BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

Paul Weir Company - Hat Creek Project - Review of Coal Fuel Specification - November 1979

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REVIEW OF COAL FUEL SPECIFICATION
HAT CREEK PROJECT
FOR
BRITISH COLUMBIA HYDRO
AND POWER AUTHORITY

Paul Weir Company
Chicago, Illinois

Job No. 2649
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In Stage I, Weirco reviewed the detailed analytical data from two points of view, coal quality and mining. In the case of the mining review, this was limited to its effect on the coal quality, i.e., how the scheduling of the mining operations could affect both short- and long-term variability in the coal quality. Interim draft reports, dated June 22, 1979, were prepared for review by B.C. Hydro. This final report includes revisions made necessary by the comments received on the draft report.

The objective of Stage II was as follows:

4. An assessment of the suitability of the Fuel Specification for design of a large steam generator and identification of any potential problem areas in design and operation.

The work in Stage II resulted in proposed modifications of the Fuel Specification based on the work done in Stage I.

The objective of Stage III was as follows:

5. Presentation of the coal fuel characteristics and any necessary description in a form suitable for inclusion in a boiler specification for release to manufacturers.

Based on the draft report covering Stages II and III and on discussions resulting from the comments received, Weirco's recommendations are included in this, our final report.

The Weirco report has been broken down into three sections: Coal Quality, Mining, and Utilization and Specifications.

Much of the work reported on by Weirco could not have been done in the time available without the excellent cooperation of B.C. Hydro's Messrs. D. K. Whish, J. J. Fitzpatrick, and the Mining Department staff. Specifically, one has to cite the outstanding manner in which the cores and core samples have been stored and catalogued for easy access. It is quite unusual to be able to go back after more than six months and be able to select samples on which meaningful analyses and tests can be run, as was possible for this review.

Respectfully submitted,

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be diverted to nearby live and dead storage piles that can provide more quality control. It is anticipated that most of the blended product (normal fuel) will have a heating value ranging between 17.0 to 19.0 MJ/Kg, dcb, with an ash content ranging from 30.5 to 36.5 percent, dcb. During periods of air stagnation, a Meteorological Control System (MCS) coal, consisting of a low SO_2 type coal, will be burned.

It is anticipated that coal beneficiation will be limited to Level 1 type preparation, i.e., crushing to 50 mm size with use of Bradford (or equivalent) type breakers to remove rock, petrified wood, etc. To improve resource recovery, some low-grade coal (high ash content) may be upgraded by removal of high ash fines by a dry screening process; the upgraded coal will then be blended into the better quality plant coal.

III. COAL QUALITY

B. C. Hydro requested an audit of the quality data collected during the exploration programs from what they have designated as Pit No. 1 in the Hat Creek Area. The core analysis data were so voluminous that decision was made to carry out the audit in phases, making use of B. C. Hydro's computer data bank.

Since four (4) different laboratories were responsible for the bulk of the analyses, albeit over different periods of time and generally on different core samples, Weirco felt that the first phase should be devoted in evaluating the internal consistency of each laboratory's results as well as the reproducibility (comparison between laboratories) of their averages for the various quality characteristics analyzed. As a result of this evaluation, Weirco felt confident in excluding the results from one of the participating laboratories in the later phases of its evaluation. A study "Inter and Intra Laboratory Reproducibility, 1976, Hat Creek Coal Analyses" performed for B. C. Hydro by Dolmage Campbell & Associates, indicated a similar conclusion for the pre-1976 reliability for the same laboratory.

Actually, it was Weirco's intention to only exclude the results of the proximate analysis and calorific value (High Heat Value = HHV) determinations. Due to the time available for completing Weirco's assignment and that required for reprogramming the computer, it was easier for B. C. Hydro to exclude all analysis results reported by the designated laboratory. Weirco does not believe that this exclusion significantly affects its overall conclusions. In distributing the core samples to the various laboratories for analysis, B. C. Hydro was careful to make sure that these were not concentrated in any one zone or section of the proposed mining area, although not all laboratories participated to the same extent. The excluded laboratory's involvement was minimal.

Phase 1 - Reliability of Laboratory Results

Weirco requested that computer printouts for all analytical results be prepared by subzones for each of the four (4) participating laboratories, B. C. Hydro (site), Commercial Testing & Engineering Company (Vancouver, B. C. and others), General Testing Laboratories (Vancouver, B. C.) and Loring Laboratory Ltd. (Calgary, Alta.). This was done. Summary tabulations were also prepared showing the mean value, standard deviation from the mean, maximum and minimum values, number of samples, and core lengths involved for each of the characteristic quality values.

For its study, Weirco prepared the following Inter-Laboratory Comparison tables, Nos. 1 through 9:

(1) Moisture, %

(2) Ash, % (dcb = dry coal basis)

(3) Sulfur, % (dcb)

(4) HHV (dcb)

(5) HHV (MAF = moisture-ash-free)

(6) SiO_2, % of Ash

(7) Al_2O_3, % of Ash

(8) Fe_2O_3, % of Ash

(9) Na_2O, % of Ash (Standard Method)

Other tabulations could have been prepared, but these are believed to be the more important characteristic values for comparisons. As can be observed by examination of the respective data, the mean and standard deviation (s) are listed for each of the subzones under each of the laboratory headings. (In the moisture comparison tables, a separate column shows the mean Equilibrium Moisture values reported by CT&E.) Weirco has also calculated the zone and overall (O/A) area mean and s values. The bottom line ranks the laboratory O/A results from low to high. These rankings and the observed differences were employed as the criteria for excluding the indicated laboratory's results in the succeeding stages.

It should be pointed out at this point that the high variances (s^2) in the observed data resulted to a large extent from the fact that only half-splits of the cores were analyzed. Holes cored through inclined beds of varying dips will intersect different masses of material for the same true coal thicknesses represented. This results in unequal representation of the coal forming materials and their respective characteristic quality values in the whole core samples collected. These inequalities will be made evident when the analytical results from the individual core samples are combined to calculate the mean and variance of the coal from the area sampled. From Weirco's limited observations in the field, the Hat Creek cores exhibited great variability both vertically and laterally, not only within the zones but within the cores themselves. Variability was least in the "D" Zone cores.

B. C. Hydro sawed the cores in half to prepare vertical half-splits for analysis. This introduces another element of variability in the results. The coal forming materials were deposited in a somewhat random manner, which was affected by the various processes resulting in the deposit as it is found today. Therefore, unless whole cores are analyzed, variability dependent on the orientation of cut must be considered. For example, the halves of cores sawed along what had been the east-west alignment of the raw coal in the ground will be of significantly different quality than if the cores had been sawed in the former north-south alignment. Thus, one should expect that the variances of half-splits would be greater than obtains for whole cores.

Phase 2 - Regression Studies

In the preparation of the tables for Phase 1, the opportunity was taken to check apparently erratic results in the following determinations: equilibrium moisture, volatile matter, carbon dioxide (CO_2), HHV (KJ/Kg.), Hardgrove Grindability Index (HGI), and sodium oxide (Na_2O), both the water-soluble Na_2O in the coal and that as a percentage of the ash. Also, an apparent anomaly in the number of samples for each of the points measured in the Fusibility of Ash determinations was investigated. There were more results to average at the lower temperatures than at the higher temperature points. There should have been the same number of values averaged at all points.

It is well-known that correlations can be obtained between the ash content and the volatile matter, between the ash content and the HHV and, for the western coals, between the ash content and the CO_2 content. Less well-known is the relationship between ash content and equilibrium moisture, and that between moisture and ash content with the HGI of western coals. Furthermore, in recent years, Weirco has shown that the standard ashing technique results in the loss of the alkalies, with the result that the Na_2O and K_2O concentrations measured in the coal ash do not adequately indicate their corresponding concentration in the coal.

Regression Analyses

Consequently, at Weirco's recommendation, B. C. Hydro proceeded to run a number of regression analyses, after excluding the obviously anomalous sample data. The reported Volatile Matter contents were adjusted for the CO_2 content. The data for the ash vs. HHV regression analyses were segregated into two categories, (1) the ash content equal to or less than ($\leq$) 60%, and (2) the ash content greater than ($>$) 60%. Both the HHV-dcb and HHV-MAF data were tested separately versus the Ash content.

The following list the correlations obtained by B. C. Hydro:

Volatile Matter$_{(CO_2\ adj.)}$, % = 48.90 - 0.475 • Ash, %

CO_2, % = 0.058 • Ash, % - 0.269

Equilibrium Moisture, % = 25.145 - 0.0617 • Ash, %

As Received Moisture, % = 28.439 - 0.1566 • Ash, %

Hardgrove Grindability Index

Weirco calculated the following exponential curve equation as the best fit for the data obtained on ten (10) tightly controlled determinations for the HGI requested by Weirco:

$$HGI = 24.40\ e^{0.02 \cdot \text{Ash, \%}}$$

The coefficient of determination for the curve equation was 0.90. It should be pointed out here that due to the limited quantity of sample material available, only one HGI determination was made at the various ash levels, the moisture being adjusted as nearly as possible to an arbitrarily selected 10% level. The 10% moisture level is projected to be near the midpoint of the range of moisture contents of the coal particles in the plant pulverizers.

Fusibility of Ash (Ash Fusion)

As discussed earlier, there was an apparent anomaly in the calculated averages for the Fusibility of Ash determinations reported by B. C. Hydro. In checking it out, Weirco was informed that values > 1500° C were not considered in calculating the original mean values for the ash fusibility. (The excluded values were said to comprise twice the number included in the original averaging.) Since there were more of these indeterminate values as the test temperatures increase, it should not be surprising that more data points would be available at the lower temperatures. The result was that all calculated mean values were biased on the low side.

Though it has never been demonstrated that the arithmetic or weighted mean of the fusibility (fusion) temperatures are meaningful, assuming that they could be averaged, the question arises as to how to handle values beyond the highest temperature indicated or observable by the pyrometers used in the determination. For the pyrometers used, this highest temperature was 1500° C, and any temperature point not reached was listed as +1500° C.

It is known that the Fusion temperatures, namely, ID - initial deformation temperature, ST - softening temperature (where H = ½W), HT - hemispherical temperature (where H = W), and FT - fluid temperature, have been found to be functions of the concentrations of the mineral constituents of the coal ash.

These functions have been used to predict the fusion temperatures of coal mixtures. How accurate are these predictions is subject to conflicting opinions.

Weirco suggested as a first approximation that values for tests in which all four (4) points (for both reducing and oxidizing atmospheres) were actually measured at less than (<) 1500° C be used to calculate the mean of the differences for (ST - ID), (HT - ST), and (FT - HT). Then these mean differences were applied (added) to each of the reported +1500° C fusibility values from determinations in which less than four (4) points were indicated as having been measured. When this was completed, new mean values were recalculated for each zone.

Weirco wishes to emphasize here that these new adjusted mean values listed in Table No. 11 are the best available, in view of the rather imprecise nature of Fusibility determinations. Though the table indicates exclusion of the data from subzones A6 and C1, Weirco feels that the validity of the calculated ranges is not affected. The high ash values excluded all tend to have fusibility values greater than 1500° C. Weirco feels that the method recommended for adjusting the mean values and calculating the respective variances (standard deviations squared) more precisely defines the ranges, as the influence of "rogue" values on the lower end of the range is minimized.

Weirco therefore recommends the use of the range defined by two times the standard deviations (2s) from the means - the 95% confidence level - as a better indication than the mean value as to where the correct values might lie.

Sodium Oxide (Na2O)

Weirco, in previous work on western coals, has discovered a potential loss of alkali content during the standard ashing procedure. As a result, the Na_2O and K_2O percentages of the ash were felt to be too low. Consequently, adding the constituent percentages for the mineral analysis of ash, one generally finds that the sum is less than 100%. The loss of alkali content has been found to be related to the water-soluble alkali content of the coal, which apparently volatilizes during ashing and is not recovered for analysis.

A number of samples from each subzone were analyzed for the alkalies by two methods, the standard and a modified method developed by Weirco in conjunction with CT&E. Essentially, the chief difference in the modified method is that the determination for alkali in the coal ash is carried out on the same sample analyzed for the water-soluble alkali. The algebraic sum of the two values then constitutes the total alkali in the mineral analysis. The new sum obtained by adding the ash constitutes can now be 100 $\pm$ 0.5%, as one should expect.

Table No. 10 summarizes the 48 sets of data obtained in testing for Na_2O and K_2O content. Averages of Ash, %, Water-Soluble Alkali, and % Volatilized, were calculated for each subzone. These averages, for each subzone, were used to adjust the reported water-soluble and alkali mean values. On an overall average basis, 36.4% and 17.0% of the Na_2O and K_2O, respectively, was volatilized in the standard procedure. Zone D samples having the lowest ash content and being lowest stratigraphically exhibited the least loss.

From Weirco's studies on a number of western coals of different rank, the indications are 1) that though generally higher in Na_2O content, the deeper the coal is stratigraphically, the smaller is the percentage of the total Na_2O volatilized; and 2) it would appear that the volatilized Na_2O is associated with the coal --- possibly as humates --- with the result that with increasing ash content, the relative proportion of the Na_2O in the ash decreases. Volatilization, associated with water solubility, tends to be increasingly more pronounced in coals nearer the surface. The correlation between ash content and loss of alkali was used in making the adjustments.

Calorific Content (HHV)

Finally, while studying the summarized data for the Phase 1 studies, Weirco became aware of the fact that assumed values for the high heat value (HHV) had been used on samples which had either not been analyzed or for which only the ash content had been determined. A study by Dolmage-Campbell and others had developed a series of linear regression equations from which the assumed values were calculated. Unfortunately, no two of these equations seemed to be in agreement. Weirco felt that the lack of agreement was due to the assumption that there was a simple linear correlation between ash and HHV from the lowest to the highest ash content.

Though, it may be stated that there was little significance in the differences between the regression equations, Weirco is bound to use the best possible information over the widest range possible. Even if true, the lack of significance in the differences between the regression equations only holds for limited sections of the regression line, and is probably divergent at the ends.

Weirco was of the opinion that the carbon content contributing to the heat values was different in the high ash material ($>$ 60% ash) from that in the low ash material and therefore there should be at least two different correlations between Ash and HHV. Furthermore, it was reasonable to assume that less apparent heat would be evolved from the higher-ash carbon because of the greater concentration of carbonates in the higher-ash fractions. The breakdown of carbonates is accomplished by absorption of heat rather than its liberation.

Specifically, with the known higher concentrations of CO_2 in the high ash samples, the ash content of these samples tends to be understated, resulting in the consequent overstating of the Btu content. Segregation of the core analysis data between high and low ash content provided an opportunity to test this opinion.

The correlations by B. C. Hydro between ash content and HHV are listed as follow:

Ash, % $\leq$ 60%: HHV - MJ/Kg. (MAF) = 32.437 - 0.167 • Ash, % (dcb)
Ash, % > 60%: HHV - MJ/Kg. (MAF) = 80.596 - 0.898 • Ash, % (dcb)

MJ/Kg. = megajoules/kilogram (actually calculations carried out on kilojoules/kilogram. MJ obtained by dividing KJ by 1,000.)

1,000 Btu = 1.05506 MJ, and
1,000 Btu/lb. = 2.326 MJ/Kg.

Figure 1, immediately following, portrays the relationship between the two linear regression equations. The dotted lines indicate the range of corresponding values defined by $\pm s$ (one (1) standard deviation of the HHV). They also define the overlapping area caused by the intersection of the lines. Interestingly enough, the lowest point of the area occurs at just under 59% ash,

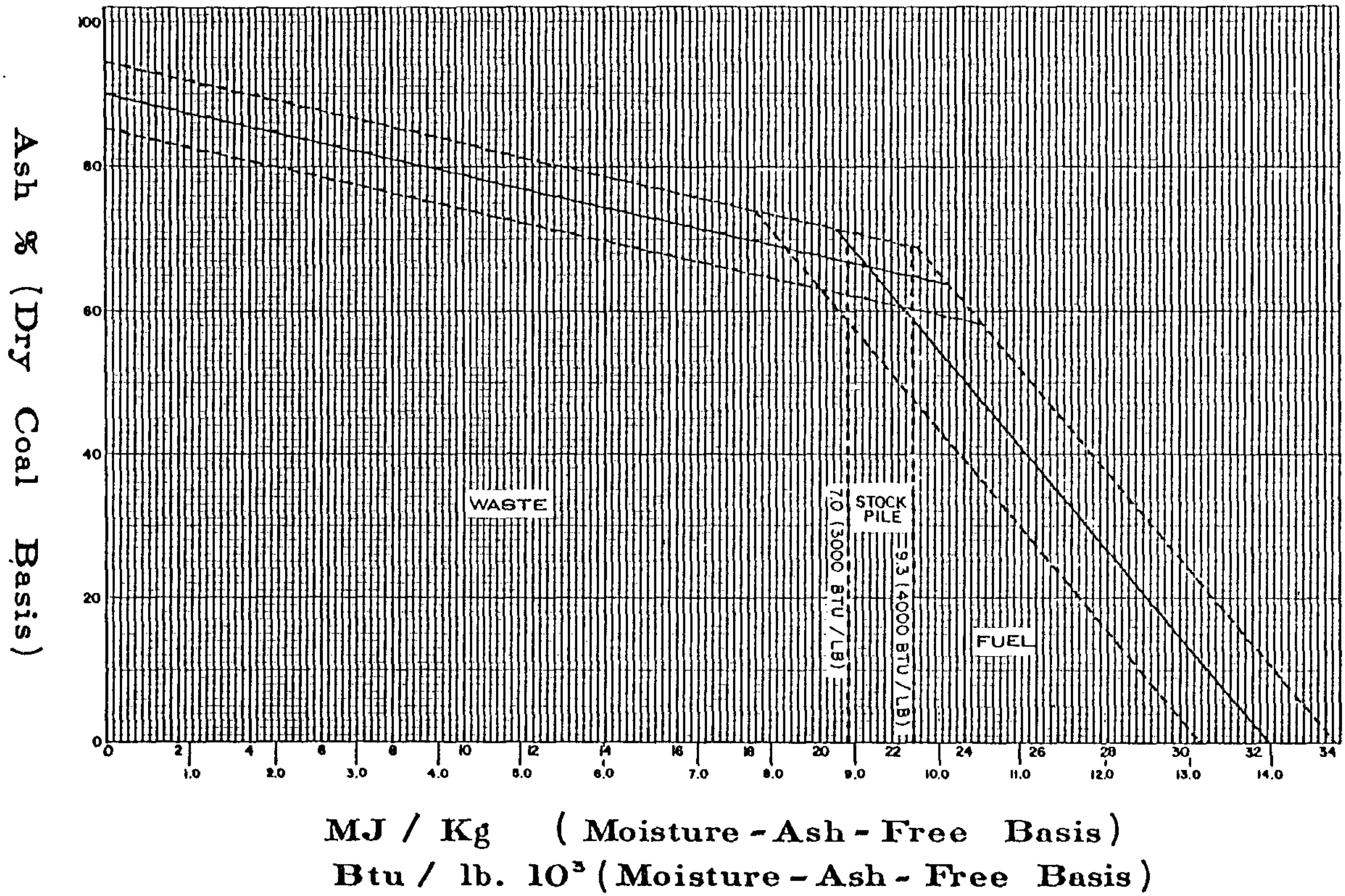
Ash % (Dry Coal Basis)
100
80
60
40
20
0
WASTE
STOCK PILE
7.0 (3000 BTU / LB)
9.3 (4000 BTU / LB)
FUEL
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34
1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0
MJ / Kg (Moisture - Ash - Free Basis)
Btu / lb. 10³ (Moisture - Ash - Free Basis)

FIGURE 1

which would seem to justify Weirco's use of 60% ash as the cut-off value between high and low ash. Also of interest is the fact that this overlapping area encompasses the range of low HHV material (between 7.0 and 9.3 MJ/Kg. (dcb)) which B. C. Hydro plans to stockpile. Presently, B. C. Hydro is investigating special handling and treatment alternatives for this material.

Phase 3 - Zone Mean Analyses

Upon completion of the preliminary studies, B. C. Hydro was requested to prepare summary analyses for each of the subzones. Then based on the projected distribution of the tons of coal for each subzone, summaries of coal quality by zones were calculated by Weirco. Visual examination of the cores had confirmed the impressions developed during the preliminary studies that certain of the subzones, namely, A6, C1 and, to a lesser extent, C2 were so dirty that selective mining should exclude the coal from these subzones from consideration as part of the specification fuel. Such exclusion would entail some decrease in the coal reserves.

These summaries segregated the results into two categories: 1) where the Ash, % (dcb) was equal to or less than ($\leq$) 60%, and 2) where the Ash, % was greater than ($>$) 60% ash. The former category represented the quality of the coal which Weirco believed could be mined selectively. The latter category represents the quality of excludable material, i.e. material if included in the run-of-mine (R.O.M.) coal would adversely affect (dilute) its quality.

Meanwhile, B. C. Hydro was redesigning its mining plan with one of its objectives being to improve the utilization of the resource by selective mining. This would involve exclusion of all bands or partings in excess of 2 meters and having a cut-off grade below 9.3 MJ/Kg. The new plan resulted in a revision of the coal distribution. Coincidentally, the new plan was said to offer better day-to-day control of the quality, though with acceptance of a slightly lower grade quality product. This made it necessary for Weirco to re-evaluate the quality of the Specification Fuel.

Table No. 12 summarizes by zones the characteristic coal quality values being projected for the Specification Fuel. Essentially, because of use of the cut-off grade, the calculated averages are for coal having less than 60% Ash content. Mean and standard deviation (s) from the mean values are listed. No dilution has been included in the calculations. Because of the difficulty in identification, Weirco feels that carbonaceous shale misidentified as coal during the drilling program would likewise be misidentified during mining. Consequently, the analytical values may be said to be already diluted. Therefore, assuming good supervision during mining and satisfactory blending, no additional mining dilution should be considered in projecting deliverable coal quality.

Table No. 13 shows the weighted composite analysis for the Pit No. 1 R.O.M. coal. Columns 2 and 3 list the mean and standard deviation values for all 16 subzones. Because of insufficiency of data, it is not possible to present "s" values for all characteristics. As was discussed earlier, ranges are listed rather than mean values for the fusion temperatures. Weirco cautions that in all cases, the true fusion mean values will approach the maximum end of the ranges.

Columns 4 and 5 are presented for comparison with the corresponding Column 2 values. Here, it is seen that, from a chemical point of view there may be little benefit derivable by exclusion of subzones A6, C1, and C2. As a group, observed differences are well within the ranges defined by 2s (the 95% confidence level). However, Weirco feels quite strongly that from a physical properties point of view, problems can be expected during handling of the materials from the subzones listed above. Weirco's visual examinations of the split-core samples and observations made in the test pit suggest the fact that when wet, it will be quite difficult to handle the Hat Creek clays on conveyors, in hoppers and bins, and through chutes and pipes.

In preparing Tables Nos. 12 and 13, use was made of the regression equations to adjust the volatile matter, the ultimate analyses -- except chlorine, sulfur, and ash -- and the HGI. The Na_2O and K_2O values shown were adjusted from the data developed from Table No. 10. The high heat values (HHV) on an equilibrium moisture basis were calculated by Weirco. The fusion temperature values (fusibility of ash) shown are the maximum (mean plus two times the standard deviation) and the minimum (mean minus two times the standard deviation) values defining the range. For the purposes of the study, the fusion values have all been rounded off to the next higher value divisible by 10.

The forms of sulfur values for each of the four major zones were obtained from a special computer study. Summaries were prepared by B. C. Hydro including all data falling entirely with the zones. Samples spanning the zone boundaries were excluded. Adjustments were made by Weirco to the values calculated for the pyritic and organic sulfur forms. This was necessary in order to resolve the discrepancy between the total sulfur contents calculated from the special study and the corresponding values determined in the overall audit.

Table No. 14 summarizes the coal characteristic values obtained on the >60% ash samples for each of the four main zones.

The quality data shown represent values for excludable material, i.e., material if mined and included with the R.O.M. coal would adversely affect (dilute) the R.O.M. quality. As indicated elsewhere, Weirco feels that this category includes carbonaceous shale.

Because of difficulty in identifying carbonaceous shale in situ, it will be mined with the coal. Hence, additional mining dilution need not be considered in projecting deliverable coal quality, especially in view of the fact that during the early period of the drilling program, carbonaceous shale may not have been identified as such. Consequently, it was probably included in those samples analyzed as coal samples. The analytical results undoubtedly reflect the inadvertent dilution of the samples.

Table No. 15 summarizes the characteristic composite quality values calculated for the four zones. The values for the > 60% ash coal correspond to those listed in Table No. 13, columns 4 and 5, for the selective mining case. The observed differences are negligible. Weirco feels that, as in Table No. 13, there should be little significant difference between the data tabulated -- with certain specified subzone data excluded -- and the corresponding averages which could be, though were not, calculated to include all subzone data.

In preparing Tables Nos. 12 through 15, use was made of the regression equations to adjust the volatile matter, the ultimate analyses -- except chlorine, sulfur, and ash -- and the HGI. The Na_2O and K_2O values shown were adjusted from the data developed from Table No. 10. The HHV -- as received and equilibrium moisture bases -- are values calculated by Weirco.

Summary

The Paul Weir Company has conducted a technical audit of the quality data obtained to date during the exploration of the Hat Creek, British Columbia, proposed mining area. The chief purpose of the audit was to assess and modify as necessary B. C. Hydro's Boiler Fuel Specification Data.

During its studies, Weirco became convinced that selective mining could be employed to improve B. C. Hydro's projected coal quality and this report addresses itself to that premise. However, lowering the ash content of the proposed boiler fuel is not without its drawback. Weirco's studies confirmed its appraisal of the fact, observed in work for others, that the reported sodium content of the coal was too low. Consequently, the recalculated Na_2O value, especially for the D Zone coal, points to the possibility of difficulty with slagging at times in burning the Hat Creek coal.

At this time, Weirco could not recommend coal preparation beyond Level 2 cleaning. (Level 2 cleaning entails dry screening at about 3/8-inch, followed by washing of the +3/8-inch only. The 3/8" x 0 is recombined with the washed $\pm$3/8-inch coal.) Certainly the effecting of a sulfur reduction of a few hundredths of a percent -- below the accepted 95% level of reproducibility of the analytical methods -- cannot justify the loss of heat value resulting from the increased moisture content of the Boiler feed. This does not take into account the problem of supplying water to do the washing nor of handling the wetted products during the hard-freeze season. Nor does it take into account environmental problems, such as water clarification and recycling, or abatement and control of potential air pollution during thermal drying of the coal to alleviate or prevent freezing of the washed coal.

Though, Weirco was instructed not to study the matter of coal preparation, in view of the fact that frequent references to the subject were made by B. C. Hydro personnel, Weirco felt constrained to touch on the subject based on its experience.

(1) The purpose of beneficiation is to upgrade the overall product with maximum coal recovery.

Washing will add roughly 3 to 8 percent to the weight of the product as water - depending on the percentage of fines in the product. The more fines, the greater will be the moisture content. Thus, there needs to be a much greater reduction in the ash content (projected by CANMET ~ 16.5%) to offset the inerting effects of the water during combustion. It takes roughly four times as many Btu to raise the temperature of one pound of water than it does to raise the temperature of one pound of ash the same number of degrees, not to mention the latent heat required to evaporate that pound of water.

As for sulfur reduction, to obtain a 25 percent reduction in the sulfur content, one would have to wash the Hat Creek coal --- averaging 0.51 percent sulfur (dcb) --- to about 0.38 percent, or a reduction of 0.13 percent sulfur. The Weirco study confirmed the Dolmage-Campbell estimate, based on limited analyses, that the pyritic sulfur content -- the only sulfur component subject to reduction by physical means --- averaged 25 percent of the total sulfur. Thus, a 25 percent sulfur reduction would require a 100 percent reduction in pyritic sulfur content. This figure is not too likely to be approached. pyritic sulfur removal will average 50 percent, with 80 percent removal approaching the maximum possible.

CANMET's report (A Pilot-Scale Feasibility Study on Water-Only Washing of Hat Creek Coal - April, 1978) did <u>not</u> suggest a 25 percent reduction in sulfur by washing, although such a statement was made. The figure reported by CANMET was an overall reduction of 11 percent total sulfur.

It was only when the sulfur was expressed as lb. Sulfur/M Btu were reductions of 25 percent achieved. However, it should be pointed out that the sulfur content of the Hat Creek coals washed was almost twice that of the Pit No. 1 average -- 0.51. As pointed out by CANMET, the reduction will be a function of the sulfur concentrations in the coal. Since the organic sulfur content ranges from 0.20 to 0.52 and this sulfur form tends to approach a constant for a given coal, it would appear that the potential for sulfur reduction by washing is minimal. In fact, the CANMET report strongly suggests the probability of a sulfur increase when washing the A and C coals. These are the coals which are in greatest need of beneficiation.

(2) As also pointed out by CANMET, their report is based on laboratory study of raw coal crushed to a topsize below that normally encountered in commercial practice and then only when dealing with metallurgical coal. Projections based on such tests are risky.

As for Level 2 cleaning, Weirco cannot hold much hope for significant benefit. Potentially, the only improvement in quality would come about through discarding the -½" material by screening. As previously indicated, B. C. Hydro is currently investigating the application of a screening process to upgrade low grade coal in order to eliminate the planned low grade stockpile. This is the most difficult size to screen, especially the ¼" x 0 when wet. Since the ½" x 0 fraction is a significant percentage of the total potential feed, such screening is not recommended. There is one benefit, albeit a minor one, which could be gained by using a rotary breaker to effect size reduction of the mine product. This would permit scalping off the silicified (petrified) wood found in the overburden. However, Weirco feels that offsetting this benefit is the fact that the bulk of the breaker rejects could be coal, which tends to be harder than the associated refuse material.

Table No. 1

INTER-LABORATORY COMPARISONS

MOISTURE, %

Subzone	CT&E Total (a.r.) Mean	CT&E Total (a.r.) ±s	CT&E Equilibrium Mean	General Testing Mean	General Testing ±s	Loring Mean	Loring ±s
A1	25.39	3.58	19.90	23.82	6.19	20.21	6.98
A2	24.76	3.47	23.27	22.37	4.14	19.29	6.11
A3	22.96	3.49	21.65	19.51	5.09	17.62	6.02
A4	22.00	3.26	20.69	18.08	5.51	19.66	7.41
A5	21.23	4.03	21.50	19.66	4.44	16.16	6.75
A6	19.24	4.07	N.D.	16.33	3.99	18.92	3.39
Mean Zone	22.60	3.65	21.27	19.68	4.91	18.41	6.61
B1	22.43	2.65	22.04	19.48	4.07	23.83	7.93
B2	21.88	3.09	22.02	18.09	4.90	24.54	5.71
Mean Zone	22.11	2.91	22.03	18.90	4.44	24.27	6.65
C1	18.17	6.97	19.91	10.26	3.23	15.13	6.32
C2	19.06	4.90	21.00	15.03	3.50	23.39	4.18
C3	21.12	4.89	21.19	17.43	3.93	20.09	6.61
C4	21.34	3.69	22.65	17.97	3.69	23.77	4.70
Mean Zone	20.14	5.00	21.15	15.88	3.63	22.08	5.15
D1	23.83	3.63	20.59	20.91	3.54	24.68	4.28
D2	23.80	2.96	N.D.	21.11	5.12	23.87	4.07
D3	25.48	3.65	25.23	20.96	3.92	24.56	4.82
D4	24.76	3.61	24.32	20.92	4.69	24.72	5.39
Mean Zone	24.40	3.45	23.38	20.99	4.45	24.44	4.66
O/A Mean Area	22.91	3.67	22.18	19.55	4.44	22.87	5.47
Rankings	(3)	(1)	-	(1)	(2)	(2)	(3)

Table No. 2

INTER-LABORATORY COMPARISONS

ASH, % (dcb)

Subzone	BCHPA Mean	BCHPA ±s	CT&E Mean	CT&E ±s	General Testing Mean	General Testing ±s	Loring Mean	Loring ±s
A1	34.13	17.65	36.68	18.76	35.04	17.21	32.39	21.30
A2	38.38	13.72	36.77	12.00	33.34	7.57	43.06	17.20
A3	45.76	16.75	48.92	14.22	45.39	15.03	49.68	13.20
A4	41.69	16.59	43.23	13.59	44.91	17.94	45.75	19.93
A5	42.66	16.61	47.29	13.16	42.58	15.89	50.45	13.03
A6	59.34	12.81	61.10	9.65	56.02	8.95	73.20	12.12
Mean Zone	41.49	16.17	44.47	13.96	42.79	15.32	48.35	16.68
B1	35.31	15.94	35.64	9.92	29.53	9.50	43.68	21.55
B2	38.80	16.30	37.02	12.41	33.60	13.21	39.31	18.77
Mean Zone	37.80	16.12	36.43	11.42	31.24	11.21	40.98	19.88
C1	62.75	11.77	58.10	10.45	56.16	9.19	70.16	17.12
C2	50.87	13.82	55.16	11.39	48.81	8.76	51.82	12.73
C3	46.19	14.69	50.43	13.36	48.71	9.32	54.04	11.20
C4	45.23	12.87	50.14	11.40	50.52	10.86	49.10	13.66
Mean Zone	50.94	13.22	52.92	11.74	50.60	9.77	53.04	13.28
D1	29.99	12.90	29.17	11.77	29.18	12.04	29.51	9.58
D2	21.97	9.09	24.47	8.92	24.32	9.96	21.63	7.49
D3	19.18	10.72	18.83	8.16	18.13	7.48	17.72	5.49
D4	24.29	11.75	25.70	10.80	24.48	8.42	23.39	9.34
Mean Zone	23.88	11.04	24.78	10.05	23.56	9.46	23.18	8.23
O/A Mean Area	37.87	14.89	36.63	10.99	33.15	11.33	35.92	13.20
Rankings	(4)	(4)	(3)	(1)	(1)	(2)	(2)	(3)

Table No. 3

INTER-LABORATORY COMPARISONS

SULFUR, % (dcb)

Subzone	BCHPA Mean	BCHPA ±s	CT&E Mean	CT&E ±s	General Testing Mean	General Testing ±s	Loring Mean	Loring ±s
A1	0.88	0.45	0.68	0.48	0.60	0.20	0.80	0.36
A2	0.79	0.31	0.72	0.26	0.76	0.18	0.99	0.37
A3	0.69	0.44	0.63	0.24	0.58	0.19	0.67	0.22
A4	0.67	0.29	0.58	0.21	0.60	0.26	0.84	0.57
A5	0.74	0.33	0.69	0.26	0.78	0.32	0.74	0.25
A6	0.52	0.32	0.53	0.19	0.64	0.15	0.56	0.38
Mean Zone	0.74	0.36	0.65	0.28	0.68	0.26	0.78	0.41
B1	0.65	0.30	0.64	0.28	0.88	0.61	0.58	0.21
B2	0.64	0.38	0.63	0.36	0.77	0.23	0.83	0.81
Mean Zone	0.65	0.34	0.63	0.33	0.83	0.49	0.73	0.65
C1	0.45	0.56	0.46	0.22	0.53	0.13	0.30	0.11
C2	0.45	0.32	0.47	0.18	0.70	0.30	0.54	0.28
C3	0.33	0.16	0.40	0.25	0.39	0.20	0.34	0.14
C4	0.39	0.52	0.48	0.38	0.27	0.08	0.44	0.33
Mean Zone	0.41	0.44	0.45	0.28	0.45	0.19	0.44	0.27
D1	0.22	0.08	0.35	0.26	0.37	0.29	0.30	0.13
D2	0.21	0.12	0.29	0.21	0.28	0.14	0.28	0.08
D3	0.24	0.08	0.30	0.13	0.30	0.08	0.38	0.14
D4	0.35	0.16	0.37	0.12	0.43	0.12	0.43	0.12
Mean Zone	0.25	0.11	0.33	0.19	0.34	0.16	0.35	0.12
O/A Mean Area	0.58	0.33	0.50	0.26	0.52	0.28	0.50	0.34
Rankings	(4)	(3)	(1)	(1)	(3)	(2)	(2)	(4)

Table No. 4

INTER-LABORATORY COMPARISONS

HHV (dcb) - KJ/KG

Subzone	BCHPA Mean	BCHPA ±s	CT&E Mean	CT&E ±s	General Testing Mean	General Testing ±s	Loring Mean	Loring ±s
A1	17,675	5,934	16,907	6,154	17,614	5,380	18,130	7,126
A2	16,265	4,592	16,903	3,851	18,093	2,449	14,935	5,489
A3	13,827	5,572	12,926	4,678	14,203	4,797	12,275	4,679
A4	15,291	5,513	14,643	4,415	14,356	5,796	13,620	7,044
A5	14,960	5,586	13,390	4,601	15,020	5,241	12,267	4,411
A6	9,333	4,257	8,756	3,163	10,834	2,769	4,776	3,307
Mean Zone	15,292	5,408	14,316	4,644	15,021	4,961	12,881	5,699
B1	17,368	<5,643	17,341	3,403	19,355	3,291	14,506	7,187
B2	16,303	<5,440	16,832	4,354	17,844	4,802	16,150	6,482
Mean Zone	16,853	<5,546	17,048	3,979	18,721	3,995	15,520	6,761
C1	8,334	3,987	9,572	3,976	10,407	2,761	5,264	5,379
C2	12,220	4,943	10,528	3,890	12,563	2,815	11,678	4,529
C3	13,284	<5,262	12,368	4,497	12,836	<3,299	10,702	4,730
C4	13,771	<4,498	12,149	3,908	12,430	3,458	12,170	4,929
Mean Zone	12,015	<4,652	11,325	4,063	12,227	<3,165	11,044	4,804
D1	19,271	4,919	19,673	3,992	19,597	4,361	19,307	3,482
D2	22,130	3,478	21,392	<3,096	21,373	<3,535	22,218	2,601
D3	23,210	3,768	23,401	3,227	23,560	2,678	23,680	2,079
D4	21,717	3,999	21,216	3,821	21,420	2,931	21,828	3,446
Mean Zone	21,549	4,053	21,331	<3,553	21,655	<3,371	21,719	2,989
O/A Mean Area	16,630	<5,092	17,091	<4,067	18,280	<3,856	17,219	4,607
Rankings	(4)	(4)	(3)	(2)	(1)	(1)	(2)	(3)

Table No. 5

INTER-LABORATORY COMPARISONS

HHV (MAF) - KJ/KG

Subzone	BCHPA Mean	BCHPA ±s	CT&E Mean	CT&E ±s	General Testing Mean	General Testing ±s	Loring Mean	Loring ±s
A1	26,344	3,284	26,078	2,966	26,706	1,976	25,688	3,636
A2	26,074	2,409	26,497	2,692	27,080	718	25,314	4,432
A3	24,719	3,649	24,756	3,770	25,543	2,115	23,879	3,276
A4	25,616	3,556	25,359	2,339	25,303	2,625	23,768	5,883
A5	25,372	3,782	24,885	2,975	25,645	2,588	24,288	3,325
A6	21,775	5,110	21,899	4,186	24,446	1,300	17,323	4,342
Mean Zone	25,457	3,491	25,209	3,016	25,718	2,269	23,739	4,527
B1	26,411	<4,476	26,766	1,449	27,347	1,356	23,944	5,252
B2	26,115	<3,401	26,395	2,637	26,617	3,595	25,945	4,643
Mean Zone	26,268	<3,992	26,552	2,213	27,041	2,548	25,178	4,885
C1	21,621	4,045	22,090	4,984	23,480	1,658	14,433	8,186
C2	24,450	4,376	22,859	4,116	24,431	2,375	23,454	3,692
C3	23,332	<5,975	24,203	3,746	24,673	<2,703	22,338	6,029
C4	24,659	<3,932	23,750	2,974	24,806	1,749	23,008	3,717
Mean Zone	23,657	<4,502	23,332	3,874	24,470	<2,139	22,199	4,834
D1	27,287	3,884	27,582	1,514	27,368	2,284	27,122	1,702
D2	28,276	2,378	28,234	<1,083	28,120	<1,237	28,288	827
D3	28,520	1,753	28,733	2,994	28,730	876	28,747	910
D4	28,471	2,315	28,426	1,825	28,282	993	28,367	1,778
Mean Zone	28,112	2,732	28,217	<1,912	28,185	<1,370	28,126	1,384
O/A Mean Area	26,011	<3,550	26,350	<2,660	26,889	<1,735	25,795	3,534
Rankings	(3)	(4)	(2)	(2)	(1)	(1)	(4)	(3)

Table No. 6

INTER-LABORATORY COMPARISONS

SiO_2, % OF ASH

Subzone	CT&E Mean	CT&E ±s	General Testing Mean	General Testing ±s	Loring Mean	Loring ±s
A1	51.34	8.35	49.47	7.16	48.60	10.78
A2	50.76	3.86	49.89	4.04	61.46	3.79
A3	53.64	4.32	49.76	4.33	48.99	9.90
A4	53.74	5.33	48.66	6.29	48.79	11.41
A5	54.39	5.17	49.25	7.86	52.97	4.70
A6	55.60	5.42	52.05	4.32	54.04	6.55
Mean Zone	53.22	5.44	49.42	6.34	52.02	8.48
B1	53.56	5.08	47.59	7.14	52.65	5.92
B2	51.64	7.55	49.09	8.46	52.06	9.72
Mean Zone	52.57	6.47	48.16	7.67	52.28	8.30
C1	53.33	3.78	51.09	4.84	50.51	19.49
C2	64.51	9.70	49.99	6.51	54.32	7.14
C3	53.74	3.54	52.50	3.43	57.94	4.47
C4	49.20	7.83	51.03	6.47	50.14	10.98
Mean Zone	56.45	7.61	51.11	5.75	53.00	9.92
D1	50.35	7.49	47.56	6.19	53.29	7.59
D2	49.84	4.74	51.07	5.27	50.04	4.76
D3	52.34	5.29	51.40	9.41	55.14	4.79
D4	61.14	8.61	61.43	4.84	60.78	7.40
Mean Zone	53.06	6.70	53.18	6.80	55.17	6.36
O/A Mean Area	53.40	6.23	51.43	6.73	53.59	7.87
Rankings	2	1	1	2	3	3

Table No. 7

INTER-LABORATORY COMPARISONS

Al_2O_3, % OF ASH

Subzone	CT&E Mean	CT&E ±s	General Testing Mean	General Testing ±s	Loring Mean	Loring ±s
A1	27.55	5.11	24.73	4.26	27.18	5.52
A2	30.96	2.76	29.74	1.81	21.08	2.44
A3	30.05	3.56	26.84	3.27	23.69	6.69
A4	28.85	3.52	26.31	4.64	27.91	6.76
A5	28.49	3.90	23.69	4.39	28.31	2.20
A6	26.97	3.72	25.23	2.18	24.42	3.47
Mean Zone	29.03	3.78	25.83	3.95	26.26	4.98
B1	30.45	5.02	25.28	4.36	27.83	4.28
B2	28.76	5.85	27.14	6.37	26.91	5.96
Mean Zone	29.58	5.46	25.98	5.21	27.25	5.39
C1	24.91	6.04	24.25	2.68	23.80	7.89
C2	19.82	3.80	25.71	3.84	28.03	3.61
C3	28.12	3.38	26.43	2.30	26.09	2.01
C4	28.20	4.38	26.33	3.80	26.22	6.47
Mean Zone	24.60	4.23	25.93	3.40	26.67	5.16
D1	29.25	5.87	26.95	3.63	30.05	4.11
D2	32.90	4.17	28.21	3.87	29.57	3.72
D3	28.17	5.82	25.37	4.75	23.18	4.47
D4	24.15	4.44	23.92	3.85	22.74	2.89
Mean Zone	28.81	5.17	26.08	4.10	26.16	3.82
O/A Mean Area	28.60	4.55	26.00	4.18	26.47	4.64
Rankings	3	2	1	1	2	3

Table No. 8

INTER-LABORATORY COMPARISONS

Fe_2O_3, % OF ASH

Subzone	CT&E Mean	CT&E ±s	General Testing Mean	General Testing ±s	Loring Mean	Loring ±s
A1	9.08	6.26	8.18	6.87	6.43	1.89
A2	7.76	3.89	7.44	4.07	3.62	1.72
A3	8.05	3.62	9.56	3.75	14.59	12.72
A4	7.62	3.60	9.55	4.59	9.65	5.93
A5	8.37	4.35	13.46	8.35	8.73	4.81
A6	8.45	5.71	10.77	4.73	9.85	8.53
Mean Zone	8.15	4.23	10.44	6.08	9.05	6.72
B1	7.15	6.21	11.29	7.43	7.26	2.92
B2	9.81	8.48	10.01	4.33	10.26	10.16
Mean Zone	8.52	7.47	10.81	6.43	9.14	8.24
C1	8.70	3.44	12.21	3.74	13.50	17.00
C2	3.82	1.53	10.08	3.98	8.21	5.91
C3	8.43	4.00	9.67	3.57	6.18	3.89
C4	10.85	7.19	10.78	6.72	12.00	10.61
Mean Zone	7.42	4.55	10.56	5.20	9.76	9.03
D1	9.21	7.93	9.35	6.76	6.79	6.14
D2	7.48	5.32	8.33	6.20	6.77	5.08
D3	7.84	5.20	8.89	10.41	7.79	4.18
D4	5.88	4.98	3.79	2.54	5.50	5.19
Mean Zone	7.71	6.11	7.52	7.21	6.67	5.20
O/A Mean Area	8.00	5.44	8.97	6.65	8.15	6.89
Rankings	(1)	(1)	(3)	(2)	(2)	(3)

Table No. 9

INTER-LABORATORY COMPARISONS

Na_2O, % OF ASH

(STANDARD METHOD)

Subzone	CT&E Mean	CT&E ±s	General Testing Mean	General Testing ±s	Loring Mean	Loring ±s
A1	0.92	0.35	1.78	0.63	1.37	0.25
A2	0.85	0.21	1.18	0.64	2.68	0.67
A3	0.78	0.27	0.62	0.17	2.12	0.73
A4	0.87	0.24	0.85	0.21	1.76	1.01
A5	0.89	0.30	0.69	0.27	2.10	0.81
A6	0.87	0.16	0.71	0.08	1.23	0.28
Mean Zone	0.86	0.27	0.87	0.35	1.93	0.80
B1	1.08	0.35	0.86	0.29	1.34	0.52
B2	0.96	0.39	1.10	0.40	1.21	0.26
Mean Zone	1.02	0.37	0.95	0.33	1.26	0.38
C1	0.57	0.28	1.13	0.23	1.10	0.40
C2	0.95	0.23	0.81	0.08	1.31	0.79
C3	0.80	0.32	0.76	0.28	1.55	0.86
C4	0.87	0.23	0.97	0.43	1.39	0.61
Mean Zone	0.83	0.26	0.91	0.32	1.36	0.71
D1	1.08	0.37	0.85	0.36	1.91	0.67
D2	1.52	0.54	1.43	0.43	2.65	0.57
D3	1.95	0.75	1.80	0.72	3.14	1.11
D4	1.51	0.55	1.59	0.55	2.98	1.26
Mean Zone	1.50	0.56	1.48	0.55	2.67	0.97
O/A Mean Area	1.08	0.39	1.20	0.46	2.04	0.81
Rankings	1	1	2	2	3	3

Table No. 10

SUMMARY OF COMPARISON: 1) STANDARD VS. MODIFIED METHODS FOR ALKALIES IN COAL
2) CT&E VS. BCHPA SITE LABORATORY RESULTS

Hole No.	Subzone No.	BCHPA Ident. No.	CT&E Ident. No. 71-	"B" Sulfur, % dcb	"C" Sulfur, % dcb	"B" Btu/Lb. dcb	"B" Btu/Lb. MAF	"C" Btu/Lb. dcb	"C" Btu/Lb. MAF	"B" Ash, % dcb	"C" Standard Ash, % dcb	"C" Standard Na_2O, %	"C" Standard K_2O, %	Residual Ash, % dcb	Residual Na_2O, % "Ash"	Residual K_2O, % "Ash"	Water Soluble Na_2O, % "Ash"	Water Soluble K_2O, % "Ash"	Calculated Total Na_2O, % "Ash"	Calculated Total K_2O, % "Ash"	% Volatilized Na_2O	% Volatilized K_2O
77-242	A1	164A	29704	-	2.75	8,207	11,756	7,942	11,545	30.19	31.21	0.42	0.71	29.66	0.50	0.85	0.240	0.147	0.72	0.96	41.7	26.0
	A1	165A	29705	-	1.44	7,397	11,547	7,027	11,332	35.94	37.99	0.60	0.72	35.77	0.55	0.91	0.445	0.076	0.96	0.93	37.5	22.6
77-247	A1	173A	29713	-	0.78	6,176	10,824	6,171	10,697	41.54	42.31	0.84	0.60	40.31	1.06	0.69	0.295	0.057	1.31	0.71	35.9	13.5
77-242	A2	166A	29706	-	0.66	6,138	10,969	5,909	10,773	44.04	45.15	0.59	0.75	42.65	0.53	0.85	0.414	0.053	0.91	0.86	35.2	10.7
77-247	A2	174A	29714	-	0.84	7,483	11,416	7,411	11,229	34.45	34.00	0.56	0.75	32.15	0.50	0.85	0.453	0.071	0.93	0.87	19.8	13.8
77-242	A3	167A	29707	-	0.45	5,237	10,346	5,174	10,469	49.38	50.58	0.65	0.80	48.00	0.55	0.85	0.380	0.042	0.90	0.85	50.0	5.9
77-247	A3	175A	29715	-	0.51	6,411	10,659	6,313	10,932	40.96	42.25	0.60	0.71	40.05	0.58	0.81	0.349	0.045	0.89	0.83	32.6	14.5
77-242	A4	168A	29708	-	0.49	6,728	11,121	6,478	11,303	39.50	41.69	0.75	0.75	39.70	0.70	0.83	0.405	0.030	1.06	0.80	29.2	6.2
77-247	A4	176A	29716	-	0.38	6,867	11,188	6,677	11,204	38.42	40.46	0.70	0.75	37.90	0.60	0.85	0.366	0.042	0.93	0.86	24.7	10.7
77-242	A5	169A	29709	-	0.83	5,720	10,807	5,569	10,776	47.07	48.32	0.61	0.78	45.35	0.55	0.81	0.519	0.056	1.04	0.87	41.3	4.9
77-247	A5	177A	29717	-	0.57	5,931	10,985	5,846	10,838	46.01	46.06	0.71	0.81	43.71	0.65	0.90	0.441	0.052	1.06	0.91	33.0	11.0
77-242	A6	170A	29710	-	0.29	1,583	6,435	1,469	6,877	75.40	78.64	0.77	1.20	76.75	0.85	1.25	0.283	0.036	1.11	1.26	30.6	4.8
77-247	A6	178A	29718	-	0.62	4,364	9,811	4,429	10,329	55.52	57.12	0.63	0.83	54.90	0.55	0.96	0.403	0.074	0.93	1.00	40.9	4.0
78-289	A6	145A	29685	-	0.55	4,298	10,555	3,990	10,094	59.28	60.47	0.34	0.90	57.78	0.48	0.96	0.111	0.021	0.57	0.94	40.4	6.3
77-242	B1	171A	29711	-	0.94	6,762	11,063	6,718	11,352	38.88	40.82	0.47	0.72	38.59	0.55	0.77	0.568	0.032	1.09	0.76	60.8	5.3
77-247	B1	179A	29719	-	0.73	7,756	11,512	7,715	11,476	32.61	32.77	0.73	0.62	30.40	0.55	0.70	0.656	0.137	1.17	0.79	37.6	21.5
78-289	B1	146A	29686	-	0.70	7,725	11,540	7,546	11,645	33.06	35.20	0.60	0.58	31.70	0.65	0.73	0.137	0.023	0.92	0.68	34.8	14.7
77-242	B2	172A	29712	-	0.68	4,911	10,218	4,933	10,449	51.94	52.79	0.65	0.65	50.74	0.55	0.80	0.468	0.023	1.00	0.79	35.0	17.7
77-247	B2	180A	29720	-	0.77	6,307	9,52077	7,493	11,551	33.75	35.13	0.84	0.55	33.36	0.50	0.67	0.734	0.105	1.21	0.74	30.6	25.7
78-289	B2	147A	29687	-	0.69	7,044	11,378	6,832	11,463	38.09	40.60	0.62	0.80	35.90	0.70	0.90	0.329	0.017	0.95	0.82	34.7	2.4

Table No. 10 (Continued)

Hole No.	Subzone No.	BCHPA Ident. No.	CT&E Ident. No. 75-	"B" Sulfur, % dcb	"C" Sulfur, % dcb	"B" Btu/Lb. dcb	"B" Btu/Lb. MAF	"C" Btu/Lb. dcb	"C" Btu/Lb. MAF	"B" Ash, % dcb	"C" Standard Ash, % dcb	"C" Standard Na_2O, %	"C" Standard K_2O, %	Residual Ash, % dcb	Residual Na_2O, % "Ash"	Residual K_2O, % "Ash"	Water Soluble Na_2O, % "Ash"	Water Soluble K_2O, % "Ash"	Calculated Total Na_2O, % "Ash"	Calculated Total K_2O, % "Ash"	% Volatilized Na_2O	% Volatilized K_2O
77-247	C1	181A	29721	-	0.39	1,933	7,157	1,962	7,404	72.99	73.77	0.34	1.13	73.00	0.40	1.77	0.245	0.039	0.64	1.30	46.9	11.5
78-289	C1	148A	29688	-	0.66	3,028	8,706	2,801'	8,469	65.21	66.89	0.55	0.80	65.64	0.60	0.95	0.369	0.034	0.96	0.97	42.7	17.5
78-292	C1	156A	29696	-	0.35	5,725	11,029	5,966	11,208	48.09	46.77	0.50	0.60	44.00	0.40	0.70	0.231	0.011	0.80	0.67	37.5	10.4
77-247	C2	182A	29722	-	0.40	4,928	10,148	5,063	10,675	51.44	52.59	0.40	0.70	48.70	0.45	0.93	0.371	0.037	0.79	0.92	49.4	23.9
78-289	C2	149A	29689	-	0.48	4,280	10,301	4,064	10,270	58.43	60.46	0.53	0.86	57.08	0.60	1.08	0.207	0.012	0.77	0.96	32.2	30.6
78-292	C2	157A	29697	-	0.19	7,187	11,534	7,080	11,533	37.69	38.61	0.66	0.60	36.30	0.73	0.67	0.355	0.016	1.04	0.65	36.5	7.7
77-247	C3	183A	29723	-	0.32	4,482	10,120	4,431	10,397	55.71	57.30	0.42	0.73	54.48	0.30	0.87	0.380	0.037	0.86	0.87	51.2	13.8
78-289	C3	150A	29690	-	0.19	3,750	9,372	3,733	9,504	59.99	60.72	0.53	0.93	58.10	0.40	1.10	0.290	0.013	0.86	1.07	36.0	11.7
78-292	C3	158A	29698	-	0.30	6,617	11,108	6,412	10,938	40.43	41.38	0.40	0.43	38.69	0.30	0.55	0.334	0.015	0.80	0.53	50.0	15.1
77-247	C4	184A	29724	-	0.19	5,319	10,483	5,270	10,553	49.27	50.06	0.35	0.56	47.08	0.41	0.70	0.447	0.050	0.83	0.71	57.8	21.1
78-289	C4	151A	29691	-	0.19	5,172	10,674	5,057	10,671	51.79	52.61	0.56	0.78	47.86	0.45	0.91	0.236	0.011	0.83	0.86	32.5	9.3
78-292	C4	159A	29699	-	0.28	8,365	11,716	8,321	11,825	28.77	29.63	0.58	0.48	27.75	0.45	0.53	0.429	0.020	1.04	0.52	44.2	7.7
77-247	D1	185A	29725	-	0.23	8,489	11,886	8,434	11,966	28.58	29.35	0.88	0.36	27.25	0.55	0.43	0.678	0.048	1.19	0.45	26.1	20.0
78-289	D1	152A	29692	-	0.27	8,453	11,897	8,350	11,813	28.95	30.16	0.48	0.40	27.81	0.75	0.56	0.434	0.017	1.13	0.53	39.8	32.5
78-292	D1	160A	29700	-	0.17	9,219	12,175	8,993	11,996	24.28	25.02	0.84	0.31	22.40	0.89	0.65	0.469	0.020	1.26	0.42	33.3	26.7
77-240	D1	141A	29681	-	0.22	6,787	11,132	6,738	11,048	39.75	39.01	0.98	0.75	37.30	0.89	0.75	0.450	0.021	1.28	0.74	23.4	-1.4
77-247	D2	186A	29726	-	0.25	8,543	12,062	8,465	12,043	29.16	29.72	0.80	0.31	27.66	0.60	0.43	0.673	0.040	1.23	0.44	35.0	39.5
78-289	D2	153A	29693	-	0.19	9,377	12,339	9,342	12,093	21.75	22.75	0.98	0.35	21.15	0.95	0.45	0.620	0.022	1.50	0.44	34.7	20.5
78-292	D2	161A	29701	-	0.20	10,038	12,267	9,884	12,252	18.24	19.32	0.99	0.227	18.08	1.03	0.43	0.359	0.021	1.52	0.62	34.9	67.6
77-240	D2	142A	29682	-	0.25	7,633	11,498	7,437	11,292	33.44	34.14	0.88	0.65	31.35	0.75	0.45	0.326	0.023	1.20	0.62	26.7	-4.8
77-247	D3	187A	29727	-	0.25	10,142	12,310	10,167	12,390	17.61	17.94	1.43	0.30	16.76	1.15	0.43	0.803	0.039	1.88	0.44	23.9	31.8
78-289	D3	154A	29694	-	0.22	10,095	12,400	9,988	12,304	18.59	18.90	1.27	0.40	17.35	1.35	0.51	0.852	0.026	2.08	0.49	30.9	18.4
78-292	D3	162A	29702	-	0.25	10,317	12,557	10,176	12,455	17.84	18.70	1.23	0.20	17.56	1.10	0.30	0.599	0.016	1.63	0.30	24.5	33.3
77-240	D3	143A	29683	-	0.23	9,496	12,037	*9,301	11,832	21.11	21.39	1.43	0.50	19.41	1.25	0.75	0.785	0.028	1.92	0.71	25.5	29.6
77-247	D4	188A	29728	-	0.36	9,805	12,418	9,835	12,468	21.04	21.12	1.23	0.20	19.65	1.20	0.38	0.651	0.041	1.77	0.39	30.5	48.7
78-289	D4	155A	29695	-	0.23	10,202	12,486	10,008	12,365	18.29	19.06	1.34	0.25	17.44	1.40	0.36	0.740	0.016	2.02	0.35	33.7	28.6
78-292	D4	163A	29703	-	0.36	9,440	12,525	9,237	12,431	24.63	25.53	1.08	0.20	23.43	1.05	0.35	0.670	0.012	1.43	0.33	26.5	39.4
77-240	D4	144A	29684	-	0.42	9,204	11,880	9,041	11,868	22.51	23.82	1.43	0.52	21.10	1.15	0.63	0.898	0.029	2.09	0.61	31.6	14.8

General Note:

B.C. Hydro did not analyze for sulfur content.

Table No. 11

HAT CREEK SUMMARY - FUSIBILITY OF ASH, °C (1)

	Zone A(a) Range(b)		Zone B Range(b)		Zone C(c) Range(b)		Composite Zones A-B-C(a)(c) Range(b)		Zone D Range(b)		Composite Zones A-B-C-D(a)(c) Range(b)	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Selective Mining Case - (Ash, % ≤ 60)												
Reducing Atmosphere												
ID - Initial Deformation	1500+	1140	1500+	1190	1500+	1160	1500+	1170	1500+	1160	1500+	1170
ST - Softening (H=W)	1500+	1190	1500+	1230	1500+	1210	1500+	1220	1500+	1200	1500+	1210
HT - Hemispherical (H=½W)	1500+	1230	1500+	1270	1500+	1230	1500+	1250	1500+	1230	1500+	1250
FT - Fluid	1500+	1270	1500+	1310	1500+	1270	1500+	1290	1500+	1270	1500+	1290
Oxidizing Atmosphere												
ID - Initial Deformation	1500+	1300	1500+	1300	1500+	1260	1500+	1290	1500+	1330	1500+	1310
ST - Softening (H=W)	1500+	1330	1500+	1310	1500+	1280	1500+	1310	1500+	1340	1500+	1330
HT - Hemispherical (H=½W)	1500+	1360	1500+	1330	1500+	1290	1500+	1330	1500+	1350	1500+	1340
FT - Fluid	1500+	1390	1500+	1340	1500+	1310	1500+	1350	1500+	1360	1500+	1360
(Ash, % > 60)												
Reducing Atmosphere												
ID - Initial Deformation	1500+	1260	1500+	1160	1500+	1180	1500+	1210	1500+	1430	1500+	1310
ST - Softening (H=W)	1500+	1300	1500+	1200	1500+	1210	1500+	1240	1500+	1490	1500+	1360
HT - Hemispherical (H=½W)	1500+	1350	1500+	1280	1500+	1220	1500+	1290	1500+	1500	1500+	1390
FT - Fluid	1500+	1390	1500+	1330	1500+	1240	1500+	1330	1500+	1500+	1500+	1420
Oxidizing Atmosphere												
ID - Initial Deformation	1500+	1420	1500	1500	1500+	1210	1500+	1410	N.A.		N.D.	
ST - Softening (H=W)	1500+	1460	1500+	1500+	1500+	1220	1500+	1440	N.A.		N.D.	
HT - Hemispherical (H=½W)	1500+	1490	1500+	1500+	1500+	1240	1500+	1490	N.A.		N.D.	
FT - Fluid	1500+	1500+	1500+	1500+	1500+	1250	1500+	1500+	N.A.		N.D.	

Notes:

(1) Rounded to next higher 10 - Adjusts for samples whose 4 fusibility values are >1500 °C.

(a) Zone A6 values excluded.

(b) Weighted mean value ±2 x s (Standard Deviation).

(c) Zone C1 values excluded.

N.A. Not Analyzed

N.D. Not Determined (Use Composite A-B-C (a)(c)).

Table No. 12

HAT CREEK SUMMARY: ZONE ANALYSES

SELECTIVE MINING

(ASH, % ≤ 60)

	Zone A		Zone B		Zone C		Zone D	
	Mean	±S	Mean	±S	Mean	±S	Mean	±S
Moisture, %								
Equilibrium	22.7	4.3	23.1	2.6	22.4	0.6	23.6	4.8
As Received	22.2	4.3	23.2	3.3	21.4	3.9	24.6	4.0
Proximate Analysis, % (dcb)								
Ash	39.9	11.6	33.5	10.8	45.0	9.6	24.6	9.0
Volatile Matter(a)	29.9	5.5	33.0	5.1	27.5	4.6	37.2	4.2
Fixed Carbon	30.2	6.1	33.5	5.7	27.5	4.9	38.2	4.7
Ultimate Analysis, % (dcb)								
Carbon	40.6	8.7	45.6	8.9	36.0	7.1	54.3	7.1
Hydrogen	3.4	0.6	3.6	0.5	3.0	0.5	4.0	0.4
Nitrogen	0.9	0.3	0.9	0.2	0.5	0.2	0.8	0.1
Chlorine	0.04	0.06	0.02	0.01	0.01	0.01	0.02	0.03
Oxygen (Difference)	14.5	-	15.7	-	14.3	-	16.0	-
Sulfur Forms, % (dcb)								
Pyritic	0.22	0.16	0.20	0.35	0.11	0.12	0.04	0.09
Sulfate	0.02	0.02	0.03	0.02	0.01	-	0.02	0.03
Organic	0.50	0.20	0.44	0.20	0.31	0.17	0.24	0.10
Total	0.74	0.27	0.67	0.47	0.43	0.25	0.30	0.13
High Heat Value - MJ/Kg								
Equilibrium Moisture Basis	12.2	3.9	13.8	3.3	11.0	3.3	16.1	3.6
Dry Coal Basis	15.8	4.0	18.0	3.7	14.0	3.4	21.3	3.2
MAF Basis	26.3	1.8	27.0	1.6	25.4	2.3	28.3	1.3
HGI @ 10% Moisture	31	-	45	-	56	-	38	-
Mineral Analysis Of Ash, %								
SiO_2 (Acid)	51.8	6.3	52.3	6.4	52.1	7.3	54.1	7.7
Al_2O_3 (Acid)	28.9	4.3	28.8	5.0	27.8	4.5	27.5	3.6
TiO_2 (Acid)	1.0	0.3	1.0	0.3	1.0	0.3	1.0	0.3
Fe_2O_3 (Base)	8.6	5.6	8.6	6.6	10.0	7.7	7.2	5.9
CaO (Base)	3.1	4.1	3.2	4.2	3.2	4.2	3.9	2.6
MgO (Base)	1.7	0.6	1.6	0.7	1.7	0.7	1.2	0.5
K_2O (Base)	0.8	0.3	0.8	0.3	0.8	0.3	0.4	0.2
Na_2O (Base)	1.3	1.0	1.5	0.6	1.3	0.7	2.9	1.5
P_2O_5	0.3	0.3	0.2	0.3	0.2	0.2	0.1	0.1
SO_3	1.9	1.3	1.8	1.2	1.3	0.8	2.0	1.0
Mn_3O_4	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2
V_2O_5	0.1	0.1	0.1	< 0.1	0.1	< 0.1	0.1	0.1
Base Acid Ratio	0.196	-	0.195	-	0.216	-	0.189	-
T_{250} °C	1300	-	1300	-	1475	-	1510	-
Water Soluble Alkalies, % (dcb)								
Na_2O	0.412	0.044	0.605	0.022	0.360	-	0.640	0.041
K_2O	0.067	0.033	0.164	0.242	0.028	-	0.026	-
CO_2, % (dcb)(b)	1.8	2.3	1.7	2.4	2.7	3.0	1.2	1.3
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Fusibility Of Ash, °C (Range)								
Reducing - ID	1500+	1140	1500+	1190	1500+	1160	1500+	1160
ST	1500+	1190	1500+	1230	1500+	1210	1500+	1200
HT	1500+	1230	1500+	1270	1500+	1230	1500+	1230
FT	1500+	1270	1500+	1310	1500+	1270	1500+	1270
Oxidizing - ID	1500+	1300	1500+	1300	1500+	1260	1500+	1330
ST	1500+	1330	1500+	1310	1500+	1250	1500+	1340
HT	1500+	1360	1500+	1330	1500+	1290	1500+	1350
FT	1500+	1390	1500+	1340	1500+	1310	1500+	1360

Notes:

dcb = dry coal basis.

(a) Adjusted for CO_2 (From regression equation for linear fit).

(b) From regression equation for exponential fit.

Table No. 13

HAT CREEK PIT NO. 1 COMPOSITE ANALYSES
SELECTIVE MINING(a)
(ASH, % ≤ 50)

	Zone Composite Mean	Zone Composite ±S	Zone Composite Mean(b)	Zone Composite Mean(c)
Moisture, %				
Equilibrium	23.1	4.0	23.1	23.1
As Received	23.2	4.0	23.2	23.3
Proximate Analysis, % (dcb)				
Ash	33.5	10.0	33.1	32.5
Volatile Matter	33.0	4.3	33.2	33.5
Fixed Carbon	33.5	5.2	33.7	34.0
Ultimate Analysis, % (dcb)				
Carbon	46.2	7.3	46.5	47.0
Hydrogen	3.6	0.5	3.6	3.6
Nitrogen	0.9	0.2	0.9	0.9
Chlorine	0.03	0.03	0.03	0.03
Oxygen (Difference)	15.4	-	15.4	15.4
Sulfur Forms, % (dcb)				
Pyritic	0.13	0.19	0.13	0.13
Sulfate	0.02	0.02	0.02	0.02
Organic	0.36	0.16	0.36	0.36
Total	0.51	0.25	0.51	0.51
High Heat Value - MJ/Kg				
Equilibrium Moisture Basis	14.0	3.6	14.0	14.2
Dry Coal Basis	18.1	3.5	18.2	18.4
MAF Basis	27.2	1.6	27.2	27.3
HGI @ 10% Moisture	45	-	45	45
Mineral Analysis Of Ash, %				
SiO_2 (Acid)	52.6	7.0	52.9	52.5
Al_2O_3 (Acid)	28.3	5.0	28.2	28.2
TiO_2 (Acid)	1.0	0.3	1.0	1.0
Fe_2O_3 (Base)	3.5	6.2	3.2	3.5
CaO (Base)	3.4	3.7	3.5	3.4
MgO (Base)	1.5	0.6	1.5	1.5
K_2O (Base)	0.7	0.3	0.6	0.6
Na_2O (Base)	2.1	1.1	2.2	2.1
P_2O_5	0.2	0.2	0.2	0.2
SO_3	1.8	1.1	1.8	1.8
Mn_3O_4	0.2	0.2	0.2	0.2
V_2O_5	0.1	$<$ 0.1	0.1	0.1
Base Acid Ratio	0.197	-	0.196	0.198
T_{250}, °C	1500	-	1500	1495
Water Soluble Alkalies, % (dcb)				
Na_2O	0.507	0.035	0.535	0.524
K_2O	0.069	-	0.062	0.072
CO_2, % (dcb)	1.5	2.1	1.7	1.7
	Max.	**Min.**	**Max.**	**Min.**
Fusibility Of Ash, °C (Range)				
Reducing - ID	1500+	1170	-	-
ST (H=W)	1500+	1210	-	-
HT (H=½ W)	1500+	1250	-	-
FT	1500+	1290	-	-
Oxidizing - ID	1500+	1310	-	-
ST (H=W)	1500+	1330	-	-
HT (H=W)	1500+	1340	-	-
FT	1500+	1360	-	-

Notes:

dcb= dry coal basis
(a) Assumes mining of all bands ≥2 metres and below cut off grade - 9.3 MJ/Kg.
(b) Excluding A6, C1.
(c) Excluding A6, C1, C2.

Table No. 14

HAT CREEK SUMMARY ANALYSES

(Ash, % > 60)

SELECTIVE MINING CASE

	Zone A (a) Mean	Zone A $\pm s$	Zone B Mean	Zone B $\pm s$	Zone C_1 (b) Mean	Zone C_1 (b) $\pm s$	Zone C_2 (c) Mean	Zone C_2 (c) $\pm s$
Moisture, %								
Equilibrium	24.06	4.25	N.A.	-	N.A.	-	N.A.	-
As Received	17.14	6.18	19.01	7.16	20.37	6.05	20.68	6.09
Proximate Analysis, % (dcb)								
Ash	67.67	6.17	68.61	6.81	66.71	4.86	66.62	4.89
Volatile Matter (d)	16.76	2.93	16.31	3.24	17.21	2.31	17.26	2.32
Fixed Carbon	15.57	3.24	15.08	3.57	16.08	2.55	16.12	2.57
Ultimate Analysis, %								
Carbon (dcb)	18.41	4.27	18.63	3.35	18.35	4.17	18.11	4.04
Hydrogen (dcb)	2.04	0.25	1.81	0.32	1.94	0.30	1.95	0.33
Nitrogen (dcb)	0.48	0.17	0.46	0.11	0.55	0.22	0.64	0.29
Chlorine (dcb)	0.05	0.03	0.01	0.01	0.02	0.02	0.02	0.03
Sulfur (dcb)	0.50	0.27	0.53	0.28	0.30	0.20	0.26	0.19
Ash (dcb)	67.67	6.17	68.61	6.81	66.71	4.86	66.62	4.89
Oxygen (diff.)	10.85	-	9.95	-	12.13	-	12.40	-
CO_2, % (dcb)	2.16	2.20	4.55	7.61	3.79	4.21	3.55	4.01
Mineral Analysis of Ash, %								
SiO_2 (Acid)	55.80	4.41	53.82	9.62	54.16	7.15	54.12	5.80
Al_2O_3 (Acid)	28.08	3.23	26.06	5.73	26.40	3.37	26.11	3.93
TiO_2 (Acid)	0.97	0.28	0.94	0.30	0.93	0.20	0.93	0.21
Fe_2O_3 (Base)	7.66	3.27	10.48	9.93	7.81	3.29	7.43	3.30
CaO (Base)	2.08	2.20	2.53	4.14	4.44	6.97	5.04	6.29
MgO (Base)	1.52	0.52	1.64	0.85	1.81	1.03	1.72	0.53
K_2O (Base)	1.22	0.49	1.34	0.28	1.29	0.36	1.25	0.41
Na_2O (Base)	1.56	0.75	2.19	0.60	2.03	1.35	2.23	1.37
P_2O_5	0.23	0.21	0.11	0.09	0.22	0.51	0.23	0.08
SO_3	0.88	0.50	0.95	0.26	0.77	0.32	0.64	0.18
Mn_3O_4	0.09	0.07	0.25	0.80	0.13	0.09	0.13	0.09
V_2O_5	0.04	-	0.04	0.01	0.03	0.01	0.03	0.02
Base:Acid Ratio	0.166		0.225		0.213		0.218	
T_{250}, °C.	1,555		1,475		1,490		1,485	
Water-Soluble Alkalies, % (dcb)								
Na_2O	0.41	-	N.A.	-	0.33	-	0.33	-
K_2O	0.03	-	N.A.	-	0.02	-	0.02	-
HHV - MJ/Kg.								
As Received Basis	5.54	2.55	5.12	2.63	5.28	2.11	5.19	2.12
Equilibrium Moisture Basis	5.08	1.71	N.A.		N.A.		N.A.	
Dry Coal Basis	6.69	1.92	6.33	2.21	6.63	1.78	6.54	1.86
Moisture-Ash-Free Basis	20.23	3.23	19.60	3.96	19.59	3.49	19.23	3.77
HGI @ 10% Moisture (e)	80	-	81	-	78	-	78	-

Notes:
(a) A-6 Excluded.
(b) C_1 Excluded.
(c) C_1-C_2 Excluded.
(d) Adjusted for CO_2 (from Regression Equation for Linear fit).
(e) From Regression Equation for Exponential fit.

Table No. 14 (Cont'd.)

HAT CREEK SUMMARY ANALYSES

(Ash, % >60)

SELECTIVE MINING CASE

	Zone D		Composite Zones (a)(b) A-B-C_1		Composite Zones (a)(c) A-B-C_2	
	Mean	±s	Mean	±s	Mean	±s
Moisture, %						
Equilibrium	N.A.	-	-	-	-	-
As Received	20.10	5.04	18.86	6.43	18.52	6.54
Proximate Analysis, % (dcb)						
Ash	69.30	5.24	67.59	5.93	67.80	6.19
Volatile Matter (d)	15.98	2.49	16.79	2.82	16.70	2.94
Fixed Carbon	14.72	2.75	15.62	3.11	15.50	3.25
Ultimate Analysis, %						
Carbon (dcb)	N.A.	-	18.45	3.99	18.43	3.91
Hydrogen (dcb)	N.A.	-	1.94	0.29	1.94	0.29
Nitrogen (dcb)	N.A.	-	0.50	0.18	0.50	0.18
Chlorine (dcb)	N.A.	-	0.03	0.02	0.03	0.02
Sulfur (dcb)	0.17	0.05	0.44	0.25	0.46	0.26
Ash (dcb)	69.30	5.24	67.59	5.93	67.80	6.19
Oxygen (diff.)	N.A.	-	11.05	-	10.84	-
CO_2, % (dcb)	4.31	9.10	3.44	4.98	3.30	5.13
Mineral Analysis of Ash, % (f)						
SiO_2 (Acid)	(54.08)	-	54.35	8.04	54.75	7.00
Al_2O_3 (Acid)	(27.52)	-	26.89	4.16	26.95	4.43
TiO_2 (Acid)	(0.99)	-	0.95	0.26	0.94	0.28
Fe_2O_3 (Base)	(7.22)	-	8.54	6.03	8.65	6.56
CaO (Base)	(3.91)	-	3.06	4.92	2.71	4.02
MgO (Base)	(1.21)	-	1.66	0.83	1.60	0.56
K_2O (Base)	(0.35)	-	1.28	0.39	1.27	0.41
Na_2O (Base)	(2.95)	-	1.91	0.98	1.92	0.75
P_2O_5	(0.09)	-	0.19	0.33	0.19	0.15
SO_3	(1.95)	-	0.86	0.38	0.86	0.37
Mn_3O_4	(0.20)	-	0.15	0.44	0.16	0.49
V_2O_5	(0.06)	-	0.04	0.01	0.04	0.01
Base:Acid Ratio	(0.189)		0.200		0.195	
T_{250}, °C.	(1,510)		1,500		1,505	
Water-Soluble Alkalies, % (dcb)						
Na_2O	N.A.		~ 0.37	-	~ 0.38	-
K_2O	N.A.		~ 0.03	-	~ 0.02	-
HHV - MJ/Kg.						
As Received Basis	4.69	2.01	5.33	2.50	5.32	2.50
Equilibrium Moisture Basis	N.A.		-	-	-	-
Dry Coal Basis	5.87	2.04	6.56	2.01	6.53	2.02
Moisture-Ash-Free Basis	18.77	4.84	19.91	3.60	19.80	3.62
HGI @ 10% Moisture (e)	82	-	80	-	80	-

Notes:
(a) A-6 Excluded.
(b) C_1 Excluded.
(c) C_1-C_2 Excluded.
(d) Adjusted for CO_2 (from Regression Equation for Linear fit).
(e) From Regression Equation for Exponential fit.
(f) (Analyses Not Available); assumed same values as for Selective Mining Case (Ash,% ≤ 60).

Table No. 15

HAT CREEK SUMMARY ANALYSES

(Ash, % ≥ 60)

TOTAL AREA NO. 1

SELECTIVE MINING CASE

	Composite Zones (a)(b) A, B, C_1, D Mean	σ	Composite Zones (a)(c) A, B, C_2, D Mean	σ
Moisture, %				
Equilibrium	N.A.		N.A.	
As Received	18.98	6.31	18.71	6.38
Proximate Analysis, % (dcb)				
Ash	67.76	5.77	67.98	6.08
Volatile Matter (d)	16.71	2.79	16.61	2.89
Fixed Carbon	15.53	2.98	15.41	3.19
Ultimate Analysis (calc.), %				
Carbon (dcb)	18.40	3.98	18.38	3.90
Hydrogen (dcb)	1.94	0.29	1.93	0.29
Nitrogen (dcb)	0.50	0.18	0.50	0.18
Chlorine (dcb)	0.03	0.02	0.03	0.02
Sulfur (dcb)	0.41	0.24	0.43	0.24
Ash (dcb)	67.76	5.77	67.98	6.08
Oxygen (diff.)	10.96	-	10.75	-
CO_2, % (dcb)	3.52	5.32	3.42	5.75
Mineral Analysis of Ash, %				
SiO_2 (Acid)	54.32	8.0	54.67	7.0
Al_2O_3 (Acid)	26.95	4.2	27.02	4.4
TiO_2 (Acid)	0.95	0.3	0.95	0.3
Fe_2O_3 (Base)	8.41	6.0	8.48	6.6
CaO (Base)	3.14	4.9	2.86	4.0
MgO (Base)	1.62	0.8	1.55	0.7
K_2O (Base)	1.19	0.4	1.16	0.4
Na_2O (Base)	2.01	1.0	2.05	0.8
P_2O_5	0.18	0.3	0.18	0.2
SO_3	0.97	0.4	0.99	0.4
Mn_3O_4	0.15	0.4	0.16	0.5
V_2O_5	0.04	0.01	0.04	0.01
Base:Acid Ratio	0.199		0.195	
T_{250}, °C.	1,500		1,505	
Water-Soluble Alkalies, % (dcb)				
Na_2O	~ 0.37	-	~ 0.38	-
K_2O	~ 0.03	-	~ 0.03	-
HHV - MJ/Kg.				
As Received Basis	5.27	2.46	5.24	2.45
Equilibrium Moisture Basis	N.A.		N.A.	
Dry Coal Basis	6.49	2.01	6.45	2.02
Moisture-Ash-Free Basis	19.80	3.74	19.68	3.79
HGI @ 10% Moisture (e)	80	-	80	-

Notes:
(a) A-6 Excluded.
(b) C_1 Excluded.
(c) C_1-C_2 Excluded.
(d) Adjusted for CO_2 (from Regression Equation for Linear fit).
(e) From Regression Equation for Exponential fit.

IV. MINING

General

The geological complexity of the Hat Creek deposit makes mine planning a critical consideration in determining the run-of-mine (ROM) coal quality. Wide variations in the in-situ quality coupled with the high rate of production (10 million tonnes per year) projected for the project can lead to a highly fluctuating product quality.

Data

The following geological data were provided by B.C. Hydro:

a. Plan map of drill hole locations.
b. Geophysical logs of 11 drill holes.
c. Thirteen cross-section drawings.
d. Computer listings of quality data by subzone.

The following data on mine planning were also provided:

1. A plan map of the proposed 35-year pit.

2. Bench plans for four elevations (820, 835, 850, and 865).

3. Computer listings showing coal quality for all blocks for six bench elevations (797, 812, 827, 842, 857, and 872). These listings include quality data for both geologic and minable coal with and without consideration of selective mining.

4. A "Summary of Mining Sequences" showing how quality fluctuations are smoothed out by the mining sequence.

In addition to reviewing the above listed data, a field trip was made to the Hat Creek project site to examine drill cores and to view the test pit excavations. Weirco personnel present on this field visit were: M. P. Corriveau, A. F. Duzy and D. L. Schaible.

Investigation

Examination of the quality data and drill cores pointed out three subzones which had such undesirable characteristics that for the purposes of this study it was decided to exclude these subzones in their entirety. Subzones A-6 and C-1 were rejected because of their very high average ash content. Subzone C-2 also exhibits high ash content but it was also rejected due to a high clay content. This clay content will cause severe handling problems in mining and conveying this material particularly under wet conditions. It is quite possible that certain portions of Sub-zones A-6, C-1 and C-2 may be selectively mined without major adverse effects on the ROM coal quality. However, the impact on coal quality would be slight and will not affect the results of our study.

The core examinations also showed that it is possible to visually differentiate the very high ash waste material from the coal. This indicates that the ROM coal quality can be up-graded by the application of selective mining practices. It was decided to use the computer to simulate the effects of selective mining. All samples which had a dry ash content of 60 percent or higher and which also were at least 2-m. thick were rejected as waste. We feel that the effects of dilution have been "built in" due to the sampling procedures which have included significant quantities of waste material in the samples along with the good quality coal. This included waste is not identifiable by the com-puter and, thusly, cannot be eliminated by the "+60 percent, +2-m." criteria, even though much of it will be rejected during actual mining operations. Therefore, no further allowance was made for dilution.

The actual simulation was done by MINTEC, Inc. of Tucson, Arizona. MINTEC has devised a block model system in which the maximum block dimensions are 150 m. by 200 m. Six horizontal mining benches (15-m. high) were superimposed on this block model and a computer listing was made which presented coal quality data for each bench by coal zones and by blocks. These six benches are the same as those listed in Item 3 under mining planning data on page 2. A summary of the sulfur and ash content for these six benches is shown in Table No. 16.

MINTEC also supplied plan maps for the four benches listed on page 1 in Item 2 under the mine planning data. These maps show the locations of the various blocks within the 35-year mining limits. Using the data from the computer listings the dry ash content was plotted for each block on all four of the bench plan maps. These maps were then reviewed to determine the fluctuations in ash content which will occur as the benches are mined at the rate of 40,000 tonnes per day.

Summary

The ROM coal quality will fluctuate on both a short-term and long-term basis.

The short-term fluctuations are the daily or weekly swings in quality which are a function of where the coal is being mined from a given bench or series of benches during that day or week. The long-term fluctuations are those changes in coal quality which occur from year to year and are a function of the overall project mining sequence. The quality of the coal varies laterally and stratigraphically over the Hat Creek deposit. This variability, coupled with the geologic structural features, result in a trend toward lower ash at the lower elevations. The data in Table No. 16 illustrate this trend for six benches near the middle elevations of the 35-year pit.

B. C. Hydro, in an attempt to balance the coal quality variations, has devised a preliminary mining sequence which begins near the middle elevations and progresses into both upper and lower levels each year. This concept should result in a fairly uniform coal quality on an annual basis. Based on Weirco's review of the data contained in the "Summary of Mining Sequences," we estimate maximum annual fluctuations of ± 3.0 percentage points in the dry ash content in the ROM coal. The effect of these variations would be to raise or lower the annual average heating value (dry coal basis) by approximately 1.0 MJ/Kg from the field average.

In our opinion, if access to all of the coal zones is maintained as detailed in the annual mining plan, on a weekly basis the dry ash content can probably be controlled to approximately ± 1.5 percentage points. The corresponding swings in the heating value will be:

± 2.0 MJ/Kg daily; and ± 1.5 MJ/Kg weekly.

As a final consideration as to the manner in which mining interfaces with the quality, Weirco was asked to evaluate the bulk density of the coal. This information is vital to the correct estimation of the quantity of the coal and how it is to be handled (stored and conveyed) for delivery to the power plant.

Insofar as bulk density is concerned, probably the best information to obtain that value was developed in B.C. Hydro's exploration program. During that program, bulk samples were tested by float-sink fractionations to determine the washability characteristics of the Hat Creek coal. Using the specific gravity (relative density) vs. yield, % curves drawn from the float-sink test results, it can be shown that at the 50 percent yield point, the specific gravity of the coal tested ranged from 1.525 to 1.555. Now, if it is assumed that the bulk samples were representative, the bulk densitites can be calculated. The following list the averages of the principal values of interest:

Coal In Place	1,525 Kg./m^3
Crushed ROM (Loose Pack)	760 Kg./m^3
Crushed ROM (Compacted)	1,090 Kg./m^3

Recommendations

The following items are recommended to aid in defining and controlling the quality of the Hat Creek coal:

1. Run analyses on bench plans from upper, intermediate, and lower elevations to verify (and quantify) the ash-depth correlation for all subzones.

2. For planning purposes, eliminate subzones A-6, C-1, and C-2 from the reserve base. (Some coal recovery from these subzones may be attempted after the mine is in operation.)

3. Specify loading and hauling equipment in numbers and sizes which will be capable of separating the coal and waste down to 1.0-to 1.5-m. thicknesses.

4. Develop a mining plan which will expose as many bench levels as is economically practicable.

Table No. 16

HAT CREEK PROJECT

SULFUR AND ASH CONTENT BY BENCHES (DRY COAL BASIS)

	Elevation 792'			Elevation 812'			Elevation 822'		
Subzone	Tons x 10^3	Ash, %	Sulfur, %	Tons x 10^3	Ash, %	Sulfur, %	Tons x 10^3	Ash, %	Sulfur, %
A-1	133	30.2	0.71	641	33.4	0.73	843	34.0	0.76
A-2	943	33.4	0.76	910	33.4	0.78	1,020	33.4	0.78
A-3	879	44.5	0.72	1,062	44.2	0.71	1,194	43.8	0.69
A-4	1,144	38.3	0.65	1,366	37.5	0.65	1,530	37.0	0.68
A-5	1,735	41.2	0.79	2,136	41.8	0.77	2,267	41.1	0.77
A-6	377	47.2	0.63	376	46.9	0.61	408	46.0	0.63
B-1	2,888	30.6	0.58	3,243	29.7	0.57	3,700	29.4	0.67
B-2	4,008	33.2	0.56	3,816	32.6	0.59	3,688	32.5	0.61
C-1	393	43.8	0.50	676	44.6	0.48	433	44.6	0.52
C-2	1,052	43.1	0.48	1,068	43.5	0.50	867	43.8	0.51
C-3	1,076	42.6	0.35	1,069	43.2	0.40	966	43.9	0.39
C-4	1,391	41.4	0.37	1,349	42.2	0.38	1,250	42.9	0.37
D-1	3,257	23.3	0.31	2,863	28.9	0.33	3,163	28.4	0.31
D-2	3,491	22.2	0.28	4,000	21.6	0.29	3,494	21.8	0.28
D-3	3,004	18.7	0.36	2,389	18.4	0.32	1,908	18.2	0.32
D-4	1,833	26.0	0.38	1,777	24.0	0.38	1,714	23.8	0.39
Totals	27,756	34.3	0.47	28,746	35.7	0.49	28,465	35.9	0.51
Adjusted Totals (1)	25,732	30.3	0.47	26,621	30.7	0.49	26,717	31.8	0.51

	Elevation 842'			Elevation 857'			Elevation 872'			Six Bench Totals And Weighted Average		
Subzone	Tons x 10^3	Ash, %	Sulfur, %	Tons x 10^3	Ash, %	Sulfur, %	Tons x 10^3	Ash, %	Sulfur, %	Tons x 10^3	Ash, %	Sulfur, %
A-1	798	33.4	0.77	849	32.6	0.80	1,039	32.1	0.84	4,303	33.0	0.78
A-2	1,157	33.7	0.78	1,217	34.0	0.77	1,140	33.9	0.77	6,387	33.7	0.77
A-3	1,188	43.6	0.68	1,345	43.7	0.65	1,170	43.6	0.65	6,238	43.9	0.68
A-4	1,415	38.2	0.68	1,270	37.4	0.70	1,160	37.6	0.71	7,885	37.7	0.68
A-5	1,966	43.9	0.79	1,579	43.2	0.78	1,303	43.7	0.78	12,064	41.9	0.78
A-6	462	45.4	0.63	333	48.2	0.65	226	51.3	0.67	2,180	47.2	0.64
B-1	2,737	29.5	0.66	1,719	30.5	0.73	1,362	31.9	0.75	15,686	30.0	0.62
B-2	2,938	31.7	0.70	1,831	35.0	0.76	1,382	37.8	0.77	17,646	33.6	0.64
C-1	267	45.0	0.59	93	48.0	0.63	40	55.2	0.70	2,144	44.5	0.52
C-2	709	45.0	0.57	444	47.3	0.54	354	48.9	0.51	4,499	44.5	0.51
C-3	762	44.4	0.37	481	45.9	0.35	331	47.2	0.35	4,635	44.0	0.37
C-4	1,127	44.3	0.37	973	45.4	0.33	448	46.3	0.29	6,688	43.4	0.36
D-1	2,588	28.8	0.38	1,336	31.1	0.29	1,033	35.2	0.28	14,242	29.2	0.31
D-2	2,733	22.7	0.27	1,186	28.0	0.24	1,010	32.6	0.23	15,414	23.2	0.27
D-3	1,328	19.0	0.37	563	22.0	0.26	574	23.2	0.23	9,766	19.0	0.32
D-4	993	24.1	0.38	440	23.5	0.34	339	21.4	0.33	7,096	23.8	0.38
Totals	22,686	33.2	0.55	15,509	36.1	0.59	13,194	37.1	0.60	136,351	34.9	0.52
Adjusted Totals (1)	21,248	32.4	0.55	14,639	35.4	0.59	12,371	36.4	0.60	127,328	32.1	0.52

Note:

(1) Excluding subzones A-6, C-1 and C-2.

Table No. 16

V. UTILIZATION AND SPECIFICATIONS

Aside from the qualitative-quantitative and mining-blending investigations, extensive investigations have been conducted with Hat Creek coal in regard to its utilization characteristics for application to the Hat Creek Thermal Project. A discussion of the investigations or results follow.

Petrographic studies have been performed with the Hat Creek coals. Briefly, results showed the absence of significant amounts of inert macerals, fusinites and semifusinites and, also, relatively small amounts of exinites for this rank of coal.

Analysis was also performed on various clay samples. Results showed significant amounts of kaolinite, quartz and montmorillonite with lesser amounts of feldspar, pyrite and siderite. Tenderers are cautioned about the large amounts of clay in this coal and to design equipment accordingly. The Stock Equipment Company has conducted flowability tests with types of Hat Creek coal.

Most sulfur in this deposit will be of the organic type. Pyrites appear to be of small size and well dispersed throughout the deposit. The mineral siderite is also present (iron carbonate).

Combustion studies of Hat Creek coal have also been performed and these are listed:

Facility Location	Description
CANMET, Ottawa	Fired in pilot scale facilities.
Alberta Power Ltd., Battle River	Full scale firing in 32 MW, pulverized coal boiler.
Babcock & Wilcox Co., Research Center	Sintering tests and burning profiles.

One pertinent result of the firing tests show the fly ash produced will be very abrasive. The cenospheres formed include many needle-like material extending outward--this apparently contributes greatly to the abrasiveness of the fly ash. Another pertinent result is the potential for slagging in the furnace, especially in the furnace throat area. This potential high rate of slagging will be caused by the large amount and type of mineral matter in the coal. More precisely, there will be significant amounts of sodium reacting with quartz and/or clayey minerals.

The fuel specifications contain ash fusibility data and ash viscosity data (T_{250}). The 250 poise viscosities are estimated from established curves via use of the base-acid ratio of the ash and silica-alumina ratios. The tenderers are cautioned about use of the fusibility-viscosity data for furnace design.

B. C. Hydro has available all coal quality data and all reports pertaining to investigations of the Hat Creek coal. Tenderers of boiler and auxiliary equipment are invited and encouraged to visit their offices to review and discuss the information.

The fuel specifications contained herein include suggested limits for design of equipment. Of course, design of equipment may be more conservative; if so, appropriate credit will be assessed during the evaluation.

The fuel specifications are included in this section of the report, as appendices and identified, as follows:

Appendix	Description
1	Coal Specifications.
2	Coal Specifications for Dust Collection System.
3	Coal Specifications for Pulverizer System.

In addition, the suggested boiler design considerations are included as Appendix 4.

APPENDICES

APPENDIX 1

Coal Specifications

THE BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
BASE BOILER BID
COAL SPECIFICATIONS

Appendix 1

A. Coal-General

The base fuel will be subbituminous coal from the Hat Creek surface mine, Pit No. 1.

B. Coal Sizing

Coal sizing will be nominal minus 50 mm (2.0 inches).

C. Types of Coal

There are three types of Hat Creek coal to be utilized and these are designated as follows:

Type
Performance Blend
Design Worst Coal
D-Zone MCS

The performance blend type shall be used as the performance coal for guarantees of unit thermal efficiency and fans, pumps, pulverizers, auxiliary horsepower requirements, etc.

The boiler shall be designed to utilize each of the three types of coal, or any combination of mixtures of the three types of coal, and operate at maximum continuous load with ample pulverizer capacity and without serious slagging or fouling of gas-side surfaces.

D. Bulk Density

The bulk densities to be used are as follows:

Equipment	Lbs./Cu. Ft.
Belts or Feeders	50
Bins	68-70

E. Coal Analysis

Hat Creek coal analyses are on an "as-received basis." Values in parentheses are on a "dry basis (moisture free)." Equilibrium moisture content is a function of the ash content of the coal. Hardgrove Grindability Index (HGI) is a function of the moisture content and the ash content of the coal. The HGI used were those determined at about the mid-moisture content of the coal.

Analyses are in accordance with current ASTM standards. Where no ASTM standards exist, analyses are in accordance with methods or procedures in use by the Commercial Testing & Engineering Company.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

COAL SPECIFICATIONS

HAT CREEK COAL

(AS RECEIVED BASIS)

Appendix 1

Type	Design (Worst Coal)	Performance Blend	D-Zone MCS	Range Minimum	Range Maximum
Moisture, Equilibrium, %	22.7	23.1	23.6	18.5	28.0
Moisture, Total, %	22.5	23.5	24.5	18.0	26.0
Volatile Matter, %	24.0	25.2	28.1		
Fixed Carbon, %	24.0	25.7	28.9		
Ash, %	29.5	25.6	18.5	(14.0)	(43.0)
Carbon, %	32.4	35.3	41.0		
Hydrogen, %	2.7	2.8	3.0		
Nitrogen, %	0.7	0.7	0.6		
Chlorine, %	0.03	0.02	0.02	(0.01)	(0.06)
Sulfur, %	0.55	0.39	0.23	(0.20)	(0.71)
Oxygen, % (By Difference)	11.62	11.69	12.15		
Gross Calorific Value					
MJ/Kg	12.71	13.85	16.08	12.33	18.81
Btu/Lb.	5,465	5,955	6,915	5,300	8,090
Hardgrove Grindability Index	49	45	38	33	55
Mineral Analysis Of Ash, %					
SiO_2	51.8	52.6	54.1		
Al_2O_3	28.9	28.1	27.5		
TiO_2	1.0	1.0	1.0		
Fe_2O_3	8.6	8.5	7.2		
CaO	3.1	3.5	3.9		
MgO	1.7	1.5	1.2		
Na_2O	1.78	2.21	2.95	0.50	4.50
K_2O	0.80	0.62	0.35		
P_2O_5	0.25	0.17	0.09		
SO_3	1.80	1.75	1.80		
Mn_3O_4	1.13	0.16	0.20		
V_2O_5	0.06	0.06	0.06		
Sulfur Forms, %					
Pyritic	0.16	0.10	0.03		
Organic	0.37	0.28	0.18		
Sulfate	0.02	0.01	0.02		
Ash Fusibilities, °C	Range	Range	Range		
IT (Reducing)	1140-1500+	1170-1500+	1160-1500+	1140	1500+
ST	1190-1500+	1210-1500+	1200-1500+	1190	1500+
HT	1230-1500+	1250-1500+	1230-1500+	1230	1500+
FT	1270-1500+	1290-1500+	1270-1500+	1270	1500+
IT (Oxidizing)	1300-1500+	1310-1500+	1330-1500+	1300	1500+
ST	1330-1500+	1330-1500+	1340-1500+	1330	1500+
HT	1360-1500+	1340-1500+	1350-1500+	1340	1500+
FT	1390-1500+	1360-1500+	1360-1500+	1360	1500+
250 Poise Viscosity, °C	1500	1500	1510	1260	1500+
Na_2O, % Dry Coal Basis	(0.43)	(0.54)	(0.64)	(0.40)	(0.70)
K_2O, % Dry Coal Basis	(0.07)	(0.06)	(0.03)	(0.03)	(0.10)

Note:

Values in parentheses are on a dry coal basis.

APPENDIX 2

Coal Specifications for Dust Collection System

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

COAL SPECIFICATIONS FOR DUST COLLECTION SYSTEM

HAT CREEK COAL

Appendix 2

The grain loading to the dust collection system shall be based upon 22.0 percent excess air at the economizer outlet with 100 percent of ash fired as carryover fly ash from the following coal:

Item	
Moisture, %	18.0
Ash, %	35.2
Sulfur, %	0.33
GCV, MJ/Kg	12.33(5,300 Btu/Lb.)
Ash Analysis, %	
SiO_2	50.1
Al_2O_3	34.1
TiO_2	0.9
Fe_2O_3	6.4
CaO	2.7
MgO	1.4
Na_2O	0.54
K_2O	0.76
SO_3	1.60
P_2O_5	0.39
Mn_3O_4	0.01
V_2O_5	0.05
(Undetermined)	1.05

APPENDIX 3

Coal Specifications for Pulverizer System

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

COAL SPECIFICATIONS - PULVERIZER SYSTEM

HAT CREEK COAL

Appendix 3

Fineness

The coal fineness for the pulverizers shall be as follows:

	Fineness	
Type Coal	%-200 Mesh 75 Micrometers Minimum	%+50 Mesh 300 Micrometers Maximum
Design (worst coal)	70	1.0
Performance Blend	70	1.0
D-Zone MCS	65	2.0

Drying Capability

Pulverizer drying capability shall be designed to evaporate a minimum of twelve (12) moisture points from the coal, i.e., from 23.5% moisture to 11.5% moisture; additional drying capability provided will be evaluated.

Mill Setting Data

The pulverizer system shall be sized to carry maximum continuous load, with one pulverizer out of service, for coal having a Hardgrove Grindability Index of 45 and a Gross Calorific Value of 5,955 Btu/lb. after an average wearing-in time of four (4) months for the remaining mills in service.

APPENDIX 4

Suggested Boiler Design Considerations

Appendix 4

SUGGESTED BOILER DESIGN CONSIDERATIONS

The following boiler design considerations are listed:

1. No division wall in furnace nor suspended surface in upper furnace, such as, platens, panels, curtain walls, etc.

2. Furnace plan heat release rate: 1,500,000 Btu/sq. ft./hr., maximum, where area equals furnace width x depth.

   Note: For release rates used herein the Btu input is that heat input from the coal.

3. Burner zone heat release rate: 400,000 Btu/sq. ft./hr., maximum, where burner zone height is centerlines of bottom row to top row of coal nozzles plus 10 feet of elevation above the top row and wall surface is the flat projected surface or perimeter of furnace.

4. Flue gas temperature entering first convection bank: 1066°C (1950°F) HVT, maximum. This temperature limit is described as the average flue gas temperature at a point one-half across the width of the furnace and

one-half way across the depth of the furnace and at a point entering the first row (lowermost) of horizontal tubes, for a tower type boiler. For boilers arranged with vertical tube banks in the high flue gas temperature zone, this temperature limit is described as the average flue gas temperature at a point one-half way across the width of the furnace (convection pass) and one-half way up the vertical convection pass and at a point entering the first vertical row of vertical tubes nearest the furnace.

5. Flue gas velocity maximum, at 22.0 percent excess air at economizer outlet, is 10.7 meters per second (35.0 feet per second).

6. Furnace hopper opening, 48 inches, minimum.

7. Distance from centerline of lower burner row to hopper work point (knuckle) is 14.0 feet, minimum (to provide clearance for one row of wallblowers).

8. Flue gas recirculation is not to be used for steam temperature control or control of combustion in the base bid. If flue gas recirculation is used in an alternate bid, the flue gas take-off shall be downstream of the main dust collector.

9. No water blowers or water assist blowers of any type will be used.

10. Coal feeders of the gravimetric type, Stock Equipment Company feeder, or equivalent, with a minimum belt width of 36 inches are preferred. European type coal feeders will be acceptable for alternate bids.

11. Ash handling equipment for furnace hopper material will be of the continuous removal type. Design shall be for 50 percent of the ash in coal fired as bottom ash.

12. Economizers shall be of the bare tube, in-line type.

13. For any horizontal tube surface with vertical, down-flow flue gas, the uppermost row of tubes shall contain tube shields over entire length.

14. In order to reduce fuel oil demand, a direct ignition coal fired system will be considered. The Zone D MCS coal (specification) may be used for this type ignition system.

15. The air preheaters shall be designed to handle a 1.0 percent sulfur content, as-received basis.