 1986), quality may be adversely affected by the presence of deleterious components such as chert in areas adjacent to the Rocky Mountains or volcanic glass in parts of the interior plateau. While sand and gravel deposits are the dominant source of aggregate in most of British Columbia, there is a local minor use of mine waste or crushed quarried rock wherever this is expedient.

Approximately 45 million tonnes of sand and gravel, valued at $98 million, were produced in British Columbia in 1980. Commercial production within the study area was some 9 million tonnes together with almost 14 million tonnes for non-commercial use. There is practically no movement of aggregate, or sand and gravel, across the provincial boundaries into or out of the study area. In total, production of 93 commercial operators is included in this study.

DEFINITIONS

The term sand and gravel, as used in this report, refers to natural deposits or unprocessed material. The term aggregate, on the other hand, refers to the product processed for industrial use by crushing or washing and screening. Conversion factors used to prepare tables in metric units are:

1 cubic metre = 2.0 short tons
= 1.3 cubic yards
= 1.8 tonnes.

ACKNOWLEDGMENTS

The author wishes to acknowledge significant contributions made to this study by a number of persons. Marilyn Hunter prepared the geological component including map compilation, terrain mapping, field reconnaissance and interviews of producers and local government representatives. Katrine Foellmer was a capable field assistant. Special thanks are due to Dr. John Clague, Dr. June Ryder, Dr. Robert J. Fulton and Don Howes for providing access to field maps of their study areas. Robert Abbott and John Baine helped to analyse the production data and the information provided by operators, municipalities and Regional Districts.

I also wish to express my sincere thanks to the municipal and regional district staff and to pit operators who provided the data necessary for this study. Also, engineering staff of the Ministry of Transportation and Highways helped us by providing information on non-commercial aggregate production and use. Finally, while acknowledging the contributions of others, I accept full responsibility for the content and accuracy of the report. Furthermore, the views expressed are those of the author and do not necessarily represent those of the Ministry or the Government of British Columbia.

GEOLOGY OF SAND AND GRAVEL

PREVIOUS GEOLOGICAL STUDIES

There is only one previously published report on sand and gravel deposits in the area covered by this study (Clague and Hickock, 1976). On the other hand, sand and gravel landforms are specifically identified on Pleistocene or surficial geology maps, many of which were useful sources of information for this study, most notably maps compjled by Nasmith (1962) for the Okanagan valley, Ryder (1976, 1981b) and Fulton (1963, 1975) for the area from Lytton to Seymour Arm and Vernon, and Reimchen (1980) and Mathews (1978) in Peace River area. Also, some valuable information on the distribution of granular soils (that is, sand and gravel) can be derived from manuscripts of soil and landform maps and terrain maps, available in blueprint copies at 1:50 000 scale from the provincial Ministry of Environment and Parks. Numerous site-specific studies are helpful in understanding the regional and local geological controls for sand and gravel deposition. The area included in this study is covered by 210 map sheets at 1:50 000 scale (Figure 1). Data from outside sources were used, to some degree, in the area represented by 139 of these sheets (Figure 2).

INVENTORY OF THE RESOURCE

The purpose of this project was to prepare a set of maps illustrating aggregate potential for all areas of the province where such information is important. Time constraints dictated that the study be confined to the identification of gravel deposits lying within a strip, 5 kilometres wide, straddling the principal highways in the province. Available geological and terrain information, supplemented by airphoto interpretation where necessary, was first compiled on base maps at a scale of 1:50 000. The area was then examined in the field, existing gravel pits documented and aggregate potential assessed in one of the following three categories:

(1) Known reserves - granular landform units with production records from existing gravel pits. On the maps they are designated Unit A, with subunits:
A^1 - sorted, gravel to sandy gravel;
A^2 - sorted, sand to pebbly sand;
A^3 - unsorted granular materials.

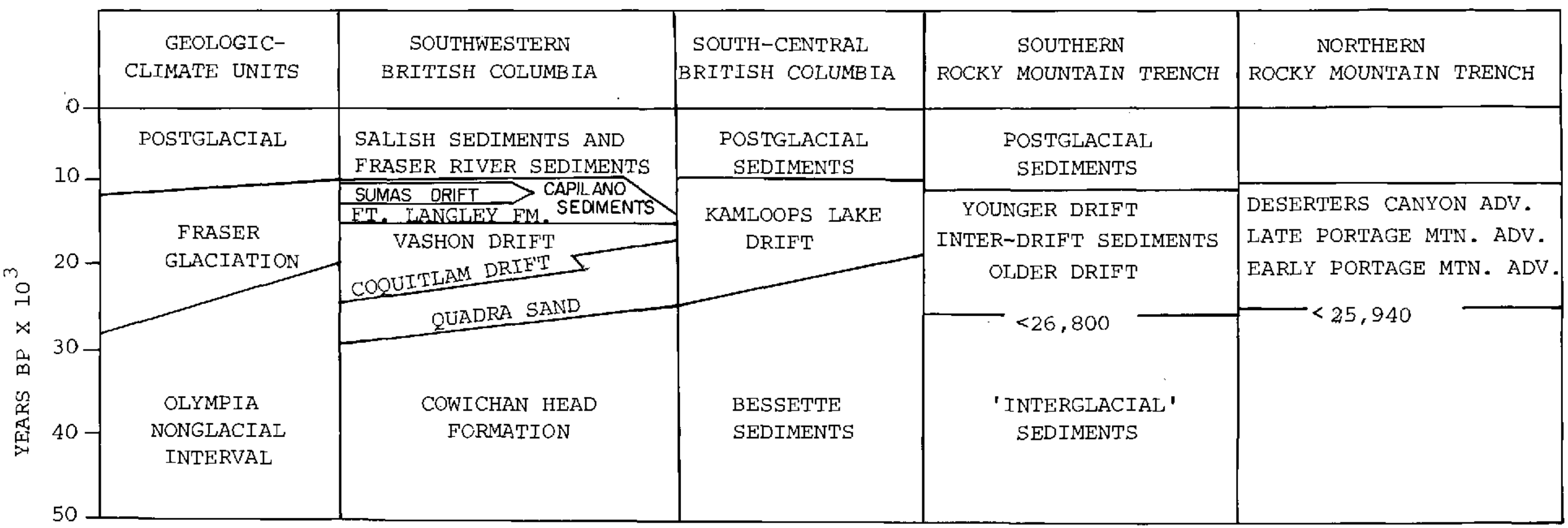


Table 1 Correlation of late Quaternary deposits and events in British Columbia, adapted from Clague, 1981.

(2) Probable reserves - as above, but no documented production. On the maps they are designated Unit B with subunits B^1, B^2 or B^3 wherever subdivision is feasible.

(3) Possible reserves - landform units which may contain sorted or unsorted granular materials as well as other genetic materials. On maps they are designated as Unit C.

This set of unpublished manuscript maps is available at the Ministry of Energy, Mines and Petroleum Resources in Victoria.

ORIGIN AND DISTRIBUTION OF DEPOSITS

The majority of sand and gravel resources in British Columbia are linked to various episodes of Fraser glaciation. Only a minority represent postglacial alluvial terraces and fans, or preglacial material. Due to differences in deglaciation history, the study area was subdivided into five specific regions which are described separately on the following pages. The boundaries of the regions are outlined on Figure 3 and represent approximate limits of areas having the same deglaciation pattern and similar Pleistocene history although deglaciation was not necessarily contemporaneous from area to area (Table 1).

Area I - South-central British Columbia (Thompson - Okanagan Basins)

South-central British Columbia was covered by ice that originated in the Coast and Cariboo mountains and coalesced over the interior plateau. Turning southward it covered all but the highest peaks north of the 49th parallel. Additional ice centred in the Monashee Mountains and Premier Ranges to the east and northeast contributed to the southward-moving mass. The southern edge of the interior plateau and the Thompson-Okanagan area has moderate relief which affected the way in which deglaciation occurred. Fulton (1967) suggests that it was achieved by downwasting, stagnation of ice tongues along valleys, and subsequent decay of separated blocks of dead ice.

As deglaciation progressed, former drainage patterns were disrupted and glacial lakes formed in ice-dammed upland valleys and marginal to ice tongues and stagnating blocks in the main valleys. The Thompson, Nicola, Shuswap and Okanagan basins contained these lakes, all of which passed through several stages of development that are now recognizable as old shorelines, outlet levels and raised deltas.

Lake levels in the Nicola basin were controlled by stream divides with present elevations of 1010 metres (3300 feet) for glacial Lake Quilchena, 930 metres (3050 feet) for glacial Lake Hamilton and 780 metres (2550 feet) for glacial Lake Merritt, the latter being the one of longest duration (Fulton, 1969). Numerous delta terraces at this lower elevation may provide potential sites for granular material. Isostatic tilting has deformed many of the shoreline features. Drainage was first to the south into the Similkameen, then east into the Okanagan and finally north into the Thompson basin.

Lake levels in the Thompson basin were controlled by retreating ice and isostatic tilting of valley outlets. Present approximate elevations of these old lake levels are: for glacial Lake Thompson, 580 metres (1900 feet), 535 to 500 metres (1750 to 1650 feet) and 500 metres (1635 feet); for glacial Lake Deadman, 430 metres (1405 feet) and 375 metres (1230 feet); and for Lake Kamloops, 355 metres (1160 feet). Drainage from these lakes was initially southeastward through present-day Monte Creek and near Chase but, with lowering ice levels, soon changed to a more easterly route, eventually escaping through the Okanagan valley. Deltaic deposits of any size are mainly associated with the Lake Deadman period.

Lake levels in the Okanagan basin are attributed to dams of drift and stagnant ice and isostatic tilting located at Okanagan Falls (Nasmith, 1962). The oldest lake levels, preserved in the geological record, were in the Coldstream area of the North Okanagan with levels above 550 metres (1800 feet); later 585 metres (1690 feet) and 506 metres (1660 feet) before joining glacial Lake Penticton, which had recognizable levels at 503 metres (1650 feet), 488 metres (1600 feet), 427 metres (1400 feet) and 354 metres (1160 feet) (Fulton, 1962). Delta terraces and shoreline features are most prominent at the 427-metre (1400-foot) elevation. Glacial Lake Penticton may have extended into the present Shuswap basin, but piracy by the South Thompson River during the last stage of deglaciation altered the flow patterns to essentially those we see today. During deglaciation, drainage was southward from the Okanagan basin.

Lake levels in the Shuswap basin were mainly controlled by stagnant ice masses and differential tilting. Present elevations of these levels are 482 metres (1580 feet), 396 metres (1300 feet), 372 metres (1220 feet) and 357 metres (1170 feet) (Fulton, 1962). Some stages were continuous with glacial Lake Penticton; all drainage was towards the Okanagan valley.

Meltwater feeding these lakes came largely from the locally melting ice and adjacent upland areas, but was augmented by meltwater originating from the wasting dead ice mass (mentioned in the discussion of deglaciation in the central interior) situated on the interior plateau west of 100 Mile House and east of the Fraser River. The approximate ends of these streams are represented by esker complexes such as those found extending northward from Chasm and Clinton and one passing the west end of Green Lake. These late-glacial streams have cut very deep canyons upon reaching the edge of the plateau, eventually finding their way into the Deadman or Bonaparte rivers. Deltaic terraces at the mouth of the Deadman River, where it emptied into glacial Lake Thompson, are particularly prominent features. Large outwash and kame terraces, which extend south and east from the Bonaparte River, probably formed while the ice still blocked escape to the Fraser River (Ryder, 1976). The melting of ice in the Fraser basin was accompanied and followed by the formation of kames, kame terraces and outwash plains, all of which were dissected by postglacial river cutting and alluvial fan development.

Outwash terraces in the south and central Okanagan basin are generally found at higher elevations on the valley walls or removed to the west (for example, Marron Canyon, Twin Lakes, Yellow Lake - Similkameen River) in parallel drainages. These deposits are the site of most commercially operating gravel pits. Another outwash terrace is located north of O'Keefe, presumably derived from a channel used at some stage of deglaciation in the area. Kame terraces in the north Okanagan valley and in one case materials of pre-Fraser origin are presently being used for granular materials. Undoubtedly, there are buried fluvial deposits derived from previous glaciations that are not indicated by surface expression and may only be outlined by detailed field investigations and drill-hole data. Such deposits could greatly augment the presently dwindling supplies of granular material in the North Okanagan.

Outwash terraces in the Kamloops area are few, however one exists at Cherry Creek and is presently being used for commercial gravel extraction. Others are located in old meltwater channels on the uplands south of the Thompson River. Buried deltaic deposits are known at a few locations where gulleys have penetrated the lacustrine silts east of Kamloops. It may be that more exist and knowledge of these would greatly benefit the dwindling supplies of aggregate in the Kamloops area. At present, some fluvioglacial terraces along the North Thompson River are being utilized.

Very few eskers exist in south-central British Columbia. Those that are present do not extend very far nor do they reach any great height.

Other sources of granular material are the postglacial alluvial fans that form a capping on most of the raised terraces in the Thompson and Nicola basins. These are, in general, poorly sorted, with constituent materials which reflect the local bedrock and unconsolidated materials.

The Similkameen valley functioned as an escape route for southward-draining waters. Kame terraces and outwash terraces formed during the stagnation of an ice tongue in the valley.

The Kettle valley was similar to the Similkameen in that it functioned as an escape route for south-flowing waters, but differed in that temporary ponding appeared to have occurred marginal to the ice during some stages of deglaciation.

Area II - Columbia - Kootenay Drainage System

The southeastern part of British Columbia, forming the Columbia - Kootenay area, was glaciated by the Cordilleran ice sheet as was the rest of the province. Ice covering this area originated in the Rocky Mountains and northern Selkirk Mountains and was augmented by local alpine glaciers. Ice movement was in a southerly direction. The area can be divided into two major subareas: the West Kootenay - Boundary country or all that area lying west of the Purcell Mountains and Northern Selkirks, and the Rocky Mountain Trench including the Elk River valley.

Clague (1973) indicates that the ice in the southern Rocky Mountain Trench remained active during deglaciation and receded by downwasting and normal frontal retreat. Tributary glaciers retreated back up their valleys prior to the disappearance of the main valley ice, resulting in temporary impoundment of ice-marginal lakes and associated deltaic development. The lakes drained to the south beneath and along the ice margins as evidenced by kame terraces and a few eskers. Several large outwash terraces were formed as a result of the central valley being filled with ice. Between the Kootenay River upstream of Canal Flats and Skookumchuk is a large outwash plain presumably formed when the Kootenay River was diverted southward from its present course before entering the valley at Skookumchuk. Similarly, the Elk River parallels the Kootenay River for some distance before entering the main stream, as can be easily seen in the extensive, kettled outwash terraces south of Elko. Deltaic deposits and outwash terraces are the main source of construction aggregate in the southern Rocky Mountain Trench.

Similar conditions may have occurred in the Elk valley, with a temporary impoundment that spilled into Alberta through the Crowsnest Pass. Fluvial terraces and kame terraces are the main source of granular material in the Elk valley.

In the present Columbia drainage of the Rocky Mountain Trench, ice-marginal lakes were more common, the main one occurring in the area from Canal Flats to north of Radium Hot Springs. Deltaic deposits and outwash channels are not so extensive further south. During deglaciation a number of larger tributary creeks entering from the west formed deltaic and kame terrace deposits along the valley margin. Drainage during this time was to the south, exactly opposite to that existing today. Some of the deltaic deposits are buried by lacustrine materials and are difficult to locate. Only where fortuitous gullying has exposed these deposits are they readily recognized. As presently known reserves of aggregate are depleted, the location of these buried deposits will become all important. Slope wash and recent fans may be found toward the valley walls and in the present floodplain, but these do not usually contain significant economic reserves and are used only for borrowing.

The West Kootenay - Boundary area appears to have become deglaciated in a manner similar to the Rocky Mountain Trench, that is, by downwasting and orderly retreat. Most certainly there was temporary impoundment and lake formation in these valleys, but extensive evidence is lacking in most cases. Some lacustrine materials occur in higher level subparallel valleys but exhibit few if any associated deltaic or shoreline features. The ice-marginal lakes may have been very short-lived. Generally, there seem to be large outwash terraces and kame terraces south of Castlegar at the confluence of the Columbia and Kootenay rivers. Trail and Castlegar both obtain their construction aggregate from these deposits. Drainage was generally southward during deglaciation but undoubtedly there were times when meltwater used different routes of escape.

Area III - Central Interior Plateau

The central interior of British Columbia was glaciated by ice formed in the surrounding mountains; the main centres of ice accumulation being the Coast Mountains to the northwest, west and southwest, and in the Cariboo Mountains to the east and southeast. Ice flowing from these

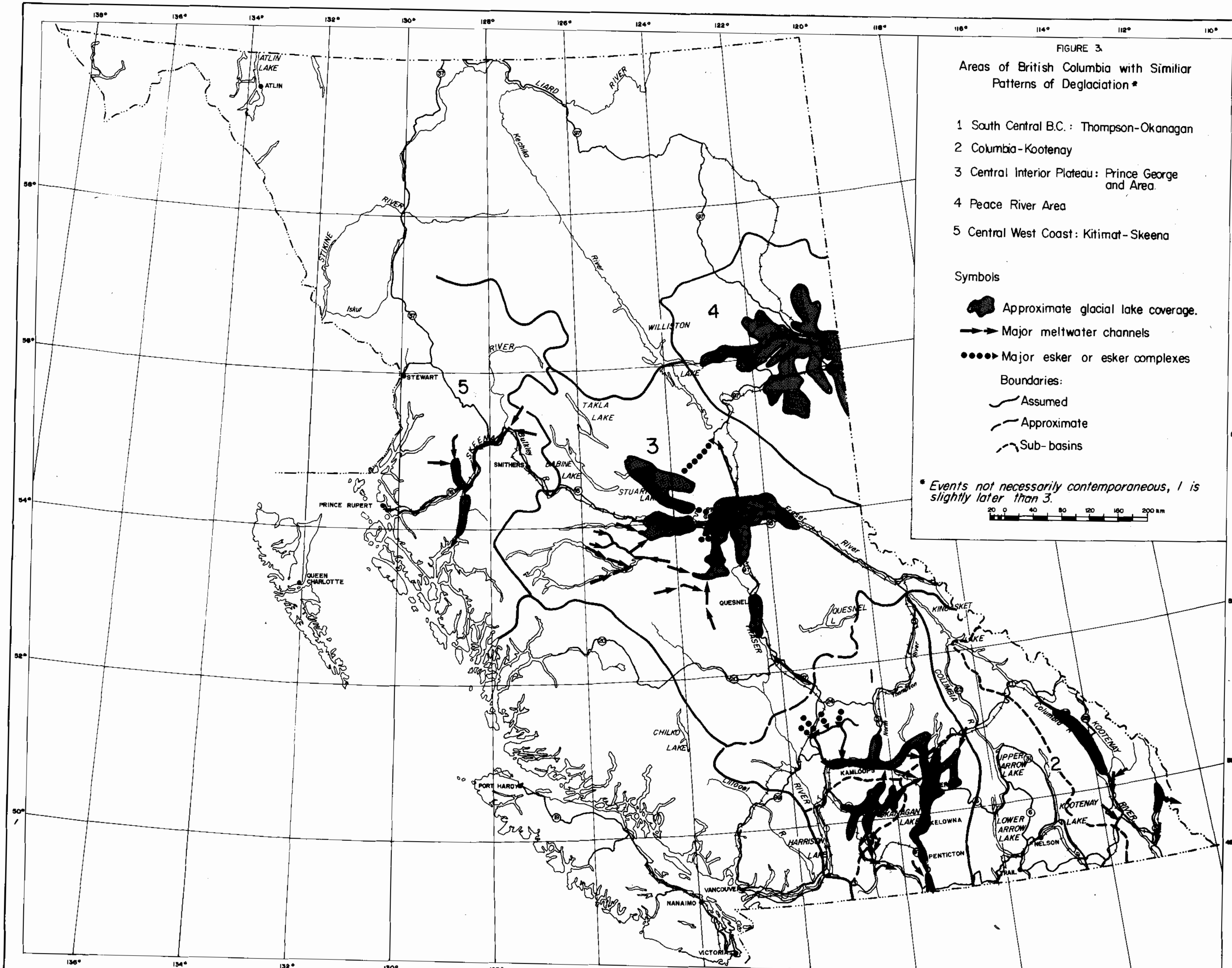


FIGURE 3. Areas of British Columbia with Similiar Patterns of Deglaciation *

centres coalesced in the vicinity of the present Fraser River valley and moved northerly past Prince George to the Parsnip valley. Tipper (1971) suggests that this particular ice mass did not override the Rocky Mountains but split into two main streams, one moving northwest along the Parsnip River and the other southeast towards the upper Fraser River. Earlier advances may have overridden the Rockies as suggested by Mathews (1980) from studies done in the Peace River area.

Deglaciation in the early stages appears to have been a combination of thinning and normal retreat along an ice front roughly perpendicular to the direction of flow (Tipper, 1971). As the ice mass thinned, topography began to exert greater control, and eventually resulted in a breakup of the ice into separated individual masses that stagnated and wasted in situ.

Concomitant with deglaciation of the interior plateau was the formation of related landform features, many of which are still intact and are easily recognized on airphotos of on the ground. In some areas drumlins, grooves and striae provide an excellent indication of ice movement. In other areas hummocky terrain with deranged drainage suggests wasting masses of stagnant ice. Large outwash channels, eskers and lateral overflow channels provide clues to the various routes taken by the enormous quantities of meltwater that were produced during deglaciation. Finally, thick deposits of bedded silts and clays and old shorelines point to the existence of large lakes, many ephemeral, formed as a result of ice and drift blocking previous drainage channels.

The meltwater deposits and lacustrine basins are of particular interest as the resultant landforms are the source of a significant percentage of the total volume of granular material extracted on a commercial basis and used particularly by the Ministry of Transportation and Highways. Approximate locations of major lake basins, meltwater channels and esker/esker complexes are shown on the accompanying map (Figure 3).

Four main lacustrine basins formed during deglaciation in the central interior of the province. These were the Fort St. James, Vanderhoof and Prince George basins with a smaller basin to the south along the Fraser River, believed to be formed by a short-lived re-advance of ice from the Cariboo Mountains. The lacustrine materials themselves are not suitable for granular materials, but gravel and sand along the old shorelines has been used for construction aggregate. Even more important are the areas where large meltwater streams have formed deltas as they flowed into these large glacial lakes. Lake Fort St. James sediments provide little or no granular material, nor does the Vanderhoof basin. However, the large meltwater streams that flowed toward these lakes left numerous outwash deposits, often forming raised sand and gravel terraces above the level of the rivers and lakes that presently occupy the channels. In theory these deposits are very suitable for granular material, but in practice many are too far removed from population centres to be economically exploitable. These deposits are potentially very good sources of granular materials. It would appear that Lake Vanderhoof drained through the present Nechako River system into glacial Lake Prince George. Large outwash terraces exist along the present-day Nechako River. The Prince George basin appears to have existed for a longer period than either the Fort St. James or Vanderhoof basins due to ice and drift blocking southerly drainage down the Fraser River, and the occurrence of a prominent bedrock lip that forms the spillway at Summit Lake. Apparently this was the outlet of glacial Lake Prince George for a considerable period of time (Tipper, 1971). North of the spillway, along the present course of the Crooked River, there is evidence of a large overflow stream that drained into the Parsnip River and eventually escaped into the Peace River valley. Large outwash terraces are located along this route. Beach gravel found along old shorelines of this glacial lake are used commercially in one area near Tabor Lake (east of Prince George). When the ice-dam that impounded the lake finally melted sufficiently to allow southerly drainage, large fluvial terraces formed south of Prince George along the Fraser River. These terraces together with the Nechako River outwash terraces, have been used extensively as granular resources in the populated Prince George area.

There are three large esker systems in the Interior Plateau, located west, northwest and north of Prince George, which formed during the earlier stages of deglaciation. The MacKinnon compound esker, which roughly parallels the northeastward direction of ice flow, lies west of Carp Lake. A possible extension of this esker complex intercepts the overflow stream in the Crooked River valley at McLeod Lake. The Stuart River compound esker extends from the southwest corner of Stuart Lake to Prince George. In places it is veneered by lacustrine materials of Lake Fort St. James, but is otherwise continuous throughout its length. The Bednesti compound esker, formed of ridges, kettles and meltwater channels, is located between Cluculz Lake and Bednesti Lake and is to date the most utilized of the three for granular materials, albeit for provincial highway needs. The Stuart River esker, in contrast, is relatively fine grained, especially at the Prince George end. Near Fort St. James the materials are being utilized, but are very sandy and contain a low proportion of gravel. Postglacial alluvial fans are the other source of granular materials and are generally found where any tributary creek joins a larger stream or enters a larger valley. The nature of the materials in these deposits depends upon the material from which they were derived. They are usually the site of borrow pits rather than large sand and gravel operations.

South of Prince George, in the Quesnel and Williams Lake area, there are no extensive deposits of fluvial or fluvioglacial deposits such as are found to the north and west of Prince George. The terraces located at the confluence of the Quesnel and Fraser rivers are the major source of granular material for Quesnel and the surrounding area. Operations in the Williams Lake area obtain granular material from former meltwater streams now occupied by Williams Creek and Hawks Creek.

Between Williams Lake and Clinton, near 100 Mile House and Lac La Hache, and westward to the Fraser River, there appears to have been a divide between meltwater flowing north and that escaping southward. Terrain in this area suggests that a large isolated mass of ice wasted in situ leaving a hummocky drift cover. Landforms with materials suitable for construction aggregate are small, sporadic and discontinuous, as might be expected in an ablation area.

Area IV - Peace River Area

The Peace River area shows the effects of multiple glaciations in the Pleistocene epoch. Several tills of different age and origin are recognized. As well, stratigraphic sections show various kinds of materials laid down in sequence. Of primary importance is the presence of not one, but two ice sheets that met or almost met just west of Fort St. John. One was the Laurentide ice which originated to the east, the other was the Cordilleran ice which, according to Mathews (1980), overrode the Rocky Mountains and spilled down the eastern slope.

Subsequent deglaciation of this area resulted in a large glacial lake being formed between the two retreating ice masses. The size and shape of this body of water changed as the ice waned. Glacial Lake Peace at one phase extended up the Peace River to the Portage and up the Murray, Pine and Sukunka rivers for significant distances. At this stage, meltwater from interior British Columbia was finding its way over the continental divide through several spillways which had become ice-free, contributing large quantities of granular material to the upper stretches of these rivers. Up to this time meltwater from Cordilleran ice had not been able to transport and deposit coarse material over the gentle slope of the Interior Platform. Gravel deposits are also located along preserved shorelines of glacial Lake Peace (especially in the Dawson Creek area) but they are shallow and discontinuous.

The major source of gravel occurs along the margins of the present Peace River and at depth within the boundaries of the interglacial Peace River valley. The area around Taylor has the greatest number of landform units (that is, fluvioglacial terraces) that are suitable for aggregate production and at present provide most of the construction aggregate for the whole region.

West of Hudson Hope, at Rocky Mountain Portage, there is a larger kame moraine and outwash channel formed when an ice mass was located directly upstream in the Peace River valley (Mathews, 1980). The materials are very suitable for construction aggregate. Laurentide ice appears to have left no obvious deglaciation landforms in the Peace River area of British Columbia, but blocked the flow of meltwater to the east. Drainage appears to have been to the north eventually escaping into the Liard River system.

Northeast of Chetwynd is a large outwash plain which was presumably related to an old route taken by the Pine River during deglaciation. This appears to be a good source of material for the developing area in Chetwynd.

Area V - Skeena and Kitimat Valleys

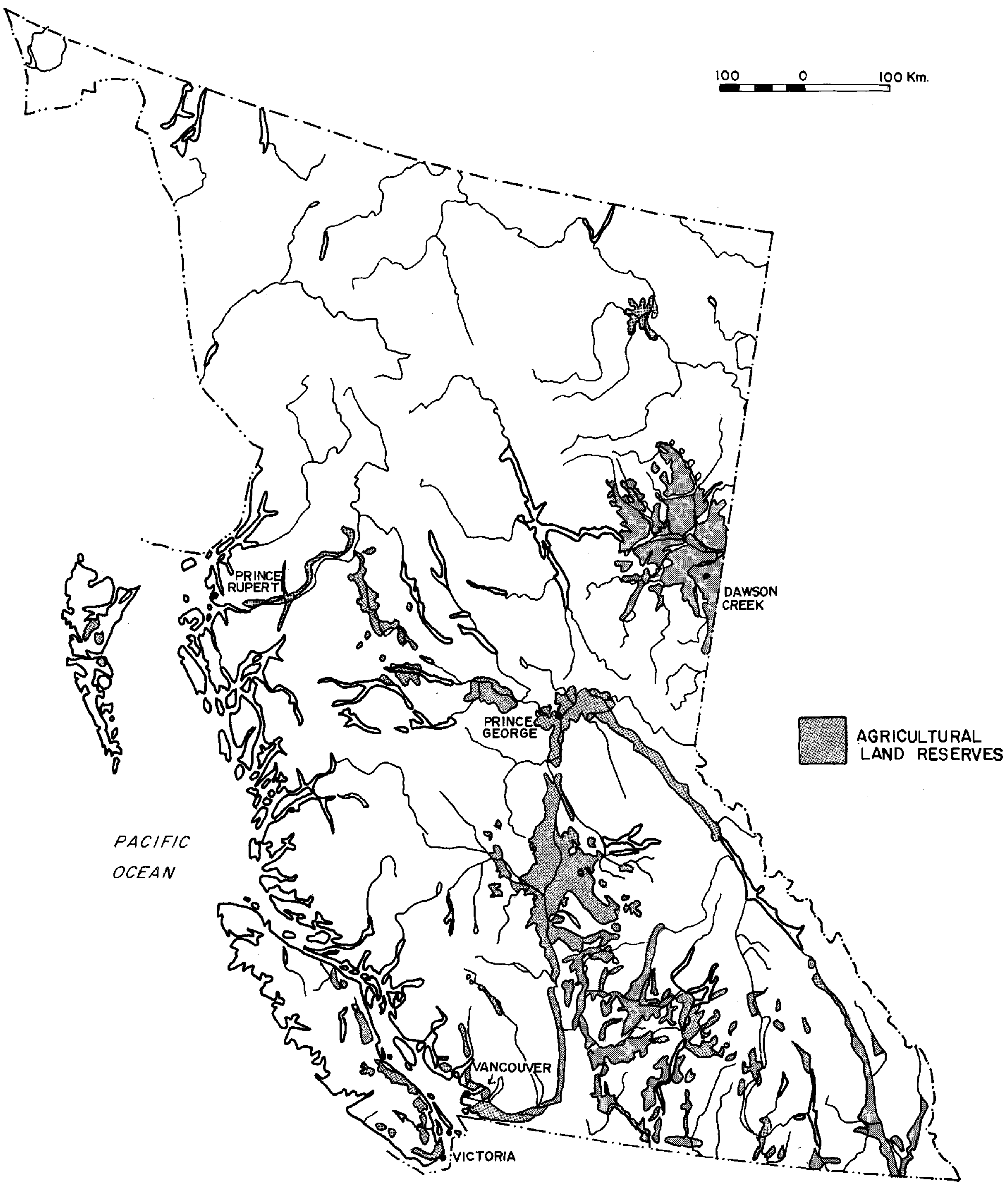
This coastal area was covered by ice that filled the valleys, leaving only the higher peaks ice-free. The weight of ice covering the Coast Mountains caused the general level to be depressed and sea level was at a significantly higher level than today, up to 200 metres above present sea level (Clague, 1984).

Terrace and Kitimat lie in a north-south corridor (Kitsumkalum-Kitimat trough) that is occupied in part by the Kitsumkalum, Wedeene and Kitimat rivers and is crossed at Terrace by the Skeena River. The landform in the corridor is a series of benches or terraces that consist of deltaic outwash materials (Clague and Hickock, 1976). In places the underlying marine sequence is exposed. The material throughout the corridor between Terrace and Kitimat could be very good for construction aggregate. North of Terrace, where the Kitsumkalum River enters the corridor, materials are very coarse and the surface topography is kettled and hummocky, suggesting that there was an ice front at that point for some time. Materials generally grade to finer textures closer to Kitimat.

The Skeena River has associated terraces on either side of the valley, upstream of Terrace, which terminate abruptly where the river enters the north-south corridor. A large outwash terrace immediately south of the entry point formed during the deglaciation when glaciers temporarily halted during retreat (Clague, 1984). This terrace is the site of several active gravel pits.

The Skeena River downstream of Terrace has no apparent deposits associated with deglaciation. This part of the Skeena River valley is devoid of outwash or kame terraces and there are no prominent raised deltas that might provide a clue to its deglaciation history. The absence of such landforms is its most notable feature. Drill-hole records, however, indicate that thick marine and glaciomarine sediments underlie Skeena River alluvium between Terrace and the mouth of the river (Clague, 1984). Steep walls of a narrow valley and fast erosion combined with fast glacier retreat are the explanation for the few visible remnants of glaciofluvial and glaciomarine sediments in this section of Skeena River.

FIGURE 4: LOCATION OF AGRICULTURAL LAND RESERVES IN BRITISH COLUMBIA



AVAILABILITY OF THE RESOURCE

A key question in our survey of producers concerned the life of existing aggregate reserves and expansion potential. About one-third of operators, mostly the small ones, could not provide an answer. The rest, however, had a very good idea about the future of their operations, either in terms of tonnage or in years of life at present production rates. In general, their estimates correlated well with our independent observations. At the time of our survey the existing commercial pits had the following expected lifetime at 1980 production rates:

Kamloops	7 years
Vernon-Armstrong	10 years
Kelowna	5 years
Trail-Nelson	<5 years
Prince George	>50 years
Peace River	5 years
Kitimat-Terrace	6 years

GEOLOGICAL LIMITATIONS

As our section on geology of sand and gravel in the study area clearly indicates, deposits are not evenly distributed throughout the province. In general terms it can be said that while the south-central or Thompson - Okanagan basin areas have substantial aggregate resources, as does the northern part of the interior plateau, there are areas where sand and gravel deposits are few and small in size.

Major deposits are definitely scarce in most of the Columbia - Kootenay drainage system. Granular deposits in the area between Williams Lake and Clinton are very small and scarce. The largest potential problem area is, however, in the Peace River region. There are no major undeveloped deposits available near present population centres and the potential for finding economically viable buried deposits is low.

TENURE LIMITATIONS

Land ownership and zoning have a signficant impact on the potential for development of aggregate deposits. There are very few restrictions on freehold land operators outside municipal boundaries and agricultural land reserves (ALR). Urban development, which is usually contained within municipal boundaries, sterilizes reserves, and results in pressure from residents for rezoning against operations. Another major obstacle for the aggregate industry is to achieve a release of even marginal quality land from the agricultural land reserve. This quite often becomes a political issue and in all parts of the province the ALR is a major hindrance to the aggregate industry on both Crown and privately owned land. ALR can however protect some gravel reserves from other forms of development. The distribution of ALR area in British Columbia is shown on Figure 4.

Another problem raised by the industry is the system of issuing leases on Crown land. Under the Land Act Regulations and Quarry Materials Policy administered by the Ministry of Lands and Forests, there is no guarantee that the person who applies for the lease on a particular piece of land will be the successful applicant. The Ministry can tender it for sale, or the property in question (containing a deposit of aggregate) may automatically be turned over to the Ministry of Transportation and Highways.

ALTERNATIVE RESOURCE

Crushed quarried rock is a routine alternative to the sand and gravel aggregate elsewhere. Wherever the industry lacks access to granular deposits of glacial or alluvial origin, or cannot bring natural sand and gravel to the marketplace at a cost acceptable by both the industry and the customer, the logical step is to open a quarry at the nearest site of massive rock. Such rock, when crushed, must meet the quality specifications (CSA or ASTM) for its intended use. This is clearly shown by the production statistics for the USA and Canada as reported by the United States Bureau of Mines and Energy, Mines and Resources Canada. In 1980, for example, the United States produced 1390 million tonnes of mineral aggregate of which 698 million were produced from crushed stone. During the same year, Canada produced about 365 million tonnes of aggregate with the crushed rock share being 88 million tonnes. More than 90 per cent of the crushed rock in Canada is produced near urban centres in Ontario and Quebec. While the information on petrographic composition of crushed rocks in Canada is not available, production data for the USA indicate that 69 per cent of rocks produced are limestone and dolomite, 15 per cent are rocks of granitic composition and 10 per cent are basic rocks (gabbro, basalt and diabase).

Over the years crushed quarried aggregate and sand and gravel have become more price competitive. While the United States Bureau of Mines data for 1979 indicate the average selling price per short ton (f.o.b. quarry) for sand and gravel was US$0.96 and for crushed rock was US$1.40, the corresponding 1985 prices were $2.47 and $2.98. The 20 per cent price spread can be easily offset by transportation cost or by higher quality product.

CRUSHED QUARRIED AGGREGATE IN BRITISH COLUMBIA

In British Columbia very little aggregate production has came from quarried rocks. With the exception of three locations in the Vancouver area and the processing of the mine waste from Texada Island, the past record of crushed rock processed for use as aggregate is insignificant. The few rock quarries that are active throughout the province are almost exclusively producing railroad ballast. Quarried aggregate was produced in a few cases for special projects, where local sand and gravel did not meet the specifications needed for the required type of product, or for the highway construction projects where there was no local source of gravel (for example, the Terrace - Prince Rupert section of Highway 16).

While suitable construction aggregate rock types can be found within a reasonable distance of almost any potential construction project throughout the province, such rocks are uncommon in the Peace River region; unfortunately, deposits of sand and gravel there are also scarce. The Peace River area lacks major sand and gravel deposits and has very few competent rocks suitable for production of quarried and crushed construction aggregate. Paleozoic limestones are one of the options. About 80 kilometres south of Chetwynd, on the Sukunka forest road, a small quarry was opened in 1983 near the confluence of Sukunka River and Baker Creek. A very fine-grained limestone of the Lower Carboniferous Rundle Group has been used in recent years to produce asphalt aggregate and other stone products for the Chetwynd area. The Mesozoic formations of northeastern British Columbia in general lack good competent rocks. The exceptions are the Upper Triassic carbonate rocks (Whitehorse Formation) and the Lower Cretaceous Cadomin conglomerate. In case of insufficient supply of sand and gravel for construction projects in the northeastern Interior Plains of the province, these three geological units are potential sources of quarried crushed aggregate.

AGGREGATE PRODUCTION AND USE

PRODUCTION CENTRES AND DISTRIBUTION PATTERNS

The distribution of production centres depends in general on the availability of the resource and the local demand for residential and industrial uses. This study indicates that transportation of processed aggregate up to 80 kilometres (50 miles) from the pit is fairly common even though most of the product is sold within a radius of 24 kilometres (15 miles) (Figure 5). With the exception of barging from Kitimat to Prince Rupert and occasionally from Prince Rupert to the Queen Charlotte Islands, all sand and gravel within the study area is transported by truck.

In all, 229 commercial pits were reviewed during this survey and of these, 93 regularly produce sand and gravel. At the time of our survey, 78 per cent of commercial operations produced from privately owned land, selling 89.5 per cent of all aggregate produced. Only 18 per cent of pits, producing 8 per cent of commercial aggregate, were located on Crown land. The rest (4 per cent of pits and 2.5 per cent of production) came from Indian Reserves. The list of operators contacted during the survey is provided in Appendix 3.

Production statistics in British Columbia are compiled by Mining Divisions (Table 2) which do not correlate well with population distribution (Table 3); an additional set of data, including the size of operation, was compiled for eight specific areas with high population density (Table 4). The resulting figures indicate annual consumption between 5 and 10 tonnes per capita in areas with mature infrastructure but lacking major industrial activity. On the other hand, oil and gas exploration and coal developments in the Peace River area and the building of ocean terminals in Prince Rupert, are clearly reflected by significantly higher per capita production figures. Non-commercial production, almost entirely representing the needs of the Ministry of Transportation and Highways are compiled by Mining Divisions only.

Of the 36 municipalities contacted by our survey, only 15 operate their own pits, two obtain all their sand and gravel requirements from pits owned by the Ministry of Transportation and Highways, and the remainder buy sand and gravel from local commercial producers.

BRITISH COLUMBIA USE CHARACTERISTICS

The end uses for sand and gravel are shown in Tables 5 and 6. The data indicate that there is very little consistency in the use characteristics over the years. All categories fluctuate depending on the type and intensity of construction activity in a given area; large projects tend to dominate the market, nevertheless, there is a consistent upward trend in the total numbers.

MARKET AREAS

Distribution of production centres and market area served are shown in Figure 5. It is clear that the commercial production of sand and gravel is concentrated in populated areas. Outside of these there is very little competition. There is a pattern showing that small producers sell mostly unprocessed pit-run material in restricted local markets, while major operators have a more diversified line of aggregate products and a wider market area.

TABLE 2 PRODUCTION OF SAND AND GRAVEL IN BRITISH COLUMBIA, 1977-1981
(tonnes)

Mining Division	1981 Comm.	1981 Non-comm.	1981 Total	1980 Comm.	1980 Non-comm.	1980 Total	1979 Comm.	1979 Non-comm.	1979 Total
Vancouver Island									
Nanaimo	2 229 873	782 657	3 012 530	2 571 859	1 004 384	3 576 243	2 311 247	680 718	2 991 965
Alberni	70 844	409 215	480 059	606 608	405 512	1 012 120	616 235	261 294	897 529
Victoria	4 232 348	319 140	4 551 488	4 533 127	168 683	4 701 810	3 539 289	124 448	3 663 737
Subtotal	6 533 065	1 511 012	8 044 077	7 711 594	1 578 579	9 290 173	6 466 771	1 066 460	7 533 231
Lower Mainland									
New West.	10 691 936	1 290 184	11 982 120	8 359 097	932 998	9 292 095	9 284 796	1 554 120	10 838 916
Vancouver	3 963 669	303 908	4 267 577	3 790 632	245 718	4 036 350	3 487 654	707 252	4 194 906
Subtotal	14 655 605	1 594 092	16 249 697	12 149 729	1 178 716	13 328 445	12 772 450	2 261 372	15 033 822
Rest of B.C.									
Atlin	-	-	-	-	31 130	31 130	-	17 510	17 510
Cariboo	863 652	2 760 768	3 624 420	540 957	2 967 574	3 508 531	1 099 081	3 778 136	4 877 217
Clinton	52 936	710 594	763 530	32 830	1 433 230	1 466 060	35 816	1 778 496	1 814 312
Ft. Steele	384 131	506 285	890 416	1 014 157	678 493	1 692 650	347 953	657 360	1 005 313
Golden	-	417 421	417 421	88 872	276 126	364 998	155 747	278 620	434 367
Greenwood	22 859	278 953	301 812	14 101	379 809	393 910	19 886	383 156	403 042
Kamloops	289 568	872 507	1 162 075	355 685	1 218 597	1 574 282	326 925	1 257 216	1 584 141
Liard	452 237	3 094 459	3 546 696	969 125	1 397 013	2 366 138	1 313 710	1 464 891	2 778 601
Lillooet	-	401 185	401 185	-	33 464	33 464	-	34 888	34 888
Nelson	181 272	543 266	724 538	352 577	499 193	851 770	256 215	503 658	759 873
Nicola	40 710	328 779	369 489	11 051	188 993	200 044	43 800	197 132	240 932
Omineca	184 570	1 051 747	1 236 317	534 486	1 173 443	1 707 929	133 131	1 551 898	1 685 029
Osoyoos	179 186	150 577	329 763	255 506	109 283	364 789	309 387	115 608	424 995
Revelstoke	425 908	134 314	560 222	-	388 201	388 201	-	391 516	391 516
Similkameen	5 893	-	5 893	82 570	164 656	247 226	-	171 776	171 776
Skeena	1 167 173	416 419	1 583 592	3 469 220	1 565 299	5 095 881	1 106 576	878 396	1 984 972
Slocan	-	402 457	402 457	-	168 383	168 383	-	169 868	169 868
Vernon	864 843	555 836	1 420 679	1 173 711	694 630	1 868 341	853 845	722 650	1 576 495
Trail Creek	58 351	152 456	210 807	53 144	344 075	397 219	-	2 906 398	2 906 398
Not Assigned	-	116 844	116 844	-	-	-	66 601	347 084	413 685
Subtotal	5 173 289	12 894 867	18 068 156	8 947 992	13 711 592	22 659 584	6 068 673	17 606 257	23 674 930
B.C. Total	26 361 959	15 999 971	42 361 930	28 809 315	16 468 887	45 278 202	25 307 894	20 934 089	46 241 983

comm - commercial

Source: B.C. Ministry of Energy, Mines and Petroleum Resources, Mineral Policy and Evaluation Branch.

Table 2

1978			1977		
Comm.	Non-comm.	Total	Comm.	Non-comm.	Total
1 478 686	268 227	1 746 913	1 828 657	741 366	2 570 023
436 888	131 214	568 102	390 610	205 210	595 820
3 803 251	141 555	3 944 806	3 778 186	400 512	4 178 698
5 718 825	540 996	6 259 821	5 997 453	1 347 088	7 344 541
6 826 099	1 108 202	7 934 301	6 512 476	1 387 740	7 900 216
3 527 554	221 514	3 749 068	3 393 181	423 900	3 817 081
10 353 653	1 329 716	11 683 369	9 905 657	1 811 640	11 717 297
-	13 553	13 553	-	40 426	40 426
745 255	405 815	1 151 070	731 869	7 037 655	7 769 524
47 498	240 036	287 534	33 548	2 278 589	2 312 137
324 704	234 113	558 817	421 547	1 321 831	1 743 378
1 379	74 955	76 334	-	427 650	427 650
18 733	135 774	154 507	13 475	726 346	739 821
707 123	584 431	1 291 554	425 976	1 625 836	2 051 812
1 207 265	886 457	2 093 722	414 878	1 783 857	2 198 735
-	5 913	5 913	-	21 355	21 355
216 477	283 802	500 279	169 382	597 559	766 941
76 246	65 077	141 253	58 054	522 436	580 490
170 128	495 674	665 802	76 771	1 978 750	2 055 521
218 757	166 222	384 979	182 789	1 019 178	1 201 967
34 000	118 216	152 216	63 465	365 975	429 440
13 876	229 562	243 438	30 567	1 448 308	1 478 875
702 181	298 259	1 000 440	997 816	1 600 978	2 598 794
-	72 484	72 484	68 544	261 001	329 545
564 051	416 600	980 651	683 317	2 097 610	2 780 927
-	10 091 311	10 091 311	25 805	346 329	372 134
434 848	109 361	544 209	-	4 983 218	4 983 218
5 482 521	14 927 545	20 410 066	4 397 803	30 484 887	34 882 690
21 554 999	16 798 257	38 353 256	20 300 913	33 643 615	53 944 528

TABLE 3

BRITISH COLUMBIA POPULATION BY SUBPROVINCIAL REGIONS AND METROPOLITAN AREAS[1]

	Population 1971	1976	1981	Per Cent Distribution 1981	Per Cent Change 1976-81
Subprovincial Regions					
East Kootenay	39 720	46 450	53 723	2.0	15.7
Central Kootenay	75 432	84 531	92 176	3.4	9.0
Okanagan-Boundary	158 364	201 340	230 006	8.4	14.2
Lillooet-Thompson	88 833	107 895	120 911	4.4	12.1
Lower Mainland	1 200 803	1 309 187	1 438 648	52.4	9.9
Vancouver Island and Coast	382 397	441 407	495 125	18.0	12.2
Cariboo-Ft. George	130 866	163 849	186 992	6.8	14.1
Peace River-Liard	43 996	44 482	55 463	2.0	23.7
Skeena-Stikine	65 310	67 109	71 423	2.6	6.4
Metropolitan Areas					
Vancouver	1 082 352	1 166 348	1 268 183	46.2	8.7
Victoria	195 800	218 250	233 481	8.5	7.0
British Columbia	2 184 261	2 466 608	2 744 467	100.0	11.3

[1]Census data.

Source: Statistics Canada.

TABLE 4
SAND AND GRAVEL INDUSTRY CHARACTERISTICS, 1980

Area	Kamloops			Vernon-Armstrong-Salmon Arm			Kelowna			Penticton-Osoyoos		
Population*	68 690			29 789			85 230			52 450		
Annual Capacity Range (Tonnes)	No. of Producers	Tonnes Produced	%	No. of Producers	Tonnes Produced	%	No. of Producers	Tonnes Produced	%	No. of Producers	Tonnes Produced	%
0 < PC < 50 000	2		3	7		59	3		5.3	3		5
50 000 < PC < 100 000	4		73	1		41	3		15.1	-		-
100 000 < PC < 150 000	1		24	-		-	-		-	1		26
150 000 < PC < 200 000	-		-	-		-	1		11.3	1		33
PC > 200 000	-		-	-		-	3		68.3	1		36
Total	7	419 411	100	8	189 469	100	10	1 520 801	100	6	565 315	100

Area	Rossland-Trail-Castlegar-Nelson			Prince George			Peace River			Prince Rupert-Kitimat-Terrace		
Population*	41 905			67 560			39 350			39 930		
Annual Capacity Range (Tonnes)	No. of Producers	Tonnes Produced	%	No. of Producers	Tonnes Produced	%	No. of Producers	Tonnes Produced	%	No. of Producers	Tonnes Produced	%
0 < PC < 50 000	2		17	1		8	2		4	3		2.5
50 000 < PC < 100 000	2		46	1		13	4		29	-		-
100 000 < PC < 150 000	1		37	4		79	-		-	1		3.3
150 000 < PC < 200 000	-		-	-		-	-		-	-		-
PC > 200 000	-		-	-		-	2		67	4		94.2
Total	5	286 558	100	6	556 111	100	8	971 058	100	8	3 748 574	100

*1981 census (by school districts).

TABLE 5

VALUE, QUANTITY AND USE OF ALL AGGREGATE PRODUCED IN BRITISH COLUMBIA, 1979-1981

	1981		1980		1979	
	Quantity 000's tonnes	Value 000's $	Quantity 000's tonnes	Value 000's $	Quantity 000's tonnes	Value 000's $
Road construction and maintenance	23 536	40 254	29 097	53 742	31 098	41 174
Ice control	1 061	3 902	1 193	3 272	2 202	8 207
Concrete aggregate	4 729	16 566	3 667	10 341	2 238	6 621
Asphalt aggregate	4 185	9 053	3 644	7 518	5 778	13 659
Railroad ballast	319	623	141	362	1 377	1 482
Mortar sand	240	56	146	370	60	252
Backfill for mines	146	533	580	644	187	194
All other fill	7 804	14 952	6 439	9 850	2 445	4 409
Other special uses	341	665	371	898	857	989
Total	42 361	87 604	45 278	79 479	46 242	76 987

Source: B.C. Ministry of Energy, Mines and Petroleum Resources, Mineral Policy and Evaluation Branch.

TABLE 6

VALUE, QUANTITY AND USE OF THE COMMERCIAL AGGREGATE PRODUCTION IN BRITISH COLUMBIA, 1977-1980

	1980		1979		1978		1977	
	Quantity 000's tonnes	Value 000's $	Quantity 000's tonnes	Value 000's $	Quantity 000's tonnes	Value 000's $	Quantity 000's tonnes	Value 000's
Road construction and maintenance	8 851	16 346	18 370	24 331	18 933		30 568	
Ice control	230	631	1 025	3 820	1 097		139	
Concrete aggregate	3 667	10 341	2 238	6 621	3 798		3 553	
Asphalt aggregate	1 854	3 824	2 232	5 276	5 182		4 186	
Railroad ballast	141	362	1 377	1 482	1 019		1 298	
Mortar sand	146	370	60	252	56		80	
Backfill for mines	580	644	187	194	194		183	
All other fill	6 439	9 850	2 445	4 409	3 343		3 665	
Other special uses	371	898	857	989	723		814	
Total	22 279	43 265	28 791	47 374	34 345	63 989	44 486	54 154

Source: Energy, Mines and Resources Canada, Mineral Policy Sector, Information Systems Division

FACTORS INFLUENCING SUPPLY

There has been very little development in the sand and gravel industry since our first study of the British Columbia Lower Mainland, published in 1981. The number of agencies involved in regulating the industry remains the same as reported in our previous study. When the Ministry of Energy, Mines and Petroleum Resources tried to address the jurisdictional problem in 1982, this initiative was abandoned after a few meetings with representatives of other government ministries and the British Columbia Land Commission, due to lack of consensus on terms of reference. The provincial aggregate industry still does not have an association which would represent the producers and present the industry's concerns to government at all levels. Such an association would also be helpful in disseminating information and expertise among its members and, through self-policing and education, would improve the industry's image in the eyes of the general public.

In his analysis of the urban problem of the sand and gravel industry Galbraith (1984) correctly points out that the costs and benefits of the aggregate market accrue largely to local areas. In the Lower Mainland, our 1978-79 study identified that the market can bear the cost of truck transportation up to approximately 32 kilometres; this study indicates that the majority of aggregate is sold with 24 kilometres of the pit and is rarely shipped more than 50 kilometres from the production centre (80 kilometres is the maximum). Therefore, it is in the interest of local population and should be the ultimate responsibility of the local government to ensure that maximum benefits are obtained by the optimal usage of local sand and gravel resources. Section (2)(a) of the Municipal Act gives Regional Districts authority to undertake analysis of aggregate resources as part of Official Settlement Plans. For municipal governments the applicable sections of the same act are 710, 711 and 716(2)(d), (e) and (f). At this point it should be mentioned that, during our survey, we found that most local governments are aware of the importance of the issue of availability of construction aggregate although parochial interests sometimes impede development. There has been a recent case in the Lower Mainland, where the municipality denied permission to open a new gravel pit using the justification that the product would be shipped to another jurisdiction. This decision was made without considering the impact it would have on the cost of aggregate to their neighbours.

REGIONAL DISTRICTS

This study examines parts of 15 Regional Districts. During the course of our survey, 13 were contacted to provide information about the way in which the aggregate issue is addressed in their jurisdiction (Appendix 1). Nine provided answers to a seven-point questionnaire, either in an interview or in writing. Summing up our findings, only two districts expressed concerns about aggregate supply and just one was willing to address the issue by taking some realistic measures to protect the resource. A brief summary of responses is outlined below.

Supply Concerns and Problems

Seven districts expressed no concerns and experienced no problems. Two districts had a supply problem, however, only one is willing to set aside potential aggregate areas.

Complaints Concerning Aggregate Production Areas

Two districts reported no complaints of any kind, two reported trivial noise and dust problems, two presented concerns about difficulty obtaining release of land from the Agricultural Land Reserves, one complained about visual impact (gravel pits creating eyesores), one stated that too many aggregate areas are held by the Ministry of Transportation and Highways and two districts did not respond.

Aggregate Resource Inventory Data

Only two respondents indicated that there is some limited information on the distribution of sand and gravel within the area under their jurisdiction, but the majority of people we contacted expressed interest in having such information made available.

Present Aggregate Consumption Figures and Demand Forecast

No Regional District administration had this type of information.

The Existence of Rezoning Plans Which Will Affect Existing Aggregate Producers in the Area

All replies were negative.

MUNICIPALITIES

A survey was taken to identify the local governments that regulate gravel extraction within their jurisdictions. Of the 41 municipalities contacted (Appendix 2), only six had soil removal by-laws and four others had policies to regulate operations of gravel pits. In addition, six municipalities (Castlegar, Kamloops, Prince George, Spallumcheen, Terrace, Trail) have specific reclamation requirements applicable to sand and gravel pits.

QUARRY MATERIALS POLICY

This policy issued by the Ministry of Lands, Parks and Housing, with an effective date of April 1, 1983, applies to sand and gravel production (including quarried aggregate) from Crown land. It outlines a variety of Land Act tenures, methods of disposition, land rental and royalty pricing and special requirements to open and operate a gravel pit or rock quarry on Crown land.

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER WORK

The purpose of this study is to follow-up our Sand and Gravel Study 1980 - British Columbia Lower Mainland (Hora and Basham, 1980), to provide a basic qualitative inventory of the aggregate resource in British Columbia, and to analyse the supply-demand situation throughout the province. This has been accomplished. The next logical step would be site-specific studies, at a more detailed scale, for growing areas of high population density facing potential shortages. These areas are Kamloops, Prince George and the Okanagan valley. A similar study should be done for the Peace River region where sand and gravel deposits are scarce.

A second parallel study should be directed toward identification of major sources of aggregate outside the present transportation corridors but within hauling distance of major markets. The information provided by the two projects would allow local governments to properly plan development and establish zoning which would minimize unnecessary clashes between the public and industry, protect reserves and optimize utilization of the resource. However to realize these objectives would require that the provincial government, in concert with local governments, undertake a major initiative to overhaul existing policies, procedures and, to a limited extent, legislation.

BIBLIOGRAPHY

Alley, N.F. (1979): Middle Wisconsin Stratigraphy and Climatic Reconstruction, Southern Vancouver Island, British Columbia, Quaternary Research, Volume 11, pages 213-237.

Armstrong, J.E. (1966): Glacial Studies, Kitimat-Terrace Area, in Report of Activities, Geological Survey of Canada, Paper 66-1, page 50.

_____ (1981): Post-Vashon Wisconsin Glaciation, Fraser Lowland, British Columbia, Geological Survey of Canada, Bulletin 322.

Armstrong, J.E. and Leaming, S.F. (1968): Surficial Geology, Prince George Map-area, British Columbia, Geological Survey of Canada, Part A, pages 151-152.

Armstrong, J.E. and Leaming, S.F. (1969): Surficial Geology, Prince George Map-area, British Columbia, Geological Survey of Canada, Map 3-1969.

Armstrong, J.E. and Tipper, H.W. (1948): Glaciation in North-central British Columbia, American Journal of Science, Volume 246, pages 283-310.

British Columbia Ministry of Environment, Terrain - Manuscript Maps, 1:50 000 (for index see Figure 2).

British Columbia Ministry of Environment, Soils and Landforms - Manuscript Maps, 1:50 000 (for index see Figure 2).

British Columbia Ministry of Environment, Terrain Classification System, 56 pages.

British Columbia Ministry of Industry and Small Business Development, British Columbia Facts and Statistics, 1983, 90 pages.

Clague, J.J. (1973): Late Cenozoic Geology of the Southern Rocky Mountain Trench, British Columbia, Unpublished Ph.D. Thesis, The University of British Columbia, 274 pages.

_____ (1974): The St. Eugene Formation and the Development of the Southern Rocky Mountain Trench, Canadian Journal of Earth Sciences, Volume 11, pages 916-938.

_____ (1975): Late Quaternary Sediments and Geomorphic History of the Southern Rocky Mountain Trench, British Columbia, Canadian Journal of Earth Sciences, Volume 12, Number 4, pages 595-605.

_____ (1981): Late Quaternary Geology and Geochronology of British Columbia, Geological Survey of Canada, Paper 80-35, 41 pages.

_____ (1984): Quaternary Geology and Geomorphology, Smithers-Terrace-Prince Rupert Area, British Columbia, Geological Survey of Canada, Memoir 413, 71 pages.

_____ (1986): The Quaternary Stratigraphic Record of British Columbia - Evidence for Episodic Sedimentation and Erosion Controlled by Glaciation, Canadian Journal of Earth Sciences, Volume 23, pages 885-894.

Clague, J.J., Armstrong, J.E. and Mathews, W.H. (1980): Advance of the Late Wisconsin Cordilleran Ice Sheet in Southern British Columbia Since 22 000 Yr. B.P., Quaternary Research, Volume 13, pages 322-326.

Clague, J.J. and Hicock, S.R. (1976): Sand and Gravel Resources of Kitimat, Terrace and Prince Rupert, British Columbia, Geological Survey of Canada, Paper 76-1A, pages 273-276.

Clague, J.J. and Luternauer, J.L. (1983): Late Quaternary Geology of Southwestern British Columbia, Geological Association of Canada, Field Trip Guidebook Trip 6, 112 pages.

Epp, P.F. and Fenger, M.A. (1978): Soil and Agricultural Capability Inventory of the Telegraph Creek Area, B.C. Ministry of Environment, 21 pages.

Fulton, R.J., (1962): Merritt, British Columbia, Geological Survey of Canada, Map 8-1962.

_____ (1963): Kamloops Lake, British Columbia, Geological Survey of Canada, Map 9-1963.

Fulton, R. J. (1967): Deglaciation Studies in Kamloops Region, an Area of Moderate Relief, British Columbia, Geological Survey of Canada, Bulletin 154, 36 pages.
_____ (1969): Glacial Lake History, Southern Interior Plateau, British Columbia, Geological Survey of Canada, Paper 69-37, 14 pages.
_____ (1971): Radiocarbon Geochemology of Southern British Columbia, Geological Survey of Canada, Paper 71-37, 28 pages.
_____ (1975): Quaternary Geology and Geomorphology, Nicola-Vernon Area, British Columbia, Geological Survey of Canada, Memoir 380, 50 pages.
_____ (1982): Quaternary Surficial Geology of the Canadian Cordillera, Geological Survey of Canada, Open File 837.
_____ (1984): Quaternary Glaciation, Canadian Cordillera, in Quaternary Stratigraphy of Canada - A Canadian Contribution to IGCP Project 24, R.J. Fulton, Editor, Geological Survey of Canada, Paper 84-10, pages 39-48.
Fulton, R.J., Achard, R.A. and Alley, N.F. (1984): Surficial Geology of N.T.S. Map Area 82M, Seymour Arm, Geological Survey of Canada, Open File 1002.
Fulton, R.J. and Smith, G.W. (1978): Late Pleistocene Stratigraphy of South-central British Columbia, Canadian Journal of Earth Sciences, Volume 15, pages 971-980.
Galbraith, D.M. (1984): The Urban Problem of the Sand and Gravel Industry in British Columbia, Unpublished MPA Thesis, University of Victoria, 64 pages.
Green, A.J. and Lord, T.M. (1975): Soils of the Princeton Area, British Columbia, Canada Agriculture, Research Branch, Soil Survey Report Number 14.
Holland, S.S. (1976): Landforms of British Columbia: A Physiographic Outline, B.C. Ministry of Energy, Mines and Petroleum Resources, Bulletin 48, 138 pages.
Hora, Z.D. and Basham, F.C. (1980): Sand and Gravel Study - British Columbia Lower Mainland, B.C. Ministry of Energy, Mines and Petroleum Resources, Paper 1980-10, 74 pages.
Howes, D.E. (1977): Terrain Inventory and Late Pleistocene History of the Southern Part of the Nechako Plateau, B.C. Ministry of Environment, Resource Analysis Branch, Bulletin 1, 27 pages.
_____ (1981): Late Quaternary Sediments and Geomorphic History of North-central Vancouver Island, Canadian Journal of Earth Sciences, Volume 18, pages 1-12.
Leaming, S.F. (1968): Sand and Gravel in the Strait of Georgia Area, Geological Survey of Canada, Paper 66-60, 149 pages.
Lefond, S.J. (1983): Industrial Minerals and Rocks, American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., S.J. Lefond, Editor, New York, 1446 pages.
Lord, T.M. and Green, A.J. (1974): Soils of the Tulameen Area of British Columbia, Canada Agriculture, Research Branch, British Columbia Soil Survey Report Number 13, 163 pages.
Manning, E.W. and Eddy, S.S. (1978): The Agriculture Land Reserves of British Columbia: An Impact Analysis, Environment Canada, Ottawa, 165 pages.
Mathews, W.H. (1955): Groundwater Possibilities of the Peace River Block, British Columbia, B.C. Ministry of Energy, Mines and Petroleum Resources, Groundwater Paper Number 3, 7 pages.
_____ (1963): Quaternary Stratigraphy and Geomorphology of the Fort St. John Area of Northeastern British Columbia, B.C. Ministry of Energy, Mines and Petroleum Resources, Miscellaneous Publications, 22 pages.
_____ (1978): Quaternary Stratigraphy and Geomorphology of Charlie Lake (94A) Map-area, British Columbia, Geological Survey of Canada, Paper 76-20, page 25.
_____ (1980): Retreat of the Last Ice Sheets in Northeastern British Columbia and Adjacent Alberta, Geological Survey of Canada, Bulletin 331, 22 pages.

Mathews, W.H. and Rouse, G.E. (1986): An Early Pleistocene Preglacial Succession in South-central British Columbia, Canadian Journal of Earth Sciences, Volume 23, pages 1796-1803.

McCammon, J.W. (1977): Surficial Geology and Sand and Gravel Deposits of Sunshine Coast, Powell River and Campbell River Areas, B.C. Ministry of Energy, Mines and Petroleum Resources, Bulletin 65, 36 pages.

Muller, J.E. and Tipper, H.W. (1962): McLeod Lake, British Columbia, Geological Survey of Canada, Map 2-1962.

Nasmith, H. (1953): Ground-water Supply for Farm Use in the Quesnel-Prince George and Vanderhoof Agricultural Areas, B.C. Ministry of Energy, Mines and Petroleum Resources, Ground-water Paper Number 1, 10 pages.

_____ (1962): Late Glacial History and Surficial Deposits of the Okanagan Valley, British Columbia, B.C. Ministry of Energy, Mines and Petroleum Resources, Bulletin 46, 46 pages.

Rampton, V.N. and Paradis, S. (1982): Surficial Geology and Geomorphology of the Kusawak Ranges, British Columbia, Geological Survey of Canada, Map 13-1981.

Reimchen, T.H.F. (1980): Surficial Geology: Dawson Creek, British Columbia, Geological Survey of Canada, Map 1467A.

Rutter, N.W. (1984): Pleistocene History of the Western Canadian Ice-free Corridor, in Quaternary Stratigraphy of Canada, A Canadian Contribution to IGCP Project 24, R.J. Fulton, Editor, Geological Survey of Canada, Paper 84-10, pages 49-56.

Ryder, J.M. (1976): Terrain Inventory and Quaternary Geology, Ashcroft, British Columbia, Geological Survey of Canada, Paper 74-49, 17 pages.

_____ (1981a): Biophysical Resources of the East Kootenay Area Terrain, B.C. Ministry of Environment, Assessment and Planning Division, Bulletin 7, 153 pages.

_____ (1981b): Terrain Inventory and Quaternary Geology, Lytton, British Columbia, Geological Survey of Canada, Paper 79-25, 20 pages.

Ryder, J.M. and Church, M. (1986): The Lillooet Terraces of Fraser River; a Paleo-environmental Enquiry, Canadian Journal of Earth Sciences, Volume 23, pages 869-894.

Ryder, J.M. and Howes, D.E. (1984): A User's Guide to Terrain Maps in British Columbia, B.C. Ministry of Environment, 16 pages.

Singleton, R.H. (1980): Stone, in Mineral Facts and Problems, United States Bureau of Mines, pages 853-860.

Stonehouse, D.H. (1982): Mineral Aggregates, in Canadian Minerals Yearbook, 1981, Energy, Mines and Resources, Ottawa, pages 26.1-26.7.

Tepordei, V.V. (1980): Sand and Gravel, in Mineral Facts and Problems, United States Bureau of Mines, pages 781-791.

Tipper, H.W. (1971): Glacial Geomorphology and Pleistocene History of Central British Columbia, Geological Survey of Canada, Bulletin 196, 89 pages.

Valentine, K.W.G., Sprout, P.N., Baker, T.E. and Lavkulitch, L.M. (1981): The Soil Landscapes of British Columbia, B.C. Ministry of Environment, 197 pages.

APPENDIX 1
REGIONAL DISTRICTS CONTACTED DURING THE SURVEY

Okanagan-Similkameen
Central Okanagan
North Okanagan
Kootenay-Boundary
Central Kootenay
East Kootenay
Columbia-Shuswap
Thompson-Nicola
Cariboo
Fraser-Fort George
Peace River-Liard
Bulkley-Nechako
Kitimat-Stikine

APPENDIX 2
MUNICIPALITIES CONTACTED DURING THE SURVEY

Princeton	Fraser Lake	Golden
Penticton	Burns Lake	Invermere
Kelowna	Terrace	Cranbrook
Vernon	Kitimat	Kimberley
Spallumcheen	Prince Rupert	Creston
Salmon Arm	Houston	Fernie
Kamloops	Hudson Hope	Sparwood
Merritt	Chetwynd	Elkford
100 Mile House	Dawson Creek	Squamish
Williams Lake	Fort St. John	Armstrong
Smithers	Trail	Westbank
Quesnel	Castlegar	Osoyoos
Prince George	Nelson	Keremeos
Vanderhoof	Revelstoke	

APPENDIX 3
OPERATORS CONTACTED DURING THE SURVEY

KAMLOOPS (AND SURROUNDING AREA)

BA Blacktop, BA Concrete - Kamloops
Casadio & Son Holding Co. Ltd. - Cache Creek
Dawson Construction Ltd. - Kamloops
Louis Creek Contracting Ltd. - Heffley Creek
Magna Bay Sand & Gravel - Celista
Metro Sand & Gravel Ltd. - Kamloops
Nicola Valley Sand, Gravel & Ready Mix Ltd. - Merritt
Norgaard Ready-Mix Ltd. - Merritt
North Thompson Ready Mix Ltd. - Clearwater
OK Builders Supplies Ltd. - Kamloops
A. Reimer Construction Ltd. - Blind Bay
Shuswap Sand & Gravel - Chase
Westsyde Road Materials - Kamloops
Yellowhead Concrete Ltd. - Kamloops

LILLOOET/LYTTON

Alpine Contracting - Lillooet

VERNON (INCLUDING ARMSTRONG, LUMBY, OYAMA)

Chaput Sand & Gravel - Lumby
Fulbrook Contracting - Vernon
Leduc Paving Ltd. - Vernon
North Valley Gravel - Armstrong
Oyama Aggregates - Oyama
Sasges Cement Products Ltd. - Vernon
Vernon Paving Ltd. - Vernon

KELOWNA (INCLUDING PEACHLAND, WESTBANK, WINFIELD)

Barry's Trucking - Westbank
Chet's Holdings - Kelowna
Ellison Gravel Products - Kelowna
Hilltop Sand & Gravel Co. Ltd. - Kelowna
Kelowna Ready-Mix Inc. - Kelowna
Mid Valley Construction Ltd. - Kelowna
OK Builders Supplies Ltd. - Kelowna
Peachland Transfer - Peachland
Peters Bros. Industries Ltd. - Kelowna
Westbank Ready-Mix Concrete Ltd. - Winfield
Westlake Paving & Aggregates Ltd. - Kelowna

PENTICTON (INCLUDING SUMMERLAND)

Cantex Engineering & Construction Co. Ltd. - Penticton
Dave Miller Trucking (1977) Ltd. - Summerland
Peters Bros. Industries Ltd. - Penticton
L.R. Wyles Trucking Ltd. - Penticton
OK Builder's Supplies Ltd. - Penticton

KEREMEOS/PRINCETON/OLIVER/OSOYOOS (INCLUDING HEDLEY, MANNING PARK)

Erv's Trucking & Excavating - Osoyoos
Oliver Ready-Mix Ltd. - Oliver
Osoyoos Ready-Mix Ltd. - Osoyoos
Tri-Valley Construction Ltd. - Princeton
V Line Construction Ltd. - Oliver

GRAND FORKS (INCLUDING BEAVERDELL, CHRISTINA LAKE, GREENWOOD, MIDWAY, ROCK CREEK)

Buster's Excavating - Greenwood
Grand Forks Ready-Mix Concrete Co. Ltd. - Grand Forks

SALMON ARM/REVELSTOKE

A.D. Gooth (South Broadview Gravel Pit) - Salmon Arm
Baird Bros. Ltd. - Enderby
Deep Creek Gravel Ltd. - Salmon Arm
Eagle Valley Cement & Gravel Co. Ltd. - Sicamous
Enderby Gravel Products Ltd. - Enderby
H & J Ready-Mix Ltd. - Revelstoke
Blackburn Excavating Ltd. - Salmon Arm
Jake & Jay Holdings Ltd. - Revelstoke
Mara Sand & Gravel Ltd. - Sicamous
Revelstoke Concrete Products Ltd. - Revelstoke
Sasges Cement Products Ltd. - Salmon Arm
Salmon Arm Gravel Products - Salmon Arm
Salmon Arm Ready-Mix Ltd. - Salmon Arm
Sicamous Ready-Mix Ltd. - Sicamous
Zappone Bros. Contracting - Salmon Arm

NELSON (INCLUDING BALFOUR, DUNCAN LAKE, FAUQUIER, KASLO, NAKUSP, NEW DENVER, SALMO, SLOCAN, SOUTH SLOCAN, VALLICAN)

Inland Ready-Mix - Nakusp
Nelson Ready-Mix Concrete Ltd. - Nelson
North Shore Contracting - Nelson
Silicon Contracting - Salmo
Sutherland Excavating & Gravels Ltd. - Nelson
WAJO Enterprises Ltd. - Fauquier
Larry Soukeroff - Nelson
David Weinrauch - Nelson
Woodcrest Holdings Ltd. - Nelson

CRESTON (INCLUDING BOSWELL, CRAWFORD BAY, RIONDEL)

Creston Sand & Gravel Ltd. - Creston
Hedlund Contracting Ltd. - Creston
Louis Salvador & Son Ltd. - Creston
Peter Androshak - Erickson
H.T. Enterprises - Ashley Draper Sand & Gravel - Crawford Bay
H.B. Toews - Creston

TRAIL/CASTLEGAR (INCLUDING FRUITVALE, ROSSLAND, THRUMS)

Blackline Asphalt Services Ltd. - Trail
Kinnaird Transfer Ltd. - Castlegar
Korpack Cement Products Co. Ltd. - Trail
Kootenay Concrete Ltd. - Castlegar
Kryski Bros. Contracting - Trail
G. Markin & Son Transport - Castlegar
Mayer Contracting - Rossland
McElree Excavating - Fruitvale
McGauley Ready Mix Concrete Co. Ltd. - Trail

Trans-X Transport Ltd. - Castlegar
H. Williamson Blacktop Ltd. - Trail

CRANBROOK/KIMBERLEY/FERNIE/SPARWOOD (INCLUDING CANAL FLATS, ELKFORD, ELKO, GRASMERE, JAFFRAY, MOYIE, SKOOKUMCHUK, YAHK)

ABBA Paving & Construction - Cranbrook
Wayne Aseltine Trucking - Kimberley
Cranbrook Sand & Gravel (1977) Ltd. - Cranbrook
East Kootenay Concrete Ltd. - Fernie
McGauley Ready-Mix Concrete Co. Ltd. - Sparwood, Elkford
OK Builders Supplies Ltd. - Cranbrook
Louis Salvador & Son Ltd. - Kimberley, Cranbrook
Salanski Contracting Ltd. - Cranbrook

GOLDEN/INVERMERE (INCLUDING DONALD, FAIRMONT HOT SPRINGS, FIELD, PARSON, RADIUM, SPILLIMACHEEN)

E.N. Elkington Ltd. - Golden
Max Helmer Construction Ltd. - Radium Hot Springs
Jopp & Sons Redi-Mix Ltd. - Invermere
C.E. Kucera Co. Inc. - Golden
Bert Miller Trucking & Contracting - Golden
Panorama Concrete Ltd. - Invermere
Sholinder & MacKay Sand & Gravel Ltd. - Windermere
Lake Windermere Sand & Gravel - Radium Hot Springs

PRINCE GEORGE (AND SURROUNDING AREA)

Bear Sand & Gravel - Prince George
Columbia Bitulithic Ltd. - Prince George
Larry Floer - Vanderhoof
Fraser Lake Excavating Ltd. - Fraser Lake
Kode Sand & Gravel - Prince George
Little River Enterprises - Fort St. James
MacKenzie Redi-Mix Co. Ltd., A.F.I. Development Ltd. - MacKenzie
Nechako Ready-Mix (1977) Ltd. - Vanderhoof
Northwest Paving Co. Ltd. - Prince George
Ocean Construction Supplies Northern Ltd. - Prince George
Omineca Redi-Mix Ltd. - Fort St. James
Prince George Gravel Co. Ltd. - Prince George
Pro Paving - Fraser Lake
River Junction Aggregate Products, Inc. - Prince George
Rolling Mix Concrete (B.C.) Ltd. - Prince George
Wansa Enterprises Ltd. - Giscome

QUESNEL (AND SURROUNDING AREA)

Everedi Concrete Products Ltd. - Quesnel
Joe Kopetski Ltd. - Quesnel
McKinley Gravel Sales - Quesnel
Purmal Excavating Ltd. - Quesnel
Quesnel Redi-Mix Cement Co. Ltd. - Quesnel

WILLIAMS LAKE/100 MILE HOUSE/CLINTON

Clark Excavating Ltd. - Williams Lake
Glendale Redi-Mix Ltd. - Williams Lake
Hamel Excavating Ltd. - Williams Lake
Katchmar Construction Ltd. - 93 Mile House
Lake Redi-Mix Ltd. (Lake Excavating Ltd.) - Williams Lake
Lake Sewer and Water Ltd. - Williams Lake
Northland Redi-Mix Ltd. - 100 Mile House
100 Mile Concrete & Gravel Co. Ltd. - 105 Mile
S.S. Contracting - Lac La Hache

BURNS LAKE/HAZELTON/HOUSTON/SMITHERS (INCLUDING GRANISLE, TOPLEY, GRASSY PLAINS, KITWANGA, TELKWA)

Bulkley Concrete Ltd. - Houston, Smithers
Flintstone Redi-Mix - Burns Lake
George's Transfer - Smithers
Hamblin Logging & Construction Ltd. - Houston
Lychak Bros. Trucking Ltd. - Smithers
Szydlik Transport Ltd. - Houston
Tatlow Trucking Ltd. - Smithers
Vernon Bros. Developments Ltd. - Houston

FORT ST. JOHN/DAWSON CREEK/CHETWYND/HUDSON'S HOPE (INCLUDING CHARLIE LAKE, POUCE COUPE, TAYLOR)

Chetwynd Redi-Mix - Chetwynd
Fort St. John Sand & Gravel (1977) Ltd. - Fort St. John
Glenn Fox Sand & Gravel - Fort St. John
Aero Asphalt Paving Ltd. - Dawson Creek
Lorean Enterprises Inc. - Fort St. John
Reg. Norman Trucking Ltd. - Dawson Creek
Nels Ostero Ltd. - Taylor
Quinns Sand & Gravel - Farmington
Rocam Construction Ltd. - Chetwynd
Swede Construction Ltd. - Chetwynd
Tremblay Sand & Gravel (1980) Ltd. - Dawson Creek
M. Weipert Holdings Ltd. - Pouce Coupe

KITIMAT/TERRACE (INCLUDING KEMANO, STEWART)

Far-Ko Contracting Ltd. - Terrace
Vic Froese Trucking Ltd. - Terrace
F.J.H. Construction Ltd. - Terrace
Hammerquist & Son - Kitimat
Ocean Construction Supplies Northern Ltd. - Kitimat
L.G. Scott & Sons Construction Ltd. - Kitimat
16-25 Transport Ltd. - Terrace

PRINCE RUPERT

Riv-Tow Straits Ltd. - Prince Rupert
Rupert Cement Products - Prince Rupert
L.G. Scott & Sons Construction Ltd. - Prince Rupert

SQUAMISH (AND SURROUNDING AREA)

Alpha Lake Aggregates Ltd. - Whistler
Coast Aggregates Ltd. - Brackendale
Sabre Companies Ltd. - Whistler

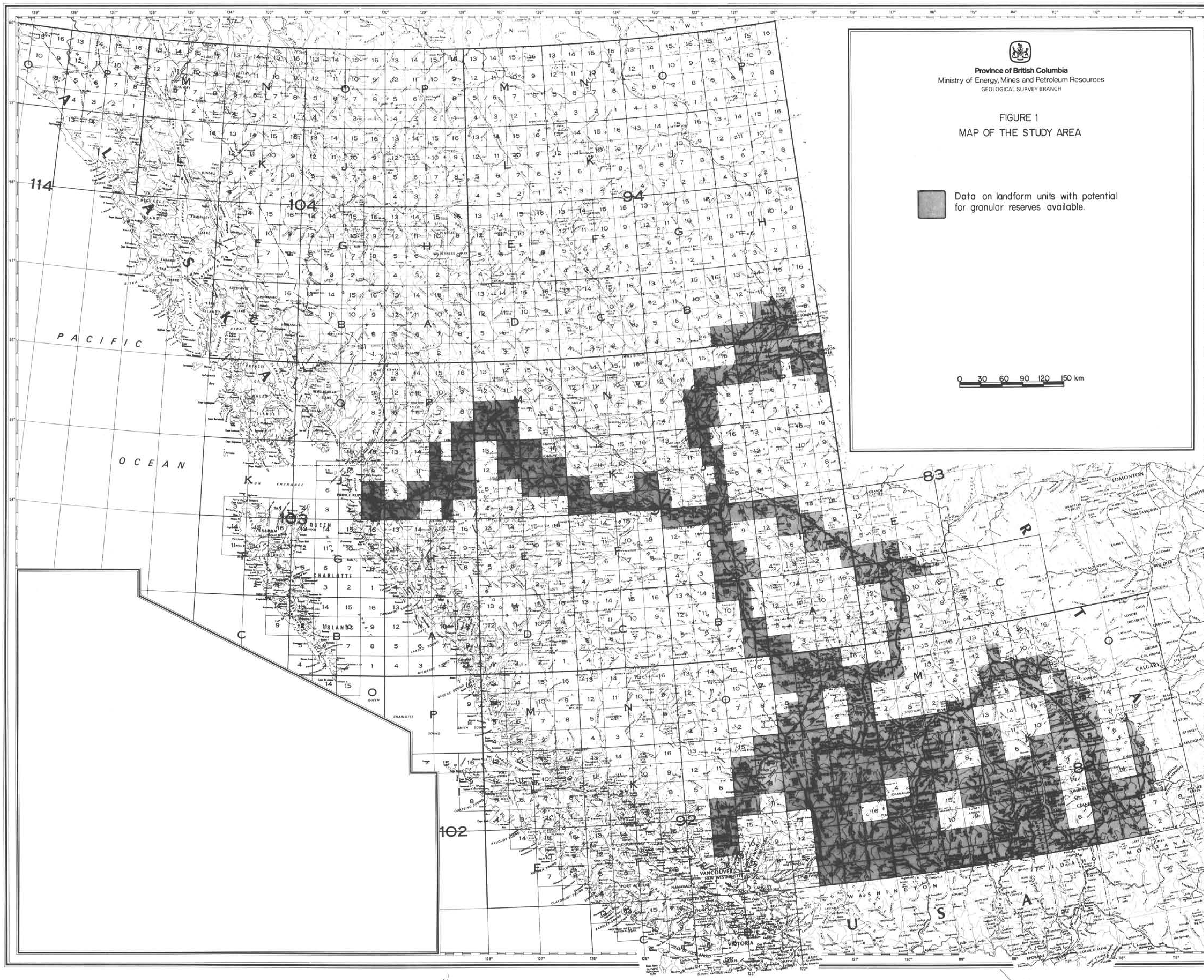
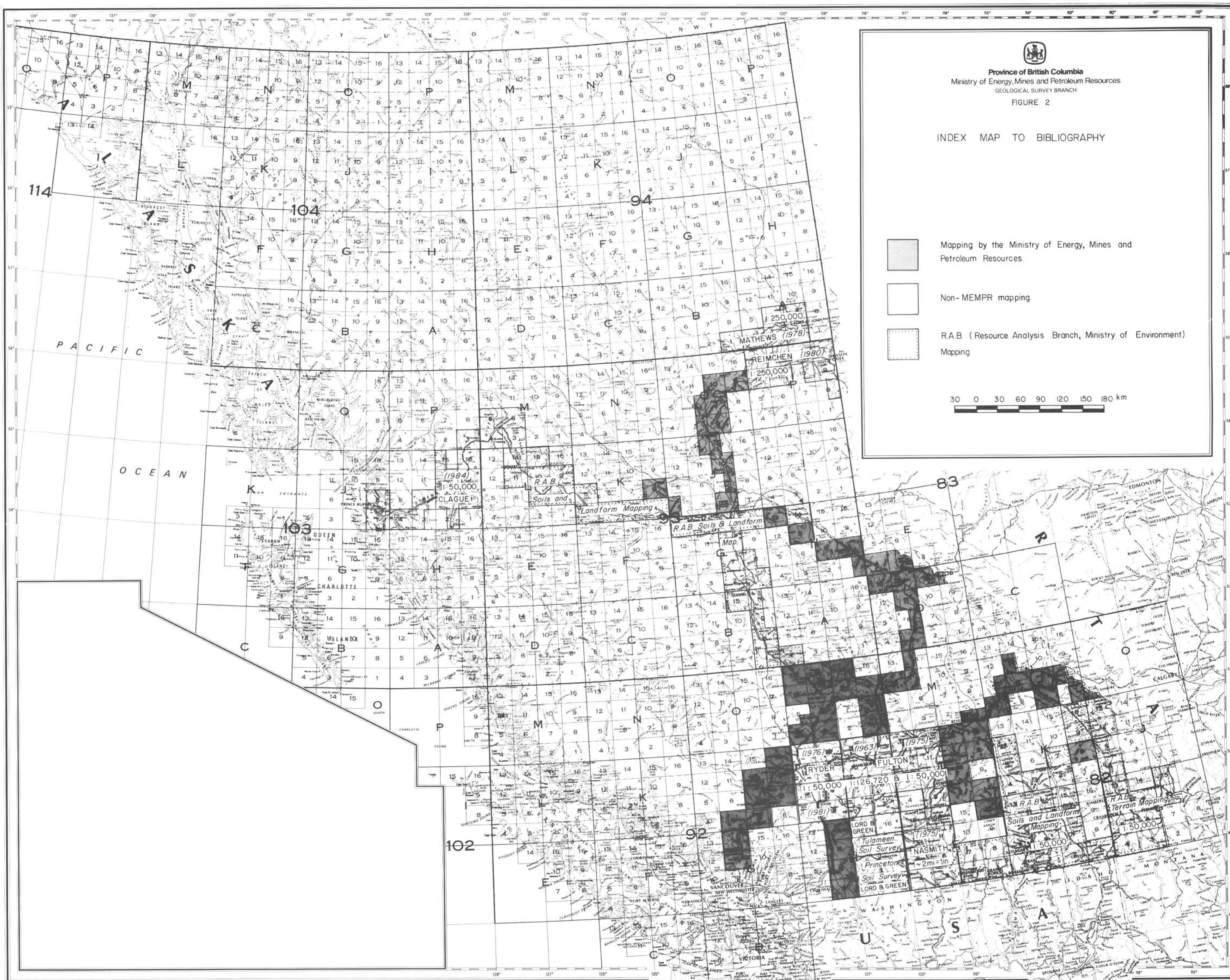
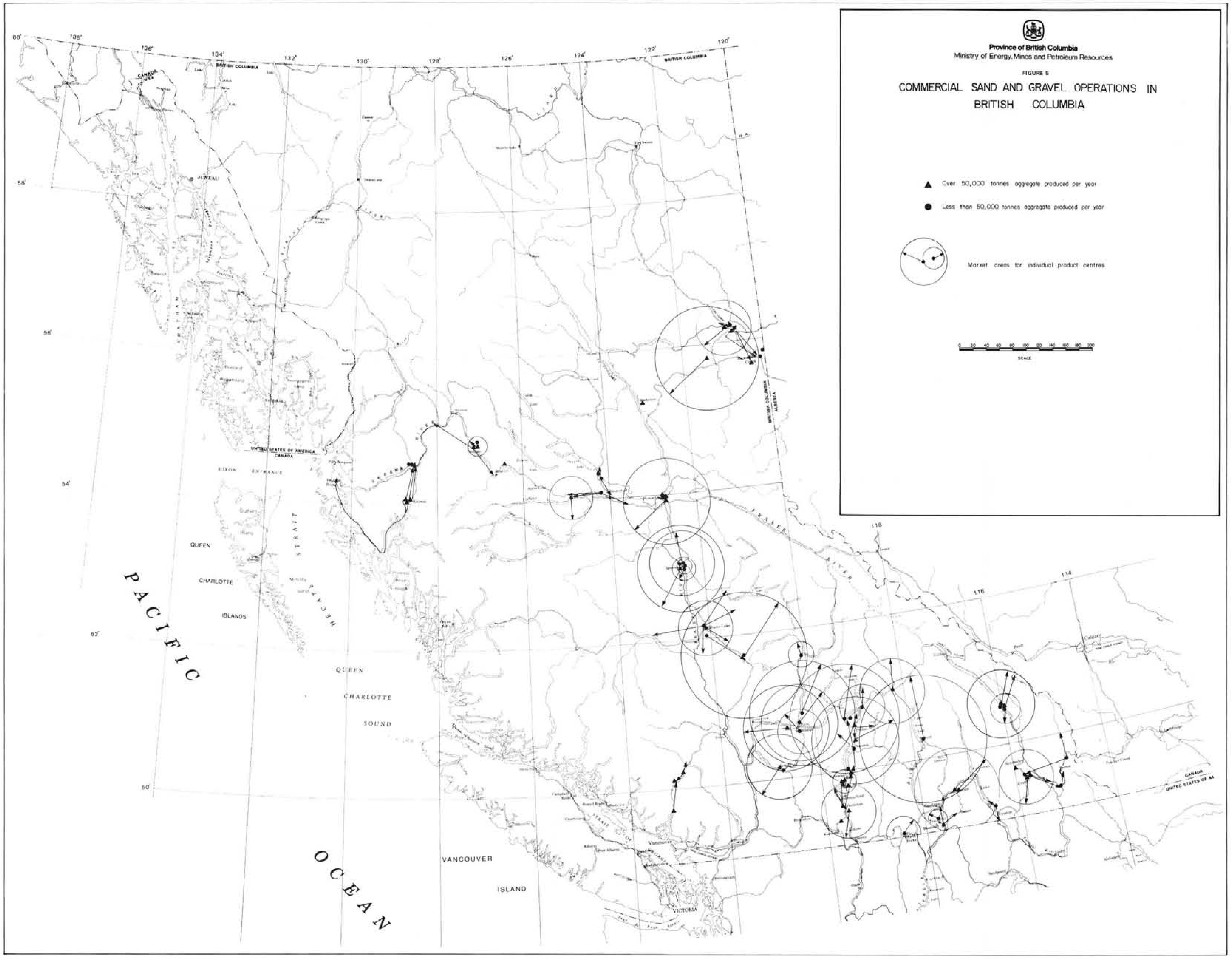


FIGURE 1
MAP OF THE STUDY AREA


Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources
GEOLOGICAL SURVEY BRANCH
FIGURE 2
INDEX MAP TO BIBLIOGRAPHY
Mapping by the Ministry of Energy, Mines and Petroleum Resources
Non- MEMPR mapping
R.A.B. (Resource Analysis Branch, Ministry of Environment) Mapping
30 0 30 60 90 120 150 180 km
PACIFIC
OCEAN
114
104
94
103
93
83
92
82
102
MATHEWS (1978)
REIMCHEN (1980)
1:250,000
(1984) 1:50,000 CLAGUE
R.A.B. Soils and Landform Mapping
R.A.B Soils & Landform Map.
(1976) RYDER 1:50,000
(1963) FULTON
(1975) 1:126,720 & 1:50,000
(1981) LORD & GREEN
Tulameen Soil Survey
Princeton Soil Survey LORD & GREEN
(1975) NASMITH ~2mi=1in
R.A.B Soils and Landform Mapping 1:50,000
R.A.B Terrain Mapping 1:50,000
VANCOUVER
VICTORIA
EDMONTON
CALGARY
U S A


Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources
FIGURE 5
COMMERCIAL SAND AND GRAVEL OPERATIONS IN BRITISH COLUMBIA
Over 50,000 tonnes aggregate produced per year
Less than 50,000 tonnes aggregate produced per year
Market areas for individual product centres
0 20 40 60 80 100 120 140 160 180 200
SCALE
PACIFIC
OCEAN
QUEEN
CHARLOTTE
ISLANDS
HECATE STRAIT
DIXON ENTRANCE
QUEEN CHARLOTTE SOUND
VANCOUVER
ISLAND
JUNEAU
VICTORIA
UNITED STATES OF AMERICA
CANADA
BRITISH COLUMBIA
ALBERTA
FRASER RIVER