K-FERNIE COAL AREA 65(1)A SOUTH EAST, B.C.

REPORT ON THE SURVEY OF FERNIE COAL MINE, B.C., CANADA

NITTETSU MINING CONSULTANTS CO., LTD. March 1966

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TABLE OF CONTENTS

PAGE

Drawings

9

I. INTRODUCTION AND GENERAL STATEMENT

Our survey team was sent to Canada early in September 1965 to investigate the Pacific Coal Limited claims, particularly with regard to coking coal, and to explore the possibility of developing the mine, located in the Morrissey Creek area near Fernie, British Columbia. The original schedule was for the survey to last for 25 days, but partial changes were made as a result of new findings on the site, which necessitated additional work: Prospect tunnels were excavated from the outcrops in order to obtain large quantities of samplings of coal free from the effects of weathering. For this purpose, one of the survey team members (Harada) stayed behind until December 20, supervising the excavation work and collecting coal samples.

The principal purpose of the survey was to reconfirm the findings reported previously by Dr. Douglas D. Campbell, a consulting engineer of Vancouver, and to study the feasibility of mine development on the basis of these findings. Reporting on that part of the Dominion Coal Block for which Pacific Coal had applied for leases (near Morrissey Creek), Dr. Campbell noted that seams K5, K8, K11 and K13, notably the last two —— with their great thicknesses, high ratio of clean coal to raw coal, and excellent coking qualities —— were the most promising sources of low-volatile coking coal to satisfy the specifications of the Japanese market.

However, our survey, hampered by snowfall, was unable to cover seams other than K1, K4, K5 and K10 in the Morrissey Creek area and K1 and K11 in the Pipeline area to the south. Even for these seams, it was difficult to track the outcrops between the two areas, so that the increase and decrease in seam thickness along the strike could not be investigated.

It was particularly regrettable that, with regard to the most promising seams, K11 and K13, which are located above the sandstone bed over K10, our attempt to conduct trenching with bulldozers in the estimated seams near Morrissey Creek was foiled by huge quantities of debris.

As for the four seams, K1, K4, K5 and K10, although we were more successful with them, the samplings obtained consisted exclusively of highly weathered outcrop coal, which provided hardly any basis for judgment of the quality of the four seams. Seam K10 was dropped as it was found inferior and not worth considering for mining.

On the principle that samplings should be gained from sites free from weathering, we excavated prospect tunnels, each 30 meters long, for seams K1 and K5 while conducting free swelling index tests, thus checking, if only indirectly, the degree of weathering. And at points where evidence of weathering was no longer found, crosscutting was made to collect bulk samples (55 drums) for drum test for shatter strength.

In parallel with the excavation work (which lasted from early October through mid-December), surface reconnaissance was made until the end of October, when snowfall forced its discontinuation. Although it could not fully confirm the seam conditions, the reconnaissance, coupled with a simplified method of measuring, located a number of sandstone beds developed predominantly in coal-bearing formations and distributed over quite an extensive range. This finding is expected to serve as valuable information in carrying out future prospecting.

At any rate, data gathered through the present survey are far too inadequate to enable one to form any judgement as to whether low-volatile coal desired by Japanese steel mills exists in the area. It is considered dangerous to deduce the distribution of coal seams and coal quality for all the claims simply on the basis of findings regarding seams K1 and K5, where samplings were taken in extremely localized regions along Morrissey Creek.

Therefore, final discussion of the business feasibility of the coal project should be based on full-scale and detailed surveys in the future concerning coal quality and seam conditions for the entire claim area. The present report sets forth a number of preconditions and, assuming that they are satisfied, proposes a plan for mining.

As for the various coal quality tests now under way, a report will be submitted as soon as the results of the tests become known.

March, 1966

Nittetsu Mining Consultants Co.
Survey Team

Leader	Kenichi Nakayama	(Mining)
	Kazumi Hatta	(Equipment)
	Kakuzo Harada	(Geology)

II. SUMMARY

During the present survey period, surface reconnaissance was conducted on a number of minor mountain ridges in the Marrisey Creek district while digging two prospect tunnels there. The tunnels extended over a distance of more than 30 meters each from the outcrops of seams K1 and K5, and crosscuts were made at points where there was apparently no influence of weathering, to collect bulk samplings for drum tests for shatter strength.

Since both these seams were found to be of mineable thickness (at the points where samples were taken), the samples are currently being tested to find whether the coal quality meets the specifications of Japanese steelmakers for low-volatile coking coal.

The surface reconnaissance failed to reveal much about the possible seams of different horizons but largely confirmed the stability of the several sandstone beds that have developed in between those seams and that appear to be continuous. This finding, which is expected to greatly facilitate future prospecting, was interpreted as suggesting a similar degree of stability for coal seams there. Accordingly, it is expected that a sizable reserve of coal exists above the level of Morrissey Creek, 1,200 meters above the sea level, although it is too early to present any figures at this stage.

Future exploration will likely include (i) trenching, (ii) sampling, (iii) drilling and (iv) surveying. And calculation of mining cost and initial expenses, planning of enterprise type and fund raising and study of the labor situation on the basis of data derived from exploration, will provide the key to launching the coal mine development project.

III. EXPLORATION

1. Name of Claims

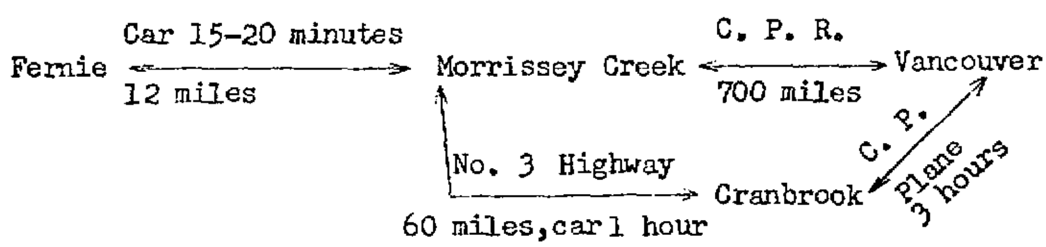
Fernie Coal Mine, Pacific Coal Limited (P. C. L.)

2. Location and Access

(1) Location

The claims are located at 49 degrees 20 minutes north latitude, 114 degrees 55 minutes west longitude, approximately 10 miles south-southwest of Fernie, British Columbia, Canada. It is on the slopes —— 1,100 to 2,200 meters above the sea level —— of the West Foothill belt of the Rocky Mountains, which runs on the border of the states of British Columbia and Alberta.

(2) Access



The easiest way to reach the coal fields is to take a plane (Canadian Pacific Airlines) from Vancouver to Cranbrook, arriving there in approximately three hours (after three stops on the way). From Cranbrook, an hour's drive eastward (about 60 miles) along the No. 3 Dual Highway will bring one to the point where Morrissey Creek joins the River Elk. From there, it is about 4 miles to the claim boundary, accessible by car. From the boundary, it is better to use a jeep to drive half a mile more along the creek to reach the outcrops of the major coal seams in the area. Anyway, the claims are very easily accessible.

3. Claims and Area

The official Dominion Coal Block covers an area 5 miles wide (northwest to southeast) and 15 miles long (southwest to northeast) in the mountainous region described above.

In the southwestern portion of the block, Pacific Coal Limited has applied for six mining leases, covering a total area of 4,300 hectares. Adjacent to these claims, to the north and across Morrissey Creek, there lie the claims of Crow's Nest Pass Coal Company. The Crow's Nest Pass mines, now abandoned, produced 500,000 short tons of coal in eight years in the early 20th century. Remnants of the best days are evident today in old pits (caved in and buried), roads, mining offices and haulage railroad tracks.

4. History

These coalfields were originally discovered in 1811 on the eastern side (Alberta side) of the Rocky Mountains. Then, in 1845, Father de Smet found coal seams on the western side of the Rockies (north of the site surveyed by us). Later, many geologists have investigated the area and published their findings in fragmentary reports.

(Note) Bibliography

(General Geology)

C.B. Newmarch: Geology of the Crowsnest Coal Basin With Special Reference to the Fernie Area Bulletin No. 33, 1953

R. A. Price: Fernie Map — Area, East Half, Alberta and British Columbia.
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(Morrissey Creek Area)

Doublas D. Campbell: Morrissey Creek Coal Project, Nov. 1, 1964 and Feb.10, 1965

John T. Boyd and Associates Mining Engineers: Preliminary Mining Study, Pacific Coal Limited October 1965

5. Climate

Located at rather high latitudes (50 degrees), the Morrissey Creek area has a long winter and this more or less restricts the operation period. The area is under the same meteorological conditions as the neighboring Michel district to the north.

6. Topography

Morrissey Ridge (elevation: 2,200 meters) runs from the north-northwest to southeast in parallel with the western foothills of the Rocky Mountains. The western side of the ridge offers a rugged terrain but the east and northeastern sides form a plateau.

Down these slopes flow many streams, approximately in a southwesterly direction, forming cascades and finally opening into the Elk River. Morrissey Creek (elevation: 1,150 meters) is one of the principal streams, originating deep in the Rockies.

Coal-bearing formations are found on the western slopes of the mountains from 1,100 to 2,250 meters above the sea level, with numerous sandstone beds of varied thicknesses sandwiched between some of them. Near the crest and branch ridges, erosion of thin overburdens exposes enormous outcrops, which run in belts along the steep slopes forming cliffs here and there, and presenting a characteristic topography.

(1) Outline

The western foothills of Morrissey Ridge contain the Fernie Formation, the western slopes of the ridge the Kootenay Formation (coal-bearing formation) and the crest of the ridge the Blairmore Formation, the last-named formation located above the second, which in turn is above the first, showing a clear-cut distribution.

(2) Formations

A. Fernie Formation

This formation consists of so-called Fernie shale, dark gray to black, found continuously on the fringe of the Fernie Coal Basin. It is a marine zone containing some dark gray and fine, calcareous sandstone, sandy shale and siltstone.

Top	Black shale (including massive, fine sandstone turned brown by weathering)
Middle	Gray shale
Bottom	Black shale (dark gray, brownish gray)

The Fernie Formation seems to shift by degrees into the Kootenay Formation above. It is said that the Fernie Formation belongs somewhere between the Lower and Middle Jurassic and Upper Jurassic periods.

B. Kootenay Formation

The Kootenay Formation is a coal-bearing formation (600 to 700 meters thick) including many thick coal seams and covers the Elk Conglomerate (approximately 500 meters thick) above.

The Kootenay Formation extends along Morrissey Creek and on the western slopes of Morrissey Ridge it is especially well developed over a distance of several thousand meters in a southwesterly direction from the creek up to the Pipeline area.

The formation consists chiefly of gray to dark gray, fine to coarse sandstone and gray to black shale or sandy shale. Above and below are about 15 coal seams of different thicknesses, as well as silstone and mudstone. Besides several belts of conglomerate sandstone consisting of quartz and chert pebbles are found. Some of the strata are cross-bedded, occasionally with ripple marks.

The formation is generally carbonaceous and often contains plant fossils, which however are all broken in small piece and thus difficult to identify. It is said to date from the Upper Jurassic to Lower Cretaceous periods (Barremian to Late Neocomian).

Several meters below the lowest coal seam (K1), there exists a bed of dark gray, medium to coarse sandstone known as Kootenay (Moose) sandstone, 40 to 50 meters thick, forming many precipices and running continuously, which is important as showing the lower limit of coal seams.

Above this formation there is a group of coal-bearing formations containing occasional thin seams of low-grade coal besides gray to black shale and consisting mostly of Elk Conglomerate, rich in chert, quartz and quartzite pebbles. These measures present a cliff formation, a characteristic topography of the area.

C. Blairmore Formation (nonmarine)

The Blairmore Formation, distributed extensively and thickly in the eastern highlands, which rise more than 2,000 meters above the sea level in the heart of the Fernie Coal Basin, is made up chiefly of sandstone consisting largely of light-colored quartz, or multicolored shale.

9

Pebbles near the base of the formation make up a conglomerate of smaller and more rounded pebbles than in the Elk Conglomerate below. The geological age of this area is estimated at Lower Createaceous.

(3) Others

Structurally, these coalfields are located in the Foothill belt of the Rocky Mountains, so that generally speaking, neighboring formations, or those west of the Fernie Formation in the West Foothills, assume a rather complicated geological structure.

However, the Kootenay and Blairmore Formations, which run from the western slopes of Morrissey Ridge to the eastern plateau, are more or less free from folding and faulting. The strata running along Morrissey Ridge, shows a large monoclinal structure with a northwest to southeast strike and a 20 degree dip to the northeast. Therefore, it is considered that the area along the 8,000 meter distance between the Morrissey Creek and Pipeline areas has a stabilized formation and offers a suitable target for mining.

8. Coal Seams

(1) Outline

Drilling conducted in 1964 located approximately 15 coal seams belonging to the Kootenay Formation, but little information is available on their thickness (notably working thickness of coal and coal seams), coal quality and sumikazari (external appearance of coal seams).

An overall study of the results of the present survey and all available data mentioned above shows that there are a number of seams—namely, K1, K2, K4, K5 and K11—worth considering for mining.

Even regarding these seams, however, very little is known about

9

their development, continuity and change in thickness in the area between Morrissey Creek and Pipeline. Such information must be obtained through future investigation.

Along Morrissey Creek, seam K1 has a working thickness of more than 10 meters while seams other than the five given above are expected to show working thicknesses of 4 to 5 meters. However, judging from the results of investigation of seams K1 and K5 by prospect tunnels, a large amount of partings (coaly shale, shale, etc.) is expected and problems must be solved with regard to clean coal to raw coal ratio and determination of mining range in coal seams.

To study the general condition in the area of about 7,000 meters in the strike direction between Morrisey Creek and Pipeline, investigation was made of representative ridges (No. 1, No. 2 and No. 3). But since there was not enough time to perform outcrop stripping, the only thing we could do was correlation of strata. On the gentle slopes in between the cliffs of these sandstone beds there are found debris of black shale, coaly shale and sandy shale, so that there is a good chance that further stripping will reveal coal seams of different horizons.

The names of coal seams in areas other than the Morrissey Creek area are all tentative ones designating estimated seams, and are subject to changes following detailed surveys in the future.

9

(2) Seams

A. Seam K1

	Morrissey Creek				No. 2 Ridge	Pipeline
	By drilling		By crosscutting			
	DH A8	DH A1	Whole seam	Portion to be mined*	Outcrop	Outcrop
Seam thickness	16.55m	11.59m	15.64m	3.01m	13.29m (+)	3.06m
Coal thickness	13.11m	11.59m	9.75m	2.65m	7.85m (+)	2.71m

* lowest portion

Crosscutting from the prospect tunnels found many partings of coaly shale or shale, ranging in thickness from 0.2 meter to a few centimeters. For operation the mining range must be selected with utmost care in connection with the ratio of clean coal to raw coal.

In crosscutting in the Pipeline area, about 7,000 meters southeast of Morrissey Creek, the coal seam thickness was found to have dropped to 3.06 meters and as for outcrops, partings and other conditions were not clear because of weathering. Nevertheless, the thicknesses of seam and coal in seam were estimated at levels permitting mining, although minimum levels.

(Note) Seam K1 is the Morrissey Creek area's lowest coal seam, which is approximately of the same horizon as seam No. 10 of the Balmer Mine, which is located to the north of the area. The Balmer Mine's seam No. 10 is now being operated with the top three meters as the mining thickness.

9

B. Seam K2

	By drilling	
	DH A1	DH A5
Seam thickness	7.01m	5.33m
Coal thickness	6.25m	5.33m

Seam K2 was located through two boring holes alone. No outcrops have yet been found, but on about the same horizon as the path linking seam K1 and K5, there is a rather thick Allochthonous coal seam, and in this neighborhood seam K2 is likely to exist. Continuous prospecting must be made to verify this possibility.

C. Seam K4

	Morrissey Creek			No.2 Ridge	Pipeline Road
	By drilling		Outcrop	Outcrop	Outcrop
	DH A7	DH A5			
Seam thickness	5.18m	1.22m	5.66m	0.45m (+)	3.38m
Coal thickness	5.18m	1.22m	5.13m	0.45m (+)	2.34m

Along Morrissey Creek, there is an abandoned pit which had been operated several decades ago. On the right wall of this pit, the coal thickness is about 5.13 meters. However, according to our drilling data obtained from DH A7 and DH A5, the thickness changes excessively and, as in K1, tends to decrease toward the Pipeline area along the strike. For the future, the area between the Morrissey Creek and Pipeline areas must be examined for coal seam development and coal quality.

D. Seam K5

	Morrissey Creek					No.2 Ridge Outcrop
	By drilling		By crosscutting			
	DH A10	DH A5	Whole seam	Top	Bottom	
Seam thickness	5.18m	5.79m	5.36m	2.93m	1.53m	2.31m (+)
Coal thickness	2.43m	0.76m	4.34m	2.51m	1.51m	2.11m (+)

Data from DH A5 and DH A10 among the drill holes made in the previous survey are not very helpful in determining the exact conditions of seam K5, but crosscutting made in the present survey for bulk sampling showed there is a considerably large reserve here, even though the seam is divided into the upper and lower parts by a belt of partings (about 0.9 meter thick) at a point approximately one-third from the bottom.

The upper half has a sufficient working thickness of both seam and coal and moreover a coal seam apparently of the same horizon and of a mineable thickness (lower limit not determined) seems to exist in No. 2 Ridge located 2,800 meters away. In future prospecting, attention must be paid to extension of the seam in this direction.

E. Seam K11

	Morrissey Creek By drilling			Pipeline Outcrop	Pipeline Road Outcrop
	DH A4	DH A6	DH B1		
Seam thickness	5.79m	8.38m	6.40m	(7.95)* 3.10m	(6.63)* 2.13m
Coal thickness	5.79m	8.38m	6.40m	3.05m	1.00m

* Whole seam thickness

9

Data obtained from drill holes DH A4, DH A6 and DH B1 in the previous survey do not tell much about the coal quality in seam K11, but indicate that the seam is of mineable thickness.

No seam was uncovered over the 7,000 meter distance between the creek and Pipeline area, but east of the Pipeline a seam that appeared to be K11 was seen scattered in upper and lower parts and deteriorated. Near the top, however, a rather abundant reserve (coal thickness: 3.05 meters) was in evidence and future findings of this part will determine whether seam K11 will offer mineable coal.

F. Seam K13

Existence of seam K13 is assumed from data obtained from DH A4, DH A6 and DH B1 in the previous drilling . Another seam apparently of the same horizon is found in the southern Pipeline area but the violent changes in seam thickness seem to render planned mining difficult.

G. Summary

From the above descriptions, it is understood that future prospecting must be depended upon largely in order to get a clear picture of the reserve conditions of seams K1, K2, K4, K5 and K11.

9. Sampling

For bulk sampling in the present survey, prospect tunnels are excavated as follows from the outcrops of seams K1 and K5 :

Seam K1	35.4 meters
Seam K5	33.7 meters

At the far end of these tunnels, crosscutting was performed and samples were collected for apparently mineable portions (as determined by sight and free swelling index tests) together with partings to make the samples best representative of the actual coal qualities.

While these tunnels were being dug, free swelling index tests were conducted in an attempt to check the effects of weathering, if only indirectly. For the test, samplings of the same horizon were taken at 1 to 2 meter intervals and where the test gave stabilized values, cross-cutting was performed to collect coal samples, as follows:

Quantity of samples

Seam K1	(Top	12 drums
	(Bottom	15
Seam K5	(Top	16
	(Bottom	12
	Total	55 drums

10. Coal Quality

The 55 drums of samples from corsscutting in seams K1 and K5 are to be washed and prepared for a designated ash content at the Kobukuro Iron Works Co., Ltd. in Kyushu and then submitted to four steel mills for drum tests for shatter strength to see whether the coal is suitable for iron manufacture.

As for fragmentary samples collected at different sites during the present survey, they are now being subjected to proximate analysis at Nittetsu Mining Company's Mitaka Laboratories.

Results of the tests will be reported as soon as they become known.

Test resutls for the fragmentary samples so far have revealed the following facts: The ratio of low-ash clean coal to raw coal will pose a problem. A volatile content of about 16 per cent may be expected, but the coal tends to show a small fluidity and rather low free swelling index. When blending Morrissey Creek coal with Japanese coal, the latter may be subject to greater restrictions than with American coal. It may be necessary to choose Japanese coal of high fluidity, such as Takashima coal or Oyubari coal. Depending on the blending ratio, Fernie coal may be able to replace part of low-volatile American coal.

11. Recommendations for Exploration

The first step toward judging the commercial value of the mine is to form an exploration plan aimed at determining as accurately and quickly as possible the quantity of economically mineable coal. Special attention should be paid to the climatic disadvantages of the area. In order that work may be begun as soon as the thaw sets in, arrangement for labor and equipment must be made well in advance to ensure smooth progress of detailed survey. The following methods are recommended for the exploration plan:

Trenching

More than 10 branch ridges where stripping of overburden can be conducted easily will be selected in the area between Morrissey Creek and Pipeline to the southeast, and large-scale cutting by bulldozers will be performed to expose coal seams of different horizons to examine the coal quality and the changes in seam thickness. Since although the coal seams are generally of sufficient thickness, there are abundant partings and coal quality is not uniform, study must be made by taking into consideration the clean coal to raw coal ratio and mining method.

Prospect Tunnel (for sampling for drum test)

Since the dominant factor in evaluating these coalfields is whether the coal produced meets the specifications of Japanese steel mills for low-volatile coking coal, the objective of prospecting must be to collect samples at sites free from the effects of weathering for seams K4 and K11 in the Morrissey Creek area and the estimated seams K1, K4, K5 and K11 in the Pipeline area. For this purpose, it is recommended that samples be collected by the same method as used in the present survey—namely, by crosscutting after digging drifts along the seams about 20 meters from the outcrops.

Regarding seam K11 in the Morrissey Creek area, where it is estimated that total length of drifts may extend over a distance in excess of 150 meters, close study is required of its location and direction.

Depending on the results of detailed surveys to follow, tunnels may have to be driven by the same method as in the present survey, for sampling in coal seams and sites other than those referred to above.

Exploratory Drilling

Trenching as described above may achieve the purpose of exploration along the strike, but as to deeper part exploration will have to depend on drilling. As the first step, several drill holes must be made and careful exploration must be made of the seam conditions in the depths.

Detailed Surveying

In parallel with the various investigations described above, the topography of the mine site must be surveyed in detail in order to ensure accuracy in exploration and to serve as a basis for building a possible preparation plant and other facilities in the area.

The result of the detailed exploratory works as mentioned above will be utilized to draw up geological maps, geological profiles and contour maps indicating the depths of coal seams, which are to serve as basic data for the overall development plan.

As for the portion below the tunnel mouth level (below the level of of Morrissey Creek), it may be considered after development has begun.

Prior to deciding on the development of the coalfields, examination must be made of various other matters other than those described above. Principal among them are the following:

Development plan

(If the main haulage tunnel is to be built in the Morrissey Creek area, it is necessary to re-examine the local geology by conducting drilling in key points, because despite past drilling in the area data on core samples are inadequate.)

Estimation of cost and capital expenditures at the mine site

Transportation (e.g. building of railway, freight rates, cost for port facilities)

Type of enterprise and financing program

Labor

IV. MINING PROGRAM

A. Summary

(1) Preconditions — Production and Personnel

In the present survey we have not been able to obtain sufficient data to formulate a concrete mining program. The survey was particularly inadequate in respect of the extent of mineable seams, their reserves and coal quality, and optimum production in relation to sales. Therefore, preconditions will be set forth as follows, and assuming that they are fulfilled, a tentative plan will be presented.

Preconditions — Production and Personnel —

Production	Daily production (clean coal)	6,520 long tons
	Grade of clean coal (Content of ash)	9%
	Ratio of clean coal to raw coal*	65%
	Days of operation per year	230 days
	Annual production (clean coal)	1,500,000 long tons
	Number of working faces	
	Continuous miners	3 sections x 2 shifts
	Cutters	6 sections x 2 shifts
	Total	9 sections x 2 shifts
	Safety ratio of production	90.5 %
Personnel	Staff members	50
	Laborers	
	Working faces	192
	Other underground workers	128

1

Personnel	Surface workers	54
	Total	374
	Grand total	424
Efficiency		15.4 l.t./man/shift

* The ratio of clean coal to raw coal, tentatively set at 65%, will depend on the preparation tests now under way, which will determine the relationship between the ratio and ash content. Depending on the results of the tests, efficiency and cost may have to be revised.

(2) Equipment Investment

I t e m s	Value (Can. $)	Depreciation Period(years)
Coal Preparation Plant		
Structures	1,969,000	20
Machinery	4,029,000	10
Total	5,998,000	
Substation, Others		
Substation and office	888,000	20
Main fan	33,000	10
Vehicles	54,000	5
Total	975,000	
Tunnels	44,000	20
Mining Equipment and Machinery	3,545,000	5
Haulage Equipment		
Locomotives and coal cars	1,018,000	10
Belt conveyers	1,300,000	3
Total	2,318,000	
Grand Total	12,880,000	

9

(3) Production Cost

	Items	Can. $ / l. t.
Labor cost	Staff members	0.238
	Laborers	1.299
	Total	1.537
Materials cost	Mechanical loading	0.523
	General, underground	0.129
	Repairs and maintenance	0.611
	General, surface	0.067
	Mine administration	0.026
	Reserves	0.136
	Total	1.492
Expenses	Depreciation	(1.580)(at 7% annual interest) 1.522(at 6% annual interest)
	Others	1.310
	Total*	(2.890) 2.832
Grand Total		(5.919) 5.861

* Expenses include taxes and royalties, which are subject to change.

2. Tunneling

(1) Site of Tunnel Mouth

The ideal site for the tunnel mouth would be the one that can ensure a minimum crosscutting required to reach all coal seams and at the same time offer sufficient space for surface equipment. As a tentative plan, the main tunnel mouth (for intake) will be opened above an outcrop of seam K4, at an elevation of 3,850 feet at DH A1. The outlet tunnel mouth will be opened on the outcrop of seam K5.

(2) Tunnels

A. Direction of Tunnels

A level will be excavated through rock in an east-northeasterly direction and as it hits seam K5, a level drift will be driven along the seam. This will serve as the main haulage tunnel. The outlet tunnel will be driven at an apparent incline of -10° along the seam and when it reaches a level of +27 feet from the main tunnel, it will run in parallel to it maintaining an inclined distance of 100 feet. (See Fig. 10)

B. Cross Section and Support (Fig. 11)

The drift will be reinforced with roof bolting where the roof is strong enough and with pillars where the side walls are feared to give away. The outlet will be reinforced in the same way as the main haulage tunnel, using timber.

3. Mining

(1) Mining System

Room and pillar working will be used, adopting the continuous miner system and the cutter system together, as shown in Figs. 12, 13 and 14.

A. Continuous Miner Section

a. Main Way (See Fig. 12)

Equipment

Continuous miner	1
Shuttle cars	2
Roof-bolting machine	1

Belt conveyor	1

Personnel

Miner operator	1
Shuttle car operators	2
Roof bolters	2
Timber man	1
Mechanic	1
Others	1
Total	8

Production

Raw coal	460 l.t./shift
Clean coal to raw coal ratio	65%
Clean coal	300 l.t./shift
Efficiency	37.5 l.t./man/shift

b. Rising Method (See Fig. 13)

Equipment, personnel and efficiency are the same as above.

c. General Mining

Equipment, personnel and efficiency are the same as above.

B. Cutter Section (See Fig. 14)

Equipment

Cutter	1
Loader	1
Shuttle cars	2
Drill	1
Roof-bolting machine	1
Compressor	1

Personnel

Cutter men	2
Loader operator	1
Shuttle car operators	2
Drill man	1
Fire man	1
Roof bolters	2
Belt operators	2
Mechanic	1
Total	12

Production

Raw coal	700 l.t./shift
Clean coal to raw coal ratio	65%
Clean coal	450 l.t./shift
Efficiency	37.5 l.t./man/shift

(2) Coal Production

Three continuous miner sections and six cutter sections will be operated, for a total of nine sections. Each section will work in two shifts. Thus, daily coal production will be:

(300 l.t. x 3 sections + 450 l.t. x 6 sections) x 2 shifts
= 7,200 l.t./day

For an annual production of 1,500,000 l.t., the daily output at 230 workdays per year will be:

1,500,000 l.t. ÷ 230 days ≑ 6,520 l.t./day

This means there will be a surplus of approximately 10% (6,520 l.t. ÷ 7,200 l.t. = 0.9055).

Mining personnel required will be:

9

(8 men x 3 sections + 12 men x 6 sections) x 2 shifts
= 192 men

Since mining will be conducted in two shifts, such works as extension of belt conveyors and tracks will be performed by third shift workers.

4. Haulage

Coal mined at the working faces will be loaded on the section belt conveyors by shuttle car and then to the main way by conveyor through each rises. In the main way, the coal will be loaded onto coal cars and by Diesel locomotive hauled out to the mouth, where it will be placed in the hopper.

Equipment required for haulage is as follows:

Steel coal cars, 10 t, (discharging from the bottom)	100
Flat trucks	4
Diesel locomotives, large	4
small	4
Rail gauge	48", 60 lbs.

5. Ventilation and Drainage

(1) Ventilation

A. Outline

Methane gas is expected to be scanty. For the main ventilation system, a fan will be installed at the mouth of the outlet tunnel. For local ventilation, local fans will be placed for working faces in the main way. Besides, brattice ventilation will be used for each face.

B. Specifications of Main Fan

Assuming that the effective wind volume will be 40% of the total flow, the former will be:

$$1,500\ m^3 \div 0.4 = 3,750\ m^3/\text{min.}$$

$$= 132,000\ \text{cf/min.}$$

Wind pressure, with a 30% allowance, will be: 3.15 ins.

Therefore, a 100 HP fan will be required.

(2) Drainage

In the early stages of development, when mining portions are all at higher levels than the tunnel mouth, underground water will all flow out through the main way.

6. Coal Preparation (See Fig. 15)

Heavy media separation will be employed for different grain sizes as follows:

25 - 150mm	Leebar heavy media separator
0.5 - 25mm	Cyclone heavy media separator
- 0.5mm	Flotator

The clean coal obtained from the Leebar separator will be crushed and together with the flotation coal (after drying) will be mixed with the clean coal from the cyclone separator, and the mixture will be shipped as one brand. Refuse from heavy media separator will be discarded through the [illegible] [illegible] together with flotation tailings after concentration by a thickener and dehydration by a filter press.

Hourly preparation capacity will be 800 t, at an annual production of 1,500,000 tons, a clean coal to raw coal ratio of 65% (ash content 9%) and 14 hour daily operation in two shifts. Equipment cost is estimated at Can.$5,998,000., but this is subject to change as details are not available as to foundation work.

7. Surface Installations

All surface installations, including the office, repair shop, warehouse, lamphouse, substation and main fan, will be built on the southwestern side of the tunnel mouth.

8. Personnel

(1) Staff Members

Superintendent	1
Assistant superintendent	1
Mine foreman	1
Assistant foreman	1
Tipple foremen	2
Section foremen 9 x 2	18
Fire bosses	2
Ventilation foreman	1
Chief electrician	1
Shop foremen	2
Underground mechanical and electrical foremen	2
Move-up foreman	1
Track foreman	1
Mechanical and electrical foreman (tipple)	1
Dispatchers	2
Division engineer	1
Transit-rod-draftsmen	5
Office manager	1
Payroll clerk	1
Shipping clerk	1

Industrial engineers	2
Purchasing agent	1
Supply clerk	1
Total	50

(2) Laborers

A. Mining

	Continuous Miner Sections (3)	Cutter Sections (6)	Total
Per shift	8 men x 3 = 24 men	12 men x 6 = 72 men	96 men
Per day	24 men x 2 = 48 men	72 men x 2 = 144 men	192 men

B. Haulage

	Number of locomotives	Men per shift	Men per day
Main Way	3(incl. 1 spare)	6	12
For shunting	3(incl. 1 spare)	6	12
Total	6(incl. 2 spare)	12	24

C. Others

Main line track	5
Slate and cleaning	3
Main line roof support	6
Ventilation	24
Rock dusting	6
Material carriers	26
Moving section	15
Repairs and maintenance section	20

9

Repairs and maintenance, surface	20
Lamphouse	3
Trucking	6
Laboratory	3
Miscellaneous	3
Tipple men	16
Substation	3
Total	158
Total for Laborers	374

9. Equipment Investment

Items	Quantity	Unit cost (Can. $)	Value (Can. $)	Depreciation period (years)
Coal Preparation Plant				
Structures	1 set		1,969,000	20
Machinery	1 set		4,029,000	10
Total			5,998,000	
Substation, Others				
Substation			272,000	20
Main fan			33,000	10
Office, others			670,000	
( ): Breakdown by depreciation period			(616,000)	(20)
			(54,000)	(5)
Total			975,000	
Tunnel				
Main rock level (12' x 15')	500'	66	33,000	20
Main fan airway (10' x 10')	200'	55	11,000	20
Total			44,000	

Mining Equipment

Items	Quantity	Unit cost (Can.$)	Value (Can.$)	Depreciation period
Continuous miners	3	154,295	462,885	5
10-Ru Joy cutters	6	60,000	360,000	5
15-Bu Joy loaders	6	53,500	321,000	5
10-Sc Shuttle cars	18	52,500	945,000	5
CD-41 Joy coal drills	6	34,000	204,000	5
Roof-bolting machines	9	33,700	303,300	5
Compressors	7	31,500	220,500	5
Mine power center	1 set		504,000	5
Cable	1 set		224,315	5
Total			3,545,000	

Transport Equipment

Rail, 60 lbs. (22,600 ft.)	210	333	70,000	10
Mine cars (10t)	100	4,400	440,000	10
Flat trucks	4	1,250	5,000	10
Diesel locomotives (30t)	4	104,000	416,000	10
Diesel locomotives (8t)	4	21,750	87,000	10
Belt conveyors	23,000 ft	55	1,265,000	2
Belt conveyor accessories	1 set		35,000	2
Total			2,318,000	
Grand Total			12,880,000	

9

10. Labor Cost

(1) Staff Members

At an average daily pay of Can. $27, the total pay for staff members will be:

Can.$27 x 50 men = Can.$1,350/day

Therefore, the per ton labor cost for staff members will be:

Can. $1,350 ÷ 6,520 l.t. = Can.$0.207/l.t.

(2) Laborers

The daily wages for laborers for different types of work are given in the list below.

Job classification	Daily wages per head	Number of personnel	Daily wages
	Can.$		Can.$
Contract miners	22.24	192	4,270.08
Locomotive drivers	17.04	24	408.96
Main line track maintenance	17.75	5	88.75
Slate and cleaning	16.55	3	49.65
Main line support	17.43	5	87.15
Ventilation	17.11	24	410.64
Rock dusters	16.55	6	99.30
Material carriers	17.11	26	444.86
Moving section	17.29	15	259.35
Repairs and maintenance section	17.29	20	345.80
Repairs and maintenance surface	17.00	20	340.00
Lamphouse	16.55	3	49.65

Job classification	Daily wages per head	Number of personnel	Daily wages
Tracking	17.04	6	102.24
Laboratory	16.55	3	49.65
Miscellaneous	16.55	3	49.65
Tipple	16.55	16	264.80
Power section	16.55	3	49.65
Total		374	7,370.18

Therefore, the per ton labor cost for labors will be

Can.$7,370.18 ÷ 6,520 l.t./day = Can.$1,13 /l.t.

(3) Summary

Total daily labor cost: Can.$1,350.+ $7,370.18
= Can.$8,720.18

Per ton labor cost: Can.$0.207 + $1.13 = Can.$1.337

Thus, estimating a wage increase of 10% over present standard and 5% for midnight work, for a total of 15%, the per ton labor cost will be:

Can.$1.337/l.t. x 115% = Can.$1.537/l.t.

11. Materials Cost

Categories	Items	Cost per day (Can. $)	Cost per ton (Can. $)
Mechanical loading	Cutting	140	0.022
	Drilling and shooting	400	0.061
	Roof support	850	0.131
	Sectional transport	10	0.001
	Bridging and cleaning	10	0.001

9

Categories	Items	Cost per day (Can.$)	Cost per ton (Can.$)
	Roof support (bolts)	2,000	0.307
	Total	3,410	0.523
General underground	Main line track	150	0.02
	Cleaning	10	0.001
	Roof support	10	0.001
	Compressed air	50	0.008
	Ventilation	280	0.043
	Rock dusting and dust allying	290	0.045
	Miscellaneous, underground	70	0.011
	Total	840	0.129
Repairs and maintenance	R and M Continuous miners	300	0.046
	R and M Cutting machines	500	0.077
	R and M Loading machines	550	0.084
	R and M Shuttle cars	550	0.084
	R and M Other sectional equipment	500	0.077
	Locomotives	300	0.046
	Mine cars	40	0.006
	Fan	30	0.005
	Tipples	650	0.100
	Dumps	100	0.015
	Substation	30	0.005
	Trucks and cars	150	0.023
	Miscellaneous	35	0.005
	Lubricants and tools	250	0.038
	Total	3,985	0.611

9

Categories	Items	Cost per day (Can.$)	Cost per ton (Can.$)
General, surface	Lamphouse and bathhouse	10	0.003
	Laboratory	10	
	Tracking	130	0.020
	Cleaning	10	0.003
	Miscellaneous, surface	10	
	Tipple operation	250	0.038
	Pumping	20	0.003
	Total	440	0.067
Mine administration	Superintendent and engineering	40	0.006
	Foremen	10	0.001
	Office	70	0.011
	Supply and purchasing	25	0.004
	Safety inspection and fire bosses	25	0.004
	Total	170	0.026
	Overall Total	8,845	1.356
	Reserve	880.50	0.136
	Grand Total	9,729.50	1.492

12. Expenses

(1) Depreciation

Depreciation on the total equipment valued at $12,880,000. will be calculated for an annual interest of 6% and 7%, as follows:

Deprecia-tion period	Acquisition cost(Can.$)	Interest %	Depreciation rate	Yearly deprecia-tion expense (Can.$)
20	2,901,000	6	0.08718	252,909.18
		7	0.09437	273,767.37
10	5,080,000	6	0.13587	690,219.60
		7	0.14238	723,290.40
5	3,599,000	6	0.23704	853,106.96
		7	0.24389	877,760.11
3	1,300,000	6	0.37411	486,343.00
		7	0.38105	495,365.00
Total	12,880,000	6		2,282,578.74
		7		2,370,182.88

Per ton depreciation

At 6% annual interest:

Can.$2,282,578.74 ÷ 1,500,000 l.t.=Can.$1.5217

At 7% annual interest:

Can. $2,370,182.88 ÷ 1,500,000 l.t.=Can.$1.580

(2) Other Expenses

Items	Cost per ton (Can. $)
General Operation	
Electric power	0.20
General expense	0.04
General office	0.02
Royalty	0.25
Compensation insurance	0.08

9

Items	Cost per ton (Can. $)
Vacations	0.05
Welfare and retirement	0.27
Pensions	0.02
Others	
Total	0.93
Others	
Operation fund	0.03
Insurance	0.04
Taxes	0.20
Taxes	0.10
Association dues	0.01
Total	0.38
Grand Total	1.31

(Note) Taxes and insurance are approximate figures.