DOLMAGE CAMPBELL & ASSOCIATES LTD.
CONSULTING GEOLOGICAL & MINING ENGINEERS
1000 GUINNESS TOWER
VANCOUVER 1, B.C.

HAT CREEK PROJECT

INTERIM REPORT ON COAL ANALYSES

NO. 1 OPENPIT DEPOSIT

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JUNE 27, 1975

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INTRODUCTION

In a letter dated June 18, 1975, from Dr. H. M. Ellis to Dr. D. D. Campbell, information was requested on the proximate, ultimate and ash analyses of coal in the No. 1 Openpit area of the Hat Creek coal deposits. In addition, an estimate was requested of the anticipated percentage of less than 3 mm coal in a feed crushed to a maximum size of 30 mm. The information is required by consultants investigating gasification and related advanced combustion technologies.

This interim report provides the best information presently available. Within one week, all proximate analysis data will have been computerized and summary tables at varying ash cut-offs produced. Revised figures incorporating significant changes will be submitted when this new information becomes available.

BACKGROUND INFORMATION

By letter dated May 8, 1975, to Dr. H. M. Ellis, Dr. L. T. Jory summarized the then available ash and gross calorific value data. A graph showing the relationship using the mean values of each drill hole was included and a copy of the same graph is attached to this report.

The proximate analysis data available on May 8 were a computer summary of all 1957-59 drill holes and individual summaries for each of the 1974-75 drill holes. Since that time minor corrections have been made to the 1957-59 data but no further computer output is available for the 1974-75 data since overall summaries are being withheld pending inclusion of proximate analyses data on the re-sampled, higher ash portions of the cores. All of the higher ash data has now been keypunched.

The range of coal quality will depend principally on the degree of selective mining employed.

The mean ash and calorific value data submitted on May 8 are detailed in the following section and form the basis for other proximate analysis data discussed in this report. For purposes of showing selective vs non-selective mining of all but major waste beds, an arbitrary ash cut-off of 44% at 20% moisture was used. The mean of samples below 44% ash likely yields a grade closely approaching the best condition possible by maximum selective mining employing excavators of moderate size. The mean of all samples likely yields a grade approaching the worst condition employing excavators of moderate size but removing by selective mining only major waste beds. Should large and relatively inflexible bucketwheels or draglines be employed, the grade attained would suffer by more excessive dilution.

It is arbitrarily concluded that to produce coal averaging less than 25% ash would prove economically undesirable because too high a percentage of the coal would have to be discarded. Similarly, it is concluded that the worst average grade resulting from the selective removal of only the major waste beds would be 31% ash. Hence, for this report data are developed for an assumed maximum quality range of 25 to 31% ash for the No. 1 Openpit deposit as a whole. For this report no consideration is given to the possibility of upgrading the coal by washing.

PROXIMATE ANALYSIS

Ash and Gross Calorific Value

The presently known mean ash and calorific values for 1957-59 and 1974-75 samples are as follows:

	Moist.%	Ash%	Gross Btu/lb.
Samples below 44% ash	20.00	25.72	6266
Samples above 44% ash	20.00	50.36	2785
All samples	20.00	28.09	5931

The mean values are weighted for core lengths but are not weighted geologically on the basis of bed or seam correlations or information on faults. When applied, such weighting will probably increase slightly the mean ash content for the deposit as a whole. The mean ash content will also increase slightly when the analyses for higher ash portions of the cores are included.

The 20% in situ moisture value is the present best estimate.

Fixed Carbon and Volatile Matter

The mean fuel ratio (fixed carbon:volatile matter) is noticeably different in 1957-59 drill holes and 1974-75 drill holes. Results are as follows:

Mean of:	Fuel Ratio
1957-59 samples	0.813
1974-75 samples	0.979
All samples	0.899

The fuel ratio of individual drill hole composites for 1974-75 drill holes varies from 0.837 to 1.155, and none are as low as the 1957-59 mean. The difference is likely due largely to better analytical work in 1974-75 rather than to the particular locations of the drill holes. Hence, it is concluded that a figure closely approaching the 1974-75 fuel ratio should be used. This is arbitrarily chosen at 0.95.

The 0.95 ratio is uncorrected for the difference between mineral matter and ash. For Hat Creek coal, the correction is significant as shown on the accompanying ash vs calorific value graph. On the graph, the regression line intersects the Y axis (zero calorific value) at about 84% ash. Traditionally, the mineral matter vs ash correction applied to proximate analysis data is the Parr formula (A.S.T.M. Designation D 388-66) developed for average eastern U.S. bituminous coals. For Hat Creek coal, application of a Parr-type formula tailored to the observed analytical data, gives a fuel ratio of about 1.2 rather than 0.95.

Sulphur

Mean sulphur analyses of proximate samples vary between 1957-59 samples and 1974-75 samples. Based on 20% moisture they are as follows:

Mean of:	Sulphur %
1957-59 samples	0.32
1974-75 samples	0.41
All samples	0.37

A plot of ash vs sulphur was made for the 1974-75 ultimate analyses samples. From the plot (not attached) it is not apparent that any consistent relationship exists between ash and sulphur. Hence, the mean value of 0.37% sulphur for the deposit as a whole should be used for the time being without regard to ash content variations.

However, for extended periods of time the sulphur content of mined coal might vary significantly above or below the mean. For example, for just the ultimate analysis samples, only 80% of the sulphur values fall within the range of 0.37± 0.24%. Thus, plant design could conceivably have to accommodate feed ranging from 0.13% to 0.61% or more in sulphur. Blending of coal to produce a uniform ash plant feed might reduce this range of sulphur contents substantially but this cannot be determined at this time.

Summary of Proximate Analyses

Based on 20% moisture, varying selective mining conditions, and uncorrected and corrected fuel ratios, the following mean values are presented for the No. 1 Openpit deposit at Hat Creek.

	Fuel Ratio (1) 0.95	Fuel Ratio (2) 1.2
1. Maximum selective mining		
Moisture - %	20.0	20.0
Ash - %	25.0	25.0
Vol. Matter - %	28.2	25.0
Fixed Carbon - %	26.8	30.0
Gross Cal. Value - Btu/lb.	6410	6410
Sulphur - Mean %	0.37	0.37
Range %	0.13-0.61	0.13-0.61
2. Minimum selective mining		
Moisture - %	20.0	20.0
Ash - %	31.0	31.0
Vol. Matter - %	25.1	22.3
Fixed Carbon - %	23.9	26.7
Gross Cal. Value - Btu/lb.	5470	5470
Sulphur - Mean %	0.37	0.37
Range %	0.13-0.61	0.13-0.61

Notes: (1) Uncorrected fuel ratio
(2) Fuel ratio corrected by Parr-type formula adapted to Hat Creek analytical data.

A range of values are shown only for sulphur. In point of fact, of course, significant variations will occur in the plant feed for all coal quality parameters.

HARDGROVE GRINDABILITY INDEX

The Hardgrove grindability index is a measure of the energy required to pulverize coal. The higher the index, the lower the energy expenditure required to achieve a given degree of pulverization.

The 1957-59 program yielded only fragmentary information. Hence, only 1974-75 work is discussed here. A plot of ash vs Hardgrove Index shows that a valid relationship exists wherein the cleaner the coal, the more difficult it is to grind. However, factors other than ash contribute to grindability. Hence, for extended periods of time the grindability might vary substantially higher or lower than the mean and prudent design would accommodate the worst condition. The choice is arbitary, however 80% of all tests done fall within + 5 units of the mean regression line and this would seem to be adequate for design purposes at this time.

Mean values and ranges for 25% and 31% ash coals, based on 20% moisture, are as follows:

Product	Hardgrove Index	
	Mean	Range
25% ash	42	37-47
31% ash	48	43-53

All tests were carried out under the normal laboratory moisture condition of the sample. The moisture level can affect the grindability index so at some time, tests should be carried out under varying moisture conditions.

ULTIMATE ANALYSIS

Ultimate analyses have been carried out on 53 samples composited from proximate analysis samples from the 1974-75 drill holes. Ultimate analyses are reported on a dry basis. Means of results as reported and corrected to 20% moisture are as follows:

	Dry Basis %	20.0% Moisture Basis %
Carbon	43.50	34.80
Hydrogen	3.39	2.71
Nitrogen	1.06	0.85
Chlorine	0.03	0.02
Oxygen (by difference)	14.92	11.94
Sulphur	0.51	0.41
Ash	36.59	29.27
Moisture	0.00	20.00

The range of ultimate analysis, based on 20% moisture, for maximum and minimum selective mining would be as follows:

	25% Ash Product %	31% Ash Product %
Carbon	37.72	33.62
Hydrogen	2.94	2.62
Nitrogen	0.92	0.82
Chlorine	0.02	0.02
Oxygen (by difference)	12.93	11.51
Sulphur	0.41	0.41
Ash	25.00	31.00
Moisture	20.00	20.00

It should be noted that these sulphur values are the 1974-75 means and have not been corrected for variation in ash content. Also the mean value, as quoted earlier, for all 1957-59 and 1974-75 drill holes is 0.37%. This figure could be validly substituted, if desired, by simply accommodating the difference in the oxygen content.

MINERAL ANALYSIS OF ASH

For the samples on which ultimate analyses were obtained, a chemical analysis of the ash was also carried out. The average values and range are presented below. These values are all arithmetic averages rather than weighted mean values. Weighted mean values will be submitted later following regression analysis of individual constituents and determination of their relative significance. It is not practical at this time to attempt to determine the values at 25% and 31% ash.

Constituent	Expressed as:	Drill hole Ave. Range	Ave. of All Samples
Phosphorous	P_2O_5	.12 - .33	.24
Silica	SiO_2	50.73 - 55.85	54.33
Iron	Fe_2O_3	5.54 - 10.11	7.40
Alumina	Al_2O_3	26.34 - 30.73	28.80
Titania	TiO_2	.65 - .99	.83
Lime	CaO	2.25 - 3.54	2.66
Magnesia	MgO	.64 - 2.60	1.40
Sulphur	SO_3	1.49 - 2.88	1.88
Potassium	K_2O	.24 - .97	.53
Sodium	Na_2O	.69 - 1.52	1.12
Undetermined (by difference)		.20 - 1.94	.91

SIZE CONSIST OF COAL

It is desired to know what percentage of coal feed would be less than 3 mm in screen size after crushing the coal to a top size of 30 mm. Lacking data on a representative bulk sample mined and processed in a generally similar manner to production conditions, only a very rough estimate can be made at this time.

Hat Creek coal is generally not well banded. Rather it tends to be massive with an irregular, somewhat woody texture. As such it would tend, on mining and crushing, to have a relatively low content of fines. Drilling results to date indicate that about 11% of coal footage drilled is closely broken with individual fractures at one inch or less spacing. Screening of several samples from a number of such broken zones indicates that the minus 3 mm fraction in these zones does not exceed 10%, hence it would be expected that the less broken coal would yield even less fines.

Generally speaking, a coal of this rank might be expected to have a fines content of roughly 5 to 15% passing 3 mm size. Indications so far are that Hat Creek coal is uncharacteristic in this regard and would contain less fines than many coals of similar rank. All that can be offered at this time is an "educated guess" that the fines content of raw Hat Creek coal, crushed to a top size of 30 mm, would likely fall within the range of 5 to 10% passing a 3 mm square screen.

Respectfully submitted,

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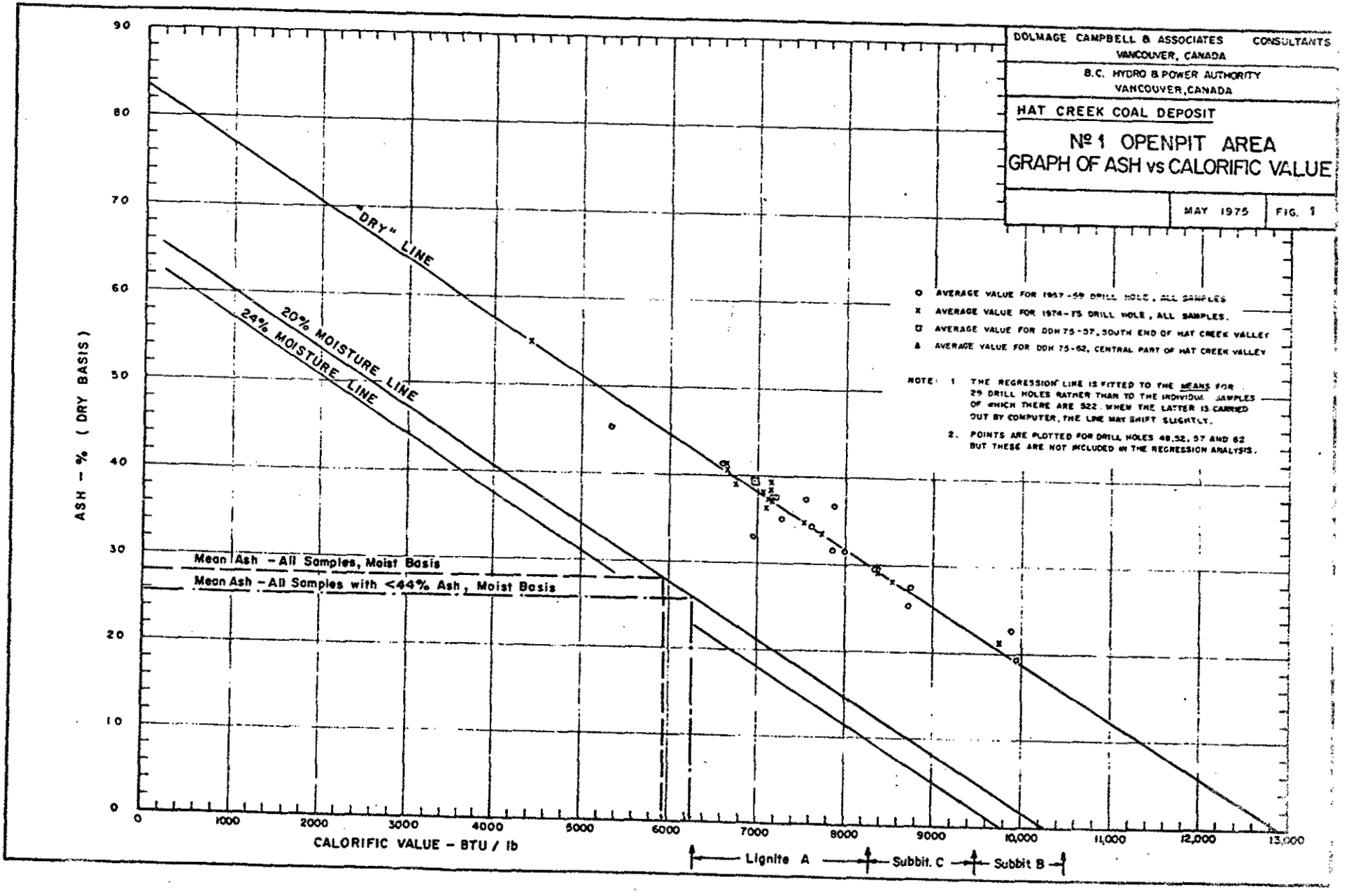
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VANCOUVER, CANADA
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HAT CREEK COAL DEPOSIT
№ 1 OPENPIT AREA
GRAPH OF ASH vs CALORIFIC VALUE
MAY 1975
FIG. 1
ASH - % (DRY BASIS)
CALORIFIC VALUE - BTU / lb
"DRY" LINE
20% MOISTURE LINE
24% MOISTURE LINE
Mean Ash - All Samples, Moist Basis
Mean Ash - All Samples with <44% Ash, Moist Basis
O AVERAGE VALUE FOR 1957-59 DRILL HOLE, ALL SAMPLES
X AVERAGE VALUE FOR 1974-75 DRILL HOLE, ALL SAMPLES.
□ AVERAGE VALUE FOR DDH 75-57, SOUTH END OF HAT CREEK VALLEY
Δ AVERAGE VALUE FOR DDH 75-62, CENTRAL PART OF HAT CREEK VALLEY
NOTE: 1 THE REGRESSION LINE IS FITTED TO THE MEANS FOR 29 DRILL HOLES RATHER THAN TO THE INDIVIDUAL SAMPLES OF WHICH THERE ARE 522. WHEN THE LATTER IS CARRIED OUT BY COMPUTER, THE LINE MAY SHIFT SLIGHTLY.
2. POINTS ARE PLOTTED FOR DRILL HOLES 48,52, 57 AND 62 BUT THESE ARE NOT INCLUDED IN THE REGRESSION ANALYSIS.
Lignite A
Subbit. C
Subbit B

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July 31, 1975

Hat Creek Project
COAL QUALITY - NO. 1 DEPOSIT
ADDENDUM TO INTERIM REPORT

1. Proximate Analyses

In our Interim Report, we suggested that very careful selective mining, involving minimal loss of total heat content, may yield a product containing a mean ash level of 25 %. We further suggested that if only the major waste beds were to be removed by selective mining, the mean ash level might be as high as 31 %. Listed in the table below are proximate analysis data for the No. 1 deposit at ash levels of 25 % and 31 %. Also listed are the overall mean values for all analyses.

UNCORRECTED ANALYSES

Constituent	Mean	Std. Dev.	25 % Ash	31 % Ash
Moisture - %	20.0	----	20.0	20.0
Ash - %	28.7	12.6	25.0	31.0
V.M. - %	27.1	5.3	29.0	25.9
F.C. - %	24.2	8.1	26.0	23.1
	100.0		100.0	100.0
C.V. - Btu/lb	5815	1900	6400	5440
S - %	0.39	0.28	0.39	0.39

The preceding data include all 1957-59 and 1974-75 analyses. Careful examination of the 1957-59 data indicates that the volatile matter as reported is approximately 2½% too high and the fixed carbon 2½% too low on the average. When this is taken into account and the water of hydration in the clay minerals associated with the coal is considered, the following reconstituted analyses can be calculated:

RECONSTITUTED ANALYSES

Constituent	Mean	25 % Ash	31 % Ash
Moisture - %	20.0	20.0	20.0
Ash - %	28.7	25.0	31.0
C.V.M(1) - %	19.7	21.1	18.8
F.C. - %	25.4	27.2	24.2
I.V.M(2) - %	6.2	6.7	6.0
	100.0	100.0	100.0
C.V. - Btu/lb	5815	6400	5440
S - %	0.39	0.39	0.39

Notes: 1. CVM - Combustible volatile matter.
2. IVM - Incombustible volatile matter.

The reconstituted analyses are considered to be the best values presently available for the No. 1 coal deposit at Hat Creek. In our Interim Report, reconstituted analyses were given by applying a fuel ratio correction but the values were incorrect because incombustible volatile matter was erroneously included in the combustible volatile matter and fixed carbon. If, in the above table, the percentages of combustible and incombustible volatile matter are added together, the figure representing the total volatile matter normally reported by a laboratory will be obtained.

As a result of having more complete data available, the mean sulphur content has been increased from 0.37 % to 0.39 %. No variation in the percentage of sulphur is indicated for the various ash levels. While some variations undoubtedly occur, they presently appear for the deposit as a whole to be too small to warrant consideration. (Note: This refers to means only, not to local variations in sulphur.)

2. Sulphur Forms

No mention of sulphur forms was given in our Interim Report. Based on 19 sets of values now available, the following pattern exists:

Pyritic sulphur - 25 % of total sulphur.
Sulphate sulphur - 3 % of total sulphur.
Organic sulphur - 72 % of total sulphur.