Cominco - Monenco Joint Venture

for

British Columbia Hydro and Power Authority

HAT CREEK COAL BENEFICIATION

2nd Draft June 1978

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SECTION 6

DESCRIPTION OF PROPOSED PLANT

6.1 OUTLINE OF MODULAR CONSTRUCTION

The plant will consist of a number of identical Modules each rated for a nominal 400 MTPH capacity. Each Module would be fed from the Raw Coal Handling System by a separate Raw Coal Feed Conveyor; thus each Module could be independently set to optimise the product yield from its particular raw coal feed. We currently envisage 5 Modules operating (= 2,000 MTPH ROM coal capacity) and have allowed for a sixth or standby Module to allow for maintenance.

The modules would be constructed to work with a common set of product conveyors:

Coarse Clean Coal Conveyor
Fine Clean Coal Conveyor
Fine Untreated Coal Conveyor
Discard Conveyor

The three coal product conveyors have been included for two reasons: firstly to facilitate separate product stockpiling if required and secondly to give flexibility in product blending without complicating the modular plant layout.

Each module would consist of:

Raw Coal Screening Section
Coarse Coal Washing Section
Fine Coal Washing Section
Thickener

The modular design has been conceived in such a manner that if Fine Coal Washing is not required then the plant could be constructed as a number of Raw Coal Screening + Coarse Coal Washing Sections working with a common Thickener. Or Fine Coal Washing Sections could be provided for only a selected number of Modules.

Alternative proposals are being investigated for treatment of the 13 mm x 0 raw coal. In this situation the Raw Coal Screening and Coarse Coal Washing Sections could remain unchanged and provide the feed to the alternative fine coal treatment.

SECTION 6

DESCRIPTION OF PROPOSED PLANT

6.1 OUTLINE OF MODULAR CONSTRUCTION - cont.

The design as a series of independent modules facilitates the stagewise development of the plant, and will greatly simplify the initial commissioning and on-going operator training programme.

Please read this Description in Conjunction with our Drawings:

F1304-0001 P Flowsheet for Coarse Coal H.M. Section (1 Module)
F1304-0002 P Flowsheet for Fine Coal Section (1 Module)
F1304-1002 P Washery Layout

The description is given for a single Module.

6.2 RAW COAL SCREENING SECTION

The Raw Coal, broken to below say 200 mm in the ROM Coal Breaker Stations, will be delivered at a steady rate not exceeding 400 MTPH to the Module.

The flow would be divided by a bi-furcated chute to two parallel streams. Raw Coal Sizing Screens will classify at 13 mm and 6 mm. The 6 mm x 0 Raw Coal will pass to Surge Hoppers. Automatic sampling facilities would deliver regular samples of 6 mm x 0 Raw Fine Coal to an Automatic Ash Monitor. From this ash measurement and the product yields, a computing system would determine the "mode" in which the module should be operating to meet current product blend requirements.

6.3 COARSE COAL WASHING SECTION

The feed to the Washing Units, 200 x 13 or 6 mm, will be passed over Wet Screens where sprays of Clarified Water will remove adhering fines which would otherwise contaminate the magnetite washing medium. (Space has been allowed for a -6 mm Raw Coal Dewatering Screen to recover these fines in the event that Fine Coal Modules are not installed).

The coal will be delivered from the Wet Screens into the LeeBar Dense Medium Baths. These baths will utilize a suspension of finely ground magnetite in water of carefully controlled density corresponding to the gravity separation required.

SECTION 6

DESCRIPTION OF PROPOSED PLANT

6.3 COARSE COAL WASHING SECTION - cont.

The Clean Coal will float off, its removal being assisted by paddles, and delivered to Rinsing Screens fitted with heavy duty wedge wire panel sieves. The entrained magnetite medium will drain off in the first section, to be returned to the Bath via the Heavy Medium Cone.

The adhering medium will be removed by heavy spraying, firstly with Dilute Medium and then Clarified Water over the second or Rinsing section.

The third or Sizing Section of the Clean Coal Screen will deliver material less than 25 mm size to a Centrifuge for further dewatering, and material greater than 25 mm to a Crusher for reduction to below 25 mm. These products will be recombined on the Coarse Clean Coal Conveyor. This Conveyor will run the length of the Plant receiving products from all Modules.

The shale or rejects material which sinks to the base of the LeeBar Bath will be elevated out of the medium by an Extractor Chain Conveyor and delivered to a similar Discard Rinsing Screen. The Discard will be delivered to the Discard Conveyor which will run the length of the Plant to serve all Modules.

6.4 COARSE COAL WASHING LIQUID CIRCUITS

The Heavy Medium will be continually recirculated through the Baths via the Heavy Medium Cones and Pumps. The medium density will be monitored to control its gravity.

The Dilute Medium resulting from the product rinsing will be passed to a recovery circuit comprising a Settling Cone and two stages of Magnetic Separators. (The operating gravity in the bath is in the range 1.3 to 1.8 S.G. The magnetic separators give a recovered pulp of 2.2 to 2.6 S.G.).

Facilities for pump, pipeline and cone drainage within the magnetics circuit will be contained within a Reinforced Concrete Walled area, and Floor Sump and Pump would return contents to the working circuit to minimize magnetite losses.

SECTION 6

DESCRIPTION OF PROPOSED PLANT

6.4 COARSE COAL WASHING LIQUID CIRCUITS - cont.

A similar Walled area and sump system will serve the non-magnetics sections of the plant and facilitate centrifuge effluent and other drainage recovery via the Raw Coal Dewatering Screen or Fine Coal Module.

Facilities have been included for a magnetite store, magnetite handling and medium preparation; a common system to service all Modules.

The Water Clafification facilities would be provided in conjunction with the Fine Coal Modules. In the event that Fine Coal Washing is not required, then one Thickener and its immediate equipment would service Five operational (+ standby) Large Coal Modules.

6.5 FINE COAL WASHING SECTION

The 6 mm - 0 Raw Coal will be fed at the required steady rate from the Surge Hoppers to the Classifying Cyclone Feed Cone where Clarified Water will be added under automatic control. The Raw Coal Slurry will be pumped in two parallel streams to a bank of Thirty-two Classifying Cyclones designed to remove the 100M x 0 material. This will be rejected as the cyclone overflow to the Tailings Thickener for disposal. The 6 mm x 100M material will be pumped in two parallel streams to a bank of Sixteen Primary Water Only Washing Cyclones and the partially cleaned overflow from this bank similarly to a bank of Sixteen Secondary Water Only Washing Cyclones.

The underflow from both sets of cyclones would be passed via a Dewatering Screen to the Discard Conveyor. (This will be a common conveyor with the Coarse Coal Section). The screen will retain only a portion of the 28 x 100M discard, the bulk of this fraction passing as tailings to the Thickener. The Fine Clean Coal Slurry (Secondary Washing Cyclone Overflow product) will be pumped to Thickening Cyclones to remove the bulk of the wash water and facilitate dewatering by means of Sieve Bend and Slurry Screens, effecting a partial classification at 28M, followed by conventional Basket Centrifuge (as in Coarse Coal Module) for the 6 mm x 28M and Screen Bowl Centrifuges for the 28M x 100M. These centrifuges will deliver product to the Fine Clean Coal Conveyor; a common conveyor running the length of the Plant.

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DESCRIPTION OF PROPOSED PLANT

6.6 THICKENER

The washing circuit has already been described above. This circuit is completed by passing the Classifying Cyclones overflow and Discard Dewatering Screen Underflow to the Thickener where it will be dosed with Flocculating Reagents to provide a continuous recirculation of water for re-use. Note that a common Clarified Water Head Tank will supply the Coarse and Fine Coal Washing Sections.

The three Flocculant Mixing Tanks and Pumps will be a common service to the six Module Thickeners. It is envisaged that Lime and two different Polyelectrolytes will need to be on service to suit varying operating conditions.

6.7 ALTERNATIVE OPERATIONAL "MODES"

The Automatic Ash Monitor within the Raw Coal Screening Section will be used to determine the "mode" in which the Module is to operate.

Reference to the Flowsheet and Washery Arrangement Drawing should be made to visualize the practical arrangement of automatically operated gates and overflow chutes by which this is achieved. The Conveyors will run the length of the Plant receiving products from all Modules.

There are fine "modes", the sequence for increasing ash content raw coal (and thus a greater degree of beneficiation requirement) being:

6.7.1 Coarse Coal Washing (+13mm)

Only the + 13 mm Raw Coal being passed to the Dense Medium Baths for washing. The Feeders at the base of the Raw Coal Surge Hoppers would be stopped, and all the 13 mm x 0 Raw Coal would overflow to the Untreated Fine Coal Conveyor.

6.7.2 Coarse Coal Washing (+6mm)

The + 13 mm and 13 x 6 mm Raw Coal being passed together to the Dense Medium Baths for washing. The Feeders at the base of the Raw Coal Surge Hoppers would be stopped, and thus the 6 mm x 0 Raw Coal would overflow to the Untreated Fine Coal Conveyor.

SECTION 6

DESCRIPTION OF PROPOSED PLANT

6.7 ALTERNATIVE OPERATIONAL "MODES" - cont.

6.7.3 Partial Washing

The Coarse and Fine Coal Washing Sections would both be operating. The determined proportion of the 6 mm x 0 Raw Coal would be delivered from the Feeders at the base of the Surge Hopper to the Fine Coal (Classifying Cyclone) Feed Cone for washing. The remainder of the 6 mm x 0 Raw Coal would overflow to the Untreated Fine Coal Conveyor.

6.7.4 Total Washing

The Feeders at the base of the Surge Hopper would be operating at 100% thus passing all 6 mm x 0 Raw Coal to the Fine Coal Washing System.

6.7.5 Low Grade Coal Washing

The module would be set as in 6.7.1 above except that the 13 mm x 0 Raw Coal would be diverted to the Discard Conveyor. Thus Clean Coal would be recovered from the + 13 mm Raw Coal only. (All Raw Coals examined to date have shown better coal in the coarser size fractions, and higher discard contents in the finer size fractions. Thus with feeds of above say 50% ash content (dry basis), there would only be a worthwhile yield from the coarser size fractions).

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SECTION 1

SUMMARY

1.1 Objectives and Fuel Specifications

The Draft Fuel Specifications (Ref. 21) envisaged a preliminary range of fuels (5500 to 7300 BTU/lb. at 20% moisture, equivalent to 6875 to 9125 BTU/lb. on the dry basis), with a norm quality of 6300 BTU/lb. This was anticipated to require some cleaning.

The objective of these coal beneficiation studies was to prepare a conceptual process plant scheme should some or all of the raw coal require beneficiation to meet the Final Fuel Specification. Preliminary scheme designs were required on a modular basis so that alternative mine plans and fuel specifications could be evaluated, along with the viability of beneficiation.

Beneficiation was also considered with respect to the control of sulphur and moisture contents and handleability characteristics, and as a means of quality control.

In March 1978 a preliminary decision was made that beneficiation was not viable as compared with lowering the preliminary range quoted above. This has been validated by the Mining Studies which have produced Mining Plans such that Beneficiation is not potentially necessary for quality control.

1.2 Beneficiation Characteristics

The Hat Creek coals tested have very difficult Beneficiation Characteristics, which are a function of the inclusion of clays and shales in fine bands and even the minutest fissures of the coals, in addition to the normal partings.

The 1976 Studies (Refs. 2 & 5) were examined (Ref. 23) and indicated that even a comprehensive cleaning plant scheme could not maintain quality with the Draft Fuel Specification. At an early stage, therefore, it was confirmed within C-MJV that sophisticated Mine Plans and Product Blending Facilities would be essential. These are detailed in the main C-MJV Report.

The coals which it is planned to mine, come from four Zones, for which typical values based on the average zone qualities (Ref. 21.1) are: -

Table 1

Zone	A-1	B-1	C-2	D-1
% by weight of Raw Coal	30	13	15	42
Raw Coal (Average in-situ quality without dilution)				
Calorific Value BTU/lb. (d.b.)	5575	7260	6180	9110
Ash Content % d.b.	48.4	36.8	44.3	24.0
Ash lb. per 10^6 BTU (A_r)	86.8	50.7	71.7	26.3
After Cleaning (Theoretical Results: no allowance for plant losses)				
Yield Wt. %	60	70	70	80
Calorific Value (BTU/lb. (d.b.)	8097	9139	8126	10180
Ash Content % d.b.	31.0	23.8	30.8	16.6
Ash lb. per 10^6 BTU (A_c)	38.3	26.0	37.9	16.3
% BTU Yield	87.0	88.1	92.0	89.4
Degree of Beneficiation $\left(\frac{A_r}{A_c}\right)$	2.27	1.95	1.89	1.61

Thus taking the weighted blend of these four Zones, a Raw Coal of 7370 BTU/lb if cleaned at 100% Organic Efficiency would yield 71.2% by weight at 9217 BTU/lb. There would therefore, be a loss of 11.0% in heating value.

It may be noted that raw D Zone coal is of similar quality to cleaned A, B and C Zone coals, which also permit a higher degree of beneficiation. There is, therefore, a possible case for cleaning the A, B and C coals and blending with raw D Zone. This would give a theoretical yield of an 8754 BTU/lb. quality at 79.6% weight, 94.5% heating value,yield. Even this 5.5% loss of heating value may be a very high price to pay for a low Degree of Beneficiation.This must be evaluated elsewhere in the Hat Creek Complex Studies.

Comparing the 9217 and 8754 BTU/lb. qualities, there is very little blend quality gain for a substantial heating value loss by washing D Zone coals. In fact, when practical cleaning efficiency factors were applied to D Zone data, the net beneficiation of the blend was negligeable or in some cases negative. Variations within the A, B and C Zones are substantial such that quality control could be assisted by cleaning. D Zone coal is of consistent quality, and is a thick zone with few discrete partings. It is however similarly "impregnated" with fine clays. Even when allowance was made for mining dilution no benefit could be calculated for cleaning D Zone coal by any method.

1.3 Interim Reports

This Volume summarises the various Interim Reports: -

	References
1976 and 1977 Washability Testwork	(5)(12)
1976 and 1977 Test Washes	(5)(6)(31)
Alternative Beneficiation Report : a review of all commercially available process schemes with detailed predictions from Washabiltiy Data	(13)
Preliminary Scheme for Modular Dense Medium and Water Cyclone Washery	(14)
Alternative Baum Washery	(15)
Tailings Disposal Requirements and Scheme	(16)
Beneficiation of Sub-Grade Coals	(17)

Actual BTU content losses would be of the order of 15 to 20% if conventional data interpretation and total washing schemes were applied to all coals with the intent of halving the ash content.

The finer raw coals are dirtier than the coarser coals : thus the frequently employed practice of Partial Washing is comparatively ineffective.

Conceptual designs and costings of two alternative conventional beneficiation plants are presented. The associated tailings thickening dewatering and disposal requirements added to the complexity of these facilities gives a high preparation cost for a low Degree of Beneficiation and resultant low grade fuel.

Extraction of the high fines is evaluated. Wet extraction would be efficient but would give a tailings problem similar to conventional beneficiation. Drying and air classification would not achieve a high degree of beneficiation, but may be worth reconsideration if more moist raw coal is encountered at greater mine depths.

The liberation of the fine clay from within the coal structure by wet attrition has been studied in laboratory(Ref. 12.2)and pilot plant work (Ref. 31) only recently completed. A relatively simple process plant which uses this method to the full may give results comparable with the most efficient conventional system. The clay thus liberated would be a tailings of very difficult dewatering characteristics. Further, larger scale, Pilot Plant work would be necessary before considering any recommendations to design the Hat Creek Complex on the basis of this method of beneficiation.

1.4 Coal Beneficiation Schemes

Following review of beneficiation characteristics, preliminary mine plans and the potential of commercially available processes, the following schemes were tabled for review. Note that in all cases D Zone coals remain untreated.

MODULAR COAL WASHERY

	Scheme 1	2	3	4	5	6	No Beneficiation R.O.M. Coal	Target Fuel Spec.
Treatment								
Coarse Coal (+13mm)	H.M. Bath	H.M. Bath	Baum Jig	None	WOC	H.M. Bath		
Fine Coal (-13mm)	W.O.	None	None	Dry/ Clas.	WOC	Dry/ Clas.		
Dry Basis Analyses								
C.V. BTU/lb	9043	7882	7853	7683	9136	8333	7327	7875
% Ash	24.5	32.5	32.7	33.9	23.8	29.4	36.3	33.7
% Sulphur							0.49	0.45
As Rec'd Analyses		1.6						
C.V. BTU/lb	6686	5891	5870	5796	6693	6266	5495	6300
% Ash	18.1	24.3	24.4	25.6	17.5	22.4	27.3	27.0
% Moisture	26.1	25.3	25.3	24.6	26.7	24.8	25.0	20.0
Wt % Yield	75.0	91.1	90.5	91.0	73.0	82.1		
BTU % Yield	91.2	97.6	96.6	96.0	88.9	93.6		
Wt % Tailings	12.6	2.9	2.9	0.0	18.9	2.9		
Degree of Beneficiation	1.83	1.20	1.19	1.13	1.90	1.39		
Capital Cost of Beneficiation & Tailings Plant $,000,000's	32.7	19.2	16.0	6.3	*	25.5		
Operating Costs for Total Average Product: $ per tonne	1.10	0.45	0.38	0.24	*	0.76		

* Scheme 5 is based on provisional interpretation of EMR Report. Scheme not costed.

1.5 Conclusions

Principal conclusions are:

Firstly, that there is no Beneficiation Process Plant Scheme which can presently be recommended as a viable part of the complex.

Secondly, that studies should be continued towards beneficiation of the lower and sub-grade coals which will be mined in significant quantities in the second decade.

SECTION 2

INTRODUCTION

This Report summarizes the studies of Coal Beneficiation for the Hat Creek Number One Deposit. These beneficiation studies were led by Simon-Carves of Canada Limited working as Coal Preparation sub-consultants to the Cominco-Monenco Joint Venture during the period May 1977 - June 1978.

"Beneficiation" has been used throughout this study as representing a more meaningful definition of the objectives than the more frequently used terms "Coal Preparation" or "coal cleaning". Because the prime interests have been the supply of heat to the boiler and ash disposal requirements, two terms have become common parlance during these studies, and must be defined: -

$$\%\ \text{BTU (or Heating Value) Yield} = \%\ \text{by weight yield of cleaning process} \times \frac{\text{Calorific Value of Cleaned Coal}}{\text{Calorific Value of Raw Coal}}$$

(Thus, if its % BTU Yield as a result of any beneficiation is 94%, then 6% more Raw Coal would have to be mined to provide the heat value needed by the generating plant).

$$\text{Degree of Beneficiation} = \frac{\%\ \text{Ash Content of Raw Coal}}{\%\ \text{Ash Content of Cleaned Coal}} \times \frac{\text{Calorific Value of Cleaned Coal}}{\text{Calorific Value of Raw Coal}}$$

(Thus, a Degree of Beneficiation of 2 means that for a given heat input to the boiler plant the ash weight input is halved).

Throughout the studies, Simon-Carves representatives worked, as a section of the Joint Venture Team, towards the total understanding of the coal deposit for its proposed utilization as feed to the Thermal Generating Plant. Thus this Report incorporates and interprets beneficiation studies initiated as part of the 1977 Testwork Programme by the BCHPA.

Simon-Carves did, however, present a number of Interim Reports during the period October 1977 to April 1978. These have now been finalized as supporting documents to this Report (See List of References).

This Report is not, therefore, concerned with that degree of coal quality control which can be achieved by virtue of mine planning, selective mining schemes, or raw coal blending. Nor is it concerned with the techniques of coal handling, screening, crushing and blending which are necessary to form a complete scheme from mine to boiler.

Most materials within and adjacent to coal seams have some heating value - thus any beneficiation involves a loss. Process plant beneficiation is generally more efficient than any selective mining.

This Report is specifically concerned with the advantages which might be realized by the incorporation into the total scheme of beneficiation plant processes. It is in fact concluded that there is no process scheme which would be a necessary or viable part of this Hat Creek Number One Deposit Mine and Thermal Generating Plant Complex. Thus the beneficiation process plant studies are separated in this Report from the wider aspects of coal preparation enumerated above, but which are covered in the C-MJV Report.

2.1 Beneficiation Plant Objectives

The objectives considered were: -

2.1.1 Reduction of average ash content.

2.1.2 Quality control by cleaning.

2.1.3 Control of moisture content.

2.1.4 Product handling characteristics.

2.1.5 Removal of clays

2.1.6 Reduction of sulphur content

2.1.7 Control of specific contaminents.

The overall consideration is whether, by some combination of beneficiation processes, it is possible to present to the boiler plant an enhanced fuel specification which will reduce generating costs. Against this must be evaluated the beneficiation plant costs and the net utilization of the mine resource.

2.2 Coal Beneficiation Characteristics

Determination of the beneficiation characteristics of a series of coals is the most important step in defining what can be achieved and evaluating the plant design. These are: -

2.2.1 Size Consist

The methods must determine the size consist which will be presented as feed to any plant, and how it will degrade (either by voluntary crushing or involuntary particle breakage) in various process operations.

2.2.2 Washability Data (Float and Sink Analysis)

The distribution between specific gravity and ash/calorific value for all particles within specified size fractions. (Similarly for sulphur). From this data the performance of all gravimetric cleaning processes may be calculated (Ref. 32).

2.2.3 Geological Data

Data from Drill Cores may be used to interpolate between the points from which the samples are taken for extensive testwork as in .1 and .2 above.

2.2.4 Observations of Pilot Mining

Site observations of any adit or pilot mine enable estimates to be made of raw coal handling, screening and size breakdown characteristics. Specific tests facilitate breaker design. Storage tests indicate factors such as stockpile slopes, liability to spontaneous combustion, coal deterioration and leachate production in long term stocking.

2.2.5 Test Washing from Pilot Mine Samples

To prove the validity of the methods and interpretation of the above data. A test wash will also yield a realistic effluent for tailings system design, flocculant selection and examination of leaching effects from the solids into washwater circuits.

2.2.6 Moisture

Moisture values of raw coals and products under conditions which are representative of anticipated mining, storage and processing must be obtained in addition to standard analyses.

2.2.7 Handleability

A number of empirical procedures have been devised in conjunction with boiler plant manufacturers to provide a basis for boiler feed bunker design, and to facilitate comparative evaluation of alternate coal quality/size consist products.

2.3 Previously Completed Studies

Previous studies were inconclusive with regard to coal beneficiation. Relevent points are: -

2.3.1 Requirement for Beneficiation

It was recognized that in many situations Thermal Generating Plants are designed to operate without any beneficiation of the run of mine coal. For example, the PD-NCB March 1977 Draft Report No. 9 concludes "On balance, it is considered that cleaning is to be avoided if an acceptable boiler design can be produced to burn the untreated, but blended, coal." (Ref. 2.1)

Analytical data from the Geological drill cores had not indicated specific problems which would necessitate beneficiation. But the variability of coal qualities through the deposit showed that extensive product blending would be necessary.

The PD-NCB outline mining scheme envisaged a cut-off grade of 4350 BTU/lb. (dry basis) which would allow a 7875 BTU/lb. (dry basis) average fuel to the Boiler Plant without beneficiation. (Ref.2.2) This was adopted as the starting point for the boiler plant and mine design in the current studies. This concept of controlling average quality by excluding coal of less than a determined quality (cut-off grade) from the product, either by leaving the Sub-Grade Coal in place, or passing it to waste piles, is the only beneficiation proposal in the preliminary studies.

The PD-NCB Report (Ref. 2.4) is somewhat sophisticated in that it envisaged facilities for: -

a) separate stockpiling of all the Sub-Grade material for possible future use.

b) Varying the Cut-Off Grade according to the current mining performance.

c) Blending material from the Sub-Grade stockpile into the mine product when this is better than average quality.

2.3.2 Coal Beneficiation Characteristics

The test programme in 1976 (Ref. 5) by Coal Science and Minerals Testing of Calgary (CSMT - part of the Birtley organisation) was observed by representatives of PD-NCB (Ref. 6) and Integ-Ebasco, as well as BCHPA. It included Size Consist and Washability Tests on three different coal samples, together with Test Washes on the three bulk samples from which these were extracted.

Standard Washability Test Procedures were found to be inadequate: the problems resulted from the sub-bituminous nature of the coals and their clay content. CSMT modified procedures and obtained apparently acceptable results. (These procedures formed the starting point for current studies).

However, this data did not correlate with the Test Wash results (Ref. 5.1)

The results were discussed (Ref. 5.2) and it was concluded that the Hat Creek coals were "formidably difficult" to wash both in terms of the washability characteristics and associated clay tailings problems.

2.3.3 Advantages of Beneficiation

There is little evidence of consideration of the principal advantage of cleaning, namely the reduction in boiler plant ash load.

The washability data obtained was not interpreted into even a hypothetical coal beneficiation process plant flowsheet. Thus the PD-NCB and Integ-Ebasco overview studies could not evaluate beneficiation advantages.

There was, however, recognition that when practical mining plans were drawn up in subsequent studies beneficiation might be necessary to achieve acceptable qualities for some periods of the mine life.

Test Burn results from the EMR Pilot Scale Boiler (Ref. 8) favoured the use of washed coal.

2.4 Beneficiation Studies Plan

At the commencement of the Joint Venture studies specific beneficiation studies were planned, with the intention of being able to present a complete coal beneficiation plant scheme at this stage, if required. These plans, which included participation in associated studies already arranged by BCHPA as part of the 1977 Pilot Mines and Test Burn Programme, were: -

2.4.1 Review literature, in particular the C.S.M.T. Report (Ref.5) and summarise the known coal characteristics.

2.4.2 Computer Process the C.S.M.T. Washability Data to show the range of coal product qualities which could be obtained from the deposit - on the assumption that these samples were representative of the bulk of the deposit. in basic characteristics.

2.4.3 Provide from above guidelines for Mine Planning, Product Blending and Waste Disposal functions on yields and qualities which could be realized by incorporation of beneficiation.

2.4.4 Detail programme and work flowsheet for obtaining all practicable beneficiation characteristics data from the 1977 Pilot Mines.

2.4.5 Arrange and supervise this Washability Testwork programme.

2.4.6 Observe coal handling during mining handling and test burn programmes, particularly with respect to clays present.

2.4.7 Review proposed E.M.R. Canmet Test Wash programme (Ref.9). Supervize sample preparation to facilitate evaluation alongside data from .5 above. This programme included tailings flocculation studies.

2.4.8 Review clay removal techniques.

2.4.9 Review tailings disposal requirements, methods and possible lagoon sites.

2.4.10 Review all commercially available beneficiation processes for applicability to Hat Creek coals, evaluating on the basis of 1976 and 1977 Testwork Data and provisional mine plans.

2.4.11 Preliminary design and order of magnitude costing of favoured beneficiation plant scheme such that alternate costs could be developed to suit various mine plans.

2.4.12 Present alternative fuel product specifications to Thermal Plant Section. Participate in "Initial Wash Plant Decision".

2.4.13 Preliminary design and order of magnitude costing of any alternatives to .11 above which merited consideration. Select favoured scheme.

2.4.14 Review possible beneficiation of sub-grade coals.

2.4.15 Design and Costing of selected beneficiation plant scheme. Integrate with raw coal handling and product blending schemes. Define ancilliary service requirements.

The testwork programmes took substantially longer than anticipated, due mainly to problems in the behaviour of the Hat Creek coals in testing and wet processing. (The Draft Test Wash Report is still in progress with EMR). Initial Mine Plan data became available early in January 1978 and was reviewed with respect to beneficiation schemes (Ref. 24).

Early in March 1978 a meeting with BCHPA representatives decided that a beneficiation plant would not be a necessary viable part of the present scheme (Ref. 24.6).

Design and costing of a selected beneficiation plant scheme was therefore not required in the more definitive form for the C-MJV Report.

Similarly the preliminary mine plans showed that the sub-grade coals would only be mined in significant quantities during the second decade of the mine life. This Report thus terminates with recommendations of obtaining further data after the mine has commenced production.

2.5 Validity of Beneficiation Studies

The present studies are based on only six full sets of Washability Data and four pilot plant Test Washes. The areas from which the coals for these tests were obtained are relatively limited due to the nature of the deposit. It could be argued that this data is inadequate for the present decision not to include for a beneficiation plant.* The following facts must therefore be clearly understood: -

2.5.1 For an integrated mine plus thermal plant complex, it is normal practice to design the boiler to burn the coal without beneficiation. Beneficiation has to make a substantial improvement to average quality or quality control to be proven economic.

2.5.2 The six sets of data cover the range 25 to 50% ash, i.e. that which might normally be considered for beneficiation. Despite this range all are of similar format, i.e. any relatively useful degree of beneficiation would result in a relatively high loss of yield of heat content.

2.5.3 There is no indication that coals from other areas of the deposit will be more amenable to beneficiation. This is confirmed by limited float and sink analyses from the drill cores.

It would in fact be impossible to envisage a major coal deposit with more difficult beneficiation characteristics than represented by this limited data. As the mine develops the following situations may evolve: -

* It most certainly could be argued that any proposal which included a beneficiation plant was based on totally inadequate data. Hence no beneficiation plant is the only practical decision.

2.5.4 Coals of better beneficiation characteristics from some areas which would be amenable to processing to reduce operational costs of the boiler plant. (Capital cost could not be reduced since "formidably difficult" coals are known to exist).

2.5.5 Difficulties in segregation of major partings from coal bands. This could require development of mining techniques, rather than a beneficiation plant.

However, the overall ash contents of the mining blocks are well established from drill core work. Thus a suitable average coal quality could be maintained temporarily at the expense of discarding some coal with waste materials. The considerable thicknesses of the major coal bands, as compared with the immediate partings, shows that the degree by which actual ash levels will exceed those currently calculated in the mine plans is small.

2.5.6 The mine plans do not call for the extraction of the lowest grade materials until the second decade of mine life. Thus it will be possible to re-appraise the case for beneficiation during the first decade.

It thus can be firmly argued that the decision to design the boiler plant to burn the raw coal without beneficiation is far more valid than to cheapen the boiler plant in anticipation that there would be no insurmountable problems in achieving an unproven degree of beneficiation.

SECTION 3

CONCLUSIONS AND RECOMMENDATIONS

The principal conclusions and recommendations of these Coal Beneficiation Studies are summarised below. For more detailed considerations please refer to the appropriate Interim Reports - See List of References.

3.1 The Hat Creek coals examined all have "very difficult" washability characteristics: all are by general definition "middlings" which do not "liberate" on crushing. The lower ash coals, i.e. D Zone, are equally difficult and do not warrant cleaning.

3.2 Only six full washability tests have been done. This must be regarded as an inadequate number for other than outline considerations of beneficiation possibilities. However, these six samples correlate to suggest a family of coals of consistently "difficult" characteristics. (This is confirmed by reference to drill core data and the nature of the deposit.) Techniques are recommended to obtain valid washability data from large diameter bore cores from the whole deposit to further validate these studies.

This is Wrong

3.3 Even the most flexible beneficiation scheme could not achieve quality control without substantial planning to this end of the Mining Operations and utilization of product blending facilities.

3.4 The coarser size fractions contain coals of comparatively low ash and a low percentage of competent shales. Conventional coal preparation techniques are therefore relatively ineffective. In particular the "norm" practice of producing "Part-Washed Blended Smalls" for a Thermal Generating Plant Feed would give little improvement in product quality.

3.5 The finer size fractions contain poor coals associated with a high percentage of soft shales and clays which would however "wash out" to permit a useful degree of beneficiation.

3.6 Testwork has specifically investigated attrition/liberation of high ash fines. Any useful degree of beneficiation would result in a tailings dewatering/disposal problem out of all proportion to this beneficiation.

3.7 There is no established full scale operation handling similar tailings within restrictions likely to be acceptable in the Hat Creek environment. No definitive proposals could therefore be made without substantial pilot plant work.

3.8 The very difficult washability characteristics would not permit effective dry cleaning, quite apart from probable moisture problems.

3.9 Drying of the finer coals and classification out of high ash fines gives a low degree of beneficiation compared to the net loss of heating value. This method may however be worthy of further investigation should higher coal surface moisture become a problem as the mine becomes deeper.

3.10 Due to the poor beneficiation characteristics, any useful degree of beneficiation would necessitate the mining of relatively large additional quantities of raw coal to maintain the required net output in terms of heating value.

3.11 Since the Mining proposals indicate that the raw coal will be dry enough to give acceptable handling characteristics, and the Burn Tests did not show insurmountable problems with "as mined" high ash samples, there is therefore little practical justification for engaging in expensive and relatively ineffective preparation processes.

3.12 Developments may permit beneficiation and utilisation of the 10% of planned output which is currently classified as Sub-Grade, together with a portion of the material just above the Cut-off Grade. Mine plans indicate most of this coal will be produced during the second decade of mine life. Investigation of suitable facilities should precede this period. The lack of definitive proposals in this area is not likely to alter the viability of the whole project, since only some 3% of the "mined heating value" is under consideration.

SECTION 4

OBJECTIVES OF BENEFICIATION IN A MINE & THERMAL PLANT COMPLEX

Mine and Thermal Generating Plant complexes are normally designed with the intention of operating the Boiler Plant on the raw coal without beneficiation. The principal reason for this is that any beneficiation plant produces a discard which has some heating value.

Thus, in their March 1977 Draft Report No. 9 (Ref. 2) PD-NCB did not include any cleaning plant proposals, but concluded: -

"On balance, it is considered that cleaning is to be avoided if an acceptable boiler design can be produced to burn the untreated, but blended, coal.

Blending does not, of course, change the average quality, only the variance. Beneficiation (or cleaning) is concerned with improving the average quality to a desired value or range of values."

In overall economic appraisal of Hat Creek, it must be acknowledged that alternative schemes will have to dispose ultimately of the same weight of ash. Only the proportions will vary between the following categories: -

a) Mine Waste	-	Overburden & Major Partings
b) Beneficiation Plant	-	Discard
c) Beneficiation Plant	-	Tailings
d) Boiler Plant	-	Bottom
e) Boiler Plant	-	Fly Ash

Thus, for example, there may be a case for simple cleaning to remove coarse shale particles, since these are much easier to dispose of than the equivalent weight of fly ash.

Beneficiation is practiced for many thermal coals. Two principal reasons are however not applicable at Hat Creek, namely:

Various degrees of beneficiation become economic as transport costs increase.

As the available coal qualities have deteriorated it has been found economic to purchase cleaned coals, rather than refurbish or downrate the existing generating plant.

The ultimate objective is the most economic overall operation. It is noted that many thermal plants purchase fuel of better quality than their design basis. Operating costs and plant availability are critical factors (particularly guaranteed availability at peak winter demand periods) which must be evaluated in the total Hat Creek study, although beyond the scope of this Report.

Practical objectives of a beneficiation scheme as part of a Mine and Thermal Generating Station complex may therefore be stated as: -

4.1 Reduction of Ash Content

Reduction of Ash Content (since on a dry basis there is a straight line correlation with calorific value, this is synonymous with Increase in Calorific Value)* to an acceptable level both on instantaneous and average bases. Acceptable must be defined in terms both of limiting values and those which give most economic overall operation.

* (Ref. 26). The regression for the coals included in present mine plans is: -

Dry Basis Calorific Value: BTU/lb. = 12,580 - 144.6·(% ash, dry basis).

Beneficiation for Thermal Generation must therefore be seen as the reduction of ash content to an economically acceptable compromise level. Generally, the scheme will be designed and operated only to remove high ash particulate matter. Thus it is an extension of the coal-shale separation process which occurs in the Mining Operation. (For example, the mining system may remove partings greater than say 0.5 metre, but this could still give too high a product ash. The Beneficiation Plant may then be required to remove say the 500 x 13mm partings).

4.2 Obtaining the Correct Size Consist Product

Although a minus 200 mesh product is fed from the mills to the boilers, the station feed is generally of the order of 30mm x 0. This top size is necessary to give acceptable handleability characteristics.

Some "difficult washability" coals liberate "ash" on crushing and thus permit a higher degree of beneficiation at a given yield value. However, washed coals of less than say 20mm x 0 are likely to have handleability problems. In the Canadian climate this will include freezing.

4.3 Avoidance of Moisture Content Increases

Most coals "as mined" have an acceptable moisture content a few percentage points above their inherent moisture content. The exception to this is where they are mined in difficult water bearing strata.

It is practicable to design coal boiler plants to accept any inherent moisture content. However, wet beneficiation methods increase the surface moisture, in many cases so as to adversely affect the handleability characteristics. Thermal drying to correct this increase is not economic unless long distance transport is involved.

Moisture content also affects the net calorific value of the fuel. Increases in surface moisture for a high inerts content coal are particularly significant.

4.4 Beneficiation to Reduce Sulphur Content

This is subject to considerable pressures from an evnironmental standpoint. (There are no standards yet agreed for Hat Creek. Standards in some countries are demanding a higher degree of cleaning than would otherwise be employed).

Hat Creek coals are generally low in sulphur.

4.5 Quality Control

Where the run of mine coal varies in quality (ash/calorific value) primarily as a result of variations in the proportion of partings and dilution rather than in the coal quality itself, cleaning is an effective method of quality control.

Where the coals vary, blending may be needed.

4.6 Clay Removal

Wet clays can give severe problems in boiler plant pulverizers. Initially consideration was given to clay removal techniques. However, the Burn Test on the Trench A sample which contained a significant amount of clay was free of these problems, and BCHPA subsequently advised (Ref. 29) that removal of clays was not longer an objective.

These objectives have formed the basis of continuing review between the Joint Venture and BCHPA Thermal Department, using their Draft Boiler Fuel Specification (Ref. 21) as the starting point.

The results of the present studies, mining plans, coal geological etc. are that beneficiation would be necessary to meet this Specification. It will be shown elsewhere that it was found economic to alter this Specification rather than to include the comprehensive Beneficiation Plant otherwise needed. Blending rather than cleaning must therefore achieve the total quality control requirement.

SECTION 5

BENEFICIATION CHARACTERISTICS OF HAT CREEK COALS

The objective of the testwork summarized in this section is to determine by laboratory methods how a coal will behave in the various processes available for its beneficiation. These tests therefore include: -

Size Consist Tests related to the proposed mining and handling systems, and also the size degradation characteristics under dry handling and wet washing conditions.

Float and Sink Tests including associated analyses, otherwise called Washability Tests.

Test Washing : to validate the above data and its interpretation in respect of selected processes, and to observe associated phenomena, e.g. effluent production.

The 1976 Testwork (Ref. 5,6) had revealed a number of serious difficulties in testing Hat Creek Coals. These were reconsidered in preparing the programmes and procedures for further testwork in 1977. (Ref. 11,sections 2 and 4)

The thoroughness of the 1976 Testwork by Coal Science and Minerals Testing was acknowledged, but considerable concern remained that their associated Test Washes did not readily correlate with prediction from their Washability Data.

A new Wet Attrition Procedure (Ref. 33) was included in the 1977 Programme. The equipment was manufactured to the recommendations of the Australian Standard (Ref. 34), and following correspondence with the Laboratories responsible for its development, the method was employed.

Table 1

Summary of Beneficiation Testwork Samples

Zone	B	B	A	B		D
Place				Trench A		Trench B
Sample	A	B	C	X	Y	Z
Year	1976	1976	1976	1977	1977	1977
Method of Obtaining Sample	Auger			Backhoe		Front End Loader
				Bradford Breaker (essentially -4") at site		
Laboratory	C.S.M.T.			Warnock-Hersey		
Size Reduction	Crushing -2"			None for main tests		
				Wet Attrition Tests		
Test Washes	C.S.M.T.			EMR		none
Plant	D.M. Cyclones 3/4"x28m W.O. Cyclones 28 x 65m			W.O. Cyclones 5/8" x 100m		
No. of runs	1	1	1	8 (for combined) (X & Y sample)		
Effluent Studies	Toxicity			Flocculation		

The 1977 Coal Preparation Testwork Programme was thus organized as part of BCHPA's programme for the Test Mines known as Trenches A and B. In particular the sample for the EMR Canmet Test Wash at the Edmonton Pilot Plant (Ref. 31) was taken to permit direct correlation with the A Trench washability test samples.

Sampling was supervised by representatives of Simon-Carves and the Laboratory Work undertaken by Warnock-Hersey Professional Services Ltd. at Calgary. Dry and wet sizing and +¼" washability data was reported by Warnock-Hersey in November 1977 (Ref. 12.1).

However pracitical difficulties were experienced with the Wet Attrition Procedure : these are discussed at some length in the February 1978 Report (Ref. 12). and the method should be more successful in future as a result of this experience.
Only recently, as the draft EMR Test Wash Report (Ref. 31) has become available, has it been possible to confirm that this procedure has in fact given realistic results. Thus eventually, after two troublesome testing programmes, there is sufficient know-how in testing Hat Creek Coals to obtain the required beneficiation data, and to validate specific methods and their interpretation.

It should be noted that the Wet Attrition Test is part of a comprehensive procedure (Ref. 33) developed for obtaining size consist and washability data from large diameter (200mm) bore cones. We strongly recommend that any future drilling programme incorporate such tests to confirm the findings of this Report. (See also the last paragraph of Section 5.1).

5.1 Size Consist

Since different size fractions will require different beneficiation processes, it is particularly important that the size consist data sets are obtained to represent that which will apply to the "as mined" coal when subjected to dry handling, wet screening and wet washing processes. Degradation in this stage may also affect float and sink analyses - see paragraph 5.

The 1976 Testwork (Ref. 5) was inherently suspect since the samples were obtained by 3 ft. diameter angles. They were thus thought to contain more fine coal than from full scale mining. Of great concern was the fact that the Wash Test results did not correlate with the data obtained by testing the crushed 3/4" x 0 feed. The -28mesh fines content of the total reconstituted product was in the range 21.4 to 39.9% compared with raw coal analyses in the range 2.7 to 19.4%. The associated clay material particularly had broken down in the wet processing (Ref. 6). It was not possible to determine the degree to which this was affected by: -

Method of Obtaining Samples
Crushing of Raw Coal -3/4"
Attrition in the Wet Washing Process
Feeding unacceptable clay material to washing process

As a result of the unsatisfactory nature of this work it was impossible to make an intelligent estimate of size consist factors, and the cursary treatment given in the PD-NCB Report was immediately identified as misleading (Ref. 2.4).

Careful attention was therefore paid to the Trench A and B Mining Tests (Ref. 27) As mined the coal was essentially minus 300MM and after handling the feed to the Bradford Breaker was generally minus 200mm. The softer clay bands within the seams would probably preclude a substantially coarser "as mined" product, and it would be normal practice to break in the mine at least to -300mm to facilitate subsequent handling.

It was considered therefore that the feed to any beneficiation scheme could be considered as -200mm.

Observations of the Bradford Breaker during the mining tests showed that the product contained between 15 and 20% +50mm from Trench A and about 10% +50mm from Trench B. Two further important observations were made at this stage: -

Slope of Rosin-Rammler Size Consist graphs similar to those reported in 1976 Testwork.

Similar progression of higher ash contents in finer size fractions to 1976 Testwork.

Thus it was concluded that the 1976 Washability Test Data could be regarded as valid information for raw coal after allowing for the change in size consist (caused by the auger method and sample crushing). It has subsequently been confirmed (Ref. 33.1) that the middlings are not liberated by crushing, and thus the 1976 Washability Curves may be considered valid.

The X and Y Samples were obtained from Trench A after the main mining operation had been completed, in order that they and the sample for the EMR Test Wash should be from immediately adjacent cuts. This sampling method did not give the higher percentage of +50mm material consistently observed in normal mining.

The size consist tests performed and results obtained are reported in detail (Ref. 12) and show a wide range of values summarized in Table 2 (A similarly wide range is noted in the 1976 CSMT Testwork).

The dry raw coal samples did, however, show that a fair basis of design for beneficiation schemes would be a norm of 50% by weight to coarse coal processing, i.e. nominal screening at not less than 13mm.

Table 2
Size Consist Tests by Alternative Methods

	Trench A X & Y Samples	Trench B Z Sample
Dry Screening		
% +½"	47.9	67.1
% -28M	6.5	2.7
Wet Screening		
% -28M	21.9	12.8
Wet Screening after Wet Attrition		
% -28M	32.9	9.9

Considerable doubt was initially expressed regarding the high fines contents from X and Y samples after Wet Screening and Wet Attrition shown here. However these were used in development of the fine coal treatment and tailings disposal schemes, and now appear to be fully justified by the EMR Test Wash Report (Ref. 31, Table 15). It is also significant to note that these results give far better agreement with the 1976 Test Washes than do the 1976 size consist tests.

However, the Z Sample results show less -28M material after Wet Attrition than by the preceding Wet Screening Test. Our detailed report on these tests (Ref. 12) notes problems with wet screening equipment and the Wet Attrition Method.

It is, however, possible to conclude that high fines contents result from breakdown in water. Visual observations during these tests confirmed that this breakdown affected not only the obvious clay/shale bands, but that the apparently good coal was broken up by "leaching" clay from the fissures.

5.2 Washability Characteristics (Float and Sink Analysis)

The 1977 Testwork was based largely on the methods developed in 1976, but with the size ranges for the float and sink testing restricted to those envisaged as appropriate for anticipated beneficiation schemes: -

4" x ½", ½" x ¼", ¼" x 28M, and 28M x 100M. (In the case of sample Z there was sufficient material to produce separate data for 4" x 1" and 1" x ½" size fractions).

The float and sink analysis of these +¼" size fractions shows negligible liberation of middlings by crushing.

The -¼" float and sink analysis was performed on samples obtained after application of the Wet Attrition Procedure. Float and sink analysis of the ½" x ¼" was repeated after wet attrition : for the +¼" size fractions there was a significant change in raw coal fractional ash contents. However, size for size, there were no significant differences between the washability curves for any data sets. All showed:

- exceedingly difficult coals to wash
- better coal in the coarser size fractions
- almost negligible quantities of 1.40 sp.gr. floats in the 28 x 100mesh size fraction
- increased high gravity material content in the finer size fractions

Ultimately a rather unique correlation has been obtained for these data sets as discussed in Section 9.3.

The net result of these studies, and their interpretation in the Alternative Beneficiation Report (Ref.13),summarized in Section 6, is that the coals are of uniformly "difficult" washability characteristics, and that beneficiation by gravimetric separation is an unusually unrewarding operation.

5.3 Sulphur Beneficiation

Sulphur is present in the Hat Creek coals in all three possible forms:

Organic Sulphur
Pyritic Sulphur
Salts, e.g. gypsum (calcium sulphate)

When burnt in conventional boiler plant virtually all of the sulphur is released to atmosphere as sulphur di-oxide.

In terms of the % total sulphur content the Hat Creek raw coals are of low sulphur content. (Average zone values corresponding to present mine plans are A : 0.72%, B : 0.68%, C : 0.43%, D : 0.32%). However, the high ash content/low calorific value of these coals means that, particularly in the case of A Zone coals, the quantity of sulphur di-oxide liberated to atmosphere will be relatively large. (It is normally measured as lb. of sulphur di-oxide per million BTU).

The primary purpose of beneficiation is normally to reduce ash content/increase calorific value. However, in some situations, a greater degree of beneficiation is now being called for to reduce sulphur di-oxide emissions as a viable alternative to the installation of wet flue gas scrubbers. The ability of beneficiation to reduce sulphur content of Hat Creek coals has thus been investigated (Refs. 11, 18).

Only pyritic material is high in gravity, so it is the only sulphur form which can be directly removed by coal washing. In many cases the degree of crushing required to liberate pyritic sulphur is in excess of that required for ash content beneficiation. Hat Creek coals do not contain a significant pyritic sulphur content.

Washing processes will leach out salts such as gypsum into the washwater. A proportion of the sulphur in the upper levels of the Hat Creek deposit is in this form. Again crushing assists by bringing these salts into more contact with water.

Organic sulphur is part of the coal substance itself, with a tendency to be associated with the lighter middlings, say 1.45 - 1.65 s.g. fractions. Thus in washing metallurgical coals a low gravity separation is frequently adopted. The secondary product then available for, say, the thermal coal market from such sources is thus of high sulphur content. (This must be recognized in any proposal to "enrich" Hat Creek coals by purchasing middlings from metallurgical coal operations). Crushing liberates organic sulphur to a similar degree to the liberation of ash. Hat Creek coals contain a very high proportion of middlings and do not substantially liberate on crushing.

Thus washing the Hat Creek coals does not effect a particularly useful degree of beneficiation in terms of sulphur content. The clean coals will in fact contain a higher percentage sulphur in most cases, but the sulphur release would be reduced by virtue of the higher calorific values.

5.3.1 <u>1976 Test Washes</u>

The 1976 washability tests did not include determination of s.g. increment sulphur values. Raw coal and clean coal product sulphur contents were however determined as part of the test washes: -

Sample	Raw Coal			Clean Coal Product				
	% Ash	% S	BTU/lb	Wt%Yield	% Ash	% S	BTU/lb	Yield CV
A	50.5	1.07	5700	51.2	32.4	1.08	8122	73.0
B	34.6	0.94	7793	65.9	22.7	0.67	9421	79.7
C	27.7	0.60	8765	76.9	20.3	0.72	9827	86.2

From the above tests, therefore, the decrease in sulphur di-oxide emissions is 29%, 41% and -7% respectively. (However the C Sample would not require beneficiation).

5.3.2 1977 Washability Data

The 1977 washability tests did include sulphur determinations, and the following theoretical values have been calculated: -

Sample	Raw Coal % Ash	%S	BTU/lb	Wt%Yield	Clean Coal Product % Ash	%S	BTU/lb	% Yield CV
X	43.4	1.38	6301	59.2	23.9	1.48	9030	84.8
Y	42.3	0.87	6456	57.2	19.0	1.09	9713	86.1
Z	26.9	0.31	8800	85.4	24.3	0.27	9190	89.2

From this data therefore, the decrease in sulphur di-oxide emissions is 25% , 17% and 16% respectively.

5.3.3 1977 Test Washes

The sample used for the EMR test washes was equal proportions of X and Y. Their results agree closely with the above predictions.

> "A 25% dry basis ash product (9200 BTU/lb) can be produced from 40% dry basis ash material (6290 BTU/lb) with a BTU yield of 86%. A reduction of 20 to 25% lb. sulphur di-oxide per million BTU can be achieved."

We calculated overall, on the basis of this limited data, that total washing of A, B and C Zone coals would give a 20% reduction in sulphur di-oxide emissions. Partial washing would effect only a 8% reduction.

Beneficiation is not therefore of great impact on any sulphur di-oxide emission control requirement. Obviously, planned utilization and blending of the much lower sulphur content D Zone coals is of prime importance.

5.4 Modification of Washability Characteristics by Size Reduction

As noted above and elsewhere (Ref.5)(Ref.33:3) the washability characteristics are not improved by crushing to liberate middlings. Thus there is no advantage to be gained by crushing to optimise the utilisation of conventional gravimetric separation.

5.5 Modification of Washability Characteristics by Wet Attrition

There is however a most substantial release of the intergrown high ash clay material shown by the liberation which will occur by wet attrition. The degree of beneficiation by this means is significant, for example for the combined X & Y data: -

Raw Coal	:	43.4% ash
Raw Coal after Attrition and Desliming at 28 mesh	:	32.5% ash
After subsequent washing at 1.6 sp.gr.	:	16.8% ash (theoretical)
1.8 sp.gr.	:	22.1% ash (theoretical)

In terms of reduction of ash loading to the boiler plant the initial reduction from 43.4 to 32.5% ash is much more significant than the subsequent gravimetric washing operations, particularly when washery yield errors are taken into consideration.

The validity of this method is evidenced by the fact that the 1976 CSMT and 1977 EMR Canmet Test Washes produced tailings quantities of the same order as those predicted from Washability andSize Consist Data obtained from this method - some three times greater than would be predicted from conventional techniques.

5.5.1 1976 CSMT Test Washes

Test Runs were conducted on three bulk samples A, B & C and were comprehensively reported (Ref.5)(Ref.6), although not integrated into the 1976 Studies.

Comprehensive evaluation of the tests is difficult due to the absence of float and sink analysis of the products and the poor correlation of the results with raw coal washability data. However, the tests provided valuable information on the anticipated practical difficulties of washing Hat Creek coals, particularly with respect to the larger production of tailings than would be predicted by conventional interpretation of data. Confirmation was obtained that the rewards of total washing would be small, for the difficulties encountered.

The primary objective of providing comparative samples for the EMR Canmet Burn Test (Ref.8) was achieved, and did indicate some advantages of producing a washed coal quality.

An Appendix (Ref. 5.3) gives data on the ecological aspects associated with washing Hat Creek coals, and does not raise undue doubts in this direction.

5.5.1 Results obtained were: -

	Raw Coal	Clean Coal	Discard (excl. Tailings)	Tailings
Sample A				
% Wt.	100.0	51.2	25.9	22.9
% Ash (d.b.)	50.5	33.3	74.3	60.3
CV (d.b.)	5700	7952	2320	4290
%S	1.07	1.08		
% Moisture	21.1	32.4		
% BTU Yield =		73.0		
Sample B				
% Wt	100.0	65.9	25.6	8.5
% Ash (d.b.)	34.6	21.9	72.5	47.8
CV (d.b.)	7793	9527	2513	6020
%S	0.94	0.67		
% Moisture	19.8	39.7		
% BTU Yield =		79.7		
Sample C				
% Wt.	100.0	76.9	10.5	12.6
% Ash (d.b.)	27.7	19.9	70.0	36.1
CV (d.b.)	8765	9897	2914	7600
%S	0.60	0.72		
% Moisture	19.5	32.1		
% BTU Yield =		86.2		

5.5.2 EMR Canmet Test Washes

Observations during the 1976 Tests indicated that a significant degree of beneficiation might be achieved by "washing" in the more generally accepted sens of wet extraction of dirt/clay fines rather than the coal preparation technique of "wet gravimetric separation" of coal from shale/rock. This would be assisted by the process of attrition which occurs for example in a multi-stage washing cyclone plant.

A preliminary test (Ref.33.2) together with examination of the 1976 data at the Western Research laboratory of EMR resulted in a joint BCHPA/EMR programme with the following objectives (Ref. 9): -

"Tests will be aimed at approximately 50% reduction of raw coal ash with minimum 90% recovery of BTU. Depending on raw coal quality as delivered we may ... have to compromise one of the above objectives ... heat valve recovery to take precedence provided that the clean coal could be kept at or below 25% ash. The objective of flocculation studies will be to determine conditions for clay removal and disposal to allow maximum recovery and recirculation or process water to the wash plant."

This programme would consist of a number of test runs. An eighty ton sample was extracted from Trench A in two lots from the strata sample immediately adjacent to the X and Y Washability Samples. This was passed through the Bradford Breaker, and the 1 5/8" x 0 raw coal was further crushed to 3/8" x 0 to suit the EMR Pilot Plant.

Eight runs, each of approximately 10 tons, were performed together with appropriate samples and analyses.

5.5.2 Full float and sink analyses on feed and products were conducted on samples from one run. Samples of tailings were taken for flocculation trials (see below).

The Report on the EMR Canmet Test Washes is currently only available in advance draft (Ref.31). There are some outstanding questions regarding this report, in particular the mess/ash balances to be resolved before a full appraisal can be made.

Basically the results as currently presented are: -

	Raw Coal	Clean Coal	Discard	Tailings
% Wt.	100.0	61.9	38.1	?
% Ash (d.b.)	40.6	23.6	59.1	
CV (d.b.)	6832	9412	4020	
%S	1.09	0.92		
% Moisture	23.4	29.6		
% BTU Yield =		79.1		

These do not appear to meet the basic objective of a Degree of Beneficiation of 2.0 with a BTU yield of not less than 90%. Data is presented to show that a plant designed specifically for Hat Creek coals would give this objective. The above mentioned mess/ash balance may also give a less pessimistic statement of the results.

On the basis of our interpretation of the ash balance these results agree quite closely with those predicted from the X & Y Washability Test Data, the latter being interpreted on the basis of the results of the Wet Attrition Tests.

5.5.2 The Draft Report (Ref.31) contains a comprehensive review of the properties of this Hat Creek sample as revealed by the wealth of supporting analyses.

Concern must be expressed regarding the product moisture contents achieved.

5.5.3 Flocculation and Water Circuit Tests

An addendum to the EMR Test (Ref.33.3) reports on the examination of flocculation characteristics.

Our principal conclusion is that a process scheme which utilizes wet attrition in conjunction with simple gravimetric separation has been amply demonstrated as the most effective method of washing Hat Creek coals. However real doubts remain as to the practicability of handling the resultant severe tailings problem.

SECTION 6

APPLICATION OF ALTERNATIVE BENEFICIATION PROCESSES

The normal objectives of coal beneficiation are the reduction of ash and sulphur and control of moisture content as discussed in Section 4. For a thermal coal, the maintenance of the product within a set range of Calorific Value is the prime concern. V O.

Reduction and control of ash content~~, or cleaning,~~ is the primary operation in coal beneficiation. Unfortunately there is no one process which can clean all size particles of coal. Frequently two cleaning processes are employed, and when preparing difficult coals to tight specifications (e.g. prime coals for export) three or four cleaning processes may be combined to optimize yield.

The reduction of sulphur content may be achieved by washing processes simultaneously with reduction of ash content dependent on the distribution of sulphur within the specific gravity fractions.

(a procedure for) reduction

Reduc~~tion of~~ moisture normally follows wet washing processes. For the purpose of this survey it is assumed that all such plants contain efficient modern dewatering screens. Thus +25mm cleaned coal would have a surface moisture of the order of 2.0% by weight above an apparently dry raw coal. On crushing to say a 25mm x 0 product size, this product fraction may appear dryer than the raw coal.

The retained surface moisture increases almost exponentially as particle size decreases below 13mm. Again, for any major plant, we can assume that the smaller coals, say -13mm, would be mechanically dried (e.g. by centrifuges) after wet processing. This could nevertheless leave a surface moisture of say 7.5% for a 13mm x 28M product.

Because of the many variables and unusual beneficiation characteristics of the Hat Creek coals, the potential application of all commercially available methods was extensively reviewed ~~during the early phases of the study~~. The Alternative Beneficiation Report (13) is being finalized on completion of the 1977-8 studies as the principal support document to this Volume.

Washing the finer sizes decreases the ash content but increases the moisture content, and simultaneously produces ~~a significant~~ more tailings ~~content~~. To minimize both these disadvantages ~~where an absolute degree of cleaning is not justified,~~ many Thermal Plant feeds are "Part Washed Blended Smalls", i.e. washed coarse coal proportioned with blended untreated finer coal.

From the viewpoint of reduction of tailings, this method obviously has its attractions for Hat Creeek, but would be relatively ineffective since the high ash material is the soft shale and clay materials which concentrate in the finer sizes.

Most "Part Washed Blended Smalls" schemes are based on the optimized utilization of a single process.

It must be realized that the normal cleaning requirement for a thermal coal preparation scheme is to "scalp out" the competent high ash partings material with a minimum loss of heating value. (E.g. a Degree of Beneficiation of 4.0 at 95% BTU yield for +13mm coals, or 90% BTU yield for -13mm coals. Thus, a Part Washed Blended Smalls scheme could give a Degree of Beneficiation of 2.0 at 95% BTU yield).

The ~~H~~ mined Hat Creek coal will have a relatively low
~~At Hat Creek there should be a very low~~ partings content and much of the ash load is contained in middlings of useful heat content which have a "fifty-fifty" chance of being misplaced to discard in ~~simple~~ processing. The theoretical Degree of Beneficiation for any gravimetric separation process is shown ~~in Table 1, page 1-2~~ to be of the order of 2.0 at 90% BTU yield.

6.1 Washing, or Gravimetric Wet Cleaning Processes

A summary of the Wet cleaning processes is as follows, and outline of descriptions of these processes are contained in Section 5.1 of the Simon-Carves Alternative Beneficiation Report (13).

Process	Possible Size Range Cleaned	Relative Accuracy
Heavy Medium Bath	500mm x 6mm	very accurate
Heavy Medium Cyclone	50mm x 0.5mm	accurate
Baum Jig	150mm x 0.5mm	less accurate
Concentration Tables	10mm x 0.25mm	less accurate
Water Only Cyclone (large)	40mm x 0.5mm	less accurate
Water Only Cyclone (small)	6mm x 0.1mm	less accurate

As a "rule of thumb" it should be noted that there are two basic groups of gravimetric wet cleaning processes: Dense Medium and Water Medium. Differences in accuracy between alternative water medium processes for a specific size range are relatively small and depend on such factors as plant loading rate. A basic process selection having been made between Dense Medium or Water Medium Processes, the final selection would normally be on the basis of practical plant and/or cost factors related to the specific duty.

Appendix III of the Simon-Carves Alternative Beneficiation Report (13) sets out the large volume of detailed predictions of performance of the alternative washing processes. To keep this work to a reasonable level, the size ranges used for each of the several processes were selected to provide the basis of anticipated plant schemes. Because of this, direct comparison is not available between say Baum Jigs and Water Only Washing Cyclones for some specific size ranges.

The practical Degrees of Beneficiation are significantly less than the theoretical values due to the misplaced material, and this emphasizes the differences in efficiency of the various processes.

Thus, for the +13mm coals at a 95% BTU Yield, we obtain typical values:

Theoretical	2.0
Heavy Medium Bath	1.85
Baum Jig	1.75
Dry Cleaning	1.60 (see below)

Similarly, for the 13 x 0.5mm coals at a 90 % BTU Yield, we obtain typical values of:

Theoretical	2.0
Heavy Medium Cyclone	1.8
Baum Jig/Water Cyclones (Two Stage)	1.65

The Heavy Medium Bath thus appears particularly viable for such difficult coals. There would be comparatively little degradation of the coal due to its short time in the wet circuit, provided the correct bath design were chosen (6.1).

The Baum Jig is traditionally used for thermal plant fuels; there is however a substantial risk of serious degradation within the jig, and this process could not be recommended for coarse or fine coal washing without substantial testwork. The ~~C.S.M.I.~~ BIRTLEY PILOT Test Wash indicated problems when using Heavy Medium Cyclones. This process must be rejected on practical grounds.

Water Only Cyclones which are now being successfully applied to several fine size consist Western Canadian coals, were recognized as potentially the least troublesome process for the -13mm coals if they should require washing (subject to satisfactory solution of water circuit-tailings disposal design problems).

Interpretation of conventional Washability Data (e.g. ~~1976 Testwork~~) would indicate that Water Only Cyclones would not be a viable proposition for +13mm coals. Not only would the yield error be significant, but it would necessitate crushing the feed -40mm which could be detrimental to product moisture control. However, this has to be considered further on account of the modification of washability characteristics by wet attrition.

6.2 Dry Cleaning Processes

Since Dry Cleaning does not produce a tailings, there would be a substantial advantage in its use for Hat Creek coals.

Air Tables, which went out of general use in the 1950's, require closely sized raw feed, e.g. 50 x 25, 25 x 12, 12 x 6 mm fractions, and are of small unit capacity. Thus plants are very complex with respect to ~~in~~ mechanical handling.

Air jigs are in development for 50 x 2mm coals, and offer promise for scalping of any dirt from thermal qualities.

All dry cleaning machines became virtually inoperable on damp feeds: generally the degree of wetting necessary to meet current dust control requirements is unacceptable to the cleaning unit.

However, the efficiency is substantially less than that of Wet Cleaning as tabulated above, page 6- 4, and is thus ineffective for Hat Creek coals.

Put Table Here.

6.3 Cleaning by Differential Crushing

The Bradford Breaker is frequently used to reject hard shale whilst simultaneously breaking softer coal prior to processing.

The Hat Creek coal is harder than the associated shales. An experimental Breaker was installed at Hat Creek as part of the 1977 BULK SAMPLE PROGRAM ~~Test Mines Programme~~ (27) and the breaking characteristics tested (27.4). The hope was that wet clays would agglomerate and pass out as rejects. In fact all clays observed as separate bands were dry and broke very readily, concentrating the high ash clays in the -13mm size fractions.

Under these circumstances, the Siebra Crusher would not beneficiate the Hat Creek coals.

~~6.4~~ Cleaning by Fines Extraction

Since the finer sizes are higher in ash content, and the quantity of fines is higher in the dirtier coals, a useful degree of beneficiation could be achieved by extracting fines.

~~6.4.1~~ Dry Screening

This is only practicable above 13mm with conventional screens or 6mm with special, e.g. heated deck, screens. Too high a proportion of the heating value remains in the -13 or -6mm size fractions for this to be acceptable.

We are however recommending that the -13mm small coal be discarded from the Sub-Grade Coals, (17). ASK OAJ about this.

~~6.4.2~~ Desliming

Desliming the dirtier coals at say 0.5mm by sieve bends or 0.2mm by hydrocyclones would be in itself an effective means of beneficiation. It would however cause as great a tailings problem as a full wet cleaning process, and is thus considered only as part of such schemes.

~~6.4.3~~ Dry Size Classification

Dry extraction by dedusters of say -0.5mm fines would not give a sufficiently high ash fines removal to be listed as a cleaning method.

The drying of the -13mm coals and subsequent fines classification has been investigated as an alternative beneficiation scheme (paragraph 6.6). Although the degree of cleaning is low, its overall benefit to product quality derives from the simultaneous reduction of ash and moisture.

6.5 Miscellaneous Cleaning Processes

Froth flotation would not be applicable to the -0.5mm fines due to the low rank of the Hat Creek coals.

Oil agglomeration is still at the development stage. Like froth flotation, it is dependent on surface properties identified with coal, but Australian research is giving encouraging results. ~~We have summarized the current position for BCHPA (35).~~ Basically reagent costs are too high for an on site thermal plant scheme and the tailings problem is no less than when using other fine coal washing processes.

~~6.6~~ Drying

As noted ~~above~~ previously, mechanical dewatering of any washery products is ~~taken as read~~ assumed.

Thermal drying has been investigated as an alternative means of beneficiation because of the high inherent moisture content of the coal.

The Roto-Louvre Dryer is the only method which can effectively remove inherent moisture, but its use is not economic, when compared with designing the boiler plant to accept higher moisture coals (20).

The Fluidized Bed Dryer would reduce the surface moisture to permit effective extraction of the high ash fines, and an alternative beneficiation scheme is based on this concept, ~~see paragraph 7.4~~.

Performance data from a facility specifically designed to optimize on classification out of the dry fines (20.) was used to evaluate the process.

~~The assistance of Thermal Dryer plant manufacturers in this section of study is acknowledged.~~

6.7 Clay Extraction and Wet Attrition

At the commencement of the studies, the extraction of clays was recognized as a possible requirement to avoid problems in the Pulverizers ~~P.F. Mills~~ at the Boiler Plant. Available methods were reviewed (10), it being noted that these were based on requirements to facilitate operation of conventional washing plant.

~~6.7.1~~ Bradford Breaker ~~as per Centralia~~

~~6.7.2~~ Simple washing may be effective for removal of clay fines adhering to coarser coal particles: for example, as described above under desliming, ~~paragraph 6.4.2~~ , this being supplemented by additional high pressure water sprays on the desliming screen.

~~6.7.3~~ Tumbling Scrubbers are used where the clays require more than water forces to effect their release. They consist essentially of a drum with lifters. Rate of tumbling, and water flows are adjusted, together with the addition of steel tumbling media - usually cubes - sufficient to break up the clays but not the required mineral, in this case the coal. Tumbling is followed by desliming.

Practical observations during the mining and test wash programmes ~~(Ref. 27)~~ had shown that the soft shale and clay would readily degrade in wet processing.

During the Wet Attrition Tests as part of the 1977 Washability Studies, it was observed also that the coals, even the relatively good coal from the D Zone, B Trench, Sample Z, degraded on tumbling in water to give an effluent with very finely divided clay. It could be fairly said that the coal was "attached" by water and the clays contained within the coal fissures "leached out".

Consequently, the size consist and washability characteristics after wet attrition are substantially modified and confirm that a process scheme which allows for this wet attrition would achieve a greater degree of beneficiation (for a given yield) than could be predicted from conventional data.

This is confirmed by the EMR Canmet Wash Test (31) where the pumping/cyclone circuits effect substantial attrition and liberation. Thus it has been shown that Water Only Cyclones could be used to provide an equivalent degree of cleaning to processes normally considered "more efficient".

A process scheme has therefore been outlined based on this work, but not costed, (Para. 7.5). This scheme may not be the most cost effective method of using this phenomenon, and doubts remain regarding the practicability of handling the large volumes of difficult tailings produced. A commercial scale pilot plant operation would be necessary prior to a major plant scheme.

SECTION 7

ALTERNATIVE BENEFICIATION SCHEMES AND COSTINGS

The required output of the Mine Complex was originally set out in the BCHPA Memo of July 11, 1977 (Ref. 30): -

For the maximum capacity factor period, 1989-1998, product production requirement of:

a) 10,894,000 ~~MTPY~~ t/y at 5,500 BTU/lb.
b) 10,119.000 ~~MTPY~~ t/y at 5,900 BTU/lb.
c) 9,272,000 ~~MTPY~~ t/y at 6,300 BTU/lb.

(These values assumed an "as delivered" coal moisture of 20%)

If we accept that only the "dirtier" coals may warrant beneficiation, see para.1.2 i.e. coals from A, B and C Zones, then we have a raw coal input to the Beneficiation Plant for the years 10 - 25 of: -

7,541,000 ~~MTPY~~ t/y

Taking the operating hours as defined in the Project Criteria Manual (Ref.25) the capacity required is : -

$$\frac{7,541,000}{365 \times 24} = 860 \text{ ~~MTPH~~ t/h}$$

A nominal capacity of 1000 ~~MTPH~~ t/h has thus been selected, which demands an average availability of 86%.

Original considerations for washing all coals ~~(Ref.14, Section 5.1)~~ called for a 2000 ~~MTPH~~ t/h nominal capacity, and the Modular Coal Washery was designed on the basis of 5 operating modules each of 400 ~~MTPH~~ t/h capacity plus a complete standby module. For the present, therefore, three of these modules would be considered, two or three being operational as needed. (Note that the 860/1000 ~~MTPH~~ t/h value given above is the average requirement over the 15 year period. Thus a 1200 ~~MTPH~~ t/h installation will allow reasonable flexibility in the shorter term.)

~~The philosophy of the coal washery design on a modular basis is discussed (Ref. 14).~~ The prime intention is to allow for maintenance within a 7 day week, 24 hour day operating schedule. For a developing situation it also allows additional capacity to be added at a later stage.

Consideration of the Raw Coal Size Consist, ~~(see Section 5)~~ and the substantial advantages of partial washing, led to some basic design incorporating Raw Coal Screening at a nominal 13mm. This would give a nominal 500 ~~MTPH~~ t/h to Coarse Coal treatment and 500 ~~MTPH~~ t/h to Fine Coal treatment. The degree of overlap between the acceptable feed size ranges to the process equipment selected means that the nominal screening size could be adjusted in the range 25mm to 6mm without the need to re-design or re-cost the schemes for Budget purposes.

Six possible schemes are re-evaluated on a common basis in this Volume, ~~whereas the Interim Reports (Refs. 14, 15 & 16) used various bases.~~ These are supported by Materials Balance diagrams based on: -

Mine Plan Data ~~(Ref. 22.2)~~

To correspond with the above Basis of Design, this takes 1000 ~~MTPH~~ t/h of Run of Mine Coal from Zones A +B + C, and 741 ~~MTPH~~ t/h of Run of Mine Coal from Zone D.

Screening the 1000 ~~MTPH~~ t/h of Beneficiation Plant feed at a nominal 13mm to give 500 ~~MTPH~~ t/hr to any coarse coal treatment and 500 ~~MTPH~~ t/h to any fine coal treatment.

Computer predictions of process yields ~~(Ref. 13, Appendix III)~~ for the X and Y Samples using "After Wet Attrition" data sets for the -13mm material. ~~(For all material for the Scheme 5)~~.

In all cases the D Zone coal is blended back without any beneficiation.

The schemes evaluated are: -

(1) Total Washing: Heavy Medium Bath + Water Only Cyclones (Modular Washery)
(2) Partial Washing: Heavy Medium Bath (Coarse Coal Sections of Modular Washery)
(3) Partial Washing: Baum Jig
(4) Dryer/Classifier Scheme
(5) Total Washing: Water Only Cyclone Washery (equivalent to EMR Canmet scheme)
(6) Total Beneficiation: (2) + (4)

7.1 Total Washing: Heavy Medium Bath + Water Only Cyclones (Modular Washery)

7.1.1 General

This scheme will consist of a number of identical Modules each rated for a nominal 400 ~~MTPH~~ t/h capacity. Each Module would be fed from the Raw Coal Handling System by a separate Raw Coal Feed Conveyor; thus each Module could be independently set to optimize the product yield from its particular raw coal feed. We currently envisage 3 Modules (1,200 ~~MTPH~~ t/h ROM coal capacity). This allows for each Module to be taken out of service in turn for maintenance.

The modules would be constructed to work with a common set of product conveyors:

- Coarse Clean Coal Conveyor
- Fine Clean Coal Conveyor
- Fine Untreated Coal Conveyor
- Discard Conveyor

~~The~~ Three coal product conveyors have been included for two reasons: firstly to facilitate separate product stockpiling if required and secondly to give flexibility in product blending without complicating the modular plant layout.

Each module would consist of:

- Raw Coal Screening Section
- Coarse Coal Washing Section
- Fine Coal Washing Section

The design as a series of independent modules facilitates the stagewise development of the plant, and will greatly simplify the initial commissioning and on-going operator training programme.

Please read this Description in Conjunction with our Drawings:
F1304-0001(1) Flowsheet for Coarse Coal H.M. Section (1 Module)
F1304-0002(1) Flowsheet for Fine Coal Section (1 Module)
F1304-1002(1) Washery Layout

The description is given for a single Module.

7.1.2 Raw Coal Screening Section

The Raw Coal, broken to below say 200mm in the ROM Coal Breaker Stations, will be delivered at a steady rate not exceeding 400 ~~MTPH~~ t/h to the Module.

The flow would be divided by a bi-furcated chute to two parallel streams. Raw Coal Sizing Screens will classify at 25mm and 13mm. The 13mm x 0 Raw Coal will pass to Surge Hoppers. These Surge Hoppers will provide feed to the fine coal washing section. In the event of a high fines loading to the plant, provision has been made for these Hoppers to overflow onto the Untreated Fine Coal Conveyor. The 25mm aperture upper deck will provide protection for the lower deck for more efficient screening.

7.1.3 Coarse Coal Washing Section

The feed to the Washing Units, 200 x 13mm, will be passed over Pre-Wet Screens where sprays of Clarified Water will remove adhering fines which would otherwise contaminate the magnetite washing medium.

The coal will be delivered from the Wet Screens into the LeeBar Dense Medium Baths. These baths will utilize a suspension of finely ground magnetite in water of carefully controlled density corresponding to the gravity separation required.

The Clean Coal will float off, its removal being assisted by paddles, and delivered to Rinsing Screens fitted with heavy duty wedge wire panel sieves. The entrained magnetite medium will drain off in the first section, to be returned to the Bath via the Heavy Medium Cone.

The adhering medium will be removed by heavy spraying, firstly with Dilute Medium and then Clarified Water over the second or Rinsing section.

The third or Sizing Section of the Clean Coal Screen will deliver material less than 40mm size to a Centrifuge for further dewatering, and material greater than 40mm to a Crusher for reduction to below 40mm. These products will be recombined on the Coarse Clean Coal Conveyor.

The shale or rejects material which sinks to the base of the LeeBar Bath will be elevated out of the medium by an Extractor Chain Conveyor and delivered to a similar Discard Rinsing Screen. The Discard will be delivered to the Discard Conveyor

~~7.1.4~~ Coarse Coal Washing Liquid Circuits

The Heavy Medium will be continually recirculated through the Baths via the Heavy Medium Cones and Pumps. The medium density will be monitored to control its gravity.

The dilute Medium resulting from the product rinsing will be passed to a recovery circuit comprising a Settling Cone and two stages of Magnetic Separators. (The operating gravity in the bath is in the range 1.3 to 1.8 S.G. The magnetic separators give a recovered pulp of 2.2 to 2.6 S.G.).

Facilities for pump, pipeline and cone drainage within the magnetics circuit will be contained within a Reinforced Concrete Walled area, and Floor Sump and Pump would return contents to the working circuit to minimize magnetite losses.

A similar Walled area and sump system will serve the non-magnetics sections of the plant and facilitate centrifuge effluent and other drainage recovery via the Raw Coal Dewatering Screen or Fine Coal Module.

Facilities have been included for a magnetite store, magnetite handling and medium preparation; a common system to service all Modules.

~~7.1.~~5 Fine Coal Washing Section

The 13mm - 0 Raw Coal will be fed at the required steady rate from the Surge Hoppers to the Classifying Cyclone Feed Cone where Clarified Water will be added under automatic control. The Raw Coal Slurry will be pumped in two parallel streams to a bank of Thirty-two Classifying Cyclones designed to remove the 100M x 0 material. This will be rejected as the cyclone overflow to the Tailings Thickener for disposal. The 13mm x 100M material will be pumped in two parallel streams to a bank of Sixteen Primary Water Only Washing Cyclones and the partially cleaned overflow from this bank similarly to a bank of Sixteen Secondary Water Only

Washing Cyclones.

The underflow from both sets of cyclones would be passed via a Dewatering Screen to the Discard Conveyor. (This will be a common conveyor with the Coarse Coal Section). The screen will retain only a portion of the 28 x 100M discard, the bulk of this fraction passing as tailings to the Tailings Thickener. The Fine Clean Coal Slurry (Secondary Washing Cyclone Overflow product) will be pumped to Thickening Cyclones to remove the bulk of the wash water and facilitate dewatering by means of Sieve Bend and Slurry Screens, effecting a partial classification at 10M, followed by conventional Basket Centrifuge (as in Coarse Coal Module) for the 13mm x 10M and Screen Bowl Centrifuges for the 10M x 100M. These centrifuges will deliver product to the Fine Clean Coal Conveyor.

7.1.6 Thickener and Tailings Disposal Requirements

These requirements have been calculated in accordance with the data in the EMR Canmet Flocculation Report (Ref. 31.), and represent a substantial increase over the requirements envisaged when the Modular Coal Washery Scheme was originally prepared.

This likewise applies to the requirements for Solid Bowl Centrifuges. The basis for calculating these requirements is detailed in Section 8.

For EACH 400 MTPH Module the requirement is: -

ONE 52.5 in diameter thickener

FOUR Bird "H" Series Centrifuges complete with all supporting facilities.

7.1.7 Scheme Capability

This is summarized on the Materials Balance Diagram F1304-0006 Sheet 1.

7.1.8 Capital and Operating Costs

These costs are summarized from the Interim Reports (Refs. 14 and 16).

Capital

Coal Preparation Plant

End Modules 2	9,554,894	
Interior Module 1	4,530,712	
Common Items	980,520	
Thickeners 3 x 51m	6,288,000	
Engineering	4,568,800	25,922,926

Tailings Disposal

Centrifuge Plant 12 units	4,720,000	
Emergency/Pumping	1,376,790	
Engineering	655,500	6,752,290
Simon-Carves Total		32,675,216

Allow for Raw Coal Stockpile
Feed and Product Conveyors
Allow for Construction of Tailings
Emergency Lagoon
Water Supply

Operating Costs per Annum

Coal Preparation Plant

Power	614,286	
Heating	115,714	
Magentite	113,978	
Flocculants	202,552	
Spares	528,470	
Labour	3,010,082	4,585,082

Tailings Disposal

Power	131,745	
Heating	46,286	
Flocculants	2,490,840	
Spares	315,332	
Labour	901,620	3,885,823
		8,470,905

Operating Cost per tonne of Coal Preparation Plant Output

$$= \frac{8,470,905}{3,341,163} = \$2,535$$

Operating Cost per tonne of Total Product

$$= \frac{8,470,905}{7,728,549} = \$1.096$$

THIS IS THE SCHEME USED FOR COMPARISON

7.2 Partial Washing using Heavy Medium Bath

This scheme will consist of three identical Modules each rated at a nominal 400 t/h ~~MTPH~~. ~~Developed from Scheme 7.1;~~ the partial washing scheme would consist of a Raw Coal screening section and Coarse Coal Washing Section. The Automatic Ash Monitor within the Raw Coal Screening Section will be used to determine the "mode" in which the Module is to operate.

Reference to the Flowsheet and Washery Arrangement Drawing should be made to visualize the practical arrangement of automatically operated gates and overflow chutes by which this is achieved. The Conveyors will run the length of the Plant receiving products from all Modules.

There are three "modes",the sequence for increasing ash content raw coal (and thus a greater degree of beneficiation requirement) being:

7.2.1 Coarse Coal Washing (+25mm)

Only the +25mm Raw Coal being passed to the Dense Medium Baths for Washing. All the 25mm x 0 Raw Coal would overflow the Fine Coal Surge Hopper to the Untreated Fine Coal Conveyor.

7.2.2 Coarse Coal Washing (+13mm)

The +25mm x 13mm Raw Coal being passed together to the Dense Medium Baths for washing. All the 13mm x 0 Raw Coal would overflow the Fine Coal Surge Hopper to the Untreated Fine Coal Conveyor.

7.2.3 Sub-Grade Coal Washing

The module would be set as above except that the 13mm x 0 Raw Coal would be diverted to the Discard Conveyor. Thus Clean Coal would be recovered from the +13mm Raw Coal only.

7.2.4 Thickener and Tailings Disposal Requirements

Calculating as previously with reference to the EMR Testwork the requirement to work in conjunction with the THREE x 400 MTPH Modules is: -

ONE 42.5m diameter Thickener

FOUR Bird "H" Series Centrifuges complete with all supporting facilities.

(Note that this is equivalent to the 3 x 125 ft. diameter thickeners and 8 centrifuges envisaged for the 6 module plant in the Interim Report on Alternative Equipment for Tailings Disposal, Ref. 16).

7.2.5 Scheme Capability

This is summarized on the Materials Balance Diagram F1304-0006 Sheet 2.

7.2.6 Capital & Operating Costs

These costs are summarized from the Interim Reports (Ref. 14, 8, 16)

Capital

Coal Preparation Plant

End Module	2	6,022,680	
Interior Module	1	2,848,344	
Common Items		980,520	
Thickeners	1 x 42.5m	1,428,770	
Engineering		4,568,800	15,849,114

Tailings Disposal

Centrifuge Plant (4 units)	2,202,666	
Emergency/Pumping	688,395	
Engineering	437,000	3,328,061
	Simon-Carves Plant Total	19,177,175

NOTE: Allow for:
Raw Coal Stockpile, Feed and Product Conveyors, Construction of Tailings Emergency Lagoon Water Supply

Operating Costs per Annum

Coal Preparation Plant

Power	320,213	
Heating	115,714	
Magnetite	113,978	
Flocculants	44,517	
Spares	284,927	
Labour	2,122,256	3,001,605

Tailings Disposal

Power	43,915	
Heating	15,429	
Flocculants	564,300	
Spares	105,111	
Labour	447,636	1,176,391
	Plant Total	4,177,996

Per tonne of Coal Preparation Plant Output

$$= \frac{4,177,996}{2,039,750} = \$2.048$$

Per tonne of Boiler Plant Feed

$$= \frac{4,177,996}{9,387,585} = \$0.445$$

7.3 Partial Washing using Baum Jig Washery

This scheme was developed after the decision by the Cominco-Monenco Joint Venture that screening out of the -13mm raw coal should be done as part of the Run of Mine coal handling and crushing facility. Any washery plant would then receive a nominal +13mm feed via a Raw Coal Stockpile. (C-MJV drawing 400-005).

The plant is designed on a modular basis with a nominal 400 MTPH unit capacity. However dry screening out of the -13mm material would require a feed rate to the washery plant of 240 MTPH. (This is the 50% over nominal 13mm = 200 MTPH + allowance for misplaced -13mm material of 40 MTPH = 240 MTPH). One big advantage of a Baum Jig system is that it can accept a 150mm x 0 feed. Only the 150 x 0.5mm particles would be cleaned, and there would be substantial problems with the high -0.5mm fines content of Hat Creek cna similar coals. The plant layout therefore includes a Desliming System to facilitate removal of the finer coal from the washery circuit as fast as possible. If therefore different circumstances to those envisaged here for partial washing were applied, then the jig unit selected could, for example, accept a 200 MTPH feed of 150mm x 0 coal. (This would require small modifications to the water circuit within the washery building and additional tailings facilities).

7.3.1 Outline of Construction and Operation

Each module would be fed from the Raw Coal Handling system by a separate raw coal feed conveyor.

Each module performs the following duties: -

Raw Coal Desliming
Coal Washing
Clean Coal Classifying

The modules would be constructed to work with three common product conveyors: -

Coarse Clean Coal
Fine Clean Coal
Discard

It would be possible for these conveyors to run in either direction.

The description is given for a single module and should be read in conjunction with our drawings F1304-0003 Flowsheet for Baum Washery and F1304-1003 Baum Washery Layout.

7.3.2 Raw Coal Handling

The raw coal, broken to below 150mm in the R.O.M. coal breaker station, and classified at 13mm, will be conveyed to the washery giving an average of 240 MTPH to each module. The raw coal is received in a 200 MT surge bin. This bin is installed to cushion any variations in the amount of feed to the plant. This is required because a Baum Jig operates much more efficiently when receiving a constant feed rate.

7.3.3 Coal Washing

The raw coal is then fed to a desliming launder and screen using a vibrating feeder.

The screen overflow passes to the Baum Washbox via a feed launder, the underflow goes to the thickener.

The washbox reject leaves via the first two elevators and the middlings by the third elevator.

The middlings are screened at 13mm, the plus 13mm being crushed and returned to the washbox feed and the minus 13mm being rejected.

7.3.4 Clean Coal Classifying

The clean coal from the washbox will be dewatered using sieves and dewatering screens.

The screens also classify the coal at 25mm, the +25mm being delivered by the coarse clean coal conveyor to the C-MJV Crushing Plant.

The 25 x 0.5mm clean coal will be dewatered by Basket Centrifuges and delivered to the Fine Clean Coal Conveyor.

The drainage from the clean coal screens gravitates to the main washery sump, i.e. with the -0.5mm coal particles. This will be pumped up to a batch of slurry cyclones. The cyclone overflow will be used as desliming and wash water.

The cyclone underflow will be flushed to a slurry dewatering sieve bend and screen. The slurry product will join the minus 25mm clean coal from the washbox and be centrifuged to remove excess moisture.

7.3.5 Tailings Disposal

The desliming screen underflow, discard dewatering screen underflows and some of the slurry cyclone overflow will be sent to the Tailings Thickener for treatment as described in Section 8.5.

7.3.6 Thickener and Tailings Disposal Requirements

As for the previous Scheme-paragraph 7.2.4

7.3.7 Scheme Capability

This is set out on the Materials Balance Diagram F1304-0006 Sheet 3.

7.3.8 Capital and Operating Costs

These costs are summarized from Interim Reports (Ref. 15 and 16)

Capital

Baum Washery

1st Module including Common Items	2,928,362	
Modules 2 and 3	5,026,894	
Thickener 1 x 42.5m	1,428,770	
Engineering	3,330,000	12,714,026
Tailings Disposal (as 7.2.6)		3,328,061
		16,042,087

Allow as in para. 7.2.6 for ancilliary items

Operating Costs per Annum

Baum Washery

Power	137,724	
Heating	86,786	
Flocculants	44,517	
Spares	178,800	
Labour	1,877,852	2,325,679
Tailings Disposal (as 7.2.6)		1,176,070
		3,502,070

Per tonne of Coal Preparation Plant Output

$$= \frac{3,502,070}{2,039,750} = \$1.717$$

Per tonne of Boiler Plant Feed

$$= \frac{3,502,070}{9,325,416} = \$0.376$$

7.4 Fines Dryer - Classifier Scheme

This Proposal (Ref. 20.3) has been based on the drying and size classification of the nominal 13mm x 0 raw coal from Zones A, B and C at a rate of 500 MTPH. This would be extracted by the C-MJV Screening Plant, Drawing CMV 400-005 and fed via a Stockpile.

The Basis of Design assumes that the air dried moisture content of this material is 20.0%. An evaporative capacity of 32.0 MTPH has been allowed to permit variations in feed moisture.

The actual duty, based on the 25.0% Total Moisture currently anticipated for the Raw Coal to a dryer product at 23.0% is 18.40 MTPH evaporation. Operating costs have been based on this latter figure, and allow for coal giving with a back-up of No. 2 Fuel Oil.

Note that the objective of the system is to permit efficient extraction of fines, not drying as such. Products dried to less than 3.0% moisture give dusting problems.

7.4.1 General

The design and costing is based on one FMC Model 12' x 18' Fluid Flow Dryer System. All auxiliary equipment such as combustion, forced and induced draft fans, coal fired air heater, #2 fuel oil start up system, oil storage tank, dust collection equipment, ductwork, material feed bin, screw feeders, air locks, complete process controls, atomizing instrumentation and control air, and scrubber recycle pump system with level controls are included. The General Layout and Process Flowsheet is shown on Drawing No. F1304-1005.

7.4.2 Description of Plant

The nominal 13mm x 0 would be conveyed to the Dryer Feed Bin, from which it would be fed by Screw Conveyors into the Fluidising/ Drying Chamber. The Screw Conveyors would be driven by D.C. motors equipped to permit variable control of the dryer feed. The Feed Bin would be equipped with level controllers - these would modulate the feed to the Fluidising/Drying Chamber or stop the Feed Conveyor Belt as appropriate. (It would be necessary to provide a by-pass ahead of this Feed Conveyor Belt.)

The coal would be dried by the upward flow of heated air through the Fluidising/Drying Chamber. This same air flow would support the coal in a fluidised state above the Constriction Deck and cause it to flow across the deck to the coarse coal discharge chute. The same air flow would naturally lift the finer particles out of the mass of coal to the Dust Collector Cyclones. The Constriction Deck would be fitted with an agitator to shake free any accumulated fly ash from the underside of this bar deck constriction, and thus maintain a uniform air flow pattern through the coal bed.

(In normal coal drying practice, the lifting of fine coal particles out of the bed is regarded as a disadvantage and the air flows and chambers are designed to minimise the solids discharge to the dust collection system. For this application, there could be changes in dryer ductwork and settling chamber profiles to accentuate the size classification capability. There would have to be pilot scale and design studies if this proposal were to be taken further).

7.4.2 The fines would be collected in Cyclones and discharged to the rejects conveyor. Ultrafines entrained in the spent gas flow would be removed by a Wet Venturi Scrubber to meet current dust emission standards prior to gas discharge to the Exhaust Stack. The scrubber sludge would be returned to the Washery circuit or discharged to a settling pond.

The principle of modern fluidised bed dryers places the dryer fan between the dryer bed and the dust collection system, thus giving sub-atmospheric pressures within the dryer and furnace. The furnace would be fired by raw coal with the start-up/secondary fuel system currently envisaged as using #2 Fuel Oil.

7.4.3 *Capability of Scheme*

This is outlined on the Materials Balance Diagram F1304-0006 Sheet 4. Further work on the feasibility of this system would be needed as mentioned above. We envisage a potential problem with the clay fines "drying onto" the coarser material rather than liberating readily at -0.5mm to the extent which has been proved possible for better coals by the commercial unit constructed by Heyl and Patterson (Ref. 20.4). It should be noted that the partition factors obtained from Heyl and Patterson have been applied to the Wet Screen analysis (Ref.12). It is probable that some clay liberation occurred in this operation, and to this extent the results shown on the Materials Balance Diagram are optimistic.

7.4.4 Effluent and Discard Disposal Requirements

There is no tailings as such from the dryer. The quantity of effluent from the Scrubbers has not been determined at this stage, but it could be assumed that this could be handled by the general site facilities. Special facilities would be needed to handle the very dry dust/discard fines to the mine discard conveying system.

7.4.5 Capital and Operating Costs

Capital

6,252,000 Total FMC scheme cost

Allow for Raw Coal Screening, Feed and Product Conveyors and Stockpiles

Operating Costs per Annum

Power	348,645	
Fuel: Coal at say $10.00 per tonne Oil for start-up	130,357	
Labour	1,180,500	
Spares	241,400	2,232,855

Per tonne of Plant Output

$$= \frac{2,232,855}{2,035,013} = \$1.097$$

Per tonne of Boiler Plant Feed

$$= \frac{2,232,855}{9,382,848} = \$0.238$$

7.5 Total Washing: Water Only Cyclones

This scheme is equivalent to the EMR Canmet Scheme Proposal. (A brief outline and materials balance diagrams for a 1500 MTPH plant based on their wash results is included in the Draft Report (Ref.31). Review of this report is not yet complete.

Any conceptual scheme and costing will therefore have to be presented at a later date, if required.

Based on the thinking in the Draft Report, and our interpretation of the X and Y sample washability data (after Wet Attrition) a provisional Mass Balance Diagram F1304-0006 Sheet 5 is included on the same 1000 MTPH basis as the other schemes described in this section.

From this it can be appreciated that a very similar degree of beneficiation to the more conventional Total Washing Scheme 1 would be obtained. The clean coal yield is predicted to be marginally lower. The washery plant costs would be significantly lower. However, the Tailings problem is substantially increased: note that some two-thirds (2/3) of the discard (or a dry solids basis) would be as tailings. Thus for EACH 400 MTPH Washery Module if calculated in the same basis as the earlier scheme, the requirement would be for

ONE 56m diameter Thickener
SIX Bird 'H' Series Centrifuges together with all supporting plant.

7.6 Total Beneficiation: Heavy Medium Bath & Fines Dryer-Classifier Scheme

Both Partial Washing by the Heavy Medium Bath Scheme and the Fines Dryer Classifier, Scheme 4, have their advantages. Particularly, these are related to the degree of beneficiation achieved relative to the tailings production.

To complete the picture therefore, a composite has been outlined of these two schemes. This is shown as the Materials Balance Diagram F1304-0006 Sheet 6.

It is of interest to note that this combined scheme achieves an average product of the order of 6,300 BTU/lb. on the as received basis, together with a satisfactory BTU yield/discard ash content and a comparatively manageable tailings problem.

Costs are obtained by adding together those from paragraphs 7.2 and 7.4. The reservations regarding the dryer scheme remain.

SECTION 8

ANCILLIARY OPERATIONS

As an introduction to the discussion of ancilliary operations, it is necessary to identify the criteria which have governed our proposed designs.

The present philosophy regarding treatment of the Hat Creek coals suggests that if a beneficiation plant is installed, then it will only be required for partial or total treatment of the A, B and C Zone coals. On average these represent somewhat over fifty percent of the total run of mine coal production.

The partial treatment may be of either the coarser or finer coals. We note that in their run of mine coal handling, screening and crushing system, the Joint Venture have allowed for possible screening at a nominal 13mm. This size could be adjusted to give approximately equal feed rates to the coarse and fine coal treatment units.

8.1 Raw Coal Handling and Screening

Peak production from the mine will be 3000 MTPH and maximum daily production has been assumed at 40,000 Tonnes represented by 20 operating hours at an average production of 2000 MTPH.

The average quantity of coal requiring beneficiation will be 22,000 MTPD and the maximum production rate of these A, B and C Zone coals is assumed as 2000 MTPH of size consist 200mm x 0.

The various alternate routings for these A, B and C Zone coals on arrival at the central Screening and Crushing plant, are as follows: -

a) Total Production is processed through the Screening and Crushing facility and delivered to the Product Blending System

b) Total Production of 200mm x 0 raw coal by-passes the Screening and Crushing facility and is delivered to the stockpiling facility prior to beneficiation.

c) The 200mm x 13mm portion of the production is delivered to the raw coal Stockpiling Facility for beneficiation and the 13mm x 0 portion is delivered to the Product Blending System. (Or vice-versa if the Dryer/Classifier Scheme is chosen).

From the Sub-Grade Coal production the 13mm x 0 may be passed to the discard disposal conveyors.

8.2 Raw Coal Stockpiling

Because of the fluctuations in output rates it is essential that raw coal be stockpiled in order to provide a constant feed to the beneficiation plant. The stockpiling facilities required prior to the beneficiation plant must be designed to handle the variations between mine production and feed to the plant and must not be considered as long term storage. For design purposes, it can be assumed that a beneficiation plant to handle up to 24,000 MTPD will employ the parameters of 20 operating hours at a constant feed of 1200 MTPH (3 x 400 MTPH Modules).

Under the design parameters of maximum mine production at 2000 MTPH it is seen that the minimum storage requirements are 8,000 Tonnes. However, if only 2 x 400 MTPH Modules were operational then the stockpiling required would be 12,000 tonnes. It is recommended that this requirement be increased by 50% and that 18,000 Tonnes of storage capability be provided prior to the beneficiation plant.

The final design of stockpiling facilities will depend upon the type of beneficiation plant that is selected but in the likely event that the plant is modular then the reclaim facilities must be designed to allow for feeds to the separate modules.

8.3 Product Blending

Responsibility for the Product Blending Scheme is with the Joint Venture. Simon-Carves participated in preliminary discussions of the requirements (Ref. 19). Blending of D Coals with A, B and C Zone Coals, whether beneficiated or not, will be particularly necessary for sulphur content control. (Ref. 19.1)

8.4 Water Requirements

Make-up water requirements are shown for the alternative schemes on the Mass Balance Diagrams, F1304-0006 Sheets 1 - 6.

The EMR Canmet Test Wash Draft Report (Ref. 31.1) gives cause for concern in that there was a rapid build-up of dissolved solids, particularly the sulphate ion. The latter reached 4000 parts per million and was still increasing. This would necessitate the use of high grade sulphate resisting cement in all washery constructions (Ref. 36) and might need special sulphate resisting linings (Ref. 37). Of equal concern is that even during these very short runs various crystalline forms of sulphate were observed in the water circuits. A special investigation of this problem would be needed prior to any washery design : at worst a substantial washwater circuit effluent may have to be accepted.

8.5 Tailings Disposal

This section summarizes and to an extent updates, our Preliminary Report of March 1978 (Ref. 16) on the Design and Costing of Alternative Equipment for Tailings Disposal. Subsequently the EMR Report (Ref. 31.1) has been received. Some findings from this latter report are used here, although review is not yet complete. Tailings are essentially the -0.5mm fines which are, in the case of A, B and C Zone coals, unwanted high ash material.

8.5.1 Tailings Plant Requirements

Requirements anticipated derive from possible beneficiation of A, B and C Zone coals:

a) Total Washing - conventional plant

b) Total Washing - with maximum attrition to liberate clays

c) Partial Washing - in this case there is still a significant tailings yield due to misplaced material in the raw coal (say nominal 13mm) screening and degradation in the washing units.

8.5.2 Tailings Disposal Methods

The table "Summary of Tailings Dewatering Methods" outlines the applicability of various methods and equipment to the Hat Creek materials. It is concluded that the only feasible methods are conventional flocculation followed by dewatering in Solid Bowl Centrifuges. Two essential reservations must be noted:

a) The Solid Bowl Centrifuges are selected as the only viable alternative. They are in the early stages of production use on similar tailings. However, the degrees of sludge compaction reported in the EMR Flocculation Testwork (Ref. 31.1) shows that the machines would be used at the limit of present experience. Larger scale washing tests coupled with pilot plant centrifuge tests on the sludges will be necessary before any wet beneficiation scheme could be proposed.

b) All experience to date indicates that an Emergency back-up must be provided. For the tailings quantities envisaged at Hat Creek this would have to be a substantial lagoon (to be costed by the Joint Venture). We have included in our costs for pumping schemes to be used in conjunction with this lagoon.

Table 3
Summary of Tailings Dewatering Methods

	METHOD	COSTS	ADVANTAGES	DISADVANTAGES	CONCLUSIONS
1.	Conventional Flocculation/ Thickeners				Necessary as initial step in disposal
2.	Super Flocculation/ Deep Cone Thickeners	High	Thick Sludge	High Flocculation costs	Hat Creek material not amenable to this process
3.	Lagoon Clarification	Very high civil costs	Flocculants may not be req'd	Large lagoons required Environmentally sensitive	Hat Creek material not amenable to this process
4.	Incorporation in Product	Low	Simple Diaposal	High Ash Sludge giving very poor handling	Unacceptable to Boilers
5.	Lagoon Disposal	High civil costs	Sequential re-use	Large lagoon required Environmentally sensitive	Hat Creek material not amenable to this process
6.	Filter Presses	Very high	High Cake Solids no flocculants	Batch process Labour intensive	Too expensive in capital
7.	Tube Presses	Very high	Continuous process	In development stage	Unacceptable
8.	Solid Bowl Centrifuges	High	Continuous process. In use on similar materials	High maintenance Very high flocculant costs	Only practical means available

8.5.3 Tailings Disposal Scheme

This scheme has been detailed in our Preliminary Report (Ref. 16) and on the enclosed drawings:

F1304-0005 Flowsheet of Thickeners and Solid Bowl Centrifuges
F1304-1004 Layout of Solid Bowl Centrifuge Plant

These drawings were based on the requirements for a provisional washery scheme which is not incorporated in this Report. The actual requirements in terms of thickener sizes and numbers of centrifuges vary with the individual washery schemes and are detailed in the appropriate paragraphs of Section 7.

The requirements are calculated on EMR Testwork data:

Thickener Solids Loading Rate : 0.106 tons per sq. ft. per day
Thickener Solids Underflow : 10% solids, weight/weight basis

8.5.4 Description of Scheme

The tailings in the washwater flow will be dosed with the normal clarifier flocculants within the washery modules and will flow to the conventional Thickener/Clarifiers. The overflow of Clarified Water will be returned to the Washery circuit, together with any required make-up water.

The Thickener underflow will be pumped to Buffer Tanks. Each pipeline will incorporate a Nuclear Density Gauge to monitor sludge consistency and facilitate balancing of the solids load withdrawl from the thickeners.

In the stirred buffer tanks the "high grade" flocculant solution will be added. The conditioned slurry would gravitate to the Bird "H" Series Deep Pool Solid Bank Centrifuges via automatic feed valves controlled by the centrifuge discharge torque drive mechanism.

The cake would be discharged to a belt conveyor for disposal. (Note that this cake is not of an adequate consistency for conveying any distance without being mixed with lump discard. It cannot be bunkered.)

The main purpose of the "high grade" flocculant is to hold the ultrafines in the centrifuge cake despite the high centrifugal classifying forces. The centrate is recirculated via the thickeners.

8.6 Solid Discard Disposal

The most adverse operating conditions which would produce the greatest volume of discard will be that condition where "Total Treatment" of the Low Grade raw coals is necessary. Operating under the "Total Treatment" condition we can anticipate that for every 100 MTPH of raw coal feed we will produce approximately 42.26 MTPH of discard with a surface moisture content of 11.6%.

This discard will be routed to the overland conveyors for ultimate disposal at either Houth Meadows or Medicine Creek.

SECTION 9

BENEFICIATION OF SUB-GRADE COALS

The Hat Creek deposit will yield a wide variety of raw coals. The "better" raw coals will have calorific values in the range up to 10,000 BTU/lb. (dry basis), whilst the bulk of the coal will be in the 6,000 to 8,000 BTU/lb. range.

Initial concepts for mining this deposit (1), (3) envisaged the average run of mine product quality being maintained by rejecting lower grade materials in the mining operation. This has in fact materialised in the C-MJV Mining Plans using a "Cut-Off grade" of 4,000 BTU/lb. to achieve an average 7,327 BTU/lb. product over the mine life.(Ref. 26).

The considerations outlined in Sections 5 & 6 of this report led to a decision (24) not to include a beneficiation process plant as a means of achieving an average 7,875 BTU/lb. product to suit the Draft Boiler Fuels Specification (21).

Increasing the Cut-Off Grade to about 5,500 BTU/lb. could achieve the 7,875 BTU/lb. average fuel, but some 60,000,000 tonnes of extracted coal would be in the 4,000 to 5,000 BTU/lb. range, and the mine could not then meet the planned output.

Energy conservation considerations have suggested that material between 2,000 BTU/lb. and the Cut-Off Grade should not be discarded. Thus we have considered the beneficiation and incorporation in the product of this 37,000,000 tonnes of "Sub-Grade" coal (22) as an alternative to stockpiling for unspecified future use.*

* It should be noted that this would mean the stockpiling of some 10% of the mine output. It would thus be a major investment requiring separate crushing, handling and stockpiling facilities. We have drawn attention to the fact that to prevent spontaneous combustion the crushing and stockpile compaction would have to be effective, and that this would dispense the better, coarser materials amongst the finer clay materials rendering future recovery and utilisation more difficult.

SECTION 9

BENEFICIATION OF SUB-GRADE COALS

9.1 Beneficiation Characteristics

The samples tested for washability (5), (12) and considered elsewhere in this report lie in the range 5,600 BTU/lb.(Sample A) to 8,800 BTU/lb. (Sample Z). They do not therefore permit the direct assessment of the beneficiation potential of the Sub-Grade coals.

Examination of these sets of washability data did not show the trends normally encountered in a deposit which result from varying thickness and frequency of shale partings within the coals seams or zones. (If this pattern had occurred then beneficiation could be projected to give a relatively low yield of say 8,000 BTU/lb. coal from the Sub-Grade coals).

SECTION 9

BENEFICIATION OF SUB-GRADE COALS

9.2 Beneficiation by Dry Fines Extraction

Projections were made of the variations in size consist and ash content trends between size fractions. These showed that fines screened out of the Sub-Grade coals would be of high ash. (Table 2 of Ref.17). For example, a 3,000 BTU/lb. (66.3% ash) coal could be screened at say 13mm to reject 2,436 BTU/lb. (70.2% ash) fines and yield 50% by weight of 3564 BTU/lb. (62.4% ash) product. This is a degree of beneficiation of 1.26 for a low cost at 60% BTU Yield. By this means some two thirds of the heating value could be contained within 50% of the feed tonnage.

We therefore recommend that as a minimum this be adopted to halve the stockpiling requirements, and more importantly, to avoid contaminating the useful fuel with the 70% ash high clay content material.

Alternatively, this comparatively useful screen overflow might be blended into the product, reducing the tonnage to be mined by 9,000,000 tonnes (paragraph 4.1.2 Ref. 17), but at the expense of product quality.

SECTION 9

BENEFICIATION OF SUB-GRADE COALS

9.3 Beneficiation by Washing

Reference is made in paragraph 9.1 above to the fact that normal relationships were not found between the washability data sets. However (on page 4-7 Ref.17 and associated Figs. 3 and 4) details are given of a rather unique correlation obtained between the Raw Coal Ash Content and Clean Coal Ash Content at a fixed yield value (irrespective of size fraction or cut-point specific gravity). A good correlation fit was obtained for all data from samples A, B, C, X & Y, and Z, and facilitated the predictions of possible beneficiation of Sub-Grade coals which conformed with all the usual rules governing mass and ash balances.

This correlation suggests that Hat Creek contains a family of related coals and related inert materials. Trends in size consits and ash contents of the size fractions can in fact be interpreted into washability curves: for example, the washability of a 30% ash 28 x 100 mesh size fraction from a low ash raw coal is very similar to that of the 30% ash 2" x ½" size fraction of a high ash raw coal. This is consistent with the suspicions of CSMT (Ref.5.2) confirmed by EMR Testwork (Ref.31.3). The difference between the various raw coals may be due therefore to the ranging degrees of "filling in" of the fissures in the coal structures by the high ash clays. These have caused at times, abnormal ash values (Ref.31)

Moreover these may be leached out by extended attrition in water as seen in the Wet Attrition Tests (12.3) and EMR Canmet Test Wash (31).

Using this method we have estimated the practical beneficiation of Sub-Grade coals. For example, a 3000 BTU/lb. (66.3% ash) raw coal could theoretically give a 5243 BTU/lb.(50.8% ash) cleaned coal product at 44.4% yield by weight (77.6% BTU yield). This is a Degree of Beneficiation

SECTION 9

BENEFICIATION OF SUB-GRADE COALS

9.3 Beneficiation by Washing - cont.

of 2.28.

Thus the Sub-Grade coals (2000 - 4000 BTU/lb.) could be washed to increase the mine yield by some 10 million tons.

However, it must be noted that:

9.3.1 these yields are theoretical and would be reduced by approximately one third when account is taken of misplaced material in a practical washing process.

9.3.2 there is a reduction in total mine product quality, even if marginal. If the cut-points were reduced to give a cleaner product, the rejects would be of relatively low ash content.

9.3.3 first estimates of beneficiation costs are high particularly when the problems of tailings disposal are taken into account. An even greater proportion of the total discard would be tailings than for the coals discussed in Section 7.

SECTION 9

BENEFICIATION OF SUB-GRADE COALS

9.4 Other Beneficiation Methods

Other methods look dubious - e.g. extended attrition and wet screening to maximize removal of interbedded clays, since the tailings problems are potentially enormous.

If partial washing were adopted, say of the +13mm sub-grade coals blended with the -13mm fines, the product quality would be very low.

We thus recommend that the fines be discarded as in paragraph 9.2 and that only coarse sub-grade coal be considered for washing if facilities are available. (See also Paragraph 7.2.3).

SECTION 9

BENEFICIATION OF SUB-GRADE COALS

9.5 Base Cut-Off Grade

The very low heating value and beneficiation potential and relatively high cleaning costs for the materials between 2000 and say 2500 BTU/lb. (dry basis) leads us to question 2,000 BTU/lb. as the Base Cut-Off Grade (Ref.22 , and Ref. 17 Table 8).

It is therefore recommended that, as a first step, the interpretation of the "2000 BTU/lb." base cut-off be established. For example on an "as received" basis at 25% moisture, 2000 BTU/lb. is equivalent to 2667 BTU/lb. dry basis. Nearly half of the Sub-Grade material would not be classed as part of the coal reserve if this value were adopted.

SECTION 10

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Float and Sink Testing of Hard Coal.

35. Coal Beneficiation by Spherical Agglomeration
Private Communication Simon-Carves of Canada to BCHPA
March 9, 1978
Review of Current Literature.

36. Canadian Standards Association
Requirements for Sulphate Resisting Cement.

37. Private Communication
Simon-Hartley Ltd. (UK) Industrial Effluents Division.

SECTION 11

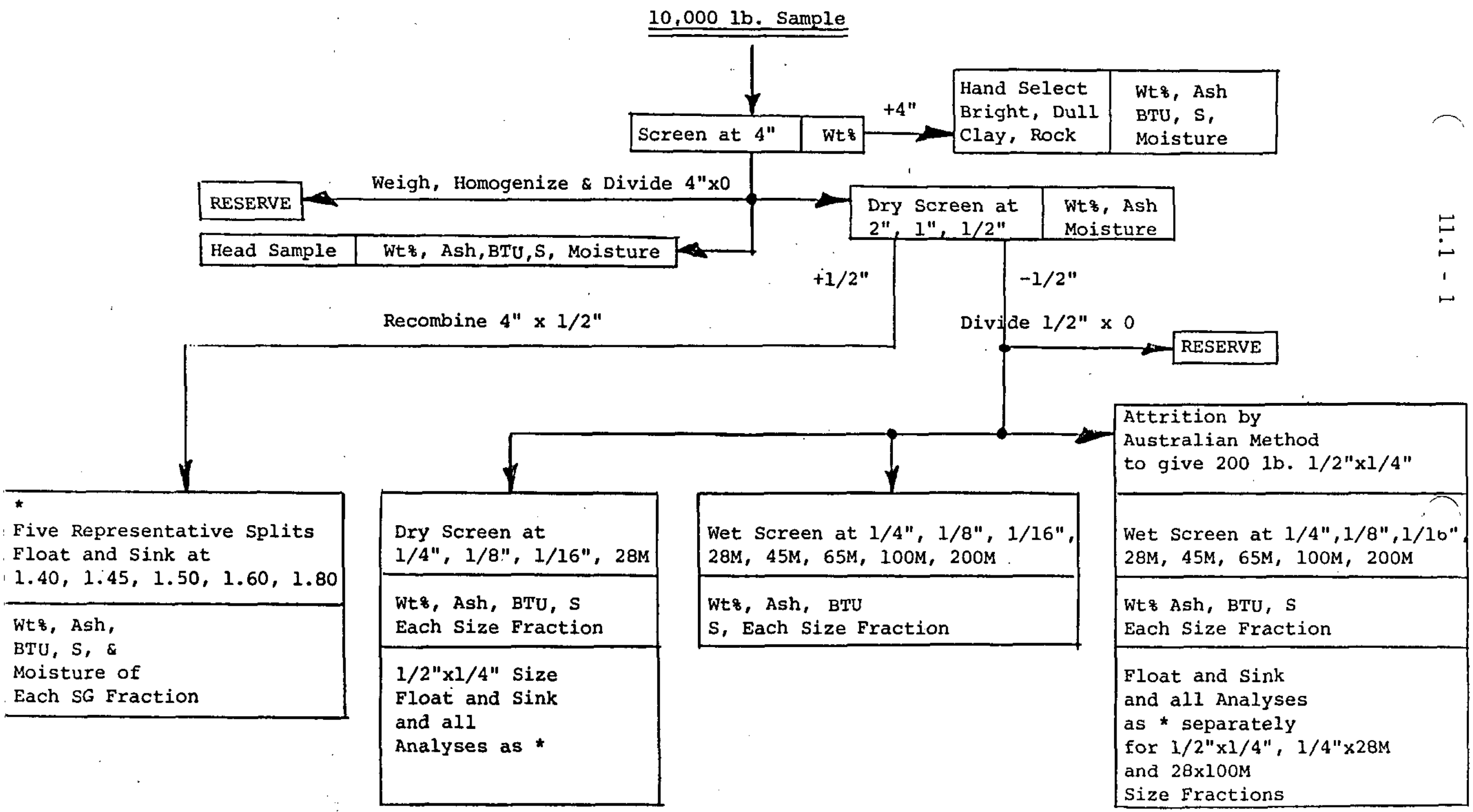
DRAWINGS

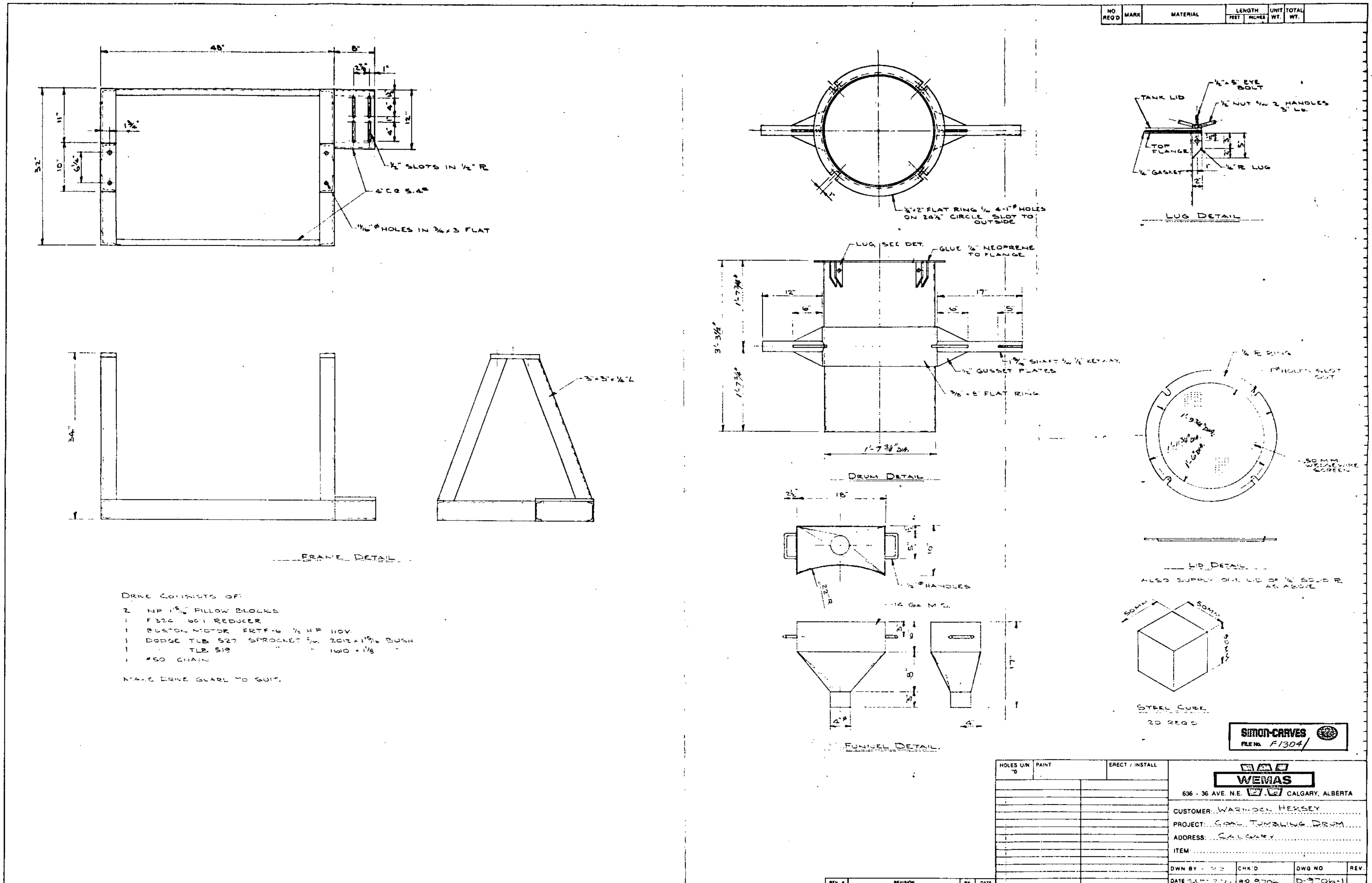
Simon-Carves
of Canada Ltd.

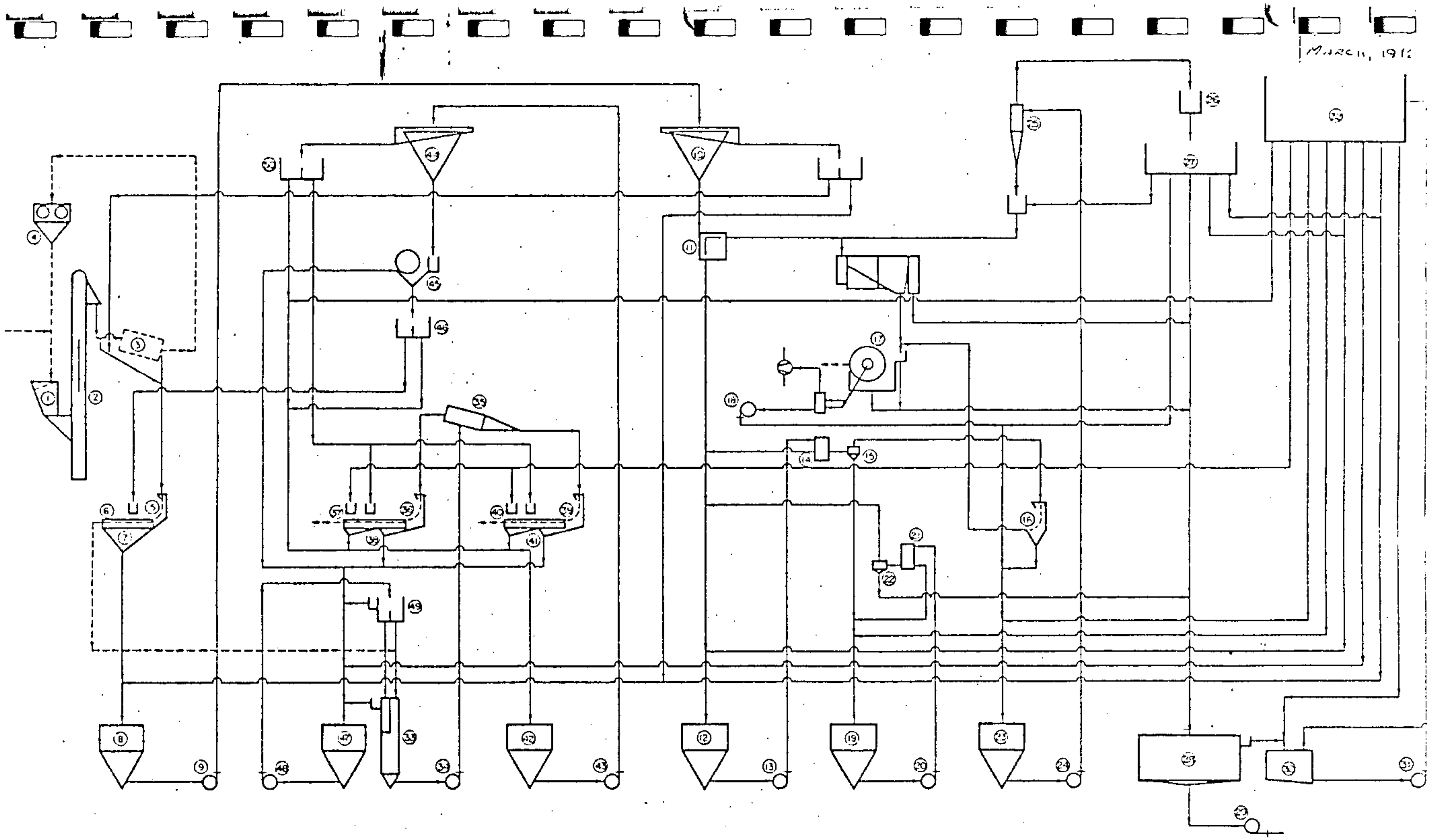
Appendix "A"

B.C. HYDRO - HAT CREEK PROJECT

SIZING AND WASHABILITY STUDIES FLOWSHEET




FRAME DETAIL
DRUM DETAIL
LUG DETAIL
LID DETAIL
FUNNEL DETAIL
STEEL CUBE
20 REQ'D
½" SLOTS IN ½" R
4" C @ 5.4#
1½" SHAFT W/ ½" KEYWAY
½" GUSSET PLATES
⅜ x 5" FLAT RING
3 x 3 x ¼" L
½" HANDLES
14 GA M.S.
TANK LID
TOP FLANGE
½" R LUG
LUG, SEE DET.
GLUE ⅛" NEOPRENE TO FLANGE
½ x 2" FLAT RING W/ 4-1" HOLES ON 26⅝" CIRCLE SLOT TO OUTSIDE
¼ R RING
50 MM WEDGEWIRE SCREEN
ALSO SUPPLY OIL LID OF ¼" SOLID R AS ABOVE
DRIVE CONSISTS OF:
2 NP 1 15/16" PILLOW BLOCKS
1 F 324 60:1 REDUCER
1 BOSTON MOTOR FRTF-6 ½ HP 110V.
1 DODGE TLB 527 SPROCKET W/ 2012 x 1 15/16 BUSH
1 " TLB 519 " " 1610 x 1⅛ "
1 #50 CHAIN
MAKE DRIVE GUARD TO SUIT.
NO REQ'D
MARK
MATERIAL
LENGTH
FEET
INCHES
UNIT WT.
TOTAL WT.
SIMON-CARVES
FILE No. F1304
HOLES U/N
PAINT
ERECT / INSTALL
REV #
REVISION
BY
DATE
WEMAS
636 - 36 AVE. N.E. CALGARY, ALBERTA
CUSTOMER: WARNOCK HERSEY
PROJECT: COAL TUMBLING DRUM
ADDRESS: CALGARY
ITEM:
DWN BY
CHK'D
DWG NO
REV.
DATE
WO 9706
D-9706-1



(1) Feed Bin
(2) Elevator
(3) Rotary Screen
(4) Jaw Crusher
(5) Sieve Bend
(6) Desliming Screen
(7) Underflow Collector
(8) 28M-0 Raw Coal Collection Tank
(9) Pump
(10) Settling Cone
(11) Diverter
(12) Primary Water Only Cyclone Feed Tank
(13) Pump
(14) Distributor
(15) Primary Water Only Cyclone
(16) Sieve Bend
(17) Vacuum Filter
(18) Filtrate Water Pump
(19) Secondary Water Only Cyclone Feed Tank
(20) Pump
(21) Distributor
(22) Secondary Water Only Cyclone
(23) Thickening Cyclone Feed Tank
(24) Pump
(25) Thickening Cyclone
(26) Overflow Distributor
(27) Head Box
(28) Thickener
(29) Waste Disposal Pump
(30) Clarified Water Collection Tank
(31) Clarified Water Pump
(32) Clarified Water Head Box
(33) Cyclone Feed Tank
(34) Pump
(35) D.S.M. Cyclone
(36) Sieve Bend
(37) C.C. Drain and Rinse Screen
(38) Underflow Collector
(39) Sieve Bend
(40) Discard Drain and Rinse Screen
(41) Underflow Collector
(42) Dilute Medium Tank
(43) Pump
(44) Settling Cone
(45) Magnetic Separator
(46) Splitter Box
(47) Correct Medium Tank
(48) Pump
(49) Distribution Box
(50) Splitter Box

FIGURE 6
11.1 - 3

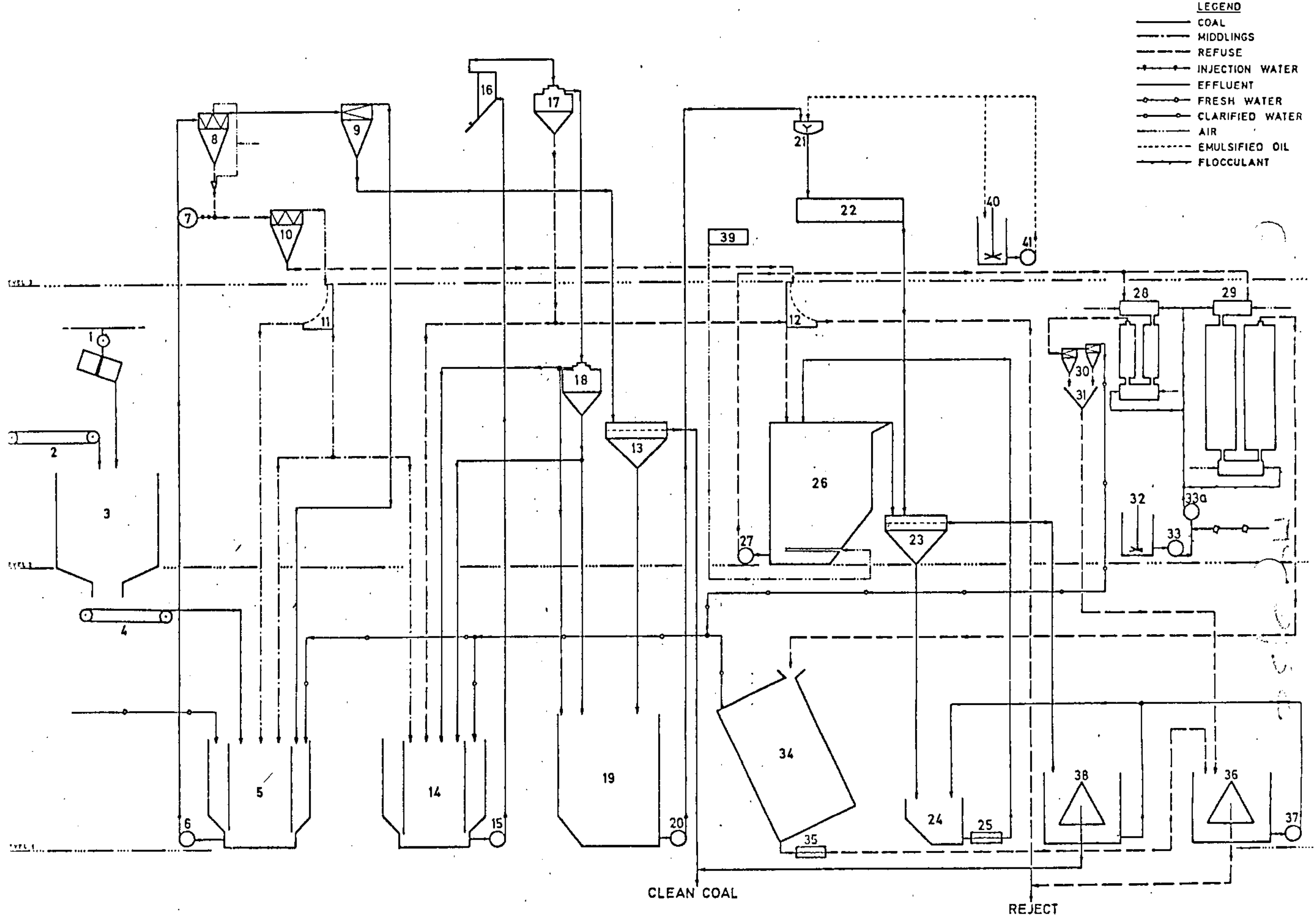
TEST PLANT FLOWSHEET

COAL SCIENCE & MINERALS TESTING

DIV. OF BIRTLEY ENGINEERING (CANADA) LTD. CALGARY, ALTA

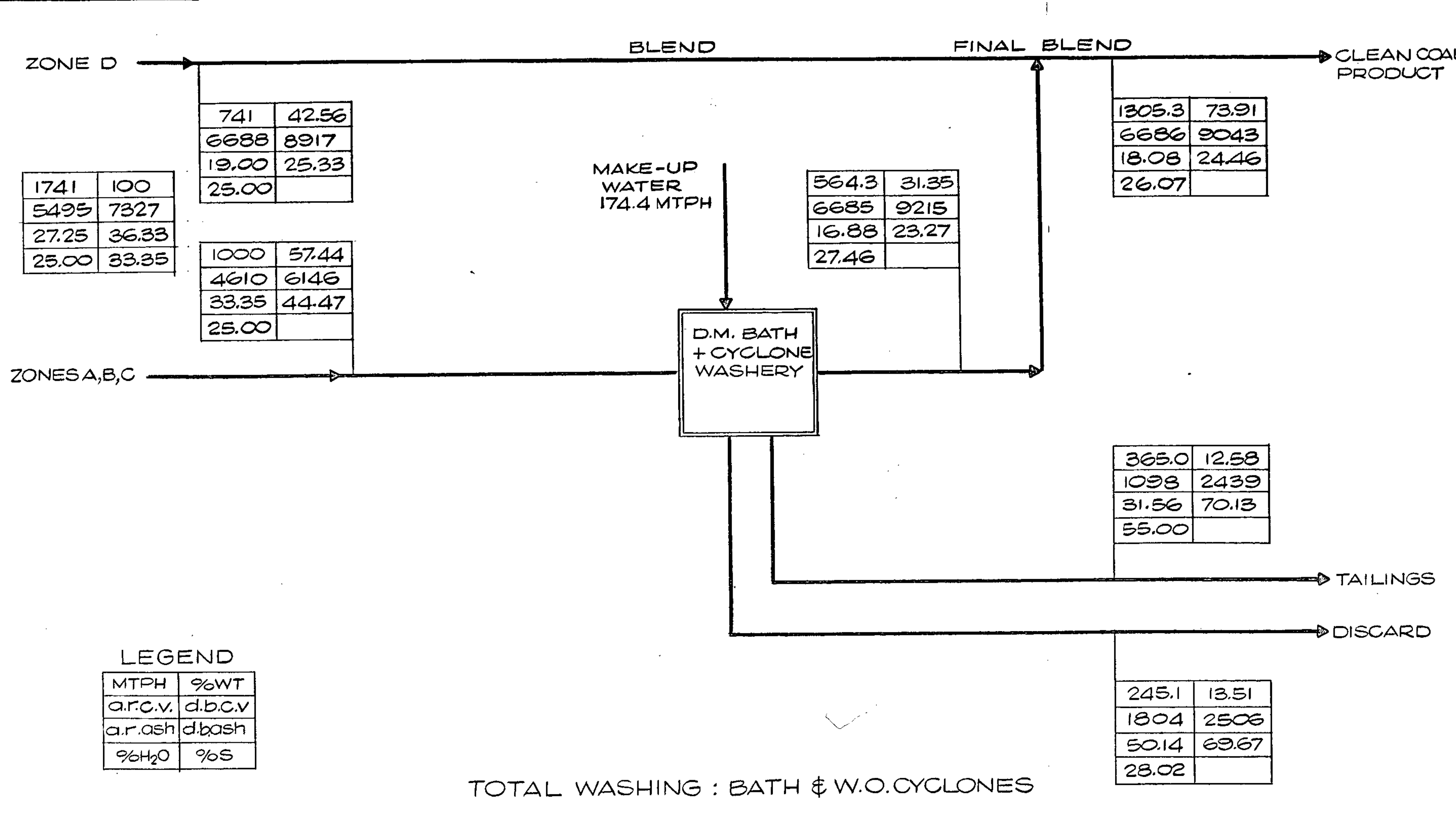
EMR — PILOT PLANT (5 tph)

11.1 - 4



EMR/WRL 5 TPH PILOT PLANT - FLOWSHEET LEGEND

	Unit No.	Item
Feed Preparation	1.	Drum Hoist, 1/2 ton cap.
	2.	Raw Coal Belt Conveyor, 1/2 HP
	3.	Raw Coal Hopper, 5 ton cap.
Main Cleaning Section	4.	Feed Conveyor
	5.	Feed Tank, 125 ig
	6.	4 x 5 Slurry Pump, 15 HP
	7.	Pulp Divider
	8.	Primary Cyclone, CWC-8"
	9.	Classifying Cyclone, 8"
	10.	Secondary Cyclone, CWC-8"
	11.	Middlings Sievebend
	12.	Refuse Sievebend
	13.	Clean Coal Dewatering Screen, 2' x 4'
Slimes Cleaning	14.	Slimes Tank, 315 ig
	15.	3 x 3 Slimes Pump, 10 HP
	16.	Degritter
	17.	Multiple CW Cyclone, 24 x 2"
	18.	Multiple Classifier Cyclone, 24 x 2"
	19.	Slimes Holding Tank, 740 ig
	20.	Circulation Pump
	21.	Oil Conditioning Tank, 1 HP
	22.	Paddle Mixer, 10 HP
	23.	Dewatering Screen
	24.	Sump
	25.	Slurry Pump, 2 HP
	26.	Aerator Cell, 1200 ig
	27.	3 x 3 Slurry Pump 7 1/2 HP
Water Recovery	28.	Flocculator, 4"
	29.	Flocculator, 8"
	30.	Classifier Cyclones, 4"
	31.	Funnel
	32.	Flocculant Mixing Tank, 45 ig
	33.	Metering Pump, 1.2 igpm
	33a.	Feeding Pump, 20 igpm
	34.	Inclined Settler, 100 igpm
	35.	Sludge Pump
Drying	36.	Reject Centrifuge
	37.	Centrate Pump
	38.	Clean Coal Centrifuge
Slimes Cleaning	39.	Aerator Blower, 120 cfm @ 10 psi
	40.	Oil Emulsifying Tank, 45 ig
	41.	Oil Pump, 3 HP



DWG. NO. F1304-0006 SHT 1 OF 6

REV.	DESCRIPTION	BY	DATE	CHK.
1	DRAFT FOR FINAL REPORT	TG	MAY 31/78	B

B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
BRITISH COLUMBIA, CANADA

DESIGNED	P.V.T.
DRAWN	T.G.
CHECKED	SGB

SCALE

PROJ. MGR. B
PROJ. DES.
D.O. MGR.

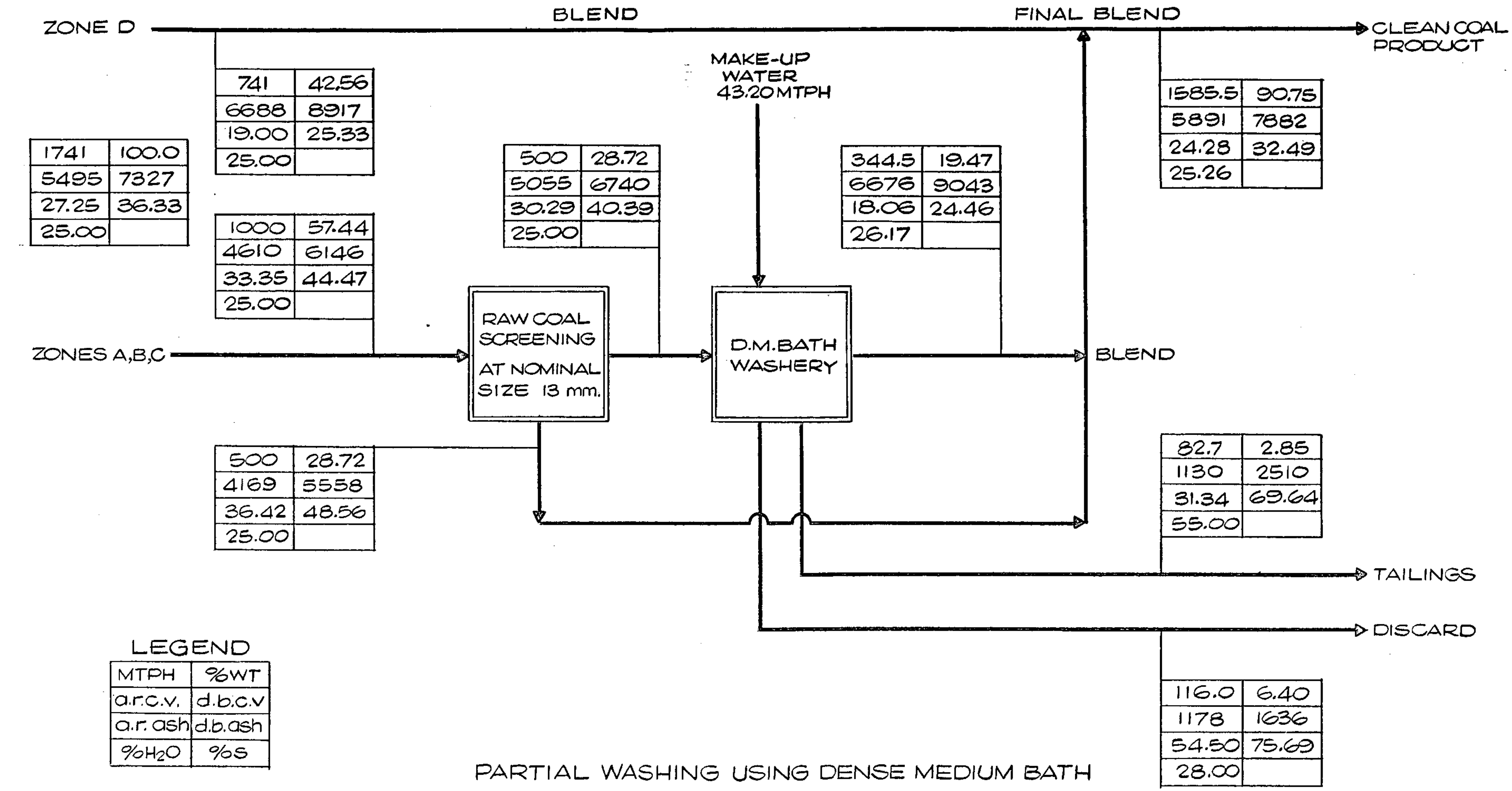
SIMON-CARVES

AREA:
CATEGORY:
DWG. TITLE: MATERIALS BALANCE D.M. BATH & W.O. CYCLONES WASHERY

CLIENT'S DRAWING NUMBER
SCAN DRAWING NUMBER F1304-0006 SHT 1 OF 6
REV. 1

SHEET SIZE I.S.O. A3

DWG. NO. F1304-0006 SHT 2 OF 6



REV.	DESCRIPTION	BY	DATE	CHK.
1	DRAFT FOR FINAL REPORT	TG	MAY 31/78	

REV | PLWK | CONC | ARCH | STWK | PIPG | ELEC | MECH | HVAC | PROJ MGR | PROJ DES

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HAT CREEK PROJECT
BRITISH COLUMBIA, CANADA

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DRAWN T.G.
CHECKED S.G.B.
SCALE
PROJ. MGR.
PROJ. DES.
D.O. MGR.

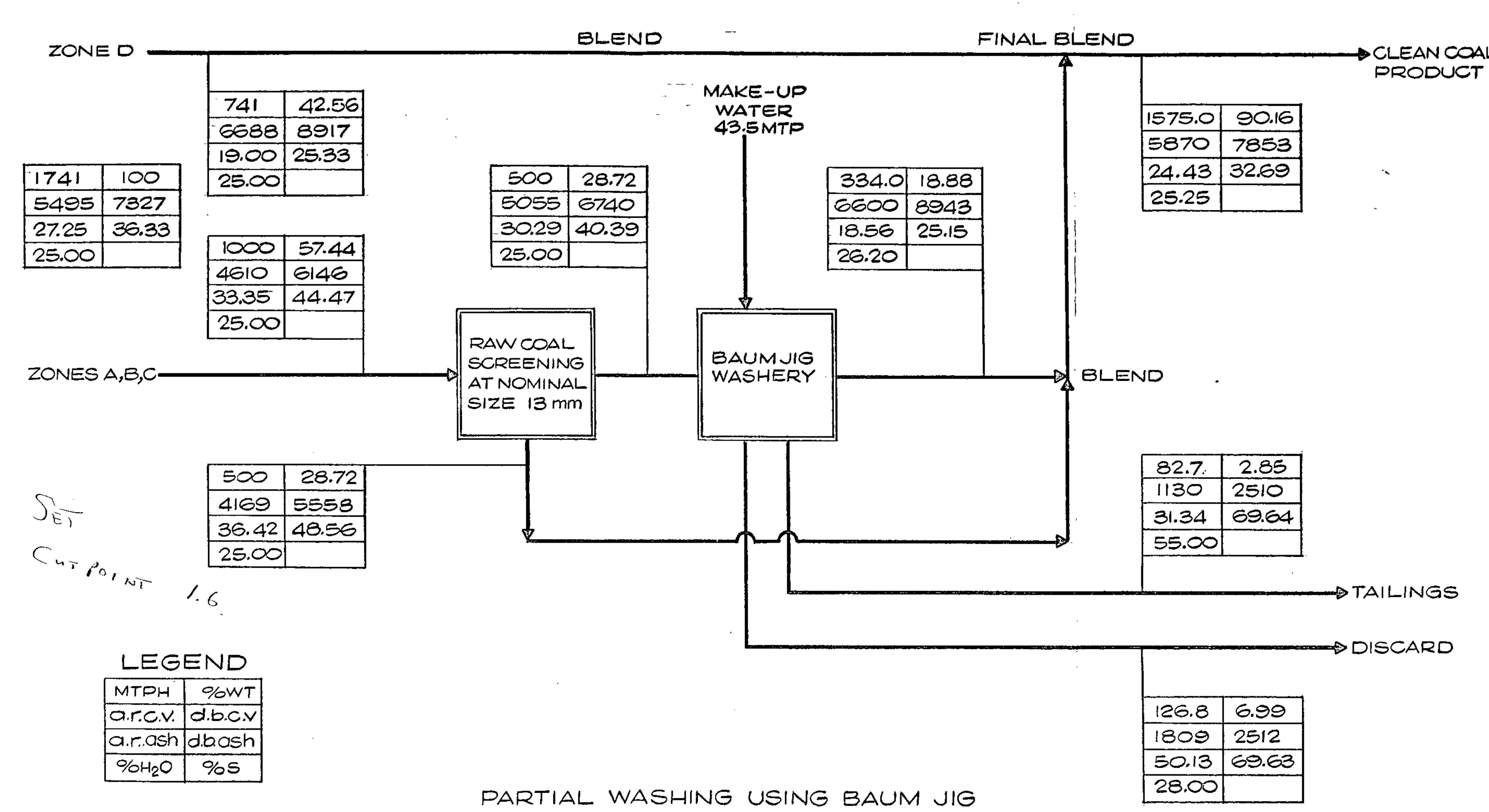
SIMON-CARVES

AREA:
CATEGORY:
DWG. TITLE: MATERIALS BALANCE PARTIAL WASHING USING D.M. BATH

CLIENT'S DRAWING NUMBER
SCAN DRAWING NUMBER F1304-0006 SHT 2 OF 6
REV. 1

SHEET SIZE I.S.O. A3

DWG. NO. F1304-0006
SHT 3 OF 6



PARTIAL WASHING USING BAUM JIG

REV.	DESCRIPTION	BY	DATE	CHK.
1	DRAFT FOR FINAL REPORT	TG	MAY 31/78	

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BRITISH COLUMBIA, CANADA

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CHECKED S.C.B.
SCALE
PROJ. MGR.
PROJ. DES.
D.O. MGR.

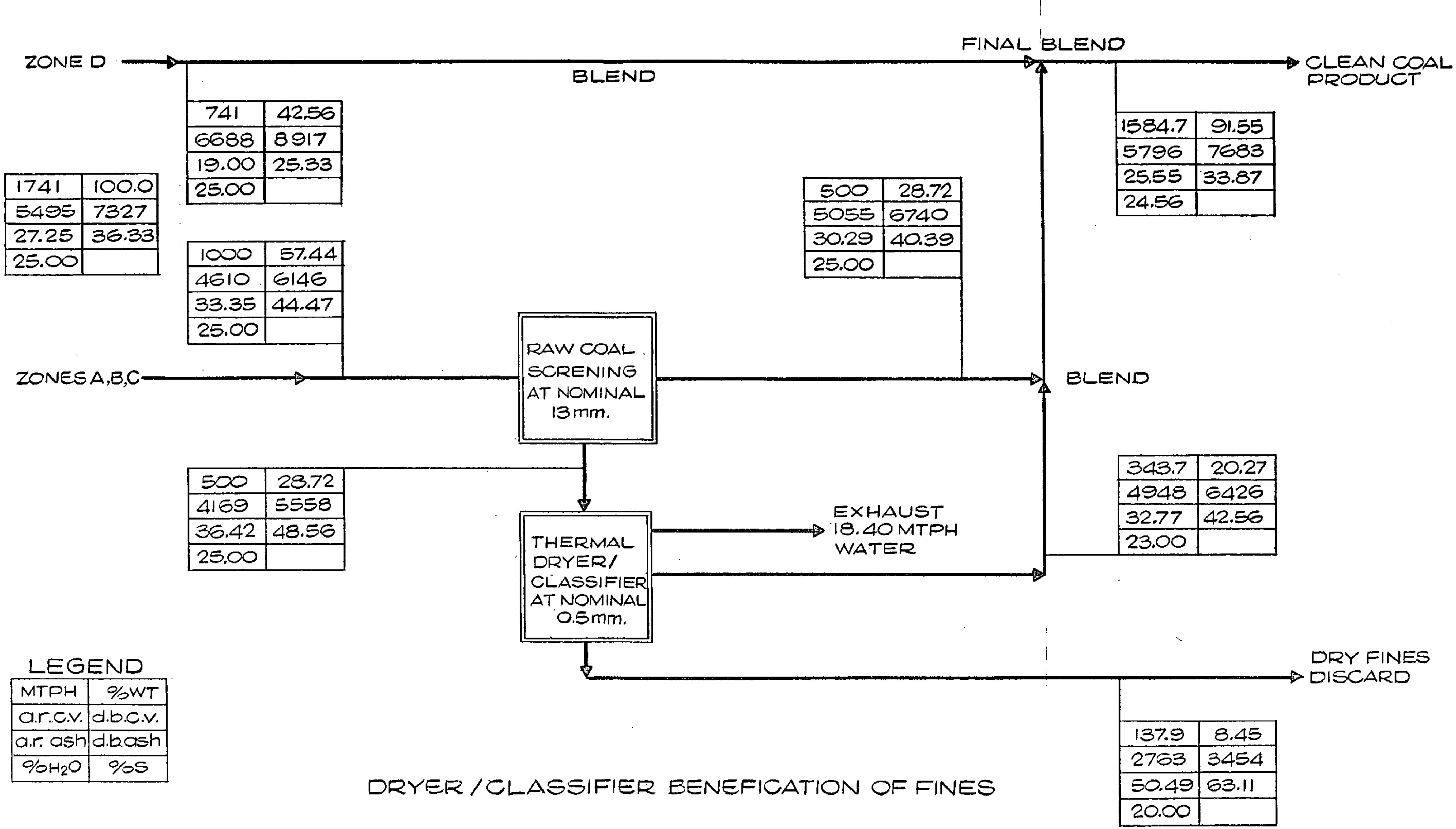
SIMON-CARVES

AREA: CATEGORY:
DWG. TITLE: MATERIAL BALANCE
PARTIAL WASHING USING BAUM JIG

CLIENT'S DRAWING NUMBER
SCAN DRAWING NUMBER F1304-0006 SHT 3 OF 6
REV. 1

SHEET SIZE I.S.O. A3

DWG. NO. F1304-0006 SHT 4 OF 6



DRYER / CLASSIFIER BENEFICATION OF FINES

REV.	DESCRIPTION	BY	DATE	CHK.
1	DRAFT FOR FINAL REPORT	TG	MAY 31/78	

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HAT CREEK PROJECT
BRITISH COLUMBIA, CANADA

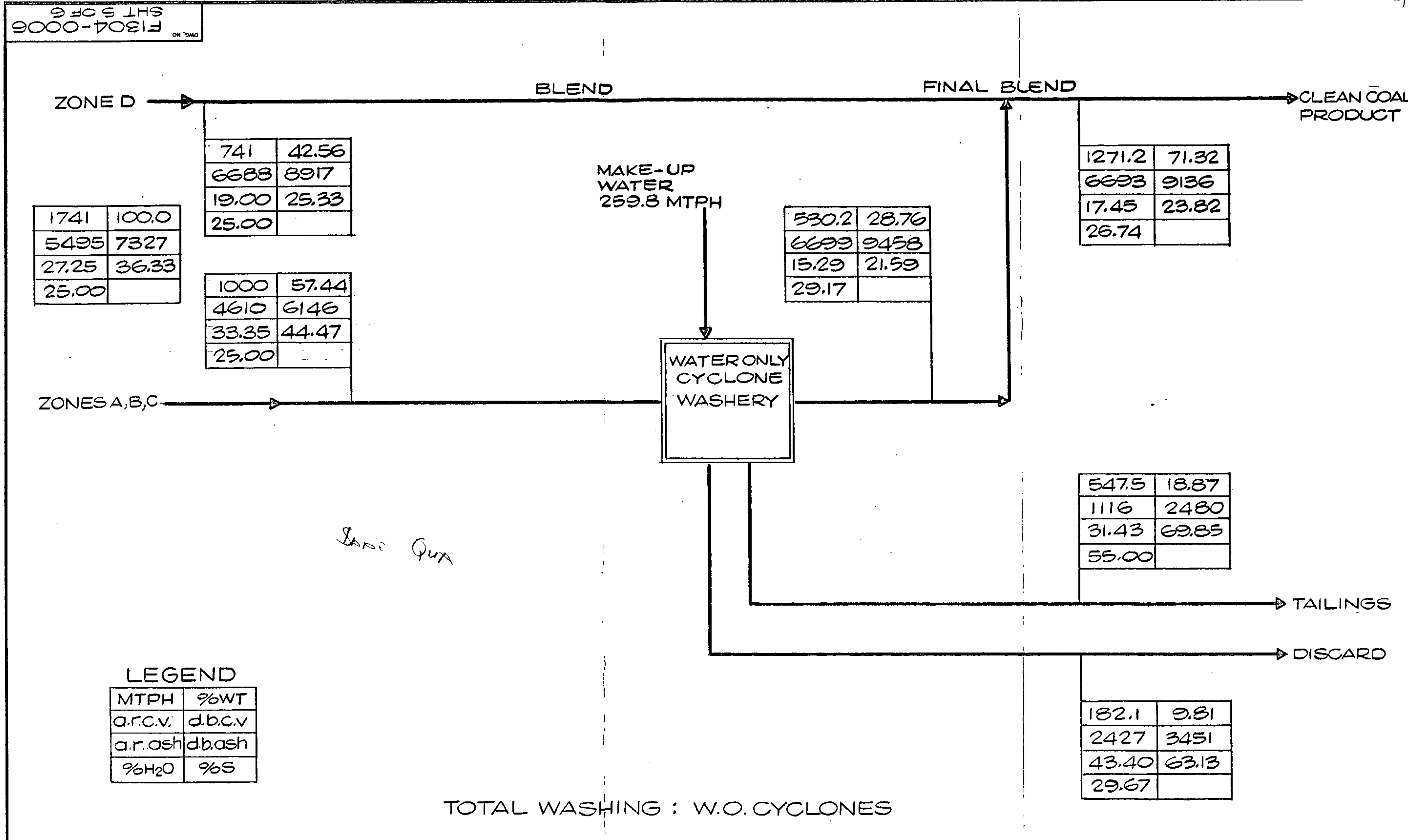
DESIGNED P.V.T.
DRAWN T.G.
CHECKED S.C.R.

SIMON-CARVES

DWG. TITLE: MATERIALS BALANCE DRYER/CLASSIFIER SCHEME

SCAN DRAWING NUMBER F1304-0006 SHT 4 OF 6 REV. 1

SHEET SIZE I.S.O. A3



REV.	DESCRIPTION	BY	DATE	CHK.
1	DRAFT FOR FINAL REPORT	TG	MAY 31/78	

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HAT CREEK PROJECT
BRITISH COLUMBIA, CANADA

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DRAWN	T.G		PROJ. DES.
CHECKED	S.C.B		D.O. MGR.

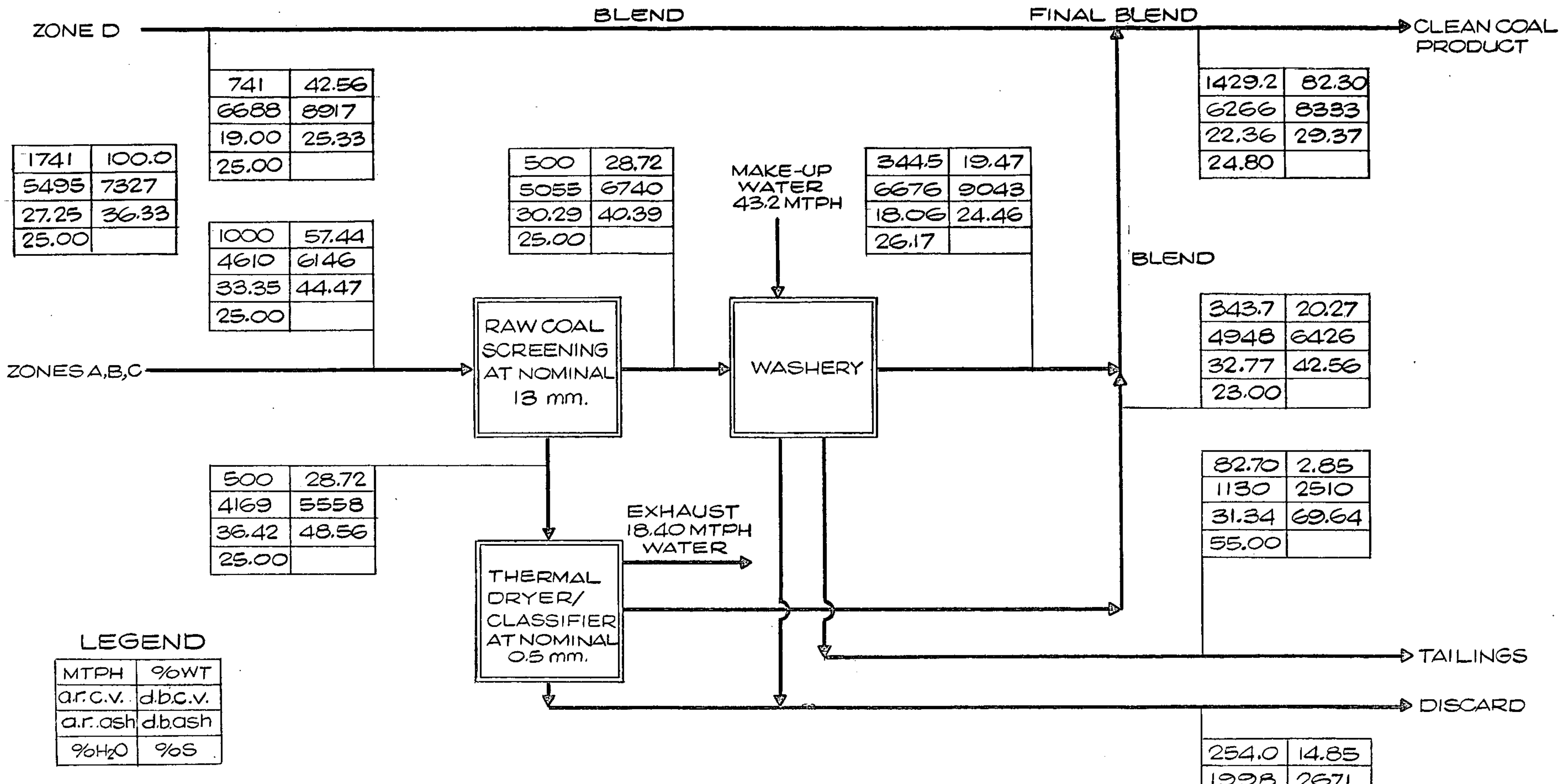
SIMON-CARVES

AREA: CATEGORY:

DWG. TITLE: MATERIALS BALANCE W.O. CYCLONE WASHERY

CLIENT'S DRAWING NUMBER | SCAN DRAWING NUMBER F1304-0006 SHT 5 OF 6 | REV. 1

SHEET SIZE I.S.O. A3



TOTAL BENEFICIATION USING DENSE MEDIUM BATH AND DRYER/CLASSIFIER

REV.	DESCRIPTION	BY	DATE	CHK
1	DRAFT FOR FINAL REPORT	TG	MAY 31/78	[illegible]

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DRAWN	T.G.	PROJ. DES.
CHECKED	S.G.F.	D. O. MGR.

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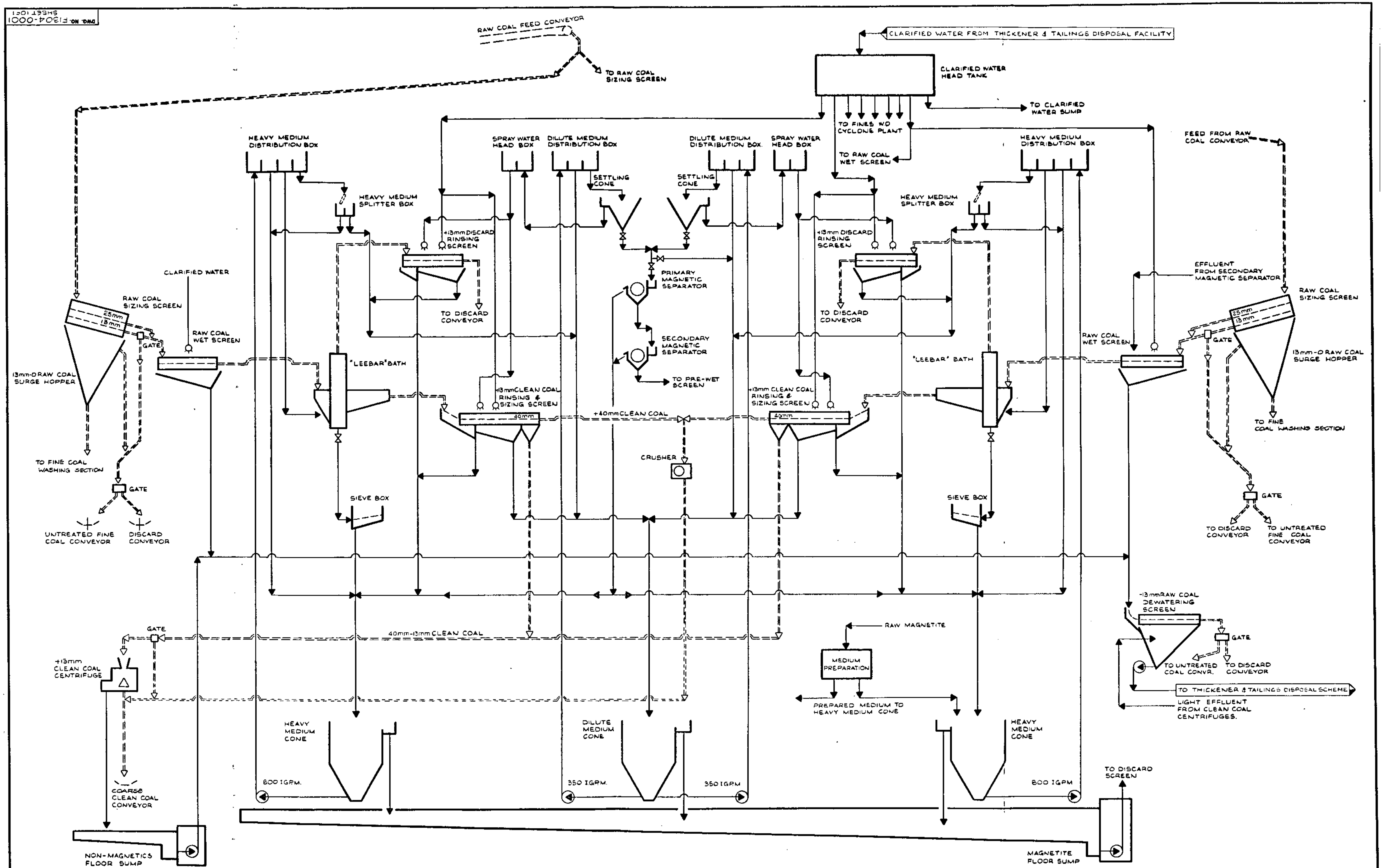
DWG. TITLE: MATERIALS BALANCE D.M. BATH + DRYER/CLASSIFIER

SCAN DRAWING NUMBER: F1304-0006 SHT. 6 OF 6

REV. 1

SHEET SIZE I.S.O. A3



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WILLIAM CORSE
NON-RESIDENT LICENCE (EXPIRY DATE 8 JAN. 1979)

REV.	DESCRIPTION	BY	DATE	CHK
2	DRAFT FOR FINAL REPORT	CW	MAY 78	
1	ISSUED WITH INTERIM REPORT		OCT 77	
P	PRELIMINARY	KS	SEP 77	

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2400 M.T.P.H. MODULAR COAL WASHERY.

SIMON-CARVES

DESIGNED D.V.W. DRAWN K.S. SEP 20/77 CHECKED S.C.B. SCALE N.T.S. PROJ. MGR S.C.B.

DWG. TITLE: FLOWSHEET FOR COARSE COAL H.M. SECTION (1 MODULE)

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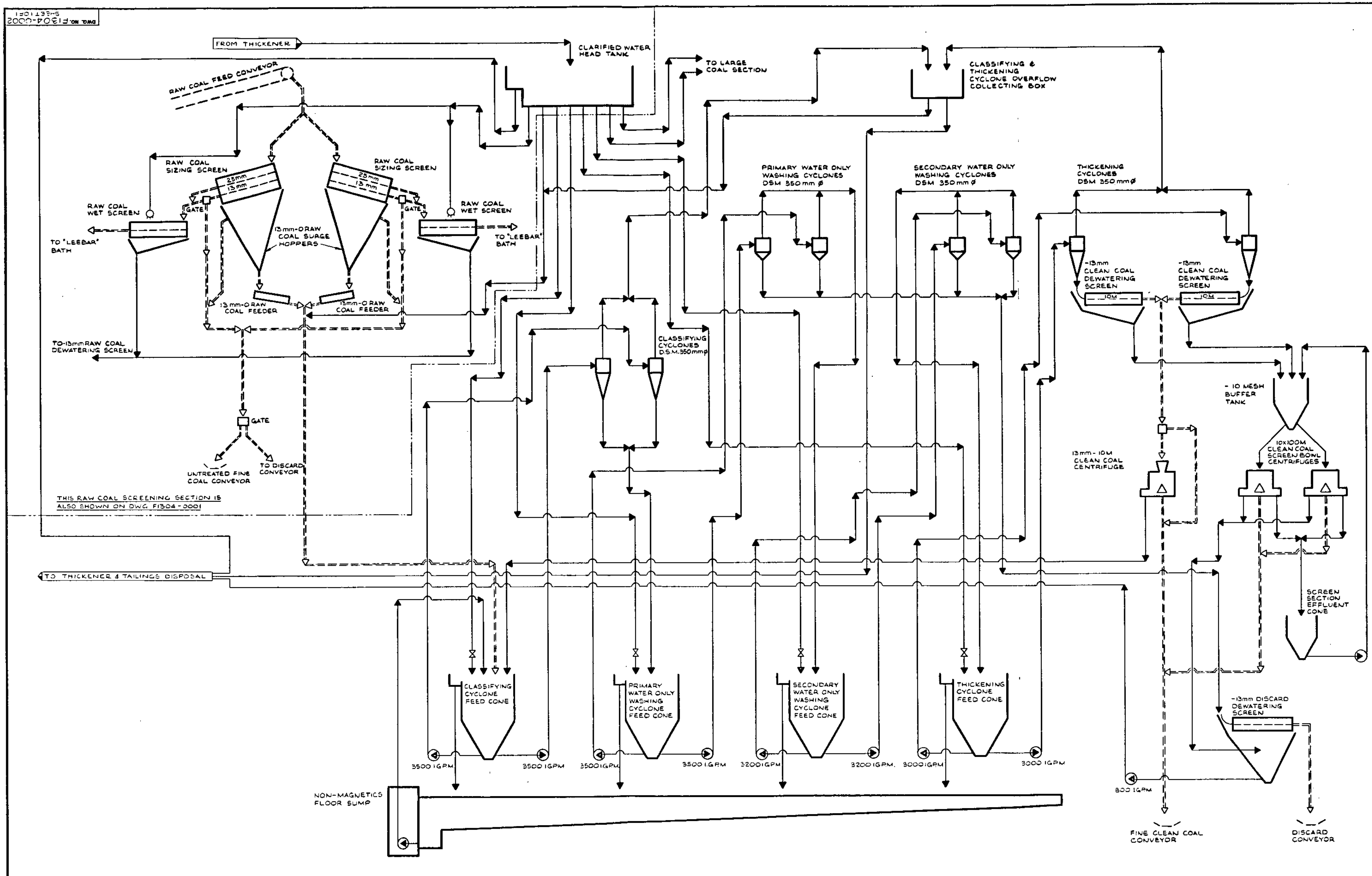

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WILLIAM CORSE

REV	PLWN	CONC	ARCH	STWK	PIPG	ELEC	MECH	HVAC	PROJ MGR	PROJ DES
11										
10										
9										
8										
7										
6										
5										
4										
3										
2										
1										

REV.	DESCRIPTION	BY	DATE	CHK.
2	DRAFT FOR FINAL REPORT	CW	31 MAY 78	
1	'ISSUED WITH INTERIM REPORT'		OCT 14/77	–
P	PRELIMINARY	K S	SEP 29/77	

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2400 M.T.P.H. MODULAR COAL WASHERY

PHOTOGRAPHIC SCALE — MILLIMETRES 5 & 10 DIV./INCH

DESIGNED	D V W		SCALE	PROJ. MGR.	S. G. B.
DRAWN	K S.	SEP 29/77	N.T.S.	PROJ. DES.	
CHECKED	S. G. B.			D.O. MGR.	

SIMON-CARVES

AREA:
CATEGORY:
DWG. TITLE: FLOWSHEET FOR FINE COAL SECTION (1 MODULE)

CLIENT'S DRAWING NUMBER	SCAN DRAWING NUMBER	REV.
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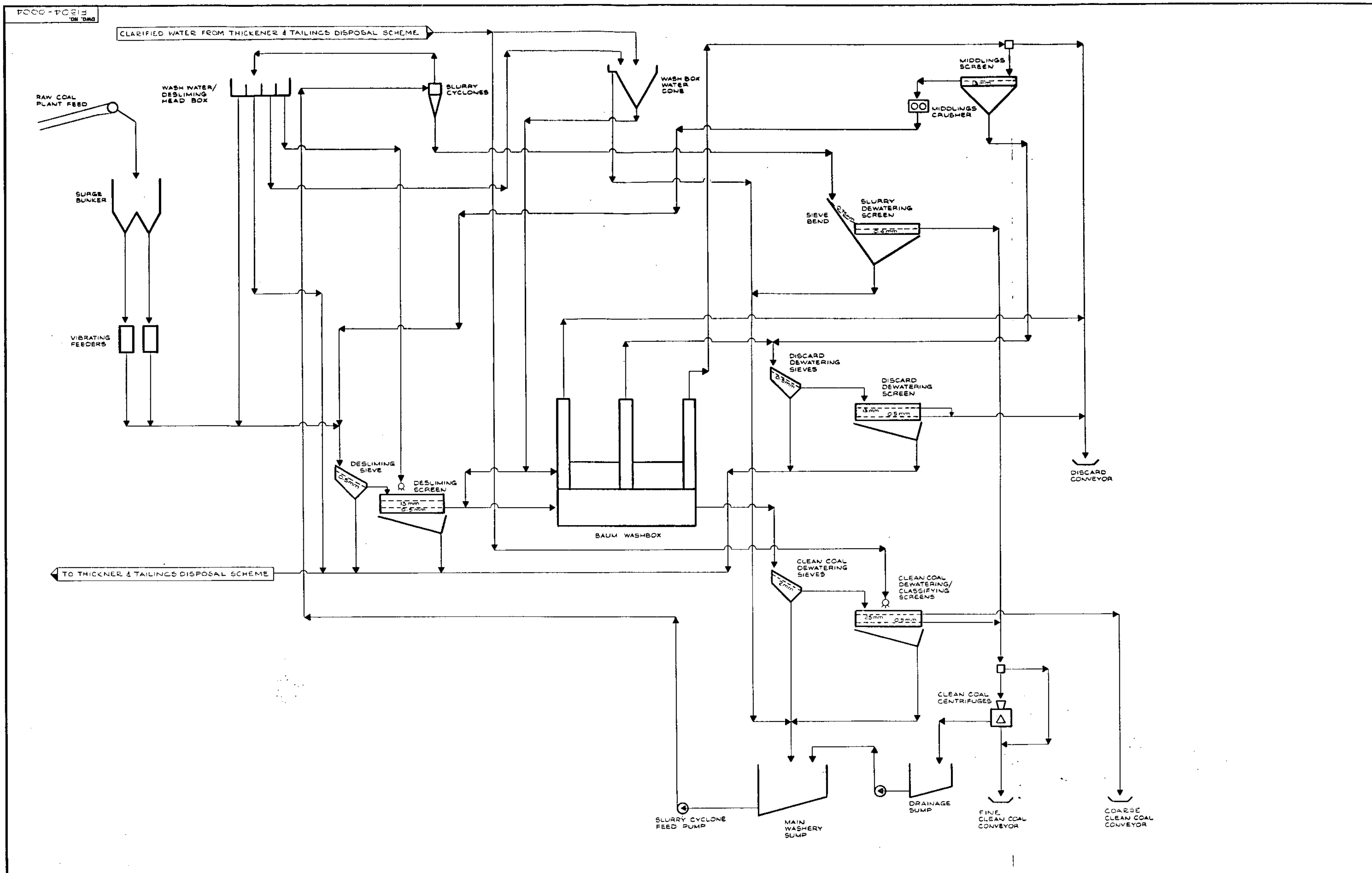

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REV.	DESCRIPTION	BY	DATE	CHK
1	DRAFT FOR FINAL REPORT	CW	31 MAY	

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HAT CREEK PROJECT, BRITISH COLUMBIA, CANADA.
MODULAR BAUM COAL WASHERY

PHOTOGRAPHIC SCALE — MILLIMETRES & 10 DIV./INCH

DESIGNED	D V W	SCALE	PROJ. MGR.	S G B
DRAWN			PROJ. DES.	
CHECKED	S G N		D.O. MGR.	

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AREA: CATEGORY:
DWG. TITLE: FLOWSHEET FOR BAUM WASHERY (ONE MODULE)

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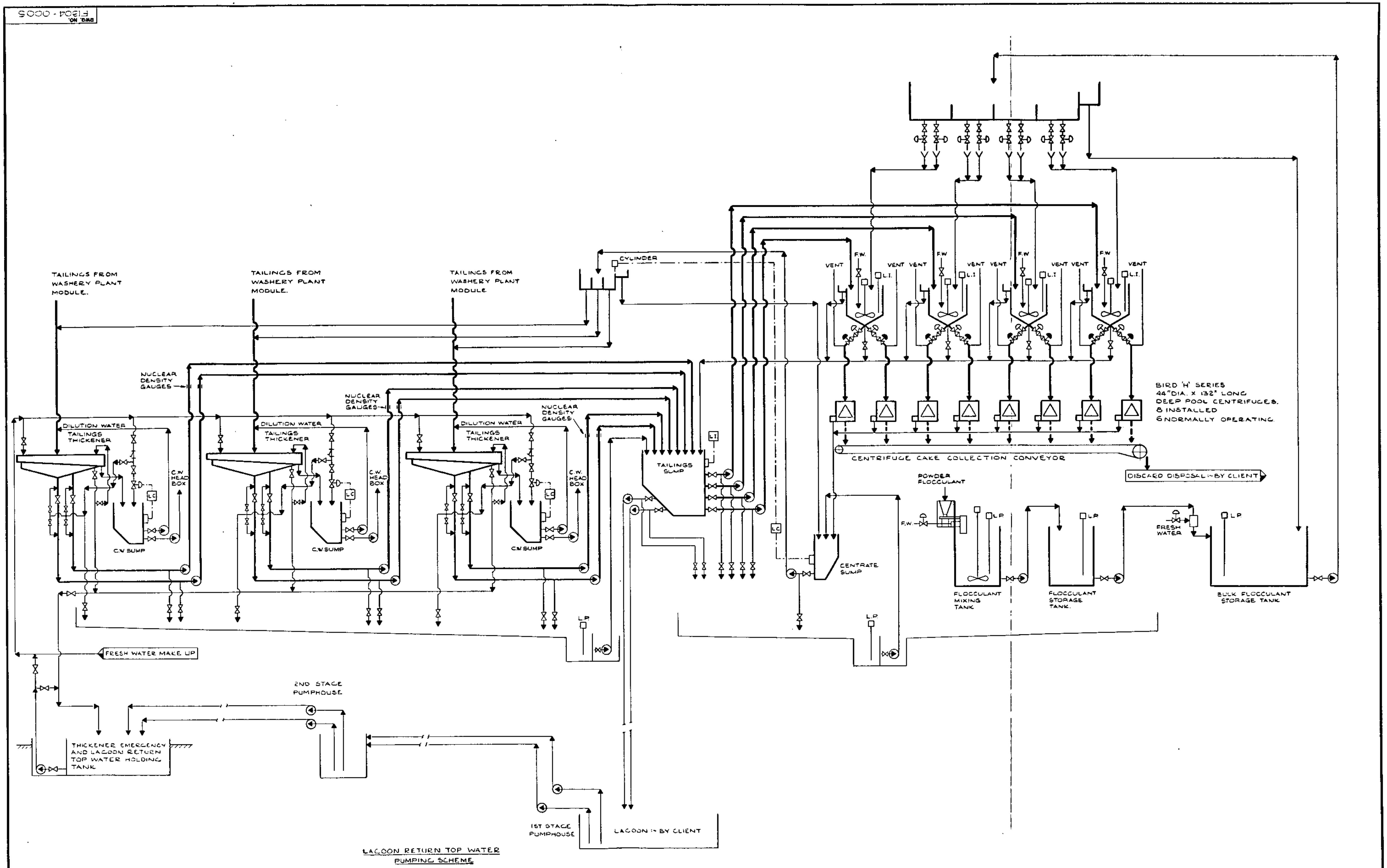

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BRITISH COLUMBIA HYDRO & POWER AUTHORITY, HAT CREEK PROJECT, BRITISH COLUMBIA, CANADA. TAILINGS DEWATERING SCHEME.

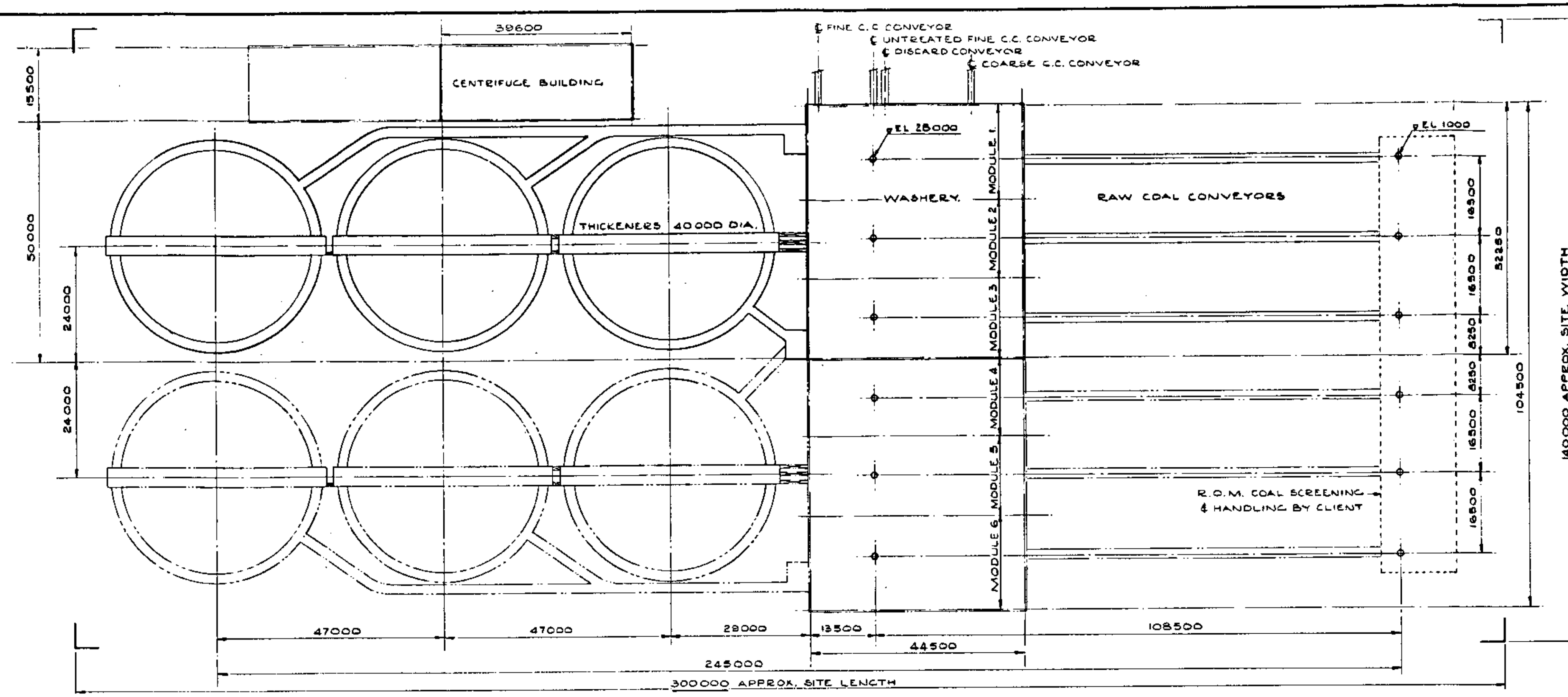
SIMON-CARVES

DWG. TITLE: FLOWSHEET FOR THICKENERS AND TAILINGS DISPOSAL SCHEME (SOLID BOWL CENTRIFUGES)

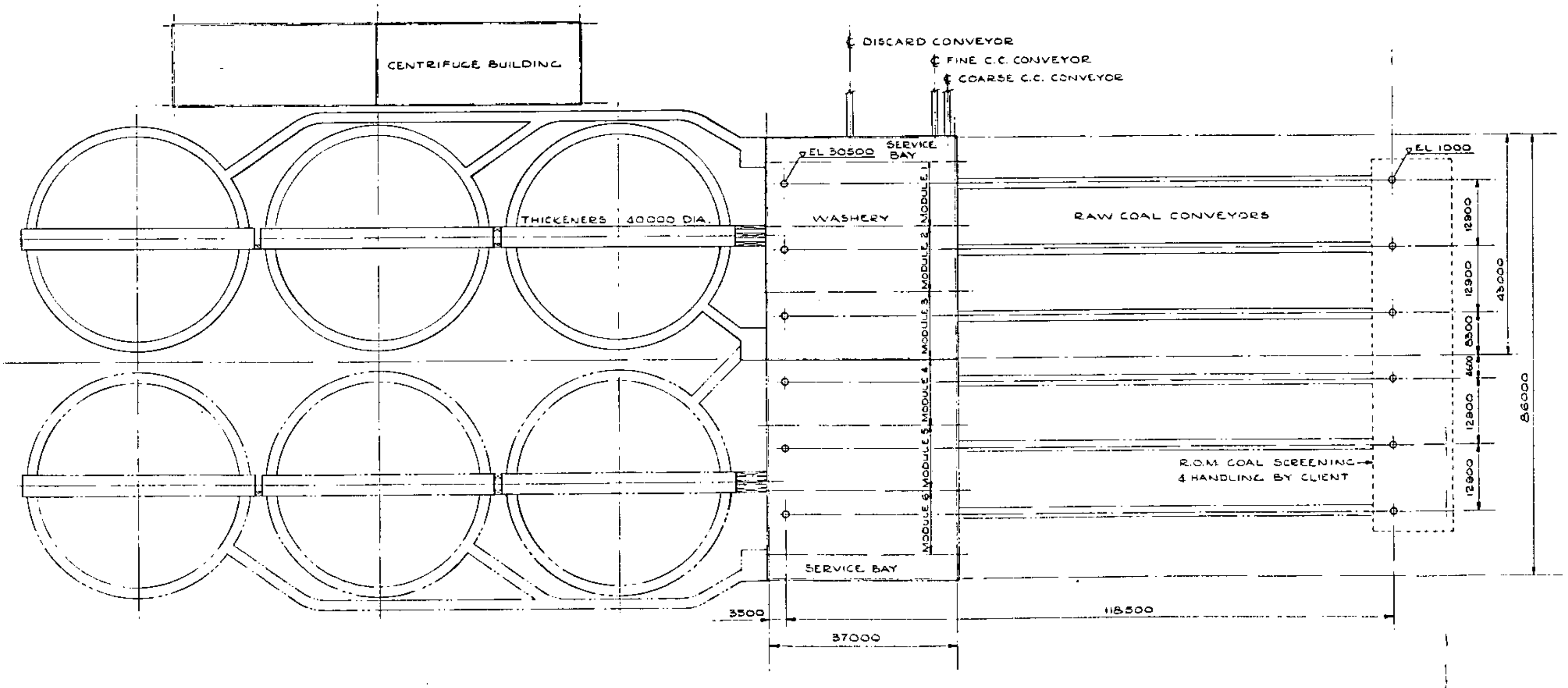
REV	DESCRIPTION	BY	DATE	CHK
1	DRAFT FOR FINAL REPORT	CW		

DESIGNED D.V.W. · DRAWN K.C.L. · CHECKED C.G.B. · PROJ. MGR. C.G.B.

SCAN DRAWING NUMBER: F1304-0005 · SHEET 1 OF 1 · REV. 1



2400 M.T.P.H. MODULAR COAL WASHERY



MODULAR BAUM JIG WASHERY

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NON-RESIDENTS LICENCE (EXPIRY DATE 8 JAN 1979)

REV.	DESCRIPTION	BY	DATE	CHK.
1	DRAFT FOR FINAL REPORT	CW		

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HAT CREEK PROJECT,
BRITISH COLUMBIA, CANADA.

PHOTOGRAPHIC SCALE — MILLIMETRES 5 & 10 DIV./INCH

DESIGNED	D.V.W.	SCALE	PROJ. MGR.	S.C.B.
DRAWN	C.W.	1:400	PROJ. DES.	
CHECKED	S.C.B.		D.O. MGR.	

SIMON-CARVES

AREA: CATEGORY:
DWG. TITLE: SITE PLAN FOR ALTERNATE WASHERY SCHEMES.

CLIENT'S DRAWING NUMBER	SCAN DRAWING NUMBER	REV.
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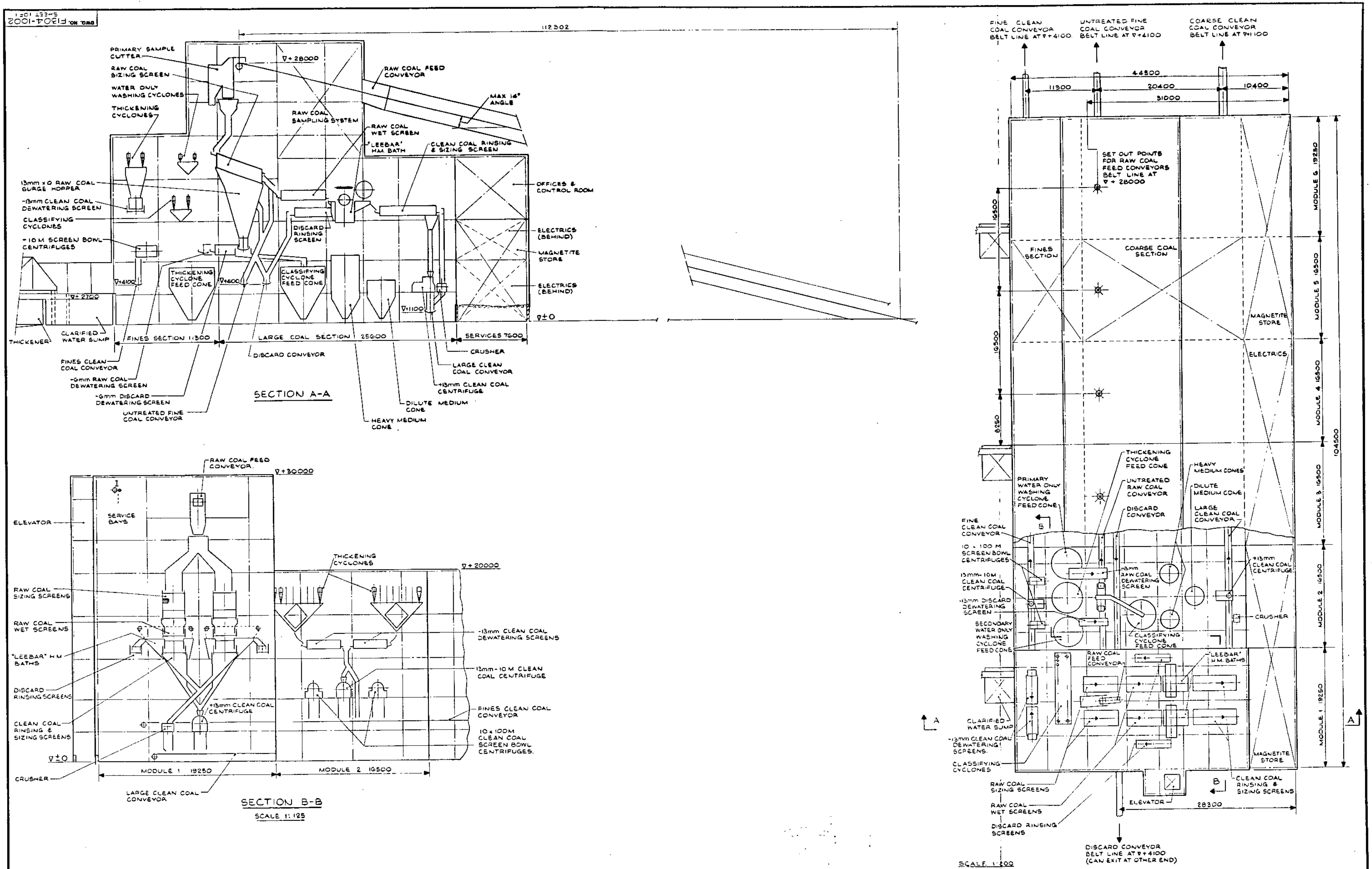

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WILLIAM CORSE
NON-RESIDENTS LICENCE (EXPIRY DATE 8 JAN 1979)

REV	DESCRIPTION	BY	DATE	CHK
2	DRAFT FOR FINAL REPORT	C.W.	31 MAY 78	
1	'ISSUED WITH INTERIM REPORT'		OCT 1977	
P	PRELIMINARY	K.S.		

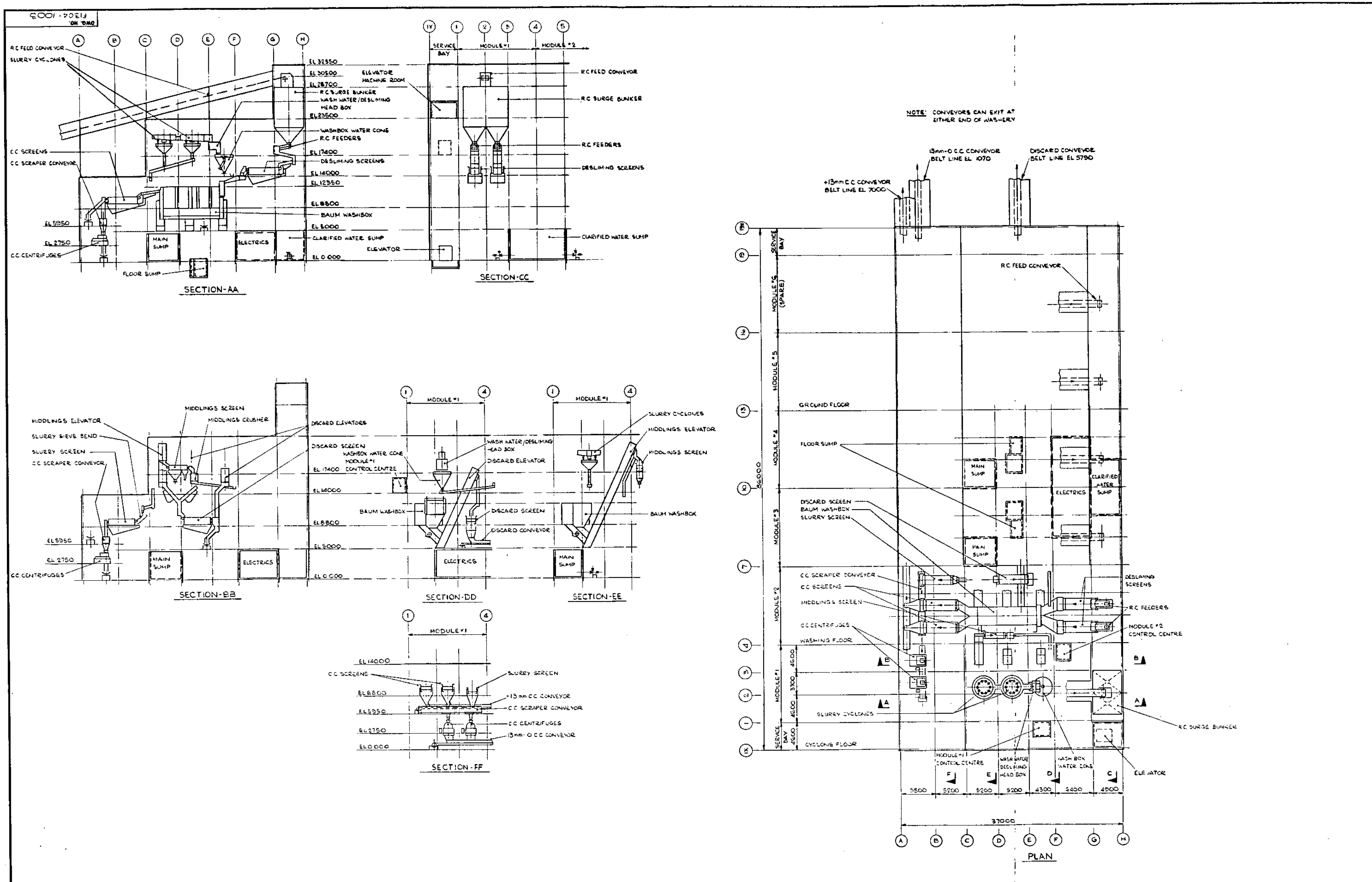
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT, BRITISH COLUMBIA, CANADA
2400 M.T.P.H. MODULAR COAL WASHERY

SIMON-CARVES

DWG. TITLE: MODULALAR COAL WASHERY LAYOUT.

DESIGNED D.Y.W. · DRAWN K.S. · CHECKED C.F. · SCALE AS NOTED

SCAN DRAWING NUMBER F1304-1002 SHEET 1 OF 1 · REV. 2



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OF THE PROVINCE OF BRITISH COLUMBIA.
WILLIAM CORSE
NON-RESIDENTS LICENCE (EXPIRY DATE 6 JAN 1979)

REV.	DESCRIPTION	BY	DATE	CHK.
1	DRAFT FOR FINAL REPORT	C.W.	MAY	
P	PRELIMINARY	KGL	FEB	

BRITISH COLUMBIA HYDRO & POWER AUTHORITY
HAT CREEK PROJECT, BRITISH COLUMBIA, CANADA
MODULAR BAUM JIG WASHERY.

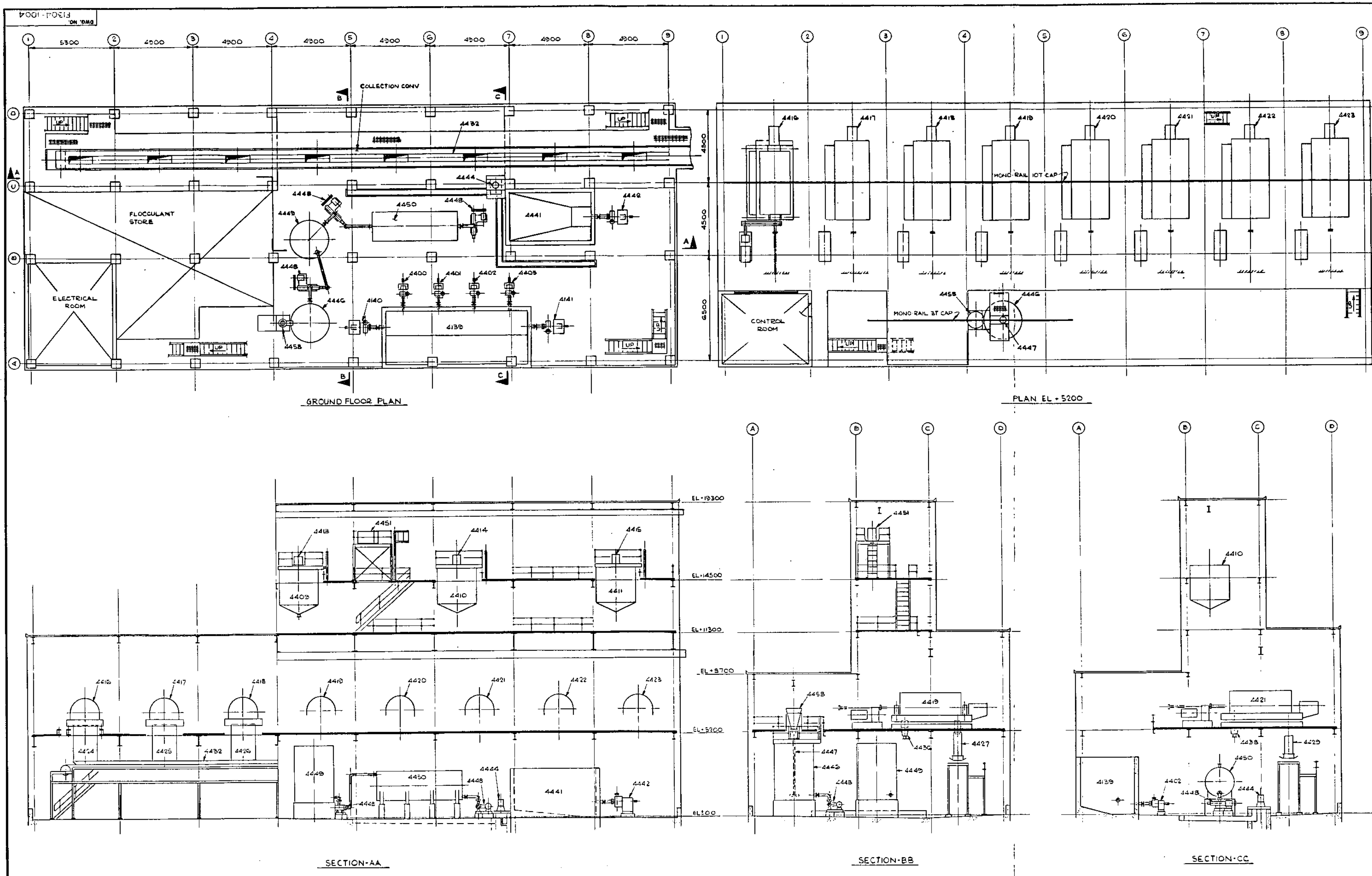
SIMON-CARVES

DWG. TITLE: MODULAR BAUM WASHERY LAYOUT.

SCALE: 1:400

SCAN DRAWING NUMBER: F1304-1003 REV. 1

SHEET 1 OF 1



THE ASSOCIATION OF PROFESSIONAL ENGINEERS
OF THE PROVINCE OF BRITISH COLUMBIA
WILLIAM CORSE
NON-RESIDENTS LICENCE (EXPIRY DATE 8 JAN 1979)

REV	DESCRIPTION	BY	DATE	CHK
1	DRAFT FOR FINAL REPORT	KGL	MAY 31/78	

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT, BRITISH COLUMBIA, CANADA.
2400 M.T.P.H. MODULAR COAL WASHERY

PHOTOGRAPHIC SCALE — MILLIMETRES 8 & 10 DIV./INCH

DESIGNED	D.V.W.		SCALE	PROJ. MGR.	S.C.G.
DRAWN	KGL	MAY 31,78	1:75	PROJ. DES.	
CHECKED	S.C.G.			D O MGR	

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SIMON-CARVES

AREA:
CATEGORY:
DWG. TITLE: SOLID BOWL CENTRIFUGE - LAYOUT.

CLIENT'S DRAWING NUMBER	SCAN DRAWING NUMBER	REV.
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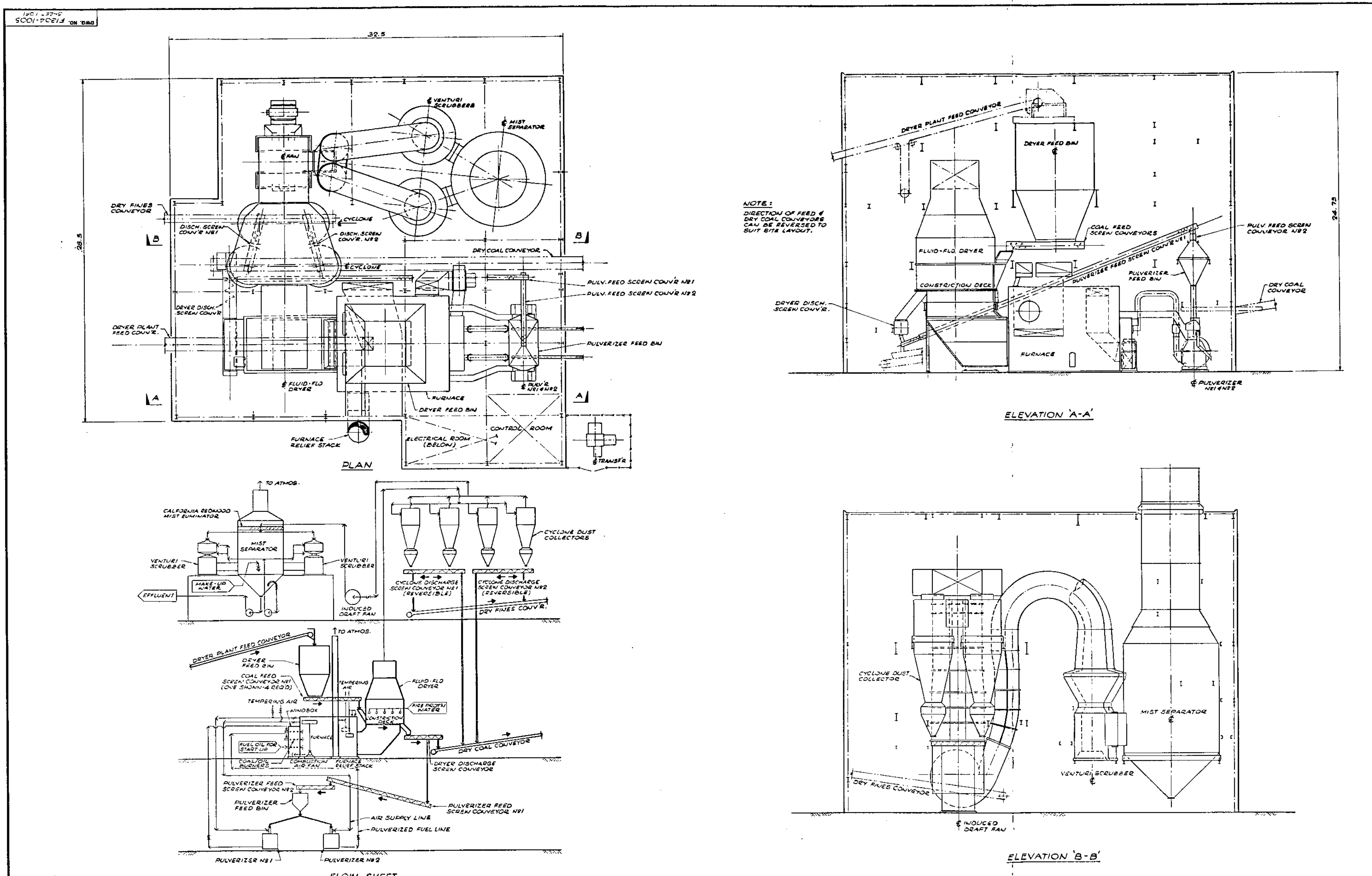

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF BRITISH COLUMBIA
WILLIAM CORSE
NON-RESIDENTS LICENCE (EXPIRY DATE 5 JAN 1979)

REV.	DESCRIPTION	BY	DATE	CHK
1	DRAFT FOR FINAL REPORT.	D.N.	31 MAY 78	

B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
BRITISH COLUMBIA, CANADA

PHOTOGRAPHIC SCALE — MILLIMETRES 8 & 10 DIV./INCH

DESIGNED	D.V.W.	SCALE	PROJ. MGR. S.C.R.
DRAWN	D.N. 7/78	N.T.S.	PROJ. DES.
CHECKED	J.C.K.		D O MGR.

SIMON-CARVES

AREA:
CATEGORY:
DWG. TITLE: THERMAL DRYER / CLASSIFIER

CLIENT'S DRAWING NUMBER
SCAN DRAWING NUMBER: F1304-1005 SHEET 1 OF 1
REV.: 1