CX-COMOX 73(6)

MEMORANDUM

OPEN FILE

TO Dr. J.T. Fyles,
Associate Deputy Minister,
Mineral Resources Branch.

FROM THE DEPARTMENT OF MINES AND PETROLEUM RESOURCES

VICTORIA, B.C., November 4, 1974

WHEN REPLYING PLEASE REFER TO FILE No.

Re: "Report on Reserves & Mining Costs of the Comox Coalfield, Vancouver Island" by C.R. Saunders, P.Eng., H.O. Howey, P.Eng., and Dr. D.D. Campbell, P.Eng. (Preliminary draft).

I have read this report with interest. My principal reaction to it is that I think the authors are considerably underestimating the difficulties of establishing a large underground mining operation in the Comox-Cumberland coalfield. Although the authors say that their estimates are preliminary ones, I think the difficulties should also be recognized and pointed out even at this preliminary stage.

The authors propose that a mine, designed to produce 2,200,000 tons per year (7,333 tons per day) could be developed in the most thoroughly explored area of the T'sable River coal measures. The proposed method of mining is based on "conventional continuous miners, shuttle cars, roof bolters, breaker feeders, conveyor belts" and etc.

Continuous miner systems are designed to operate best in relatively flat-lying strata, undisturbed by faults and other structural irregularities, and with a reasonably competent roof or hangingwall above the coal seam. Few of these conditions are likely to occur in the T'sable River coalfield. In the proven part of the coalfield the thickness of the coal zone varies from 5 to 16.7 feet, and even with our present very limited knowledge three faults are shown on the plan as intersecting the area. In the old mine fairly close timbering was necessary; to what extent this could be replaced by roof bolting only is a question that only can be answered by practical research. If considerable faulting was present some methods of support other than bolting would certainly seem to be necessary.

In order to produce 7,000 tons per day, as many as ten continuous miners would be required. Under ideal conditions a single machine has produced up to 2,000 tons a day on three shifts, but in this Province in the East Kootenays production has I believe rarely exceeded 900 tons a day on two-shifts under conditions somewhat more favourable than those likely to be experienced at T'sable River. In order to deploy 10 machines, extremely extensive development work would be necessary. Another point to be borne in mind is that continuous miners are designed to cut in coal. One wonders how they would perform in a 'coal zone' in which a 3-foot band of fairly tough shale or 'bone' occurred?

In the old T'sable River mine two quite serious outbreaks of spontaneous combustion occurred, each time during the extraction of coal pillars close to faults. In each case it was necessary to seal off part of the workings. To what extent is this liable to recur in this coalfield, and what provisions ought to be made for leaving coal in place in the vicinity of faults?

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[redacted]

I would suggest that answers should be sought to all of these questions before a decision is made to invest in an underground mining project on a scale vastly larger than was attempted in the T'sable River area in 1948 to 1967. An intensive drilling programme would of course be required to give a very precise picture of the structures and attitude of the seam. Some programme of research and development, preferably including some trial mining would be desirable, with a full investigation of alternative methods and systems, with studies of what is being done in other countries in similar conditions, if these exist.

These operational studies should be undertaken under the supervision of a reputable consultant with actual operating experience in underground coal mining, who is in a position to appreciate the problems in establishing a successful large underground coal mining operation.

The Grande Cache project of McIntyre Porcupine Mines Ltd. is an example of a major coal mining project which was embarked upon without a full appreciation of what kind of difficulties and problems would be encountered. The results, as you know, have been disastrous for the company. I would not like to see B.C. Hydro get into a similar situation, and this can be prevented by a clear recognition of the possible problems right from the start.

A.R.C. James, P.Eng.,
Senior Inspector of Mines.

ARCJ:sl

CX-COMOX 73(6)

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British Columbia
Hydro and Power Authority

Report on the

RESERVES & MINING COSTS

of the

COMOX COALFIELD

Vancouver Island, B.C.

PRELIMINARY DRAFT

January 31, 1974.

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H.O. Howey, P. Eng.
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Vancouver, Canada.

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SUMMARY

The Comox coalfield occupies the eastern coastal plain of Vancouver Island. It comprises an area some 20 miles in length by four to ten miles in width, centred on the old coal mining town of Cumberland near the larger coastal community of Courtenay. Mining in the area, from deposits at Cumberland and Tsable River, produced over 20 million tons of coal during the period 1875 to 1967.

All of the coal leases in the area are believed to be held by Weldwood of Canada Ltd. although this information has not been confirmed as yet.

All of the Vancouver Island coal deposits occur within the Comox Formation, the lowest unit of the Nanaimo group of Late Cretaceous age. These rocks rest unconformably on a basement of moderate relief consisting of Karmutsen Formation basic volcanic rocks of Upper Triassic age. Two adjacent but reasonably distinct deposits, Cumberland and Tsable River, occur within the Comox coalfield. The coal seams or zones within these deposits dip generally to the northeast at $5^{\circ} - 25^{\circ}$. Some irregularities in attitude, thickness and coal quality are evident and are the result of depositional environment and subsequent slumping and faulting.

Continuity of coal seams is commonly suspect whereas the continuity of coal zones (coal-shale sequences) is reasonably good. Consequently, for this study the coal reserves have been calculated for zones rather than seams, with the primary limitations of a maximum of 50% ash (inherent ash in the coal plus the 100% ash of waste rock) and a four-foot minimum mining thickness.

The most readily available reserves of coal for a thermal plant occur in the Tsable River area of the Comox coalfield. In this deposit there is a major reserve of underground coal indicated by existing drill holes. Assuming a mine recovery of 75 percent, based on the extraction in the previous mines, the recoverable reserves at Tsable River are estimated to be:

	Short tons (x 1000)	Moist. (%)	Ash (%)	V.M. (%)	F.C. (%)	G.C.V. (Btu/lb.)	S (%)
Proven & Probable	45,471	1.4	35.1	26.1	37.4	9591	1.4
Possible	99,165	1.4	39.0	25.1	34.5	9537	1.4
Total:	144,636	1.4	37.8	25.4	35.4	9554	1.4

The tonnage potential of the Comox Coalfield, (Tsable River and Cumberland), suggested by existing drill hole and mine data, appears to be excellent for underground coal, as indicated by the following reserve estimates for the total in situ coal reserves:

	Short tons (x 1000)	Moist. (%)	Ash (%)	V.M. (%)	F.C. (%)	G.C.V. (Btu/lb.)	S (%)
Proven & Probable	64,450	1.4	34.8	26.1	37.7	9644	1.4
Possible	440,549	1.3	35.8	25.0	37.9	9764	1.4
Total:	504,999	1.3	35.7	25.1	37.9	9752	1.4

A diamond drill (surface) exploration program is required both to confirm "possible" reserves and to provide more analyses and detailed structural data for the "proven-probable" reserves in order that accurate mine plans and costs may be compiled. The most important exploration program is that recommended for the Tsable River deposit. (This data is being compiled).

The Tsable River indicated coal reserves would support a 600 Megawatt thermal plant for approximately 20 years. The potential coal reserves, suggest that they are sufficient to support such a plant for at least an additional 40 years.

Preliminary cost estimates to supply coal to a 600 M.W. thermal plant located at or near the mine site are as follows:

Capital cost -	$8 - 10 million.
Operating cost -	$10. - $15. per ton (Approx. range)
Cost per million Btu's -	$0.52 - $0.79.

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INTRODUCTION

TERMS OF REFERENCE:

The purpose of this report is to satisfy the following three principal objectives which are discussed in the three parts that comprise the body of this report.

PART 1 Determine the coal reserves of the Comox area from present data.
PART 2 Determine the capital and operating costs for supplying coal to a 600 M.W. thermal plant located in the Comox area and fueled by Comox coal.
PART 3 If sufficient reserves are indicated and costs are not totally unreasonable, develop an exploration proposal to delineate a measured or proven reserve in the order of 50 million tons.

AVAILABLE DATA:

Complete and readily available records concerning mining and exploration do not exist for the Comox area, primarily because of the lengthy history of coal mining in the area during which time records have been lost, names changed, etc. Sources of basic data are rather varied and occasionally somewhat strange, although the primary sources are, as usual, company and government records and reports. The data and records are generally old and somewhat incomplete and in some instances contain minor but still frustrating discrepancies. However, a surprisingly large amount of data was located and has been employed in the assessment of the Comox reserves. This data consists primarily of borehole recordings, mine plans, and coal analyses results.

In more detail, the data consist of 117 written and 54 graphic (old blue prints) borehole logs from the Cumberland area, and 80 written logs for the Tsable River area. Mine abandonment plans, or equivalent, are available for all mines; some of these plans contain borehole locations and brief notes concerning coal intersections and seam nomenclature. Partial or complete proximate analyses totalled 114 for Cumberland and 12 for Tsable River. Many of these can not be related to specific seams but have still been useful in obtaining averages for the two areas of study.

LOCATION: (Figure 1)

The Comox coalfield occupies part of the eastern coastal plain of Vancouver Island near the town of Courtenay. It is bounded to the north by Dove Creek and Tsolum

River and to the south by Wilfred Creek. Its eastern margin can for the present be considered to be the Strait of Georgia and the western boundary the erosional edge of the Cretaceous coal-bearing strata, beyond which are exposed the older volcanic rocks of the Karmutsen Formation. Within these boundaries, the Comox coalfield occupies a strip four to ten miles in width and 20 miles in length. This area of some 125 square miles, within the much larger "Comox Basin", is potentially coal-bearing.

Topography within the area is quite subdued, with elevations ranging from about 1500 ft. to sea-level. The gentle slopes and low-profile hills are thickly forested with secondary growth conifers; the original forests were logged some 25 to 50 years ago. Precipitation is moderate for coastal areas, averaging 40 inches per year.

The principal communities in the area are Courtenay and Comox. Smaller settlements are Fanny Bay, Buckley Bay, Union Bay, Royston and Cumberland. Only Cumberland, which was the centre of coal mining activity in the past, lies inland from the coast. Good access is provided by the coastal Island Highway (No. 19), by secondary roads inland to the west, and by numerous operating and abandoned logging roads. The Esquimalt and Nanaimo branch of the Canadian Pacific Railway links Courtenay to Victoria, some 140 miles to the south.

HISTORY:

Coal mining on Vancouver Island, together with placer-gold mining in the Cariboo, is the oldest mineral industry in British Columbia. Although gold made a more spectacular impact on the development of the mainland there is no doubt coal was most important to the settlement and economic growth of Vancouver Island. Earliest coal mining on the Island was carried out in the Suquash area near Port McNeill in 1835 but with the discovery of the Douglas seam in 1851 emphasis shifted to the Nanaimo area. Work began in the Comox field in a small way in 1875 when the Baynes Sound Colliery was opened but it was not until 1888 that continuous, larger scale operations were initiated when the Dunsmuir syndicate opened the Union Colliery near Cumberland.

Seven underground mines worked three of the Comox coal seams in the Cumberland field, the last being the No. 8 Mine which closed in 1953. Only one seam was worked in the Tsable River area and from only one mine, the Tsable River Mine. It operated from 1945 until 1967. With its closure, all coal mining ceased on Vancouver Island. The tonnages produced from the Comox field are:

Cumberland (1876-1953)	18,360,000
Tsable River (1946-1967)	2,180,000
Comox	20,540,000

Most of the coal from the Comox field was used for thermal purposes, either for residential and commercial heating or for "bunkering" ships, and consequently the decline and demise of the industry can be directly correlated with the increasing use of petroleum for these purposes. A coking plant, consisting of 100 beehive-ovens, was built at Union Bay in 1896. The coke was produced mostly from washed fines and was used primarily in two small copper smelters at Crofton and Ladysmith. It appears that the coking plant was in intermittent operation until about 1922 and could produce 30,000 tons annually.

In the early 1900s there was also a brick-plant at Union Bay using fire-clay from the mines for fire-brick and clay from a local pit for common bricks.

Mine labour was a continuing problem for all of the Vancouver Island coal mine operators with respect to labour-management relations, availability of experienced coal miners, and availability of labour willing to work in underground coal mines. The first miners were brought from the Staffordshire coal-mining area of England. Later imports of workers were unskilled labourers from China and Greece. It is doubtfull if any skilled underground coal miners are presently available in western Canada and consequently it may be necessary, if underground mining is re-established, to import at least a cadre of experienced coal miners from some other region or country.

COAL LEASES

(Determination of the type and ownership of coal leases in the Comox area is in progress. Data obtained to date indicate that most, if not all, of the coal leases are held by Weldwood of Canada Ltd., Vancouver.)

PART 1

COAL RESERVES

GEOLOGICAL SETTING

REGIONAL:

All of the Vancouver Island coal deposits occur within the Nanaimo Group of Late Cretaceous age. This group is distributed in basin-like areas along the low eastern coastal plain of (southern) Vancouver Island, (Fig. 2), where overburden of Pleistocene till and alluvium generally restricts the best exposures to stream channels and coastal shorelines. Lithologies within the group, with the exception of coal seams, are clastic and range from boulder conglomerate to shale with most of the intervening lithologic spectrum represented.

The Nanaimo Group rocks rest unconformably on, principally, Upper Triassic basic volcanic rocks of the Karmutsen Formation and, to a lesser extent, on cherty metasedimentary rocks of the Sicker Group (Permian and older?) or the younger (Middle Jurassic) granodioritic rocks of the Island Intrusions. Tertiary intrusive bodies of quartz diorite and dacite porphyry, commonly in the form of sills, are found within the lower units of the Nanaimo Group. In places these sills have intruded strata adjacent to coal seams and transformed the coal into noncommercial coke.

In the past, five "basins of deposition" containing Nanaimo Group sediments were distinguished on Vancouver Island: Suquash, Comox, Alberni, Nanaimo and Cowichan Basins. These outcrop areas however probably do not represent sedimentary basins but rather are disconnected erosional remnants of a large area of deposition whose present distribution is largely controlled by post-Cretaceous block-faulting and tilting, preserving these sediments in structurally depressed areas. The Comox Basin is the largest of these areas, extending from Nanoose Harbor in the south some 12 miles north of the city of Nanaimo, northwestwards along the eastern coast of Vancouver Island for approximately 75 miles to just north of the city of Campbell River. All mining and most exploration has been done in the central portion of this "basin" in the vicinity of the town of Cumberland. This central area is referred to as the Comox coalfield.

FORMATIONS: The strata that comprise the Nanaimo Group are divided into five sedimentary cycles that represent depositional changes due to fluctuating sea levels. These changes are represented by changes in rock facies, (types), through the following sequences:

(1) Fluvial to deltaic and/or lagoonal.
(Forms one formation comprised of nonmarine sandstone, conglomerate, shale and (lagoonal) coal.)

to (2) Nearshore marine to offshore marine.
(Forms one formation comprised of marine siltstone and shale).

Thus each cycle consists of two formations (see Table 1); however, the coal-bearing lagoonal facies is only found in the first cycle in the Comox Basin. This coal-bearing cycle is termed the Comox Formation and is the host for all of the commercial coal deposits in the Comox area.

COAL MEASURES:

The strata of the Comox Formation comprise the coal measures of the Comox coalfield. The study of these rocks is now confined to surface exposures along rivers and creeks and to the examination of records from several hundred boreholes drilled during the period of the operation of the coal mines. There is little if any data now available from studies of, and experiences with, the rocks in the mines, if any such work was undertaken or recorded.

In the Cumberland area the pre-Cretaceous unconformity surface is irregular and the lowest coal seam, No. 4, locally laps onto it. As a result of compression and/or faulting, all of the seams are to some extent "draped" over the pre-existing basement. Individual coal seams split, merge, and pinch-out into shale beds or are replaced by sandstone beds.

Mine operators in the Cumberland area distinguished four coal seams by number; No. 1, No. 2, and No. 4 seams were mined extensively whereas little or no mining was done in No. 3 seam. In the Tsable River area only one seam, No. 2, near the base of the formation, was worked but it cannot be correlated with any reasonable certainty to a specific Cumberland seam.

The depositional environment of the coal, or more correctly, of the peat bogs which were later transformed into coal, has a bearing on the physical characteristics of the resulting coal seams and the enclosing strata. It has been suggested that the seams in the Comox Formation were deposited in coastal lowland areas. The environment was probably lagoonal, being separated from the sea by sandbars. The repeated build-up and destruction of these marginal sandbars together with differential compaction resulted in the recurrence of localized swamp (and peat bog) conditions. This localization of swamps was also profoundly affected by the rather appreciable relief of the pre-Cretaceous basement. Thus in places in the coal field, the lower seams are interrupted by paleotopographic "highs" whereas the upper seams are continuous across these buried hills.

TABLE NO. 1

NANAIMO GROUP--TABLE OF FORMATIONS

CYCLE	FORMATION (earlier name)	LITHOLOGY
Fifth	GABRIOLA (Hornby)	Conglomerate & sandstone
---------- Erosional Interval ----------		
Fourth	SPRAY	Siltstone & shale
	GEOFFREY	Conglomerate & sandstone
---------- Erosional Interval ----------		
Third	NORTHUMBERLAND (Lambert)	Siltstone & shale
	DE COURCY (Denman)	Sandstone, minor conglomerate
---------- Erosional Interval ----------		
Second	CEDAR DISTRICT (Trent River)	Siltstone & shale
	EXTENSION-PROTECTION (minor)	Conglomerate & sandstone
---------- Erosional Interval (lengthly) ----------		
First	HASLAM (Trent River)	Siltstone & shale
	COMOX	Coal, Sandstone, minor conglomerate
---------- Unconformity ----------		

The structure of the coal measures is generally one of gently warped and tilted fault-blocks. Faults in the pre-Cretaceous rocks may become only flexures in the overlying sediments or they may split and diverge into zones of fault-slices. No mines have been developed across major faults. Smaller faults have been a greater hinderance to mining because they disrupt the normal sequence of mine development and coal extraction, cause thickening or thinning of seams, and have resulted in extreme fracturing of the coal. They are zones of weakness and therefore require relatively more support than other areas within the mine workings.

COAL SEAMS:

The coal seams of the Cumberland and Tsable River areas are part of the Comox Formation that rests unconformably on Triassic Karmutsen Formation volcanic rocks. A total of eight underground mines worked three seams at Cumberland and one seam at Tsable River.

Characteristically, the coal is associated with layers of grey or brownish-grey shale. Rarely, a band of clean coal is enclosed between a sandstone roof and floor; commonly the coal is wholly enclosed in shale. The seams have no trace of anything resembling underclays, rootlets, tree stems, branches, or leaves. More or less fissile carbonaceous shale and the brown compact shale known as "bone" occur intercalated within the coal itself. These impurities vary from paper-thin lamina to bands that comprise so much of the seam that it is rendered non-commercial. This is particularly the case where the seam closely approaches the pre-Cretaceous rocks. Neither in the outcrops nor in the bore holes has a clean seam of coal been observed resting directly on the old volcanics, though dirty coal, or shale with coaly streaks, frequently does so.

The thickness of coal in any given seam may range from a fraction of an inch to many feet, 25 feet of coal being the thickest obtained in any single seam.

The seams dip gently to moderately, (5° - 25°), northwestward, conforming in gross attitude with the slope of the pre-Cretaceous basement rocks.

In non-mined areas, borehole recordings indicate many instances where coal "zones" rather than simple or individual coal seams are present. These zones consist of a coal-shale sequence varying in aggregate thickness from 1-2 ft. to 25 ft. In the past they would have been of no interest unless at least one of the coal seams within the zone was about three feet or greater in thickness and, by correlating among several boreholes, covered some appreciable area. For the present study, in which "clean" coal is desirable but not absolutely essential, these zones may be quite significant; they can be correlated from hole to hole with greater confidence than individual coal seams, and they have much greater areal extent than individual seams. Where they contain a high proportion of coal seams they may represent an appreciable tonnage of thermal coal, albeit with a relatively high ash or waste content.

COAL TONNAGE

DEFINITIONS:

To avoid ambiguity and confusion with reserves for other coalfields the following definitions are provided; they are intended to apply to the Comox coalfield in particular:

Coal Zone - one or more coal seams which are stratigraphically close enough together to be mined as a unit and which are separated from other zones by appreciable waste sections.

Coal Seam - essentially a continuous bed of coal; may contain thin partings of shale.

Waste - rock which can be removed from the coal during the mining process or, more probably, by a beneficiation process. Readily observable and measureable rock beds within a coal zone; generally referred to as partings.

Ash - non-combustible matter in coal; does not include waste in coal zones where the waste has been defined and measured separately from the coal.

Zone Ash - the weighted total of ash plus waste (with the waste assumed to be 100% non-combustible matter.)

As Received Moisture - the moisture content of coal as delivered to a stockpile. The moisture content of samples when they arrive at the laboratory.

Proven Reserves - coal occurring in three or more boreholes spaced not more than 1600 ft. apart, and for which there is a relatively high degree of confidence in the correlation of the seam or zone between holes; a maximum projection of 800 ft.

Probable Reserves - coal projected a maximum of 1600 ft. beyond proven coal, or, coal occurring in three or more boreholes spaced not more than 3200 ft. apart, and for which there is a moderate degree of confidence in the correlation of the seam or zone between holes.

Possible Reserves - coal projected beyond probable coal or beyond one or more borehole intersections for a maximum distance of 3200 ft. Reserves for isolated drill intersections of coal seams or zones for which correlation cannot be established.

CALCULATION PROCEDURES:

In all aspects of the work leading up to the final reserve figures, basic data have been employed wherever possible. Only where no such data is available has use been made of previous compilations. For example, borehole locations have been taken from large scale mine or surface plans where such detailed information is available. Where not available, locations have been accepted as shown on previously compiled maps.

The determinations of coal tonnage involved the following steps: first, the plotting of all boreholes on plan and as graphic logs; second, correlation of the coal seams and zones in the boreholes by use of the graphic logs; third, the outlining of reserve areas on plan; and, fourth, the calculation and summation of tonnages. Correlating the various coal intersections proved to be the most inexact and potentially most error-prone phase of the work. The variable and often quite large spacing between boreholes, lensing and shaling-out of seams, possible faulting, local and regional dip variations, etc. all contributed to the difficulties encountered during this phase. The degree of confidence of the correlation is reflected in part by the classification which has been assigned to the various coal blocks. All coal intersections were correlatable, (assigned a seam or zone name), in the Tsable River area but less than half were correlatable in the Cumberland area. Consequently, a large portion of the Cumberland tonnage is not specifically assigned a seam name although it consists, at least in part, of coal from each of the known (mined) seams in the area.

It was found that correlating coal zones could be done with considerably more confidence than correlating individual seams. Consequently, all correlation was done on a "coal zone" basis and, ultimately, tonnages were calculated for zones rather than seams (although not uncommonly a zone consists of only a single seam).

The maximum allowable ash content, being the inherent ash in the coal plus the 100 % ash content of the waste, was arbitrarily set at 50 % for individual intersections. Assuming 15 % ash in the coal and specific gravities of 1.3 for coal and 2.6 for shale (the most probable waste rock) this maximum 50 % ash, in effect, limits the proportion of waste to generally 25 % of the total zone thickness.

RESERVE TONNAGE:

The total in-situ, drill- indicated tonnage of the mineable coal seams, (or zones), at Comox are summarized in Table 2. The reserves, given in Table 2 by seams and classification for both the Tsable River and the Cumberland deposits, total as follows:

Proven - probable	- Tsable River -	60,629,000 short tons @ 22.2% waste.
	- Cumberland -	3,821,000 short tons @ 18.0% waste.
	TOTAL COMOX	64,450,000 short tons PROVEN - PROBABLE @ 22.0% waste.
Possible	- Tsable River -	132,220,000 short tons @ 23.4% waste.
	- Cumberland -	308,329,000 short tons @ 23.0% waste.
	TOTAL COMOX	440,549,000 short tons POSSIBLE @ 23.1% waste.

The classification of tonnage is designed to express a relative, although not precise, degree of confidence or expectation that the particular tonnage exists. Thus there is a much higher expectation of the proven tonnage existing in the amount and form shown than there is for the possible tonnage. To quantify this confidence, the following limitations can be applied to determine tonnages of coal which can reasonably be expected to be present in the coalfield: proven x (0.9); probable x (0.7); possible x (0.3).

RECOVERABLE TONNAGE:

For underground coal mines, such as those at Comox, the coal left in the seams for support of the mines can amount to as much as 50 percent of the in-situ reserves, depending on the mining method employed and the rock stresses in each particular deposit.

Previous mining at Cumberland employed the longwall method, which in effect extracted over 90 percent of the reserve coal. At Tsable River, which operated later, the room and pillar method was employed but underwent modification as the pillars were later extensively extracted, for a total extraction of 100 percent in some places and 60 percent in others.

TABLE 2

COAL TONNAGE RESERVES (Short tons)

TSABLE RIVER

Classification	Seam (Zone)	Tons (x 1000) * Zone	Coal	Waste	% Waste (by weight)
PROVEN	2	13,095	10,004	3,091	23.6
PROBABLE	2	42,585	33,643	8,942	21.0
PROBABLE	1	4,949	3,513	1,436	29.0
	Sub-total	47,534	37,156	10,378	21.8
TOTAL PROVEN-PROBABLE		60,629	47,160	13,469	22.2
POSSIBLE	1A	12,178	9,953	2,225	18.3
POSSIBLE	1	31,071	24,196	6,875	22.1
POSSIBLE	2	88,971	67,151	21,820	24.5
	Sub-total	132,220	101,300	30,920	23.4
TOTAL TSABLE RIVER		192,849	148,460	44,389	23.0

CUMBERLAND

Classification	Seam (Zone)	Zone	Coal	Waste	% Waste (by weight)
PROBABLE	4	3,821	3,133	688	18.0
POSSIBLE	1	17,020	14,779	2,241	13.0
POSSIBLE	2	30,906	20,985	9,921	32.1
POSSIBLE	4	64,205	49,479	14,726	22.9
POSSIBLE	Uncorrelated	196,198	152,119	44,079	22.5
	Sub-total	308,329	237,362	70,967	23.0
TOTAL CUMBERLAND (99% POSSIBLE)		312,150	240,495	71,655	23.0

*Zone = the total tonnage that must be mined to obtain the coal.
Coal = coal seams within the zone.
Waste = rock layers within the zone.

Minimum mining width = 4 feet
Tonnage factor: Coal = 24.5 cu. ft./ ton
Waste = 12.25 cu. ft. / ton

For the purpose of this present study, pending more definitive engineering and mine planning, a preliminary figure of 75 percent for recoverable coal has been applied to the Comox area reserves. Using this factor, the recoverable portions of the above total coal reserves become:

RECOVERABLE PROVEN-PROBABLE RESERVES: 48,338,000 short tons
@ 22.0 % waste. (Tsable River = 96 %)

RECOVERABLE POSSIBLE RESERVES: 330,412,000 short tons
@ 23.1 % waste. (Cumberland = 70 %)

COAL GRADE

The majority of the available coal analyses used in this study, 114 for Cumberland and 12 for Tsable River, are for coal intersections in boreholes. A few are for surface prospects but very few are for samples taken in the operating mines. The dependability of individual analyses is unknown but is assumed to be reasonably good, considering that the majority were done by the companies involved for their own use.

The only area of particular concern is the "as received" moisture content. Presumably the "as received" moisture reported on the analyses sheets is the moisture content of the samples "as received" at the laboratories. How closely this moisture content will correspond to a thermal plant "as received" moisture content is uncertain. However, it is likely that the "as received" moisture is reasonably representative of the "bed" or "in situ" moisture of the coal seams. As such it should also be representative of the moisture content of coal supplied to a thermal plant stockpile.

The available "proximate analysis" data for the Comox coalfield is summarized in Table 3. The average proximate "as received" analysis for the Tsable River No. 2 Zone reserves, which comprise the bulk of the proven - probable tonnage, is:

Moisture	Ash	Vol.	Fixed Carbon	S %	BTU/lb.
1.44	19.89	33.72	44.95	1.54	12,271

Besides the averages given in Table 3 the range of analyses values can be useful and significant. The figures which follow are presented on an "as received" basis except for the Gross Calorific Value, which is on a dry basis.

	Cumberland	Tsable River
Moisture	0.45 - 4.30 %	1.20 - 1.70 %
Ash	6.80 - 27.22 %	10.72 - 34.58 %
Volatile Matter	28.09 - 37.70 %	29.60 - 36.25 %
Fixed Carbon	42.44 - 55.95 %	38.60 - 53.68 %
Sulphur	0.20 - 3.92 %	0.80 - 2.78 %
G.C.V.	10,148 - 14,246 Btu/lb.	11,139 - 13,470 Btu/ lb.

TABLE NO. 3

COMOX COALFIELD--PROXIMATE ANALYSES

Deposit	Zone	As Received Most. %	Ash %	Volatile Matter %	Fixed Carbon %	S %	GCV* Btu/lb.	Dry Ash %	GCV Btu/lb.
CUMBERLAND	1	1.13	14.78	36.93	47.16	3.23	12,478	14.95	12,621
	2	1.48	11.72	34.45	52.80	2.16	13,125	11.44	13,391
	4	1.59	14.51	31.56	52.34	0.94	12,778	14.74	12,985
	Uncorrelated	1.14	15.42	32.01	51.43	1.28	12,801	15.60	12,948
Total Cumberland		1.27	14.78	32.42	51.53	1.40	12,817	14.97	12,982
TSABLE RIVER	2	1.44	19.89	33.72	44.95	1.54	12,271	20.18	12,450
	Others**	----	17.28	30.68	52.04	1.45	13,045	17.28	13,045
Total Tsable River		1.44	19.24	32.96	46.36	1.52	12,408	19.46	12,599
TOTAL COMOX COALFIELD		1.33	16.46	32.63	49.58	1.45	12,665	16.68	12,836

** Tsable River - "Others" - Analyses for seams 1 and 1A which cannot be specifically assigned to either seam .

* G.C.V. = Gross Calorific Value

All 'total' figures were determined by weighting the individual figures with their respective reserve tonnages.

The figures presented are the best indications of the real values obtainable from available data.

The heating value of the coal from the various zones and the two deposits, Cumberland and Tsable River, can be compared more readily when their calorific values are shown on a dry, ash-free basis (DAFCV).

	Zone	D.A.F.C.V. (Btu/lb.)
Cumberland	No. 1	14,840
	No. 2	15,121
	No. 4	15,230
	Uncorrelated	15,341
	Total:	15,268
Tsable River	No. 2	15,598
	Others	15,770
	Total:	15,643
Comox (Cumberland & Tsable River)	Total:	15,406

The rank of the Comox coals (all seams) based on the A.S.T.M. classification is "High Volatile A Bituminous".

GRADE QUALIFICATIONS:

The coal reserves presented in this report cannot be accepted at face-value without some discussion of their confidence and validity. The confidence placed on the basic data is expressed to some degree in the tonnage figures by the classification (proven, probable, possible) assigned to these figures; the same cannot be said for the analyses summaries.

The analyses averages for the Comox coalfield are reasonably acceptable, as are the averages for the Cumberland deposit. There are sufficient individual analyses within these averages to lend reasonable confidence to the results. However, the Tsable River averages and individual zone averages are somewhat suspect because of the few pieces of basic data from which they are derived. A good example of possible bias is contained in the data for the ash content of the No. 2 Zone at Tsable River. The average shown in Table No. 3 of 19.89% Ash was derived from only seven individual analyses of which one is 34.58% Ash. This one abnormally high Ash assay has increased the average for the No. 2 seam by 2.45% from 17.44% to 19.89% Ash.

Of particular concern is the moisture content of the coal. The figures shown in Table 3 are derived from the available basic data (individual sample analyses) and are presented as being representative of the sample "as received" moisture content and therefore, as previously explained, the moisture content of coal delivered to a stockpile (assumed to be near the mine). However, earlier reports have quoted figures of 2.0 - 4.1% and 3 - 6% for "as received" moisture contents. Why the previous figures are so much higher is not known. However, the validity of the moisture figures in Table No. 3 is supported to some degree by comparison to values noted in two references. One of the references quotes (for coal of High Volatile A Bituminous rank - the rank of Comox coal) an average "as received" moisture content of 2.1% and the other gives a range of 1-3%.

SUMMARY

COMOX COAL RESERVES

A summary of the Comox Coalfield calculated reserves is presented in Table 4 of this report. The figures shown include the waste that would be mined with the clean coal seams from the "coal zones". At this time there is no good reason to expect that this waste rock could be economically avoided in mining. Thus, the coal (and waste) shown in Table 4 is that which can be most economically mined and delivered to a thermal plant, with no beneficiation to reduce the waste content. It should be appreciated, however, that the "ash" shown in Table 4 is at least 50 percent waste rock that would be readily separable in a washing plant should it be desirable to produce a higher calorific furnace feed.

With the waste included, the Tsable River reserves, are:

	SHORT TONS (x1000)		AS RECEIVED					
	Coal Zone	Recoverable (75%)	Moist. %	Ash %	V.M. %	F.C. %	S %	GCV
Proven-Probable	60,629	45,472	1.4	35.1	26.1	37.4	1.4	9,591
Possible	132,220	. 99,165	1.4	39.0	25.1	34.5	1.4	9,537
TOTAL:	192,849	144,637	1.4	37.8	25.4	35.4	1.4	9,554

These reserves are the most readily confirmed by further drill exploration and the most readily available for mining in the Comox coalfield.

TABLE NO. 4

SUMMARY OF COAL ZONE RESERVES (IN SITU)

COMOX COALFIELD

		Zone Tonnage * (000)	Analyses -- As received Basis Moist. %	Ash %	V.M. %	F.C. %	GCV	S %
Cumberland	- Probable	3,821	1.6	29.9	25.9	42.6	10,478	0.9
	- Possible	308,329	1.3	34.4	25.0	39.3	9,861	1.4
	- Total	312,150	1.3	34.4	25.0	39.3	9,869	1.4
Tsable River	- Proven & Probable	60,629	1.4	35.1	26.1	37.4	9,591	1.4
	- Possible	132,220	1.4	39.0	25.1	34.5	9,537	1.4
	- Total	192,849	1.4	37.8	25.4	35.4	9,554	1.4
COMOX (Cumberland plus Tsable River)	- Proven & Probable	64,450	1.4	34.8	26.1	37.7	9,644	1.4
	- Possible	440,549	1.3	35.8	25.0	37.9	9,764	1.4
	- Total	504,999	1.3	35.7	25.1	37.9	9,752	1.4

* Short tons = 2000 lbs. / ton.

PART 2

REQUIRED EXPLORATION

PROPOSED EXPLORATION

(This portion of the project has received little study as yet; however, the examination of the coal reserves indicates that a portion of the Tsable River No. 2 zone warrants the initial exploration in the Comox area).

PART 3

COAL PRODUCTION COSTS

OPERATING AND CAPITAL COSTS

(Mining costs and capital costs for an underground mine at Tsable River are currently under study. Without the data that would be obtained from the exploration drilling recommended in this report a detailed and definitive mining cost cannot be developed without a relatively low factor of dependability; nevertheless, pending such exploration results, costs can be estimated assuming reasonably uniform mining conditions at Tsable River.

The following cost estimates represent the ranges derived in the study to date. This section of the report is in progress.)

BASIS FOR COST ESTIMATES:

B.T.U. value of coal delivered to thermal plant (at 37.8% Ash) 9550

Yearly requirement for 600 M.W. plant = 2,200,000 tons
Daily mine coal production @ 300 op. days = 7,333

Minimum mining height 4 ft.
Maximum mining height 25 ft.

MINING METHOD:

The mining method is based on developing the mine in the most thoroughly explored area of the Tsable River coal measures. Capital and operating costs were estimated on the basis of using the room and pillar method in extracting the coal. Although greater recovery could be realized by using the longwall method it would be presumptive to plan on it until the coal seams and particularly the roof over the coal have been explored by underground entries.

Plans were based on the use of conventional continuous miners, shuttle cars, roof bolters, breaker feeders, conveyor belts and all the necessary appurtenances such as ventilation fans, tubing transformers, pumps and other minor equipment.

It was assumed that the thermal plant would be in the general Comox-Cumberland area and that the coal would not have to be transported more than 10 miles from the mine to the plant.

ESTIMATED CAPITAL AND OPERATING COSTS:

Until more exploration is done the cost estimates are preliminary ones but are based in part on comparable operations. These costs are presented as a range which is considered conservative. These estimated costs can be refined and possibly reduced as more detailed information is obtained.

It is estimated that to develop the mine and supply all the necessary equipment and structures to mine and transport 2.2 million tons of 9550 Btu per pound coal to a stockpile at the thermal plant will require a capital outlay of 8 to 10 million dollars.

The operating costs per ton of coal delivered are estimated to be in the range of $10. to $15.

Cost per million Btu's - $0.52 to $0.79.

CONCLUSIONS

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CONCLUSIONS

A study and analysis of the available data indicate that there still exists an appreciable quantity of (thermal) coal in the Comox coalfield. The coal is present in a number of seams in two adjacent and reasonably well-defined deposits, Cumberland and Tsable River. The seams range in thickness from a few inches to over 25 ft. and dip generally to the northeast at 5^{o} - 25^{o}.

Correlation of coal intersections in boreholes, leading to tonnage estimates, was conducted on a coal zone rather than coal seam basis because, although individual seams may pinch-out, shale-out, etc. and are therefore extremely difficult to correlate, coal zones tend to be more continuous and a much higher confidence can be placed in the resulting correlation. However, where correlation is difficult and suspect most of the coal reserves have been placed in the least confident reserve classification of "possible" coal.

Accepting the validity of reasonably continuous coal zones and recognizing that thermal plant feed need not consist of "clean" coal, a potentially large tonnage of "thermal coal" is apparent in the Comox area. For this study an upper limit for ash content of a zone (inherent ash in the coal plus the waste rock in the zone) has been arbitrarily set at 50% for individual intersections; the resulting average ash content for all of the Comox "thermal coal" is 35.7%. The installation of a relatively simple washing plant would, of course, produce a very much cleaner coal to the furnace; however, detailed exploration, careful mine planning and selective mining could also probably reduce this ash content (and thereby increase the heating value per unit of "coal".

The total reserves of Comox coal are calculated to be (short tons):

	Tonnage('000)	Moisture(%)	Ash(%)	G.C.V.(Btu/lb.)	Sulphur(%)
Proven & Probable	64,450	1.4	34.8	9644	1.4
Possible	440,549	1.3	35.8	9764	1.4
TOTAL:	504,999	1.3	35.7	9752	1.4

The coal is classed as "High Volatile A Bituminous".

The most significant reserves are those for the No. 2 Zone at Tsable River, (all of the above proven and 80% of the probable). This zone appears to have the best continuity, contains areas of appreciable thickness and has the most definitive tonnage information. Analyses data is sparse, however, and may be somewhat misleading. Assuming a 75 percent extraction of the Tsable River reserves the coal available to a thermal plant would be (to the nearest 100,000 short tons):

	Recoverable Tonnage ('000)	Moisture(%)	Ash(%)	G.C.V.	Sulphur(%)
Proven & Probable	45,500	1.4	35.1	9591	1.4
Possible	99,200	1.4	39.0	9537	1.4
TOTAL:	144,700	1.4	37.8	9554	1.4

The proven and probable reserve of the above recoverable tonnage of this mine-run coal from Tsable River would support a 600 Megawatt thermal plant for approximately 20 years. This life would be doubled if only half of the "possible" coal reserve at Tsable River were to be "proven", and could possibly be easily tripled if exploration of the Cumberland "possible" reserve proved fruitful.

With this in mind it is evident that initial drill exploration in the Comox area should be concentrated on the Tsable River reserves, particularly on the No. 2 Zone.

Preliminary cost estimates for the development and mining of sufficient coal (2.2 million tons annually) to supply a 600 M.W. thermal plant located at or near the mine site are: capital costs - 8-10 million dollars; operating costs - $10.-$15. per ton; cost per million Btu's - $0.52 - $0.79. It must be emphasized that although these costs are very preliminary estimates based on similar operations, they are considered to be somewhat conservative, particularly the cost per million Btu's which is affected by ash and moisture estimates as well as mining cost estimates.

Respectfully submitted,
DOLMAGE CAMPBELL & ASSOCIATES LTD.

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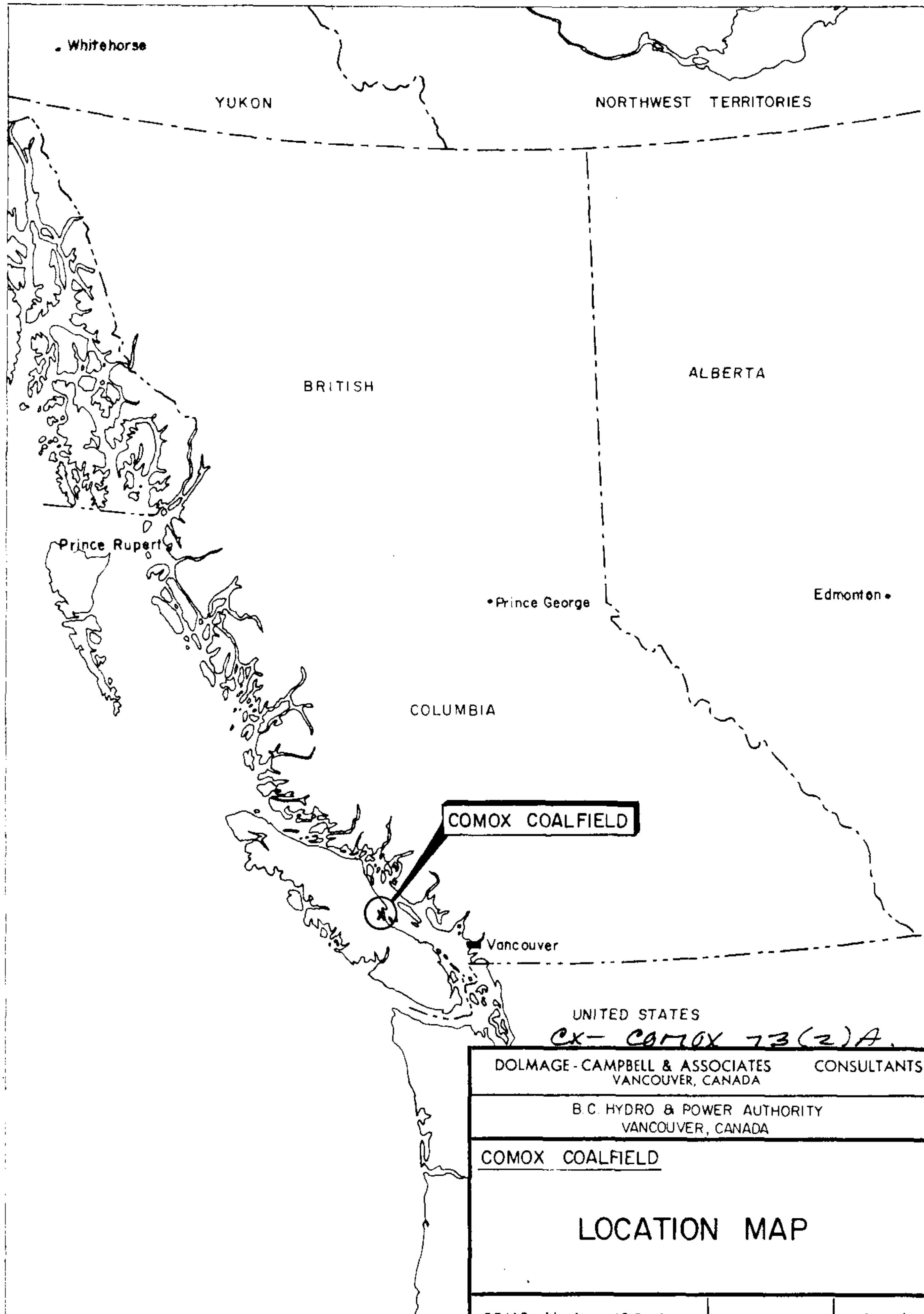
Vancouver, Canada.



Cx- COMOX 73(2)A.

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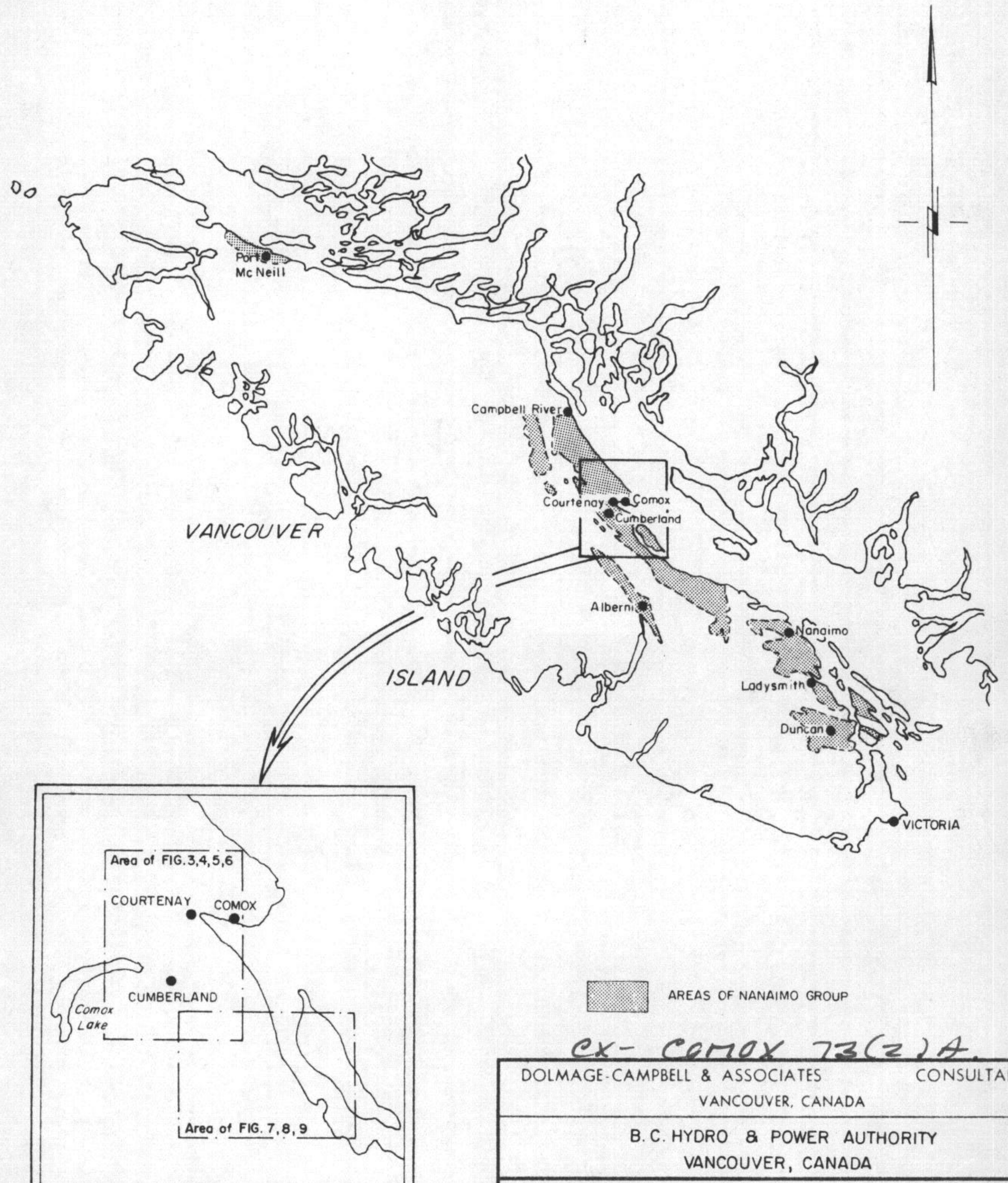
COMOX COALFIELD

LOCATION MAP

SCALE: 1 inch = 120 miles | JAN., 1974 | FIG. 1

DWG 074-6A



CX- COMOX 73(2)A.

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COMOX COALFIELD

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SCALE 0 10 20 30 40 50

JAN., 1974

FIG. 2

DWG. G74 - 7A

53
2 of 2

CX- COMOX 73(2)A.

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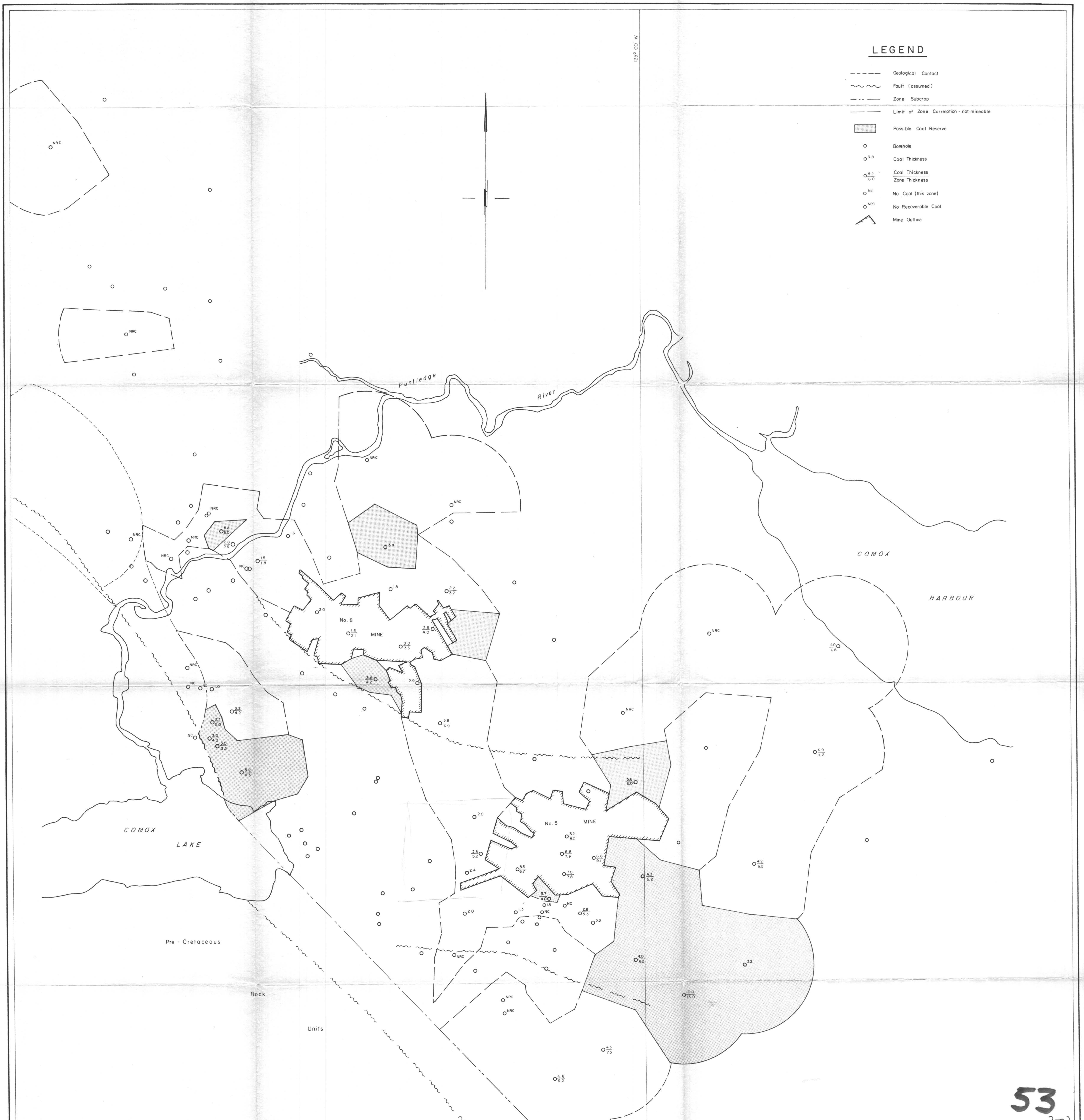
COMOX COALFIELD-CUMBERLAND AREA

No.1 ZONE

SCALE: 1" = 2000'	JAN., 1974	FIG. 3

DWG. G74 - 8



53
2 of 2
CX- Comox 73(2) A.

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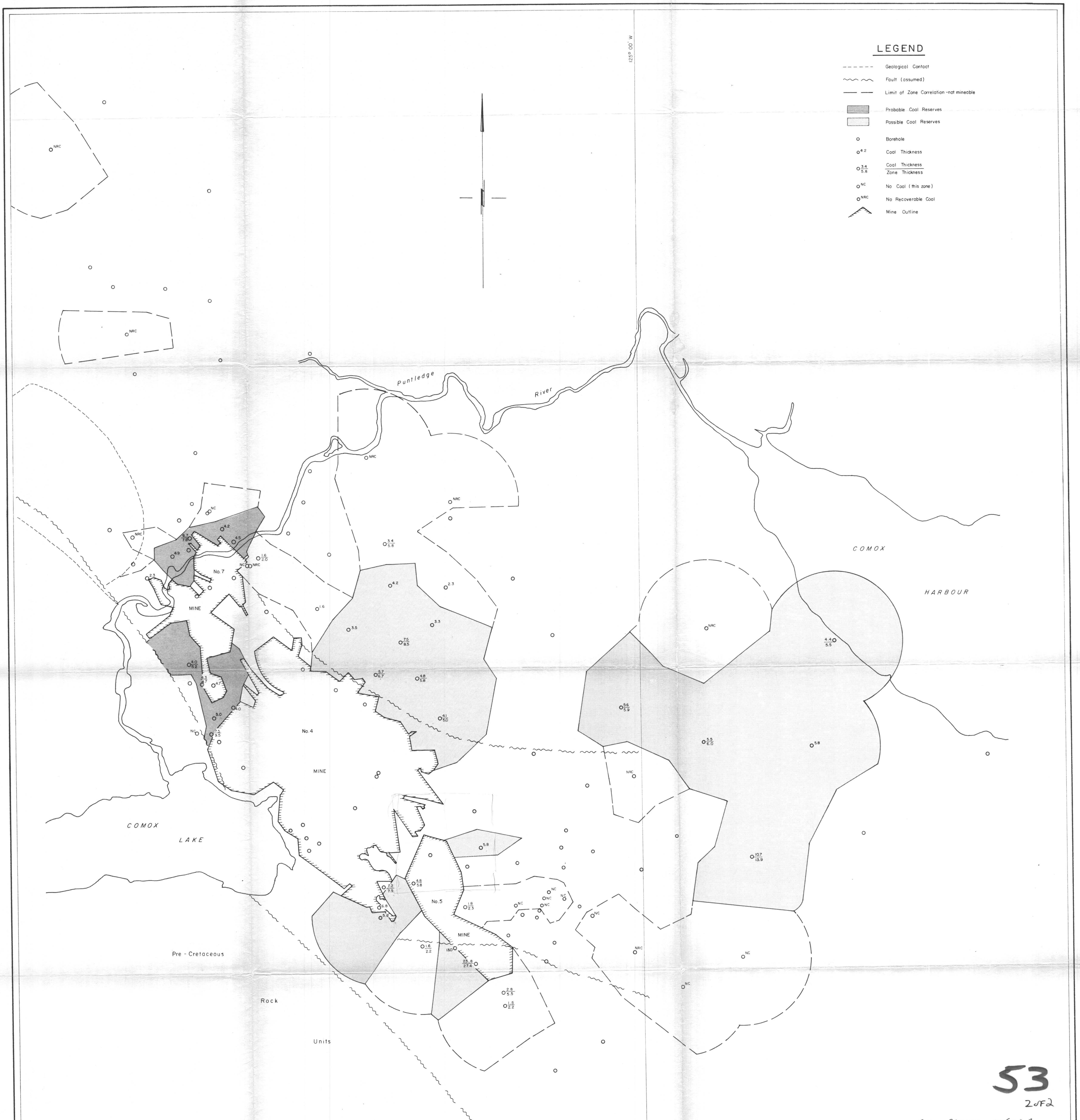
COMOX COALFIELD - CUMBERLAND AREA

No. 2 ZONE

SCALE: 1" = 2000' | JAN., 1974 | FIG. 4

DWG. G74-9



53
2 of 2

CX- COMOX 73(2)A.

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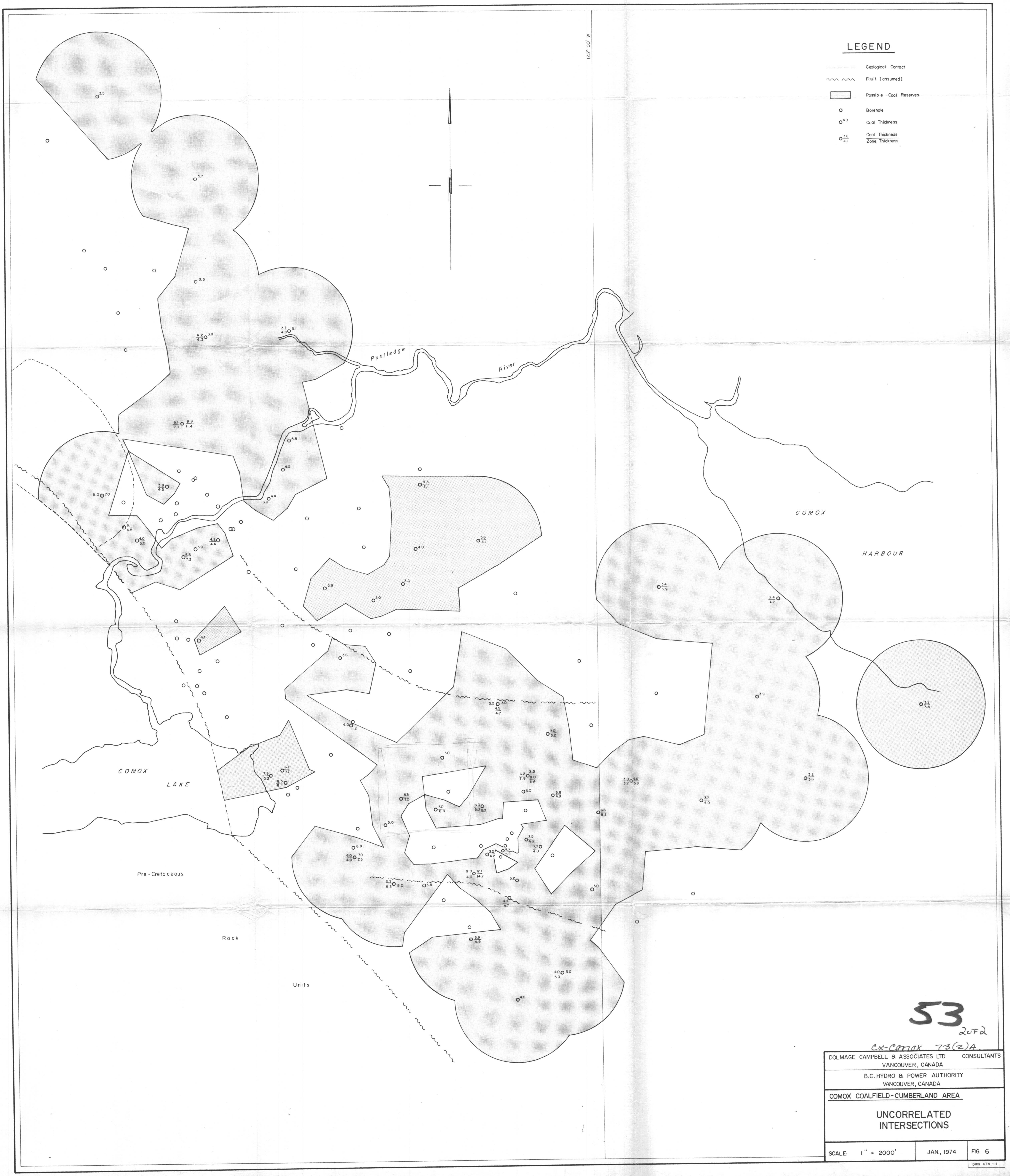
COMOX COALFIELD-CUMBERLAND AREA

No. 4 ZONE

SCALE: 1" = 2000' | JAN., 1974 | FIG. 5

DWG. G74-10



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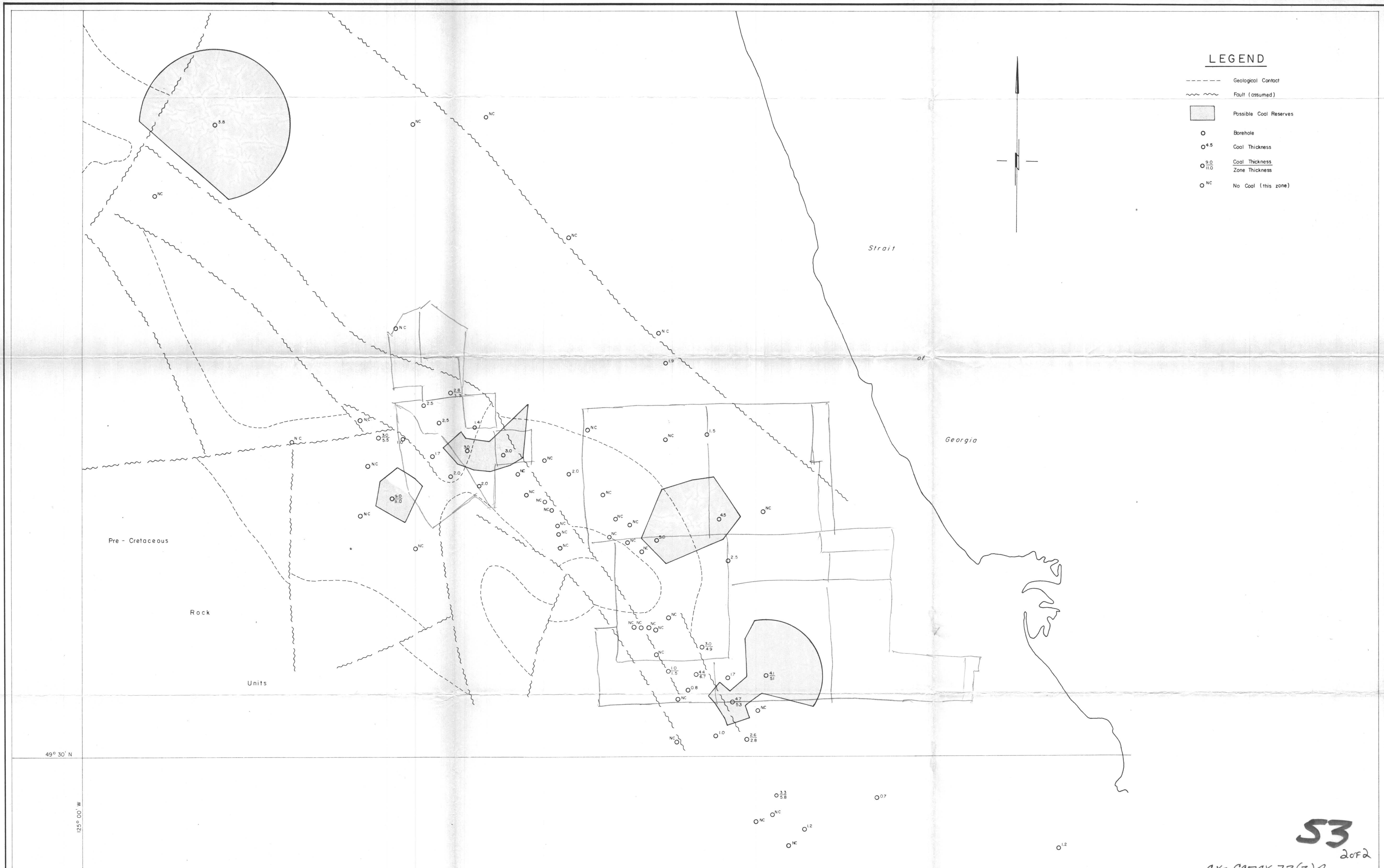
COMOX COALFIELD-CUMBERLAND AREA

UNCORRELATED INTERSECTIONS

SCALE: 1" = 2000' | JAN., 1974 | FIG. 6

DWG. G74-11



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COMOX COALFIELD - TSABLE RIVER AREA

No. 1A ZONE

SCALE: 1" = 2000'	JAN., 1974	FIG. 7

DWG. 674-12

53
2 of 2

CX- COMOX 73(2)A.

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COMOX COALFIELD - TSABLE RIVER AREA

No. 1 ZONE

SCALE: 1" = 2000' | JAN., 1974 | FIG. 8

DWG. G74 - 13

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COMOX COALFIELD - TSABLE RIVER AREA

No. 2 ZONE

SCALE: 1" = 2000' | JAN., 1974 | FIG. 9

DWG. G74-14