860037

SUKUNKA/BULLMOOSE

Coal Mine Project

BP Coal Limited
Technical Division
July 1977

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1. INTRODUCTION

This report describes the coal reserves and geology of the Sukunka/Bullmoose property and the proposed plans of BP Canada and BP Coal for its exploitation, which will lead ultimately to the export of 3 million tonnes per annum of low/medium-volatile coking coal.

The Geological Section of the report describes the stratigraphy, geological structure and coal reserves of the property. Details of the BP exploration programme planned to commence in July 1977 are given in an additional report. The information given for Sukunka is based principally on previous investigations commissioned by Brameda Resources and the associated company of Coalition Mining between February 1972 and March 1976 and reported by Clifford McElroy and Associates, coal geological consultants of Sydney, Australia. That relating to Bullmoose is based wholly upon work carried out by Teck Corporation.

The section of the report on the mining programme for Sukunka/Bullmoose describes the two proposed phases of development. The first of these (the Short Term Plan) is largely based on existing facilities and infrastructure, and is planned to commence in 1978, whereas the second phase (the Long Term Plan) involves a great expansion of output and depends upon B.C. Government provision of facilities requiring large capital expenditure.

The exact timing of the second phase will depend upon the scheduling of the recently announced British Columbia Railway (BCR) branch line, port facilities, new township, associated infrastructure, etc. BP has so far assumed a target date of 1984 for completion of the mine development, coal preparation plant, outloading station, etc. required for this phase. This plan is realistic but somewhat conservative, and the programme could be accelerated under certain circumstances.

At this stage the mining plan depends on the interpretation of the geological information made available to BP by Brameda. It may, therefore, be subject to modification as a result of the BP exploration programme commencing in the 1977 summer season.

The sections of the report on coal quality and coal preparation provide details, based upon analyses of samples from borehole cores and existing mine workings, of the properties of raw and washed coal from the two principal seams, and a description of the type of "packaged" coal preparation plant that is envisaged for installation near Chetwynd to treat the coal produced during the first few years of mine development. A prediction is made of the quality of the coal that might be marketed after treatment in this plant.

2. SYNOPSIS

Geology

The Sukunka area has previously been explored by Brameda Resources and associated companies using a combination of outcrop stripping, underground working and diamond drilling. Some 200 boreholes have been drilled at Sukunka and this area can be regarded as geologically proven.

The Bullmoose area is less well known, and the geological interpretation given in this report is based solely upon some outcrop stripping and 20 boreholes drilled by the Teck Corporation. BP intends drilling a further 38 boreholes at Bullmoose during 1977 and, in consequence, the geological structure given in this report must be regarded as provisional and subject to possible change.

Coal seams occur at three stratigraphic horizons in the Lower Cretaceous strata of the Sukunka/Bullmoose area. These horizons are the Gates Member of the Commotion Formation, the Upper Gething Formation and the Lower Gething Formation. In general, all the coal seams are subject to lateral variations in thickness and quality. The Chamberlain Seam of the Upper Gething Formation is the most consistent seam, persisting over some 30-35 km^2 at a thickness greater than 1.5 m.

The BP mining plan is based mainly on the working of the Chamberlain Seam but may be subject to some slight modification when the results of the 1977 exploration programme, which will further test the Gates Member and other seams in the Gething Formation, are known.

The structure at Sukunka/Bullmoose is complex, although dips within the proposed mining areas are not expected to exceed 1 in 5. The general structure is a syncline which is markedly asymmetrical in the Bullmoose area with a gently dipping eastern limb and a vertical to overturned western limb. In the Sukunka area this structure is less pronounced. A number of low-angle reversed faults run subparallel to the strike, and a zone of such structures bounds the workable area of coal in the east. Mining in the first instance will be confined to a structurally simple area lying between the eastern fault zone and the keel of the syncline.

Reserves within the Sukunka area can be included in the "measured" category as defined by the US Bureau of Mines or the Australian States of Queensland and New South Wales, whilst those at Bullmoose are currently "inferred". BP's latest estimate of reserves is 183 million tonnes in situ (approximating to 89 million tonnes saleable) of which 170 million tonnes in situ (82 million tonnes saleable) lie in the Chamberlain Seam. Of the total of 183 million tonnes in situ, 118 million tonnes can be considered as "measured".

Mining Programme

The reserves of 89 million tonnes saleable are adequate to support a planned output of some 3 million sales tonnes per annum over a life of 20 years.

In order to achieve this objective a new main line railway and port facilities are required. A threshold or minimum tonnage of 8 million sales tonnes per annum from the north-eastern coalfield in B.C. is necessary to justify the large capital expenditure. Taking into account market and financial considerations, BP has selected 1984 as the likely date for commissioning of these facilities. Sukunka, however, owing to its proximity to the existing railhead at Chetwynd and its superior coal quality, is able to produce and market coal much sooner.

The development of the Sukunka/Bullmoose project is seen therefore in two phases, namely:-

(1) A Short Term Plan (Phase I), commencing in 1978,with production increasing to the rate of 0.5 million saleable tonnes per annum in 1980, the raw coal being trucked by road to Chetwynd and treated in a pilot coal preparation plant, and the saleable coal loaded on to the existing rail services for consignment to the Neptune Terminal at Vancouver.

(2) A Long Term Plan (Phase II), with a production of 3 million sales tonnes per annum from a large mine and major heavy-medium coal preparation plant, the saleable coal being handled by a rapid loader into unit trains on a new railway line for transport to Prince Rupert. The mine will be located on the eastern side of the Bullmoose property, and development will be primarily in the Chamberlain Seam.

During the Short Term Plan programme the general strategy will be to work the main developments and production units by proven conventional equipment, i.e. continuous miners and shuttle cars, before considering the commitment of large sums of capital expenditure on more sophisticated mining systems such as longwall or shortwall installations.

The Long Term Plan will incorporate, in addition to the coal preparation plant and rapid-loading station, permanent workshops, change houses and administration holdings, and a new township at Tumbler Ridge to house mine personnel and their families. This township will also serve other mines in the locality. The location of some of these facilities will depend upon the exact location of the proposed BCR branch line but it is proposed to site them as close to the rail system as possible, for various technical, social and environmental reasons.

The recruitment and training of some 1,000 personnel required for these mines will require energetic recruitment and careful planning in order to achieve the planned development.

The use of contract labour for mining in the Phase I Short Term Plan is being considered and industrial relations experts will be consulted to advise upon the implications of this possibility.

Coal Quality

The Chamberlain Seam, upon which the mine development is very largely based, and which is the only seam planned for working in the initial years, consists almost entirely of clean coal, except where it is split into two beds of which the upper is usually inferior in quality. The coal in the seam (or its lower bed) shows a general variation in thickness from about 1.4 to 4.4 m, with an average of about 2.6 m; the ash of this raw coal ranges generally between 3 and $9\frac{1}{2}$%, averaging about $5\frac{1}{2}$%, and the free swelling index from 5 to $7\frac{1}{2}$, averaging $6\frac{1}{2}$. In the proved region the seam is generally overlain by up to 0.2 m of carbonaceous mudstone that must be considered to form part of the run-of-mine (r.o.m.) product when the seam is worked.

Samples of this seam from borehole cores and existing mine workings, floated at S.G. 1.60, give yields averaging over 95% of coal with average air-dried values of about 1% moisture, 4% ash, 0.4% sulphur and $7\frac{1}{2}$ free swelling index. The maximum fluidity of this coal, in an unoxidised condition, probably averages over 200 d.d.p.m. The volatile matter of the coal, on the dry, mineral-matter-free (d.m.m.f.) basis, varies from about 19 to 25%, covering the upper part of the low-volatile bituminous coal class and the lower part of the medium-volatile bituminous coal class of the A.S.T.M. coal classification system.

The only other seam proposed for working under the mine development plan is the Skeeter Seam, which consists typically of an upper bed of clean coal about 1.7 m in thickness, separated by a siltstone band from a thinner, lower bed of less clean coal. The quality of the coal floated at S.G. 1.60 from borehole core and mine samples of this seam is similar to, but not quite so high as, that of the Chamberlain Seam; average air-dried values are about 1% moisture, $5\frac{1}{2}$% ash, 0.45% sulphur and 7 free swelling index. Volatile matter (d.m.m.f. basis) varies from about $19\frac{1}{2}$ to $25\frac{1}{2}$%.

Coal Preparation

It is proposed to treat the output from the Chamberlain Seam in the early years of mine development in a "packaged" coal preparation plant, of c. 150 tonnes per hour capacity, to be installed near Chetwynd. Operation of this plant will provide valuable data for certain aspects of design of the permanent plant.

From the information currently available on the size consist and washability of the coal, it is envisaged that the plant will be of the heavy-medium cyclone type and that the r.o.m. coal will be reduced to a top size of 38 mm and wet-screened at 0.5 mm, for treatment of the -38 x 0.5 mm material in the cyclone. There are several possibilities for treatment of the -0.5 mm fines, although it appears likely that if they were blended in raw condition with the +0.5 mm washed coal an acceptable market product would be obtained.

As all the existing washability data are of limited value, details of design of the packaged plant will not be decided until full washability testing has been carried out on bulk samples of the seam, taken and handled in a manner intended to simulate the condition of r.o.m. coal as it will be fed into the plant. This sampling is to be given the utmost priority.

From the existing data, it is projected that a yield of about 85% might be obtained of as received coal with 8% total moisture, 6% ash, $17\frac{1}{2}$ - $20\frac{1}{2}$% volatile matter, less than 0.5% sulphur and a free swelling index of $7\frac{1}{2}$ to $8\frac{1}{2}$.

The results of the planned exploration programme should enable a decision to be made as to the practical feasibility of preparing two separate products - a low-volatile metallurgical coking coal and a low/medium-volatile metallurgical coking coal.

3. GEOLOGICAL SECTION

3.1 Location, Topography and Access

The Sukunka/Bullmoose property occupies an area of some 165 km^2 and is located 60 km south of the township of Chetwynd in north-eastern British Columbia. Fig. 1 on page 6 shows the location of the property, its relationship to other proposed coal developments and the existing infrastructure of the region.

The terrain at Sukunka is mountainous with deeply cut valleys and elevations varying between 760 and 1,980 m above sea level. Dense coniferous forest covers all but the highest ridges and there is a considerable fire risk during the summer months.

Access to the property is via a Provincial dirt road running from Chetwynd along the Sukunka River Valley. Part of this road is also used by the Quintette coal project of Denison Mines and by logging teams operating in the hills.

A semi-permanent base camp has been established in the north-west of the Sukunka area, and adit entries have been made into the coal at two localities known as the "No. 1 Mine" and the Chamberlain "Window" (see Fig. 2 on page 7). A number of surface buildings have been erected at the No. 1 Mine site.

About 320 km of temporary roads have been made across the area to provide access for exploration drilling and these are being progressively restored.

3.2 Previous Investigations (see Fig. 3 on page 8)

The Sukunka/Bullmoose property was initially leased by Brameda Resources in 1969. The northern or Sukunka part of the property was explored in joint venture with Brascan Resources and a development company known as Coalition Mining was formed with interests held by Brameda, Brascan and the Australian coal mining concern of Austen and Butta Ltd.

The southern or Bullmoose part of the property was optioned by Brameda to the Teck Corporation who subsequently earned a 50% interest in it by undertaking further exploration.

The Governor-in-Council has approved the proposal by BP to purchase the Brameda and Teck interests in Sukunka/Bullmoose. These interests amount to 87½% of all the seams at Sukunka, and 100% of Bullmoose excluding the Gates Series of coal seams from surface to a depth of 152.3 m (500 ft). By agreement with the Canadian F.I.R.A. the BP interests may be reduced to 80% of each property.

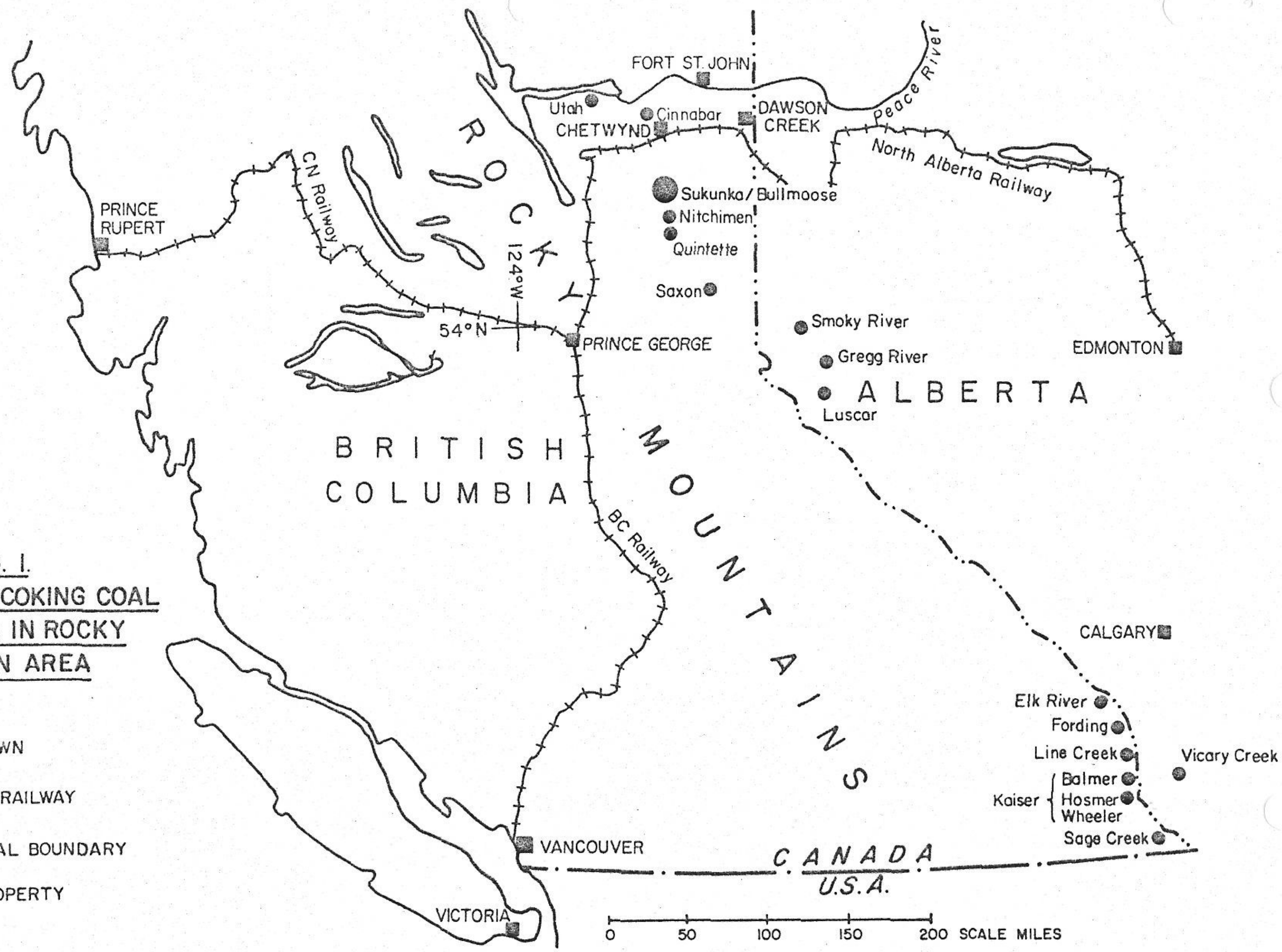
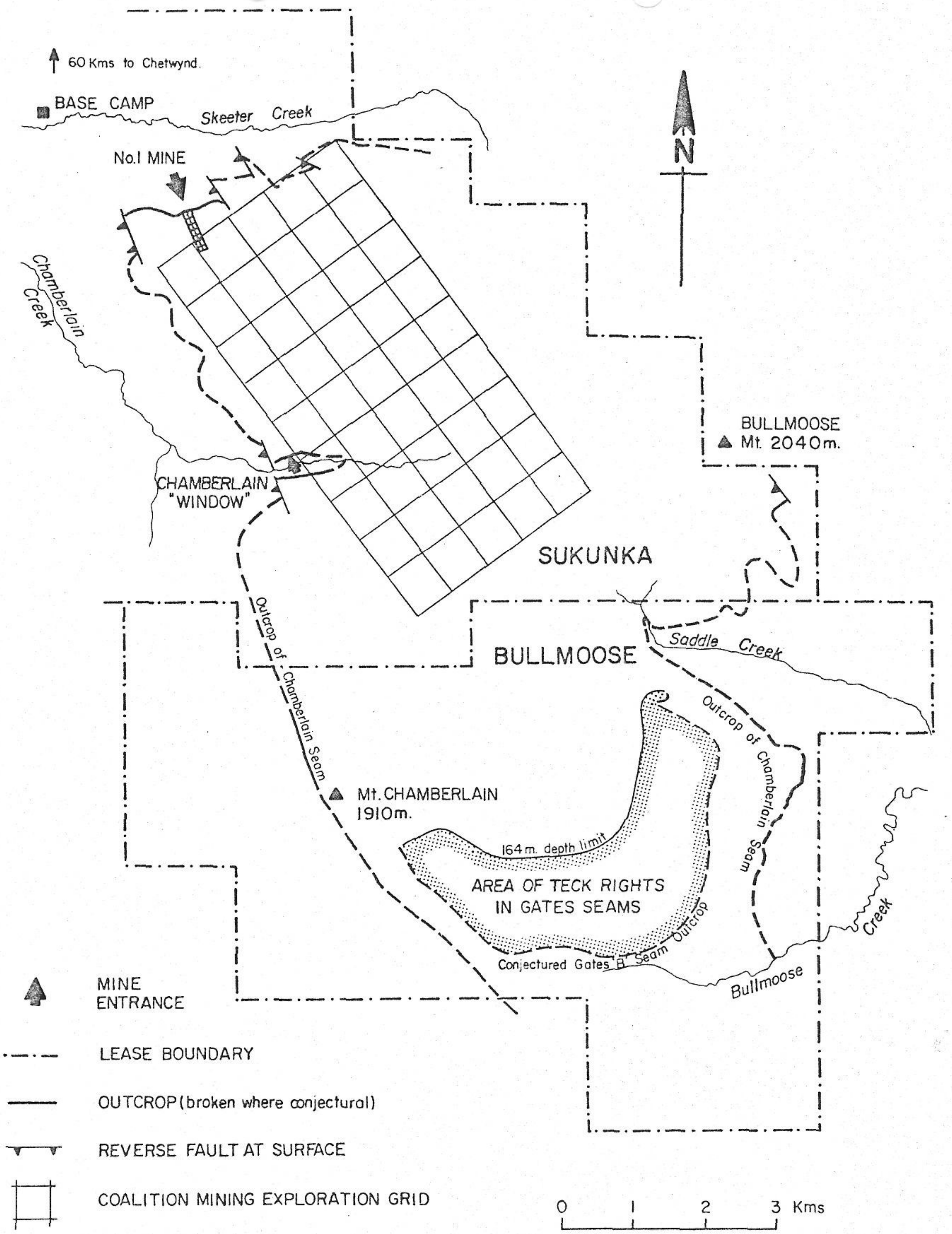


FIG. 1.
LOCATION OF COKING COAL PROPERTIES IN ROCKY MOUNTAIN AREA



GEOGRAPHY OF SUKUNKA - BULLMOOSE AREA

FIG. 2

SUKUNKA / BULLMOOSE AREA
EXISTING PROVINGS

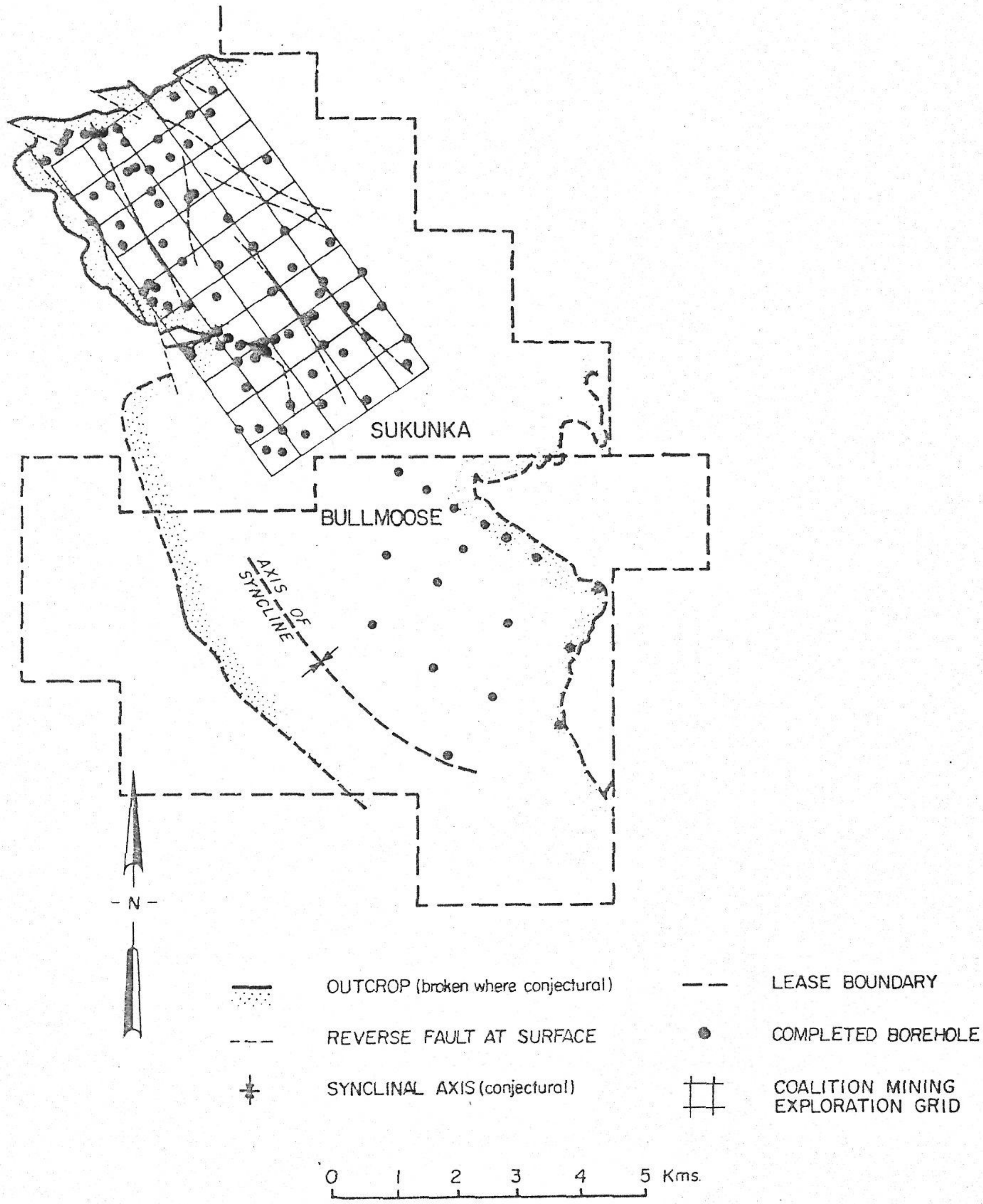


FIG. 3.

Prior to BP's entry into the project the Sukunka area was extensively explored by Clifford McElroy and Associates, Australian coal consultants, acting on behalf of Coalition Mining, whilst the Bullmoose area was only sparsely drilled by Teck beyond the areas of shallow Gates Series coal which may have some opencut potential (see Fig. 3 on page 8).

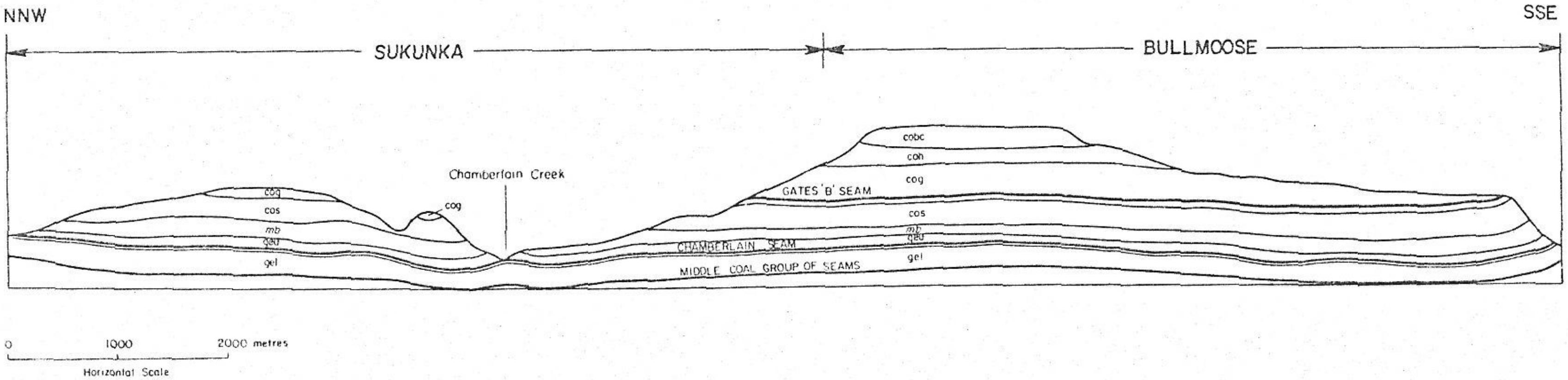
The Sukunka lease extends over 105 km^2 but intensive proving has been restricted to a rectangular block some 3 x 6 km in extent. Brameda put down 50 boreholes within this area, drilling a total of 13,526 m. McElroy extended this work and between 1970 and 1972 a further 83 bores were sunk to increase the amount of drilling to 33,622 m, mainly within the same block. The effective borehole spacing is on a 610 m grid with locally intensive infill. At the same time the area was mapped on the scale 1 : 4,800 and a base map on the scale of 1 : 12,000 was constructed from aerial photographs taken for the purpose. Five adits were driven to obtain bulk samples of the Chamberlain and Skeeter Seams (three by Brameda, totalling 105 m, and two by McElroy, totalling 42 m). Additionally, the outcrop was stripped to expose a total length of 4,510 m of the Chamberlain and Skeeter Seams. It was upon the basis of this work that McElroy made his recommendations. These are contained in multi-volume reports supported by a wealth of plans, basic data and expanded comment on particular items (see Appendix I on pages 59 and 60).

These reports represent a carefully considered appraisal and a credible interpretation of the data. It is worth noting that McElroy consulted H.E. Collins of London, A. Hargraves of Broken Hill Proprietary Co. Ltd., Australia, A.C. Cook of Wollongong University College, Australia, and T.F. Birmingham and A.R. Cameron of the Geological Survey of Canada, and that the whole report was validated by Robinson and Robinson Inc. of Charleston, West Virginia, USA.

Subsequently, 30 bores were drilled in a small area in the north-west corner of Sukunka to establish the possibilities of strippable coal from the Skeeter and Chamberlain Seams, and this work was followed by drilling 15 further boreholes in an attempt to define opencut reserves in the Gates Seams and in the Lower Gething Middle Coals. Electric logging was used on many bores put down by McElroy and some unsuccessful trials were made to determine structure and minor faulting by seismic reflection techniques.

In the Bullmoose area, the only significant provings are 19 boreholes put down to below the Chamberlain Seam in 1971/72 and one further hole drilled in 1975. Additionally, some 805 m of Chamberlain Seam outcrop were stripped, mainly on the eastern side of the property. These provings are distributed in a pattern with centres approximately 1,220 m apart, except for one NW-SE traverse with holes at 610 m intervals. Other work on Bullmoose, including that carried out in 1976, has been mainly aimed at identifying potential opencut reserves in the Gates Seams.

CROSS-SECTIONS SUKUNKA / BULLMOOSE PROPERTY



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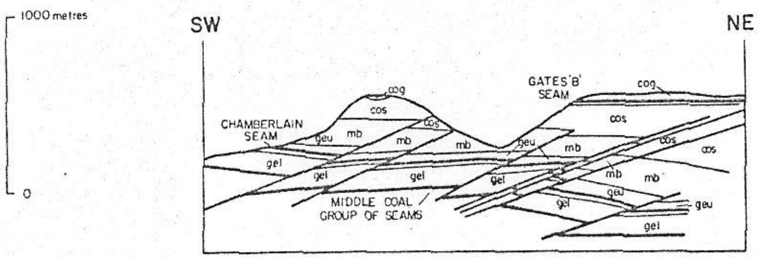


KEY

BOULDER CREEK	cobc
HULLCROSS	coh
GATES	cog
SUKUNKA	cos
MOOSE BAR	mb
UPPER GETHING	geu
LOWER GETHING	gel

FIG. 4.

Sur No 17430

As a result of all the work undertaken to date, reserves have been identified in the Gates, Bird, Skeeter, Chamberlain and Middle Seams, but only those in the Chamberlain Seam, and possibly the Skeeter Seam, are critical to the feasibility of developing an underground mine in the Sukunka/Bullmoose area.

A summary of the data available prior to BP's entry into the project is given in Appendix I on pages 59 and 60.

3.3 Geology

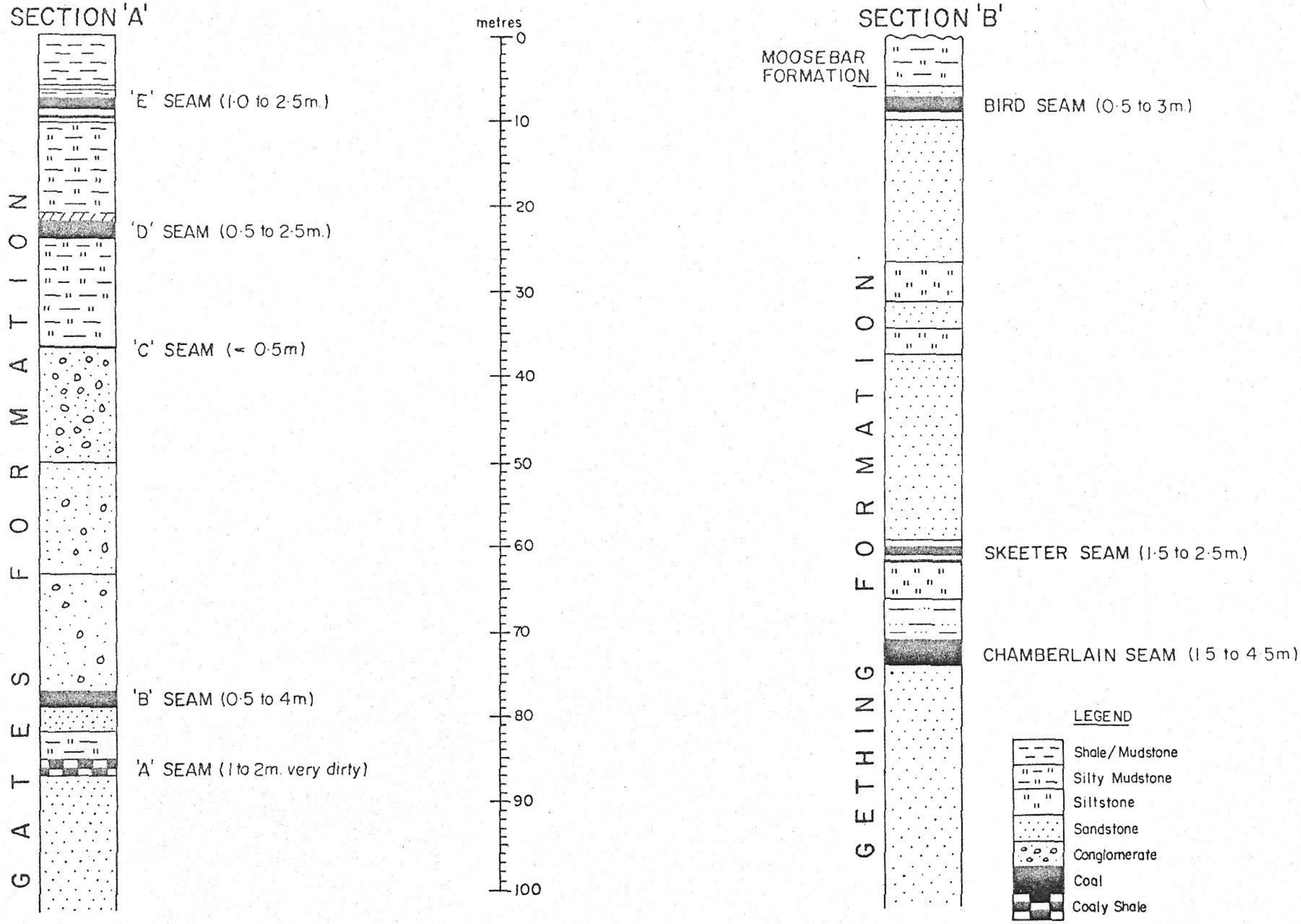
3.3.1 Stratigraphy

The coal bearing formations of the western foothills of the Canadian Rocky Mountains are Lower Cretaceous in age. In general these strata have been folded into a series of wide synclinal troughs separated by complex, deformed anticlinal rises. The Sukunka/Bullmoose area is one such broad synclinal and within it the stratigraphic sequence is as follows:-

	Geological Sequence		Approximate Thickness (m)	Coal Seams
LOWER CRETACEOUS	Commotion Formation	Boulder Creek Member	60	
		Hullcross Member	105	
		Gates Member	180	Gates Series
		Sukunka Member	120	
	Moosebar Formation		90	
	Gething Formation	Upper Gething	60	Bird Skeeter Chamberlain
		Lower Gething	180	Middle Coals
	Cadomin Formation.			

Within this sequence coal seams occur in the Gates Member of the Commotion Formation, in the Upper Gething, and in the Lower Gething. In previous exploration drilling, Coalition Mining have concentrated their Sukunka effort on the coals of the Upper Gething, whilst Teck have made the Gates Member their primary target at Bullmoose. Fig. 4 on page 10 shows two sketch cross-sections through the Sukunka/Bullmoose area, depicting the structure and the distribution of the stratigraphic units within the property as a whole.

Typical generalised sections of the coal bearing sequences are shown on Fig. 5 and described below:-



SUKUNKA / BULLMOOSE
TYPICAL VERTICAL SECTIONS OF COAL BEARING SEQUENCES

FIG. 5.

Gates Member		Upper Gething		Lower Gething
Gates E Seam	1 to $2\frac{1}{2}$ m	Bird Seam	$\frac{1}{2}$ to 3 m	Middle Coals (sequence only seen at isolated outcrops and yet to be correlated)
Measures	12 m	Measures	50 m	
Gates D Seam	$\frac{1}{2}$ to $2\frac{1}{2}$ m	Skeeter Seam	$1\frac{1}{2}$ to $2\frac{1}{2}$ m	
Measures +	54 m	Measures	5 to 12 m	
Gates B Seam	$\frac{1}{2}$ to 4 m	Chamberlain Seam	$1\frac{1}{2}$ to $4\frac{1}{2}$ m	
Measures	6 m			
Gates A Seam *	1 to 2 m			

+ Including the thin Gates C Seam

* Mainly carbonaceous shales.

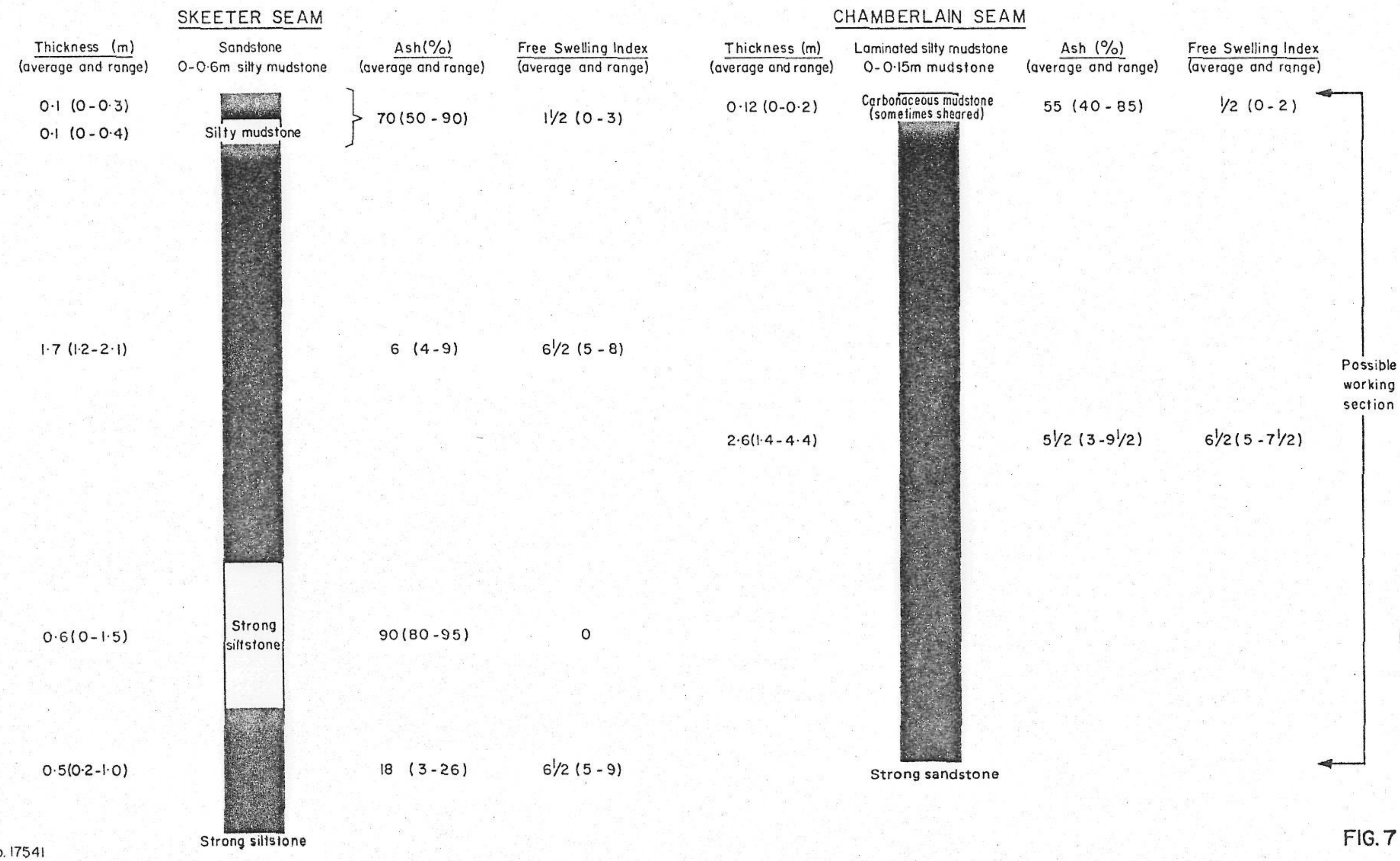
All the coal seams are subject to lateral variation in thickness and quality, and there is some evidence of seam splitting. Of the seams in the Gething Formation the most persistent coal horizon is the Chamberlain Seam, which underlies almost the whole area, although it thins to the south and eventually becomes uneconomic. Fig. 6 in pocket at rear of folder is an isopachyte plan of the Chamberlain Seam drawn from the results of previous drilling. In general the Chamberlain Seam is of consistently high quality and maintains a mineable thickness over some 30-35 km^2.

The BP mining plan described in this report is largely concerned with working the Chamberlain Seam. Over the northern and eastern parts of the Sukunka area this seam is a simple bed of coal but in the south-west it is possible that a thin upper bed splits off (Fig. 6). The limited data available suggest that this split line may continue south-eastwards across the Bullmoose area where the seam first thickens and then deteriorates into uneconomically thin leaves. The variation in total seam thickness is from 1.37 to 8.30 m, with the thickest sections occurring in the south-east Sukunka/north-east Bullmoose area. Even where the seam is split, the workable lower bed is some 2.1 m thick, and most of the reserves are in coal sections greater than 2.4 m in thickness. The Chamberlain Seam is well proven within the Sukunka area but information is scanty in the Bullmoose area. It is, however, clear that the southern boundary of Sukunka is drawn across an area of thick Chamberlain Seam and that the Bullmoose area contains potentially valuable additional reserves. These reserves will be more accurately delineated by the 1977 BP exploration programme.

The Skeeter Seam is potentially only of economic value in the northern part of Sukunka. It is a composite seam with dirt bands near the roof and in the lower half, and the whole seam (including dirt bands) varies between 1.2 and 4.0 m in thickness, deteriorating and thinning to the south (Fig. 6). The seam is possibly mineable over the northern part of Sukunka where, typically, it comprises a main bed 1.2 to 2.1 m thick separated by up to 1.37 m of strong, carbonaceous siltstone from a bottom bed 0.15 to 0.91 m thick. The main bed roof is a carbonaceous siltstone with local development of a thin "rider" coal. A possible working section would include only the main bed, with the working floor on top of the major dirt band. Generalised sections of the Skeeter and Chamberlain Seams are shown on Fig. 7.

SUKUNKA / BULLMOOSE

GENERALISED SECTIONS SHOWING STRUCTURE AND BASIC QUALITY OF PRINCIPAL SEAMS



Sur.No. 17541

FIG. 7

The Bird Seam, which lies above the Skeeter Seam, is not considered to be an economic working proposition in the Sukunka area, but it is of workable thickness in Bullmoose. It is separated from the Chamberlain Seam by 30 to 45 m of strata including the Skeeter Seam, and varies up to 2.74 m in thickness, splitting into several leaves in the south. Owing to its lower quality, however, it is unattractive as a primary target, although it will be investigated further during the 1977 BP exploration programme.

Within the Sukunka/Bullmoose area, the Gates and Middle Coals have not been intensively explored. It is BP's intention to drill further cored holes through these horizons during the 1977 exploration programme in order to investigate their mining potential, particularly in the Bullmoose area.

3.3.2 Structure

According to McElroy, the Sukunka area is divided into three main blocks or plates by two major low-angle reverse faults which strike NW-SE and overthrust to the north-east, the middle plate being further subdivided by lesser thrusts (see Fig. 4 on page 10 and Fig. 8 in pocket at rear). The major faulting cuts the Commotion Formation whereas the subsidiary faults are absorbed in the Moosebar Formation. McElroy further considers that the strata between the thrusts are comparatively free from steep dips and minor faulting, and certainly few faults are present in the accessible seam workings. The structure within the grid area is thought to be a series of gentle anticlines and synclines with axes lying in a NW-SE direction, parallel to the thrusts (see Figs. 4 and 8). No such detailed evaluation has been made by Teck for the Bullmoose area, but McElroy's structure would suggest that the strata in the northern part of Sukunka could be more intensely faulted than in the southern part of Sukunka or in Bullmoose. Broadly, the structure of Bullmoose is synclinal, with a shallow eastern limb falling to the south-west at about 1 in 5 or 1 in 6 to an axis running parallel to, and slightly west of, the western edge of the Sukunka grid. The western limb is steep and brings the Gething Formation back to outcrop before the strata turn over in a tightly folded anticline and pass into another smaller and shallower syncline which is in turn cut off by NW-SE faulting. This small syncline and the northern part of the steep west limb of the major syncline are contained in the "Chamberlain property" lying immediately west of Bullmoose.

The Chamberlain Seam outcrops all round the main syncline and also along the unfaulted margins of the smaller "outlier" syncline, but has only been exposed to a very limited extent (Fig. 3). The high ground in the centre of the Bullmoose area produces a rapid build-up of cover above the Chamberlain Seam to over 760 m.

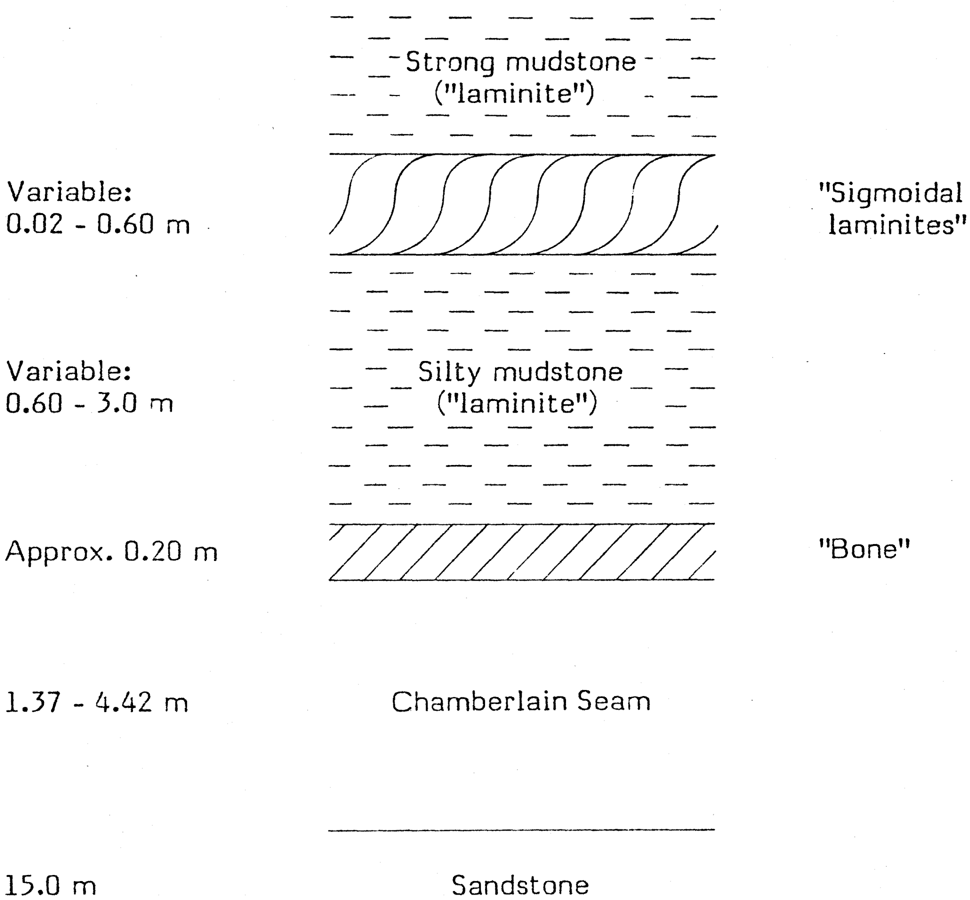
The overall structure of the property as interpreted from the previous drilling can be seen on Fig. 8, which is a structure contour plan drawn on the base of the Chamberlain Seam, and also on the cross-sections, Fig. 4. Further drilling as part of the 1977 exploration programme is expected generally to confirm this structure, although it it considered likely that some modifications to it may be necessary when the results of that drilling are known.

3.3.3 Mining Geology

The immediate roof of the Chamberlain Seam is a 15 cm layer of carbonaceous mudstone known as "the Bone". It is overlain by a few centimetres of strong, dark mudstone passing rapidly into a strong banded silty mudstone which extends upwards for at least 3 m and passes into siltstone.

Intense shearing has been seen at two horizons, one in the "Bone" immediately above the seam and the other at a variable interval, generally less than 3 m above the seam. The upper shear zone was referred to by McElroy as the "sigmoidal laminites".

The "Bone" was sheared into an incoherent mass of polished lenses over most of the No. 1 mine workings but was generally undisturbed in the headings at the "Window" (see Fig. 2 on page 7). The "sigmoidal laminites" were present everywhere but varied in interval from 0.6 to 3 m above the seam, and in thickness between a few centimetres and some 0.6 m. Its upper and lower boundaries are sheared along bedding planes, and within the layer the bedding is contorted into an "S" shape and is slickensided. This succession is sketched below:-



The roof of the Chamberlain Seam, where it occurs as described above, is considered to be weak due to the presence of the sheared zones of the "Bone" and "sigmoidal laminites". Possible ways to control the "Bone" would be either to mine it with the coal or to leave a supporting coal roof. The silty bedded mudstone above is considered satisfactory for mining provided that it is properly supported. The "sigmoidal laminites" constitute a zone of total weakness and rock bolt anchorages must be located in strata above this shear zone.

The floor of the Chamberlain Seam is a sandstone of great strength. It must be resistant to minor faulting, and this factor could be the reason why stress has been relieved by roof shears. It will be a cause of serious pick wear if machine operation is careless.

The roof of the Skeeter Seam is a strong, coaly and silty mudstone seatearth, 0.15 to 0.30 m thick and locally including a thin rider coal. These strata pass upwards into strong sandstone. The lower roof material does not show any marked tendency to fall, but its general lack of bedding has led to an uneven separation from the coal. The Skeeter Seam floor is a strong siltstone and appears good.

In the solid, the coals of both the Skeeter and Chamberlain Seams are strong, and falls of side are generally absent in the workings.

The No. 1 Mine workings in the Skeeter Seam carry a small reversed fault, visible on the surface bench from which entries are driven. In general, it does not seem that any particular difficulty has been encountered in maintaining roof control beneath the fault. No faulting can be seen within the Chamberlain Seam workings, though near to the entrance in the Chamberlain "Window" the Chamberlain thrust is exposed in the side of the access road. Strata are broken and tilted over a zone some 75 m wide at this locality.

3.4 Reserves

The extent of proving within the Sukunka and Bullmoose areas has been described in Section 3.2 above and is illustrated in Fig. 3 on page 8. Subsequent to this exploration, McElroy estimated the total in situ reserves of the Chamberlain and Skeeter Seams in Sukunka as 123 million tonnes made up of 108 million tonnes of Chamberlain and 15 million tonnes of Skeeter. He was not commissioned to evaluate Bullmoose, though he drew attention to the extension of the Sukunka coals into the area. As a result of their own exploration, Teck Corporation estimated a total in situ reserve of 82 million tonnes of Chamberlain Seam at greater than 1.5 m thickness in this Bullmoose area.

The combined reserves of Sukunka/Bullmoose in the Skeeter and Chamberlain Seams were re-estimated by BP using both McElroy's and Teck's data. The results of this assessment are shown in Table 1 below.

Table 1 - Chamberlain Seam and Skeeter Seam Reserves at Sukunka/Bullmoose (million tonnes)

Area	Chamberlain Seam			Skeeter Seam			Total		
	In Situ	Mineable	Saleable	In Situ	Mineable	Saleable	In Situ	Mineable	Saleable
Sukunka	118	72	60	13	10	7	131	82	67
Bullmoose	52	28	22	Nil	Nil	Nil	52	28	22
Total	170	100	82	13	10	7	183	110	89

The best proved of these reserves are those within the Sukunka area which was the subject of much of the McElroy work. These reserves are drilled to a proving density which conforms with the "measured" standard as defined by the U.S. Bureau of Mines and by the Australian States of Queensland and New South Wales. This area was also the only part of the property for which McElroy made an estimate of saleable yields. The estimates made by McElroy and by BP for this block are compared in Table 2 below.

Table 2 - Comparison of BP and McElroy Reserves in Sukunka Exploration Grid Block (million tonnes)

Seam	McElroy		BP re-estimate	
	In Situ	Saleable	In Situ	Saleable
Chamberlain	69	39	64	36
Skeeter	15	7	13	7

There are possibly some 25 million tonnes additional inferred reserves of Chamberlain Seam at Bullmoose, in the steep ground of the west limb of the syncline, which are not included in the above estimates. These may be ultimately workable by hydraulic mining or some alternative technique, but are not currently regarded as economic. There are also possibilities for additional reserves in the Bird, Middle and Gates Seams, which are as yet very poorly proved. These coals are not as attractive in terms of quality as are the Chamberlain and Skeeter Seams but could possibly contribute to the later development of the mine. The additional reserves in these seams could possibly be in excess of 50 million tonnes, although those in the Middle Seams will occur at considerable depth in the centre of the property.

3.5 Proposed Future Exploration Programme

During the summer of 1977, BP proposes to conduct a comprehensive exploration programme, a copy of which is attached. It will be mainly directed towards increasing knowledge of the Bullmoose area. This programme will consist of field and underground mapping, bulk sampling and the drilling of 38 fully cored boreholes, at nominal 600 m centres, to the Chamberlain Seam. Five of these boreholes are scheduled to be drilled deeper in order to intersect the Middle Seams which lie below the Chamberlain horizon.

Full details of the objectives of this exploration, together with the work programme, manning, evaluation and budgeting proposals, are contained in BP Coal Technical Division Report No. 77/7/Ca/Su/4, "Sukunka/Bullmoose - Revised 1977 Exploration Programme", a copy of which accompanies this report.

4. MINING PROGRAMME

4.1 Introduction

4.1.1 Reserves

Examination of the coal reserves on the Sukunka/Bullmoose property indicates that there are some 170 million tonnes in situ in the Chamberlain Seam plus some 13 million tonnes in the Skeeter Seam. It is estimated that 110 million tonnes can be recovered by conventional mining techniques, including bord-and-pillar, pillar extraction, and possibly shortwall or longwalling techniques, equivalent to 89 million sales tonnes of low/medium-volatile coking coal. These reserves will therefore support a planned output of some 3 million sales tonnes per annum for over 20 years.

4.1.2 Port and Railway Facilities

The B.C. Government is committed to the policy of developing the Peace River Coalfield in north-east British Columbia. In order to achieve this objective new main line railways and port facilities are required, which need minimum or threshold tonnages before the large capital expenditure can be justified. The indications are that the Sukunka/Bullmoose project producing 3 million sales tonnes per annum, and the Quintette project of Denison Mines just south of the BP properties producing some 5 million sales tonnes per annum, would provide the minimum threshold tonnage needed. The timing of this project depends therefore upon obtaining adequate markets and contracts for this type of coal and the necessary time to plan, design and construct the railway and the port facilities. Taking into account market and financial considerations, BP has selected 1984 as the likely date for commissioning of the facilities.

Sukunka, however, owing to its proximity to the existing railhead at Chetwynd and its superior coal quality, is able to produce and market coal much sooner. The date of 1st January 1979 has been set as the target for production at the rate of 0.35 million sales tonnes per annum, increasing to 0.5 million tonnes in 1980.

The development of the Sukunka/Bullmoose project is seen therefore in two phases, namely:-

Phase I — A Short Term Plan, commencing in 1978, with production increasing to the rate of 0.5 million saleable tonnes per annum in 1980, the raw coal being trucked by road to Chetwynd and treated in a pilot coal preparation plant, and the saleable coal loaded on to the existing rail services for consignment to the Neptune Terminal at Vancouver.

Phase II A Long Term Plan, with a production of 3 million sales tonnes per annum from a large mine and major heavy-medium coal preparation plant, the saleable coal being handled by a rapid loader into unit trains on a new railway line for transport to Prince Rupert. The mine will be located on the eastern side of the Bullmoose property, and development will be primarily in the Chamberlain Seam.

It is recognised that the programme to achieve full output of 3 million sales tonnes per annum by 1985 can be accelerated, provided that the following conditions are met:-

(1) Rail and tidewater terminal facilities are available sooner than the assumed date of 1984.

(2) The necessary authorisations from Government and local agencies, particularly in regard to environmental aspects, are made available early enough to allow definitive planning and design of facilities to be undertaken.

(3) The 1977 exploration programme has confirmed BP's overall judgement of the Sukunka and Bullmoose reserves in terms of quantity, quality and geological structure.

(4) The underground development programme has proved that the mining conditions can sustain the scheduled production programme.

(5) The resources and services necessary for the development programmes are made available early enough for the various schedules to be maintained or improved upon.

4.2 Phase I - Short Term Plan

4.2.1 Introduction

The BCR line to the Neptune Terminal in North Vancouver is currently underutilised and the spare capacity for carrying additional coal will be the subject of a separate study.

Neptune Terminal has advised a present ability to handle additional tonnage in excess of 2 million tonnes per annum, although this may be constrained owing to the social factors of transporting coal through the North Vancouver suburbs and the overall capacity of the BCR line. Firm commitments will be made to Neptune Terminal as soon as the rail carrying capacity is secured.

This spare capacity forms part of BP's Short Term Plan for the Sukunka/Bullmoose mine development and aims to take advantage of the downstream transport facilities and create a viable producing mine that is independent of the time schedule for the additional transport infrastructure. The Short Term Plan allows BP to proceed now without having to wait for major policy decisions by either the Federal or Provincial Government in regard to the infrastructure and the timing of the implementation of these decisions. However, the Short Term Plan dovetails neatly with the Long Term Plan and can be phased out as the long term mine facilities and infrastructure are made available.

4.2.2 Planning Strategy

Commencing July 1977, the exploration programme will concentrate on the Bullmoose reserves. By 1978, it is hoped that the geological structure and reserves will be proven sufficiently in the Saddle Creek area for underground development to be undertaken with confidence. At this stage, applications will be made for licences for limited production under the Coal Act. The benefit to be derived from these licences would be:-

(1) the early establishment of mine portals and associated surface ancillary works;

(2) an indication of mining conditions, e.g. roof, floor, water, gas, coal hardness, etc;

(3) the production of bulk samples of coal for analysis, trial washing and consumer tests.

The present indications are that in the Bullmoose part of the take the coal in the Chamberlain Seam is thicker than in the Sukunka part, and fault intensity is lower. The Bullmoose reserves appear, therefore, to be eminently suitable for the development of two separate mines from the Saddle Creek area, which would be conveniently sited in relation to the new railway and townsite on the eastern side of the property.

4.2.3 Advantages of the Short Term Plan

Mining Conditions

The earliest start possible on mine development should be made; this will give the maximum time for the practical investigation of underground mining conditions and enable the most suitable mining equipment and systems to be selected for the Long Term Plan.

Cash Flow

It is believed that production on a lower scale prior to the Long Term Plan, with its associated infrastructure and large scale expenditure, will provide a feasible and profitable undertaking that will assist the funding of the operation.

Markets

The Short Term Plan production can establish customer confidence by means of reliable deliveries of coal to the correct quality specification. This will be beneficial for the establishment of the necessary relationships for the Long Term Plan.

Coal Preparation

In the past, coking coals in British Columbia have proved to be difficult to treat efficiently. A pilot coal preparation plant in the first phase, coupled with the opportunity to obtain regular bulk samples, will provide the best information possible for the design of an efficient washery for the Long Term Plan.

Training

The first phase will provide the opportunity for a nucleus of managers, supervisors and workmen to become fully experienced and expert in local conditions. This team will be entrusted with the training of the labour required for the development of the Long Term Plan. The training will be undertaken with the assistance of government facilities and financial participation.

4.3 Mine Development

4.3.1 Existing Workings

The existing workings comprise development drivages in the Skeeter and Chamberlain Seams at the Sukunka No. 1 Mine which are sited on the northern outcrops. Other entries in the Chamberlain Seam have been driven from the western outcrop at the Chamberlain "Window". The total developed drivages are (approximately) as follows:-

	Total Drivage (m)	Development Advance (m)
Sukunka No. 1 Mine, Skeeter development	2,682	366
Sukunka No. 1 Mine, Chamberlain Seam	3,261	671
Chamberlain "Window", Chamberlain Seam	274	56

Additionally, a connecting drivage of approximately 15 m has been driven between the Skeeter and Chamberlain Seams in the No. 1 Mine.

The workings have been examined at various times since 1974 by BP mining engineers and geologists. The mine development work commenced in 1973 and ceased in March 1976.

The drivages in all cases were laid out at 37 m centres with cross-cuts generally at 46 m centres. The cross-cuts were driven either at right angles to the line of the main development or set off at 120^{0}. All drivages were nominally 5.5 m wide but in fact were up to 6.4 m wide. The drives were taken to the full seam height, varying between 2 and 3 m.

In the Skeeter Seam the section included a stone parting of variable thickness up to 0.37 m (see Fig. 7 on page 14). In certain sections of the Chamberlain Seam a weak shale band, 0.15 to 0.23 m in thickness, lies immediately above the seam and was also taken with the coal since it could not be supported.

Several methods of roof support have been used throughout the drivages, with varying success. These have included:-

(1) Rock bolts, mechanical wedge type.

(2) Rock bolts of mechanical wedge type with 51 mm hardwood board fixed under the base plate. These gave effective support.

Both arrangements were used in conjunction with square set timbers, comprising 300 mm diameter legs and round bars, set at 2.13 m intervals (see Figs. 9 and 10 on pages 25 and 26).

At the Chamberlain "Window" the roof conditions in the Chamberlain Seam were good. At the No. 1 Mine the Skeeter Seam roof conditions were also good but conditions in the Chamberlain Seam were variable. Those entries driven to the nominal width of 5.5 m and properly supported remained in good condition. Where widths exceeded 5.5 m and support was inadequate limited falls took place. Most of these falls could have been avoided if the drives had been mined at the correct width and the roof properly supported.

No significant underground faulting was detected although minor reversed faults were traversed without undue problems. On these occasions the coal thickened to over 3 m. The Chamberlain Seam is underlain by a hard, abrasive sandstone floor which causes severe wear on caterpillar tracks and cutter picks on the continuous miners.

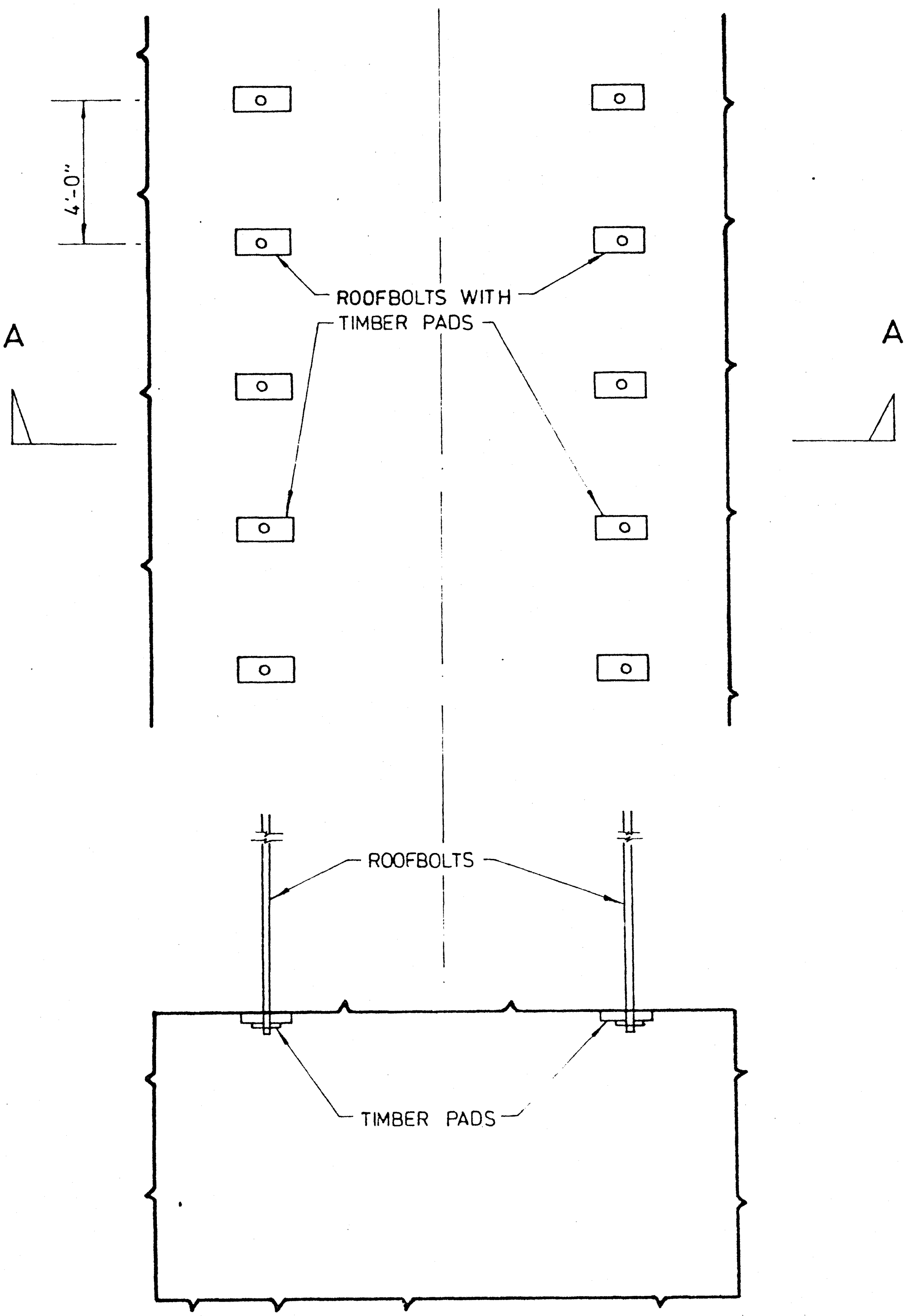
Ventilation

Whilst the workings have not been ventilated mechanically for some time, methane gas has not accumulated or been reported in the mine, even though it has been previously indicated in boreholes from the surface.

B P SUKUNKA - BULLMOOSE PROJECT

FIG. 9

METHODS OF SUPPORTING ROADWAYS
ROOFBOLTS SET IN PAIRS



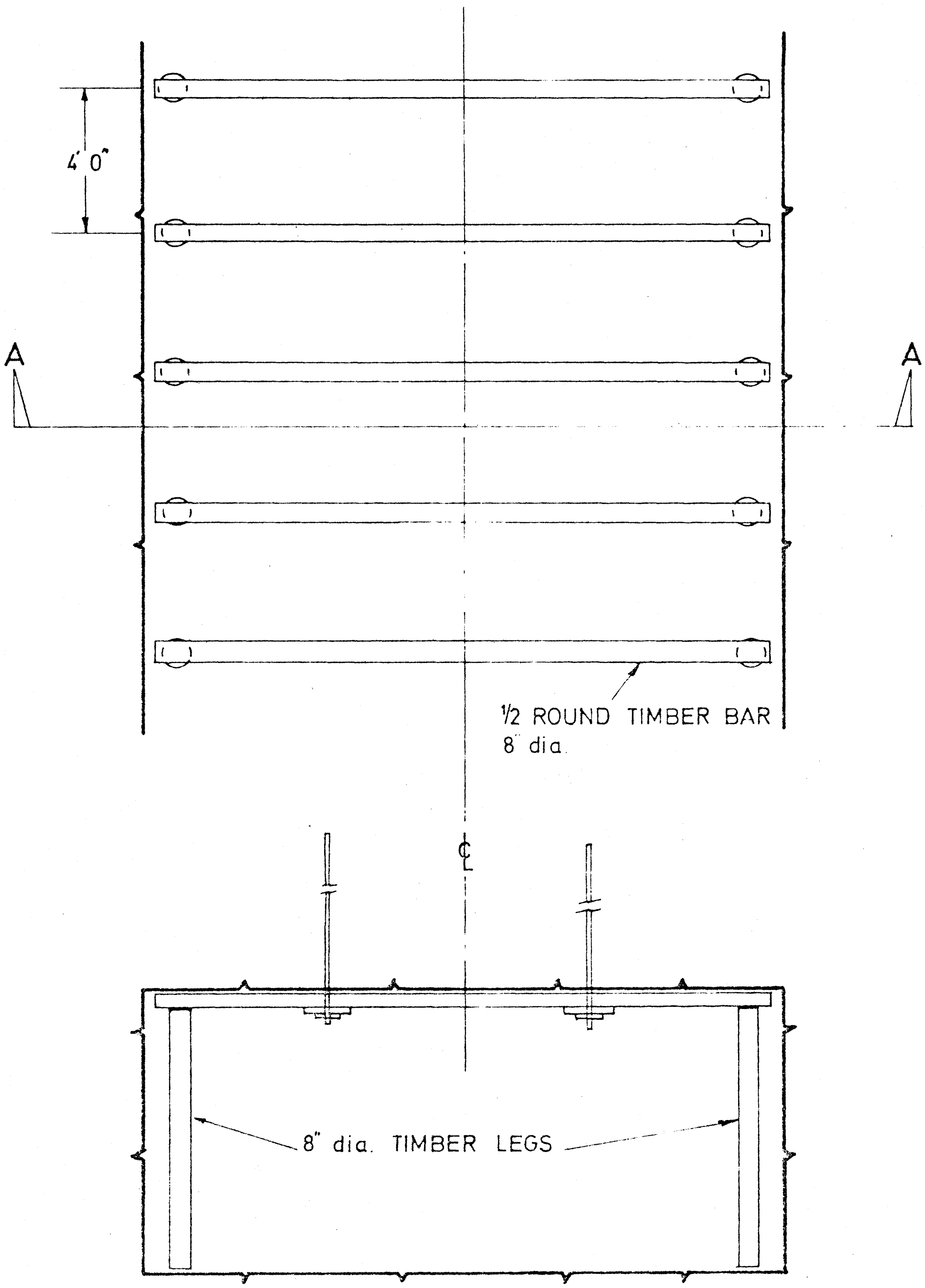
SECTION ON A-A

B P SUKUNKA - BULLMOOSE PROJECT

IG.10

METHODS OF SUPPORTING ROADWAYS.

TIMBER LEGS WITH TIMBER BAR AND ROOF BOLTS.



SECTION A—A

The general mining development and layout of the Sukunka/Bullmoose property is shown on Plan No. 1 in pocket at rear. The primary objectives are (1) to develop sufficient "pit room" to allow required production levels to be attained and (2) to connect developments from Saddle Creek with those from the Chamberlain "Window". The actual direction and location of developments will depend upon major faulting proved by the 1977 exploration programme. The layout of production panels will also depend upon the faulting and normally will not be required to traverse large faults.

It is proposed to open up the take of each of the two separate mines by means of a four-entry main development roadway system. Each entry would be driven on 40 m centres at 5 m width, taking the full section of the seam where this is practical, i.e. up to 3.5 m total seam section. Roof bolting would be the main support system, supplemented by timber roof bars and props as used previously.

This method of support is expected to be satisfactory for over 95% of the total drivage work that has to be undertaken. Where the drivages have to pass through weak ground such as a main overthrust fault area, then it is anticipated that the drives may have to be fully lined with colliery arches set at 1 m centres (see Fig. 11 on page 29).

.4 Production Schedule

4.4.1 General

The saleable production in Phase I is shown in Table 3 on page 30 together with the source (seam and area).

Raw coal production was estimated on the basis of a conservative yield of 70% of saleable coal, and is shown in Table 4 on page 31. In normal mining conditions it is considered that a significantly higher yield would be obtained, but 70% has been assumed, to take into account abnormal mining conditions during the primary development stage when mine entries may have to traverse faults or bad ground and encounter excessive dilution or contamination. Secondary development and production panels will normally avoid these conditions.

Water

The Chamberlain Seam workings at the No. 1 Mine have been partly flooded but the make of water is not excessive and the workings can be readily pumped dry.

The seam gradients in both mines vary between flat and 7^{o}.

4.3.2 Bullmoose Area Mines

It is considered that the development of the Chamberlain Seam in the Bullmoose area is the priority task, once the exploration programme of 1977 has sufficiently proved the structure. It is proposed that this part of the take and reserves will be the early working area of the two mines in the Long Term Plan.

The reasons for the establishment of two mines are:-

(1) Development in two different directions enables more flexible planning if unforseen geological problems occur. Sufficient face room and production capacity can be developed in one mine even if the development of the other mine encounters some difficulties.

(2) Face room and production capacity can be built up more quickly.

(3) This method of development will prove a wider area of the reserves, thereby enabling the mines more easily to maintain a consistent coal quality by blending output from different areas of the take.

(4) In the event of a major breakdown in one mine, production can be maintained in the other, and stepped up if necessary.

(5) An output of 1.5 million tonnes per annum (equivalent to some 8 producing units) approximates to the optimum size of underground mine for good organisation and efficiency. It is expected that the two mines will induce a spirit of healthy competition between their respective management organisations. Furthermore, it is considered that a single mine to provide the total output (3 million tonnes per annum or 16 units) would cover an area too large and unwieldy for adequate and personal supervision.

(6) The provision of separate mines can assist in the industrial relations field since the organisation is more personal between men and management, with the added possibility that disputes may be limited to one mine only.

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B P SUKUNKA - BULLMOOSE PROJECT

FIG. 11

METHODS OF SUPPORTING ROADWAYS

STEEL ARCHES

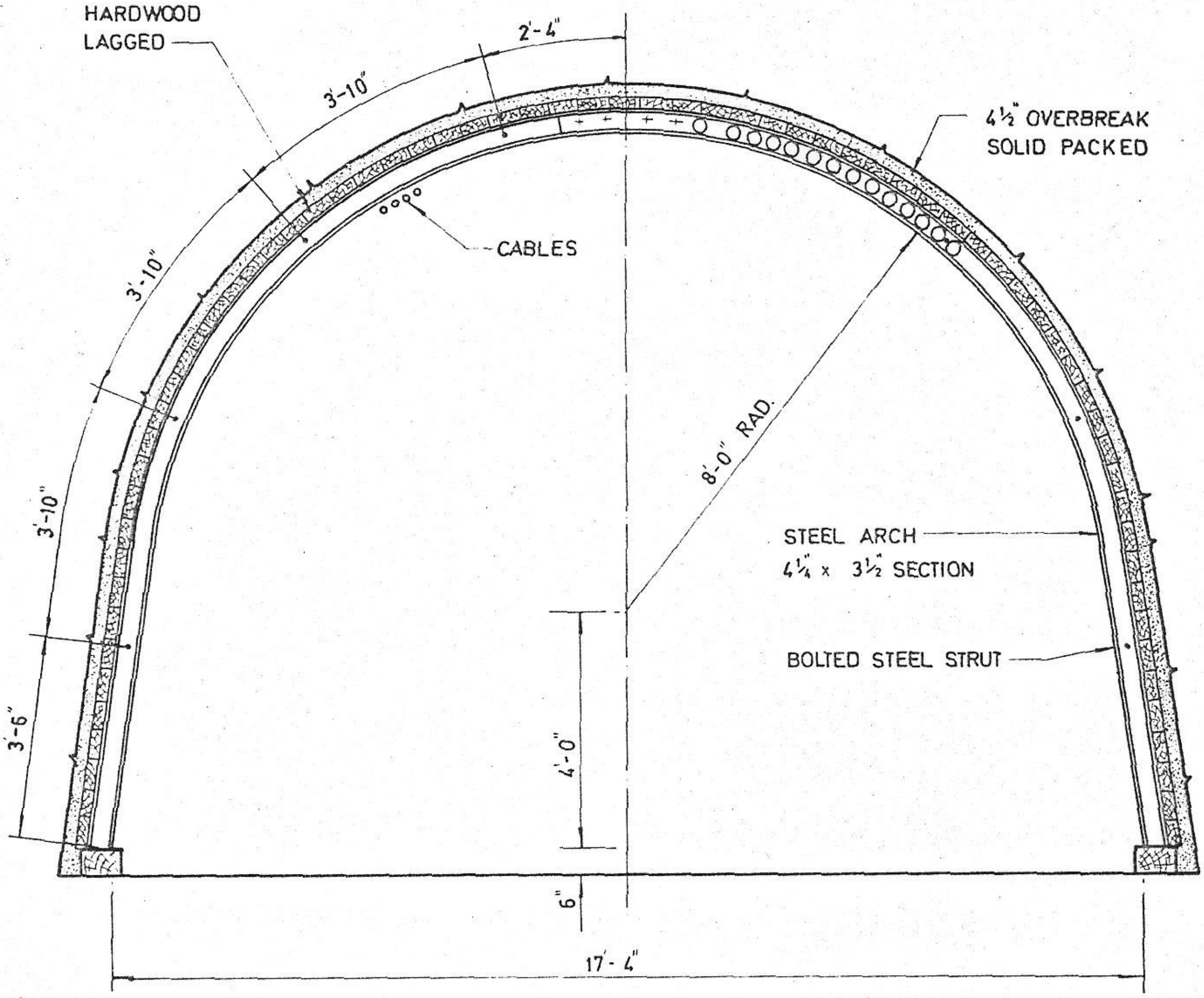


Table 3 - Phase I Saleable Production

Year	Saleable Tonnes	Sources
1978	40,000	Production permit for limited output.
1979	350,000	Mine development in Chamberlain Seam from Sukunka and Bullmoose with balance from production units at Sukunka.
1980	500,000	Mine development in Chamberlain Seam from Sukunka and Bullmoose with balance from Sukunka.
1981	500,000	Mine development in Chamberlain Seam from Sukunka and Bullmoose with balance from Sukunka.
1982	800,000	Increased mine development in Chamberlain Seam from Sukunka and Bullmoose with balance from Sukunka.
1983	1,100,000	Mine production in Chamberlain Seam from Sukunka and Bullmoose with continuing mine development in Bullmoose.

The development and production sections are shown in Table 4 over.

Table 4 also shows by year the number of operating units required for Phase I. Each unit comprises a continuous miner and two shuttle cars.

4.4.2 Production Schedule 1978-83

1978

Initially it is hoped to obtain limited production licences from the B.C. Government Mines Department for the production of 100 tonnes daily by the middle of 1978 from each of two development mines, located at Saddle Creek. The initial task will be the establishment and consolidation of the mine portals followed by a twin-entry development in each mine that will advance some 500 m during the year.

Regular sampling of the coal in situ will take place in all the main drivages. Some 40,000 tonnes of saleable coal will be produced during 1978 as the start of the following production schedule:-

Table 4 - Phase I Development and Production Sections

Year	Saleable Output (thousand tonnes)	R.o.m. Output (based on 70% yield of saleable coal) (thousand tonnes)	Chamberlain "Window"					Saddle Creek					Total Develop-ment (m)
			No. of Units			R.o.m. Output (thousand tonnes)		No. of Units			R.o.m. Output (thousand tonnes)		
			Total	Develop-ment	Produc-tion	Develop-ment	Produc-tion	Total	Develop-ment	Produc-tion	Develop-ment	Produc-tion	
1978	40	60	Nil	Nil	Nil	Nil	Nil	2	2	Nil	60	Nil	1,340
1979	350	500	3	1	2	90	230	2	2	Nil	180	Nil	6,000
1980	500	715	3	1	2	90	355	3	3	Nil	270	Nil	8,000
1981	500	715	3	1	2	90	355	3	3	Nil	270	Nil	8,000
1982	800	1,150	4	1	3	90	525	5	4	1	360	175	10,000
1983	1,100	1,575	4	1	3	90	525	6	1	5	90	870	4,000
Total	3,290	4,715	-	-	-	450	1,990	-	-	-	1,230	1,045	37,340

N.B. The 70% yield from the r.o.m. product provides for the dilution from the following roof and the exclusion of the $-\frac{1}{2}$ mm fraction. A higher yield can be obtained by washing down to 100 mesh and improved roof control to minimise the dilution.

Assumptions:-

(1) Drivage dimensions 5 x 2.5 m = 18.75 t/m advance at 1.5 S.G.

(2) Output per machine on development = 300 t/d
" " " " production = 700 t/d

(3) Workdays - development = 300d/a (contractors)
- production = 250d/a (BP direct labour)

(4) Output: (2) x (3) - development = 90,000 t/a
- production = 175,000 t/a

4.4.3 1979

During 1979 a sales production of 350,000 tonnes is planned. This will be obtained from two full development sections (2 drives each) in the Chamberlain Seam advancing the entries from Bullmoose commenced in 1978, along with one development section from the Chamberlain "Window" entrance. R.o.m. output from these development units is estimated at 90,000 tonnes per annum each, i.e. a total of 270,000 tonnes per annum. The balance of the output will be from the Chamberlain Seam at Sukunka and will require two production sections on normal bord-and-pillar working, prior to pillar extraction. The rates of production from developments are very conservative (only 300 tonnes per unit per day) and take into account that these roadways will require permanent supports for the life of the mine, and will involve development through barren areas such as faults, dykes, etc. Total r.o.m. production is 540,000 tonnes per annum, assuming a yield of 70% from the pilot coal preparation plant. The annual advance in each of the three developments will be some 2,000 m.

4.4.4 1980

Development in the Chamberlain Seam will be increased to three units at Bullmoose and remain at one unit at Sukunka. Two units at Sukunka will be production panels with a planned rate of output of 700 tonnes per day per unit. The total r.o.m. output is estimated at 715,000 tonnes for the year.

4.4.5 1981

The same rate of production is planned as for 1980, but before the end of 1981 the drivage work and trunk conveying system will have advanced to the stage where all the coal produced in the two mines can be conveyed to the Chamberlain "Window" portal. This change will eliminate the longer road haul out of Saddle Creek via Martin Creek to Chetwynd.

4.4.6 1982

Following the completion of the redirected underground trunk conveying system, the development in the Chamberlain Seam at Bullmoose will be increased to four units, with one unit continuing at Sukunka. The production units at Sukunka will be increased from two to three and a production panel will commence operations at Bullmoose. The total r.o.m. output is estimated at 1,150,000 tonnes.

4.4.7 1983

A major changeover from development to production will be made in the Chamberlain Seam at Bullmoose by switching three more of the units on to production, and adding a further production unit. One unit will continue development at Bullmoose and one at Sukunka. The production panels at Sukunka will continue as before.

4.4.8 The build-up of output in 1982 and 1983 in excess of 500,000 sales tonnes requires an increase in capacity of:-

(1) Rail transport facilities.

(2) Coal preparation plant capacity.

(3) Township housing.

Provided that the township, rail system and port loading facilities are in the process of construction or nearing completion for Phase II, coal can be processed in the first section of the major coal preparation plant. If the Government infrastructure is delayed indefinitely the pilot washing plant at Chetwynd may be extended by an additional module.

In the latter case the maximum throughput would depend upon the total annual tonnage that could be:-

(1) Transported safely by road from the mine to Chetwynd.

(2) Transported by BCR to tidewater.

(3) Handled at the Neptune Terminal.

(4) Transported through the northern suburbs of Vancouver without serious complaint from the local population.

It is considered that an annual saleable output of 1.5 million tonnes can be achieved by the proposed Short Term Plan facilities and transport routes, provided that the pilot-plant washing capacity is increased accordingly.

4.5 Equipment

4.5.1 The underground experience obtained during the development work for the Short Term Plan will enable an informed selection to be made of the most suitable and efficient mining equipment and systems for the long term expansion. However, during the Short Term Plan BP's general strategy will be to work the main developments and initial production units by proven conventional equipment, i.e. continuous miners and shuttle cars, before committing large sums of capital expenditure on more sophisticated mining systems where the suitability and success cannot be guaranteed without full knowledge of underground geological and operating conditions.

4.5.2 The current plant inventory at the existing mines includes the following machines:-

Continuous Miners

1 No. Lee Norse 105 H.H
1 No. Lee Norse 60 H
1 No. Lee Norse 48 H

Shuttle Cars

2 No. Joy 10 S.C.
2 No. Lee Norse Hydro cars (1 L.H. and 1 R.H. reel)

Conveyors

3 No. tandem driveheads
4 km of 1066 mm conveyor structure and belting

Roof Bolter

1 No. Fletcher twin-boom machine

Supplies

1 No. Rhino diesel driven transporter.

One unit made up from the above machines, powered by the existing Cat. 399 generators located at the Chamberlain "Window" Mine, can be put into operation on either development or production with the minimum delay (see Table 4 on page 31). The Short Term Plan is to commence mining at the Chamberlain "Window" Mine entrance in early 1979 with the above equipment. Additional equipment requirements include a continuous miner, two shuttle cars and one roof bolter by 1979. Additional diesel generating capacity will be required until such time as power is received from B.C. Hydro.

4.5.3 Mining work is scheduled to commence at Saddle Creek in 1978, when the two 100 tonnes per day mines are brought into operation. The machines to be employed on the coal development drives would have the following general specifications:-

Continuous Miner (e.g. Joy 10 C.M.-2 or other equivalent)

(1) Capable of cutting 5 m entries with two passes in seam heights from 1.5 to 3.0 m.

(2) Loading capacity 8 to 12 tonnes per minute.

(3) Ground clearance 300 mm.

(4) A.C. motors (550 or 1000 V) and controls, F.L.P. type.

(5) Hydraulic system utilising non-flammable fluid, e.g. Aquacent, to comply with B.C. Mines Regulations 1977.

(6) Designed for sub-assembly replacement for down-time reduction and lower maintenance costs.

Shuttle Car (e.g. Joy 10-S.C. or National Mine Services equivalent)

(1) Turning radius - inside turning radius 9 ft, essential for making intersections of minimum exposed area in order to reduce roof support problems.

(2) Ground clearance 260 mm.

(3) 10 tonnes capacity, to be trammed at over 4 miles per hour and discharged in less than 0.7 minutes.

(4) Dependable operation on steep inclinations.

(5) A.C. motors (550 or 1000 V) and controls, F.L.P. type.

(6) Hydraulic system utilising non-flammable fluid.

These machines or their equivalents operate at seven underground mines of Clutha Development Pty. Ltd. in New South Wales, in which BP has a 50% interest, and give an adequate operational performance. The continuous miners are capable of an average annual production in excess of 200,000 tonnes.

4.5.4 Roof bolting will be undertaken by machines such as the Fletcher roof bolter, although further field trials are needed underground to establish the hardness of the roof beds and the penetration rates.

4.5.5 During the first few months of development drivage, it will be acceptable for the machine crews to walk to their work places, but progressively the need for man-riding will become essential. An efficient arrangement is to have a diesel driven (F.L.P. engine) personnel carrier such as a Mine Rover in which the entire machine crew can travel from the mine entrance to their work place, returning outbye at the shift end by the same means. During the shift the carrier can be used for materials transport as required. Currently the B.C. Mines Inspectorate are conducting a special investigation into the use of diesel engined plant underground and it is not known at this stage whether the diesel Mine Rover would be allowed underground.

4.5.6 The main transport system to bring the coal to the surface will be an integrated trunk conveyor system based on 1066 mm belts operating at a speed of 2.54 to 3.56 m/s. Due allowance will be made for the friable nature of the coal and the need to minimise degradation in the design of transfer points and bunkerage.

4.6 Mine Surface Arrangements

4.6.1 Existing Arrangements

Saddle Creek

No facilities presently exist at the probable location of the portals for the two separate mines. Everything has to be provided, including road access, power and water supply, office and workshop accommodation, ventilation, stores, change house and coal truck-loading arrangements.

Chamberlain "Window"

There is a 6.5 km road access from the mine portal down to the mine camp. The Canfor truck road from the camp to Chetwynd is 60 km long. Ventilation and power generating facilities exist at this entry to service one continuous miner unit. No truck loading facilities exist at this entry.

Sukunka No. 1 Mine

The main services for the operation of the Coalition mine have been provided at this location and cover:-

(1) Mine workshop.

(2) Generating plant.

(3) Ventilating fan - with propane-gas-heated intake.

(4) Conveyor system to bring the coal to the surface.

(5) Prefabricated office accommodation.

The upper reaches of the road between the camp and No. 1 Mine entry include steep gradients which limit the truck-haul loads to approximately 15 tonnes. The road distance from No. 1 Mine to the mine camp is 2.4 km further than the distance from the mine camp to the Chamberlain "Window". Trucks were loaded directly from the drift conveyor or, alternatively, coal was accumulated at the end of the conveyor and reloaded into the coal trucks by front-end loader.

Mine Camp

A prefabricated camp is located on the valley floor below the No. 1 Mine. Accommodation for 60 persons can be provided at this point, along with general office accommodation for mine services, e.g. survey office and mine manager's office.

4.6.2 Proposed Arrangements

Road Haul

Under the Short Term Plan, output of up to 715,000 r.o.m. tonnes per annum is scheduled to be hauled from the mine mouth by road truck and delivered to the pilot washery plant located at Chetwynd. Possible transport arrangements for additional output are discussed in Section 4.4.8 of this report. The haul distance is approximately 60 km and it appears that the optimum load that can be hauled by an "on-highway" truck along the proposed route is approximately 35 tonnes. Discussions have taken place with competent and experienced haulage organisations, and one of these, Trimac, has shown special interest in operating on contract to transport the total output from the mine to the pilot washing plant.

Having examined both the No. 1 Mine surface facilities and those at the Chamberlain "Window" it has been decided that the road haul from the Chamberlain "Window" will provide the optimum service, as it is the shorter route to Chetwynd and the gradients are less steep.

During the years 1979 - 1981 coal will be produced at two separate points, namely, the Chamberlain "Window" and Saddle Creek. Coal hauling can be terminated at Saddle Creek in 1981, when the revised underground conveyor system will permit all coal produced to be transported to the Chamberlain "Window". However, during this three-year period some 800,000 r.o.m. tonnes will require hauling by truck from Saddle Creek to the Chetwynd pilot washery. The haul route is approximately 109.5 km in total length, and will require both the upgrading and extension of the truck road currently serving the BP gas well C20L located at the head of Saddle Creek.

Similar coal storage and truck-loading arrangements will be required at both Saddle Creek and the Chamberlain "Window". These facilities will comprise silos of not less than 500 tonnes capacity, constructed so that they are contained within the surrounding land surface. This feature will provide some insulation and prevent the coal freezing within the silos. The trunk conveyor system transporting the coal out of the mine will discharge the coal directly into the silos.

A truck turn-round point will be constructed at the draw-off point located at the base of each silo. Advantage will be taken of the steep terrain to design the silos and their draw-off points to reduce the gradients of the approach road.

Power Supply

Preliminary discussions have taken place with B.C. Hydro for the permanent supply of electric power to the mines. It is unlikely that any supply can be effected before mid-1980 and, consequently, temporary diesel driven generating capacity will be provided at both the mine entrances. This power supply will cover the requirements of the face mining equipment, conveyor system, ventilation, pumping, workshop equipment, office heating and lighting. This temporary generating capacity will be of the order of 5 MVA at each mine site by 1981.

Ventilation

Each mine system will be provided with its own exhausting ventilating system, i.e. one fan at the Chamberlain "Window" and two fans at Saddle Creek. These fans will have a capacity of 70 m^3/s. Ventilation capacity can be increased by installation of additional units.

Each intake portal will incorporate a heating arrangement by propane gas to ensure that the intake air is maintained at a level above freezing point. The possibility of a heat-exchange arrangement between return and intake air-flows will be investigated at a later stage.

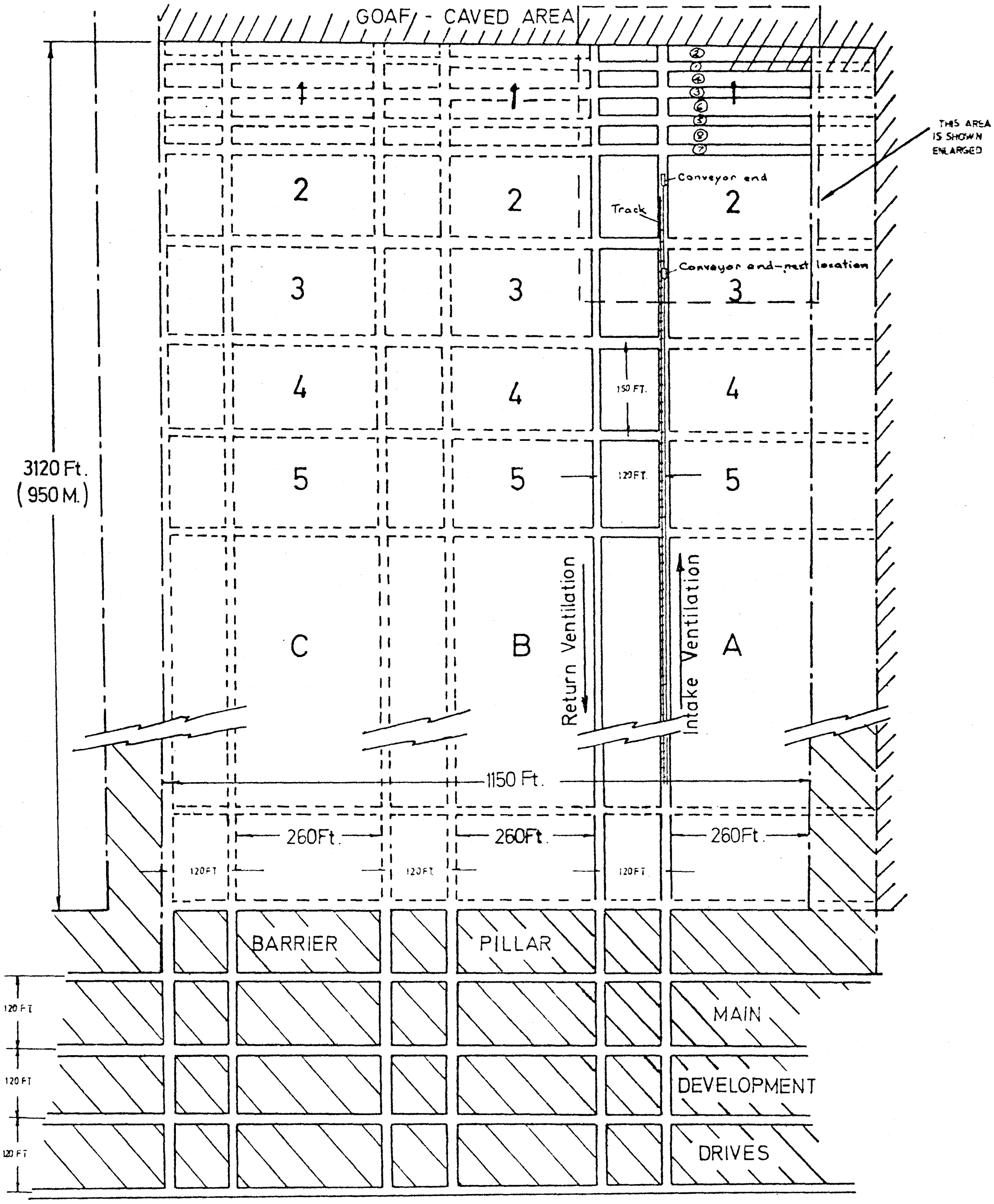
Water Supply

Water will be provided from independent creek sources at both Saddle Creek and the Chamberlain "Window" until the Long Term Plan permanent supply is available.

4.7 Method of Working

4.7.1 The BP Short Term Plan strategy is to develop the properties by two separate mines. The initial production within each mine will be by means of conventional equipment operating a bord-and-pillar extraction system as a first working, followed by pillar extraction on second working. Minor development work has taken place at the No. 1 Mine entry and the Chamberlain "Window", and has provided a limited operating experience. Hence it is considered that, by using a proven system operated by proven equipment, the number of risk variables to be encountered during the early development period can be significantly reduced.

Plan No. 2a



PRODUCTION PANEL

Pillars

Caved Area

Extraction Sequence :-

A 1 to 5 etc.

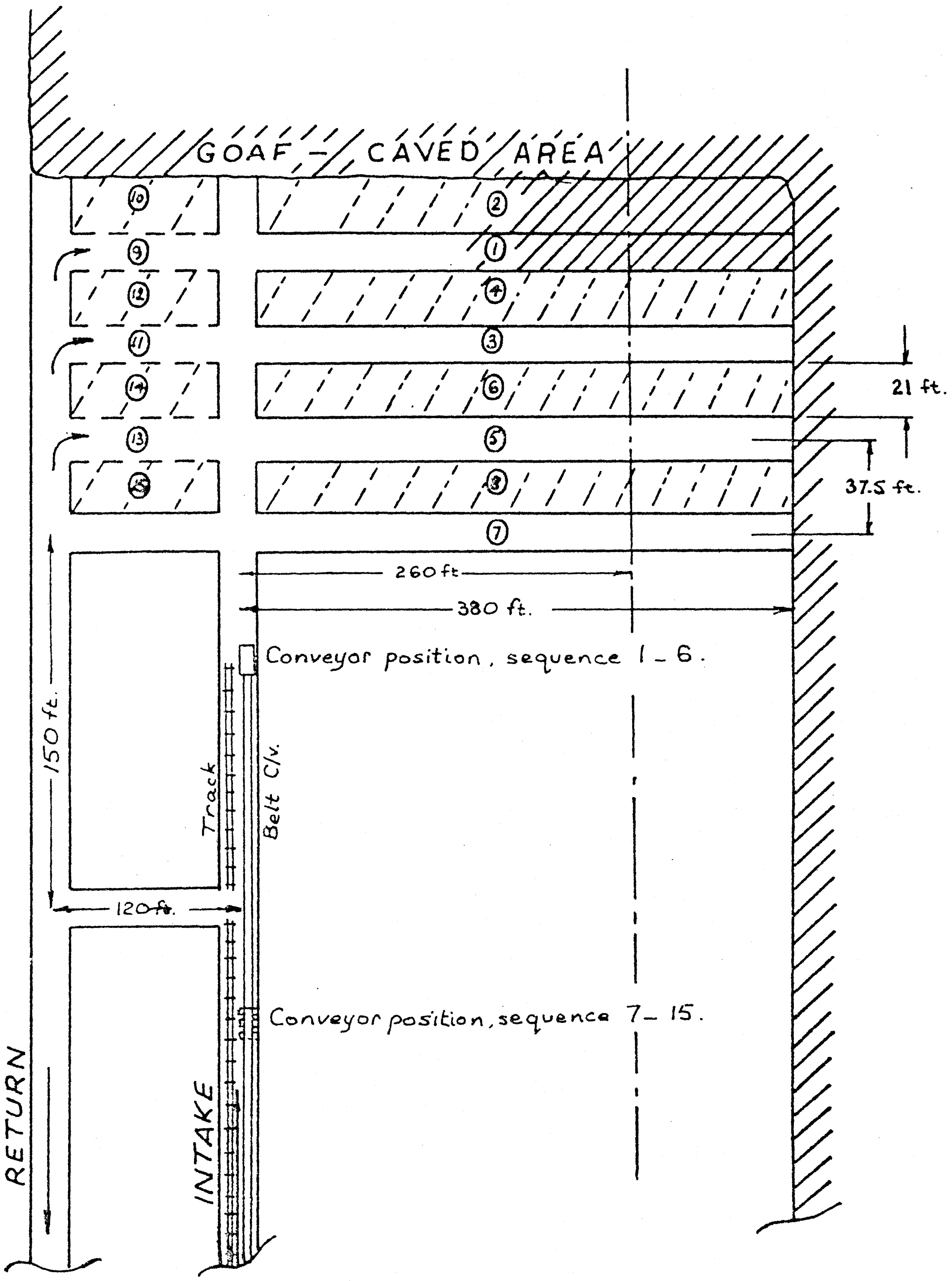
B 1 to 5 etc.

C 1 to 5 etc.

Not to Scale

Sur Nº 17286

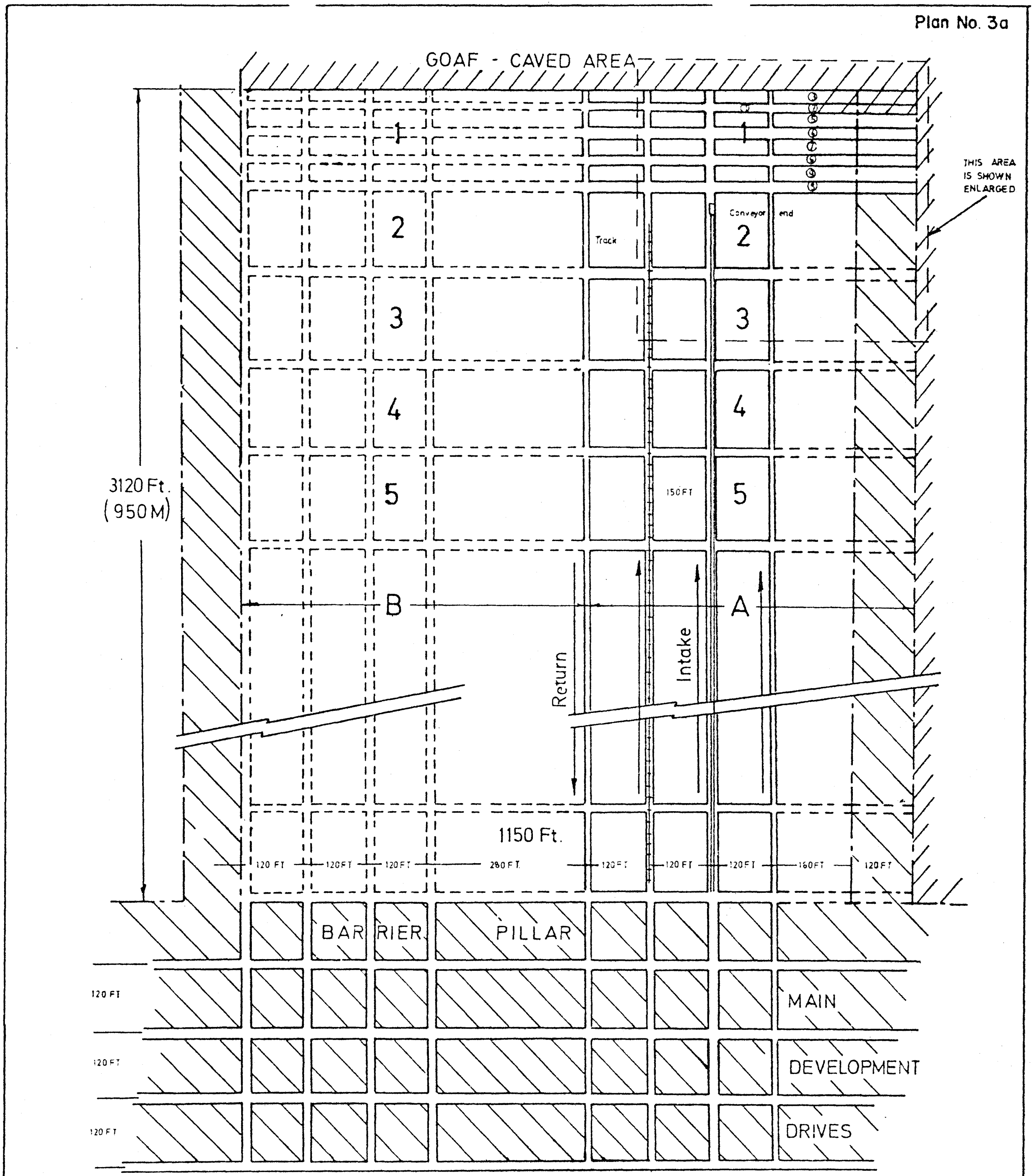
Plan No. 2b



Production Panel — Second Working Sequence

Not to scale.

...r No 17287

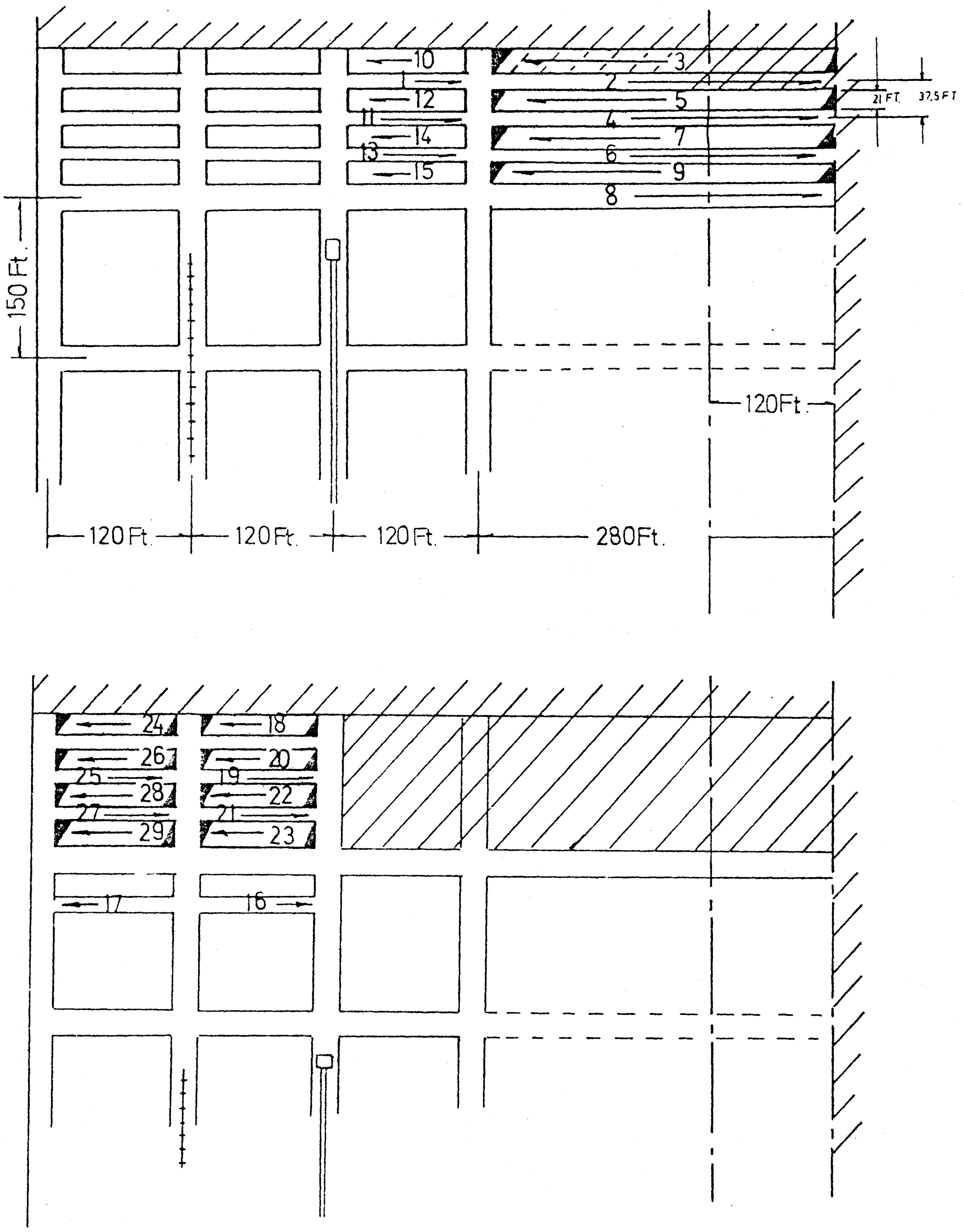


PRODUCTION PANEL

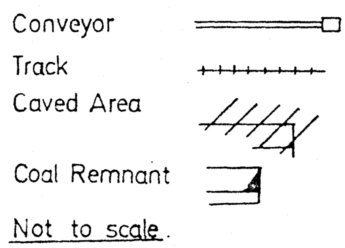
Ventilation
Pillars
Caved Area
Extraction Sequence :—
A 1 to 5 etc.
B 1 to 5 etc.

Not to Scale

Plan No. 3b



PRODUCTION PANEL – WORKING SEQUENCE



4.7.2 The flexibility of the bord-and-pillar system in negotiating faulting and other geological disturbances will enable maximum development of the reserves and ensure that less coal is sterilised. The planning of the Sukunka/Bullmoose take will involve a multi-seam extraction layout in certain areas. Over 90% of the dedicated total reserves lie in the Chamberlain Seam, which will be the first seam worked and also provide the bulk of the mines' output. Extraction in descending order will be practised for the working of the Skeeter and Chamberlain Seams in the north-west of the Sukunka take, as these seams lie within 10 m of each other. The Bird Seam lies some 40 m above the Chamberlain Seam and the Middle Coals some 180 m below. Consequently it may be necessary and important to plan the development in these areas in such a way that main roads are either protected by pillars or are located in the de-stressed area of exhausted workings of other seams.

4.7.3 Plans Nos. 2a, 2b, 3a and 3b on pages 39 to 42 show two methods of working a typical reserve block of coal some 950 x 350 m in area. In both cases a first working takes the development the full length of the block. The pillars formed in the advance are then split and extracted. As the operator of the continuous miner is always under supported ground, this safety technique dictates the length of each lift. The method shown in Plan No. 2a involves only two drives to the end of the block before pillaring is commenced and would be beneficial in areas of high strata stress likely to present difficult conditions for the maintenance of roadways, in contrast with the method shown in Plan No. 3a, in which the ratio of second working to first working is less.

4.7.4 After having gained some experience in working the Chamberlain Seam, consideration will be given at a later stage to variation in the development layout to form a pillar approximately 50 to 60 m wide, suitable for a shortwall retreat system. The pillar so formed would be extracted by the continuous miner taking a series of open-ended lifts whilst the roof is supported by self-advancing chocks. The benefits to be obtained by this system over the conventional pillar extraction methods are increased safety and a higher percentage extraction. Future legislation in respect of the working environment at the coal face may leave the shortwall system as the only one that permits all men to work on the fresh-air or dust-free side of the continuous miner and under controlled roof conditions. The system has the merit that it reduces the risk of roof falls and the consequent burying of a continuous miner.

4.7.5 In the deeper parts of the mine, i.e. those in excess of 1,500 ft, the bord-and-pillar system may encounter strata control problems that require consideration to be given to a longwall retreat extraction system. This has similar advantages to the shortwall system in terms of safety and working environment. However, the approach will be a cautious one, as the promise and potential of longwall mining in North America is still largely unfulfilled, notwithstanding over a decade of costly experimentation.

4.7.6 In a similar manner, the application of hydraulic mining will be considered for those areas of the Bullmoose Mine lying to the west of the synclinal trough. However, until the area has been explored to determine the seam gradient, seam section and roof characteristics, little further can be undertaken at the early planning stages.

4.7.7 The actual "mix" of systems cannot be predicted at this stage, but it is considered unlikely that one system in itself will prove to be the most efficient means of coal extraction over the whole of the reserves. For instance, longwall systems need large regular rectangular blocks for working, and leave many remnants or corners unworked and the coal permanently sterilised. Shortwalls are more flexible in regard to their dedicated reserves, since the panels are narrower. However, bord-and-pillar first workings followed by pillar extraction as second workings can extract most awkward-shaped reserve remnants, and this scheme is likely to be the main method of extraction during the early years of production.

4.8 Phase II - Long Term Plan

4.8.1 The major features of the Long Term Plan to handle three million sales tonnes per year will be:-

(1) A heavy-medium coal washing plant, to handle over 750 tonnes per hour.

(2) A rapid-loading station to handle unit trains of 8,000 to 10,000 tonnes capacity, outloading coal in four hours or less.

(3) Additional underground sections and equipment.

(4) Permanent workshops, change houses and administration buildings.

(5) A new township to house the mine personnel and families.

4.8.2 The location of the key items (1) and (2) above will depend on the exact location of the new BCR branch line, but it is proposed to site them as close to the BCR rail system as possible.

There are major technical, social and environmental reasons for this policy. Technically, it is easier to construct and maintain mine facilities in the foothills than on the steep mountain slopes existing in the Saddle Creek portal area. Furthermore, the climatic conditions are less severe in the valley and communications and transport are easier and shorter. Technical investigations will be undertaken by consultants who will be employed to consider the various alternatives that are available to the project in regard to both the transport arrangements and the townsite for housing over 1,000 persons who will be required to operate the mine at full output.

4.8.3 The announced Government intention is to bring the rail connection in from the south via the Anzac route, to service not only the Sukunka/Bullmoose Mine, but also the Denison Quintette prospect and possibly others. Information on this aspect of Government policy was given by the Minister for Economic Development, Mr. D. Phillips, on 26th May 1977, when he stated that engineering studies would start immediately on the construction of the 11 km rail link that would connect the proposed new townsite of Tumbler Ridge, 96 km south of Chetwynd, to Anzac, 112 km north-east of Prince George. This rail link is estimated to cost $140 million and the announced route indicates that it is envisaged that coal would travel by the BCR to Prince George and then be transported along the Canadian National Railway (CNR) to the port facilities at Prince Rupert. The Tumbler Ridge site is favoured by the Provincial government for the erection of a town of about 10,000 people, chiefly employed in the coal industry, but also employed in other economic sectors. The townsite is approximately 48 km from Saddle Creek and, whilst there is an alternative townsite which is nearer, investigations have shown that the cost of providing services, e.g. water, at Tumbler Ridge would be less.

4.8.4 The termination point of the rail link branch line is not yet known to BP, so it is not possible to estimate the cost to BP of providing a coal transport link. However, with a rail link approaching towards Chetwynd from the south, the transport link would be approximately 15 km, compared with 49 km if the branch line terminates in the Murray Valley south of Mt. Speiker. Should the Anzac rail link fail to materialise for market or other economic reasons, a rail spur from Chetwynd would be reconsidered. This latter plan would enable the major coal preparation plant to be located closer to Chetwynd and to house all the mine personnel there. This feature has a number of other advantages as the facilities of shops, schools and hospital at Chetwynd are available. Some 4,000 persons live in Chetwynd and its immediate surrounds, so that a more balanced community could evolve, with the Sukunka/Bullmoose personnel living in the town, than would be likely at Tumbler Ridge in the early years of its existence.

4.8.5 There are significant social benefits to be gained from locating the major preparation plant, rapid-loading station, and as much of the administration offices and other facilities as possible, close to the chosen township location. Such siting would minimise the distance that the personnel employed at these places would have to travel daily, and those travelling to the mine would be limited to underground personnel and engineering staff working on scheduled maintenance of plant and breakdowns.

Considerable benefit would accrue from the location of the plant and other facilities in the valley, as surface physical damage would be lower than on the exposed mountain slopes. In addition, such location would permit the use of grassed earth mounds and the planting of trees to screen the installation and improve the visual aspects.

4.8.6 The transport of the coal from the Saddle Creek portals to the major coal preparation plant will be the subject of several studies by specialist consultants to consider the following alternatives and recommend the most suitable system:-

(1) Rail spur extension from branch line.

(2) Conveyor belt, fully dog-housed.

(3) Off-highway vehicles on dedicated road.

(4) Aerial ropeway system.

If the Anzac rail link terminates in the Murray River Valley, then each of the above systems could involve a further alternative, namely, a tunnel drivage through Mt. Speiker to provide the optimum transport connection. All the studies will take into account the environment, construction time, freezing of coal, coal breakage, manpower, capital cost and operating costs.

4.8.7 Additional mine services such as power and water can be made available. Preliminary discussions have been held with B.C. Hydro and indications given of the provisional estimates of the build-up of power requirements. Adequate water supplies exist both in Sukunka Creek and Chamberlain Creek to supply the dam that will be constructed to service the underground mine with all water requirements for dust suppression and fire-fighting. Discussions with the appropriate Water Authority for the supply of water to the coal preparation plant will take place when its location is being investigated. Road access will be from Chetwynd via the truck-haul road in the initial development years. It is expected that the Provincial highway from Chetwynd to Tumbler Ridge will come via Martin Creek and Chamberlain Creek, thereby providing ready access to the Saddle Creek portals.

4.8.8 The recruitment and training of some 1,000 personnel will probably represent the largest single constraint on the mines' development. Some skilled operators, formerly employed at the mine when it was operated by Coalition Mining, are currently available in Chetwynd. It is expected that these people could be readily recruited and would then form the nucleus for training new entrants. Based on the experience of other mining companies in both British Columbia and Alberta, the recruitment of green labour backed up by adequate training facilities provides the best solution for the mid-term and long term manning of the mine. Hence, the recruitment campaign will be angled at the younger element of the population in the locality. It is expected that a person undergoing a five to six months' induction and training course will be competent to make a worthwhile contribution to the mines' operations at the end of the period.

It is in the area of skilled mechanics and electricians that the most difficult recruitment problems will occur. This difficulty is due mainly to the time that the individual needs to complete his technical training and gain operational experience that will enable him to qualify for the appropriate Mines Department certificate. Where necessary, overseas recruitment will be undertaken to obtain these skilled technicians should local and nationwide recruitment in Canada fail to provide the required number.

5. COAL QUALITY

Most of the proved reserves are within the Chamberlain Seam, which is the only seam proposed for working in the first few years of the development of the mine. The only other seam expected to be worked in the foreseeable future is the Skeeter Seam, which contains the remaining proved reserves, but which only appears to be thick enough to be economically workable in the northern part of the Sukunka area. The planned exploration may enable reserves to be credited to the Bird and Gates Seams, but these are unlikely to affect present proposals for the development of the mine.

5.1 Chamberlain Seam

The Chamberlain Seam is split into two beds in the south and along most of the eastern margin of the proved part of the Sukunka area, and probably also in the western part of the Bullmoose area. Where the seam is split, the upper bed is generally thin and of poor quality and has not been included in the reserves assessment. In the south of the Bullmoose area the seam (or its lower bed) becomes too thin to be economically workable.

On the basis of some 130 boreholes in the Sukunka area and 20 in the Bullmoose area, together with measurements from the existing Sukunka mine workings, the thickness of coal within the Chamberlain Seam (or its lower bed), where this is workable, is shown to vary generally between 1.4 and 4.4 m, averaging about 2.6 m. The ash of this raw coal ranges generally between 3 and $9\frac{1}{2}$%, averaging about $5\frac{1}{2}$%, and the free swelling index from 5 to $7\frac{1}{2}$, averaging $6\frac{1}{2}$ (see Figure 7 on page 14). This coal is generally overlain by up to 0.2 m of carbonaceous mudstone ("Bone") with ash varying from about 40 to 85% and probably averaging about 55%; this material, which may be highly sheared, must be reckoned as forming part of the r.o.m. product from the working of the whole seam. The average overall r.o.m. ash could be of the order of 15%.

The general range of, and average, values of the properties of material floated at S.G. 1.60 from this seam, based on float-and-sink testing of borehole core samples and a number of face samples from existing Sukunka workings, are as follows:-

Property	General Range	Average
Yield (%)	89 - 100	97
Moisture (air-dried) (%)	0.5 - 1.1	0.9
Volatile matter (air-dried) (%)	18.1 - 23.8	21.9
Ash (air-dried) (%)	2.4 - 6.2	4.1
Total sulphur (air-dried) (%)	0.21 - 0.53	0.37
Free swelling index	$5\frac{1}{2}$ - 8	$7\frac{1}{2}$
Phosphorus (air-dried) (%)	0.011 - 0.040	0.024
Maximum fluidity (d.d.p.m.)	8 - 417	173
Calorific value (air-dried) (Btu/lb)	14,300 - 15,200	14,740

With regard to the maximum fluidity values shown above, determinations carried out in 1970 and 1971 by six Japanese steel companies on three samples of coal from the Sukunka Chamberlain Seam gave average values of 553, 1,808 and 1,470 d.d.p.m., but there was an extremely wide range of values recorded by the different companies for each sample, and it is believed that these companies may have used test equipment with different scale readings. However, the average values obtained suggest the possibility that some of the borehole samples were appreciably more oxidised before testing than were the samples tested by the Japanese companies, with the consequence that generally lower values of maximum fluidity were obtained for such borehole samples. There is also the related possibility that some of the lower values for free swelling index obtained on the borehole samples were due to oxidation of the coal, as the three samples tested by the Japanese companies gave averages of 8 (range $7\frac{1}{2}$ - $8\frac{1}{2}$), 8 (range 7 - 9) and $7\frac{1}{2}$ (range 7 - 8), four face samples from adits gave values of 8 and $8\frac{1}{2}$, and a bulk sample of 11 tonnes tested by Warnock Hersey Professional Services Limited gave a value of $8\frac{1}{2}$.

The volatile matter of the coal shows a general regional decrease, with local variations, from the north-west and west of the Sukunka area towards the east, south-east and south of that area and into the Bullmoose area. This variation is mapped in Fig. 12 in pocket at rear, the isovols relating to volatile matter calculated to the basis of 8% moisture and 6% ash, quality criteria for as received coal that have been quoted in discussion between BP Coal and the British Steel Corporation on sales contracts for this coal. It will be seen that the general range of volatile matter over the mapped region is from about $17\frac{1}{2}$ to $20\frac{1}{2}$% on this basis, but that a large part of the Bullmoose area has yet to be explored. As the unexplored portion contains the deeper part of the main synclinal axis, it appears likely that the volatile matter of the coal will be generally, and perhaps significantly, lower here than in much of the mapped region.

Calculated to the dry, mineral-matter-free (d.m.m.f.) basis, the volatile matter varies over the mapped region from about 19 to 25%, a range that covers the upper (volatile matter) part of the low-volatile bituminous coal class and the lower (volatile matter) part of the medium-volatile bituminous coal class of the A.S.T.M. coal classification system.

The variation in free swelling index of the coal is shown in Fig. 13 in pocket at rear, but this map is subject to the qualification referred to above concerning the possible oxidation of the coal from some of the boreholes before it was analysed, a factor which may have resulted in significantly lower values of free swelling index for these boreholes.

5.2 Skeeter Seam

The Skeeter Seam consists essentially of a main bed of clean coal separated by a hard siltstone band from an underlying thinner bed of generally less clean and sometimes inferior coal. The immediate roof of the seam consists of coaly and silty mudstone, some of which might form part of the r.o.m. product resulting from the working of the seam.

On the basis of some 35 boreholes over the northern part of the Sukunka area, where this seam is of workable thickness, the main bed varies generally from 1.2 to 2.1 m in thickness, averaging about 1.7 m (see Fig. 7 on page 14). The ash of this bed varies generally from 4 to 9% and averages 6%, whilst its free swelling index ranges generally from 5 to 8 and averages $6\frac{1}{2}$.

The general range of, and average, values of the properties of coal floated at S.G. 1.60 from this seam, based on float-and-sink testing of borehole core samples and face samples from Sukunka mine workings, are as follows:-

Property	General Range	Average
Yield (%)	66 - 100	91
Moisture (air-dried) (%)	0.5 - 1.0	0.9
Volatile matter (air-dried) (%)	19.4 - 24.4	22.2
Ash (air-dried) (%)	3.7 - 8.4	5.7
Total sulphur (air-dried) (%)	0.34 - 0.60	0.45
Free swelling index	$5\frac{1}{2}$ - 8	7
Phosphorus (air-dried) (%)	0.006 - 0.029	0.018
Calorific value (air-dried) (Btu/lb)	14,150 - 14,870	14,460

5.3 Bird Seam

The limited amount of information available on the quality of the Bird Seam appears to indicate that the coal, although highly swelling, has a generally high sulphur content (2.0% or more) which would render it unacceptable for metallurgical coke-making unless it were blended in small amounts with coal of much lower sulphur content.

The exploration programme should reveal whether there are any appreciable reserves in this seam in the restricted area over which it is available to BP for working.

5.4 Gates Seams

The limited amount of information on the Gates Seams over the area where they are available to BP for working suggests that they are generally of inferior quality in comparison with the Chamberlain and Skeeter Seams, and that probably only one of them, the B Member, may contain economically workable reserves. Much more information on these seams will be obtained by the planned exploration programme.

6. COAL PREPARATION

The production from the Chamberlain Seam in the first few years of the development of the mine will have to be washed in order to meet an acceptable market specification. An off-the-shelf "packaged" coal preparation plant of c. 150 tonnes per hour capacity is envisaged for this duty, since not only are the construction and delivery times much shorter for this type of unit, but also at the end of its useful life on this project, when the permanent plant is brought into commission, it could readily be dismantled and transported for use at another site. Operation of this plant would also yield a wealth of data on the variations in size consist of the mined coal, and this information would be valuable in optimising on certain aspects of design for the permanent plant, including the requirements for pre-washing and post-washing storage and blending systems to ensure that a uniform product is marketed.

It is considered that the "packaged" plant should be located at an industrial site near Chetwynd rather than at the mine. At the former location it would be better from an environmental viewpoint; it would be easier to construct and commission; living and working conditions for operating and ancillary staff would be more attractive and convenient; transport of people, materials, spares and equipment for the necessary repairs, maintenance, inspection and testing of the plant would be easier; and the restricted area of the mine site would not be occupied in the short term by coal stockpiles and reclaiming facilities which would place constraints on the mine layout. These factors are considered to outweigh the cost of transporting from the mine to the plant the material that would be discarded from the r.o.m. product.

"Packaged" plants have gained some popularity recently and there is a wide variety of washing units available. However, the large percentage of fines that is expected with this friable Western Canadian coal militates against the use of either jigs or heavy-medium baths and, although the evidence available suggests that the Chamberlain Seam presents a fairly easy washing proposition, the very poor efficiency of the water-washing cyclone tends to outweigh the simplicity and relative cheapness of the circuitry for this type of plant. This reasoning leads to the choice of a heavy-medium cyclone as the preferred method of washing the initial production from the Chamberlain Seam.

The flow sheet for this type of installation would start with a reduction of the r.o.m. coal to a top size of c. 38 mm, suitable for the feed to the cyclone. This reduction would most probably be achieved by screening at 38 mm and passing the oversize through a double-roll crusher, but there is the possibility of using a rotary breaker in the circuit with the resulting advantage of rejecting any coarse contaminating material from the roof or floor of the seam. Results of size analysis of an 11-tonne bulk sample indicate that not more than 10% of the coal may be greater than 38 mm in size.

The -38 mm x 0 feed would then be wet-screened at 0.5 mm to provide the -38 x 0.5 mm feed sizing for the cyclone. This device would provide the most efficient wash for this sizing, and a probable error of 0.03 at a cut-point of 1.50 S.G. should be readily obtainable. After washing, the products would be passed over rinse and dewatering screens to recover the magnetite, and the clean coal passed through a centrifuge to reduce its free moisture content. For this small plant with a minimal labour requirement, the provision of magnetite grinding facilities would be an unwelcome addition.

It is noteworthy, therefore, that other coal preparation plants in Western Canada purchase their magnetite supplies in the ready-ground condition.

There are many possibilities for the treatment of the -0.5 mm fines, which have comprised up to 40% of the feed in some Western Canadian plants. The only reasonably firm decision at this stage is that it does not appear to be practical at present to incorporate froth flotation in the packaged plant, although this process would undoubtedly form a part of the major plant circuit. The results of washability tests on the bulk sample referred to above suggest that the -0.5 mm raw fines could be blended with the +0.5 mm washed coal to give an acceptable product. The most attractive scheme would be to pass the -0.5 mm fines to a thickener, probably of the Lamella type because of space limitations, and to recover the thickened product on a vacuum filter. As an alternative, since the coarse end of the -0.5 mm fraction seems to be very clean but the ash of the ultra-fine material is higher, the +150 mesh material could be separated in a classifying cyclone and partially dewatered on a Derrick screen, and the -150 mesh fraction sent to a thickener and the underflow rejected to tailings ponds, but this latter course could be subject to environmental constraints. There are other methods of achieving this result but, whichever method is adopted, the high moisture content of the fines will result in handling problems for the product during the Canadian winter. Consideration will be given to the installation of a thermal drying unit suitable for this size of plant, and, whichever circuit is selected, the appropriate precautions will be taken against the weather to ensure year-round operation.

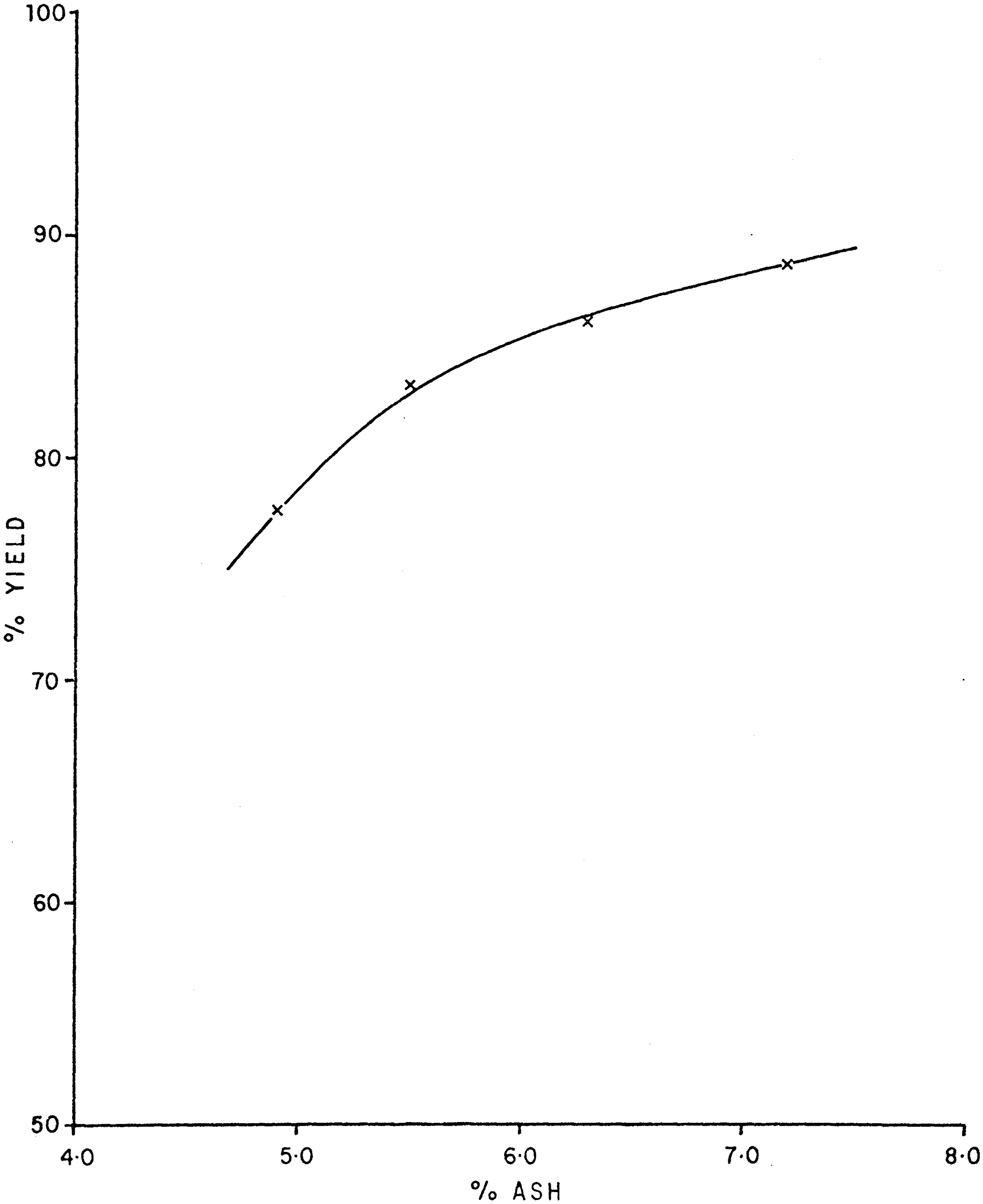
These conclusions have been based on the existing washability data on the Chamberlain Seam at Sukunka. It is unfortunate that all of these data (most of which relate to laboratory float-and-sink analysis of borehole core samples) are of limited value or deficient in some respect. Such is the case even with the only bulk sample of sufficient size (referred to above) that appears to have been taken and subjected to washability testing, as no details are available as to how this sample was obtained or handled prior to testing and, in consequence, it is not known whether it was truly representative of the whole working section of the seam at the sampling location, or whether any attempt was made to ensure that its size consist when tested would closely resemble that of the material as it would be fed into a coal preparation plant. The taking and testing of bulk samples of the seam by clearly specified procedures, which will be supervised and monitored by consultants experienced in sampling requirements and techniques, is therefore to be given the utmost priority, in order that washability data may be obtained on which the design of the "packaged" plant may be finalised.

From the existing data, the best projection that can be made of washery yield v. ash for +0.5 mm washed coal blended with -0.5 mm raw fines is shown in Fig. 14 on page 53. On this basis an overall yield of about 85% might be obtained of a product of the following quality:-

Moisture (as received) (%)	8
Ash (as received) (%)	6
Volatile matter (as received) (%)	$17\frac{1}{2}$-$20\frac{1}{2}$
Total sulphur (as received) (%)	0.5 max.
Free swelling index	$7\frac{1}{2}$ - $8\frac{1}{2}$
Maximum fluidity (d.d.p.m.)	10 - 400
Maximum dilatation (%)	20 - 70

FIG. 14

PROJECTED RELATIONSHIP OF YIELD & ASH CHAMBERLAIN SEAM



If the exploration programme proves that the coal in the Bullmoose area is of significantly lower volatile matter than that in the Sukunka area, it may be practicable and desirable to prepare and market two separate products - a true low-volatile coking coal of under 20% volatile matter on the dry, ash-free (d.a.f.) basis, and a low/medium-volatile coal of 20 - 25% volatile matter (d.a.f. basis).

7. TRANSPORTATION

7.1 Phase I - Short Term Plan

Reference has been made earlier in this report to the transport system to be adopted in the Short Term Plan or Phase I of the project. This system involves the transport of coal from the mine by truck, using existing roads, to a coal preparation plant located in Chetwynd. The cleaned coal will be delivered to a coal loadout system for transport to the shipment port of Neptune Terminal in 100-ton rail cars of a type matching those already in use, in order to facilitate tippler indexing. This route has been previously used for the dispatch of test shipments of coal to potential customers. It is estimated to have existing surplus capacity of at least 0.5 million tonnes per annum which could be utilised by BP in the Phase I development stage.

The surplus capacity will be the subject of a special study by consultants and the results of this study may be expected to show surplus capacity in excess of that referred to above.

7.2 Phase II - Long Term Plan

Previous sections of this report have referred to the transport system envisaged under Phase II of the project. This system is planned to form a part of the overall development of north-east British Columbia by the Government.

The Provincial Government is considering the development of a north-east region transportation system which will include new coal handling facilities at Ridley Island off Prince Rupert. Additionally, branch lines to service the Sukunka/Bullmoose and Quintette developments will be required, together with adequate mine-car capacity. It is considered that a committed regional coal production of 8 million tonnes per annum will be required to initiate the construction of the transport system.

From 1984 coal will be conveyed to the surface at Saddle Creek (see Fig. 2 on page 7) on the south-east side of the Bullmoose property. Coal will be transported from the mine to a preparation plant located as close as possible to the new rail line.

The form of transport system and route from Saddle Creek to the preparation plant have not yet been established. The various methods which can be considered are referred to in Section 4.8.6 and will be the subject of several alternative transportation studies.

7.3 Fall Back Plan

In the event of indefinite delays in the development of the new regional transport system, consideration will be given to extending the transportation of coal from the mine via Chetwynd to Neptune Terminal. This arrangement is considered capable of handling up to 1.5 million tonnes per annum. Routes via the lower mainland ports of Port Moody and Roberts Bank, although not impossible, appear impractical owing to problems of interchange between rail systems.

8. ENVIRONMENTAL STUDIES

8.1 Introduction

The Guidelines for Coal Development published by the Environment and Land Use Committee, a Cabinet Committee of the Government of British Columbia, requires the proposals for the development and the continuing operation of the coal mine to be submitted in a four-stage assessment process, with review at each stage.

Stage I should identify the major economic, environmental and social impacts of the proposed development, and should examine alternatives for mitigating and avoiding any adverse effects. Subsequent stages require more detailed and specific studies of the impact of the development programme on the area. Following the approval of the operational plans and the granting of the necessary permits required under the various Mining, Pollution Control, Water Rights, Highways and Forestry Acts, provision is made by the various Provincial Government agencies for specific and continuing responsibilities during both the development and subsequent on-going operations, with special reference to air and water quality and surface land reclamation.

8.2 Background

On the acquisition of the Sukunka/Bullmoose property it was found that both Brascan (Sukunka) and Brameda (Bullmoose) had initiated environmental studies that were to lead to the submission of the Stage I proposals. BP has continued with this work using the same consultants, namely, B.C. Research (B.C.R.) for the Sukunka property and International Environmental Consultants (I.E.C.) for the Bullmoose property.

The Government of British Columbia conducted a detailed study of the north-east region of the Province in 1976 to evaluate the potential of the area as a source of coking coal for export markets. The study included transportation, environment, socio-economics and manpower. BP has been informed by the Government of British Columbia that much of the study information will be made available to BP in the form of raw data to avoid duplication of work by BP's consultants, and should be included in its assessment of the impact of the planned operations on the environment.

8.3 Current Work Programme

As required by the Guidelines, BP will present a prospectus to the Deputy Minister of Mines, outlining the proposed exploration and mining programmes for the joint Sukunka/Bullmoose properties.

As the Government information is made available the consultants will combine it with their own collected information to provide a comprehensive report. In addition, B.C.R. has been asked to conduct the socio-economic study for the combined property, and I.E.C. has been asked to report on the Townsite 2 area as it is a possible location for the final coal preparation plant. The two consulting organisations will write a combined final report and, assuming the availability of Government data, this report will be completed by August 1977. This final report will be submitted to the B.C. Government as a Stage I : Preliminary Assessment submission.

8.4 Future Work Programme

Following the submission of Stage I and the ensuing discussions with Government, work on the Stage II (Detailed Assessment) and Stage III (Operational Plans and Approval Applications) will be continued.

The timing of the submission of the remaining stages will depend to a large extent on the publication of the Government's decisions relating to townsites and rail transport, as the detailed planning of the mine surface facilities will need to take these two elements into full account.

The Short Term Plan for the mine development requires the provision of rail loading facilities at Chetwynd, the construction of a pilot coal washing plant, the transport of the coal from the mine to Chetwynd and the commencement of mine development in 1978/79. From discussions that have been held with Government agencies it is understood that the Short Term Plan proposals can be considered and approved by a shortened procedure without going through the normal four-stage assessment procedure. Hence, the Short Term Plan development programme is based on the assumption that the necessary approvals will be forthcoming at the required construction times.

9. INDUSTRIAL RELATIONS

During the operation of the mine from 1973 to 1976 a collective bargaining agreement was entered into between Coalition Mining Ltd. and the International Union of Operating Engineers. This agreement is still operative and covers all employees other than supervisory and office staff.

During the construction period of both the Short Term and Long Term Plans it will be necessary to employ specialist contract labour to undertake various works, e.g. construction and installation of the mine surface electrical reticulation system and construction of the major coal preparation plant. It is understood that those in this contract labour force will be required to become members of the appropriate construction union for the duration of the contract. Many Canadian contractors have working agreements with the various unions involved in British Columbia, such that construction work at the mine will be handled under the accepted union procedure.

Consideration has been given to the possible use of mining contractors to undertake part of the underground development drivage work. This arrangement would be beneficial in that skilled operatives could be made available by the contractors at the start of the mine development, at which time direct labour recruitment and training will have only just commenced and the initial supply may not be sufficient to service the development.

It may be preferable to keep the contract mining operatives separate from the direct labour operatives, and this could be achieved by using direct labour for all the work undertaken from the Chamberlain "Window" entrances and restricting the contract work to that undertaken from Saddle Creek. It is likely that the contractor would be paying his operatives by means of a productivity bonus, i.e. at a higher total rate of remuneration than that of direct employees, and this factor could be a source of dissatisfaction. Similarly, the contractor may establish a custom - and - practice arrangement that would be difficult to extinguish when his contract work was completed and he had withdrawn from the mine.

In order to ensure that the contractor/union relationship does not impose restrictions and expensive constraints on the mine's long term operations, particularly at the end of the underground contract work, it has been decided to investigate the whole question with the assistance of an industrial relations consultant before decisions regarding undergound development are formulated.

APPENDIX I

SUKUNKA/BULLMOOSE - SOURCES OF INFORMATION

References marked with an asterisk are held by BP Canada, and selected extracts only are available in the office of BP Coal in London.

* 1. Cargo Superintendents, "Study of Washability Characteristics, Skeeter and Chamberlain Coals", prepared for Coalition Mining, January 1972.

2. Teck Corporation (Hindson) report, Bullmoose Project, Sukunka Blocks 'B' and 'E', prepared for in-company analysis (Brameda/Teck/Coalition), February 1972.

* 3. McElroy, Sukunka Coal Project, Report No. 1 (12 volumes), prepared for Coalition Mining, March 1972.

* 4. McElroy, Sukunka Coal Project, 1972 Supplement (5 volumes), prepared for Coalition Mining.

5. McElroy, Sukunka Coal Project Geological Summary, prepared for Coalition Mining, July 1973.

* 6. K.G.K. (Japan Overseas Coking Coal Dev. Co.), "Sukunka Mine Feasibility Study" (4 volumes), prepared for Nissho-Iwai Co. Limited, August 1973.

7. K.G.K., three mining development plans, feasibility study for Brascan, August 1973.

8. G. Armstrong and N.W. McInnes, reports following a visit to the Sukunka property in April 1974.

* 9. McElroy, Plate 1 Area Report (4 volumes), prepared for Coalition Mining, March 1975.

10. H.G. Stephenson, "Report on Strip Mine Reserves and Costs for Various Stripping Ratios, Plate 1 Area Sukunka", prepared for Brascan Resources, March 1975.

* 11. McElroy, Sukunka Coal Project, Geological Report on Lower Gething (Middle Coals Area) Sequence in Vicinity Skeeter Creek (4 volumes), prepared for Coalition Mining, June 1975.

12. Quadra Economic Consultants, "Analysis of Alternative Transport Systems Chetwynd to Sukunka", prepared for Coalition Mining, September 1975.

13. Kaiser Canada, "Coal Preparation Plant Flowsheet Development, Sukunka Mine", prepared for Coalition Mining, November 1975.

14. Rescon Devel., "Sukunka Revised Feasibility", report for Brascan Resources, December 1975.

15. H.G. Stephenson, "Preliminary Report on Surface Mining in the Plate 26 Area", prepared for Brascan Resources, December 1975.

16. Brameda Resources, Annual Report, 1975.

* 17. Pet-Ko Geological Services, Sukunka Coal Project, Gates Member Report (2 volumes), prepared for Coalition Mining, January 1976.

18. Teck Corporation (Versoza), Bullmoose Project, "Summary of Exploration and Progress Report on the Chamberlain and Bullmoose Projects", in-company report as 2 above, March 1976.

19. Warnock Hersey Professional Services Ltd., "Report of Washability Study on Bulk Sample from Chamberlain Creek", prepared for Brascan, March 1976.

20. K.G.K., "A Financial Report on Sukunka Coal Project", prepared for Brascan Resources, March 1976.

21. H.G. Stephenson, "Sukunka Underground Mining Methods", report for Brascan Resources, May 1976.

22. H.G. Stephenson, "Development of an Underground Mine at Sukunka, B.C.", June 1976.

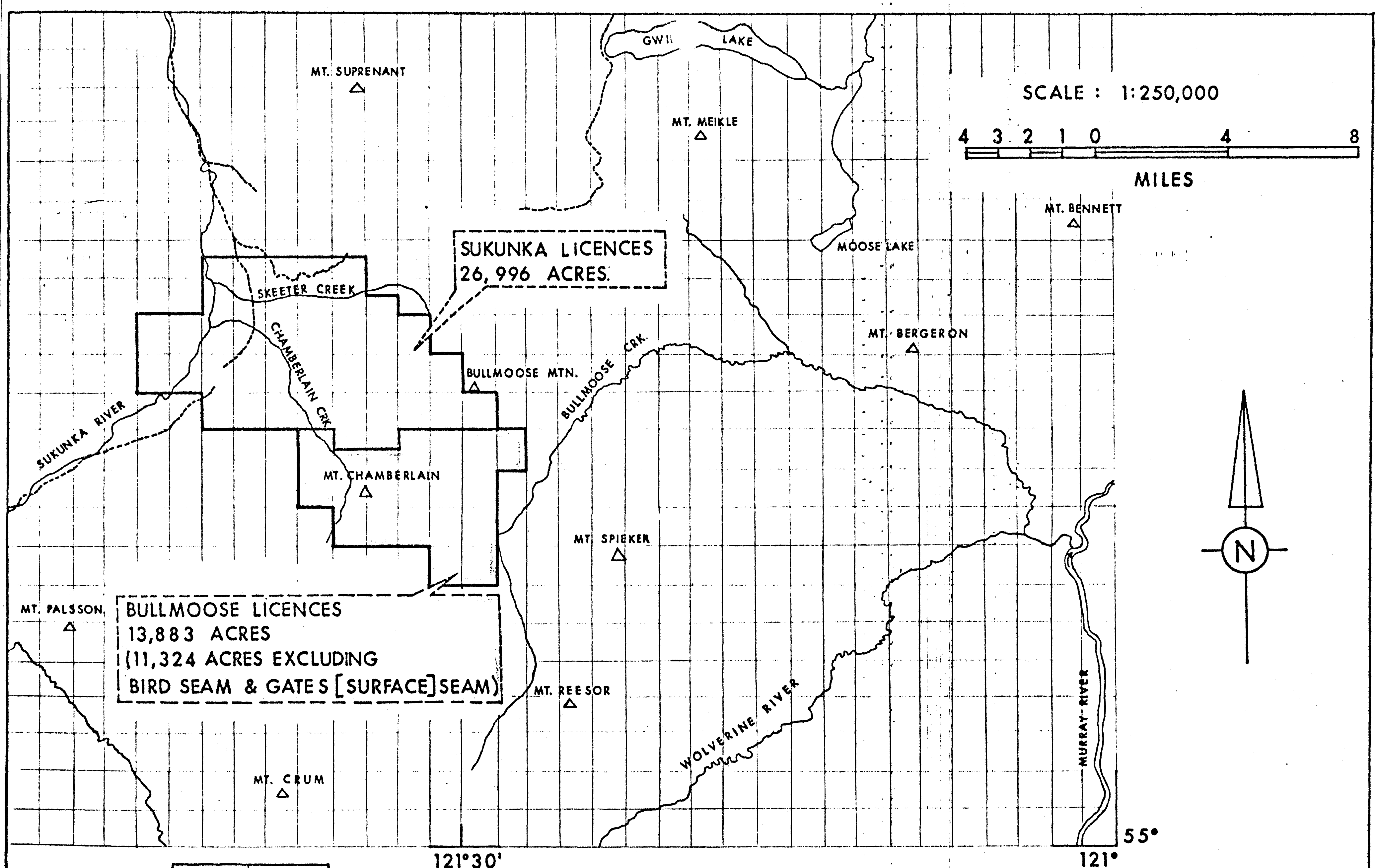
23. Alain le Bis, "Sukunka Coal Project Economic Analysis", June 1976.

24. Coal Week, extract on relinquishment of Brascan option, June 1976.

25. A. Kahil, report following visit to Sukunka, June 1976.

26. Kaiser Canada, "Coal Preparation Plant, Preliminary Estimate of Capital Cost", prepared for Coalition Mining, June 1976.

27. BP Coal - Technical Division, "Sukunka - Preliminary Study", October 1976.



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