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COAL RESOURCES AND COAL MINING ON VANCOUVER ISLAND

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1. EXECUTIVE SUMMARY

1.1 COAL RESERVES AND RESOURCES

There are three important areas of coal deposition on Vancouver Island (Figure 1-1). In order of importance they are:

- The Comox coal basin is the largest and most important area in terms of remaining coal resources. In the past, over 15 million tonnes of coal were produced from this basin. The Quinsam mine, located in the northwest corner of the basin, is the only producing coal mine on Vancouver Island. The Comox basin stretches 120 kilometres from the 50th parallel at Campbell River, south to the Parksville area. It covers an area of 2 070 square kilometres on Vancouver Island and may extend eastward beneath the Strait of Georgia.
- The Nanaimo coal basin has produced more than 50 million tonnes of coal. It extends from Lantzville in the north to Ladysmith in the south, a distance of approximately 32 kilometres.
- The North Island area, also known as the Suquash coal basin, is the site of the earliest coal mining on Vancouver Island which started in 1849. Poor quality and ash partings in the coal seams limited development in this area in the past. Coal-bearing sediments exist northwest of Coal Harbour, on the north shore of Holberg Inlet, and in the area between Port McNeill and Port Hardy, the site of the original Suquash mine.

TABLE 1-1

VANCOUVER ISLAND COAL RESERVES million tonnes

COAL RESOURCE AREA	PROVEN RESERVES	ULTIMATE RESOURCES	TOTAL RESOURCES AND RESERVES
COMOX COAL BASIN	47.52	261.43	308.95
NANAIMO COAL BASIN	3.34	7.67	11.01
NORTH ISLAND BASIN	0	18.1	18.1
TOTALS	50.86	287.2	338.06

Note: calculations only use seams greater than 1.5 metres in thickness. Reserve and resource numbers are based on the system of insitu reserve classification outlined in Table 4-3-2 (in section 4.3.6 of this report).

1.1.1 Areas of Interest for Future Developments

The Comox basin provides the best potential for future reserves, and a number of areas within the basin are discussed in this report. The Tsable River deposit is second to Quinsam in economic importance. It has 11 million tonnes of indicated reserves, based on drilling, and an ultimate potential resource of 100 million tonnes. Located near Tsable River in the centre of the Comox basin, the property is close to existing infrastructure and tidewater. The Allen Lake area has potential coal resources of over 45 million tonnes. Based on old drilling results, and the area's proximity to former mining areas, it may contain mineable coal.

The Browns River area has a potential resource of over 18 million tonnes. The Campbell River area lacks exploration information, however, old drilling results indicate that a coal seam of mineable thickness exists. This area is close to Quinsam and could benefit from infrastructure already in place.

Areas worthy of consideration in the Nanaimo basin are the Wolf Mountain and Morden mine areas. The Wolf Mountain mine, which was active for a short period in the 1980s, contains a well documented reserve of 3 million tonnes. The small reserve base limits its attractiveness. The Morden mine area, which is located southeast of Nanaimo, is located in a semi-urban to rural-residential setting and has almost 7 million tonnes of potential resources.

1.2 COAL QUALITY

Most Vancouver Island coals are of high-volatile A to high-volatile B bituminous rank. They are excellent thermal coals and, in a few areas, they also have coking properties. Thermal coal quality data for coals from several mines in the Nanaimo and Comox coal basins are shown in Table 1-2. Sulphur contents of the coals range from moderate to low. Coals of the Cumberland coalfield (central part of the Comox basin, Figure 1-1) are higher in sulphur content than those of the Nanaimo coal basin. The Quinsam mine produces thermal coal which has very weak coking properties. The sulphur content increases in seams higher in the section. Calcite is common on cleats in some coals (Ryan, 1994). This is an advantage for reducing the risk of acid rock drainage, but may affect the behavior of the ash when the coal is burnt. Coals from both basins are generally hard, resist breakage during handling, and compared to coals of similar rank from southeast and northeast British Columbia, generate less fines. Some coals from the Comox coal basin (Tsable River) have good coking qualities. Thermal coal from Quinsam is sold to Japanese and South American buyers.

TABLE 1-2
PRODUCT COAL QUALITY, SELECTED MINES
NANAIMO AND COMOX BASINS

	H_2O%	ASH%	V.M.%	F.C.%	S.%	kcal/kg
NANAIMO						
Wellington seam						
Northfield mine	2.49	10.19	40.1	47.2	?	7192
Beban mine, Extension	1.78	11.5	39.0	47.7	?	7200
White Rapids mine	1.27	9.47	39.2	49.8	0.83	7362
Timberlands Mine	2.06	6.46	37.8	53.7	?	7616
Douglas seam						
No.10 mine, South Wellington	1.59	9.57	39.7	49.2	0.5	7187
COMOX						
No.2 seam						
No. 5 mine	1.14	11	34.5	53.4	2.12	7417
No. 8 mine	0.99	10.58	35	53.5	?	7492
Tsable River mine	1.2	15.61	36.1	48.3	1.91	6918
QUINSAM						
No.1 seam	2.97	12.26	37.4	47.4	0.8	6639

Note: data from Buckham (1947), except for Quinsam. V.M. = volatile matter, F.C. = fixed carbon, S = sulphur.

1.3 MINING COSTS

Vancouver Island coal deposits are generally only mineable by underground methods, due to geological factors, and in some cases, land-use and environmental constraints. Mining and production costs will therefore be higher than for typical Canadian producers, for example the large-scale open pit mines in southeast British Columbia and Alberta. Given prevailing mining conditions in most Vancouver Island coal areas, it may be difficult to mine underground for less than $18.00 per raw tonne (circa 1996). This translates into a total mine-site production cost of $32.50 per tonne of clean coal, assuming a 75% yield, a $3.50 cleaning cost and $5.00 for general and administration expenses. The administration cost will vary depending on level of production, royalty structure, property tax and other factors.

Proximity to tidewater reduces transportation costs and increases the attractiveness of Vancouver Island coal deposits. Transportation costs for Vancouver Island's existing and potential producers are likely to be less than $12 per tonne of coal FOB (free-on-board ship), compared to the $23 to $25 range for southeast British Columbia and Alberta producers. Any improvements to infrastructure or barge-loading and ship-loading facilities will further reduce FOB costs of Vancouver Island coals.

1.4 INFRASTRUCTURE

The Quinsam coal preparation plant is the only one operating on the Island at the moment. The Wolf Mountain mine used a portable coal preparation plant located near Nanaimo. The facilities associated with earlier mines have all been dismantled. A new centrally located wash plant is unlikely to meet the needs of new producers, because of the varying quality of coals from potential producing areas and their scattered locations, however, it may be possible in the case of the Tsable River and Cumberland areas.

The public road infrastructure is generally good in most areas of potential coal developments. The new Inland Island Highway, which will provide a better link up and down the length of eastern Vancouver Island, will be of considerable benefit to potential coal producers in this region.

Present barge-loading facilities which can service Vancouver Island coal mines are limited to two sites:

- The Duncan Bay Marine Terminal, which is located south of Middle Point near Campbell River. This facility services the Quinsam coal mine and other industrial users.
- The Ocean Cement Brechin Point barge ramp, which is located adjacent to the Departure Bay ferry terminal in Nanaimo. This facility has been used to ship coal from the Wolf Mountain and Twinforks mines.

At present there are no ship-facilities on Vancouver Island for the bulk loading of coal on to ocean-going vessels. Quinsam Coal Corporation currently uses the Texada Island ship-loading facility, which was refurbished in 1989 and became operational in 1990. The facility includes a 200 000 tonne coal-stockpile area. Ships up to Panamax size (70 000 tonnes) currently use the Texada Island facility, which has a water depth of 13.7 metres at zero tide. Loading rates average 1 200 tonnes per hour. Minor eqipment additions would be necessary to load wider Cape size vessels.

Even at the current level of usage, the Texada Island facility is the cheapest export route for coal from Vancouver Island. There are no facilities for off-loading barges at Roberts Bank.

1.5 TENURE AND LAND-USE ISSUES

This report was written in early 1996. All conclusions on land-use issues and land tenure were correct at the time of writing but may now be out of date. The reader is advised to seek updated information from the appropriate sources.

Weldwood of Canada Limited is the major owner of fee-simple and coal exploration licenses in the Comox basin (Figure 1-1), which contains the largest share of the coal resources on Vancouver Island. Weldwood is not an operating coal company. Hillsborough Resources Ltd. and its subsidiary Quinsam Coal Corporation have an agreement with Weldwood to develop its Comox basin coal rights. Other smaller areas of coal licenses, including Chute Creek near Quinsam, may be developed by other companies.

Land-use classification is an important consideration in the development of coal mines on Vancouver Island. The government of British Columbia announced its Vancouver Island land use plan in June, 1994. It identifies four main land-use classifications;

- Protected areas, covering 13% of the Island;
- Forest Land Reserve, covering 81% of the Island;
- Agricultural Land Reserve, covering 3% of the Island;
- Settlement lands, accounting for 3% of the Island.

The Forest Land Reserve is designated for integrated resource use, including mining. Coal resource development and mining requires a much smaller operating land-base than that required by other resource developments, such as forestry. Underground coal mining requires a smaller land base than open-pit coal mining. For this reason, underground mining often will enjoy a greater degree of public acceptance. Because the major coal basins are located on the more developed eastern side of the island, coal projects may have to compete with urban and semi-urban population growth. With a forecast population growth of 2 to 3% per year in the two main areas of coal resource potential (Comox and Nanaimo coal basins), proper planning and public relations work are important parts of initial project evaluations and development.

1.6 HISTORY OF COAL MINING

The history of coal mining on Vancouver Island spans almost 150 years of development (1849 to present) and took place during two periods. During the first period, from 1849 to 1967, more than 65 million tonnes of coal were mined; 50 million tonnes from the Nanaimo basin and 15 million tonnes from the Comox basin. The settlement of Vancouver Island, especially in the eastern lowland areas of Nanaimo and the Comox Valley, was tied inextricably to this period of coal mining and much of Nanaimo’s growth can be attributed to the coal industry.

The second period of coal mining activity started in the 1970s when oil prices suffered two catastrophic shocks as a result of the pricing policies of the OPEC cartel. Resource companies scrambled to assemble coal land packages in western Canada. In 1973, the provincial government introduced new mineral land tax measures as part of a restructuring of the Mineral Act. As a result, Weldwood surrendered more than 80% of its fee-simple lands to the Crown, retaining approximately 47 750 hectares (118 000 acres), as shown in Figure 1-1. At the same time, the government imposed a moratorium on the issuing of new Coal Exploration Licenses on the Island, pending the introduction of a coal policy that would accommodate the coal developments that were rapidly taking place in many parts of the province. In 1977 the government lifted the moratorium on new coal exploration licenses. At that time, the Quinsam property, on Weldwood freehold land, was the only coal property being developed on Vancouver Island, but the lifting of the moratorium triggered vigorous license acquisition on Crown land. From the early 1980s until very recently coal prices dropped steadily, dampening the vigorous exploration activity that had taken place on the Island during the late 1970s up until 1981. Most of this exploration was not very successful, because it focused on lands previously surrendered to the Crown because of lack of mining potential. The only two developments of note were the Wolf Mountain underground mine, west of Nanaimo, which produced 117 200 tonnes of thermal coal during the period 1986-1988 and the continuing development of the Quinsam property, west of Campbell River.

Regional exploration work by Weldwood of Canada Limited, done in 1975, identified significant mining potential in the Middle Quinsam area, west of Campbell River (Figure 1-1). In 1976, Weldwood entered into a joint venture partnership with Luscar Ltd., a major Alberta-based coal mining company. Luscar began detailed exploration and development work on the Quinsam Property in September 1976 but sold its operating interest in the property to Brinco Mining Ltd. in 1980. Brinco, in turn sold its interest to Hillsborough Resources Ltd. in 1991. Quinsam Coal Corporation, which is 63% owned by Hillsborough Resources and 37% owned by Marubeni Corporation (the coal-sales agent), operates the Quinsam mine. The mine has produced over 2.5 million tonnes of coal since start-up in 1987. Operations which began as small-scale open-pit mining are now totally underground room-and-pillar mining using conventional continuous miner equipment.

The mine, which employs about 140 people, is producing at an annual rate of about 550 000 clean tonnes, from three underground continuous miner sections. The company has arranged financing from the British Columbia Transportation Financing Authority to upgrade the existing road and port facilities. The mine has a minimum 15-year life, based on identified *in situ* reserves of 38 million tonnes. Coal is shipped 33 kilometres by truck from the mine to the barge-loading facility at Middle Point and transshipped by barge to a coal-stockpiling area and ship-loading facility on Texada Island.

1.7 CONCLUSION

Vancouver Island has a long history of coal mining dating back to 1849. Mining has been an important component of the Island's economy in the past, particularly in the Comox Valley and at Nanaimo. Although the Quinsam mine, in the Comox basin near Campbell River, is the only operation currently producing coal on the Island, the potential for additional coal developments is good. The Comox basin, with proven reserves of 48 million tonnes and potential resources of 261 million tonnes, appears to be the most promising area for development. Other areas with lesser potential are the Nanaimo and North Island coal basins. The Island has good quality thermal and metallurgical coals.

The Vancouver Island Land-Use Plan announced by the Province in June, 1994 reduced much of the land-use uncertainty. None of the major coal deposits are in the areas designated to be protected. In addition, most of the coal deposits are in parts of Vancouver Island designated for integrated resource use, including mining. Geological factors indicate that most of the coal deposits on the Island are only amenable to underground mining. Vancouver Island coal from Quinsam has already been successfully sold to the Japanese and South American markets. Proximity to tidewater and the resulting low mine-to-ship transportation cost, give Vancouver Island a significant competitive advantage in world coal markets.

2. INTRODUCTION

2.1 PURPOSE OF STUDY

The purpose of this study is as follows:

- To document remaining coal resources of Vancouver Island, and to describe their quantity, quality and mineability.
- To identify the location of these resources, and to discuss what effect their eventual development may have on other stakeholders and tenure owners.
- To rank the coal-resource areas, with respect to their development potential, in terms of their size, geological complexity, and general characteristics.
- To discuss, in general terms, land-use issues, settlement plans and other socio-economic factors, which may effect potential coal developments.
- To describe the history of coal mining on Vancouver Island since its beginning in 1849.
- To describe the history of coal-land titles and their present distribution and ownership.
- To provide insight into the problems that prospective coal operators have to face, in order to identify and develop a coal mine on Vancouver Island.

2.2 OVERVIEW

Coal mining played a major role in the economic development and settlement of Vancouver Island from the years 1849 to 1967. Sixty-five million tonnes of coal were mined during this period. Coal from the Comox and Nanaimo areas became well known as a superior boiler fuel and as a domestic heating fuel. By the mid-1950s demand for coal was replaced by petroleum products and the coal mines of Vancouver Island were abandoned. The last mine (Tsable River mine) to close down in 1960 marked the end of an era. By the mid-1970s, sharp increases in oil prices rekindled interest in coal and Vancouver Island, with its proximity to tidewater and markets, became an area of activity once again.

Today, one coal mine (the Quinsam mine, near Campbell River) provides employment for over 140 workers and contributes substantially to the local economy. The mine exemplifies the path that developers must follow before a mine goes into production. Many years of planning and evaluation are required, concerning geological conditions, mining methods, environmental constraints and land-use and transportation issues. Future mines will have the same path to travel, and various stakeholder and interest groups must be kept fully informed, through the various stages of development, in order for a coal mine to gain public acceptance.

Quinsam's experience shows that coal reserves are in fact waiting to be developed on Vancouver Island and these reserves can be mined with minimum disturbance to the environment. The land-base requirements for such mines are minimal and the benefits to the local and provincial economies are substantial. A gradual tightening of world coal supplies (both thermal and metallurgical) and a fundamental adjustment in currency exchange rates has set a positive outlook for western Canadian export coal. Vancouver Island is well positioned to participate in this demand cycle.

The existence of 48 million tonnes of potentially mineable coal is documented and additional resources in excess of 250 million tonnes may be present. Just as in the past coal mining era, coal resource development can play a positive and beneficial role in sustaining a viable Vancouver Island economy.

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3. GEOGRAPHY AND HISTORY OF MINING, VANCOUVER ISLAND

3.1 GENERAL DESCRIPTION

Vancouver Island is located in the southwestern corner of the Province of British Columbia, separated from the rest of mainland British Columbia by the Strait of Georgia in the south and Johnstone and Queen Charlotte straits in the north. The Strait of Georgia varies from 20 to 30 kilometres wide. Johnstone Strait is much narrower, varying from less than one kilometre wide north of Campbell River (approximately halfway up the east coast of Vancouver Island), to five kilometres wide further north. Queen Charlotte Strait, at the northern tip of the Island, averages 25 kilometres in width.

The largest island on the Pacific Coast of the Americas, Vancouver Island has a wide diversity of climate and topography, although the typical Pacific northwest coastal marine climate is most representative of the area. The Island landmass is dominated by coniferous forests, although many lowland areas have been logged and converted to agricultural lands. The Vancouver Island Ranges, chief among them the Beaufort Range, form the backbone of the Island, and stretch from southeast to northwest along almost the entire length of the Island. Several of the higher peaks of the range rise above the 2 000 metre elevation, with the Golden Hinde at 2 200 metres being tallest.

Vancouver Island is home to several clans of aboriginal people, including the Kwakiutl peoples on the north coast, the Nu'Chanulth of central part and the Hul'qumi'num and Te'Mexw peoples in the southern part of the Island. The Island was first explored by Europeans (Spanish and British), and first charted by Captain George Vancouver in 1792. It was made a British Crown Colony in 1849. Vancouver Island united with the mainland colony of British Columbia in 1866, together forming the Province of British Columbia which joined Confederation in the Dominion of Canada in 1871.

3.1.1 Land Mass

At 32 134 square kilometres, Vancouver Island stretches in a northwest direction from latitude 48° 15' to 50° 42' north and from longitude 123° 00' to 128° 24' west. It is 460 kilometres long and varies from 65 to 130 kilometres wide.

3.1.2 Climate and Topography

The climatic variations on Vancouver Island are many and wide-ranging. They are chiefly a result of localized weather patterns influenced by the local topography. The range of climactic subdivisions on the Island is illustrated on Figure 3-1 (Chapman, 1952). In general terms, the Island is characterized by a humid marine climate typical of the Pacific northwest coast. There are major seasonal fluctuations in precipitation, which is in the form of rain, or snow on the higher elevations, and occurs mainly between the months of November and April. The dry season spans the balance of the year (May to October). Rainfall amounts vary from less than 50 centimetres in the southeastern portions of Vancouver Island to over 600 centimetres along the west coast and in the northern one-half of the Island.

Specific areas on the southeast coast, in particular the Cowichan Valley, Saanich Peninsula and some of the adjacent Gulf Islands, such as Saltspring Island, are quite arid in the summer season. The types of vegetation found on the Gulf Islands reflect these dry microclimates, which are due to a rain-shadow effect induced by the Olympic Mountains of Washington state. The official forest fire season, paralleling the dry season, starts on April 15 and closes on October 15. By early September, however, the heavy overnight accumulations of dew from the humid marine air lessen the fire hazard risk substantially.

The rugged, mountainous terrain of the Island is incised by numerous deep fjord inlets on the west coast, Alberni Inlet being the most notable. The eastern coastline, north as far as the City of Campbell River, is characterized by lowlands, low foothills and wide valleys. The northern tip of Vancouver Island is a low, rolling area of frequently swampy terrain interspersed with low mountains.

Land surface elevations on Vancouver Island range from sea level to 2 200 metres above sea level. The mountains which stretch the length of the Island provide a scenic background but more importantly serve to divide the Island into three physiographic sub-divisions:

- West Coast Lowlands.

- Beaufort Highlands.
- Eastern Vancouver Island Lowlands.

Each of these subdivisions possesses its own unique climatic trends, in part due to topography, and in part due to the effect of the Beaufort Range on the Pacific weather patterns. Some of the weather patterns are deflected away to circle in a counterclockwise motion up the Strait of Georgia, providing some precipitation to the eastern lowland. Rainfall on the eastern lowlands is typically about 100 centimetres as compared to up to 600 centimetres in areas such as Cameron Lake (on the west side of the Beaufort Range), Brooks Peninsula, and Cape Scott on the northwestern tip of Vancouver Island. In winter, snow accumulations are common above the 300-metre elevation. Snow does fall on occasion at lower elevations, even at sea level, but seldom stays for more than a few days at a time. The central peaks of the Beaufort Range are high enough to receive large accumulations of snow in the winter, supporting several glaciers.

Temperatures on Vancouver Island range from -20 C to +32 C. Mean summer temperatures in are in the low to mid 20s and in winter are in the 5 C to 10 C range at the lower elevations.

3.1.3 Population Growth and Demographics

Despite its large size, Vancouver Island is sparsely populated, due in large part to its rugged topography. Large concentrations of people are found in three areas:

- Capital Regional District (estimated population 500 000)
- Nanaimo-Parksville area (estimated population 85 000)
- Comox Valley, Campbell River area (estimated 80 000)

Together, these three areas are home to approximately 80% of the Island's population. The remaining 20% is scattered in smaller towns. Except for Port Alberni (1991 population of 18 400), most of them such as Port Hardy (1991 population of 5 000) and Port McNeill (1991 population of 2 700) are resource-based communities of less than 5 000 people. Isolated hamlets and fishing villages dot the coastline, some only accessible by boat.

Pulp and lumber mills have laid the foundation of population growth in certain areas. Other resource industries, such as mining and commercial fishing, are important contributors to the Island economy and have fostered growth in more remote areas. The types of communities found in these areas are industry-dependent and tend to prosper or decline with the business cycle. Port Alberni, which is primarily a forest products centre, is a good example of the boom-and-bust type of economy that results from dependence on one industry. Port Hardy is another example of resource industry dependence; the town will probably undergo economic upheaval in the coming decade because of the closure of the Island Copper mine and the continuing contraction of the logging and fishing industries.

In attempts to smooth out the cycles of resource industry dependence, many communities on Vancouver Island have made serious commitments to tourism. Tourism ranks as a major economic force in some areas, notably the Comox Valley and elsewhere along the east coast. The total impact of tourism on the overall economy of the Island is probably underestimated. It is evident, over the past two decades, that many people who visit Vancouver Island on their vacations retire there some time later. As many tourists are middle-aged or older, the Island has gained a reputation as one of the most desirable places to live in retirement. A retirement economy, if it can be labeled as such, has sprung up in places like Parksville-Qualicum, the Comox Valley and Campbell River. Victoria has always enjoyed special status as a retirement haven, but as real estate prices rise retirees have begun looking elsewhere, where house prices are still within their budgets.

How do these population demographics affect the potential developments in coal mining? Most of the potential coal mining areas are located along the east coast in the physiographic region referred to as the Vancouver Island Lowlands Belt. By coincidence, this is where most of the population growth will be in the coming decades. This is due to the availability of services, existing roads and other infrastructure, a more moderate climate including less rainfall, and more subdued topography which is amenable to urban development.

Two examples of high-growth areas are the Regional District of Comox-Strathcona, which includes much of the area of the Comox coal basin, and the Nanaimo Regional District, which covers the Nanaimo coal basin. Between 1981 and 1991, the population of the Comox-Strathcona Regional District increased by almost 21%, and the population of the Nanaimo Regional District grew by 32%.

3.2 HISTORY OF COAL MINING ON VANCOUVER ISLAND

3.2.1 The Hudson's Bay Company

Coal mining on Vancouver Island began in 1849 when the Hudson's Bay Company sent a small group of Scottish and Welsh miners to Fort Rupert on the northeast coast, approximately halfway between what are now the towns of Port Hardy and Port McNeill and a few kilometres south of the existing Port Hardy airport. A thin coal seam outcropped on the beach at the mouth of Suquash Creek, a few kilometres south of the fort. Other seams were discovered by shallow boreholes put down from the outcrop, and limited development work was begun. Between 1849 and 1851, a shaft was sunk and drivages were developed from the shoreline, out under the waters of the Queen Charlotte Strait. A few hundred tonnes of coal were mined, but due to the irregularities of the seam, the hostility of the local natives, and finally, news of the more promising discoveries at Nanaimo, much further to the south, the Suquash mine was abandoned.

The Hudson's Bay Company subsequently moved its miners to Nanaimo and operated mines for a decade under the name of the Nanaimo Coal Company. These mines provided coal for bunkering vessels used in the Hudson's Bay Company's fur trading. The vessels plied the waters of the Pacific Northwest coast, trading for furs with the various native tribes which inhabited the area. Coal was the preferred fuel when it could be procured, as wood was more labour intensive and bulky to handle.

In 1862 the Hudson's Bay Company, realizing that the Nanaimo mines held great promise and that it was in the fur trading business and not in the coal mining business, sold the rights to the coal to an Englishman named James Nichol. He formed the Vancouver Coal Mining and Land Company for the purpose of mining and selling coal from the Nanaimo area holdings. This company continued to operate the mines until 1902, when it was bought by the Western Fuel Company of California. At this time, California, in particular the San Francisco area, provided the largest single market for Vancouver Island coal.

The Western Fuel Company continued to operate the mines at Nanaimo until 1918, when it was incorporated under the laws of British Columbia and became the Canadian Western Fuel Company, which later became the Western Fuel Company of Canada Limited (incorporated in 1923). Finally, in 1928, the Western Fuel Company was bought by Canadian Collieries (Dunsmuir) Ltd.

3.2.2 Wellington Colliery

Robert Dunsmuir was the most famous, and arguably the most hated, man associated with the Vancouver Island coal industry. He worked for the Hudson's Bay Company until 1864, when he began prospecting on his own behalf. After examining several areas around Nanaimo in 1869, he made a discovery at Wellington, a few kilometres north of the city. The mining venture at Wellington became known as Dunsmuir, Diggle and Company. Various partners participated with Dunsmuir in this venture, but in 1883, Dunsmuir bought the company which then became known as R. Dunsmuir and Sons. The Wellington mines were extremely profitable and provided wealth and stature for Dunsmuir and his sons James and Alexander.

During the 1870s, British Columbia was encouraged by the Dominion of Canada to join Confederation. In order to convince British Columbians of the benefits of joining, and to solidify the new confederation, one of the terms of the agreement was to build a transcontinental railway. The original agreement, signed in 1871, committed the Dominion of Canada to start construction of the railway before 1873. As 1873 came and passed, British Columbians threatened secession and it was not until 1883 that Robert Dunsmuir's newly formed Esquimalt and Nanaimo Railway Company was granted some 750 000 hectares of land covering most of the eastern coastal lowlands of Vancouver Island, in return for the building of the railway from the Esquimalt dry-docks to the City of Nanaimo. This Esquimalt and Nanaimo Railway Belt, as it was called, stretched from the southern tip of Vancouver Island to the 50th parallel at Campbell River. Dunsmuir thus effectively controlled 95% of the coal measures (including fireclay) in the eastern lowlands as well as the gravel and minerals (excepting gold and silver). The few exceptions were located in the south Nanaimo area, where 'settler's rights' were granted prior to the 1883 agreement. These rights included surface and subsurface control. Other exceptions included those coal mining companies which were granted fee-simple rights prior to 1883 and which operated independently of the Dunsmuir interests. These included, most notably, the Vancouver Coal Mining and Land Company (later bought by the Western Fuel Company) and Pacific Coast Coal Mines.

Robert Dunsmuir died in 1889 and his son James took over the affairs of the Dunsmuir companies. In 1905 James sold all the assets of the Esquimalt and Nanaimo Railway, except for title to the coal, gravel and fireclay, to the Canadian Pacific Railway Company Ltd. In 1910 he sold all of the coal mines and associated rights to the promoters of the Canadian Northern Railways, who re-organized the properties under the name of Canadian Collieries (Dunsmuir) Ltd. and continued to operate mines in the Nanaimo and Comox coal basins until 1960. In later years the company was known as Canadian Collieries Resources Ltd. and after the era of coal production the company was again renamed, to Wellington Colliery Company Limited.

3.2.3 The Comox Mines

Approximately 14.5 million tonnes of coal were mined in the Cumberland area by Canadian Collieries (Dunsmuir) Ltd. between the years 1888 and 1955. Eight mines, known simply as the No. 1 Mine though No. 8 Mine, worked three thick coal beds, the No. 1, No. 2 and No. 4 seams, all of which were found within the Comox Formation near the village of Cumberland and Comox Lake. An additional 1.54 million tonnes of coal was extracted in the Tsable River area, about 11 kilometres southeast of Cumberland. Union Bay, on the western shore of Baynes Sound, 18 kilometres southwest of Cumberland, was the shipping and bunkering terminal for the area, and a central preparation plant serving all of the mines in the vicinity was located there.

The earliest attempt at mining in the Comox basin began southwest of Union Bay in 1869, when the Baynes Sound Coal Company tried to develop a coal outcrop at Tsable River, but this mine was little more than a prospecting operation, although a railway was built out to tidewater, and loading wharves were erected. A short time later, Sam Cliffe and partners formed the Union Collieries to develop mines in the Cumberland area, which came to be called Union Camp. The first entry, the No. 3 tunnel, was driven in the Comox No. 1 seam (the uppermost of the thick coal seams in the Comox Formation) just west of the village of Cumberland. The No. 1 slope, further to the west, was developed at about the same time in the No. 4, or “Lower” seam (so-named because it was the lowermost of the thick coal seams). The Union Collieries struggled for lack of capital and was purchased by Robert Dunsmuir and Sons Ltd. in 1883.

New mining developments followed rapidly in the next ten years and in 1890 and 1895 the two most important of the early Comox mines opened. The No. 4 slope on the east shore of Comox Lake opened in 1890 and the No. 5 shaft 1.2 kilometres northwest of Cumberland opened in 1895. By 1900, these mines were producing between 200 000 and 250 000 tonnes annually. A railway had been built, linking the mine tipples with the town and the shipping point at Union Bay.

Table 3-2-1 provides information on the depth of mine shafts and the seams worked in each shaft. Table 3-2-2 documents tonnages for the Comox mines throughout the mining period from 1897 to 1938.

TABLE 3-2-1

DEPTH OF SHAFTS AND SEAMS WORKED IN THE COMOX MINES

MINE	DEPTH		SEAM
	feet	metres	
No. 5 Mine	275	83.8	No. 1 Seam
			No. 2 Seam
			No. 4 Seam
No. 6 Mine	233	71	No. 1 Seam
	595	181	No. 4 Seam
No. 8 Mine			No. 1 Seam
	706	215	No. 2 Seam
	969	295	No. 4 Seam

Canadian Collieries (Dunsmuir) Ltd. operated the Comox mines during nearly all of the life of the coalfield. The company’s managers reported only a limited amount of data regarding annual tonnages and mining costs, especially prior to the 1930s. Many tonnages reported by the company were aggregates for all of the Comox mines taken together, making it difficult to determine the output of each individual mine during the years before 1938. The author has, in his personal library, Canadian Collieries (Dunsmuir) Ltd.’s monthly operating reports of the Comox mines from the period 1938 to 1953, when the No. 8 Mine finally closed. Prior to 1938, the annual reports of the Minister of Mines are the best source of coal production data. A set of these reports is available for study at the Nanaimo Community Archives.

The Comox mines were technically advanced for their time, being partially mechanized and electrified well before 1900. The first documented use of electricity underground in the Comox basin was in the Comox No. 4 mine about the end of July, 1891, when four electrically driven coal-cutters were installed (A.F. Buckham, personal diary). The usual method of mining was longwall, in which the coal was mechanically undercut, shot from the solid, and hand loaded. Some of the rock was hand picked from the longwall face. At times, when a middle parting existed, it was cut out first and removed, then both the top and bottom benches of coal were shot after undercutting the floor. Shale and rock were used as stowage material in the "gob" area where coal had previously been removed. Room-and-pillar work was undertaken where thicker seam sections allowed it. Even in the later mines, some degree of hand mining was done, as the run-of-mine coal from the hand mining places was of higher quality than that produced by the mechanized sections.

TABLE 3-2-2

TONNAGE MINED IN THE COMOX MINES PRIOR TO 1938

MINE AND SEAM	PERIOD	AREA WORKED (hectares)	OUTPUT (tonnes)
No.4 mine			
No.4 seam	1890-1935	537	5 783 000
No.5 mine			
No.1 seam	1895-1924	121	1 315 000
No.2 seam	1906-1938	198	1 633 000
No.4 seam	1895-1906	49	490 000
No.6 mine			
No.1 seam	1899-1917	70	771 000
No.4 seam	1899-1917	9	100 000
No.7 mine			
No.4 seam	1902-1921	97	1 043 000
No.8 mine			
No.1 seam	1911-1914	?	?
No.4 seam	1911-1914	?	?
	TOTALS:	1 081	11 135 000

After A.F. Buckham, 1947.

3.2.3.1 Comox No. 4 Mine

The Comox No. 4 mine was developed in the No. 4 seam, a short distance above the base of the Comox Formation. The immediate floor of the No. 4 seam was 0.6 metre (2 feet) of fire clay, which was occasionally recovered for commercial sale. The coal thickness was usually 1.2 to 2.1 metres (4 to 7 feet), with total mining height (including the fire clay) of 1.8 to 2.7 metres (6 to 9 feet).

The mine was entered by means of a main slope driven northeastwarrd from the outcop of the coal. Level entries were turned off along strike on either side of the main slope. Double stalls, or rooms 11 to 12 metres (36 to 40 feet) wide with a central packwall, were driven parallel to the slope with 18 metre (60 foot) wide pillars between the stalls. Crosscuts or breakthroughs were opened between stalls every 24 metres (80 feet). A line curtain for ventilation was used to drive the slope and stalls until ventilation could be opened to the outcrop. The pillars were recovered upon retreat. Gathering haulage was by mules pulling 1.5 tonne (1.7 ton) wooden cars. These were hoisted to the outside by rope in trains of ten cars.

The shale roof of the No. 4 seam was supported by sets of round, untreated timber. Each set consisted of two posts and a header, 3.7 to 4..9 metres (12 to 16 feet) long. The mining regulations required a timber set to be used every 1.2 metres (4 ft) along the workings. Extra posts, without headers, were placed along the sides of the workings, between the timber sets and the coal ribs. Undercutting by hand in the early days was later replaced by pneumatic undercutting using stand-mounted Ingersoll-Rand and Siskol air picks. Drilling was also done from a stand. Later, a hand-held, motor-driven breast auger was used to drill the coal face. In the latter days of the mine, Joy II BU loaders, 10 SC shuttle cars and Goodman universal cutting machines were in general use.

The mine was ventilated by a Sirocco fan 3.7 metres (12 feet) in diameter, which circulated 62 300 cubic metres (220 000 cubic feet) of air through the mine at 7.5 p.s.i. water gauge pressure.

3.2.3.2 Comox No. 5 Mine

The Comox No. 5 shaft was sunk in 1898, to work the basal No. 4 seam. In 1906, workings in the No. 4 seam were abandoned due to poor seam section, after producing about 490 000 tonnes. Overlying workings in the No. 1 seam were abandoned in September 1924. Buckham (unpublished notes) estimated 1.32 million tonnes were extracted from the No. 1 seam in No. 5 mine. During the 1920s and 1930s a set of cross-measures rock slopes were driven to provide access to the No. 2 seam from the old shaft landing in the No. 1 seam, and a rock tunnel from the No. 1 seam workings was driven out to the surface on the northwestern outskirts of Cumberland. Development in the No. 2 seam was continued until the mine was abandoned in 1947, after total extraction of approximately 2.9 million tonnes.

The method of working in this mine was primarily longwall, with some mechanization in the form of duckbill development and belt conveyor very late in the mine's life. Connections to the adjoining No. 6 mine were established in 1908 to improve ventilation, and to provide an alternate means of egress for the miners in the event of an accident.

3.2.3.3 Comox No. 8 Mine

The Comox No. 8 mine was perhaps the most modern of the Comox mines. Shaft sinking began in 1911. Twin shafts were sunk to a depth of 215 metres (706 feet) and 295 metres (969 feet), which were the levels of the No. 2 seam and the No. 4 seam, respectively. Production had barely begun when the mine closed down in 1915. The mine sat idle until 1936, when it was pumped out and refurbished. The No. 2 seam was developed first and sustained the mine for a lengthy period. Later, a rock slope was driven from the No. 2 level down to the No. 4 seam. A very small amount of production was taken from the No. 4 seam but this work was little more than prospecting and it was found that the seam was too dirty to sustain mining operations.

Longwalling was the main method of mining at No. 8. Longwall faces were approximately 90 metres (300 feet) long. The main middle parting was cut out of the seam by Anderson-Boyes cutting machines, and the coal was shot down and loaded onto conveyors by gangs of ten men. The conveyors consisted of five-ply rubber belts with 3.2 millimetres (1/8 inch) and 1.6 mm (1/16 inch) covers.

Wooden cribs filled with waste rock were used to hold the roof. The roof did not break readily and the weight extended past the coal face for approximately 40 metres (130 feet) until it was shot down.

According to William Johnstone, a retired mine manager living in Victoria, B.C., several panels of coal were left when the mine was abandoned. These panels were scheduled to be mined on the retreat, but the mine was closed first. The blocks are 183 x 610 metres (600 x 2 000 feet) and the seam thickness is 1.1 metres (3.5 feet).

No. 8 mine closed in 1953 after producing a total of 2.54 million tonnes of coal.

3.2.3.4 Tsable River Mine

Underground development work started at the Tsable River mine in 1945, after an earlier unsuccessful attempt to work the No.1 seam. The coal here was 2.4 to 3.7 metres thick, and lay close to the irregular surface of the underlying pre-Cretaceous volcanic rocks.

A temporary slope was driven in on the outcrop of the seam on the north side of the Tsable River valley. It was aligned roughly to the north and advanced approximately 275 metres (900 feet) at which point a counter slope was driven back towards the surface for 215 metres (700 ft) at approximately 30% grade. This was done because the original entry was unsuitable for the long-term hauling of coal to the surface. As the original slope was driven in, problems were encountered with water coming out of the roof, creating soft roof conditions. When the new main slope was driven back to surface, problems were again encountered when it entered sand and gravel overburden while still 45 metres (150 feet) away from the projected portal. A dragline was used to dig a V-cut to allow the placement of solid timbering and lagging all the way in. As the mine developed, three exploratory drifts were driven to the west to attempt to develop the coal seam under the Tsable River valley. Drivage was stopped in this direction because of deterioration of the coal seam section and increase in the amount of roof water.

In 1946 the first coal was trucked to Union Bay, but production was limited until electrical power reached the mine in 1947, allowing the use of a 75 horsepower electric hoist. The main rock slope through to surface was also completed in 1947. In 1949 a tipple, 500 horsepower main slope hoist (later upgraded to 1 500 horsepower), wash-house, lamp room, and offices were constructed.

The mine was officially opened for commercial production in 1949. In 1951 a Joy loader was installed and in 1952 the first multiple shooting of coal from the working-face took place. In 1954, development drivage production was 18 446 short tons and the last reported commercial production was in September 1959, although pillar robbing operations occured until 1964 (A.F. Buckham, personal diary). The mine closed in 1964 after producing approximately 1.80 million tonnes of coal.

Entry to the mine was by tracked haulage from the car dump at surface down the Main Slope, which went down at 30° for the first 215 metres, then at 17° on the coal seam. The mine was worked by the room-and-pillar method; coal was undercut and shot off the solid, then loaded out by duckbill loaders onto section belts or mine cars. A total of six duckbill loaders were used while the mine was being developed. An Eimco mechanical loader (scoop-tram) was also used to a certain extent, however it did not perform well due to the wet floor conditions, steep pitch and lack of loading height in some areas. The mine-run coal was dumped over a series of screens at the surface tipple, then trucked to Union Bay where it was washed.

The coal seam dipped to the northeast at 10° to 18°. At least one major fault was encountered, with an upthrow of 5.5 metres (18 feet). A corresponding downthrow was encountered some distance further down in the mine, bringing the seam back into its normal orientation. Parallel faults were encountered 274 metres (900 feet) apart. Two diagonals were driven in order to traverse this faulted section. Many other minor faults are recorded in the mine’s monthly operating reports. On the east side of the main slope, the coal seam deteriorated against the volcanic basement rock, which can be seen outcropping for a distance of a few hundreds of metres along the main road to the mine. The thickness and quality of the seam deteriorated ahead of the Main Slope. Typical seam sections in this part of the mine are presented in Table 3-2-3.

TABLE 3-2-3

TYPICAL SEAM SECTIONS IN TSABLE RIVER MINE

LITHOLOGY	THICKNESS (centimetres)
Right (east) side of main slope	
coal	71
bony coal	25
bone	20
shale	145
coal	18
shale	13
coal	81
total section mined	373
No.3 Left panel	
coal	81
shale	15
coal	15
shale	30
coal	122
total section mined	264

Although the coal seam at Tsable River was substantially thicker than those which were worked in the Comox mines, faulting on both a large and small scale had an adverse impact on mining. Also, the coal seam was very close to the irregular volcanic basement surface, causing areas of non-deposition or dirty seam section. Roof water also caused problems, especially prior to the electrification of the mine. Due to the high sulphur contents of the coal and its medium to high volatile content, spontaneous combustion occurred in at least two of the old panels.

3.2.3.5 Coal Beneficiation

At the pit-heads of the Comox mines, the run-of-mine coal was conveyed across picking tables where five or six young men picked out and discarded pieces of dirty coal and rock. Some mines undertook additional pretreatment of run-of-mine coal. For instance, a reference from a 1939 report documents the installation of a crusher at the No. 5 tipple:

> "A second-hand Jeffrey 30 x 30 roll crusher has been purchased for installation on the No. 5 Tipple to crush the oversize coal. This will obviate rehandling all the C.P.R. rail coal at Union Bay".

Run-of-mine coal was pre-screened before the coal was loaded into railway cars bound for Union Bay; however, most of the sizing and cleaning operations were undertaken at the Union Bay washery. The washery was built prior to 1900, but was considered quite efficient for its time. The major equipment was a Luhrig coal washer which consisted of four cones and tables, with a total capacity of 65 tonnes per hour. The washery operated in this original configuration during a 42-year period from 1898 to May, 1941. During the last two decades of operation, the plant was extremely run-down and outmoded.

In May, 1941, two of the original cones were removed to make way for two new Vissac jig vessels. In September of the same year a briquetting plant was built beside the original plant in order to handle some of the washed fines. This upgrading work generally improved the recovered yields from 75% to about 82% .

More than 100 beehive coke ovens were also operated at Union Bay, producing coke for various smelters along the Pacific Coast (chiefly in the San Francisco, Tacoma and Portland areas). Coke making was discontinued in 1922 (Muller and Atchison, 1971).

3.2.4 The Decades of Peak Production, 1910-1930

The collieries of Vancouver Island reached their zenith by 1910. Annual production had exceeded the million long ton level by 1898 and by 1910 surpassed the 1.5 million long ton mark (Muller and Atchison, 1971). A strike during 1912, which lasted until September of 1913, severely curtailed production, as did the shortage of labour during the first years of World War I. By 1916, annual production was back up to 1.5 million long tons. Peak production was in 1922 (Muller and Atchison, 1971), when the Vancouver Island collieries produced 1 754 656 long tons. During the middle to late 1920s, substitution of oil for industrial and domestic heating, and for the bunkering of ships, began to make inroads into the market for Vancouver Island coal. After 1929, annual production never again exceeded a million long tons.

During these highly productive years, prospecting and exploration work were carried out at a relatively fast pace. New mining areas were delineated as fast as existing areas were depleted. As is usually the case in most coalfields, the best mines, the No. 4 and 5 mines at Cumberland and the No. 1 (Harbour), Wellington (Diver's Lake) and Extension mines at Nanaimo were identified near the outset of development. These mines sustained the bulk of the production through the 1920s and beyond, although declines, even at these mines, became evident around 1930.

Researchers into coal mining on Vancouver Island agree that as the deeper mines exceeded 300 metres of cover, gas emissions and outbursts became a common occurrence. This is especially true for the southern part of the Nanaimo basin, where extreme thinning and pinching of the Douglas seam may have caused abnormal stresses due to structural irregularities (Rice, 1922; Touhey, 1923; Wilkinson, 1926; Wilson and Henderson, 1927; Strachan, 1942). Despite this, depth of cover and the propensity for outbursts did not cause undue loss of life. There is evidence to suggest that the miners learned to harness the power of the outbursts to release significant amounts of loose coal that could be relatively easily mined. The experienced miner in these conditions learned to anticipate when these outbursts would occur by reading the early warning signs of such an occurrence.

3.2.5 The Declining Years of Production

During the 1930s, coal production on Vancouver Island generally declined, primarily due to the following factors:

- Mining conditions: as the easier, near surface coal mines were exhausted, deeper mines were developed with more difficult mining conditions and increased production costs.
- Cost of labour: the earlier Dunsmuir legacy of non-negotiation with organized labour had gradually disintegrated after the lengthy strike of 1912-13. All through the 1930s, the union movement fought to improve wages and working conditions and by 1938 the last two Vancouver Island mines to organize signed up with the United Mine Workers of America (Bowen, 1982).

- Declining markets: although the market for coal strengthened somewhat just prior to and during the Second World War, the overall trend was one of decline as oil gradually replaced coal as the fuel of choice.

The No. 1 mine in Nanaimo closed down in 1938, marking an accelerated trend in declining production for Vancouver Island mines. This mine had become the symbol of mining on the Island during its long history.

Great loss of life occurred in the Vancouver Island coal mines prior to World War II. To a great extent, the deaths were due to ignorance on the part of management and the miners. Open-flame lamps were dangerous in the gassier mines and some of the disasters have been attributed to smoking. Poor ventilation practices were obviously a critical factor in the mines, especially the early operations. In later years, breaking through into water-filled old workings caused flooding of the mines, which occasionally claimed lives. Even as late as 1937 three men drowned in the Beban mine at Nanaimo, when it was flooded by an inrush of water from old workings of the nearby No. 1 Extension mine.

A.F. Buckham (unpublished notes) recorded the official death toll of Vancouver Island coal mines as 686 in the Nanaimo coalfield and 305 in the Comox coalfield, for a total loss of life of 991 men. Table 3-2-4 identifies the larger coal mine disasters in the Vancouver Island mines during the period 1852 to 1958.

TABLE 3-2-4

VANCOUVER ISLAND COAL MINE DISASTERS

DATE	COALFIELD	COLLIERY	FATALITIES	CAUSE
April 17, 1879	Nanaimo	Wellington No.1 slope	11	Fire and explosion
June 30, 1884	Nanaimo	Wellington No.3 shaft	23	Explosion
October 14, 1885	Nanaimo	East Wellington No.1 shaft	5	Car fell down shaft, hit cage
May 3, 1887	Nanaimo	Nanaimo No.1 shaft	150	Explosion and fire
January 24, 1888	Nanaimo	Wellington No.5 shaft	77	Explosion
February 15, 1901	Cumberland	Comox No.6 shaft	64	Explosion
September 30, 1901	Nanaimo	Extension No.2 slope	16	Fire
July 5, 1903	Cumberland	Comox No.6 shaft	16	Explosion
October 5, 1909	Nanaimo	Extension No.2 slope	32	Explosion
February 9, 1915	Nanaimo	South Wellington No.1 slope	19	Inrush from old workings
May 27, 1915	Nanaimo	Reserve shaft	22	Explosion
June 3, 1917	Cumberland	Comox No.6 shaft	4	Explosion
September 10, 1918	Nanaimo	Protection shaft	16	Shaft hoisting rope broken
August 30, 1922	Cumberland	Comox No.4 slope	18	Explosion
February 8, 1925	Cumberland	Comox No.4 slope	33	Explosion
		SUMMARY		
		Nanaimo	686	
		Cumberland	305	
		TOTAL	991	

Notes: disaster arbitrarily defined as 4 or more resulting fatalities. Data from A.F. Buckham, January 29, 1958.

By the end of World War II, Vancouver Island production had declined to about 500 000 tonnes per year. When the No. 8 mine in the Cumberland field closed in 1953, aggregate production sank to below 200 000 tonnes. The last major mine of any size was the Tsable River mine, which opened in 1947. By 1954 it had reached a production level of about 200 000 tonnes per year and it remained a viable operation until about 1960. After 1960, Canadian Collieries (Dunsmuir) Ltd. sold it to three employees, who then operated it, removing pillars, with a reduced workforce, until 1966. This mine was the last on Vancouver Island to close in the first era of coal mining (1849-1967).

During the first thirteen decades of coal production on Vancouver Island (1849-1967), approximately 65 million tonnes of coal was mined. Fifty million tonnes of this total was produced from the Nanaimo coal basin, and the remaining 15 million tonnes was produced from mines in the Comox coal basin (including Tsable River). There appeared to be little hope of a resurgence in coal mining, but in the 1970s several developments in the world economy and in British Columbia politics rekindled interest in coal on Vancouver Island.

3.2.6 The Rebirth of Coal Exploration and Development, 1973 to the Present

In the early 1960s all the assets of the old Wellington Colliery Company Ltd. were purchased by the American Plywood Company, which was the forerunner of Weldwood of Canada Limited. The Wellington Colliery Company was purchased mainly for its extensive forest land holdings because, at the time, it was thought that the coal rights were essentially worthless.

In the late 1960s, the Esquimalt and Nanaimo Railway Company, then a part of Canadian Pacific Enterprises Ltd., transferred all of its mineral rights in the E. & N. Land Grant to PanCanadian Petroleum Ltd., the newly formed natural resources affiliate of CP Rail.

In the early 1970s, oil prices suffered two catastrophic shocks as a result of the pricing policies of the OPEC cartel. The days of excessively cheap oil appeared to have passed as these extreme upward movements in prices forced economists to re-evaluate their models. Forecasts of $100 per barrel crude oil began to appear, creating great unease among the oil-dependent countries, in particular the United States which at that time was a major importer of Middle Eastern oil. Almost overnight, alternate fuels took on great significance, such as "King Coal", and synthetic oil from the Athabasca tarsands, which were known to contain at least as much locked-in oil reserves as the Arabian Peninsula. Resource companies scrambled to assemble coal-land packages in western Canada and elsewhere. Long-established coal companies were quick to react and the major oil companies were not far behind; they needed to diversify in order to weather the oil price shocks.

In 1973, the Government of British Columbia introduced new mineral land tax measures as part of a re-structuring of the Mineral Act. At the same time, the Government imposed a moratorium on the issuing of Coal Exploration Licenses pending the introduction of a new coal policy that would take account of the accelerated coal developments that were already occurring in many areas of the Province.

When the new Mineral Land Tax Act was enacted in 1973, PanCanadian Petroleum (which was not a mineral or coal producer) was faced with the specter of very substantial taxation on its mineral rights within the E. & N. Railway Belt. In view of this major carrying cost, and the conclusion that these mineral rights were of no substantial value other than for coal, PanCanadian decided that it should surrender its interests to the Crown, subject to settling Weldwood of Canada's claim to the coal and fireclay through its wholly-owned subsidiary, Wellington Collieries Ltd. This in turn forced Weldwood to evaluate the coal rights over the entire area of the E. & N. Grant with the intention of surrendering much of the area, thereby reducing the tax burden. Weldwood retained Michele P. Curcio, a coal consultant from Alberta, to assist with in this study. From 1973 to 1975, Mr. Curcio assembled a team of experts who evaluated the old Canadian Collieries data, performed field work and exploration drilling on a regional scale, and produced a fairly detailed evaluation of the E. & N. Grant area.

Of the 750 000 hectares (1.8 million acres) of fee-simple rights owned by Weldwood, 670 000 hectares (1.68 million acres) were surrendered to the Crown, leaving Weldwood with 47 750 hectares (118 000 acres). Later on, additional lands were surrendered, reducing Weldwood's fee-simple holdings to 37 600 hectares (93 000 acres). The retained area is shown on Figure 4-3.

On the strength of the initial evaluation, Weldwood decided to continue the assessment of its mineral resources (in particular its coal resources), by concentrating its exploration efforts in the most promising areas identified in the study. These were north of the Comox-Cumberland area as far north as Campbell River and the 50th parallel, the northern limit of the E. & N. Railway Belt.

By 1976, Weldwood's exploration efforts had led to the delineation of a substantial coal resource in the Quinsam Lakes area, approximately 24 kilometres (15 miles) west of the City of Campbell River. The company decided to segregate this area from the rest of its holdings and bring in an operating partner to determine the extent of the coal reserve at Quinsam and to proceed with its development if it were found to be viable. Luscar Ltd., a privately owned coal mining company based in Edmonton, Alberta, and one of the largest coal producers in Canada, became the operating partner. A joint venture company named Quinsam Coal Ltd. was formed, and intensive exploration work in the Middle Quinsam Lake and surrounding areas began in October of 1976.

During the period 1976 to 1980, the Luscar-Weldwood joint venture partnership completed over 500 drill holes and core holes in the Middle Quinsam area and outlined a total *insitu* coal resource of some 33 million tonnes, of which some 22 million tonnes consisted of near-surface *insitu* reserves (to a maximum cover depth of 75 metres). An additional 12 million tonnes was indicated underground reserves (to a maximum cover depth of 180 metres).

The Quinsam project reached the Prospectus stage of the Mine Development Review Process in 1977, Stage I in 1978 and Stage II in 1979, however the Coal Guidelines Steering Committee requested additional information regarding environmental impacts of such a project. This was due to the extremely sensitive nature of the area, which is important as a salmon-rearing habitat, with a major salmon hatchery downstream from the proposed mining development on the Quinsam River.

In 1980, after submitting the Stage II phase of the mine development program to the Coal Guidelines Steering Committee, Luscar Ltd. informed Weldwood that other corporate priorities and the considerable financial risk necessitated the termination of their involvement in the Quinsam Project. Brinco Mining Ltd. then took over Luscar's position as operating partner of the Quinsam Joint Venture. In late 1981, Brinco Mining Ltd., a Vancouver-based public company, acquired Luscar's interest. During 1981 and 1982, Brinco undertook a major feasibility study of the Quinsam property, at the same time taking steps to convince the local people of Campbell River that mining could be done safely and at minimal risk to the environment.

A store-front office was opened in Campbell River, and an aggressive public relations campaign was initiated. Detailed environmental work was done, with particular emphasis on surface and groundwater studies and the proposed mine's effect on these resources. Studies of acid rock drainage potential were also undertaken in order to assess the overall impact of mining development. The addendum to Luscar's old Stage II Study was finally submitted to the Coal Guidelines Steering Committee in May of 1983. The project received approval-in-principle, subject to a public inquiry. The public inquiry was the first of its type in the province. Held in Campbell River, it lasted 20 days and consisted of expert testimony and question and answer sessions with representations from many local citizens and groups both for and against development.

The end result was the granting of the mining permits to Brinco Mining Ltd. for the development of the Quinsam coal mine. This lengthy and costly process was significant in that it convinced other companies that coal mining on Vancouver Island could be resumed, despite the poor environmental and social history associated with the business in its somewhat chequered history.

The provincial government lifted the moratorium on new coal exploration licenses on Vancouver Island in late 1977. Prior to this, the Quinsam property, by virtue of its freehold disposition, was the only coal property undergoing active exploration and development. The lifting of the moratorium triggered vigorous license acquisition on Crown Land, which included a large portion of the E. & N. Land Grant previously surrendered to the Crown by Weldwood of Canada Limited.

A few of the more important examples are:

- In the first active exploration thrust after the lifting of the moratorium, Hudson's Bay Oil and Gas Company Limited optioned approximately 8 000 acres (3 240 hectares) at the north end of the Alberni Valley.
- Positions in the Nanaimo basin were taken up by other major oil companies such as Gulf Canada Resources Ltd. and Esso Resources Canada Ltd. around the western and southern margins of the basin in order to explore for relatively shallow coal resources. Of particular note is the farm-in arrangement on a block of coal licenses in the Mt. Benson area, which Gulf Canada acquired from Netherlands Pacific Mining Ltd., subject to a royalty interest. Subsequent drilling on this ground by Gulf Canada identified a small reserve of coal which later supported an underground mine operated by Wolf Mountain Limited Partnership (as discussed in section 4.4.3.2).
- Positions along the eastern perimeter of the Weldwood fee-simple coal rights were taken up, most notably by Canadian Occidental Petroleum Ltd. and secondly by Esso Resources Ltd. north of the 50th parallel.
- BP Canada Ltd. applied for thousands of hectares in a 50-kilometre strip of land in the Parksville area, between Nanoose Bay to Fanny Bay, with the intention of proving up reserves between the two known coal basins.

From the early 1980s to very recently, coal prices were in steady decline. This was due in part to the drop in oil prices as the OPEC cartel lost some of its cohesiveness, and in part to the steady development of large coal mines, both in Canada and overseas (Australia, Colombia and Indonesia), which created a supply imbalance. This overhang on the world coal market was exacerbated by the recession in the late 1980s in many of the large economies such as Japan, the United States and Europe.

This coal price decline had the effect of dampening the vigorous activity experienced in Vancouver Island coal exploration during the late 1970s up until 1981. By 1983, the Quinsam project was fully permitted but significant coal price declines had adversely affected the economics of a large, high strip-ratio open-pit concept to the point where a new feasibility study had to be undertaken. This resulted in a slow start-up, small-scale open-pit operation in an attempt to generate cash flow while allowing export selling prices to improve (see section 5).

3.2.7 The Current Situation

Today, the Quinsam mine is the only producing coal mine on Vancouver Island. All coal is mined underground, by the conventional room-and-pillar method. Two separate underground mining areas, the 2-North and 2-South mines, are active. A third mine (the 4-South mine) is presently being permitted and developed. This mine will replace the short-lived 2-South mine which will be exhausted some time in 1996. The mine, which currently employs about 140, is producing at an annual rate of approximately 550 000 clean tonnes from three underground continuous miner sections.

4. GEOLOGY OF VANCOUVER ISLAND COALFIELDS

4.1 GENERAL DESCRIPTION

Coal-bearing sediments of the Upper Cretaceous Nanaimo Group are present along the eastern lowlands of Vancouver Island and in other outlying areas of low topography, notably the Alberni Valley. They are also found in several areas across the northern part of Vancouver Island, for example, near Port McNeill, Coal Harbour and Winter Harbour, in the downwarped troughs. In the Eastern Lowlands, sediments of the Nanaimo Group cover a strip 200 kilometres (124 miles) long by up to 24 kilometres (15 miles) wide, stretching from Sidney, just north of the Victoria, to Campbell River, about midway up the eastern coast of the Island.

Early work by Clapp (1912a, 1912b, 1914a) divided the area of Nanaimo Group and younger sediments into several basins (Table 4-1-1). In addition to these areas, some very small sub-basins contain sediments of the Nanaimo Group. A large area of the Georgia Strait, including most of the Gulf Islands, is an extension of the Nanaimo basin. This area contains significant thicknesses of Nanaimo Group sediments and extends across the International border into the San Juan Islands of the United States. Muller and Jeletzky (1970) describe the depositional basins, as "disconnected erosional remnants of a larger area of deposition whose present distribution is largely controlled by post-Cretaceous block faulting and tilting, preserving these sediments in structurally depressed areas".

TABLE 4-1-1

AREA OF NANAIMO GROUP AND YOUNGER SEDIMENTS

BASIN	AREA	
	square kilometres	square miles
Quatsino Sound	127	49
Suquash	425	164
Comox	2 070	789
Alberni	171	66
Nanaimo	1 330	513
Cowichan	663	256
TOTAL AREA	4 786	1 837

4.1.1 Stratigraphic Setting

Muller and Atchison (1971) describe five distinct cycles of deposition (each about 300 metres thick) making up the Nanaimo Group. These cycles are made up of a succession of fluvial, deltaic and/or lagoonal (coal-bearing), to near-shore marine, to off-shore marine sediments. According to Muller and Atchison, ”the coal-bearing lagoonal facies is only found in the first cycle in the Comox basin and in the second cycle in the Nanaimo basin ... the coal seams in the Comox basin occur in the Comox Formation whereas those in the Nanaimo area are found in the younger Extension-Protection Formation. Thus, contrary to earlier beliefs, the coals of Cumberland are not correlative with those of Nanaimo.”

Later work has shown that the coals in the Nanaimo area are indeed not correlative with the coals in the Cumberland area. In fact, coal-bearing lagoonal facies of the first cyclothem (Comox Formation.) and the second cyclothem (Extension-Protection Formation) have been identified in the Nanaimo basin as discussed by Cathyl-Bickford (1991). She describes a well drilled by British Petroleum (BP Yellow Point d-84C) which continued into Comox Formation, where it encountered a gassy coal at least 3 metres thick at a depth of approximately 1 570 metres. The Yellow Point well is significant, in that it is the first well to discover coal in the Comox Formation of the Nanaimo Group in the Nanaimo basin. Prior to drilling this well, Comox coals were not believed to occur this far south.

The discovery of coal in the Comox Formation in the Nanaimo basin supports the idea put forth by Muller and Jeletzky (1970) that the five or six areas containing Nanaimo Group sediments were preserved from later erosion by post-Cretaceous block faulting and downwarping and are merely remnants of a much larger basin. Bustin and England (1991) estimate the thickness of the Nanaimo Group sedimentary rocks to approach or exceed 4 000 metres. Only the lower 1 500 to 2 000 metres are preserved on the east coast of Vancouver Island, although thicknesses increase eastward in the Gulf Islands. Table 4-1-2 illustrates the stratigraphic divisions of the Comox and Nanaimo basins, showing the generally accepted nomenclature as of 1970.

TABLE 4-1-2

STRATIGRAPHIC COMPARISON OF COMOX AND NANAIMO BASINS

STAGE	STRATIGRAPHIC NOMENCLATURE			CYCLOTHEM
	COMOX BASIN	UNIFIED NOMENCLATURE	NANAIMO BASIN	
Maestrichtian	Hornby Fm.	Gabriola Fm.	Gabriola Fm.	Fifth
Maestrichtian	Spray Fm.	Spray Fm.	Northumberland Fm.	Fourth
Campanian	Geoffrey Fm.	Geoffrey Fm.	Northumberland Fm.	Fourth
Campanian	Lambert Fm.	Northumberland Fm.	Northumberland Fm.	Fourth
Campanian	Denman Fm.	De Courcy Fm.	De Courcy Fm.	Third
Campanian	Trent River Fm.	Cedar District Fm.	Cedar District Fm.	Second
Campanian	Extension-Protection Fm.	Extension-Protection Fm.	Extension-Protection Fm.	Second
Campanian	Trent River Fm.	Haslam Fm.	Haslam Fm.	First
Santonian	Comox Fm.	Comox Fm.	Comox (Benson) Fm.	First

Note: after Muller and Jeletzky (1970).

TABLE 4-1-3

REVISED STRATIGRAPHIC NOMENCLATURE OF THE NANAIMO GROUP AT NANAIMO

STAGE	FORMATION	MEMBER	THICKNESS	LITHOLOGY
Maestrichtian	Gabriola		350 - 600?m	Sandstone and conglomerate
Early Maestrichtian	Spray		100 - 145 m	Shale and siltstone (turbidites)
Early Maestrichtian	Geoffrey		120 - 150 m	Conglomerate and sandstone
Late Campanian to earliest Maestrichtian	Northumberland		200 - 300 m	Shale and siltstone (turbidites); minor sandstone
Late Campanian	De Courcy		275 - 430 m	Sandstone; minor conglomerate and siltstone
mid Late Campanian	Cedar District	Boat Harbour	20 - 100 m	Shale and siltstone (turbidites); sandstone
mid Late Campanian		Woods Islands	0 - 70 m	Sandstone; minor siltstone
mid Late Campanian?		Holden-Corso	290 - 350 m	Shale and siltstone (turbidites); sandstone dykes
early Late Campanian?		Oyster Harbour	0 - 60 m	Sandstone; minor siltstone
early Late Campanian		Granby	20 - 100 m	Shale; glauconitic pebbly shale at base
Early Campanian to early Late Campanian?	Protection	McMillan	35 - 70 m	Sandstone; minor siltstone and shale
Early Campanian		Reserve	40 - 80 m	Sandstone, siltstone, shale and coal
Early Campanian		Cassidy	80 - 135 m	Sandstone and gritstone; minor siltstone
Early Campanian	Pender	Newcastle	30 - 60 m	Shale, sandstone, conglomerate and coal (Douglas and Newcastle seams)
Early Campanian		Cranberry	50 - 195 m	Shale and siltstone; conglomerate and sandstone
Early Campanian	Extension	Millstream	90 - 230 m	Conglomerate and gritstone; minor sandstone, siltstone and coal
Early Campanian		Northfield	0 - 45 m	Siltstone, shale, sandstone, gritstone and coal (Wellington seam)
Early Campanian	East Wellington		5 - 47 m	Sandstone; minor gritstone and siltstone
Santonian to Early Campanian	Haslam		65 - 150 m	Siltstone and sandstone (turbidites) at top, grading down to massive shale at base
Santonian to earliest Campanian?	Comox	Dunsmuir	0 - 120 m	Sandstone; minor siltstone, shale and coal (Blackjack seam)
Santonian		Cumberland	0 - 60 m	Sandstone and siltstone; minor shale and coal (Yellow Point seam)
Santonian to Turonian?		Benson	0 - 150 m	Conglomerate, red shale and pebbly siltstone

Muller and Jeletzky's stratigraphic nomenclature was used by most authors between 1970 and 1978, when a further modification was proposed by Ward (1978). Table 4-1-3, adapted from Cathyl-Bickford and Hoffman (1998), illustrates current practice in the Nanaimo basin, based on Ward's nomenclature with the addition of some members within the coal-bearing part of the Nanaimo Group.

4.1.2 Structure

Muller and Atchison (1971) describe the general structure of the coal measures as one of gently warped and northeast tilted fault blocks separated by northwest-trending faults. These northwest-trending faults are normal gravity faults, in most cases, downthrown to the northeast. Muller and Atchison refer to Buckham's (1947a) hypothesis that near-vertical faulting in the Pre-Cretaceous rocks may have resulted in less steeply dipping faults in the coal measures of the Nanaimo Group. They also advanced the idea that one single fault originating in the pre-Cretaceous volcanics diverges into several related faults in the sedimentary sequence, resulting in "fault slices with repeated sections of steeply-dipping Nanaimo beds."

Predominantly northwest-striking normal faults are the major structural features over most areas of Nanaimo Group deposition. The displacements on these major faults can vary from tens to hundreds of metres downthrown to the northeast. Locally, these normal faults are complicated by block-faulted zones of differential downwarping and uplift. These faults are sometimes are cut off by east trending faults with varying strike-slip displacements. In some areas, in particular the southern part of the Nanaimo basin, these cross-faults result in thrust belts where a low-angle compression component of thrust has folded the relatively plastic beds of the coalbearing formations into a series of anticlines and synclines. These folds are further complicated by low-angle shearing which migrates through the softer formations (*i.e.* the coals and shales) and dissipates some of the regional stress.

It is not within the scope of this report to accurately define the structure of the Nanaimo Group sediments. However, the depositional environments, in combination with structure, will be the major factors in determining the economic potential of future mineable areas of coal, and of potential coalbed methane resources. An example is the Quinsam area. The sedimentary basin which contains the significant deposits of coal around Middle Quinsam Lake is physically cut off from the rest of the Comox basin by a basement topographic high of exposed Triassic and older volcanic rocks. This basement high is fault bounded and elongate in a northwest direction, paralleling the major bounding structures. While the Comox coal measures were being formed, this topographic feature provided shoreline control. The resulting backshore and embayment area to the west (*i.e.* the Middle Quinsam area) was protected, forming a lagoonal environment conducive to the uninterrupted accumulation of vegetation. A similar situation exists at Tsable River. These two examples are easily recognized due to their location on the western margins of the area of deposition. Other similar structures no doubt exist at depth.

The correct interpretation of structural styles and the identification of this type of fault-bounded topographic depression will be key elements of exploration programs aimed at locating mineable reserves of coal. Structural style is equally important in the evaluation of coalbed methane potential where migrating gas can become trapped in porous reservoirs where impermeable shales have been thrust over the reservoir rocks.

4.1.3 General Coal Distribution

Figure 1-1 illustrates the general distribution of coal-bearing sediments of the Nanaimo Group on Vancouver Island. The distribution of coal measures in the submarine portions of the basin *(i.e.* under the Strait of Georgia) is not shown.

Stratigraphy, sedimentology and coal potential of the Comox, Extension, Pender and Protection formations are fairly well defined in the landward portions of the basins. Other isolated coal occurrences have been documented in some of the overlying or upper cycles but it is not known how extensive these are. Most of them are in the Gulf Islands. In light of their location their economic significance is dubious, and as such they are not discussed in detail.

The coal deposits of the Comox Formation (in the lowest cycle in the Nanaimo Group) are the largest in aerial extent. They occur as far north as the 50th parallel (Campbell River and Quinsam area) and south through Cumberland into the Fanny Bay area. With the more recent discoveries of Comox coals in the Nanaimo coal basin (Section 4.1.1) the inferred belt of Comox coal deposition is up to 150 kilometres long and as much as 20 kilometres wide. This is subject, of course, to substantial areas of erosion and non-deposition such as the major area barren of coal deposition referred to as the Nanoose arch (Bickford and Kenyon, 1988). The Nanoose arch separates the Comox coal basin to the north from the Nanaimo coal basin to the south.

As many as ten distinct coal seams within the Cumberland and Dunsmuir members of the Comox Formation have been identified by previous workers. Bickford and Kenyon (1988) have proposed a regional correlation of the coal seams as indicated in Table 4-1-4. There is some question as to how the Tsable River coals correlate to those of the Cumberland area. In all areas of Comox deposition, the seam closest to the Triassic basement rock is the thickest and best developed. Although it is true that frequent basement topographic highs interrupt the depositional continuity of this coal zone, it is still the best exploration target. Coal seams higher up in the sequence are generally thinner and are more prone to contain sandstone lenses and partings within the coal zone.

TABLE 4-1-4

CORRELATION OF COMOX COALS IN THE COMOX BASIN

	AREA				
MEMBER	QUINSAM	CHUTE CREEK	WOODHUS CREEK	CUMBERLAND	TSABLE RIVER
Dunsmuir	No. 4 seam	A and B seams		W seam	
	No. 3 seam	C and D seams		X seam	
				Y seam	
				Z seam	
				No. 1 (Upper) seam	No.1 seam
Cumberland	No. 2 seam		Upper seam	No. 2 (Farm) seam	No.2 seam
	No. 1 Rider seam		Lower seam	No. 2A seam	
	No. 1 seam			No. 3 seam	No. 3 seam
				No. 3A seam	
				No. 4 (Lower) seam	

Note: after Bickford and Kenyon (1988).

Coals of the Suquash basin and other outlying areas are more difficult to correlate. At Suquash, the thin, dirty coal seams that were first prospected and mined around 1850 have been correlated with Comox deposition. The rank of the coal is high-volatile C bituminous. Most of the Comox coals are high-volatile A or B. Whether the Suquash coals are directly correlative to the Comox, Extension, Pender or Protection formations, or younger than any of them, is unclear.

4.1.4 Coal Quality

Generally speaking, Vancouver Island coals are high-volatile A or B bituminous. They are ideal thermal coals for use in electric power generation and other industrial boiler applications. Compared to coals of similar rank from the interior of British Columbia, they exhibit a very low fines content (generally less than 30% minus 6 mm in the product) and resist breakage better, with Hardgrove index values ranging from 45 to 60. Most Island coals resist breakage during handling and this is especially true of most of the coal from the Comox coal basin. In the past coal mining era, Cumberland coal was prized as a stoker product for its properties of coarse resilience and high volatile content. Wellington seam coal from the Nanaimo mines also made an excellent stoker coal. Douglas seam coal, subject to much thinning and pinching with many areas of “rash”, or dirty sheared coal, was softer and did not stand up as well to handling.

Table 4-1-5 illustrates some of the common coal sizes produced in the Nanaimo mines (from Canadian Collieries monthly reports). The difference in character of the Douglas and Wellington seams of the Nanaimo coal basin is evident in the recoveries of the coarser premium coal sizes (No. 1 and No. 2 nut).

Some of the Cumberland coals exhibited coking qualities. Beehive coke ovens were operated for over 40 years at Union Bay. Similarly, Douglas seam coal from the southern part of the Nanaimo coalfield produced a good coke. The Granby Consolidated mine at Cassidy produced mostly coking coal for the company’s copper smelter at Anyox and other smelter operations along the coast and into the United States.

TABLE 4-1-5

COMMON SIZE SPECIFICATIONS AND WASHERY YIELDS, NANAIMO MINES

COMMERCIAL NAME	WASHED COAL SIZE inches	millimetres	% RECOVERY Wellington seam	Douglas seam
No. 1 nut	2.5 x 1.5	64 x 38	13.85	4.96
No. 2 nut	1.5 x 0.87	38 x 22	10.45	7.12
Pea	0.87 x 0.19	22 x 5	20.00	21.91
Washed smalls	0.19 x 0	5 x 0	25.61	32.26
Boiler smalls	0.19 x 0	5 x 0	6.64	6.04
Refuse	0.19 x 0	5 x 0	23.45	27.71

In specific areas, where the coals are in close contact with Tertiary intrusives, for example in the northwest part of the Cumberland field in the Anderson Lake and Browns River area, the coal seams are anthracitic, and most of the volatile matter has been driven off. None of these anthracites have ever been produced and sold, chiefly due to their high ash contents. Kenyon and Bickford (1989) suggest that some of coal rank variations in the Comox basin are due to later intrusive activity and possible hydrothermal alteration. They cite the example of anthracite in the Anderson Lake and Browns River area. Apart from this anomalous situation, however, the general trend of increasing coal rank from north to south in the Comox basin has been demonstrated by their work. They suggested two possible explanations for this trend: progressively deeper burial of the coals to the south of the Comox basin, or a higher geothermal gradient existed in the south end of the basin. In their studies of the Nanaimo coal basin, they did not detect a lateral rank increase.

Buckham (1947a) provided a range of product coal qualities for various mines in the Nanaimo and Comox basins, as shown in Table 4-1-6. For comparison purposes, a typical Quinsam coal specification is added to the table. Coking properties are not shown in this tabulation, however, some Comox coals demonstrated good coking quality. Quinsam coal has very weak coking properties.

TABLE 4-1-6

PRODUCT COAL QUALITY, SELECTED MINES
NANAIMO AND COMOX BASINS

	H_2O	ASH	V.M.	F.C.	S.	kcal/kg
NANAIMO						
Wellington seam						
Northfield mine	2.49	10.19	40.1	47.2	?	7192
Beban mine, Extension	1.78	11.5	39.0	47.7	?	7200
White Rapids mine	1.27	9.47	39.2	49.8	0.83	7362
Timberlands mine	2.06	6.46	37.8	53.7	?	7616
Douglas seam						
No. 10 mine, South Wellington	1.59	9.57	39.7	49.2	0.5	7187
COMOX						
No.2 seam						
No. 5 mine	1.14	11	34.5	53.4	2.12	7417
No. 8 mine	0.99	10.58	35	53.5	?	7492
Tsable River mine	1.2	15.61	36.1	48.3	1.91	6918
QUINSAM						
No. 1 seam	2.97	12.26	37.4	47.4	0.8	6639

Note: data from Buckham (1947a) except for Quinsam.

Generally speaking, coals of the Cumberland member are higher in sulphur content that those of the Nanaimo coal basin. Coals higher in the Comox Formation typically contain higher sulphur contents. Coals in contact with a sandstone roof of deltaic or near-shore origin usually are higher in sulphur than those in siltstone or mudstone sequences. The thinner seams are higher in sulphur than the thicker intervals.

Calcite, in the form of sheeting on cleat surfaces and thin laminations on bedding planes, is common in many coal areas. The amount of calcium oxide (CaO) in coal may approach 3% in some clean coal such as the Quinsam #1 seam (Ryan, 1994). The Wellington seam at Wolf Mountain also contains calcium oxide in excess of 2% in coal. Generally there is an inverse relationship between sulphur and calcite content and some of the higher sulphur seams have significantly lower calcite levels. Calcium oxide can affect the tendency of the coal to foul boilers and in this respect can be detrimental to overall coal marketability, however, the abundance of calcite helps to neutralize any acidity which may result from rapid oxidation of pyritic sulphur.

4.2 SUQUASH BASIN AND OUTLIERS

4.2.1 Stratigraphic Units, General Geology, Structure and Surficial Geology

Muller (1977) describes Upper Jurassic and Lower Cretaceous sedimentation in northwestern Vancouver Island as follows:

> "the eastward onlapping wedge of clastic sediments consists of upper Middle to Upper Jurassic, as yet unnamed sediments, the Lower Cretaceous Valanginian to Barremian Longarm Formation, and the Aptian to Cenomanian Queen Charlotte Group. The lower formations, mainly greywacke and siltstone, only occur in small areas along the west coast and are only a few hundred metres thick. Further east, the upper conglomerate is up to 1,000 metres thick and contains cobbles of volcanic rocks and of porphyritic granitoid rocks, presumably derived from high level plutons. Clearly these beds are of a clastic wedge, shed westward from the extinct but still elevated Jurassic volcanic arc."

The general range of southwesterly dips measured in the Lower Cretaceous sedimentary sequences around Coal Harbour and the Quatsino Sound area reinforces Muller's theories of eastward onlap during Lower Cretaceous time. Muller continues:

> "The Upper Cretaceous shelf sequence of the west coast is succeeded by the Upper Cretaceous Nanaimo Group of eastern Vancouver Island. Only in one place in the central northern part of the island are the two sequences believed to be in stratigraphic contact. Elsewhere Upper Cretaceous sediments overlie with marked unconformity pre-Cretaceous rocks including Jurassic Island Intrusions. The molasse-type coal-bearing marine and deltaic deposits of sandstone, siltstone, shale, and conglomerate contain Santonian to Maestrichian fossils ... the Early Cretaceous basin was on a shelf sloping southwestward to the Pacific Rim trench. The Upper Cretaceous "Georgia basin" was inboard of emerging Vancouver Island ranges and deepened to the northeast."

This difference between Lower and Upper Cretaceous sedimentary buildups is clearly evident in the field. In the Upper Cretaceous rocks of the Suquash area, measured dips are predominantly to the northeast and east, as opposed to general southwesterly dips measured in the Lower Cretaceous sediments in the Coal Harbour area. The significance of this can be found in the differing characteristics of the rock types in each of the areas, and more importantly, the characteristics of the coal seams. It also means that observations and conclusions drawn from the Upper Cretaceous sediments do not apply to Lower Cretaceous rocks, because the source areas for sedimentation are different.

Post-Cretaceous structural deformation in the northern Vancouver Island area is responsible for the preservation of both the Lower Cretaceous sediments around Coal Harbour, Quatsino and Holberg Inlet, and the Upper Cretaceous sediments of the Suquash area on the northeast coast. This deformation takes the form of major normal (gravity) faults, which, in many cases, are bounding features of sedimentary basins. The Cretaceous sediments are preserved on the down-dropped structural blocks. In many cases, this faulting occurs as a number of related 'step' faults. This is best exemplified along the southwest edge of the Suquash area, where two or possibly more subparallel northwesterly trending normal faults, represent the edge of the basin. Post-Cretaceous movements have resulted in minor folding. This folding is not clearly evident in surface exposures because the folds are generally gentle and broad with shallow dips, however, drilling in the Suquash area has confirmed their presence.

The northern part of Vancouver Island was subjected to glaciation during the Pleistocene, when glaciation covered Georgia Strait, Queen Charlotte Strait and the entire island with a continuous ice sheet originating on the mainland and flowing southwest (Muller, 1977). During the Pleistocene a number of glacial pulses originated from centres on Vancouver Island, and ice flowed outwards in all directions, especially down the major valleys such as the Nimpkish Valley, south of Port McNeill. Glacial erosion and scour occurred at the higher elevations, while varying thicknesses of glacial debris and outwash material were deposited on the lowland areas, in particular the relatively flat-lying sedimentary basins. This glacial deposition has masked the underlying sediments very effectively on northern

Vancouver Island, especially in the Suquash area, where unconsolidated overburden is known to be up to 100 metres thick. Surface exposures of Cretaceous sediments are thus few in number, and occur along the tideline where the erosive action of the sea has uncovered the bedrock, or along major fault contacts, where scarp lines occur.

4.2.2 Distribution of Coal-Bearing Rocks

Figure 4-1 illustrates the extent of Cretaceous sedimentary deposition on northern Vancouver Island. As described in Section 4.1.1, the Suquash basin is estimated to cover 425 square kilometres (Clapp, 1912a). In the area between Port Hardy and Port McNeill, the sedimentary deposits occur over a coastal strip of land, 4 kilometres wide and 32 kilometres long. The balance of the basin lies under the Queen Charlotte Strait, Broughton Strait and the western part of Malcolm Island. Muller (1977) considers the Suquash coal-measures to be of Campanian age, correlative with the Northumberland and DeCourcy formations of the Nanaimo basin (Table 4-1-2). Other outlying sedimentary deposits are Lower Cretaceous age. These sediments occur in the Coal Harbour area, the north shore of Holberg Inlet, Winter Harbour area, and along the north shore of Quatsino Sound (Figure 4-1).

4.2.3 Past Coal Mining and Known Coal Deposits

4.2.3.1 Suquash

James (1969) describes early developments at Suquash:

> "Indians of the Beaver Harbour area brought specimens of coal to Dr. W.F. Tolmie at Ft. McLoughlin in the year 1835. In 1847 the Hudson's Bay Company decided to open up a mine in this area to supply steamships with bunker fuel. A party of miners arrived from England in 1849, and mining was carried out on a limited scale until 1852. It is believed that the workings were in outcrops at Suquash, and that about 10,000 tons of coal was mined. The workings were abandoned after the discovery of richer deposits at Nanaimo."

While there is no evidence of these earliest workings, it is believed that they were located in a thin 0.5 to 0.8-metre coal seam which is exposed at low tide near the mouth of Suquash Creek. Boreholes drilled by Pacific Coast Coal Mines Ltd. in 1908 along the shore near the mouth of the creek identified a coal seam at a depth of 173 feet. James (1969) goes on to document development work done by this company:

> "A shaft was sunk 200 feet from the shoreline to the No. 2 seam. This shaft was a twin-compartment shaft 6 by 10 feet in the clear. Between 1909 and 1914 about 12,000 feet of development drivage was done in the seam. The workings extended 1,350 feet south of the shaft. Two pairs of dips headings were driven east northeast, one for 1,200 feet, or 1,080 feet beyond the shoreline, and the other for 500 feet. A longwall face 800 feet long was opened up to the south of the shaft on the landward side but was only worked on a very limited scale. A start was made on the sinking of a large new shaft 1,500 feet southeast of the original one. All work was suspended on the outbreak of World War I and was not resumed again until 1920. The original shaft was then unwatered and a considerable amount of location work was done on the surface with a view to handling a large production. However, in 1922 all operations ceased. According to reports, 12,000 to 16,000 tons of coal was mined in the period from 1909 to 1914 by Pacific Coast Coal Mines Ltd".

It is interesting to note that the entire operations of Pacific Coast Coal Mines Ltd., including its mines at Nanaimo, ceased and the company went out of business.

Much later, development was again attempted in the Suquash area. In 1952 a small, publicly traded company named Suquash Collieries Ltd. was formed to develop the coal reserves in the area. The old shaft was pumped out and some sampling of the seam was undertaken, however, actual mining operations never got underway and the leases were dropped.

4.2.3.2 Coal Harbour and Vicinity

The coal measures in the vicinity of Coal Harbour were known since the 1870s. Robertson (1899) states:

> "On the north-west Coast, near Quatsino Sound, coal has for years been known to exist, this area having been reported on by the Geological Survey in 1868, and again by Dr. G.M. Dawson, in the survey report for 1886. Seams of coal, 4 feet thick, were then reported and some little development work done, but this was later discontinued. In 1897, the West Vancouver Commercial Company

began development of certain areas in this district and is reported as having met with considerable success, and to be now sinking a shaft on a 5 foot seam, with some hundreds of tons of coal on the waste heap. Some 12 men are employed in this development work, and a steam hoist and other machinery have been erected".

"The coal measures also occur and have been somewhat prospected at Alert Bay on the northeast Coast, ... but so far none of the discoveries have received development sufficient to show their value."

Brewer (1900) states:

"At Quatsino, on the northwest Coast of Vancouver Island, the West Vancouver Commercial Company has opened up a number of coal seams, but has not, as yet, become a shipper."

Morgan (1901) states:

"Near the northwest end of the Island, in Quatsino Sound, there has been considerable activity in prospecting for both copper and coal during the past year. The Hallidie Syndicate, of San Francisco, has expended quite a considerable amount of capital in developing coal propositions, and it is reported that coal of a good grade is being mined from a five foot seam. If this proves to be a good coking coal, the West Coast of Vancouver Island will offer such advantageous opportunities for smelting (should the ore bodies prove of sufficient extent and grade) as can be found in but very few localities on the American Continent.

The coal fields on Quatsino Sound, West Coast of Vancouver Island, have this past summer received some systematic exploration - with what results has not yet been learned. This coal is of good quality and in fair-sized bed, but the measures are suspected of being faulted and the extent of the field has not as yet been well-defined. Should these coal areas prove of consequence they will have an important bearing on the Pacific Ocean carrying trade."

Leeson (1904) states:

"On the West Arm iron and coal deposits have been discovered, ... On the north side of the main sound and on Forward Inlet, coal formation occurs, some small croppings of a fine quality of coal being known on Winter Harbour, although none of sufficient size to work."

Robertson (1908) states:

"The fact that coal measures, and probably workable seams exist on the West Arm of Quatsino Sound has been known for many years, as the coal seams at Coal Harbour were at least partially prospected some years ago by a California company, which acquired the land and did a little work, but not enough to prove or disprove whether the seams were sufficiently extensive to permit their being worked."

Early attempts at development near the village of Coal Harbour occurred before 1900, and exploration and development work after 1900 moved to other areas, including further west along Holberg Inlet. This early work included the drilling of at least six boreholes and resulted in the sinking of at least three shallow shafts, which were subsequently abandoned. Some of these old workings were found in recent reconnaissance (Gardner, 1985b). Although at least two different coal zones were mined to a limited extent during this early work, less than 1 000 tonnes of coal were produced from the area. The reasons for this are not clear, but the relatively poor quality of the coal is the most obvious. Alfred Ilstad, an area resident for over sixty years, remembers a story about one of the coal-burning ships coming in to Coal Harbour to bunker coal for the trip to Vancouver. Apparently the captain had to stop somewhere along the coast to procure firewood in order to assist the combustion of the coal. On the return trip up the Vancouver Island coast, he related this and said that he would never bunker at Coal Harbour again.

4.2.3.3 Holberg Inlet

The area along the north shore of Holberg Inlet (or the West Arm, as it was earlier named) was prospected in the early 1900s. The following excerpts are from Leeson (1905):

"It is reported that a Mr. Pearson, of Vancouver, with three others, arrived by a recent steamer at the West Arm to bore for coal, but the extent of their intended operations has not been ascertained."

> "Mr. Pearson, of Vancouver, is steadily working on the West Arm, employing three to five men running tunnels and drilling for coal, but with what result is not yet known."

Developments in the Coal Harbour area are discussed by Robertson (1908) and the following is a précis of his comments.

> About midway along the length of the West Arm, on the north side, the coal-bearing formation crops out on the beach; these measures extend to the west almost the entire length of the Arm. For some years the Quatsino Coal Syndicate, under the management of Thomas. P. Pearson, had been prospecting for coal in this area, and, in 1905, put down three boreholes at what is known as Pearson's Lower Camp. The first hole was drilled near the beach to a depth of 47.5 metres; the second hole was sunk about 500 metres inland and was drilled to a depth of 66.4 metres, while the third hole was collared about 1.2 kilometres inland and was drilled to a depth of 12.2 metres. No coal of workable thickness was encountered; some 7 to 10 centimetre seams were intersected in the second hole and also some gas, but the workings were eventually abandoned.
>
> Mr. Pearson then moved westward along the Arm to within 5 to 8 kilometres of its western end, where he established his 'Upper Camp', and took up ten prospecting areas in the vicinity. On one of these areas he was able to locate a very fair seam of coal, somewhat impure at the outcrop but showing great promise. The point at which the coal outcrops is about 1.6 kilometres from the shore on the steep bank of Pearson Creek, 30 metres above the bed of the creek and 55 metres above sea level. The seam dips S. 30° W., at a moderate angle, into the bank and towards the arm.
>
> The work done consisted of an upper tunnel, a cross-cutting adit, which cuts a coal seam 24 metres from the portal; the outcrop of this seam is visible higher up in the hillside. At a somewhat lower level, the second reaches the coal at 33 metres from the portal. A slope in the coal connects the two levels and has been sunk about 8 metres below the lower level, and a drive about 45 metres long has been made in the coal along its strike. At the time of the report drilling was in progress to test the seam down dip.
>
> The seam, as exposed, lay under a clay-shale and over a sandstone; total thickness is 4.03 metres divided in three by clay partings 22 to 30 centimetres thick. The lowermost 91 centimetres is mixed black shale and coal. The three layers of coal seemed about the same quality and a sample representing the average of the upper part of the seam gave the following analysis: moisture 1.8%; volatile matter 30.67%; fixed carbon 19.63% and ash 47.9%.
>
> Robertson (1908) goes on to report:
>
> "It is premature, as yet, to predict what the future of the discovery may prove to be; it is a strong, well-defined coal seam, somewhat dirty where struck, but that trouble may disappear in a short distance. The area of the seam remains to be determined, which will require time, but as a prospect is such that a railway to the Arm and good shipping facilities could be easily and cheaply obtained. The management is going ahead slowly but surely, and within a year should have some interesting data to present."

Reports by Sherberg (1909) and (1910) indicate that Mr. Pearson continued to work on the property and activity continued in the area for another 3 years. Sherberg (1911) notes:

> "Development work has been carried on continuously during the past year by Thomas Pearson of Vancouver, on the coal property, situated on the West Arm of Quatsino Sound, owned by the Quatsino Coal Syndicate. The underground work has been extended to about 600 feet. In the latter part of September a diamond drill was brought here and work started on a coal property consisting of twenty claims situated on the north side of the main channel of Quatsino Sound, opposite Limestone Island. The Manhattan Coal Company, which owns a few coal claims on the south side, will be ready in about a week to start work on its property near Monkey Creek with a diamond drill."
>
> "On Vancouver Island, in addition to the areas actually being worked, there is a Cretaceous coalfield in the Quatsino Mining Division on Quatsino Sound now being developed by Mr. Thomas Pearson and associates, which gives promise of containing extensive beds of workable coal; prospecting workings have been in progress here for about four or five years, with considerable success."

Sherberg (1912) notes:

> "Under the management of Thomas P. Pearson, development work has been carried on continuously on the coal property owned by the Quatsino Coal Syndicate. The property is situated on the West Arm of Quatsino Sound. The underground work has been extended 800 feet. On the several other claims on the Sound very little work has been done during the year."

References to this early prospecting work abruptly cease in about 1912, and no further reference to the Holberg Inlet area could be found. There appears to have been no further exploration for coal at Holberg Inlet since this early activity.

4.2.4 Recent Exploration Activities

4.2.4.1 Suquash

In 1974, British Columbia Hydro and Power Authority acquired an option on the Suquash area from Cobre exploration Ltd. A detailed diamond-drilling program was carried out in the area northwest and southeast of the old Suquash Mine (Figure 4-2, boreholes S-74-01 to S-74-13). B.C. Hydro's apparent intent was to identify a minimum of 65 billion tonnes of coal in this area in order to satisfy requirements for a coal-fired generating station on Vancouver Island. The results of this drilling were apparently not very encouraging, as shortly afterwards, Hydro dropped all of the coal licenses in the Suquash area.

In 1979, Ramm Venture Corporation, a small Vancouver company, took out seventeen licenses covering most of the sedimentary basin adjacent to the old Suquash mine. This property was then optioned to Filtrol Corporation of Los Angeles, California which was looking for a source of coal to supply its Columbia cement plant at Bellingham, Washington. Filtrol drilled five rotary drill-holes in the area adjacent to the old Suquash minesite (Figure 4-2, boreholes SU-80-01 to SU-80-05). Again this exploration work was not encouraging and this company subsequently dropped its option on the property. Ramm Venture let the licenses lapse and since that time there has been no activity in the Suquash area. Currently there are no existing coal licenses or freehold rights in the area (Gardner, 1980).

A resource of 18.1 million tonnes is estimated for the Suquash basin (Figure 4-2).

4.2.4.2 Coal Harbour and Vicinity

There has only been one attempt at exploration work in the Coal Harbour area in recent years. This was by the same company, Filtrol Corporation, that drilled in the Suquash area in 1980. During the Suquash drilling, the drill rig was dispatched to Coal Harbour to test the near-surface showing on the north side of the harbour. Two shallow rotary holes were drilled, with negative results. The geophysical logs showed one relatively clean coal band approximately 0.8 metres thick, followed by a zone of shale and coaly shale approximately 2 metres thick, at a depth of 3.4 metres in the first hole. The second hole, located approximately 300 metres southwest of the first, showed the same zone at a depth of 10.7 metres and a thickness of 1.8 metres, however, the entire zone was of inferior quality, with a 1 metre coaly shale band within the zone.

In 1984 and 1985 the author undertook geological mapping at Coal Harbour on behalf of Texaco Canada Resources Ltd. Old mine workings and coal seam exposures were located and examined. The emphasis was moved along the north shore of Holberg Inlet, where two erosional remnants of sediment were mapped in some detail. Coal seam outcrops were located and sampled. Texaco applied for and received coal exploration licenses in this area with a view to drilling some holes. This work was never undertaken and the licenses were allowed to lapse (Gardner, 1984d; 1985b; 1985c).

A coal seam thought to be equivalent to the one prospected by Pearson & Associates (1905-1911) was examined and sampled during the 1984-85 work (Figure 4-2, locality No. 5). The gross thickness of this exposed coal zone was measured at 2.8 metres (Gardner, 1985 b). The section was analysed at greater than 50% ash, with much of the ash inherent within the seam. At a 1.6 density separation, yields were less than 20% to produce a 5 500 kilocalories product. In view of the inherently dirty nature of the coal and its difficult washing characteristics, no potential resources are estimated for this area.

4.2.5 Potential Coal Resources

4.2.5.1 Suquash

The previous exploration programs have negated the possibility of near-surface, or underground mineable coal reserves beneath land, except for an area to the south and east of the old Suquash mine. This 400 hectare area is possibly underlain by a dirty coal zone containing as much as 50% parting material and lying below a depth of 200 metres. The total thickness of the zone is shown by the drilling to be in excess of 3 metres, of which only about 1.5 metres can be expected to be clean coal. Using this 1.5 metre thickness, the *insitu* reserve potential under the land portion would be in the order of 9.1 million tonnes (assume no dip on the coal, a factor of 22 861 tonnes/hectare, and a density of 1.5 for coal).

Using a radius of influence equal to the distance between drill-holes S-74-06 and SU-80-01 to project to the seaward side of SU-80-01, an additional 9 million tonnes is estimated as an *insitu* reserve under the sea adjacent to borehole SU-80-01, bringing the total to 18.1 million tonnes. Given the depth to coal and the high percentage of waste material that would have to be mined with the coal, this drilling target is not attractive. However, there are some indications that the thickness and number of individual coal bands is increasing in a southeasterly direction. Additional exploration work could conceivably identify an area of clean coal, which would enhance the economics. This work would require off-shore drilling, which would be costly.

4.2.5.2 Coal Harbour and Vicinity

Due to uniformly steep dips, thin coal seams and lack of favourable structures such as anticlinal folds, the possibility of significant strippable coal resources in the Coal Harbour area is virtually nil. This conclusion is reinforced by the massive, thick-bedded conglomerate unit exposed immediately above the uppermost coal zone, on the east side of Coal Harbour. The data collected in the Coal Harbour and Holberg Inlet areas to date indicate that underground coal mining here is not attractive. This is primarily due to the extremely dirty nature of the coal seams, but complex structure is also indicated.

4.2.5.3 Winter Harbour and Vicinity

The Winter Harbour area was prospected for coal between 1886 and 1911 and some diamond drilling was undertaken. No drill-logs are on file for these holes. No coal occurrences have been identified in the Winter Harbour area in recent reconnaissance work by the author. Thick-bedded conglomerates cover most of the sedimentary area and, farther inland, these rocks are in direct unconformable contact with the Triassic Karmutsen Formation. The lack of observed coal occurrences and the absence of any reference to coal exposures in the early records indicates that the area is probably a poor exploration target.

4.2.6 Coal Quality

Notwithstanding the abundance of shale and dirt bands within the coal seams at Suquash, the rank of the coal is that of high-volatile bituminous B or C, which is slightly lower than that of the coals of the Nanaimo and Comox basins. Some early work is documented by Dowling (1915). Dowling's analytical results are presented in Table 4-2-1.

TABLE 4-2-1

SUQUASH OUTCROP COAL QUALITY

	LOCALITY		
	South of Kliksiwi [Cluxewe] River	Suquash	Kiuk River
Hygroscopic water %	3.65	5.03	3.68
Volatile combustible matter %	42.23	41.51	39.29
Fixed carbon %	39.84	46.52	47.03
Ash %	14.28	6.94	10.00

Note: data from Dowling (1915).

The following statements are taken from Dowling's report:

> "From small seam of coal on stream about three-quarters of a mile south of mouth of Kliksiwi [Cluxewe] River. This coal produces a coherent but tender coke, and is considerably acted on by a solution of caustic potash."
>
> "From Suquash. This coal yields a moderately firm coke, and is considerably affected by a solution of caustic potash, yielding a brownish-yellow colour, like the last ... From a thin seam at Kiuk River. This coal yields a firm coherent coke, and is scarcely affected by a solution of caustic potash."

Table 4-2-2 summarizes analyses of samples from the 52 metre (170 foot) level of the Suquash mine.

TABLE 4-2-2

SUQUASH MINE COAL QUALITY

Grab sample taken from the foot of the shaft:			
PROXIMATE ANALYSIS:	As Received basis, %	Capacity Moisture basis, %:	
Moisture	5.7	9.0	
Ash	11.0		
Volatile Matter	36.2		
Fixed Carbon	47.1		
Calorific Value (kcal/kg)	6 433		
(BTU/lb)	11 580		
ULTIMATE ANALYSIS:			
Sulphur	0.98		
From a channel sample of coal representing 120 cm in a total seam thickness of 198 cm; all heavy partings discarded:			
PROXIMATE ANALYSIS:	As Received basis, %:	Capacity Moisture basis, %:	Dried basis, %:
Moisture	8.7	9.0	0.0
Ash	9.0	9.0	9.8
Volatile Matter	36.0	35.9	39.4
Fixed Carbon	46.3	46.1	50.8
Calorific Value (kcal/kg)	6 222	6 200	6 811
(BTU/lb)	11 200	11 160	12 260
ULTIMATE ANALYSIS:			
Sulphur	0.4	0.4	0.4
FUEL RATIO (F.C./V.M.):	1.3		
COKING PROPERTIES:	agglomerating; FSI 1.5; soft, weak coke.		
CLASSIFICATION:	high-volatile C bituminous		
Dry, mineral-matter-free fixed carbon:	56.9		
Moist, mineral-matter-free calorific value:	6 956 kcal/kg (12 520 BTU/lb)		
Dry, mineral-matter-free calorific value:	7 644 kcal/kg (13 760 BTU/lb)		

Note: data from Hope Engineering Ltd. (1953).

These analyses indicate that other coal seams in the Suquash basin may be of similar quality to the worked seam at the 52-metre level in the Suquash mine. It is difficult to arrive at a firm conclusion on the overall quality of coal in the Suquash area, considering the lack of data.

4.3 COMOX BASIN

The Comox basin is the largest and most important area on Vancouver Island in terms of remaining coal resources. This is because the Nanaimo basin (the second important area) was so heavily mined in the past that most of the coal resources were worked out.

The Comox basin stretches from the 50th parallel at Campbell River, south as far as the Parksville area, a distance of approximately 120 kilometres (Figure 1-1). Its average width is 13 kilometres and it is seldom wider than 40 kilometres. It is separated from the Nanaimo basin by the Nanoose arch. The southern one-third of the basin (from Fanny Bay to Parksville) is covered by a thick blanket of glacial outwash and till deposits which makes exploration work difficult and expensive. Ground surface elevations in sedimentary basin range from sea level to 300 metres, although some uplifted erosional remnants reach the 600 metre elevation.

The basin extends eastward beneath the Strait of Georgia for an undetermined distance. There are sedimentary rocks of Late Cretaceous or Tertiary age in three areas on the eastern side of the Georgia Strait: at Gillies Bay on the west side of Texada Island, at Lang Bay a few kilometres south of Powell River on the western coast of the Mainland, and at Scuttle Bay on the Sliammon Indian Reservation a short distance to the north of Powell River (Gardner, 1978). The Gillies Bay deposit has been placed in the Upper Cretaceous Nanaimo Group by earlier workers (Muller and Jeletzky, 1970), however, its relation to the massive limestone complex in the northern part of Texada Island and Triassic Karmutsen Formation, which dominates the southern two-thirds of Texada Island is not well known. However, the presence of these sedimentary deposits indicates that the basinal area of the Comox Formation probably extended right across the Georgia Strait during Cretaceous/Tertiary time.

The Cumberland coalfield is located midway along the length of the Comox basin, centred just east of Comox Lake. North of Browns River, the basin has been broken by a large Tertiary laccolith that forms Constitution Hill. Farther north in the Campbell River area, the landward portion of the basin widens out. A small coalfield, known as the Middle Quinsam area, hosts an important coal reserve now being developed at the Quinsam mine (Section 4.3.6.1). The Middle Quinsam area is separated from the wide lowland sedimentary area by a prominent ridge of Triassic Karmutsen basalt.

4.3.1 Stratigraphic Units and General Geology

Table 4-1-2 identifies the major stratigraphic divisions within the Comox basin. The chief coal-bearing formation is the Comox Formation (in the first cyclothem). From the top down, the formation consists of the following three sub-divisions:

- Dunsmuir Member: Primarily medium to coarse-grained sandstones representing near-shore beach and barrier bar deposits, the Dunsmuir Member varies from 90 to 240 metres thick. It contains several thin coals but they are generally dirty and high in sulphur.
- Cumberland Member: This is the primary coal-bearing unit in the Comox basin and consists of sandstones and siltstones, with minor shales and coal. The unit is up to 150 metres in thickness (Bickford and Kenyon, 1988). Sandstones dominate the upper part of the member, with siltstones forming the lower portion.
- Benson Member: This unit consists of readily identifiable cobble and boulder conglomerates resting unconformably on the old Triassic erosional surface. It primarily represents Cretaceous valley fills and river channel deposits. It is up to 300 metres thick (Bickford and Kenyon, 1988).

Overlying the Comox Formation is the Trent River Formation. It is primarily dark shales and correlates with the Haslam shales of the Nanaimo basin. There are some localized coarser resistant units within the formation. England (1989), Kenyon and Bickford (1989) and Bickford *et al.* (1990) recognised several members within the Trent River Formation in the Comox sub-basin. From the top down, these are:

- Royston Member: Kenyon and Bickford, (1989) proposed the name Royston Member to replace the Pender Formation which is not identifiable in the Comox basin. It consists of 150 to 220 metres of dark grey to olive-drab mudstone, siltstone and fine-grained sandstone, containing numerous ammonite and bivalve fossils.
- Tsable Member: England (1989) introduced this unit which represents a ridge-forming conglomerate member 40 to 140 metres thick exposed between Cumberland and Royston. It pinches out to the northwest (not found north of the Puntledge River) and southeast (less than 5 metres thick on the Trent River). The Tsable Member is interpreted as a submarine canyon fill (Kenyon and Bickford, 1989) due to the presence of intraclastic

breccia, composed of fragments of sedimentary rock similar to those of the Comox Formation, within the lower part of the member.

- Browns Member: a ledge-forming sandy unit mainly in the north part of the Cumberland basin (north of the Cumberland coalfield). It consists of bioturbated sandstone and siltstone and contains abundant bivalve fossils. Bickford and *et al.* (1990) suggest that the Browns Member is erosionally truncated on its southern contact with the adjacent Tsable Member. The Browns Member is up to 20 metres thick and represents off-shore sandbar deposition.

- Puntledge Member: up to 150 metres of dark marine shales and siltstones containing numerous ammonites and bivalves.

At least 600 metres of the above sediments are preserved in the landward portion of the Comox basin in the Royston area. This thickness of sediments is documented by old boreholes in the Royston and Tsable River areas. Recent drilling by Nova Corporation in the Black Creek area between Courtenay and Campbell River also identifies at least 600 metres of Comox and Trent River sediments.

In general, the beds of the Comox Formation dip gently to the northeast at angles between 4° and 24°, depending on proximity to the Beaufort Range front. Some of the major normal faults within the Comox Formation have vertical displacements greater than 100 metres. Bickford *et al.* (1990) identified several major low-angle extensional fault features in the Mount Washington, Trent River and Tsable River areas. These faults follow the pre-Cretaceous erosional surface and locally splay upwards into the softer, more plastic mudstones and coals of the Cumberland member and the soft shales of the Trent River Formation.

4.3.2 Distribution of Coal-bearing Sediments

The coal-bearing sediments of the Cumberland and Dunsmuir members of the Comox Formation can be confirmed in old boreholes, early geologic mapping by Richardson (1872), Clapp (1912b), McKenzie (1922), and Buckham (1947a) and by more recent mapping undertaken by the British Columbia Ministry of Energy and Mines (Kenyon *et al.*, 1991; Cathyl-Bickford, 1992a; Cathyl-Bickford and Hoffman, 1992; 1998). Comox Formation coal-measures extend northward from Wilfred Creek (5 kilometres south of Tsable River) to Upper Campbell Lake. The outcrop trace of the coal-measures varies locally, but generally parallels the 300 metre elevation along the foot of the Beaufort Range, with the exception of a few structurally-elevated remnants and outliers.

Figure 1-1 illustrates the extent of part of the coal-bearing formations in the Comox basin. Correlation of Comox coal seams within the Comox basin is shown in Table 4-1-4 (following Bickford and Kenyon, 1988). In keeping with earlier practice in the Comox basin, coal beds in the Dunsmuir Member are designated W through Z and No. 1, in order from top down, and coal beds in the Cumberland Member are designated No. 2 through No. 4, in order from top down. The following general description of the coal seams is based mainly on Bickford and Kenyon's work at Cumberland:

- The W, X, Y, and Z coal seams are spaced roughly equally throughout the top two-thirds of the Dunsmuir Member. These coals are typically 30 centimetres thick.

- The No. 1 seam is about 25 metres above the base of the Dunmuir Member. Its thickness, 0.75 to 2.1 metres, is consistently greater than that of the overlying coals. The roof of the No. 1 seam is a strong massive sandstone and the floor is a dark grey shale.

- The No. 2 seam is the most persistent of the Cumberland coals. It consists of 0.75 to 1.5 metres of dull and bright coal with thin bands of hard, black carbonaceous shale. Its roof is a hard, but fissile, dark grey carbonaceous siltstone and its floor is a strong, light grey, rooty, sandy siltstone. A correlative bed in the Tsable River coalfield (there also known as the No.2 bed) has a thickness of 1.8 to 4.2 metres. Coal occurs at this stratigraphic level in the Quinsam coalfield, as the Quinsam No. 2 (averaging 1.5 metres) and Woodhus Creek Upper (averaging 1.6 metres) seams.

- The No. 2a seam consists of 0.3 metres to 0.6 metre of coal, with a roof and floor of siltstone. It thickens to the north and is best developed north and west of the Oyster River. It is tentatively correlated with the Woodhus Creek Lower (up to 3.6 metres thick) and the Quinsam No. 4 (averaging 2.9 m. thick) seam.

- The No. 3 seam consists of 1.3 to 1.6 metres of coal and partings of dirty coal and sandstone. It has a hard sandstone or shale roof and a sandstone floor.

- The No. 4 seam is the thickest coal at Cumberland, but its distribution is interrupted by basement paleohighs projecting up as hills above the level of the coal bed. It consists of 1.2 to 2.4 metres of dull and bright coal, with thin dirt bands, chiefly of black coaly shale. Its roof is a weak carbonaceous shale and its floor varies from pale green seat-earth mudstone to brown ferruginous siltstone. Boreholes in the Royston area and areas around Tsable River indicate that the lower bed (No. 4 seam) is locally up to 4 metres thick.

4.3.3 Coal Quality

The coal quality of the Cumberland coalfield is discussed in Section 4.1.4. Comox basin coals generally have a rank of high-volatile bituminous A or B, which is ideally suited to thermal power generation. They have some coking properties that lend themselves to a blend metallurgical coal or the semi-soft coking coal market. Even though the Free Swelling Index of some of these coals is high (7.5 to 8.0), the high percentage of inherent ash in the seams usually causes poor yields when washing to a less than 10% ash product. Other properties, such as high sulphur content in some instances, also affect their marketability as pure coking coals.

4.3.4 Coal Rights Ownership

In 1985 the area in the Comox basin under fee simple ownership or as coal exploration licenses totalled 75 060 hectares (185 480 acres). This represented the maximum extent of coal land holdings in the Comox basin at any time since the 1977 removal of the moratorium. Figure 4-3 illustrates the current status of coal rights ownership in the Comox basin, based on information provided at the Office of the Gold Commissioner (Ministry of Energy and Mines) and the Land Titles Office. Ownership is summarized in Table 4-3-1.

TABLE 4-3-1

COAL LAND HOLDINGS
IN COMOX BASIN AS OF 1985

WELDWOOD OF CANADA LIMITED	
Freehold coal rights	34 000 ha
Coal exploration licences	2 950 ha
Freehold land leased out	600 ha
TOTAL	37 550 ha
QUINSAM JOINT VENTURE (WELDWOOD AND BRINCO MINING LTD.)	
Freehold coal rights	13 150 ha
Coal exploration licences	2 850 ha
TOTAL	16 000 ha
CANADIAN OCCIDENTAL PETROLEUM LTD.	
Applied for lands	16 200 ha
NUSPAR RESOURCES LTD.	
Coal exploration licences	2 250 ha
Option on freehold land	400 ha
TOTAL	2 670 ha
ESSO RESOURCES LTD.	
Applied for lands	2 670 ha
TOTAL COAL LAND HELD	75 060 ha

Note: areas calculated from 1:50 000-scale NTS maps.

Since the provincial government amended the Coal Act in 1987, work commitments to hold coal exploration licenses were waived in favour of a simple annual license fee. This has had a dampening effect on the amount of exploration work which has taken place. The extent of coal rights ownership in the Comox basin has declined in the past ten years. This is due to a number of factors:

- The world oversupply for thermal and metallurgical coal, which took hold in the early 1980s, caused a rapid and prolonged decline in the average selling price of coal. This factor seriously affected the overall economics of new coal developments, not just on Vancouver Island, but in most coal producing areas;
- The general change in corporate philosophy of the major petroleum companies to concentrate on their core businesses of petroleum exploration, development and marketing, thus divesting themselves of many peripheral businesses such as minerals development and alternate fuels including coal;
- Exploration work by some companies, notably Canadian Occidental Petroleum Ltd., has failed to produce results indicating that economic coal seams exist in some of the areas of the Comox basin;

4.3.5 Previous Exploration Work

Since Weldwood of Canada Limited began a detailed evaluation of its coal rights in the E & N Railway Belt in 1973, exploration of the coal measures in the Comox basin has continued somewhat sporadically. This is due, in part, to the dominant position Weldwood has in controlling most of the lands with potential for economic reserves. Some of the areas which Weldwood surrendered to the Crown were re-applied for by various companies, and these areas have received varying amounts of exploration work during the past 15 years.

4.3.5.1 Weldwood of Canada Limited

Weldwood’s initial exploration program, completed in 1973 to 1975, was regional in scope and covered the entire Comox basin, and to a limited degree the Nanaimo basin (Curcio, 1975; 1979). The work consisted of field mapping of structure, followed by a program of widely spaced random drilling, intended to confirm the results of the Canadian Collieries (Dunsmuir) Ltd. diamond drill-holes completed between about 1900 and the 1950s. The work program was intended to provide a basis for evaluating Weldwood's extensive land position, with a view to trimming it down and providing a focus on areas offering the best coal mining potential. The study identified the following resources:

- Seven to eleven million tonnes of coal tailings from old mining operations in the Cumberland area..
- Substantial sand and gravel deposits.
- Undetermined amounts of coal in the ground.

Based on the results of the Weldwood exploration work, the following conclusions were drawn:

- The intensity of coal mining in the vicinity of Nanaimo during the past century had exploited most of the easily recoverable coal resources; waste-pile and gravel resources were of minimal value - therefore, the whole of the southern area could be surrendered to the Crown.
- Abundant gravel deposits and known underground coal resources, with potential for additional surface and/or underground coal reserves indicated that the Union Bay area (the central part of the E. & N. Grant) should be retained, although areas highly populated, or underlain by deeply buried coal, could revert to the Crown.
- Large unexplored areas of the Comox Formation, with some indications of near-surface coal north of Comox as far as Campbell River, put this area ahead of others in terms of possible development.

Weldwood decided to continue the evaluation of its coal resources by concentrating its exploration efforts in the northern reaches of the E & N Land Grant, around Campbell River. Some re-evaluations of the regional geologic data and misplaced records of surface and subsurface ownership prompted Weldwood to re-acquire some of the area it had initially surrendered in 1974. This the company had to do in the form of coal exploration licenses, which carried annual work commitments in order to keep the licenses in good standing. The company has been performing the necessary exploration work annually for a number of years in order to keep these licenses. Since the regional program in 1975, very little work has been done on the freehold areas, except those included within the Quinsam joint venture.

Other companies have become active since the lifting of the moratorium on coal licensing on Vancouver Island in 1978. Coal licenses have been applied for but not received in many areas, pending the government resolving possible land-use and environmental issues.

Weldwood continued to maintain all of its fee-simple lands throughout the period 1976 to 1987. By 1983, some of its areas that were held under coal exploration license required additional work credits in order to maintain them in good standing. Small drilling and mapping programs were undertaken on these licenses in 1983, 1984 and 1985 (Gardner, 1983a; 1983b; 1985e). The most important of these were the Hamilton Lake coal licenses, about 6 kilometres southwest of Cumberland, where coal seams are exposed near the Cumberland water supply reservoir at Hamilton Lake (Section 4.3.6.4).

4.3.5.2 Luscar Ltd. (Quinsam Joint Venture)

Following completion of Weldwood's regional exploration program, the company decided to bring in an operating partner with coal mining expertise in order to further the exploration thrust and focus in on the northern part of the Comox basin. In 1976, Luscar Ltd. and Weldwood formed Quinsam Coal Ltd., a joint venture partnership, and started exploration in the Middle Quinsam area.

Phase I of the exploration work consisted of surveying a baseline that roughly paralleled the formation strike (55° west of north) and producing 1:2 400-scale topographic maps using air photogrammetry. Drilling and coring operations were then conducted on a grid. Air-rotary drilling using a downhole percussion hammer, followed by geophysical logging, provided the initial data points for the construction of geologic cross-sections. These air-rotary holes were drilled on a spacing of 300 metres on grid lines 460 metres apart. Infill coring was then initiated between the drillholes, closing the spacing down to 150 metres on the grid lines. Only the coal seams, together with a small amount of roof and floor rock, were cored. Core points were interpreted from the cross-sections that had been produced from the initial air-rotary drill-holes.

Phase II work consisted of more detailed drilling and coring, and bulk sampling. Phase II drilling and coring was designed to close down the spacing in the grid to 75 by 150 metres. This was accomplished by infill drilling on the existing grid lines, and the completion of additional grid lines every 75 metres. The same method of air-rotary pre-drilling to core points was used in this phase. Open-pit bulk samples were taken from the outcrop of each of the three main coal seams. These bulk samples were designed to augment the coal-quality data resulting from the grid pattern coring work. Other work, such as geotechnical and groundwater evaluations that did not fall into the context of exploration work but that were necessary in contributing to a feasibility study that would determine the economic viability of the deposit, was also undertaken during Phase II. As discussed in section 3.2.6, Luscar terminated the joint venture arrangement with Weldwood Canada Limited in 1980.

4.3.5.3 Brinco Mining and Hillsborough Resources Ltd.

From the beginning of its involvement in the Quinsam project in 1981, Brinco Mining Ltd. advanced the project through an addendum to the Stage II submitted by Luscar and a public inquiry process instituted by the Provincial Government Coal Guidelines Steering Committee. The Stage II phase consisted of detailed environmental and social impact studies which prepared the project for the mine permitting phase. In conjunction with these detailed environmental and social impact studies, Brinco also completed two feasibility studies and other detailed engineering work and mine planning. Important community relations work also contributed strongly to the overall status of the project.

By 1981, the importance of the Quinsam deposit and its potential impact on the future of Vancouver Island coal development was being recognized in industry and government circles. However, its sensitive location and the lack of other operating coal mines on Vancouver Island, dictated that due diligence on the part of the regulatory and permitting authorities was of great importance. The success or failure of the Quinsam project would have lasting impact on future planned developments in other areas on Vancouver Island. Exploration work on the Quinsam property continued sporadically throughout the 1980s as development and mining permits were being sought, but it was mostly confirmatory work.

In 1990 and 1991, Consolidated Brinco, through its sister company Western Canadian Mining Ltd., performed approximately $600 000 of exploration drilling on Weldwood fee simple lands south of the Tsable River area. This represented the first major exploration program on Weldwood lands since the completion of the Quinsam program in 1980.

Later in 1991, Brinco Mining merged with Hillsborough Resources Ltd., a division of Canadian Mine Development Ltd. Hillsborough then began vigorous development of the Quinsam mine with a view to developing it totally as an underground operation. With this in mind, the company spent $500 000 in 1992 on exploration drilling and coring to provide additional information on structure and coal quality in the underground portions of the area, which had received only a minor amount of work previously (Gardner and Lehtinen, 1992). In 1994, with assistance from the provincial government in the form of an Accelerated Mine exploration Grant through the Explore B.C. Program, Hillsborough drilled additional step-out holes down dip to confirm the continuity of the No. 1 seam.

4.3.5.4 Canadian Occidental Petroleum Ltd.

Canadian Occidental Petroleum Ltd. (CanOxy) emerged as the second-largest coal rights owner behind Weldwood, by pursuing an aggressive program of coal license acquisition in the early 1980s (Figure 4-3). By 1985, CanOxy had acquired or applied for approximately 16 200 hectares (40 000 acres) of lands from Campbell River south as far as Fanny Bay. Most of this land was previously part of the Weldwood coal rights which were surrendered in the mid 1970s. The lands applied for consisted primarily of the down-dip extension of the coal measures to the east of the Weldwood fee-simple blocks (Gardner, 1985a). A substantial block of coal exploration licenses in the northern part of the Alberni Valley was also acquired. CanOxy obtained a joint venture partner, Toyomenka Canada Ltd. (Tomen), a Japanese trading company with varied interests in coal and minerals in western Canada. During the period 1985 to 1994, three substantial exploration programs were performed by CanOxy and Tomen. None of these programs was successful in identifying mineable reserves of coal, although some holes intersected seams of mineable thickness. Subsequent to this work and due to the refocusing of Canadian Occidental into its key businesses of oil and gas production and chemicals, the company liquidated its coal and industrial minerals division.

Lanterman Creek

Approximately $85 000 was expended on a drill program by CanOxy at Lanterman Creek in the Alberni Valley in April and May 1985. A total of 1 076.5 metres of drilling was completed in ten rotary-drill-holes and one core hole. This drilling was conducted in the general area of the original Hudson Bay Oil and Gas drilling in 1979, and confirmed the lack of a mineable coal seam in the upper Alberni Valley.

McIvor Lake

In 1987, CanOxy acquired 1508 hectares of coal exploration licenses in the McIvor Lake area, just west of the City of Campbell River. In the fall of 1988, the company drilled eight rotary drill-holes (two of which were cored) for a total drilled metreage of 1708 metres of drilling at a cost of $150 000. The company also completed over $50 000 of environmental baseline monitoring and impact studies.

Tsolum River

In 1988, CanOxy acquired coal exploration licenses covering 14 345 hectares over a 50 kilometre length from the City of Courtenay to the Campbell River airport. The property generally followed the course of Tsolum River, from which it took its name. In 1993, a shallow reflection seismic program was undertaken in order to identify drilling targets. In February and March 1994, six drillholes totalling 1 945 metres were completed. Total costs of this work approximated $250 000.

4.3.5.5 Ramm Ventures Corporation

In 1979, Ramm Ventures Corporation, a Vancouver public company, acquired ten coal licenses in the Ash River area of the northern Alberni Valley. This company subsequently farmed out the licenses to Hudson Bay Oil and Gas Ltd. which performed $150 000 worth of drilling on the land. The exploration drilling was not successful and the licenses were allowed to lapse (Gardner, 1984b). The ground was later acquired by Canadian Occidental Petroleum Ltd. who undertook additional exploration drilling in the area which was also negative.

4.3.5.6 Nuspar Resources Ltd.

In 1980, Nuspar Resources Ltd., a small public company based in Victoria. Nuspar Resources acquired an option on the Chute Creek coal licenses from Sulpetro Ltd. (Figure 4-4A). The Chute Creek license area was ground that was once held by Weldwood, explored by Luscar Ltd. in 1977 and surrendered to the Crown. Subsequent to this, Sulpetro Ltd. acquired the ground as coal exploration licenses. Nuspar also optioned a 409 hectare (1 010 acre) parcel of land on the Iron River, known, as Lot 242, from Kaiser Aluminum Inc. This parcel abutted on the Quinsam coal project lands and in fact received drilling by Luscar in 1979. At the time the title status had not been correctly identified.

Nuspar's program of drilling and trenching at Chute Creek identified a 2.02 million tonne reserve of coal (Section 4.3.6.3). Approximately 3.8 million tonnes of coal were identified on Lot 242 and Nuspar drove an adit into the seam to obtain a bulk sample. In 1987, Brinco acquired Lot 242 from Kaiser Aluminum when Nuspar did not meet its option commitments.

4.3.5.7 Shanoro Development

In 1983, Shanoro Development acquired an option on Weldwood land in the Cowie Creek area just south of Tsable River. This company did not proceed with any exploration work and the option was extinguished.

4.3.6 Known Coal Deposits

In order to qualify the discussion on known and potential coal resources in this section and the one following, it is necessary to define a reserve classification system. The system used for this report is widely used by coal mining companies in Canada and the United States (Table 4-3-2). It provides the framework for categorizing coal reserves in the following pages. The use of this system is directed toward identifying the best exploration targets. These are usually the targets which have the largest potential resources, although this does not hold true in all cases.

TABLE 4-3-2

COAL RESERVE CLASSIFICATION SYSTEM

A. PROVEN RESERVES:	Reserves which have been developed to a confidence level to permit meaningful engineering plans for mine construction and development.
1. PROVEN, **Measured:**	No further drilling is considered necessary prior to mine commitment.
2. PROVEN, **Indicated:**	That portion of a proven reserve where minor engineering questions could arise which would require some additional drill holes.
B. ULTIMATE RESOURCES:	Resources believed to exist but which require additional drilling or test-pit development prior to mine design.
1. ULTIMATE, **Inferred:**	Drilling and geological mapping have developed the reserve accuracy to a point where a mineable reserve is probable. Extensive additional drilling is required.
2. ULTIMATE, **Hypothetical:**	Geologic mapping and scattered drilling indicate the presence of a coal seam or seams of thickness sufficient to be mineable.
3. ULTIMATE, **Speculative:**	Coal-bearing formations exists which are known to contain coal seams sufficiently thick to be mineable, as determined by regional and adjacent geological information.

A critical factor in determining the value and potential mineability of a coal deposit is the thickness of the coal seam. Although coals as thin as 1 metre are commonly mined by underground methods in various parts of the world, factors such as proximity to markets, relative demand, and the degree of subsidization come into play. It is the author's opinion that seams less than 1.5 metres thick are not economic to mine by underground methods at today's prices (even though the technology is available). This will probably hold true in the short and medium terms. For the purposes of this study, a minimum seam thickness of 1.5 metres is used as the cut-off for establishing a known or potential resource. However, this cut-off has not been applied to certain low-ratio, small scale open-pit deposits documented in the study.

As a result of the previously documented exploration work, several coal deposits have been identified in the Comox coal basin. With the exception of the Middle Quinsam and the Tsable River deposits, the other deposits are less than 10 million tonnes in size with limited potential for expansion.

4.3.6.1 Middle Quinsam Deposit

Of all the current exploration targets in the Comox Basin, the Middle Quinsam deposit has received by far the most exploration work. Although its total extent has not yet been clearly defined, it represents the largest undeveloped coal reserve in the Comox coal basin and on Vancouver Island (Eastwood, 1984).

Recent reserve calculations by Quinsam and its new equity partner, Marubeni Corporation place the total *insitu* proven mineable reserve at 38 million tonnes (Figure 4-4B). Earlier reserve estimates by Luscar Ltd. and others had suggested 44 million tonnes proven. This had included substantially more open pit mineable coal, especially in the thinner No. 2 and No. 3 seams. Potential surface and underground mineable reserves on the property estimated by the author in 1985 are summarized in Table 4-3-3. Those underground resources classified as B-2 (ultimate-hypothetical) are in the area between the Echo No. 3 borehole, the Miller No. 1 borehole and beneath pit 7S, where some deep holes indicate a No. 1 seam of mineable thickness beneath the surface-recoverable No. 3 seam within the boundaries of the pit.

TABLE 4-3-3

MINEABLE COAL RESERVES, MIDDLE QUINSAM MINING BLOCK

AREA	CATEGORY A	CATEGORY B	COAL SEAM	MINEABLE TONNES (in millions, dry basis)	OVERBURDEN / CLEAN COAL RATIO (cubic metres / tonne)
SURFACE RECOVERABLE COAL RESERVES					
Pit 3N	A-1		No. 1 seam	5.539	
Pit 3N	A-1		No. 2 seam	1.334	
Pit 3N	A-1		No. 2R seam	0.369	
Pit 3N	A-1		TOTAL	7.242	19.88:1
Pit 2N	A-1		No. 1 seam	2.906	
Pit 2N	A-1		No. 1R seam	0.475	
Pit 2N	A-1		No. 2 seam	0.176	
Pit 2N	A-1		TOTAL	3.557	25.2:1
Pits 1S, 2S and 3S	A-1		No. 1 seam	2.936	
Pits 1S, 2S and 3S	A-1		No. 2 seam	0.699	
Pits 1S, 2S and 3S	A-1		TOTAL	3.635	14.07:1
Pit 4S	A-1		No. 3 seam	2.174	
Pit 4S	A-1		TOTAL	2.174	19.87:1
Pit 5S	A-1		No. 1 seam	0.53	
Pit 5S	A-1		No. 1R seam	0.099	
Pit 5S	A-1		No. 2 seam	0.037	
Pit 5S	A-1		TOTAL	0.666	27.98:1
Pit 6S	A-1		No. 3 seam	1.002	
Pit 6S	A-1		TOTAL	1.002	25.27:1
Pit 7S	A-2		No. 3 seam	4.000	
Pit 7S	A-2		TOTAL	4.000	unknown
			GRAND TOTAL ALL PITS	21.905	
UNDERGROUND COAL RESERVES					
Downdip from Pits 2N and 3N	A-2		No. 1 seam	11.068	
Pits to Miller No. 1		B-2	No. 1 seam	38.667	
Downdip from Pit 4S	A-2		No. 3 seam	1.608	
Downdip from Pit 4S		B-1	No. 3 seam	2.115	
Downdip from Pit 4S to Pit 6S		B-1	No. 3 seam	4.496	
			GRAND TOTAL UNDERGROUND	57.954	

Drilling subsequent to these 1985 estimates, and moving some reserves from the open pit to the underground category, has changed some of the figures from the ultimate to the proven category. From an *insitu* geological standpoint, the total reserves have not changed significantly as a result of later exploration work. Further exploration drilling is required in order to determine whether the coal seams are continuous across the major synclinal structure and their maximum extent down the plunge. The *insitu* coal reserves identified by the exploration drilling to date are chiefly surface-recoverable reserves, and there is considerable potential to increase the total reserve base of the Middle Quinsam mining area by proving additional underground reserves.

Geology

The Middle Quinsam area is an outlier of the main part of the Comox basin and the coastal lowlands to the east. It is separated from this lowland area by a low ridge of Karmutsen Formation basalt. The semi-confining effect of this ridge may have helped to create the conditions necessary for the formation of coal seams in this area during Late Cretaceous time.

The Middle Quinsam coal deposit lies within a broad syncline, which plunges gently to the northwest. The coal seams outcrop along the southwest limb of the syncline on the north side of Middle Quinsam Lake and dip gently to the northeast at 6° to 10°. On the opposite limb, sediments lap against the volcanic ridge that separates the sub-basin from the low-lying coastal area and dip to the southwest at angles of 6° to 22°. Steeper dips associated with this limb at the southeast end of the structure are related to the intrusion of a Tertiary stock. The syncline is approximately 4 kilometres wide and 10 kilometres long.

Up to 200 metres of the lower part of the Comox Formation has been preserved from erosion at Middle Quinsam. Two distinct members are present within this section: the lower member, made up of medium greenish grey siltstone and brownish grey mudstone includes the main or No. 1 seam; and an upper member, made up of white to grey, medium to coarse grained sandstone, with minor mudstones and two coal seams (the No. 2 and No. 3 seams). The total stratigraphic separation between the No. 1 and the No. 3 seams is approximately 60 metres.

The change in lithology between the upper and lower members is due to a change in the depositional environment: the lower member accumulated in a quiescent coastal swamp or lagoonal environment, and the upper member was deposited in a higher-energy fluvial or deltaic environment. This difference is reflected in the character of the coal seams: the No. 1 seam, within the lower member, consists of clean coal 2.4 to 4.6 metres thick, with a roof and floor of carbonaceous mudstone; the Nos. 2 and 3 seams, lying within the upper member, are higher in ash and sulphur, and contain sandstone partings and a sandstone roof and floor.

In addition to the three main seams, there are two small "rider" seams. These rider seams are thin and are characterized by very high sulphur contents. Locally they are incorporated into the main seams. The No. 1 seam, which accounts for more than 70% of the total surface-mineable reserve in the Middle Quinsam area, ranges in thickness from less than 1 to as much as 5.5 metres thick. Generally, however, the No. 1 seam averages between 2.43 and 4.57 metres. In the northwest part of the mining area, it contains up to two 10-centimetre thick bone bands. Including these thin partings, the seam averages approximately 9 to 10% ash *insitu* and the sulphur content approximates 0.6 to 0.7%. In the south part of the mining area (south of the Quinsam River), the seam increases in average thickness, and contains 12 to 15% ash. Sulphur contents also increase to approximately 1%.

The No. 2 seam is found approximately 18 metres above the No. 1 seam in the mining area. It usually averages just over a metre in thickness, however, in some locations, notably the Pit 2N area adjacent to the north side of Middle Quinsam Lake and the Quinsam River, the No. 2 seam thins and almost disappears. The average *insitu* ash and sulphur contents for this seam approximate 15% and 2.5% respectively.

The No. 3 seam is approximately 37 metres above the No. 2 seam over most of the mining area. This seam averages a total thickness of approximately 5 metres, of which about 2.5 metres is clean coal, the remainder being numerous partings of sandstone and mudstone. Not including the parting material, the average ash content is 15 to 18%. The average total sulphur content is 3.25%.

The initial mining area (*i.e.* the area of open-pit reserves along the southwest limb of the structure) can be divided into two blocks on the basis of structure. The dividing line is a linear topographic feature which contains Long Lake and which continues in a northeasterly direction, culminating near the previously mentioned Tertiary intrusion. This lineation is the surface expression of a major cross-fault through the basin. North of this fault, the structure is very uniform and simple; to the south, it is complicated by a smaller anticline-syncline pair. The exact relationship of this fault to the coal measures is not well understood. There is certainly vertical displacement in the order of 18 metres, however, seam correlations across the fault are difficult and there may be some lateral movement as well. Movement along this fault plane may have occurred both pre- and post-depositionally. The anticlinal structure south of the main fault plunges east-southeast. It abuts the fault zone at Long Lake. Dips on the limbs of the anticline vary from 10° to 20°.

A second fault complicates the anticline on its southeast end, close to the Iron River. It is downthrown to the south by as much as 18 metres. The No. 3 seam, which approaches the surface near the crest of the anticline, thins markedly as it crosses the fold hinge. This is probably a depositional feature and could indicate that some manifestation of the anticline was in place prior to No. 3 seam generation. This is further supported by the great thickness of coal in the No. 1 seam to the southwest of the anticline (Pits 1S, 2S and 3S), where the seam reaches a maximum thickness of 5.5 metres, and then disappears completely on the southwest limb of the anticline.

4.3.6.2 Lower Quinsam Deposit

The Lower Quinsam deposit (also known as Quinsam East) was explored by Luscar Ltd. in 1977 and 1978. The work included the drilling of 48 holes on a grid pattern over the deposit area. It is located 9.7 kilometres southeast of the Quinsam mine. Total road distance along a roundabout route using existing logging roads is 34 kilometres.

The deposit is located in the Campbell River lowlands, which encompass the area underlain by Cretaceous sediments between the Campbell and Oyster rivers and extending inland an average of 12.9 kilometres to the boundary of sedimentary deposition near the first major volcanic ridge. The area is fairly flat as compared to the Middle Quinsam and Chute Creek areas, varying in elevation from 0 to 245 metres, the average being approximately 120 metres. Major drainages include the Oyster River on the south and its associated tributaries such as the Little Oyster River and Woodhus Creek; as well as Campbell River on the north, with its major tributary the Quinsam River flowing out of Lower Quinsam Lake near the western edge of the lowland area and meandering through it, joining the Campbell within the Campbell River city limits. There are large amounts of glacial deposits in the area; consequently outcrops of Comox Formation sediments are scarce. Glacial outwash deposits in the northwest part of the lowlands area are important producers of industrial aggregates such as sand and gravel.

The eastern part of the lowlands area has been developed to some extent; small farms, acreages and subdivisions occupy a narrow strip along the Island Highway and the coastline. The Campbell River airport is located in the centre of the lowlands area, approximately 5 kilometres from the coast. South of the city, numerous industrial logging roads provide vehicle access to many parts of the area, however, swampy terrain is common in the lowlands and, as a result, older roads and trails are sometimes impassable even to four-wheel-drive vehicles.

Exploration Work

In 1922, J.E. Gill, J.D. McKenzie, and H.A. Rose, working for Canadian Collieries (Dunsmuir) Ltd. and the Geological Survey of Canada, completed a fairly detailed field survey of the area surrounding the town of Campbell River to as far south as Browns River, just north of Courtenay. This fieldwork included several traverses of the creeks and rivers in the Middle Quinsam and Lower Quinsam Lake areas. In the 1950s, Canadian Collieries undertook some drilling in the area as a result of this early mapping. Weldwood of Canada Limited conducted drilling in the lowlands area in 1975 as part of its regional exploration program (Curcio, 1975). Weldwood drilled and geophysically logged six holes totalling 1 246 metres. The complete sedimentary section was only penetrated in three of the holes (Oyster River No. 1, Quinsam Lake No. 1, and Oyster River No. 2), all in the southern end of the area.

In 1977, the Quinsam joint venture investigated an area around Woodhus Creek known as Quinsam East by drilling 23 holes, with two of these being cored through the coal horizons. During this period, some wildcat drilling was conducted with little success around Lower Quinsam Lake (Quinsam Joint Venture, 1978). The following year the Quinsam joint venture drilled some 25 additional holes, several of which were cored (Luscar Ltd., 1979).

Geology

A coal seam outcrops on Woodhus Creek near the northwestern end of the deposit. From outcrop it dips uniformly to the northeast at approximately 20°. The dip flattens to 12° to 16° about 300 metres northeast of the outcrop line at a depth of about 45 metres. Because of this fairly steep dip close to outcrop, the reserve area is a long, narrow strip up to 3.2 kilometres long by 0.8 kilometres wide.

The reserve area is divided into three blocks. The northwest block has 2.23 metres of coal over 4.30 metres of section; the middle block has 2.59 metres of coal over 5.97 metres of section and the southeast end block has 4.85 metres of coal over 17.8 metres of section.

The seam splays in three distinct bands to the southeast, separated by significant thicknesses of sandstone. Some faulting is evident within the deposit area, with a northwesterly striking normal fault with up to 45 metres of displacement paralleling the strike of the formation.

Reserves

The Quinsam joint venture drilling of 1977 and 1978 identified proven reserves of 5.02 million tonnes of coal in place to a depth of 61 metres of cover, with an overburden volume of 49.24 million bank cubic metres. The ratio of cubic metres of overburden to tonnes of coal in place is 9.8:1. The Quinsam East deposit would be placed in the A-2 category since minor engineering questions could arise, requiring additional work. An additional 3.15 million tonnes of potential surface recoverable coal falling in the category B-2 (hypothetical) is also indicated by the drilling.

4.3.6.3 Chute Creek Deposit

The Chute Creek deposit is located 19 kilometres southwest of Campbell River and 5 kilometres to the south of the operating Quinsam mine. The deposit was first identified by Luscar Ltd. in 1977 and deemed uneconomic to develop. Drilling in the area by Luscar and subsequent operators, proved lateral thinning of the Chute Creek coals in all directions. The licenses were then acquired by Sulpetro Ltd. which optioned them to Nuspar Resources Ltd. In 1985 the author estimated *insitu* reserves at 2.02 million tonnes.

The major coal bed at Chute Creek is the A seam, lying within the Dunsmuir Member of the Comox Formation. Bickford *et al.* (1989) correlated the Chute Creek A seam with the Z seam at Cumberland and with a seam (possibly the Quinsam No. 4 seam) overlying the Quinsam No. 3 seam (see Table 4-2-1). As is typical of the Dunsmuir Member coals throughout the Comox basin, the Chute Creek A seam is thin (averaging 1.8 metres inclusive of several partings of sandstone with variable thicknesses) and high in sulphur (averaging 1.75%). A second coal bed, the Chute Creek B seam, is split away from the A seam by a sandstone parting. According to the B.C. Coal Quality Catalogue (Information Circular 1992-2), the Chute Creek A seam is of high-volatile bituminous A rank (see Table 4-3-4).

TABLE 4-3-4

CHUTE CREEK COAL QUALITY

PROXIMATE ANALYSIS (%)		ULTIMATE ANALYSIS (%)	
Moisture	3.26	Carbon	71.73
Ash	10.36	Hydrogen	4.97
Volatile Matter	36.83	Nitrogen	1.17
Fixed Carbon	49.55	Sulphur	1.75
Calorific Value	6783 kcal/kg	Oxygen	9.75

Note: based on channel sample of outcrop (Kenyon *et al.*, 1991)

4.3.6.4 Hamilton Lake Deposit

The Hamilton Lake coal deposit lies in the upland area southwest of Cumberland. The deposit is split into two halves by the valley of the Trent River, which has cut its course down through the coal-measures into pre-Cretaceous basement rocks. Figure 4-4A illustrates the location of the two coal reserve areas (referred to as Block A, north of the river, and block B, south of the river).

Three major coal zones have been identified within the Cumberland Member in the northern part of Block A, north of the river. The gross thickness of the coals varies from 1.5 metres for the upper zone to approximately 3 metres for the lower zone. The lower zone is characterized by a parting about 90 centimetres thick. The total stratigraphic thickness from the top of the upper seam to the bottom of the lower seam varies from 12.2 metres in the north part of the block to over 26 metres in the south. The coal zone containing the three individual seams outcrops at the north end of the deposit near the shore of Hamilton Lake. The zone crops out to the south of this exposure on a northeast-facing dip slope. The seams thin and pinch as they approach a volcanic contact to the northeast. The volcanic rocks isolate these coal measures from the adjacent freehold areas on the lowlands to the northeast. They also thin toward outcrop to the southwest. To the southeast the seams splay apart but thicken; however, depth of cover increases in this direction.

The 1978 Quinsam joint venture report calculates reserves of 6.42 million tonnes of coal within Block A; not all of this reserve would be surface mineable. This reserve can be relegated to the B-1 category (inferred: tonnage may vary +/-50%). Block B, which was the subject of a ten-hole drilling program in 1984, has inferred reserves of 2.6 million tonnes of *insitu* coal at an approximate raw strip ratio of 10:1.

Coal rank at Hamilton Lake is medium to high-volatile A or B bituminous, with sulphur contents ranging from 0.90% in the lower bed to 2.5% in the upper bed, and averaging about 2.0%. The Free Swelling Index of the coal ranges from 5.5 to 7. This range of quality is typical of other thin-seam areas on the margins of the Comox basin, where sulphur contents increase up-section. All three coals have a wide range of ash contents, with *insitu* ash above 20% and much higher where partings split the coal beds. The dirty nature of the coal beds is the primary negative factor affecting the economics of mining in this area. Based on existing information, clean coal yields would fall well below the 70% range, and might average below 60% when dilution factors associated with thin-seam mining are taken into account. Open-pit mining of the Hamilton Lake area is a long term development proposition because of the thin seams, high strip ratio and low clean coal yields (Gardner, 1985e).

4.3.6.5 Tsable River Deposit

The Tsable River deposit is second only to the Middle Quinsam deposit in terms of short-term to medium-term economic importance. Coal resources of 11 million tonnes *insitu* have been defined by drilling in 1991. Previous to this, the author had estimated 7.38 million tonnes of *insitu* ultimate inferred and an additional 8.85 million tonnes of additional ultimate hypothetical reserves (1985), for a total of 16.23 million tonnes. This reserve is entirely in the lowest coal seam in the sequence. The upper seam, although indicated to be of economic thickness (> 2 metres) in some small areas, is not the prime exploration target. The established coal reserve is open to the southeast along strike and has not been well defined down dip, where depth of cover will exceed 300 metres. Figure 4-4A illustrates the location of the deposit, immediately south of the Tsable River, in the area of Cowie and Cougarsmith creeks.

The coal quality has been defined by Canadian Collieries (Dunsmuir) Ltd.'s old data and more recent analyses as high-volatile A bituminous, with a Free Swelling Index of 6 to 8, indicating good metallurgical properties. Kenyon and Bickford (1989) report a maximum reflectance value of 0.97% from a 2.08-metre coal exposure on Wilfred Creek (upper seam), in the southeastern part of the deposit. The coal rank of the lower seam is similar.

McKenzie (1922), Buckham (1957) and Cathyl-Bickford (1992a) have documented the structural complexity of this deposit, but not enough information is yet available to definitively identify all of the major faults which may impact on mining. Certainly the Tsable River deposit must be categorized as an underground mineable reserve, with limited potential for open-pit mining along the western and southwestern margins, where the two coal beds approach the surface. Formation dips in these areas are greater than 20° to the northeast, severely limiting the open-pit potential. Until further exploration drilling is undertaken by the operators (Hillsborough Resources Ltd. and Weldwood of Canada Limited), the full potential of the deposit can only be speculated on. Outside of the initial area of interest, potential coal resources are placed in the ultimate hypothetical category and are discussed in Section 4.3.7.5

4.3.7 Areas of Potential Coal Resources

The following sections deal with potential coal resources. Under the reserve classification system used in this study, all of these areas would fall under the B ultimate resources category, subdivided into inferred, hypothetical or speculative, based on the amount of information available in each area.

4.3.7.1 Tsolum River Area

Three exploration programs have been completed in the Tsolum River area:

- Weldwood drilled a number of holes in 1979 near the headwaters of the Tsolum River, near the northeast foot of Constitution Hill, which is a major Tertiary intrusion, which has metamorphosed the surrounding Cretaceous sediments.
- Novacorp drilled exploratory wells for coalbed gas in the area.
- Canadian Occidental Petroleum undertook a seismic reflection program followed by drilling on its Tsolum River property to the north east of the Weldwood block in 1994.

An outcrop on Murex Creek (Figure 4-4B), is described by Bickford *et al.* (1990) as follows:

> "The Murex Creek coal is probably correlative with the Comox No. 3 bed. It is only 1.31 metres thick, with a net coal content of 66% by thickness, but it is of interest because it has a mean maximum vitrinite reflectance of 2.52 per cent, indicative of semi-anthracite rank."

Murex Creek, which is a tributary of the Tsolum River, is located on the north end of Constitution Hill. This Tertiary intrusion has metamorphosed and increased the rank of the coal in this area. The mineability of the deposit is in question due to its thinness and amount of parting dilution within the seam. Although information from Weldwood's 1979 drilling is not available to the author, Canadian Occidental Petroleum's drilling has shown that the seam (or seams) thins out along strike to the northwest. Based on this, a limited area of coal deposition with seams from 1 to 1.5 metres thick is likely. The boundaries of this area are not well established. In view of the available information indicating less than 1.5 metres of seam thickness, the potential coal resource has not been quantified in this report. However, the increased rank of the coal may make this area of more interest in the future.

4.3.7.2 Anderson-Dove Area

Early prospectors identified numerous coal outcrops on Anderson's Hill, south of Constitution Hill, and along Dove Creek, which flows around the southern end of Constitution Hill. In 1975 Weldwood of Canada drilled 15 holes in the area (Curcio, 1975) and a further 19 holes in 1978. Some near-surface reserves of coal were identified as a result of this drilling.

In broad terms, the Anderson-Dove area consists of structural blocks of the Comox Formation, separated from each other by major northwest-striking normal faults downthrown to the northeast. In the western parts of these blocks, erosion has removed the upper parts of the Comox Formation, exposing the lower section which contains the coal seams. The faults sometimes leave volcanic basement rock exposed between the Comox blocks, thus, isolating the Anderson West group of coal licenses from the remainder of the Comox basin.

Anderson West Area

The western part of the Anderson-Dove area, covered by the Anderson West licenses, is underlain by the lower part of the Comox Formation, which wedges out against the uplands on the margin of the Comox basin. Coal formation in this area was limited to relatively thin and badly split, dirty seams. Only very small areas may be economic for surface mining and due to the thinness and dirtiness of the seams, underground mining is out of the question.

In the southern part of the Anderson West license block, the best developed seam occurs near the top of the section. Its thickness approaches 1.2 metres, however, some of the section consists of coal and shale mixed. A second seam, approximately 3.5 metres below the main seam measures 0.73 metres of shaly coal. A number of thin seams occur in the Comox below these two seams, and although they are traceable over most of the southerly part of the license area, their thinness, poor quality and depth of cover make them unattractive.

In the northern part of the Anderson West license area (south of the Dove Creek valley), a coal zone occurs within the top 13 metres. This zone of coal and shaly coal is 1.57 metres thick within a total seam section measuring 2.81 metres.

Two cored holes in 1978, one in the south area and one in the north area, provide an insight to trends in *insitu* coal quality. The main seam in both areas has a high ash content, with low inherent moisture, low volatile matter and high fixed carbon contents. Sulphur contents are variable but in general concentrations in the south are low in sulphur and the north high. Preliminary findings indicate that the coal is non-agglomerating.

These general trends in coal quality indicate that the coal has been subjected to a rank increase as a result of the Tertiary intrusive activity just to the north at Constitution Hill. It is postulated that sills and dykes, which do not outcrop, have intruded the Comox Formation in this area, causing a local increase in coal rank.

The 1978 Quinsam joint venture report on the Anderson West coal licenses estimated a total of 4.0 million tonnes of coal on the license area. This estimate is broken down as follows: the North block which has 2.54 million tonnes and the South block which has 1.49 million tonnes. This tonnage occurs in the upper seam, which is, on the average, within 11 metres of the surface on the north and south blocks. This gives a total in-place overburden to clean coal ratio of less than 10:1 for both of the upper seam deposits. These reserve estimates can be relegated to the category of B-1 (inferred: numbers could vary +/-50% as a result of additional drilling).

Dove Creek Area

The Dove Creek area lies south of Constitution Hill in the Dove Creek and Browns River watersheds. As is the case in the adjoining Tsolum River area, coal seams thick enough for economic underground extraction, have not yet been identified. Seam thickness, as evidenced by outcrops on Browns River and Dove Creek, reaches 1.41 metres at 76% clean coal by thickness (Bickford *et al.*, 1990) in the Browns River outcrop and identified in drill-holes in the area. The best drill-hole intersection is Weldwood's Browns River No. 3 hole, where the total coal bed section is 3.44 metres, of which 1.37 metres is clean coal (40 % coal). This section is not economic to mine. No quantification of coal resources has been attempted in this area, however, if economics of underground thin-seam mining change in the longer term, this area may be deserving of further exploration drilling (Gardner, 1983a).

4.3.7.3 Cumberland Area

The Cumberland area includes the area previously mined up until 1952, extending from the southern limit of mining (Comox No. 5 and No. 6 mines) north to Browns River (Figure 4-4A). It contains three possible coal resources:

- Unworked areas of coal reserves within the old mining areas.
- Coal waste heaps resulting from earlier mining activity.
- An area between Puntledge River and Browns River which was not worked in the past but had received considerable attention in the form of diamond drilling.

Unworked Remnants

There are indications of varying amounts of coal left in the ground in the No. 2 seam and the No. 4 seam. In the area of the Comox No. 8 mine, old boreholes suggest that unworked reserves of coal in the No. 4 seam remain available. Although some development of the No. 4 seam was done in No. 8 mine, by means of a staple-shaft and a rock slope down from the No. 2 seam workings, the No. 4 seam was found to contain too many rock partings to be economically recoverable. Canadian Collieries (Dunsmuir) Ltd.'s data suggest that a total of 4.1 million tonnes of coal remains available in the No. 4 seam, and an additional 1.4 million tonnes in the No. 2 seam.

Canadian Collieries (Dunsmuir) Ltd. has also estimated a No. 4 seam reserve of 455 000 tonnes around the Comox No. 6 Mine and 6.35 million tonnes in the area of the Comox No. 5 mine workings.

In view of the poor records of worked-out areas in the older mines, and the difficulties associated with re-entering previously mined and flooded areas, the above estimates of tonnages left in the ground are speculative. The costs and attendant risks of re-entering these areas do not justify placing these reserves in the potential category.

Coal Waste Heaps

Coal waste heaps are located at Union Bay, Pidgeon Lake (No. 5 mine), Bevan (No. 8 mine), No. 7 mine, Comox Lake (No. 4 mine), Cumberland (No. 1 and No. 2 mines), Tsable River and along the Cumberland-Union Bay railroad grade (Curcio, 1975):

- The Union Bay waste heap is located on tidewater near the old Union Bay load-out site, at the former location of the coal washery. A large amount of fine coal was lost from the washery (75% recovery prior to 1941 and 82% recovery after that date until it was shut down). The Union Bay waste heap has been estimated by Weldwood to contain approximately 5 million tonnes of material.
- The Pidgeon Lake area encompasses four waste heaps close to one another, around the old Canadian Collieries railway grade which carried the coal to Union Bay. Weldwood estimates 6.53 million tonnes of waste coal at this site, which was the refuse area for Comox No. 5 mine. Up to and including the present time, part of the Pidgeon Lake area is being used by the Comox-Strathcona Regional District as a domestic-waste disposal site (the Pidgeon Pond landfill). There are many areas within the coal waste piles where spontaneous combustion has occurred or fires have been propagated as a result of human activity.
- Weldwood estimates 2.27 million tonnes of coal waste is contained within the Bevan waste heap, which was the refuse area for Comox No. 8 mine.
- The waste heap of No. 7 mine is located approximately 2.4 kilometres west-southwest of the Bevan waste heap. Weldwood did not estimate tonnages for this site.

- The Comox Lake waste heap fronts directly on Comox Lake at the old Comox No. 4 mine. The site is treed over to a great extent. Weldwood estimates that 1.54 million tonnes of coal waste is deposited in this area.
- The Cumberland area includes a number of small waste piles adjacent to the Cumberland town limits, including waste coal from the old No. 1 and No. 2 mines, just to the southwest of the town. The total of these areas amounts to about 33 500 tonnes.
- The Tsable River mine waste heap is situated on the north bank of the river, some 7.5 kilometres due southwest of the Union Bay site. No estimates have been made for this waste heap area.
- Mine refuse, including fine coal, was used for construction of fills and roadbeds along parts of the abandoned Wellington Colliery Railway grade between Cumberland and Union Bay. Near the lower end of the grade, at Trent River, a berm of coal waste averages 6 metres in height. No estimates of quantity or quality of material have been made. In recent years, some of the coal waste material has been used by developers for landscaping and fill.

In 1985 the author estimated tonnages of coal waste heap material based on historical mine production figures and preparation plant recoveries. Table 4-3-5 summarizes these findings.

TABLE 4-3-5

PREDICTIONS OF COAL WASTE DUMP QUANTITIES IN COMOX BASIN

COAL WASTE AREA	QUANTITY (kilotonnes)
Cumberland (No. 1 and No. 2 mines)	168
Comox Lake (No. 4 mine)	1 100
Pidgeon Pond (No. 5 mine)	990
Puntledge (No. 7 mine)	200
Bevan (No. 8 mine)	528
Union Bay (washery site)	3 527

Weldwood has also studied the quality of coal waste heap material. Washability tests in 1974, on reverse-circulation drilling samples, indicate that a saleable product at 22% ash and 6 271 kcal/kg could be produced at a 31% average recovery. Weldwood estimated 2.35 million tonnes of recoverable coal based on 31% average recovery from 7.6 million tonnes of raw waste. If a more conservative 18% recovery factor is used, 1.172 million tonnes of saleable product is indicated to be contained in the waste heap areas.

Puntledge-Browns Area

The Puntledge-Browns area comprises a 2 900-hectare block which was drilled but remained undeveloped during the period of mining at Cumberland (Figure 4-4A). This area extends from Puntledge River north to Browns River. The closest old mine was the Comox No. 7 mine at Bevan, which worked the No. 4 seam. Exploratory driveages from No. 7 mine extended northwards under Puntledge River for a short distance. It is not known whether mining was terminated due to structural complications or thinning of the seam in this area.

Canadian Collieries (Dunsmuir) Ltd. drill-holes indicate that the No. 4 seam is the prime exploration target in this area and can be expected to reach thicknesses of greater than 3 metres, although the inevitable shale partings will be found to a greater or lesser degree. The No. 2 seam, while attaining thicknesses of 2 to 2.5 metres, is more variable in distribution and continuity.

The resource potential for the area is calculated assuming a potential area of No. 4 seam of 7.28 square kilometres, an average clean coal thickness of 1.8 metres and an average specific gravity of 1.4. The value calculated is 18.346 million tonnes.

This potential resource is placed in the B-2 category, ultimate hypothetical resources (geologic mapping and scattered drilling indicate the presence of a coal seam of a thickness sufficient to be mineable).

No estimates of potential resources for the No. 2 seam are made for the area due to drill-hole information indicating less than 1.5 metres average thickness and variations in lateral distribution.

4.3.7.4 Allen Lake Area

The Allen Lake area is situated between the town of Cumberland on the north and the Trent River on the south (Figure 4-4A). The area of interest forms an irregular block 1 to 3.5 kilometres wide and almost 9 kilometres long. The block is located between Allen Lake on the southwest and Royston on tidewater. The southwestern edge which would be the most likely location for underground entries to the coal seams, is approximately 11 kilometres from Union Bay by private industrial road.

The area is on strike with the prolific Cumberland coalfield, where about 16 million tonnes of coal were mined from an area measuring 3 kilometres wide by 8 kilometres long. The lowest coal seam (the No. 4 seam) lies directly over the basement paleosurface of the Triassic Karmutsen Formation volcanics; drill-holes indicate that in some instances, the lowest seam is within inches of the basement. This may indicate that the seam quality is inferior. Drill-hole information also indicates that the No. 2 seam may also present some possibilities for mining, although, as in other areas its thickness is questionable and its lateral continuity varies.

The structure of the Allen Lake area is a simple monocline, dipping to the north-northeast at of 2° to 10°. The western boundary of the coal measures is controlled by faulting. A major normal fault, striking north is indicated in this area and has downthrown the Comox coal measures 30 to 50 metres to the northeast. There is little likelihood of finding near-surface lower seam coal in the area due to this fault.

The area has received some exploration drilling in the past. Five drill-holes were completed by Canadian Collieries (Dunsmuir) Ltd. in 1922 and 1923; six other holes were completed in the Block B area, some as late as 1946. Weldwood of Canada completed three rotary drill-holes in 1974-1975 as part of a regional exploration program. These holes are labelled Allen No. 1, and Trent No. 1 and No. 2 on Figure 4-4A. Weldwood also drove an 18 metre prospect adit into the upper seam, near the east side of Allen Lake.

Of the six holes drilled to date in area A, all intersected at least one coal seam greater than 1 metre in thickness. The thickness of the lowest seam (No. 4 seam) in one hole (CX-179) is recorded as 3.35 metres with no intervening partings. Partings of various thicknesses are present in the other holes. Presently-available information suggests that at least one coal seam is present over the area, ranging from 1.0 to 1.5 metres in thickness and thickening down the dip to greater than 3 metres in some areas (see holes CX-179 and CX-167).

Potential resources are placed in the B-2 category: ultimate hypothetical resources, insofar as geologic mapping and scattered drilling indicate the presence of a coal seam of a thickness sufficient to be mineable. Assuming a 1.5 metre average seam thickness over the total possible area of 2 100 hectares, a potential resource of 45.66 million tonnes is indicated.

4.3.7.5 Tsable River Area

The Tsable River area was discussed in Section 4.3.6.5. In addition to the known coal reserve that was drilled off by Canadian Collieries (Dunsmuir) Ltd. in the 1950s (Buckham, 1957) and Brinco/Hillsborough in 1990 and 1991, potential coal resources may occur in two other areas (Figure 4-4A): contiguous to the existing known coal reserve on the south side of the Tsable River (Tsable River South on accompanying figure), and contiguous to the abandoned Tsable River mine on the north side of the Tsable River (Tsable River North).

Table 4-3-6 summarizes major coal unit intersections in the existing Canadian Collieries (Dunsmuir) Ltd. boreholes to the southeast of the known coal reserve on the south side of the Tsable River.

TABLE 4-3-6

MAJOR COAL UNIT INTERSECTIONS IN TSABLE RIVER SOUTH

BOREHOLE	UPPER SEAM (thicknesses in metres)			LOWER SEAM (thicknesses in metres)		
	Gross Coal	Parting	Net Coal	Gross Coal	Parting	Net Coal
TR-57	1.24	0.25	0.99	3.23	1.45	1.78
TR-59	0	0	0	2.39	0.20	2.19
TR-61	0.81	0.15	0.66	1.01	0.33	0.68
TR-62	1.40	0.05	1.35	2.00	0.36	1.64
TR-63	1.32	0.46	0.86	1.55	0.23	1.32
TR-78	1.14	0.18	0.96	1.32	0.41	1.73
MEAN:	1.18	0.22	0.96	1.92	0.50	1.56

The known coal reserve at Tsable River South is open down dip and along strike to the southeast. Old drill-hole information in this area indicates that the two main coal seams are present, although thicknesses are variable.

The establishment of the initial area of mineable reserves, however, would suggest that these reserves can be increased by step-out exploration. Based on average seam thickness of 1.56 metres for the lower seam (Table 4-3-6) and seam boundaries shown on Figure 4-4A, an estimated potential resource of 26.2 million tonnes is possible. This resource would be placed in the category of B-2: ultimate hypothetical resources (mapping and scattered drilling indicate a coal seam of mineable thickness). No estimates are placed on the upper seam due to its thin character.

Table 4-3-7 summarizes Canadian Collieries borehole data for the potential resource area to the north of the Tsable River.

TABLE 4-3-7

MAJOR COAL UNIT INTERSECTIONS AT TSABLE RIVER NORTH

BOREHOLE	UPPER SEAM (thicknesses in metres)			LOWER SEAM (thicknesses in metres)		
	Gross Coal	Parting	Net Coal	Gross Coal	Parting	Net Coal
TR-17	0.53	0	0.53	3.43	0.05	3.38
TR-20	0.15	0	0.15	0.69	0	0.69
TR-22	2.03	0	2.03	2.84	0	2.84
TR-23	0.71	0	0.71	4.52	0.53	3.99
TR-25	not deep enough			not deep enough		
TR-26	2.59	0.68	1.91	7.62	1.37	6.25
TR-29	0.76	0.15	0.61	1.83	0.05	1.78
TR-33	1.63	0	1.63	1.12	0	1.12
TR-36	0.61	0	0.61	1.83	0.05	1.78
TR-37	0.97	0	0.97	3.58	1.12	2.46
TR-44	0.15	0	0.15	1.68	0.15	1.53
Tsable Riv. 1	1.46	0.27	1.19	1.07	0	1.07
Langley Lk. 2		not deep enough			not deep enough	
MEAN:	1.05	0.10	0.95	2.60	0.39	2.28

The lower seam, at an average thickness of 2.28 metres (Table 4-3-7), potentially has up to 61.7 million tonnes of resources, assuming arbitrary boundaries of the eastern coastline and the Tsable River on the south, and drill-hole control on the north and west (Figure 4-4B). This resource potential would be classified as B-2: ultimate hypothetical resources (mapping and scattered drilling indicate a coal seam of mineable thickness). No resource is calculated for the upper seam in this area due to its thin nature.

The resource estimates given above are speculative due to arbitrary boundaries (not geologically inferred) and the questionable reliability of the old drill-hole data. They simply indicate areas of good potential that are deserving of further exploration work and geological evaluation. The size of the areas and potential resources make them good targets for identifying a "stand alone" mining situation of greater than 10 million tonnes.

4.3.7.6 Alberni Valley

Coal seams have been known to occur in the Port Alberni area and in the northern part of the Alberni Valley since the early 1900s. Limited mining, which can only be classed as prospecting work, occurred south of Port Alberni, in 1911 (Cathyl-Bickford and Hoffman, 1991).

Sediments of the Nanaimo Group cover an area 50 kilometres long and up to 8 kilometres wide extending the length of the Alberni Valley to as far as the Elsie Lake area. A 6 metre thick coal exposure was identified near the northern end of Elsie Lake on a small tributary of the Ash River in the early 1950s. This coal was dirty, but of sufficient thickness to indicate potential for coal of mineable thickness and quality (Gardner, 1984b). Several operators (Section 4.3.5.4) have acquired coal exploration licenses and performed work in this area.

Exploration work has included a total of 24 widely spaced rotary drill-holes, with some limited coring work. The last program was conducted by Canadian Occidental Petroleum Ltd. in 1985 and consisted of ten holes. With the benefit of information from fourteen previous holes, the program did not intersect any coal beds more than 0.8 metre thick. Eight of the holes reached volcanic basement rock.

Exploration results to date show that the Alberni Valley area holds little potential for containing mineable reserves of coal; this area is unlikely to receive additional attention in the future. No potential resources are estimated for this area.

4.3.8 Summary of Coal Reserves and Resources in the Comox Basin

Table 4-3-8 summarizes the total estimated proven coal reserves and ultimate coal resources in the Comox basin. This table reflects the reserve classification system used in this study. The third division of the ultimate resource category, speculative resources, is not used. This division has been combined with the second division, ultimate hypothetical resources, to better reflect the historical information available for these areas. The use of the term "resources" implies that these areas are targets for exploration. Measured reserves, which fall within the proven category, are a result of extensive exploration work. During the course of this work, ultimate coal resources are usually pared down substantially to finally arrive at a proven reserve figure.

TABLE 4-3-8

COAL RESERVES AND RESOURCES IN THE COMOX BASIN

AREA	A. PROVEN RESERVES		B. ULTIMATE RESOURCES		TOTALS
	A-1. Measured	A-2. Indicated	B-1. Inferred	B-2. Hypothetical	
Middle Quinsam	12.01	16.30	10.32	38.66	77.29
Lower Quinsam		5.02		3.15	8.17
Campbell River			16.81	27.50	44.31
Chute Creek		2.02			2.02
Anderson Lake N			2.54		2.54
Anderson Lake S			1.49		1.49
Browns River				18.35	18.35
Allen Lake				45.66	45.66
Coal Refuse Heaps		1.17			1.17
Hamilton Lake A			6.42		6.42
Hamilton Lake B			2.63		2.63
Tsable River N				61.70	61.70
Tsable River S		11.00		26.20	37.20
TOTALS	12.01	35.51	40.21	221.22	308.95
	Total Proven Reserves: 47.52 million tonnes		Total Ultimate Resources: 261.43 million tonnes		

To sum up, a total proven *insitu* coal reserve of 47.52 million tonnes and a total ultimate coal resource of 261.43 million tonnes may be present in the Comox coal basin. Of this 309 million tonne projection, approximately 25% (77 million tonnes) may be present in the Middle Quinsam mining block. The remainder is distributed throughout the Comox basin as tabulated. More than 90% of these estimated coal resources would be classified as underground mineable reserves.

4.4 NANAIMO BASIN

The Nanaimo basin was the most important area for coal mining and development on Vancouver Island during the years 1852 to 1964. During this period approximately 50 million tonnes of coal were mined from three different seams.

Mining started at Nanaimo Harbour, where the first coal seams were shown to the Hudson's Bay Company by local aboriginal people. Development then spread into surrounding areas as more discoveries were made. Today, the City of Nanaimo (population 65 000) covers most of the old workings, including the original Hudson's Bay Company mines. Suburban developments in the northern part of the city cover practically all of the original Dunsmuir mines in the Divers Lake, Long Lake and Northfield areas.

4.4.1 Stratigraphic Units and General Geology

Clapp (1912a; 1914a) established the stratigraphic framework of the Nanaimo Group in the Nanaimo basin. Much of Clapp's pioneering work has stood the test of time, but some revisions have been subsequently made in light of detailed work by Ward (1978), Bickford (1983), and Mustard (1994). Table 4-4-1 is adapted from Cathyl-Bickford and Hoffman (1998), following Mustard's 1994 revision of age assignments of some of the formations.

TABLE 4-4-1

REVISED STRATIGRAPHIC NOMENCLATURE OF THE NANAIMO GROUP AT NANAIMO

STAGE	FORMATION	MEMBER	THICKNESS	LITHOLOGY
Maestrichtian	Gabriola		350 - 600?m	Sandstone and conglomerate
Early Maestrichtian	Spray		100 - 145 m	Shale and siltstone (turbidites)
Early Maestrichtian	Geoffrey		120 - 150 m	Conglomerate and sandstone
Late Campanian to earliest Maestrichtian	Northumberland		200 - 300 m	Shale and siltstone (turbidites); minor sandstone
Late Campanian	De Courcy		275 - 430 m	Sandstone; minor conglomerate and siltstone
mid Late Campanian	Cedar District	Boat Harbour	20 - 100 m	Shale and siltstone (turbidites); sandstone
mid Late Campanian		Woods Islands	0 - 70 m	Sandstone; minor siltstone
mid Late Campanian?		Holden-Corso	290 - 350 m	Shale and siltstone (turbidites); sandstone dykes
early Late Campanian?		Oyster Harbour	0 - 60 m	Sandstone; minor siltstone
early Late Campanian		Granby	20 - 100 m	Shale; glauconitic pebbly shale at base
Early Campanian to early Late Campanian?	Protection	McMillan	35 - 70 m	Sandstone; minor siltstone and shale
Early Campanian		Reserve	40 - 80 m	Sandstone, siltstone, shale and coal
Early Campanian		Cassidy	80 - 135 m	Sandstone and gritstone; minor siltstone
Early Campanian	Pender	Newcastle	30 - 60 m	Shale, sandstone, conglomerate and coal (Douglas and Newcastle seams)
Early Campanian		Cranberry	50 - 195 m	Shale and siltstone; conglomerate and sandstone
Early Campanian	Extension	Millstream	90 - 230 m	Conglomerate and gritstone; minor sandstone, siltstone and coal
Early Campanian		Northfield	0 - 45 m	Siltstone, shale, sandstone, gritstone and coal (Wellington seam)
Early Campanian	East Wellington		5 - 47 m	Sandstone; minor gritstone and siltstone
Santonian to Early Campanian	Haslam		65 - 150 m	Siltstone and sandstone (turbidites) at top, grading down to massive shale at base
Santonian to earliest Campanian?	Comox	Dunsmuir	0 - 120 m	Sandstone; minor siltstone, shale and coal (Blackjack seam)
Santonian		Cumberland	0 - 60 m	Sandstone and siltstone; minor shale and coal (Yellow Point seam)
Santonian to Turonian?		Benson	0 - 150 m	Conglomerate, red shale and pebbly siltstone

The Nanaimo basin is structurally complex. Uplift associated with tectonic plate movement is the dominant structural mechanism. This uplift is differentially distributed and has occurred at two distinct times since the beginnings of sedimentary deposition in Late Cretaceous time. Other factors governing the structural style involve local strike-slip fault movements on pre-existing shear planes and isostatic rebound of basinal areas following the retreat of the Pleistocene glaciation.

4.4.2 Distribution of Coal-Bearing Rocks

In the Nanaimo basin, coal-bearing rocks of the Nanaimo Group are known to extend from Lantzville in the north to Brenton in the south, a strike length of 32 kilometres, and from Wolf Mountain in the west to Yellow Point in the east, a dip width of 12 kilometres.

Three laterally persistent and relatively thick coals and numerous thinner, less persistent coals are present in the Nanaimo basin. Figure 4-8 illustrates the extent of coal seam distribution in the Nanaimo basin and indicates the approximate extent of mine workings.

The three major coal seams are, from the top down:

- The Douglas seam, which is the thickest of the Nanaimo coals, but is subject to extreme variations in thickness, varying from 0 to more than 21 metres thick and averaging 2.5 metres (Cathyl-Bickford *et al.*, 1992). It occurs within the Newcastle Member of the Pender Formation (Table 4-4-1). The Douglas seam's lateral continuity diminishes in the southern part of the field south of the Nanaimo River estuary (Graham, 1924).
- The Newcastle seam, which ranges from 0 to 1.6 metres thick and averages 1.2 metres. The Newcastle Seam occurs near the base of the Newcastle Member of the Pender Formation. It is a harder, blockier coal than the Douglas seam and produced good stoker coal due to its resilience. It has not been extensively worked, except in the area surrounding Newcastle Island in Nanaimo Harbour.
- The Wellington seam, which occurs near the base of the Northfield Member of the Extension Formation and covers a wide area. The coal's thickness varies from 1.2 to 2.7 metres, locally thickening further due to minor faults and rolls (Cathyl-Bickford, 1992b). The Wellington, being the lowest worked seam, outcrops along the western flank of the Nanaimo basin but pinches eastwards and generally does not underlap the Douglas seam workings (Bickford and Kenyon, 1989).

Until very recently the Comox Formation was thought to be barren in the Nanaimo basin in contrast to the significant coal horizons found within it in the Comox basin to the north. Gas exploration drilling by British Petroleum in 1986 (BP Yellow Point d-84-C) intersected a coal seam approximately 3 metres thick at 1570 metres depth in the Comox Formation beds (Cathyl-Bickford, 1991).

4.4.3 NANAIMO COAL MINES

4.4.3.1 Douglas Seam

Mining in the Douglas seam was confined to the southern and eastern parts of the Nanaimo coalfield. The Douglas seam was the first to be identified and developed by the Hudson's Bay Company. Shallow workings in the old Hudson's Bay Company No. 1 mine are located under much of downtown Nanaimo. The New No. 1 mine, which was the longest running mine on Vancouver Island, was located adjacent to the old No. 1 pithead. From the tipple and headframe of the No. 1 mine, workings radiated out to the east and south, extending as far south as the Nanaimo River estuary and east out under Protection Island and the Strait of Northumberland for a distance of 1800 metres. Other mines, such as the Southfield No. 3 mine, Southfield No. 5 mine and the Alexandria mine followed the outcrop line of the Douglas seam to the south. The Reserve mine, which was located on the east side of the mouth of the Nanaimo River, developed an extensive area of Douglas seam from a shaft 291 metres in depth.

The No. 10 South Wellington mine was an important mine in the Douglas coal seam, producing 2.7 million tonnes between 1937 and 1952. Other Douglas seam mines in the South Wellington area included the Wellington-Extension No. 5 mine and the Morden mine, which was a shaft mine located to the east of South Wellington and on strike with the Reserve mine.

The Morden mine was first operated by Pacific Coast Coal Mines Ltd., the same company that tried to reopen the Suquash mine near Port McNeill. The mine was opened in 1913 and operated in a limited development mode until 1921 when it closed down for no apparent reason. The following excerpts from the Minister of Mines Annual Reports describe this stage of the mine's development.

Robertson (1920) notes:

> "Extensive development work underground has been carried on during the year. The new shaft bottom has been widened to allow the handling of more coal. The Main Slope has been driven through almost 900 ft. of rock fault and has again struck coal, although only 4 ft. high, it is of very good quality. A main diagonal slope has been turned off the Main Slope, and will replace the old slope which has been abandoned on account of the haulage system. This new development work is being pushed ahead as speedily as possible, as the Main Slope, striking this big fault, seriously delayed development."..."The coal is well adapted for steam purposes and varies from 3 to 30 ft. in thickness."

Regarding the following year's progress, Robertson (1921) notes:

> "The main entries of the mine will be pushed ahead vigorously there being some 1800 acres of virgin territory yet to be developed in this mine; from the average tons to the acre already produced from the

worked portion of the mine, it is estimated this territory will yield 1 000 tons per day for the next fifty years."

In the spring of 1921, the Morden mine lapsed into a state of neglect. Robertson (1922) notes:

"This company did not do any work underground at either its Morden or its Suquash Collieries, employing only 1 man at each, practically as watchmen."

The Morden mine remained closed until 1930, when Canadian Coal and Iron Company Ltd. acquired the property. Morgan (1931) described progress toward reopening the mine:

"The Morden mine was formerly operated by Pacific Coast Coal Mines Ltd., but was closed down in 1921 and remained closed until February, 1930, when the Canadian Coal and Iron Company Ltd. re-opened the Morden shaft and the work of de-watering of the mine commenced. A large amount of work was necessary to repair the caved roadways and the dewatering of the mine was considerably hampered by several large caves in the main slope. A small quantity of coal was produced the following month, and subsequent months, by skipping the pillars in some of the roadways that were being reopened. A little over 3 000 tons of coal was recovered in this manner during the period of operation. Some prospecting was done on the west side of the shaft, but the main seam was not located at this point. A distance of about 700 ft. was cleaned up and re-timbered on the Main Slope, when the mine again closed down in the middle of August and has remained closed up to the time of writing. At the present time only a watchman is employed looking after the plant and equipment." Jackson (1931).

After only 7 years and less than 500 000 short tons of production, the Morden mine closed down in August of 1931, and has remained closed ever since. The shafts and workings are now flooded, and the pithead itself has been made into a park. James (1969) discusses the remaining potential of the Morden Property:

"There are approximately 1 800 acres of coal lands in the Morden Property. Only 70 acres have been worked.....From the 70 acres that has been developed, approximately 7 000 tons per acre of coal has been extracted. If it could be proved that even 1 000 acres of the remaining 1 700 could produce 7 000 tons per acre, this would mean 7 million tons of coal.....Looking at the composite plan of the Douglas seam mines, it will be noted that the Morden mine lies in practically the same zone along the strike of the seam as the Reserve mine, and between the two mines and to the dip of the Pacific Coast coal mine, the Alexandria mine, and No. 5 mine (Canadian Collieries Ltd.), there is an unworked area approximately one mile along the strike and from 3 000 to 4 000 ft. along the pitch."

The Morden mine demonstrably occupies an area of increased structural irregularity within the coal-measures (Buckham, 1944). The lack of comprehensive exploratory drilling probably contributed to the lack of success by the operators of this mine. However, the Douglas seam does exist here and, with proper planning and mine layout, there is some potential for recoverable reserves in this area.

The Granby No. 1 Colliery (1918 to 1937) and Bright mines (1950 to 1953) were located farther south on the Douglas seam trend, near Cassidy, just south of the Nanaimo River. The Douglas seam was subject to major structural deformation in this area. Metallurgical grade coal for coke making was produced from the Douglas seam here. Both mines terminated against a major transverse fault paralleling Haslam Creek and downthrown to the south. The phenomenon of outbursts due to methane gas emissions is well-documented in the Granby mine (Rice, 1922; Touhey, 1923; Wilkinson, 1926; Wilson and Henderson, 1927; Strachan, 1942). Muller and Atchison (1971) discuss mining in the Douglas seam:

"The Douglas seam has been subject to many 'outbursts' in workings at depth greater than 1 000 feet. These were reported in the British Columbia Minister of Mines Annual Reports for 1921 regarding the Granby No. 1 Colliery and for 1943 and 1944 in the adjacent Canadian Collieries Number Ten mine....The outbursts appear to have been a reason why workings were generally not advanced deeper than one thousand feet, even where good coal was present at lower levels."

Neither the Granby nor the Bright mines was successful in driving across the major fault and developing in the downthrown block on the south side of the structure.

4.4.3.2 Wellington Seam

The Wellington seam was first developed in about 1870 by Robert Dunsmuir near Divers Lake, northwest of Departure Bay in Nanaimo. Development of the Wellington Colliery mines proceeded steadily. In the year 1894, six interconnected entries into the Wellington seam in the Divers Lake area produced 383 006 tonnes of coal (Bickford, 1993). In 1895, the Wellington seam was traced southwards to Extension, southwest of Nanaimo, and the mines of the Extension Colliery were opened. These mines were more profitable than the Wellington Colliery (due to there being thicker coal at Extension) and by 1906 annual production at Extension reached 370 542 tonnes (Bickford, 1993).

Although the Wellington seam outcrop line was well defined by the 1920s, mining in some areas, such as around the Nanaimo River and on the east limb of the Extension anticline (i.e. Harewood and Extension No. 4), was sporadic and relatively unprofitable due to seam thinning and variations in ash content. Developments were not planned, in the sense of acquiring information beforehand. The generally established method was to locate seam outcroppings and follow them in with development headings. If difficult conditions were encountered, workings were abandoned and attention was turned to the next prospective area. Although surface drilling was established as an exploration tool in the Nanaimo basin before the turn of the century, equipment was primitive and progress was painstakingly slow. Some of the deeper holes (*i.e.* 200 metres plus) took more than a year to complete.

The last of the large mines at Extension Colliery was abandoned in 1931 and its owners, Canadian Collieries (Dunsmuir) Ltd., resorted to leasing out small unworked areas around the abandoned mines to private contractors. The Beban mine was one of the larger contract operations (employing about 35 miners) and the Chambers mine (essentially a pillar-robbing operation) operated right through the Depression years. By the late 1930s Canadian Collieries (Dunsmuir) Ltd. had largely shifted its attentions from Nanaimo to the Comox basin, but two smaller mechanized longwall mines, the Timberlands (Wellington No. 8) and White Rapids mines, continued to operate in the Wellington seam south of Extension. Typical Wellington seam thickness in these mines was 1.5 metres in the No. 8 and 1.2 metres for the White Rapids mine. The White Rapids was the last mine to close in the Nanaimo coal basin during the first great coal mining era: Canadian Collieries (Dunsmuir) Ltd. abandoned it on July 28, 1950 and several employees pulled pillars until 1953 (Bowen, 1982).

It was not until the resurgence in the price of coal in the 1970s sparked renewed interest in coal in the Nanaimo area that coal mining was reactivated. Exploratory drilling on Wolf Mountain by Gulf Canada in 1981 identified an area of Wellington seam coal of sufficient thickness and extent to mine. A small partnership, Wolf Mountain Coal Limited Partnership, removed 117 200 tonnes in the Wolf Mountain deposit in 1986 and 1987 (N.E. Roberts, personal communication). This small start, together with a surface pillar mining operation near the old Chambers mine by Twinforks Mining Ltd. which recovered approximately 5 000 tonnes also in 1986, are the only other coal mining developments in the Nanaimo basin in recent years.

4.4.4 Recent Exploration

Exploration interest in the Nanaimo area increased in the late 1970s when the coal license moratorium was lifted. In the Nanaimo area, Weldwood had relinquished all the Canadian Collieries (Dunsmuir) Ltd. fee-simple coal rights to the Crown. Due to much of the Nanaimo area being settled prior to the 1883 Dunsmuir Railway Agreement, there were many other areas of settlers' rights. Much of the Hudson's Bay Company land was also owned in fee-simple. A number of companies began to acquire licenses and examine fee-simple holdings in the Nanaimo area. Figure 4-5 illustrates the existing licenses and applied-for lands at the height of the acquisition phase in the early to mid-1980s.

4.4.4.1 Netherlands Pacific Mining Ltd.

The first company to obtain Coal Licences at Nanaimo was Netherlands Pacific Mining Ltd., an affiliate of Chinook Construction Ltd. In 1978, Netherlands Pacific applied for approximately 13 355 hectares (33 000 acres) of coal exploration licenses in the western margins of the Nanaimo basin. The company was trying to identify areas of near-surface coal near the base of the Nanaimo Group, either in the Comox Formation or in the Haslam Formation shales. Mapping by Buckham (1947b) and studies by James (1969) had identified the Blackjack seam in this interval but it had never been mined. Netherlands Pacific optioned their property to Gulf Canada Resources Ltd. in 1981 after doing a small amount of geologic mapping and trenching.

4.4.4.2 Gulf Canada Resources Ltd.

Immediately after obtaining their option on the Netherlands Pacific property, Gulf Canada embarked on a program of drilling and mapping along the western margin of the Nanaimo basin. A number of holes were drilled, all of which were blanks except one which tested an erosional remnant of the Extension Formation atop Wolf Mountain, at the southeast end of Blackjack Ridge (Buckham, 1947b), which intersected the main Wellington seam with a good mineable thickness. Gulf Canada judged the potential coal-bearing area surrounding the discovery hole to be too small to meet its corporate objectives, so the option on the property was dropped.

4.4.4.3 Esso Resources Ltd.

Shortly after Netherlands Pacific applied for its license blocks, Esso Resources Ltd. applied for two license blocks adjacent to the southern parcel of Netherlands. Part of the Esso area was held in abeyance pending the resolution of land-use issues. The western area of licenses, which were uninhabited land, were granted. Esso drilled a number of holes (shown on Figure 4-5) which proved that the Wellington seam had been widely eroded in this area and this part of the Esso license block was surrendered back to the Crown (Peach, 1981).

4.4.4.4 Mayo Holdings Ltd.

Mayo Holdings Ltd. is an affiliate of Mayo Forest Products Ltd. The Mayo family of Cowichan Lake have held large business interests in the forest products and real estate sectors in the Nanaimo area for many years. Mayo Holdings Ltd. purchased the old Pacific Coast Coal Mines property, which included the Morden mine and the coal shipping point at Boat Harbour, north of Yellow Point. The coal property, held by a subsidiary company called Westland Resource Industries Ltd., consists of 566.5 hectares (1 400 acres) of fee-simple coal rights in the vicinity of the old Morden mine and extending to the north and east. In order to round out the property package, the company applied for 1 376 hectares (3 400 acres) of coal licenses in 1980. These licenses were not granted, pending the resolution of land-use issues in the area (Lozoway and Symes, 1980).

Westland made a farm-out agreement with Novacorp Engineering Ltd. (a subsidiary of Nova Corporation), and Novacorp drilled seven coalbed gas testholes within the Westland property. Five of these holes reached the Douglas seam (Cathyl-Bickford, 1991). Novacorp and Westland could not reach a funding arrangement for production testing and Novacorp has since terminated its option in the area.

4.4.4.5 Westmin Resources Limited

Westmin Resources Ltd. applied for substantial areas of coal licenses in the area surrounding the Westland license applications in the Jack Point, Duke Point and Yellow Point areas. These licenses have not been granted, pending the resolution of land-use concerns.

4.4.5 Known and Potential Coal Deposits

There are several small areas within the Nanaimo basin which contain reserves of coal left over from the previous mining developments. The economic potential of some of these areas is in doubt due to their location adjacent to the City of Nanaimo. Coal deposits have been identified to the north and south of the city; those on the south side of the city, as discussed below, appear to have greater potential for future development.

A summary of known coal reserves and resources for the Nanaimo basin is presented in Table 4-4-2. It does not take into account speculative reserves which may exist in the Douglas and Wellington seams at depths greater than 300 metres, since the lack of definitive information on seam thickness and deformation in these deep areas does not allow a reasonable estimate to be made.

TABLE 4-4-2

COAL RESERVES AND RESOURCES IN THE NANAIMO BASIN

AREA	A. PROVEN RESERVES		B. ULTIMATE RESOURCES		TOTALS
	A-1. Measured	A-2. Indicated	B-1. Inferred	B-2. Hypothetical	
A: South Cassidy				1.01	1.01
B: Morden-Reserve				6.35	6.35
C: Wolf Mountain	1.94	1.16			3.10
D: Little Ash			0.10		0.10
Coal Refuse Heaps[1]		0.24	0.21		0.45
TOTALS	1.94	1.40	0.31	7.36	11.01
Total Proven Reserves: 3.343 million tonnes			Total Ultimate Resources[2]: 7.667 million tonnes		

Note 1: Recoverable tonnes at average 18% yield.

Note 2: Total includes recoverable tonnes from coal refuse piles, assuming 18% yield.

Table 4-4-2 demonstrates that easily accessible reserves in the Nanaimo basin are very limited. While there is definite potential to increase the ultimate resources in the southern and eastern parts of the field (Areas "A" and "B"), access to the Douglas seam in this area would probably be by vertical shaft. In this case, development costs would require a minimum of 10 million tonnes of proven *insitu* coal reserves and a favourable business climate to justify development.

The most likely scenario for coal development in the Nanaimo area is for a small-scale operation of less than 250 000 tonnes per year which would require the reserve areas of Wolf Mountain and the coal refuse heaps to sustain initial development. Other small-scale activities such as pillar-robbing along the surface outcrop of the Wellington seam might prolong the life of such an operation. The reclamation and land rehabilitation aspects of such operations may add to the financial and environmental appeal by restoring otherwise useless land parcels to a more productive use.

4.4.5.1 North Nanaimo

This area includes parts of the Wellington seam to the west and north of the original discovery made by Robert Dunsmuir near Divers Lake. Shallow abandoned workings are evidenced by subsidence along the outcrop line of the Wellington seam. Pillar removal may provide limited opportunities for small tonnage recovery in this area, however, the stand-alone economic viability of this is in serious question.

A more likely scenario would be to enhance the value of the land, which is a liability in some of these locations, due to the shallow depth of cover and extent of mined-out workings. This type of project could be classed more as a real estate development, rather than a mining project, and whatever coal is extracted would contribute to the overall economics of property development. Some of the remaining shallow coal has been rendered inaccessible by the construction of the Nanaimo Parkway over the Wellington Seam outcrop, west of Divers Lake.

Approximately 100 000 tonnes of Wellington seam coal remains unworked to the southeast of the Little Ash mine, along the northeastern flank of the Millstone River Valley (Figure 4-5). This coal is under less than 30 metres of cover. Approximately 70% of the deposit is overlain by sands and gravels. A limited open pit may be viable at this location, although land-use issues are of prime importance in any possible developments here.

To sum up, there is no large potential for the identification and subsequent extraction of significant coal reserves at North Nanaimo.

4.4.5.2 South Nanaimo

The South Nanaimo area encompasses both the Wellington and Douglas seams. Due to its greater structural and depositional complexity, not all the mineable reserves were developed or extracted in the previous mining operations.

Morden-Reserve Area

Coal resources in the Douglas seam have been identified by widely-spaced boreholes between the Morden and Reserve mines (Buckham, 1974; Gardner, 1979). Two coalbed methane testholes, Novacorp Cedar a-30-F and d-31-E, were drilled in the Morden-Reserve area by Novacorp Engineering Ltd. in 1986. Both testholes intersected the Douglas seam. In the a-30-F testhole, the Douglas seam is over 2 metres thick, including one parting of 0.20 metre near the base. In the d-31-E testhole, the Douglas seam is about 1 metre thick. A third hole, Novacorp Cedar b-29-F, which was drilled across the Nanaimo River, east of Morden Colliery, did not intersect a mineable seam at the Douglas horizon, possibly due to the proximity to the Nanaimo River Fault.

Deep exploratory wells drilled by BP Resources near the coastline to the east and southeast of the Morden-Reserve area (BP Laurel Harmac c-36-F and BP Yellow Point d-84-C) encountered the Douglas seam horizon at 610 metres and 1 018 metres, respectively (Cathyl-Bickford, 1991), but their geophysical logs do not indicate a mineable seam at either of these locations. Although the data obtained from this drilling are inconclusive, they do demonstrate the potential for mineable thicknesses of Douglas seam in the area between the Morden and Reserve mines. The Morden-Reserve area may possibly extend as far east as Round Island, where a 2-metre coal seam, perhaps correlative with Douglas seam, is documented in old records.

Douglas seam resources in the immediate vicinity of the Morden mine have been estimated at 6.35 million tonnes *insitu* (James, 1969).

South Cassidy Area

Other Douglas seam reserves may be present to the southeast of the Cassidy fault, which is a major downthrow structure found parallel to Haslam Creek. The Granby and Bright mines worked the upthrown block to the north. Neither mine was successful in negotiating the fault and accessing coal on the downthrown side. Coal in this area would be found at depths exceeding 300 metres. The prevalence of gas outbursts in previous mining in this area would impact on mining techniques and a de-methanation program in advance of any proposed mining would be a prerequisite.

F.W. Gray (1952) estimated an *insitu* coal reserve of 1.01 million tonnes of coal on the downthrown side of the Cassidy Fault immediately south of the Granby and Bright mine workings (Figure 4-6). This tonnage could be substantially increased with some deep drilling to the south and east, where there are currently no delimiting drillholes.

Wolf Mountain Area

The most significant known deposit in the Nanaimo coal basin is the Wellington seam remnant at Wolf Mountain. The coal is of good quality thermal grade, with two major rock bands in the middle to upper part of the seam and several small and discontinuous carbonaceous bands. The seam averages about 2.4 metres in thickness but variations are common and associated with faulting, washouts and depositional thinning and thickening of individual plies. Exploration work by the Wolf Mountain partnership indicates that the deposit is contained within a faulted syncline with its axis running generally east-west. The north limb of the fold dips to the south at a steep angle averaging about 23°. The south limb is more regular, dipping gently to the north at about 7° (Roberts, 1985).

The *insitu* tonnage of this deposit is fairly well defined at 3.1 million tonnes. These reserves are divided into 1.94 million tonnes on the south limb of the syncline and 1.16 million tonnes on the steeper north limb. Depending on mining methods, total raw coal recovery would approximate 2 million tonnes.

Harewood-Extension Area

The Wellington seam may also be present on the east limb of the Extension anticline between the old Harewood colliery and the Extension Prospect mine (Figure 4-5). Indications are that the Wellington seam is extremely variable in this area and generally of a thickness less than 1 metre thick. The same is true of the area around the Extension No. 4 mine along strike to the south. With more detailed drilling, it may be possible to identify localized occurrences of Wellington seam more than 2 metres thick, however, the chance of defining a mineable coal reserve of more than 2 million tonnes is remote (Gardner, 1984a).

Coal Mine Refuse

A coal resource in the South Nanaimo area which has been quantified and has potential for development is in the numerous coal mine waste heaps and refuse piles which are scattered throughout the area (Gardner, 1985d). A small company, Countryside Coal Resources Ltd., had agreements in place with the owners of most of these refuse piles to recover saleable coal product, subject to a royalty provision. Esso Resources Ltd. entered into an option agreement with Countryside to consider development of the waste heaps. In 1983, Esso performed drill sampling and surveying of three of the largest waste heaps in the South Nanaimo area: the Extension No. 1 waste heap, the Extension No. 4 waste heap and the South Wellington No. 10 waste heap. The results of the study indicated that more than 1.35 million tonnes of coal waste material is contained within these three refuse heaps. Countryside Coal's field estimates of the other smaller and more scattered waste heap areas indicated additional potential for a further 1.15 million tonnes of material, for a total of 2.5 million tonnes.

Of the 1.35 million tonnes tested, clean coal recoveries varied from less than 10% to as high as 28% to produce a 15% ash thermal product, with an average yield of about 18%. This indicates the potential to recover 450 000 tonnes of coal product from the various refuse heaps. The technology for recovering coal from old refuse heaps is well proven in Europe and the eastern United States; small portable wash plants are in use in many areas. The benefits of reprocessing these waste piles are both economic and aesthetic, and the recent firming in coal prices may provide the impetus for a new group to re-evaluate this coal recovery project.

4.5 COWICHAN BASIN AND THE GULF ISLANDS

The Cowichan basin and the Gulf Islands area are essentially extensions of the Nanaimo basin (Clapp, 1914b; Clapp and Cooke, 1917). A brief description of the geology of these areas and their coal occurrences is in order. However, these areas have very low potential for coal development, due to a number of factors.

4.5.1 Cowichan Basin

The Cowichan basin covers an area of 663 square kilometres (256 square miles), stretching from Lake Cowichan on the west to Cowichan Bay on the east, a distance of approximately 40 kilometres (Figure 4-7).

No coal seams have been identified in the Cowichan basin, even though the area is relatively settled and hundreds of domestic water wells have penetrated the sedimentary formations in the valley of the Cowichan River.

The most recent coal exploration in the Cowichan basin occurred during 1980 when BP Explorations Ltd. filed on coal licenses covering 4 900 hectares in the southern part of the Cowichan Valley. When geologic mapping failed to establish the typical coal-bearing sequence found in the Nanaimo area to the north, BP abandoned the licenses.

4.5.2 Gulf Islands Area

The Gulf Islands area covers approximately 583 square kilometres (225 square miles) in the lower part of the Strait of Georgia. The Gulf Islands trend actually extends across the International Boundary into the San Juan Islands of the United States.

Early work in the Gulf Islands established the presence of a coal seam approximately 3 metres thick beneath Tumbo Island, the outermost island in the chain. This work was done around the turn of the century, when at least two diamond-drill holes and one prospect shaft were completed. Later geological work in the Gulf Islands focused on the oil and gas potential (Mahannah, 1964). Charter Oil Company drilled an exploratory well (Charter Saturna No.1) on Saturna Island in 1957. The well's log reported approximately 1.5 metres of coal at 230 metres depth, although the driller could not record an accurate thickness because of caving. Other exploratory wells were drilled on the adjacent Lower Mainland during this period, all with discouraging results.

A third documented coal occurrence is in a water well drilled in September 1978 on Saltspring Island at Lot B, Section 86 near the junction of Horel Road and Ganges-Fulford Road (Gardner, 1984c). The driller recorded 1.5 metres of coal at 41 metres depth.

None of these coal occurrences correlate with any of the known coal seams in the lower part of the Nanaimo Group. Instead, they fall within the upper cyclothems, which are not known to contain economic coals. Figure 4-7 illustrates the general geology of the Gulf Islands area (after Muller and Atchison, 1970) and shows the location of the three coal occurrences. No resources have been projected for this area, as little hard evidence is available as to seam thickness, coal quality or structural conditions.

It is most unlikely that a successful coal mine could be developed in the Gulf Islands area due to land-use conflicts and environmental sensitivity. The British Columbia Government has had a long-standing policy of not granting any off-shore coal exploration licenses. The Gulf Islands area is administered by the Islands Trust, which is firmly opposed to any and all types of mining.

5. OPERATING COAL MINES AND EXISTING INFRASTRUCTURE

5.1 INTRODUCTION

At the present time the Quinsam coal mine, which is a 550 000 tonne per year underground operation west of Campbell River (Figure 5-1), is the only operating coal mine on Vancouver Island. The only other mine which operated during the past three decades is the Wolf Mountain mine near Nanaimo, which produced less than 120 000 tonnes before shutting down (see section 4.4.3.2).

5.2 QUINSAM COAL MINE

The history of the Quinsam mine is covered in part in section 3.2.6. The mine was initially designed as an open-pit to a maximum cover depth of 61 metres (200 ft.). The original concept was for a 15-year open-pit mine life, at a production rate of 910 000 clean tonnes, with some undetermined possibilities for an underground mining at the same time as or after the open-pit operation. In 1981, after Luscar Ltd. withdrew from the project, Brinco reviewed the overall mine plan, made some changes and adjustments. The company brought in a number of experts to evaluate some of the sensitive issues of the mining proposal after which it submitted an addendum to Luscar's Stage II submission in August of 1982. Approval-in-Principle was then granted for the project, subject to a public inquiry which was conducted in 1983.

Concurrent with the additional mine approval work, Brinco Mining Ltd. performed a detailed mine technical review and feasibility study. Additional exploration work was conducted to provide more information on coal quality.

When coal prices began a substantial and prolonged decline, the new operator elected to replace the large open-pit development plan with a smaller scale open-pit operation, a protracted start-up, and immediate plans for limited underground development. Under this scenario, the project began in 1985 with small-scale bulk samples to test the acceptability of the coal in the export market.

5.2.1 Surface Mines

In 1986, the first open-pit was developed in the 2N area on the north side of Middle Quinsam Lake, where the No. 1 seam is of sufficient quality to mine without washing. The mine is serviced by a 25 kilovolt power line from the B.C. Hydro feeder line located 8 kilometres to the north on Highway 28.

Between 1987 and 1994, open-pit operations were a significant part of overall mine development, although not on the scale originally planned. Aggregate open-pit production approached 1.2 million tonnes during this 7-year period. The biggest single year of open-pit production was 1992, when 300 000 tonnes of clean coal were produced from the open-pit mine out of the total 486 000 tonnes clean product (balance coming from the underground mine).

5.2.2 Underground Mines

In 1990, an underground test mine was developed and gradually underground production increased from less than 120 000 clean tonnes in 1990 to 180 000 clean tonnes in 1992 and over 400 000 clean tonnes in 1993 (75 % of total mine production). By the end of the first quarter 1994, open-pit mining had ceased and underground mining accounted for all production. Current underground mining is by the conventional room-and-pillar method, with main development advance on three parallel headings, 6 metres wide, on 36-metre centres. Sections are turned off the main development and advanced on five or more headings of the same general configuration as the main development. Two metre resin-point anchor roof bolts are installed on a 1.2 by 1.2 metre pattern for roof support in all main development and section development roadways. When the sections are advanced to a predetermined point, the support pillars are removed on a retreating system back as far as the protective barrier pillar at the main development, and the overlying roof strata are allowed to cave.

The underground operations consist of two separate underground mining areas, the 2-North and 2-South mines. A third mine (the 4-South mine) is presently being permitted and developed, to replace the short-lived 2-South mine which will be exhausted some time in 1996.

5.2.2.1 2-North Mine

The 2-North mine is accessed by two parallel portals installed near the toe of the worked-out open-pit highwall in the 2N open pit. The main conveyor delivers run-of-mine coal directly to an open stockpile near the dump pocket of the coal preparation plant. A 50-metre by 3-metre diameter vertical ventilation raise equipped with main and secondary exhausting fans, provides ventilation for the underground workings, with intake air being drawn in through the supply portal and main conveyor portal. The 2-North and 3-North deposits (both of which will be interconnected) represent more than 60% of the total mine reserve base and coal from this mine will provide most of the low-sulphur No. 1 seam feedstock for the projected 15-year life of the operation, with some of the satellite operations providing higher sulphur No. 3 seam coal for blending off.

As of June 1995, the mine was equipped with two 1100 volt continuous miner sections, each consisting of one Joy 12CM/11 continuous miner, two Joy 10SC/22 shuttle cars, one Fletcher DM roofbolter, one Stamler feeder/breaker and one Eimco 3.5 cubic yard Scooptram supply vehicle.

5.2.2.2 2-South Mine

The 2-South mine is located 4.5 kilometres south of the Quinsam coal preparation plant. This one-section mine is an extension of the 2S and 3S open-pits, and consists of three parallel underground entries accessing the No. 1 seam from the toe of the 2S-pit highwall. The equipment used is identical to that used in the 2N underground mine. The mine operates under a maximum cover depth of 80 metres, with a maximum length of advance of approximately 1 kilometre. Structural boundaries and thinning of the No. 1 seam on all sides limit the extent of the underground workings, so that the reserves will likely be exhausted some time in 1996.

5.2.3 Coal Preparation Plant

With the opening of the underground mine in 1990, a coal preparation plant was required to clean the increased dilution from the mined coal, in order to produce an acceptable export product. A small, heavy media bath-type coal preparation plant with a capacity of 100 tonnes per hour was installed and commissioned in February 1991. Later that year, two water-only cyclones were added to the circuit. While the plant is adequate for a 600 000 tonne per year operation, expansion is required to bring the production level up to 1.2 million tonnes per annum. Work on this expansion is presently underway, and includes the addition of a complete heavy media cyclone circuit with dewatering capability in the form of basket centrifuges.

5.2.4 Current and Projected Production Levels

The Quinsam mine, which currently employs about 140 people, is producing at an annual rate of approximately 550 000 clean tonnes from three underground continuous miner sections. In 1995 capital expenditures in the form of additional mining sections and an expanded coal preparation plant, will bring annual production up to 1.2 million clean tonnes. Concurrently, the company has arranged financing from the British Columbia government to upgrade the existing road and port facilities.

5.2.5 Existing Transportation Infrastructure

The Quinsam mine is accessed by 20 kilometres of paved highway west of Campbell River (Highway 28 to Gold River). The Argonaut Mainline, an all-weather Forest Service Road, leads to the mine property, 8 kilometres south of the Highway 28 intersection. The total road distance to the Federal Harbours and Ports multi-user barge ramp facility at Middle Point (8 kilometres north of Campbell River) is 33 kilometres. The mine contracts 25 owner-operated haul trucks to transport coal to the barge ramp. Trucks off-load coal onto the 5 800-tonne barges using a set of portable steel ramps, and the barges are trimmed by a front-end loader. The barges then transport the coal approximately 60 kilometres to a stockpiling and ship-loading facility on Texada Island which is described in section 5.4.

5.2.5.1 Transportation Infrastructure Upgrading

With financing in the form of a loan from the provincial government through the British Columbia Transportation Financing Authority, Quinsam has embarked on a transportation upgrade project. This project entails:

- Upgrading the 8 kilometres of Forest Service road and mine access road with asphalt hard-top.
- Building a conveyor barge-loader and covered coal-storage building at the Middle Point loading facility.

The transportation upgrade will benefit the Quinsam coal mine in the following ways:

- The road paving, together with the 20 000 tonne covered coal-storage facility at tidewater, will allow the use of larger B-Train truck units hauling on a more regular frequency than the "campaign" type loading practice where 25 trucks are on the road all at once when the barge arrives. This will reduce the truck haul frequency, and allow for more competitive transportation pricing due to the larger payloads and regular schedule.
- The conveyor barge-loading system will reduce demurrage time for loading barges from 14 hours to about 5 hours. It will also reduce the amount of coal spillage and associated environmental problems inherent in the current system of trucks and equipment running on the coal as the barge is being loaded.
- The improved road will provide safer access to the mine for its employees and suppliers, and stop the tracking of mud on to Highway 28, creating safer conditions for the travelling public.

The existing Middle Point loading facility will not be affected by the installation of the barge-loader, and other users will benefit by the removal of Quinsam coal barge traffic from the existing berth. The coal storage and barge-loading facility will be functional throughout the projected 15-year life of the Quinsam mine. During this period, the facility would presumably be available to other potential coal mines in the area. It is amenable to the transfer of other mineral products such as construction aggregates and limestone, or forest products such as hog fuel or wood chips, after coal mining ceases.

5.3 EXISTING ROAD INFRASTRUCTURE

Access to most areas with the potential to sustain coal mining operations on Vancouver Island is excellent. This is due to the relatively subdued topography and close proximity to tidewater of most of the area underlain by coal-bearing sediments, together with hundreds of kilometres of logging roads. The logging roads were mostly constructed to withstand off-highway loads of up to 120 tonnes. Some of the logging roads are designated as forest access roads on Crown Land (for example the Argonaut Main which accesses the Quinsam mine) and are therefore maintained under road use permits by the principal logging or forestry companies in the area. The Ministry of Forests usually only issues one road use permit to the main user. Other users are then required to reach side agreements on road use and maintenance with the main operator. In the case of private roads, precedent-setting fees for the use of the roads imposed by some companies in the past can be quite onerous (as much as $.05 per tonne per kilometres in addition to road maintenance costs) for a mining company which depends on access over privately owned land.

The public highway system, which at this time is being upgraded to include the Inland Island Highway, is also well positioned to accommodate any potential coal developments. This is particularly true of potential developments in the Comox basin, where the new highway will provide a much-improved transportation corridor through relatively un-populated areas as an alternative to the existing Island Highway which generally follows the coastline and has promoted a relatively continuous series of housing developments along its length during the past few decades.

5.4 COAL-HANDLING FACILITIES

Locations of marine coal-handling facilities are shown on Figure 5-2. In past practice, Vancouver Island coal via industrial or common-carrier railroads to three ship-loading points: Ladysmith (south of Nanaimo), Boat Harbour (east of Nanaimo), and Union Bay (south of Courtenay). None of these shipping points has any remaining infrastructure in place for either the handling of rail cars or the loading of ships. Rail is no longer a viable economic alternative for transporting coal on the Island. However, any of these three points could be easily accessed by truck if the infrastructure were in place to transfer the coal onto barges or ships.

It is probable that the Boat Harbour ship-loading point, which is now an up-scale rural residential area with views of the Gulf Islands, will never accommodate any type of industrial facility due to land-use conflicts associated with such development. This conclusion is based on a report prepared by the Assessment and Planning Division of the Ministry of Environment (Lozoway and Symes, 1980). Some of the conclusions of this report are as follow:

1. Environmental concerns identified to date do not appear to represent a major obstacle to the proposed development.

2. Land use and social/community concerns present severe constraints to the revival of coal mining in the Cedar area, to development of Boat Harbour as a coal port, and the utilization of transportation corridors thereto.

3. The nature of land use and community patterns in the Boat Harbour area render it unsuitable for use as a coal port.

Ladysmith, the site which Robert Dunsmuir shipped coal from the Extension mines, would no longer be available for the bulk loading of coal on board ships. Union Bay, which is still relatively undeveloped, is a reasonable candidate for a marine facility, although it is difficult to envision anything more than a barge-loading facility here. Weldwood of Canada Limited retains a foreshore lease at Union Bay, as well as surface title over most of the area.

5.4.1 Barge-Loading Facilities

Present barge-loading facilities which can service Vancouver Island coal mines are limited to two sites:

1. Duncan Bay Marine Terminal, located just south of Middle Point and 2 kilometres north of the Elk Falls pulp mill at Campbell River. This facility is operated by the Canadian Coast Guard for Harbours and Ports Canada. It serves the Quinsam mine and other industrial users who use it for trans-shipping heavy mobile equipment to and from coastal logging operations, supply and servicing to aquaculture facilities and other industrial users such as scrap-metal recyclers. Coal from Quinsam provides more than 90% of the total revenues at the facility at present. The facility is being upgraded to accommodate coal barges at the end of the causeway, leaving the existing berth totally available for other traffic (see section 5.2, above).

2. Ocean Cement's barge ramp at Brechin Point, in Nanaimo, located adjacent to the Departure Bay ferry terminal. Ocean Cement is a division of Lafarge Canada. In recent years it has handled bulk shipping of shale aggregate from the Dunsmuir shale pit in North Nanaimo. This material is used as a feedstock for the Canada Lafarge cement plant in Richmond. The Brechin Point facility has previously handled coal shipments from the Wolf Mountain and Twinforks mines. While it is quite satisfactory as a barge loading-facility, the increased movement of truck traffic in the area would be of concern if an operating coal mine were to use it.

5.4.2 Ship-Loading Facilities

5.4.2.1 Texada Island

The Texada Island ship-loading facility, located on the northwestern shoreline of Texada Island, is well protected from the southeasterly winter storms. The original wooden piling structure is slowly being replaced by steel and all of the dolphins are now steel. The twin-loading conveyor booms and all conveyor components have been refurbished.

The facility is capable of delivering up to 2 000 tonnes per hour on to the ship. An operational average delivery rate is between 1 200 and 1 500 tonnes per hour. Coal is reclaimed from the 200 000 tonne stockpile area by front end loader and truck while ship-loading operations are taking place. The trucks dump directly into a 150 tonne hopper which feeds the main conveyor of the ship-loader via two variable speed feeders.

Ships up to Panamax size (70 000 tonnes) currently use the facility, which has a water depth of 13.7 metres at zero tide. The facility's dolphins are designed to handle larger Cape size vessels (H. Diggon, Operations Manager, personal communication, 1995), but minor additions to the ship-loading equipment would be necessary to load these wider vessels.

Proposed improvements in barge loading and unloading systems using conveyors will increase the efficiency of the total operation from mine to ship. Even at the current level of usage, the Texada facility is the most cost-effective to the coal shipper, of all the coal ports on the British Columbia coast. Texada Island is well-positioned to service other potential coal-producing areas along the east coast of Vancouver Island by virtue of its location in the Strait of Georgia.

5.4.2.2 Roberts Bank

While it is possible that the Roberts Bank coal terminal, operated by Westshore Terminals at Tsawwassen (south of Vancouver), could receive and handle coal shipments from Vancouver Island, there are no facilities in place to receive and off-load barges. Engineering designs and capital cost estimates for such facilities have already been done.

6. VANCOUVER ISLAND LAND-USE CLASSIFICATIONS

This report was written in early 1996. All conclusions on land-use issues and land tenure were appropriate and correct at the time of writing but may now be out of date. The reader is advised to seek up dated information from the appropriate sources.

6.1 COAL RIGHTS TENURE HOLDERS

There are two types of coal rights tenure on Vancouver Island: fee-simple (freehold) title and Coal Exploration License. Section 3 of this report describes in some detail how the tenure evolved from the original Esquimalt & Nanaimo Railway Land Grant to the present day. Because of the hundreds of title transfers, forfeitures, subdivisions and other ownership transactions within the original E & N Grant area, the accurate identification of fee-simple coal rights (and other tenure) is extremely difficult for some titles within the Grant even for experts in the Land Titles Office. A comprehensive land titles document or database for the area covered by the E & N Grant has not been compiled.

With approximately 27 415 hectares (67 742 acres) and 13 793 hectares (34 081 acres) of fee-simple coal rights respectively, Weldwood of Canada Limited and Quinsam Coal Corporation are the most important coal tenure holders on Vancouver Island. This report demonstrates that the largest potential for future coal development is within the Weldwood and Quinsam control blocks. The other fee-simple owner of note is Mayo Holdings Ltd. of Nanaimo, which own 567 hectares (1 400 acres) in the Cedar district southeast of Nanaimo. Other small fee-simple rights holders are not well documented and consist mostly of settler's rights in the Nanaimo district which was settled prior to the 1883 Dunsmuir agreement.

The coal exploration license holders include a number of active and inactive exploration or resource companies with title to various licenses along the east coast of Vancouver Island. Weldwood of Canada again accounts for a substantial portion of the total license area at 5 800 hectares (14 300 acres), as does Quinsam Coal Corporation, which purchased its rights from Weldwood in 1990, at 2 600 hectares (6 425 acres).

Figures 4-3 and 4-5 illustrate the coal rights ownership in the Comox and Nanaimo basins. There are presently no holders of coal rights in the Suquash basin of northern Vancouver Island.

The most important player in recent years in terms of coal license acquisition and evaluation is Canadian Occidental Petroleum Ltd. Due to negative exploration results and a change in corporate priorities, Canadian Occidental has recently forfeited all of its holdings on Vancouver Island, which amounted to some 16 000 hectares (40 000 acres).

6.2 SURFACE RIGHTS TENURE HOLDERS

Apart from Crown lands, the major owners of surface rights on Vancouver Island are the large forest resource companies. MacMillan Bloedel Ltd. is the largest owner of surface rights in the eastern Vancouver Island lowlands. Other owners of significant amounts of surface title are Timberwest Forest Ltd. (a division of Fletcher Challenge Canada Ltd.), the Hancock Resources Group (which recently purchased all of Weldwood of Canada Limited tree farm areas), and Pacific Forest Products (Canadian Pacific Enterprises Ltd.).

6.3 ABORIGINAL ISSUES

On Vancouver Island, as in the rest of British Columbia, very few treaties regarding the use of land and resources have been signed with First Nations. This has left the question of aboriginal rights unresolved.

Recent court decisions have begun to clarify the nature of aboriginal rights and, as a consequence, redefine the legal relationship between the Province and aboriginal peoples. The courts have declared that aboriginal rights were not extinguished when British Columbia joined Confederation, that they continue to exist, and that they are protected under Canada's constitution.

The courts have also indicated that treaty negotiations, rather than costly court battles, are the best way to arrive at fair and lasting solutions that will put an end to the uncertainty regarding the use of lands and resources in the province.

6.3.1 The Province's Legal Obligations

The most detailed description of aboriginal rights, and of the Province's legal obligations toward aboriginal people, is contained in the 1993 decision of the British Columbia Court of Appeal in *Delgamuukw v. The Queen*. The Court declared that aboriginal people in British Columbia have constitutionally protected, unextinguished, non-exclusive aboriginal rights, other than a right of ownership or property right, within their traditional territories. The Court held that these aboriginal rights arise from activities which:

- are integral to the distinctive culture of an aboriginal society and practised for a sufficient length of time before 1846, the date of sovereignty in British Columbia;
- are exercised by the collective aboriginal group;
- are generally site-specific;
- may vary depending upon the aboriginal group and its distinctive patterns of historical occupancy and use of the land;
- include fishing, berry-picking and hunting, for sustenance, social and ceremonial purposes;
- may be practised in modernized form; and
- may not be currently practised.

The Court also held that the Province has a legal obligation to ensure that its actions and decisions concerning Crown land do not infringe these existing aboriginal rights, unless infringement can be justified according to the strict standards established by the Supreme Court of Canada in *Regina v. Sparrow (1990).*

6.3.1.1 Provincial Government Guidelines

In response to the Delgamuukw decision, the Ministry of Energy and Mines has prepared guidelines to assist its staff to ensure that aboriginal rights are respected on Crown land.

These "Guidelines for Avoiding the Infringement of Aboriginal Rights" require the government to take all reasonable steps to determine if aboriginal rights exist in the area of any proposed activity on Crown land prior to engaging in or authorizing such activity. If it is determined that a proposed activity would infringe on aboriginal rights, the activity must be modified to avoid the infringement, unless infringement can be legally justified.

A key element of the guidelines is a requirement for government staff to notify and consult with First Nations about proposed activities within their traditional territories in order to determine if these activities would result in an unjustifiable infringement of existing aboriginal rights. The level of consultation required varies depending upon the degree of impact the proposed activity is expected to have on lands or resources within First Nation traditional territory.

6.3.1.2 Implications for the Mining Industry

The legal obligation to ensure that activities carried out by the mining industry or other third parties on Crown land which are authorized by the government do not unjustifiably infringe aboriginal rights, rests with the government, not the mining industry or other third parties. The government cannot delegate or transfer this responsibility to the mining industry. In some cases, the government may require the industry to consult directly with First Nations about the potential implications of its activities, but it cannot delegate the ultimate responsibility to the mining industry.

In all cases, however, the government encourages the industry to consult directly with First Nations whose interests may be affected by proposed mining activities, in order to develop common understanding of the proposed activity and build positive, co-operative working relationships.

6.3.2 Treaties and Treaty Negotiations in B.C.

In British Columbia, two treaties have been signed with First Nations: one includes parts of Vancouver Island, where 14 treaties were concluded by the then Colony of Vancouver Island between 1850 and 1854 (the

Douglas Treaties); and other one covers the Peace River area, where five bands signed Treaty 8 with the federal government between 1900 and 1914.

The First Nations which are party to the Douglas Treaties include: the Kwakiutl people near Port Hardy; the Saalequun near Nanaimo; and several First Nations on the southern tip of Vancouver Island, including the Esquimalt, Sooke, Songhees, Beecher Bay, Pauquachin, Tseycum, Tsartlip and Tsawout. The Douglas Treaties are problematic because of the vagueness of their wording and the varying interpretations which result. However, the courts have confirmed that the rights protected under these treaties include the right to hunt over unoccupied lands (even private unoccupied lands) and to fish, as has traditionally been the practice.

The absence of further treaties with First Nations in British Columbia has created uncertainty with respect to the Province's jurisdiction over lands and resources. British Columbia is committed to negotiating modern-day treaties with First Nations – treaties that will clarify aboriginal rights to land and resources and address issues such as self-government and the social, economic and environmental concerns of all parties. In 1990, the Province formally joined the treaty negotiations between the Nisga'a Tribal Council and Canada which had been underway since 1976.

In addition, in 1993, the Province, the First Nations Summit and the federal government established the British Columbia Treaty Commission to oversee and facilitate treaty negotiations through a six-stage process. As of August 1995, 48 First Nations had initiated negotiations under the auspices of the commission. Nisga's negotiations, mentioned above, predate the establishment of the Treaty Commission and are outside the Commission's process.

In most cases, negotiations under the Treaty Commission's process are focused on procedural issues and are still at an early stage, as of the writing of this report.

6.3.2.1 Interim Measures

Because treaty negotiations in many cases may take several years to conclude, interim measures agreements are being negotiated in order to balance the province's interests in lands and resources with those of First Nations during the pre-treaty period. These agreements do not replace or limit the scope of treaties. To date, approximately 50 interim measures agreements have been entered into between the province and First Nations; for the most part, these agreements do not deal directly with subsurface resources.

Objectives of the interim measures are two-fold:

- to ensure that the government meets its legal obligation to avoid unjustifiable infringement of existing aboriginal rights; and
- to build positive, co-operative relationships between government, industry and First Nations.

The government shares information on mineral potential and tenures with First Nations. It has also hosted a number of mineral and energy forums which focus on building relationships between First Nations and the mining industry.

6.3.2.2 Implications for the Mining Industry

Treaties will bring more certainty to land and resource use, help attract new investment for resource development, create social stability and put an end to costly legal battles between First Nations and the Province. The interim measures will promote positive and co-operative relationships between government, industry and First Nations.

In concluding treaties with First Nations the Province's stated objective is to minimize the impact on private interests, such as leases or tenures. Where treaty settlements result in unavoidable impacts on existing commercial interests, fair and consistent province-wide standards will be applied to determine reasonable and timely compensation.

6.4 THE LAND-USE CLASSIFICATION SYSTEM

The Commission on Resources and Environment (CORE) was mandated by the provincial government in 1992 to develop a comprehensive land-use strategy for British Columbia, among other key responsibilities. CORE worked with government and the public to develop broad principles for social, economic and environmental sustainability. These principles were published in a Land Use Charter which was endorsed by the government in principle. This Charter provided the foundation for more specific land-use goals, published by CORE in January, 1994 after extensive round-table discussions with the public and all stakeholder groups.

CORE released its recommendation for a Land Use Plan for the Vancouver Island, in February, 1994. The subsequent review of the recommendations by the government led to modifications; the resulting Vancouver Island Land Use Plan was announced in June, 1994. The plan identifies four main land-use classifications, protected areas, Forest Land Reserve, Agricultural Land Reserve and settlement lands. Protected areas are not open for mining. Forest Land Reserve is open for all resource uses, including mining. The Agricultural Land Reserve and the settlement lands are not closed for mining, but depending on the location, they have significantly increased restrictions.

Figure 6-1 illustrates the Vancouver Island Land Use Plan as it relates to the area of Nanaimo Group sedimentary deposition which is known to contain possible coal resources. This map is intended for illustrative purposes only. For decision-making, readers should consult authoritative maps produced by the government.

6.4.1 Protected Areas

There are 23 protected areas outlined which comprise 12.75% of the total Vancouver Island land base. These areas have all been identified and their boundaries mostly defined by the time of this study. None of the protected areas encroach on potential coal resource areas which may be developed in the future. A further 0.25% is yet to be protected; comprising small areas, they are not anticipated to impact coal resources.

6.4.2 Forest Land Reserves

Eighty-one percent of the Island's land base is dedicated for commercial forestry and other resource uses, including mining. Within the Forest Land Reserve classification there are three sub-classifications, Low Intensity Areas, High Intensity Areas and General Forest Areas.

- Low Intensity Areas (LIAs) require special planning in recognition of environmental, cultural or recreational values and to form biodiversity corridors linking protected areas. All lands within this classification have all been identified and their boundaries defined by the time of this report. None of the LIAs encroach on potential coal-resource areas which may be developed in the future. Forestry, mining and other commercial resource development are permitted uses in the LIAs (which cover approximately 8% of the total land base), subject to government standards and a demonstrated respect for identified special values for that particular location. Special values considered are; visual quality and scenic values, cultural, heritage and archeological values, biodiversity connective value, community watershed water quality value, recreation and opportunity values, and fish and wildlife habitat and population values.
- High Intensity Areas (HIAs) are yet to be designated at the time of this report. These areas will consist of high-yield forestry lands and they will be identified through a special planning process. They will be designated under the Forest Practices Code to allow companies to use labour-intensive forest management to produce higher value and higher volumes of merchantable timber. Mining is permitted in these areas.
- General Forestry Areas will consist of the remaining forest reserve. Mining and other resource extraction will be permitted in these areas. The majority of the areas with potential for coal mining development fall within this category.

6.4.3 Agricultural Land Reserves

This classification covers 3 % of the total Island land base. There are several classes of agricultural land; mining is possible in some of them. Special conditions must be met for any non-agricultural resource development or land use to be undertaken within these areas. A small percentage of the potential coal resources falls within these areas.

6.4.4 Settlement Lands

According to the Vancouver Island Land Use Plan, just over 3% of the total Island land base is covered by human settlements. Local municipal governments play the primary role in deciding land-use patterns within these areas.

6.5 MINING WITHIN THE AGRICULTURAL LAND RESERVES

As noted above, approximately 3% of the Vancouver Island land base is covered by Agricultural Land Reserves. The governance of this land falls within the Ministry of Environment Lands and Parks and it was instituted to prevent agricultural land from being encroached on by other land users. It is primarily designed to limit urban sprawl into areas of considerable agricultural value, but has implications on other resource developments which may want to share the land base. It is incumbent on proponents of alternate use to demonstrate value. The stringent guidelines for taking land out of Agricultural Land Reserves (which requires high-level governmental approval) ensure that only serious projects of great merit can succeed in taking precedence over the land's agricultural value.

While coal mining can perhaps be demonstrated to co-exist with agricultural uses (especially underground coal mining at significant depths of cover), the classification of land within the Agricultural Land Reserve is an important consideration in assessing potential coal mining developments. Only a small percentage of the potential coal resource areas fall within this land classification. However, this would have particular impact on potential coal mining developments in the eastern part of the Nanaimo basin *(i.e.* the Morden-Reserve area and the Cassidy area) and parts of the Comox Valley.

Recent great successes in land reclamation initiatives in the eastern United States, the United Kingdom and parts of Europe certainly demonstrate that agricultural land can be restored to its original use and productivity. The cost components of permitting prior to coal mining, land-use fees, and high reclamation costs after mining is complete, are all contributing factors which must be considered during the conceptual and feasibility stages of such a project.

6.6 PUBLIC CONCERNS RELATED TO COAL DEVELOPMENTS

Coal mining is no longer a major way of life on Vancouver Island. Development of coal mines near residential areas on Vancouver Island would therefore require a great deal of primary information dissemination and public education, as well as exhaustive public consultation. Public consultation is mandated by existing provincial legislation.

Two significant problems must be overcome when planning underground coal mines around residential developments on the Island:

- Accurate prediction and minimization of surface subsidence associated with the extraction of coal seams.
- Coal preparation plant refuse disposal.

Both of these problems can be solved by proper engineering practice. Mining-induced subsidence is a function of depth of cover above the mine workings, thickness of extraction, and amount of coal left in the ground as pillar support. Refuse disposal can be addressed by the proper location of the coal preparation plant with respect to suburban developments, perhaps using selective disposal techniques such as injection of slurried tailings into old underground workings, or reclamation of disused and abandoned quarry sites on surface.

A third issue is the movement of coal from the mine production facilities to its various markets. Public concerns include safety, visual and noise pollution and other environmental considerations.

The mining proponent must clearly communicate the extent of its mining activities and transportation methods to the public. This process of communication is one of the most important parts of the over-all development of a coal mining project on Vancouver Island. The way in which public communication is implemented may make the difference between success and failure. The mining proponent must also establish lines of communication with local and provincial government agencies early on in the development process.

7. OUTLOOK FOR COAL MINING DEVELOPMENTS ON VANCOUVER ISLAND

7.1 INTRODUCTION

This section will attempt to forecast coal mining developments on Vancouver Island, based on the data presented in this report. It is difficult to forecast a time frame for development due to the unpredictability of world markets, in particular those of the net coal-importing countries, such as Japan, Korea and some countries in Europe. The balance of trade between Canada and these countries is a matter of concern, as are currency exchange rates. These subjects are not within the scope of this report, however, a general discussion of the basic current production cost and revenue structure for Vancouver Island coals may be useful to the reader. These production costs are meant only to provide a framework for the reader to use as a comparison of Vancouver Island economics *versus* those of other mining areas.

In 1996, the outlook for coal prices appears to be positive. The world coal market has recently undergone a period of adjustment which resulted from rapid expansion of sources of supply for both thermal and metallurgical product. This expansion of world supply was triggered by the large increases in the price of oil in the early to mid-1970s, which brought new coal mines on stream, thus creating a supply overhang. This over supply has now been matched by increased demand, with a resulting increase in selling price. With the current economic expansion in the developing countries, together with strong demand from the mature economies, the price should maintain an upward trend for some time to come (Table 7-1-1).

TABLE 7-1-1

COAL EXPORT PRICE - ASIA (US$ per tonne, FOBT)

YEAR	MONTH	COAL TYPE	
		COKING	THERMAL
1994	January	$46.38	$32.02
	February	$46.47	$33.14
	March	$46.93	$33.75
	April	$43.15	$30.27
	May	$43.13	$31.96
	June	$44.46	$30.17
	July	$42.41	$28.03
	August	$44.33	$30.83
	September	$42.16	$29.95
	October	$41.48	$30.17
	November	$40.79	$30.98
	December	$42.38	$29.98
1995			
	January	$40.79	$31.95
	February	$43.51	$30.11
	March	$42.38	$28.42
	April	$47.57	$36.07
	May	$48.38	$33.37

7.2 PRODUCTION COST AND REVENUE STRUCTURE

Each particular "brand" or source of coal has its own pricing structure. The general price for thermal coal of the type currently produced on Vancouver Island is about $40.50 US per tonne (P. Kittredge, A.E.C. Resource Consultants, personal communication, August 1995). Metallurgical coal commands a general 10 to 15% price premium over the thermal price.

For the potential Vancouver Island coal producers, if the barge-loading slip is within about 30 kilometres of the mine, then the transportation cost should be about $12.00 per tonne, FOB ship. This transportation charge includes all components of transportation and transhipment of coal prior to and including ship-loading, such as loading and trucking of coal product, road-use charges, barge-slip tariffs, barge and tug transportation costs, tidewater stockpiling charges, stockpile reclaim and ship-loading fees. Depending on the ownership of the infrastructure and the annual production volume, the $12.00 figure could be reduced by as much as 50%.

The actual production costs for coal mines on Vancouver Island would vary considerably for each potential mining area. Due to the limited size and high stripping ratio of most of the potential open-pit mining areas outlined in the study, open-pit mining costs would be higher than for larger open-pit operations in other areas of British Columbia. Open-pit costs of the type identified in this study could vary considerably but cost projections of a minimum of $18.00 per raw tonne (including capital cost component) are forecast, and these costs could range upward from this figure, depending on the economic cut-off ratio used.

Underground costs are also difficult to generalize. The type of underground mining conditions found in most areas of Vancouver Island dictate a very flexible type of conventional mining system such as continuous miner and shuttle car feeding a conveyor. The production limitations of this type of mining system impact on the overall mining costs. For shallow mines *(i.e.* less than 200 metres of cover), this system is quite acceptable and average costs of $18.00 per raw tonne (including capital cost) are achievable. For mines deeper than 200 metres, the geologic structure of the Island usually means difficulties in accessing the mineable area. Shafts or long cross-measure drifts, necessary to access the mining area, mean much higher mine development and capital costs. While the conventional mining system of continuous miner and shuttle car is still applicable in this type of situation, the system should be co-ordinated with a higher productivity system such as longwall (or a derivative) to follow on. In this context, the continuous miner sections serve not only as initial production units, but as "trailbreakers" to block out areas of the mine which are amenable to highly mechanized, higher productivity longwall-type systems. The disadvantage of this is that the continuous miner sections are on development advance most or all of the time, and low-cost pillar-removal coal is deferred until much later when the longwall panels are set up. Generalized production cost estimates for this type of mine are pure guesswork until a proper feasibility study is worked-up and production scheduled and costed for the life of the operation. It is almost certain that production costs for this scenario would be higher than $18.00 per tonne.

7.3 COMOX BASIN

The development potential of the Comox basin is good to excellent. This is evidenced by Quinsam Coal, which has matured into a moderate-sized underground mine producing over 500 000 tonnes of clean coal per year and is scheduled to more than double this annual production rate over the next three years. There is a possibility of finding additional reserves in areas to the east of the current Quinsam mine (Figure 4-4B). While access to the coal in this area is substantially more difficult than at Quinsam (due to greater depth of cover), its close proximity to services, power and existing transportation infrastructure is favourable. Because of these factors, the area is deserving of further exploration work.

Further south in the Cumberland area, the Brown's River and the Allen Lake areas (Figure 4-4A) are interesting. Of the two, the Allen Lake area (discussed in section 4.3.7.4) presents the best possibilities for development. Reasons for this include: a simple structural style, better historical drilling records with more favourable coal seam intersections indicated; no habitation over most of the projected coal resource; and closer proximity to a potential tidewater shipping facility at Union Bay. Access to the coal seam in either of these areas will present some difficulties. A phased exploration approach is recommended for these areas to limit financial risk during the initial evaluation stage.

The Tsable River area south of Cumberland is the most advanced potential mining area on Vancouver Island and second only to Quinsam in terms of its stage of development. Initially drilled in the 1950s by Canadian Collieries (Dunsmuir) Ltd., the area immediately south of the abandoned Tsable River mine was the subject of more drilling in 1991 (20 holes). The information base is sufficient for conceptual mine designs and preliminary economic feasibility studies. Additional drilling is required to finalize a mine layout and to extend the reserve base (currently 11 million tonnes). A detailed feasibility study and environmental permitting would then follow.

Other exploration targets within the Tsable River area are identified in the study (see section 4.3.7.5). These targets are of a longer term nature due to the lack of existing information. Significant depths of cover are also indicated but potential coal resources exceed 20 million tonnes (*insitu* ultimate resources), enough to warrant considerable interest.

An extension of the coal resources in the Comox basin is the old mine waste dumps (discussed in section 4.3.7.3). These dumps could augment production from potential mines in the Cumberland area (*i.e*. Browns River or

Allen Lake). The low-cost feedstock from the mine waste dumps may possibly justify a separate coal preparation plant given the right coal selling price, however, it is more reasonable to treat the dumps as an add-on to any mining project.

7.4 NANAIMO BASIN

The short to medium-term coal development potential of the Nanaimo basin is limited to one or two possibilities. The first possibility is a rehabilitation of the Wolf Mountain mine (see section 4.4.5.2) as a small underground producer, with the coal waste dumps in the surrounding area as additional feedstock to augment production. The Wolf Mountain mine, by virtue of its small reserve base, would be limited to a maximum of two operating sections. With the contribution of coal reclaimed from mining waste dumps, it is conceivable that production of 150 000 to 350 000 tonnes per year could be achieved for a few years.

The second possibility is production from either the Cassidy fault area or the Morden mine area. Based on the current coal prices, the existing information base and possible problems with mining conditions, these two areas will have difficulty attracting the type of exploration funding required for a detailed evaluation of coal seam characteristics and mining conditions. If coal prices increase, then these prospects may generate greater interest.

For the longer term, mining coal at cover depths exceeding 400 metres may be possible. Recent petroleum industry drilling indicates the potential for finding coal seams at significant cover depths. In particular, coals in the Comox Formation, which had not been identified in the Nanaimo basin until 1986, offer long-term potential. It is quite possible that with additional exploration offshore, new coal seams in the upper cyclothems may be identified, raising the possibility of multi-level mining.

Policies regarding the dispensation of off-shore (submarine) coal rights will have to be addressed at some point in order to provide proponents with the assurance required to pursue a project of this scale.

7.5 THE NORTH ISLAND

The North Island area has not been a significant producer in the past, even though serious attempts at coal mining have taken place. There are two areas of potential interest (see section 4.2.5). The first is the Suquash area, which was the site of the first coal mining on Vancouver Island in 1849. The second is along the north shore of Holberg Inlet, north and west of Coal Harbour. Structurally, this area would appear to be difficult to mine, with indicated dips of greater than 20°. The area is also limited in extent and cut off on the northeast side by plutonic rocks.

The Suquash area has received considerable attention and most of the landward portion of the basin contains no economic coal seams. The seaward portion of the basin is open to speculation due to lack of information. Existing information does indicate that there is some improvement in coal seam characteristics in an easterly direction. Again, policy decisions would have to be made by government with respect to the granting of off-shore coal licenses before any corporation would be able to justify a high-cost off-shore exploration program.

8. CONCLUSIONS

8.1 FUTURE MINING POSSIBILITIES

The Nanaimo basin was largely mined out in the first period of coal mining which lasted from 1849-1967. During this interval over 50 million tonnes of coal were produced. The Comox basin, to the north, was not as heavily exploited during this period, when 15 million tonnes of coal were produced, and the Comox basin still contains substantial resources. The most northerly, North Island basin has seen exploration and mining intermittently since 1847, but production has been minimal and no mineable reserves are identified. Table 8-1-1 summarizes the remaining reserves and resources for the three basins.

TABLE 8-1-1
VANCOUVER ISLAND COAL RESERVES million tonnes

COAL RESOURCE AREA	PROVEN RESERVES	ULTIMATE RESOURCES	TOTAL RESOURCES AND RESERVES
COMOX COAL BASIN	47.52	261.43	308.95
NANAIMO COAL BASIN	3.34	7.67	11.01
NORTH ISLAND BASIN	0	18.1	18.1
TOTALS	50.86	287.2	338.06

Note calculations only use seams greater than 1.5 metres in thickness.

The future development potential of the Comox basin is good to excellen. Reserves and resources of coal are presented in Table 8-1-2.

TABLE 8-1-2

COAL RESERVES AND RESOURCES IN THE COMOX BASIN

AREA	A. PROVEN RESERVES		B. ULTIMATE RESOURCES		TOTALS
	A-1. Measured	A-2. Indicated	B-1. Inferred	B-2. Hypothetical	
Middle Quinsam	12.01	16.30	10.32	38.66	77.29
Lower Quinsam		5.02		3.15	8.17
Campbell River			16.81	27.50	44.31
Chute Creek		2.02			2.02
Anderson Lake N			2.54		2.54
Anderson Lake S			1.49		1.49
Browns River				18.35	18.35
Allen Lake				45.66	45.66
Coal Refuse Heaps		1.17			1.17
Hamilton Lake A			6.42		6.42
Hamilton Lake B			2.63		2.63
Tsable River N				61.70	61.70
Tsable River S		11.00		26.20	37.20
TOTALS	12.01	35.51	40.21	221.22	308.95
	Total Proven Reserves: 47.52 million tonnes		Total Ultimate Resources: 261.43 million tonnes		

Note: reserves shown for coal refuse heaps are recoverable tonnes at average 18% yield.

The Tsable River area south of Cumberland is the most advanced potential mining area on Vancouver Island, and second only to Quinsam in terms of its stage of development. The area immediately south of the Tsable River mine, initially drilled in the 1950s by Canadian Collieries (Dunsmuir) Ltd., was the subject of more drilling in 1991 (20 holes). The information base is sufficient for conceptual mine designs and preliminary economic feasibility. Additional drilling is required to finalize a mine layout and to extend the reserve base (currently 11 million tonnes).

Additional reserves may exist in an area some distance east of the current Quinsam mine (Quinsam East, Figure 4-4B). While access to the coal in this area is more difficult than at Quinsam (greater depth of cover), its location and close proximity to services, power and existing transportation infrastructure are favourable. Because of these factors, the area is deserving of further exploration work.

Further south in the Cumberland area, the Brown's River and the Allen Lake resource areas (Figure 4-4A) are of note. Of these two, the Allen Lake area presents the best possibilities for development because it has a more straightforward structural style, better historical drill records with more favourable coal seam intersections indicated, no habitation over most of the projected coal resource, and closer proximity to a potential tidewater shipping facility (Union Bay). Access to the coal seam in either of these areas will present some difficulties.

Reserves and resources in the Nanaimo basin are not extensive (Table 8-1-3), and coal development possibilities are limited, in the short to medium term, to one or two possibilities. The first is a rehabilitation of the Wolf Mountain mine as a small underground producer, with the coal waste dumps, in the surrounding area, as additional feedstock to augment production. The Wolf Mountain mine, by virtue of its small reserve base, would be limited to a maximum of two operating sections. With some additional production from the coal waste dumps, it is conceivable that production of 150 000 to 350 000 tonnes per year could be achieved for a few years. The second possibility is production from either the Cassidy fault area or the Morden mine area. These two areas will have difficulty attracting funding for exploration and feasibility studies because of low coal prices, lack of information and the indicated problems with respect to mining conditions. If coal prices increase, then these prospects may generate greater interest.

TABLE 8-1-3

COAL RESERVES AND RESOURCES IN THE NANAIMO BASIN

AREA	A. PROVEN RESERVES		B. ULTIMATE RESOURCES		TOTALS
	A-1. Measured	A-2. Indicated	B-1. Inferred	B-2. Hypothetical	
A: South Cassidy				1.01	1.01
B: Morden-Reserve				6.35	6.35
C: Wolf Mountain	1.94	1.16			3.10
D: Little Ash			0.10		0.10
Coal Refuse Heaps[1]		0.24	0.21		0.45
TOTALS	1.94	1.40	0.31	7.36	11.01
Total Proven Reserves: 3.343 million tonnes			Total Ultimate Resources[2]: 7.667 million tonnes		

Note 1: Recoverable tonnes at average 18% yield.

Note 2: Total includes recoverable tonnes from coal refuse piles, assuming 18% yield.

In the future it may be feasible to mine at cover depths exceeding 400 metres, in which case it may be possible to mine deeply buried Comox Formation coals in the Nanaimo basin. These seams, which offer long-term potential, have been located by recent drilling by the petroleum industry and were not known to exist prior to 1986. It is quite possible that with additional exploration offshore, coal seams may be found in the upper cyclothems of the Nanaimo Group.

The North Island area has produced little coal in the past, even though serious attempts at mining have taken place. There are two areas of potential. The first is the Suquash area, which was the site of the first coal mining on Vancouver Island in 1849. The second is along the north shore of Holberg Inlet, north and west of Coal Harbour. This area is very limited in extent.

The Suquash area has received considerable attention and most of the landward portion of the basin has been identified as containing no economic coal seams. The seaward portion of the basin is open to speculation. Existing information indicates that there is some improvement in coal seam characteristics in an easterly direction (*i.e*. offshore).

8.2 COAL QUALITY

Generally speaking, Vancouver Island coals are of high-volatile A to B bituminous rank. They are ideal thermal coals for use in electric power generation and other industrial boiler applications. With a Hardgrove Index of between 45 to 60, most Island coals are resistant during handling, and compared to coals of similar rank from northeast and southeast British Columbia they exhibit a low fines content. Some of the Comox coals have good coking qualities.

8.3 ECONOMIC CONSIDERATIONS

Proximity to tidewater gives a competitive edge to Vancouver Island coal deposits. This is because the transportation cost from mine into ship, which is likely to be less than $12.00 per tonne and could easily be reduced, is substantially lower than that for other British Columbia and Alberta producers. Any additions or expansion of transportation infrastructure on Vancouver Island, in particular improvements or additions to barge-loading or ship-loading facilities, will reduce transport costs and have a beneficial effect on the economics of Vancouver Island producers.

Any new coal mines on Vancouver Island will probably be underground mining operations due to complexities in geological structure, depth of coal and other factors such as land-use and environmental factors. As such, mining and production costs will be higher than for the large open pit operations in north and southeast British Columbia. It is difficult to get underground mining costs below $18.00 per raw tonne (including capital cost component), given prevailing mining conditions for most Island coal areas.

Due to dilution from underground mining operations and a characteristic tendency of Vancouver Island coal seams to contain significant in-seam partings, clean coal recoveries from mines on the Island tend to be lower than 75%. Wolf Mountain, for example, never exceeded clean coal recoveries of 70%. Most of the Comox mines averaged 71 to 74% recovery through the Union Bay wash plant, not taking into account the scalping of coarse rock at the pitheads. If an average recovery of 75% is used, $18.00 per tonne of raw coal translates into $24.00 per tonne of clean coal. With a preparation plant cost of $3.50 per clean tonne and general and administration expense of $5, minegate costs will be approximately $32.50 per clean tonne.

8.4 TENURE

Weldwood of Canada Limited is well positioned to participate in any future coal developments because it is the major owner of fee-simple and coal exploration license areas, which have the best development potential in the Comox basin. Weldwood is not an operating coal producer. Hillsborough Resources Ltd. has emerged as the dominant operating company on Vancouver Island. Hillsborough and its subsidiary company Quinsam Coal Corporation have acquired the right to develop its coal lands in the Comox basin. While other smaller license areas (for example the Chute Creek coal deposit) may be developed in future years, these will have to be integrated with other larger developments likely to come on stream within the Weldwood holdings in order to take advantage of the available infrastructure and services which will result from the larger coal developments.

8.5 LAND-USE CONSIDERATIONS

Land-use considerations are as important as technical aspects of a project when planning its development on Vancouver Island. Fortunately, most of the coal deposits underlie Forest Land Reserves, which are designated for integrated resource use including mining. Some title and ownership questions, such as aboriginal claims and off-shore rights, remain unanswered, but are not these issues are not major hindrances to mine development. Coal mining requires a substantially smaller operating land base less than other resource industries such as forestry. Underground coal mining, in turn, requires less of a land base than does open-pit coal mining; it should therefore enjoy a greater degree of acceptance.

Future coal mining developments on Vancouver Island will have to compete with urban and semi-urban population growth. This is particularly true in the case of possible coal developments in the Nanaimo and Campbell River areas, and to a lesser extent in the Cumberland-Tsable River area. Coal mining and associated infrastructure will become increasingly significant in the economy of Vancouver Island, and while coal may not regain the importance it enjoyed in the first part of the century, the coal mining industry will play a vital role for decades to come.

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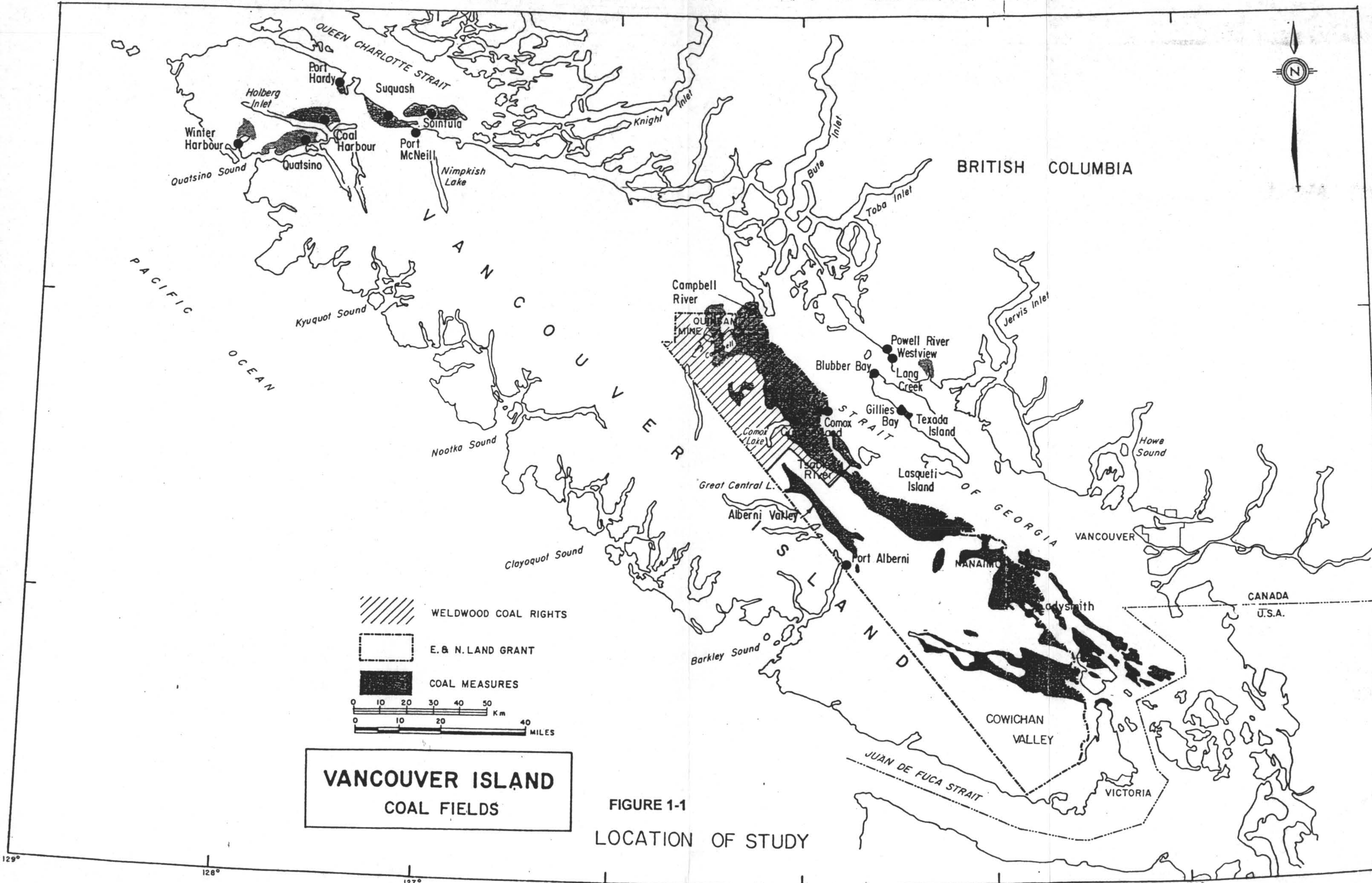


VANCOUVER ISLAND
COAL FIELDS

FIGURE 1-1

LOCATION OF STUDY

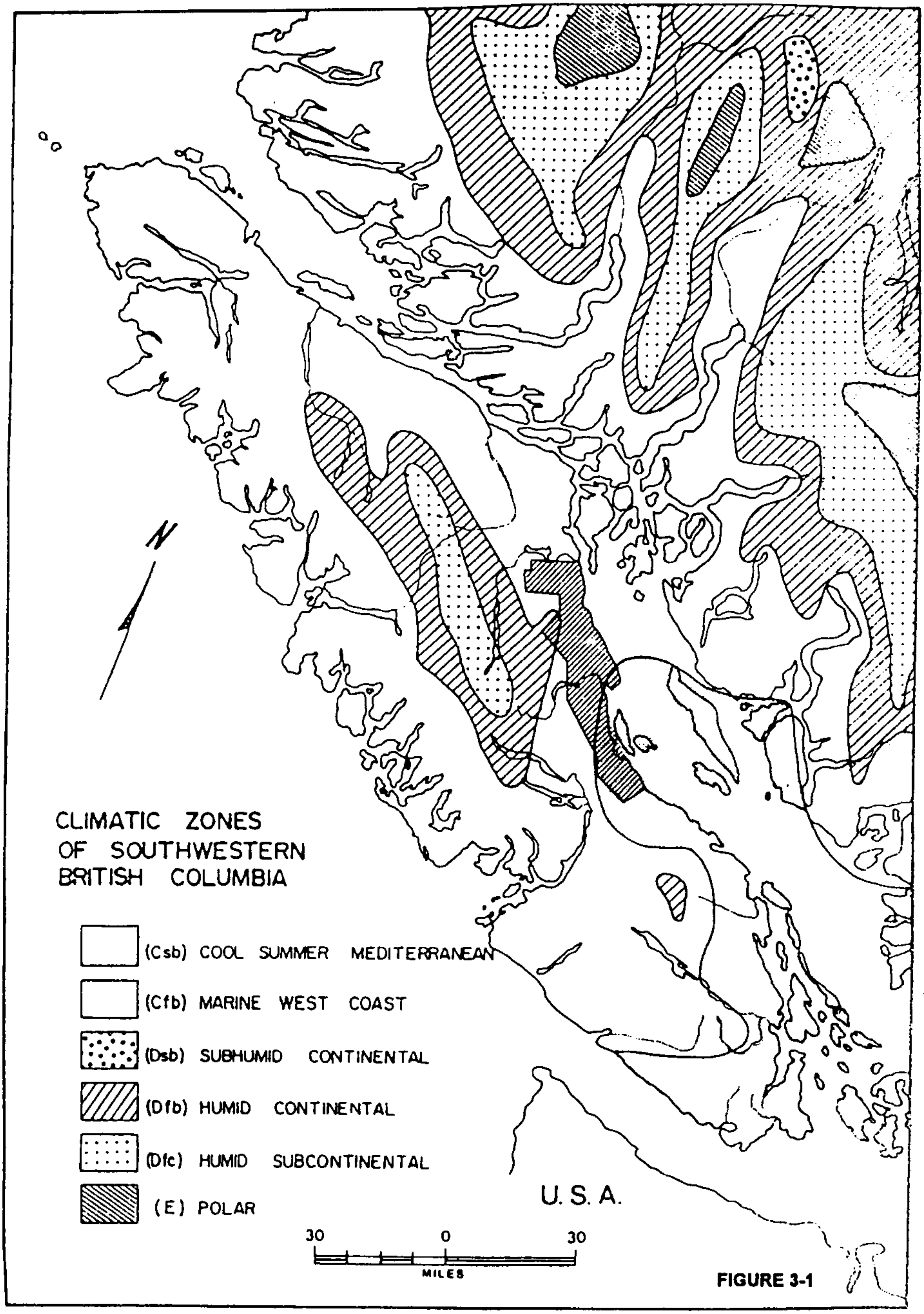
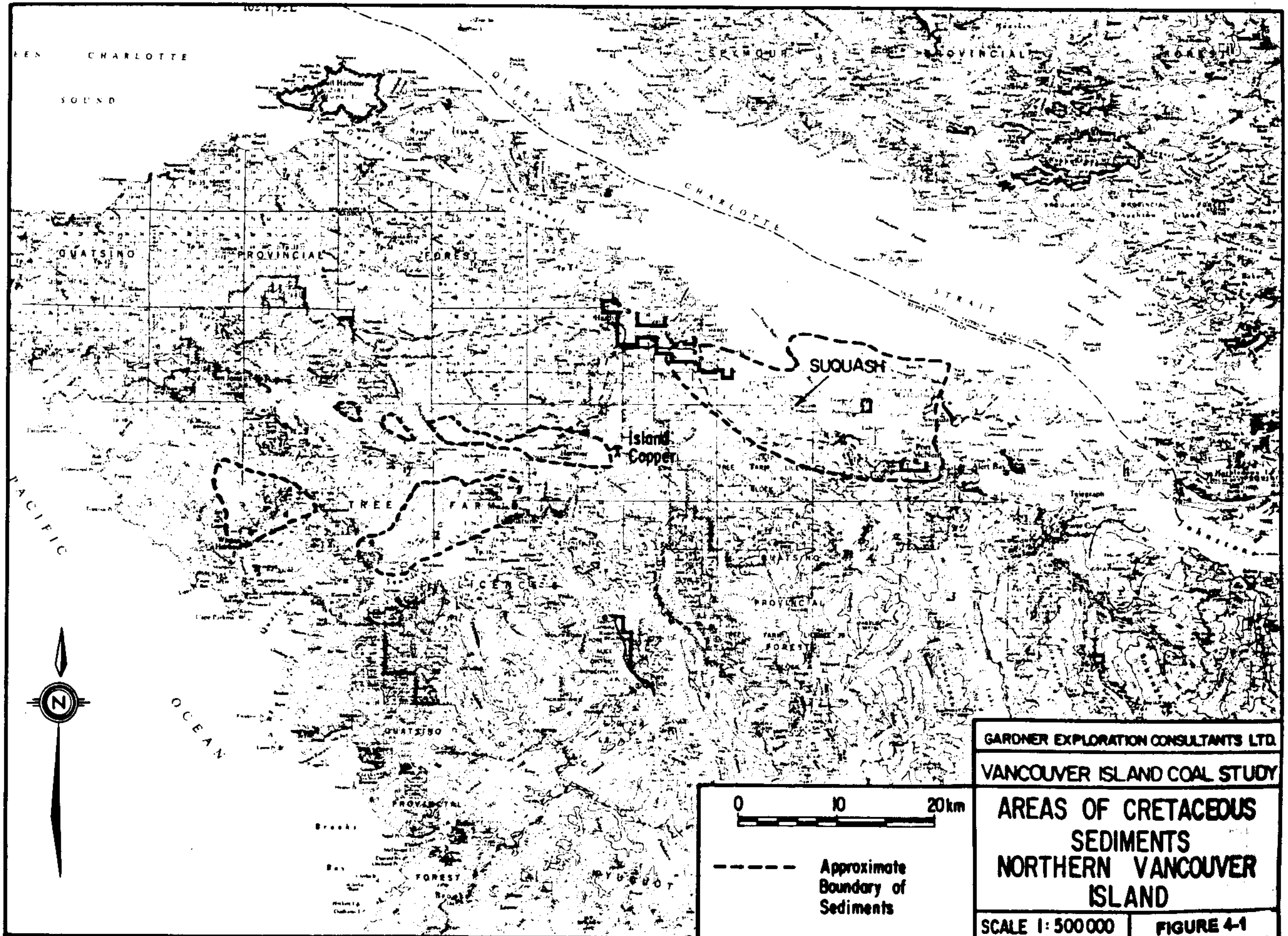
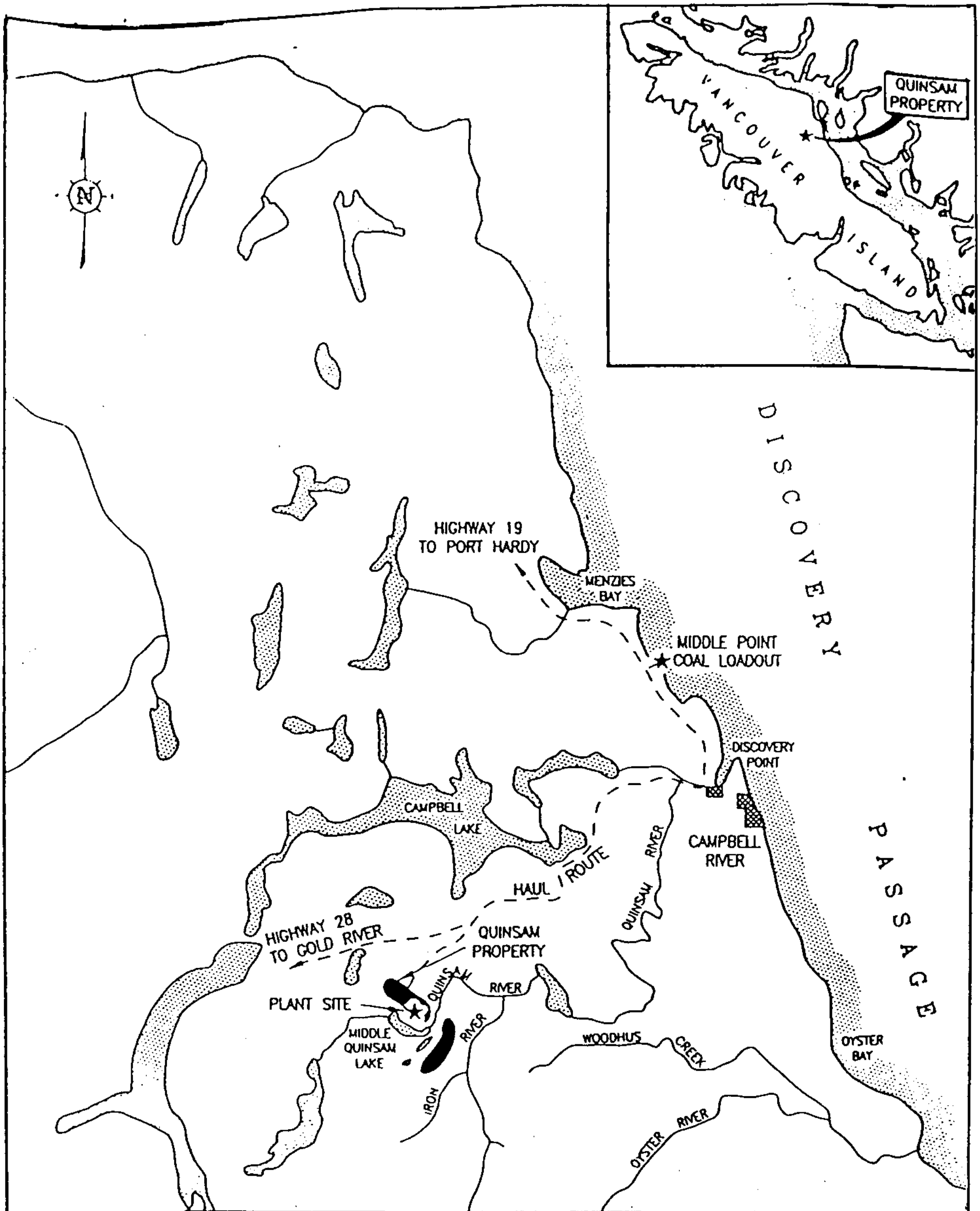

CLIMATIC ZONES
OF SOUTHWESTERN
BRITISH COLUMBIA
(Csb) COOL SUMMER MEDITERRANEAN
(Cfb) MARINE WEST COAST
(Dsb) SUBHUMID CONTINENTAL
(Dfb) HUMID CONTINENTAL
(Dfc) HUMID SUBCONTINENTAL
(E) POLAR
U.S.A.
30
0
30
MILES
N

FIGURE 3-1



CHARLOTTE
SOUND
QUATSINO PROVINCIAL FOREST
QUEEN CHARLOTTE STRAIT
SEYMOUR PROVINCIAL FOREST
SUQUASH
Island Copper
TREE FARM LICENCE
PACIFIC OCEAN
QUATSINO PROVINCIAL FOREST
0 10 20km
Approximate Boundary of Sediments
GARDNER EXPLORATION CONSULTANTS LTD.
VANCOUVER ISLAND COAL STUDY
AREAS OF CRETACEOUS SEDIMENTS NORTHERN VANCOUVER ISLAND
SCALE 1: 500000
FIGURE 4-1



1 5 km
SCALE

SCALE	1:250,000
DATE	
DESIGNED	S.C.
DRAWN	E.P. JUL 8/94
CHECKED	
APPROVED	

QUINSAM MINE
GENERAL LOCATION & ROUTE MAP

FIGURE 5-1

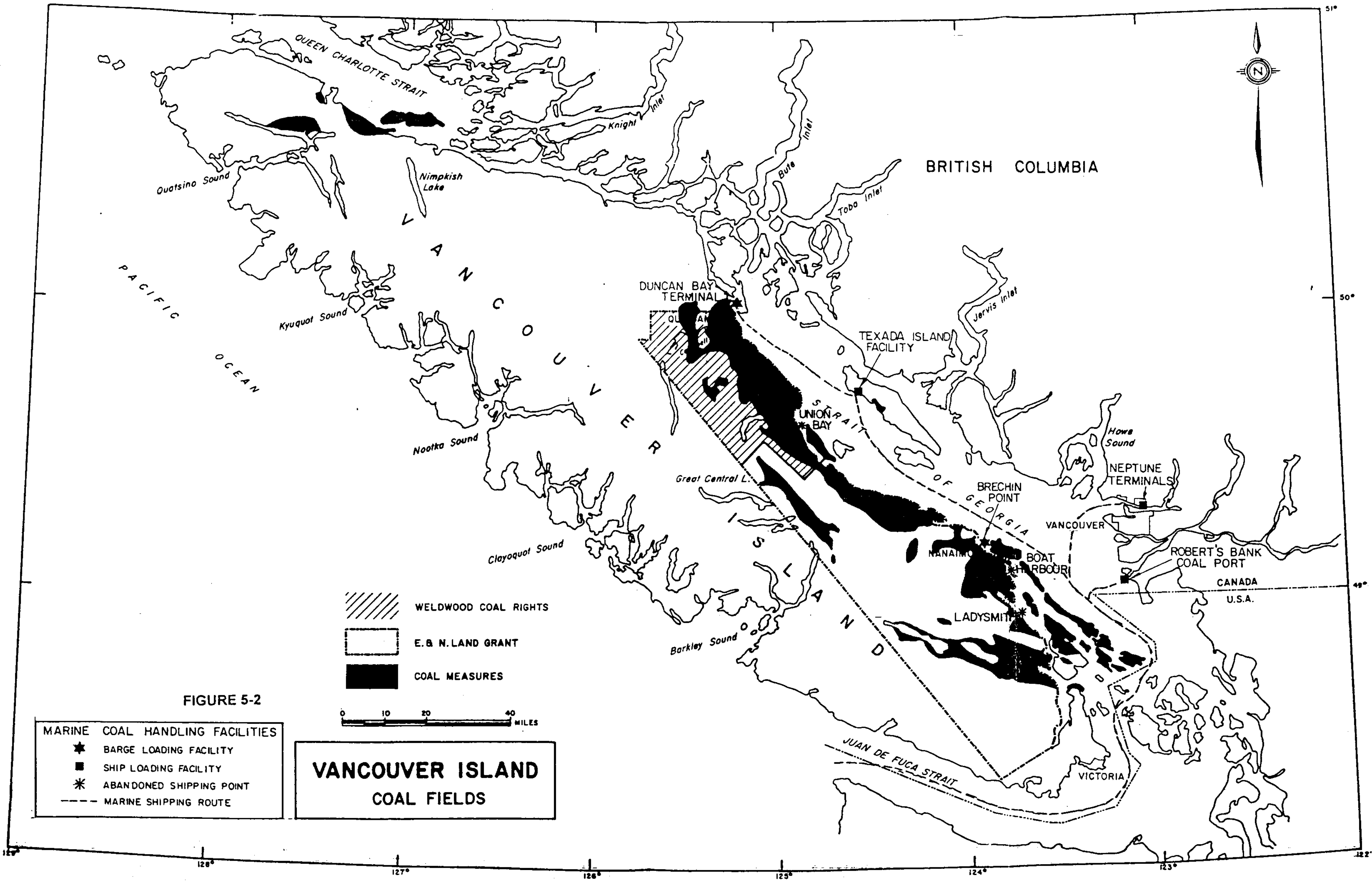
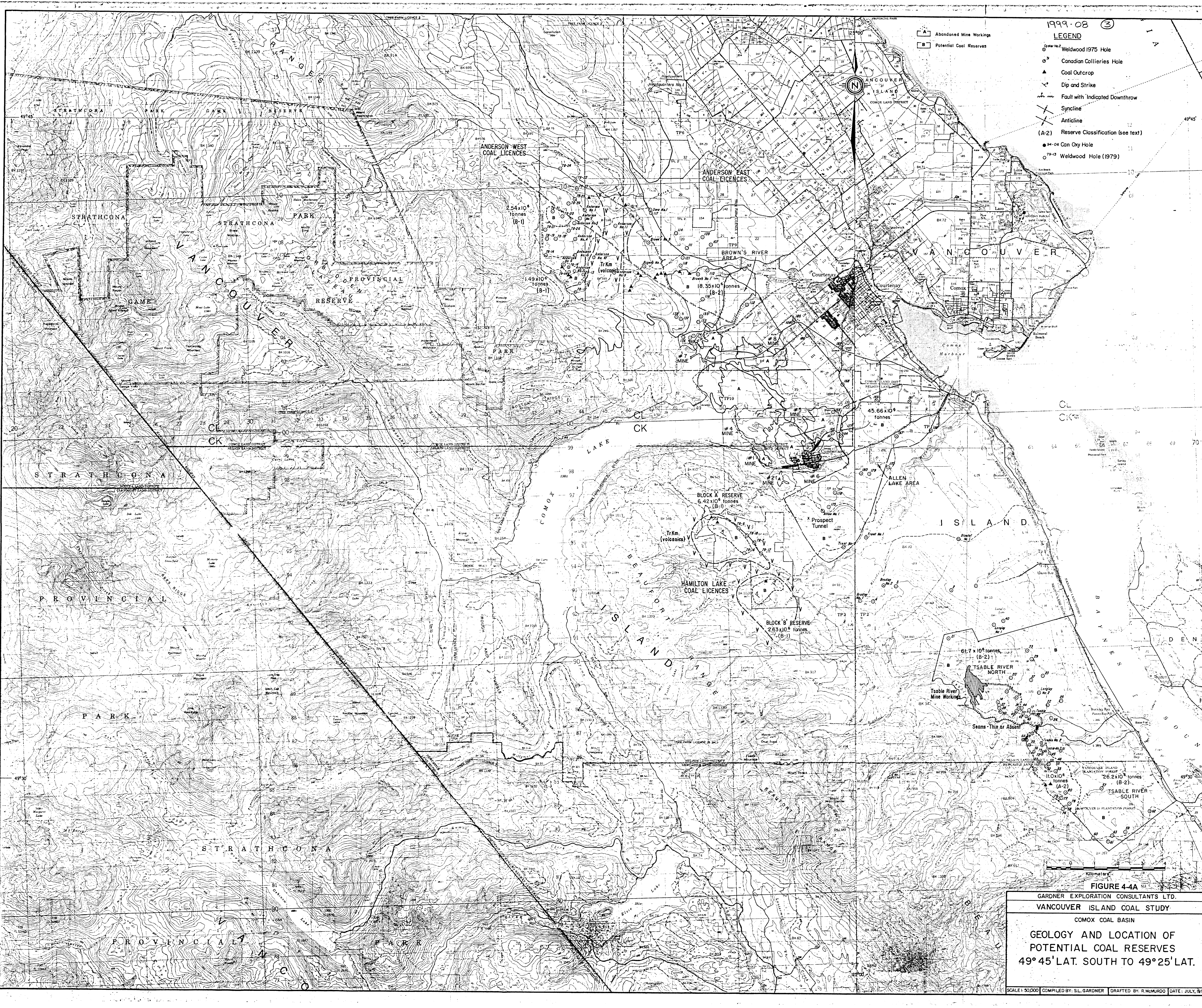


FIGURE 5-2

VANCOUVER ISLAND
COAL FIELDS


QUEEN CHARLOTTE STRAIT
(~50 fathom water depth)
Sedimentary Shelf (Projected Approximate Extent)
Area of inferred in-situ coal resources 18.1 million tonnes
MALCOLM ISLAND
Thick Glacial Cover (no outcrops)
BROUGHTON STRAIT
QUATSINO PROVINCIAL FOREST
VANCOUVER ISLAND
Triassic Karmutsen Fm. Basalt
Upper Cretaceous Sediments
Jurassic Bonanza Group Volcanics
Cleskiaugh Creek Coal Area
Hushamu Creek Coal Area
Lower Cretaceous Longarm Fm. Sandstone - Shales
Lower Cretaceous Queen Charlotte Fm. Conglomerate
Tertiary Volcanics
Lower Cretaceous Queen Charlotte Sediments
Jurassic Bonanza Grp. Volcanics
Queen Charlotte Fm.
UTrQ Lmst
LEGEND
Formation Strike and Dip
Fault Contact With Indicated Direction of Downthrow
Formational Boundary
Unconfirmed Coal Occurrence
Confirmed Coal Occurrence
Old Borehole
Recent Borehole
Volcanic Terrain (Pre-Cretaceous)
Sandstone
Conglomerate
Limestone
Siltstone
Inferred Subcrop - Outcrop of Coal Seams
Road Traverse
IJB Jurassic Bonanza Group Volcanics
UTrQ Upper Triassic Quatsino Limestone
TrKm Triassic Karmutsen Basalt
0 1 2 3 4 5 6 7 8
kilometres
Scale 1:100,000
FIGURE 4-2
GARDNER EXPLORATION CONSULTANTS LTD.
VANCOUVER ISLAND COAL STUDY
POTENTIAL COAL-BEARING SEDIMENTARY DEPOSITS SUQUASH BASIN AND OUTLIERS
1999-08 ①
COMPILED BY: S.L.GARDNER
DRAFTED BY: R. Mc MURDO
DATE: JULY, 1995


1999-08 (2)
LEGEND
A Weldwood of Canada Ltd. - Fee Simple Coal Rights
B Weldwood of Canada Ltd. - Coal Licences
C Quinsam Coal Corporation - Fee Simple Coal Rights
D Quinsam Coal Corporation - Coal Licences
E Canadian Occidental Petroleum Ltd. - Coal Licences (Surrendered)
F P. Forster - Coal Licences
CANADIAN OCCIDENTAL (Surrendered)
STRAIT OF GEORGIA
VANCOUVER ISLAND
STRATHCONA PROVINCIAL PARK
COMOX LAKE
kilometres
Scale 1:100,000
FIGURE 4-3
GARDNER EXPLORATION CONSULTANTS LTD.
VANCOUVER ISLAND COAL STUDY
COMOX COAL BASIN
COAL RIGHTS OWNERSHIP
(TO JULY 1995)
NTS 92F/6, 92F/7, 92F/10, 92F/11, 92F/14, 92F/15, 92K/3
COMPILED BY: S.L.GARDNER
DRAFTED BY: R. McMURDO
DATE: JULY, 1995



1999-08 (3)
LEGEND
Abandoned Mine Workings
Potential Coal Reserves
Weldwood 1975 Hole
Canadian Collieries Hole
Coal Outcrop
Dip and Strike
Fault with Indicated Downthrow
Syncline
Anticline
(A-2) Reserve Classification (see text)
94-06 Can Oxy Hole
79-13 Weldwood Hole (1979)
ANDERSON WEST COAL LICENCES
ANDERSON EAST COAL LICENCES
2.54x10⁶ tonnes (B-1)
1.49x10⁶ tonnes (B-1)
BROWN'S RIVER AREA
18.35x10⁶ tonnes (B-2)
45.66x10⁶ tonnes
BLOCK A RESERVE 6.42x10⁶ tonnes (B-1)
Prospect Tunnel
HAMILTON LAKE COAL LICENCES
BLOCK 'B' RESERVE 2.63x10⁶ tonnes (B-1)
ALLEN LAKE AREA
61.7x10⁶ tonnes (B-2)
TSABLE RIVER NORTH
Tsable River Mine Workings
Seams-Thin or Absent
11.0x10⁶ tonnes (A-2)
26.2x10⁶ tonnes (B-2)
TSABLE RIVER SOUTH
Courtenay
Comox
Cumberland
COMOX LAKE
STRATHCONA PROVINCIAL PARK
Kilometers
FIGURE 4-4A
GARDNER EXPLORATION CONSULTANTS LTD.
VANCOUVER ISLAND COAL STUDY
COMOX COAL BASIN
GEOLOGY AND LOCATION OF POTENTIAL COAL RESERVES
49° 45' LAT. SOUTH TO 49° 25' LAT.
SCALE 1: 50,000
COMPILED BY: S.L. GARDNER
DRAFTED BY: R.McMURDO
DATE: JULY, 1995

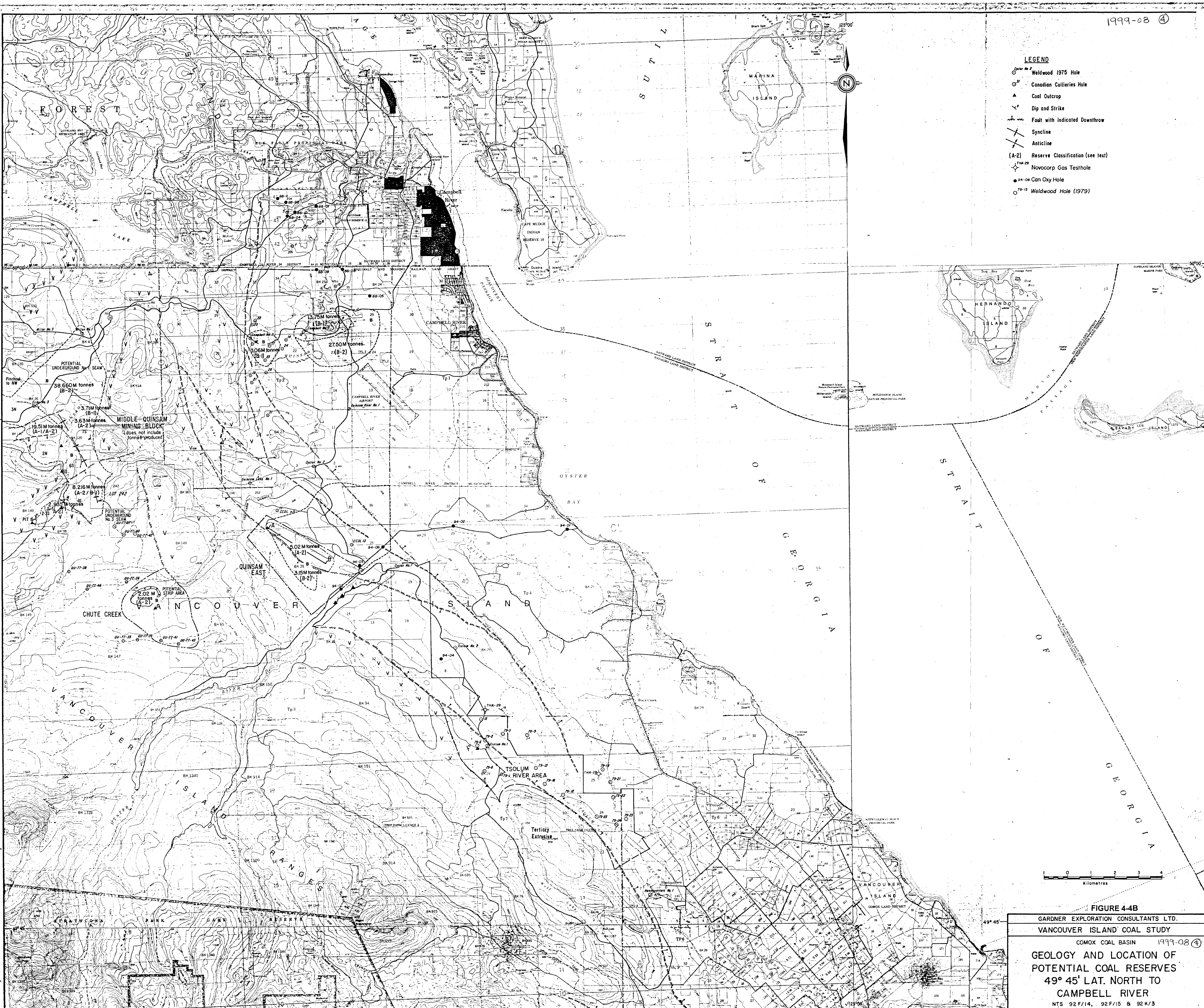


FIGURE 4-4B

GARDNER EXPLORATION CONSULTANTS LTD.

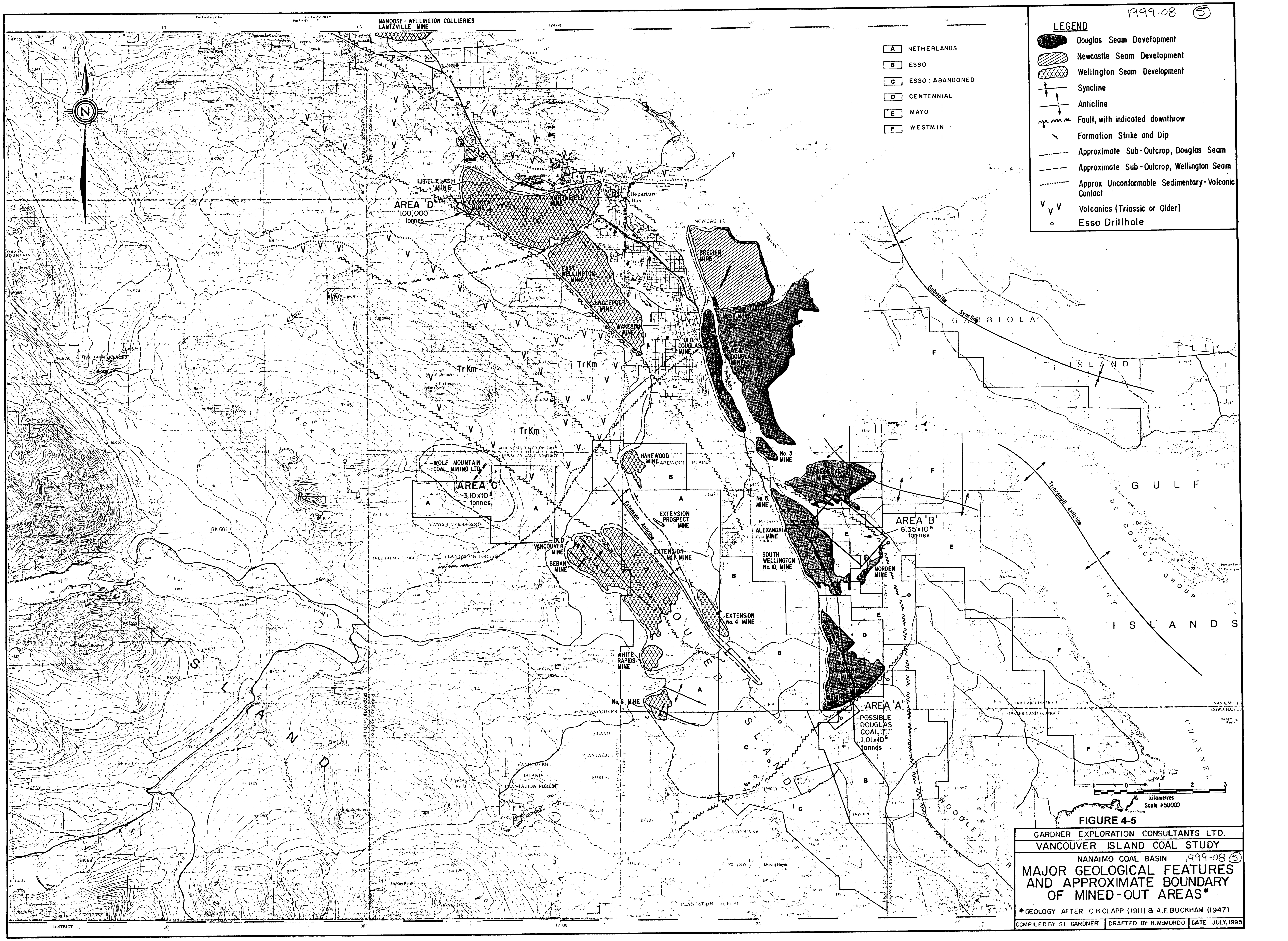
VANCOUVER ISLAND COAL STUDY

COMOX COAL BASIN 1999-08 (4)

GEOLOGY AND LOCATION OF POTENTIAL COAL RESERVES 49° 45' LAT. NORTH TO CAMPBELL RIVER

NTS 92 F/14, 92 F/15 & 92 K/3

SCALE 1:50,000 | COMPILED BY: S.L. GARDNER | DRAFTED BY: R.McMURDO | DATE: JULY, 1995


1999-08 (5)
LEGEND
Douglas Seam Development
Newcastle Seam Development
Wellington Seam Development
Syncline
Anticline
Fault, with indicated downthrow
Formation Strike and Dip
Approximate Sub-Outcrop, Douglas Seam
Approximate Sub-Outcrop, Wellington Seam
Approx. Unconformable Sedimentary-Volcanic Contact
Volcanics (Triassic or Older)
Esso Drillhole
A NETHERLANDS
B ESSO
C ESSO : ABANDONED
D CENTENNIAL
E MAYO
F WESTMIN
NANOOSE - WELLINGTON COLLIERIES LANTZVILLE MINE
LITTLE ASH MINE
AREA 'D' 100,000 tonnes
NORTHFIELD MINE
BRECHIN MINE
EAST WELLINGTON MINE
JINGLEPOT MINE
WAKESIAH MINE
OLD DOUGLAS MINE
NEW DOUGLAS MINE
No. 3 MINE
RESERVE MINE
HAREWOOD MINE
WOLF MOUNTAIN COAL MINING LTD.
AREA 'C' 3.10x10⁶ tonnes
EXTENSION PROSPECT MINE
No. 5 MINE
ALEXANDRIA MINE
SOUTH WELLINGTON No. 10 MINE
AREA 'B' 6.35x10⁶ tonnes
MORDEN MINE
OLD VANCOUVER MINE
BEBAN MINE
EXTENSION No. 4 MINE
EXTENSION No. 4 MINE
WHITE RAPIDS MINE
No. 8 MINE
AREA 'A'
POSSIBLE DOUGLAS COAL 1.01x10⁶ tonnes
Extension Anticline
Gabriola Syncline
Trincomali Anticline
TrKm
GABRIOLA ISLAND
GULF ISLANDS
DE COURCY GROUP
VANCOUVER ISLAND
kilometres
Scale 1:50000
FIGURE 4-5
GARDNER EXPLORATION CONSULTANTS LTD.
VANCOUVER ISLAND COAL STUDY
NANAIMO COAL BASIN 1999-08 (5)
MAJOR GEOLOGICAL FEATURES AND APPROXIMATE BOUNDARY OF MINED-OUT AREAS*
*GEOLOGY AFTER C.H.CLAPP (1911) & A.F.BUCKHAM (1947)
COMPILED BY: S.L. GARDNER
DRAFTED BY: R. McMURDO
DATE: JULY, 1995

1999-08 (6)

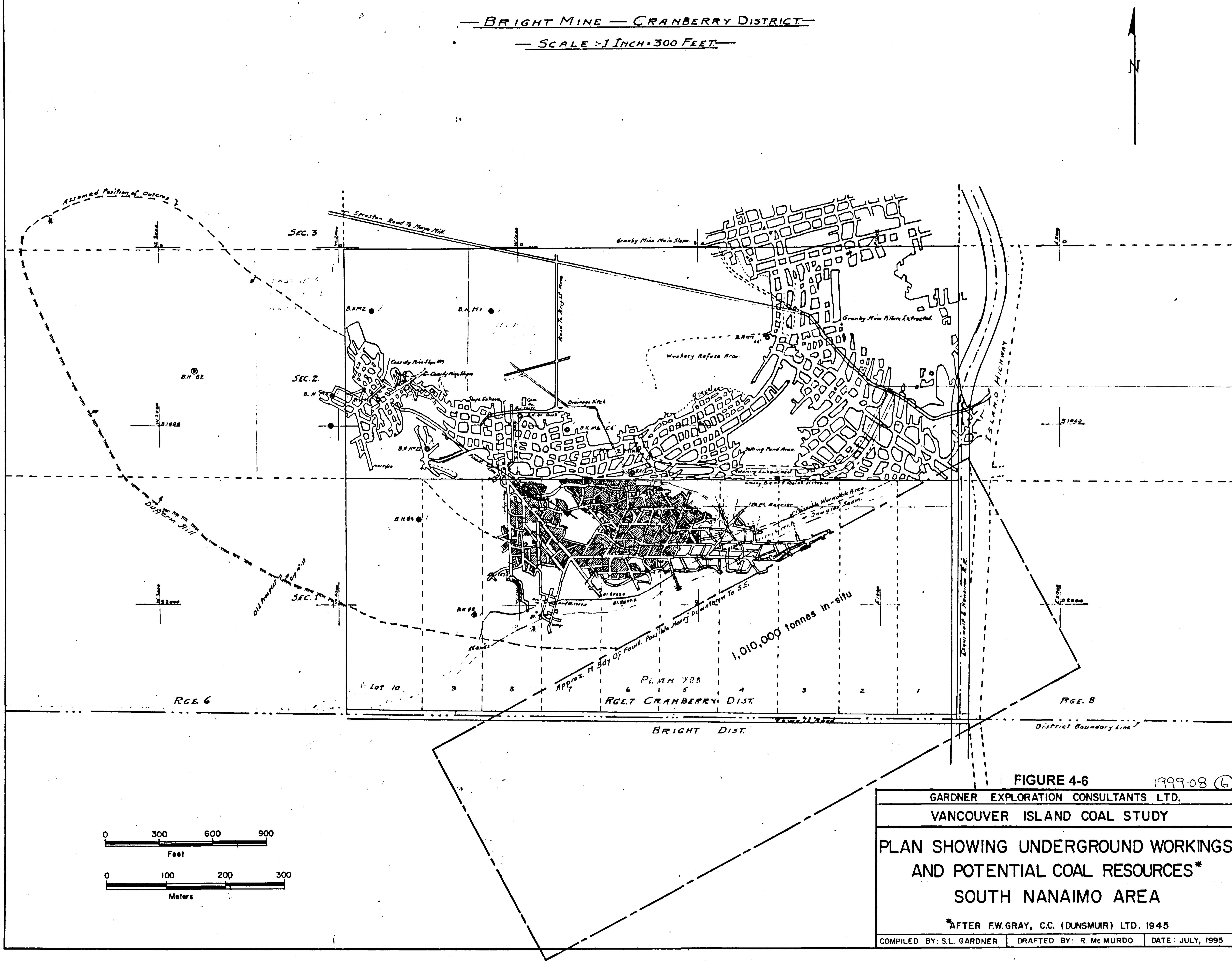


FIGURE 4-6 1999-08 (6)

GARDNER EXPLORATION CONSULTANTS LTD.

VANCOUVER ISLAND COAL STUDY

PLAN SHOWING UNDERGROUND WORKINGS AND POTENTIAL COAL RESOURCES* SOUTH NANAIMO AREA

*AFTER F.W. GRAY, C.C. (DUNSMUIR) LTD. 1945

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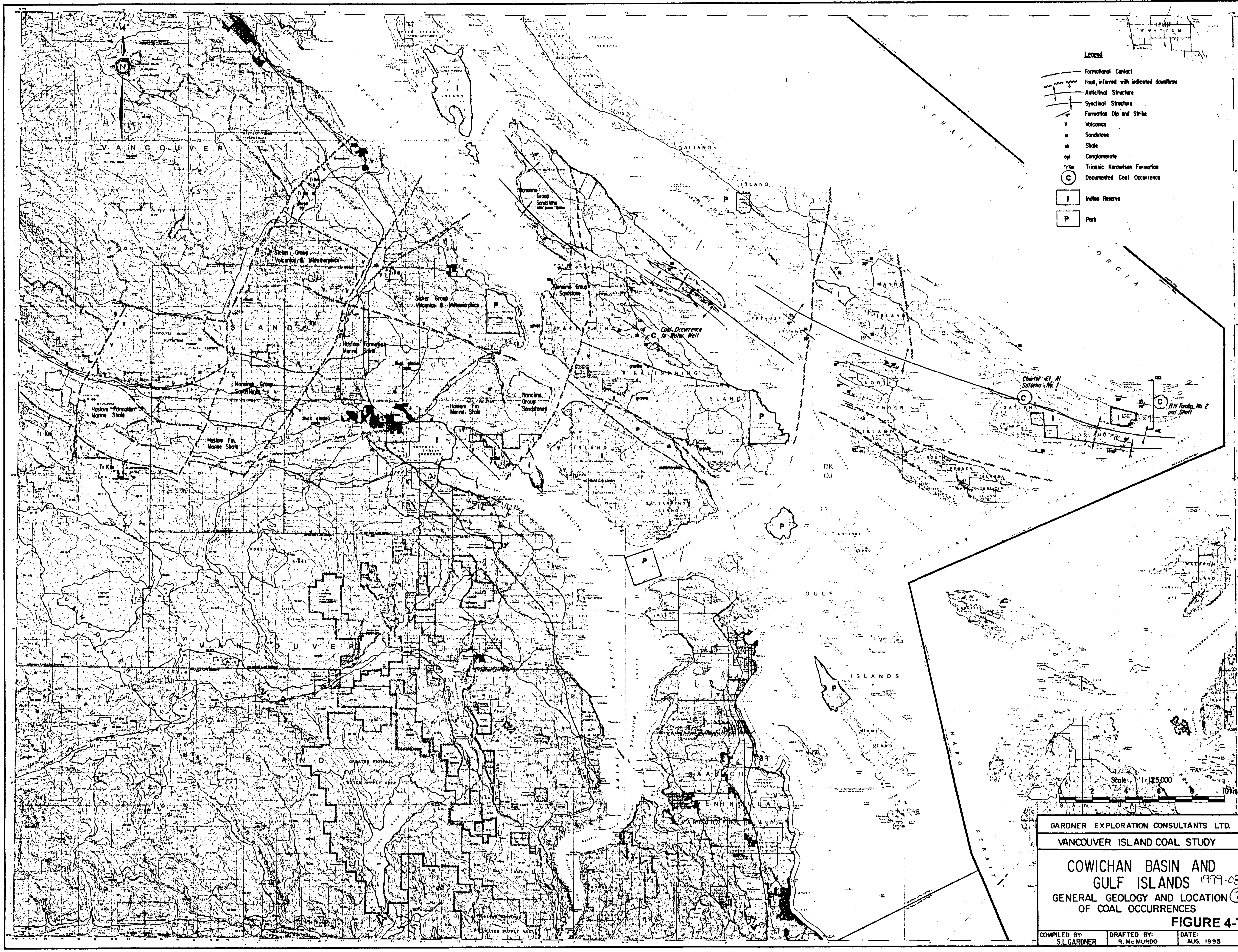
1999-08 (7)



GARDNER EXPLORATION CONSULTANTS LTD.

VANCOUVER ISLAND COAL STUDY

COWICHAN BASIN AND GULF ISLANDS 1999-08

GENERAL GEOLOGY AND LOCATION (7) OF COAL OCCURRENCES

FIGURE 4-7

COMPILED BY:	DRAFTED BY:	DATE:
S.L. GARDNER	R. Mc MURDO	AUG. 1995


FIGURE 6-1
Vancouver Island Land Use Plan
Protected Areas
General Forest & High Intensity Areas
Low Intensity Areas
Settlement Lands
Agriculture/Aquaculture Land Reserves
Area of Coal-bearing Sedimentary Formations
Scale
0 10 20 30 40 50 60 70 80 90 100 Kilometres
0 10 20 30 40 50 60 70 Miles