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FEASIBILITY STUDY ON RECOVERY OF THERMAL COAL FROM WASTE DUMPS IN NOVA SCOTIA

M.W. MIKHAIL, L.C. BIRD AND N.T.L. LANDGREN

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FEASIBILITY STUDY ON RECOVERY OF THERMAL COAL FROM WASTE DUMPS IN NOVA SCOTIA

by

M.W. Mikhail*, L.C. Bird** and N.T.L. Landgren***

ABSTRACT

Through funds made available in 1972 by the Nova Scotia Department of Mines and Energy and the federal Department of Regional Economic Expansion, a program was initiated to recover saleable coal from mine waste dumps adjacent to the existing Acadia wash plant in Stellarton, N.S. The main objectives of the program were to recover coal for thermal power generation, eliminate the risk of spontaneous combustion in the dumps, and generate employment in the area for former miners.

Following evaluation of the waste dumps during 1972, the Acadia wash plant was modified to treat high ash waste material. The first production was recorded in late 1974 after a period of manpower training, trial runs, and adjustment of the wash plant circuits. By the end of 1979 a total of 738 202 t of dump material had been processed and a total of 205 212 t of thermal coal produced for power generation and domestic use in Nova Scotia. This recovery was satisfactory and the overall operation was considered a success.

The successful Stellarton operation led to considering the possibility of recovering thermal coal from other dumps. Evaluation of the Westville dumps indicated total recoverable reserves of 1 346 617 t averaging 53.85% ash. A bulk test on 504 t of the dump material with extensive sampling was conducted to evaluate the Stellarton plant. Equipment performance was reported and results discussed. From the washability characteristics of dump material and results of the bulk test, parameters for plant design were defined and two options were proposed. One was to use the existing plant with some modifications and the other to build a modular mobile plant suitable for future use at dump sites in the province other than Westville. At 25% ash level, recoverable coal from the Westville dump was estimated to be 551 892 t, which is equivalent to a 41% yield by mass.

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ÉTUDE DES POSSIBILITÉS DE RÉCUPÉRER LE CHARBON THERMIQUE DES TERRILS DE NOUVELLE-ÉCOSSE

par

M.W. Mikhail*, L.C. Bird** et N.T.L. Landgren***

RÉSUMÉ

Grâce aux fonds versés en 1972 par le Ministère des Mines et de l'Énergie de la Nouvelle-Écosse et le Ministère fédéral de l'Expansion économique régionale, un programme a été mis sur pied pour récupérer le charbon vendable des terrils avoisinants de l'installation de lavage du charbon Acadia à Stellarton (N.-É.). Les principaux objectifs du programme étaient de récupérer le charbon pour la production d'énergie thermique, éliminer les dangers de combustion spontanée dans les terrils et créer des emplois dans la région pour les anciens mineurs.

Suivant l'évaluation des terrils en 1972, l'installation de lavage Acadia a été modifiée pour traiter des matières ayant une forte teneur de cendre. La production a débuté à la fin de 1974 suivant une période d'entraînement de la main d'oeuvre, des marches d'essai et une mise au point des circuits de l'installation. A la fin de 1979, 738 202 tonnes de rebuts avaient été traitées et 205 212 tonnes de charbon thermique avaient été produites pour la production d'énergie ou pour l'usage domestique en Nouvelle-Écosse. Cette récupération était suffisante et le projet s'est avéré un succès.

Le succès de l'entreprise de Stellarton a incité la possibilité de récupérer le charbon thermique d'autres terrils. Les réserves récupérables totales des terrils de Westville ont été évaluées à 1 346 617 tonnes avec en moyenne 53,85% de cendre. Afin d'évaluer l'installation Stellarton, un essai en vrac a été effectué sur 504 tonnes de rebuts avec échantillonnage intensif. Le rendement de l'équipement a été évalué et les résultats sont expliqués. A partir des caractéristiques de lavage des rebuts et des résultats des essais en vrac, des paramètres de conception de l'usine ont été définis et deux possibilités ont été proposées. L'une d'elles consiste d'utiliser l'installation existante avec quelques modifications et l'autre consiste de construire une installation modulaire mobile susceptible d'être utilisée ailleurs dans la province sauf à Westville. À Westville, comme la teneur de cendre est de 25%, on estime à 551 892 tonnes le charbon récupérable des terrils, qui est équivalent à un rendement de 41% en masse.

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INTRODUCTION

Coal mine waste material has been accumulating over a period of more than 100 years in the province of Nova Scotia. No washing was practised in the early years of operation; high-ash coarse particles were sorted by hand and the high-ash fine coal fraction was sometimes removed by screening and discarded. Later on, partial washing of the coarse fractions of +6.3 mm resulted in high losses of useable fine coal. Today, an estimated 54 million tonnes of coal mine waste material is to be found in Nova Scotia dumps close to existing small communities. The presence of low-ash coal in the dumps creates both environmental and safety hazards. The emission of smoke containing sulphur dioxide from spontaneous combustion of the coal has been a constant source of complaint in some of the communities. High coal prices and environmental considerations may in some cases justify cleaning up such dumps provided the value of the recovered thermal coal covers the cost of reclamation.

Through funds made available by the Nova Scotia Department of Mines and Energy (DME) and the federal Department of Regional Economic Expansion (DREE), a program was initiated in 1972 to recover saleable coal from mine waste dumps adjacent to the existing Acadia wash plant in Stellarton, N.S. The main objectives of the program were to recover coal for thermal power generation, eliminate the risk of spontaneous combustion in the dumps and generate employment in the area for former miners. Production started in late 1974 and by 1979 an annual rate of recovery of about 42 600 t of coal from about 154 000 t of dump material had been attained. Reject material from the plant was used for construction of a recreation area and the reclaimed areas were graded and seeded. The coal product was sold to the Nova Scotia Power Corporation for use in the Trenton generating station. Because of rising coal prices, revenues have substantially offset the operating costs of the program. Reserves of dump material next to the Stellarton wash plant will be exhausted by 1980 and a number of options are now being considered for the recovery of thermal coal from other dumps.

A drilling program was initiated by DME to estimate reserves in the Westville waste dumps 12 km from the Stellarton wash plant. Splits from borehole composite samples were sent to the CANMET laboratory in Sydney for proximate and washability analysis. DME requested assistance from the Western Research Laboratory (WRL) of CANMET in Edmonton to evaluate feasible options for future consideration based on the washability data. A meeting was held between the staff of DME and WRL in Stellarton on December 11 - 12, 1979 to evaluate washability characteristics of the samples from the drilling program and to plan for a bulk test in the Stellarton wash plant to evaluate performance of the individual process units. Samples collected from the bulk test performed on January 7, 1980 were shipped for analysis to the Warnock Hersey Professional Services Ltd. laboratory in Calgary, Alberta.

This paper briefly reviews the existing Stellarton wash plant facility and presents an evaluation of the washability characteristics of Westville waste dump material in relation to the bulk test. Plant design options for recovery of thermal coal from the Westville dumps are presented with the possibility of extending the program to other coal waste dumps in Nova Scotia.

REVIEW OF EXISTING OPERATION

Original evaluation of drillhole samples from the Allen, Albion and Lee coal waste dumps in 1972 indicated the presence of 1 000 000 t of raw material averaging 56.7% ash content (Fig. 1) (1). The study indicated a theoretical mass recovery of 26.2% at 19.6% ash content. Through an agreement between DME and the federal Department of Energy, Mines and Resources, J. Visman of WRL was assigned to design a 91 t/h plant for recovery of thermal coal from these dumps. It was decided to incorporate the new design with some of the existing equipment in the Acadia wash plant built in 1947. The new design included some of the features of the CANMET coal preparation

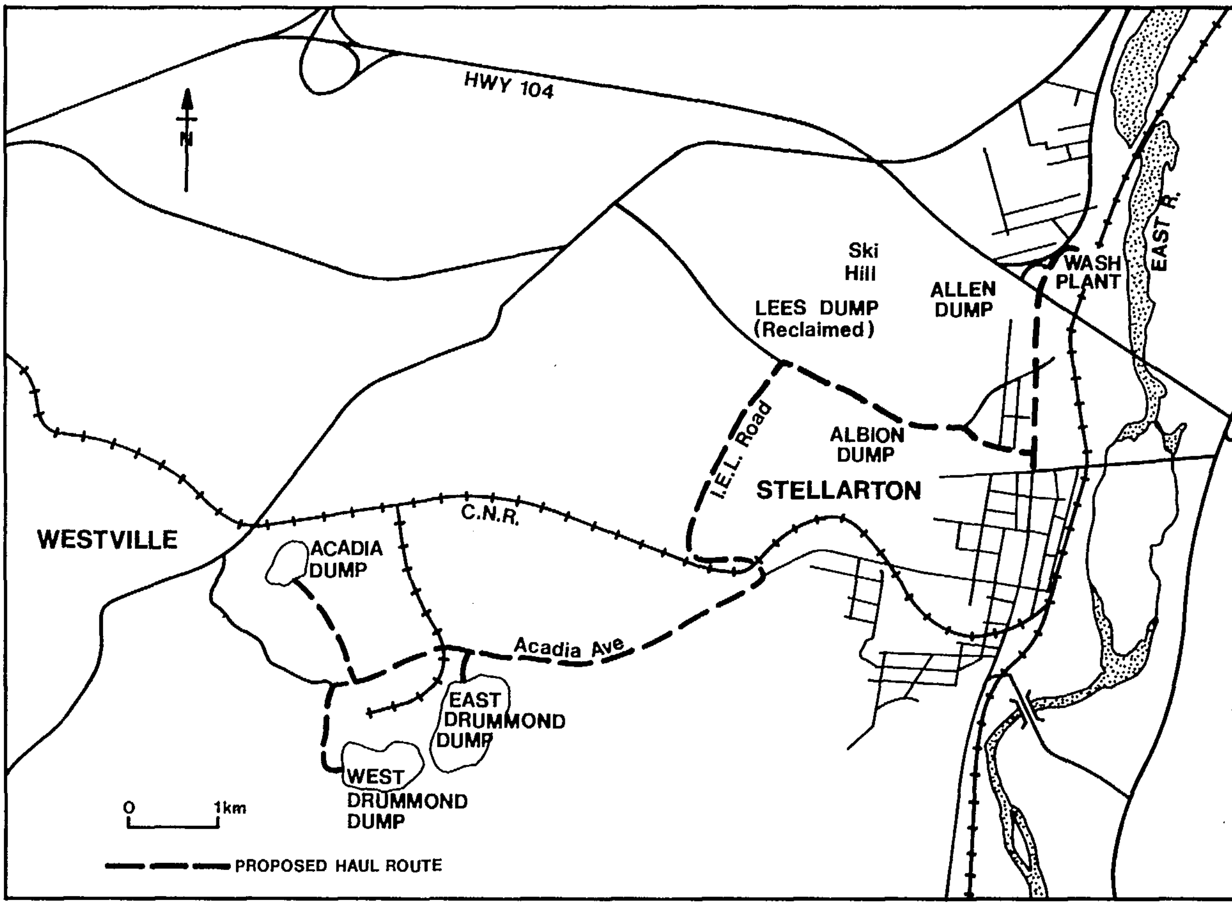


Fig. 1 - Stellarton operations and Westville area dumps

process, developed earlier at WRL with patents assigned to J. Visman (2).

The CANMET process is based on the use of water only or autogenous separators and features the following:

1. a coarse cleaning section for bulk washing of the raw coal which includes two-stage compound water cyclone (CWC) treatment with the option of recovering middlings as a third product or of recirculating them for rewashing in the same cyclones
2. a fine-coal cleaning section which also includes a two-stage CWC circuit for cleaning the minus 0.6-mm fraction
3. a water treatment section which uses a cyclonic flocculation system and thickening to produce clarified water for recirculation, the aim being a closed circuit, zero discharge, system
4. a dewatering and partial drying section which includes vibrating screens and oil agglomeration for dewatering of the minus 0.6-mm coal, and centrifuges for mechanical dewatering.

The existing raw feed and product handling facilities, a crusher, and a Vissac jig were incorporated in the new flowsheet to make as much use as possible of available equipment in the old wash plant. In the integrated plant as designed, the raw coal was crushed to minus 152 mm and screened into two size fractions. The coarser 152 x 44.5-mm coal was washed in the Vissac jig and the finer 44.5 x 0-mm fraction in a single 61-cm CWC. The minus 4.8-mm product of the 61-cm CWC overflow was rewashed in a two-stage, 30.5-cm

CWC system. The plus 4.8-mm products were dewatered on vibrating screens and the minus 4.8-mm clean coal and refuse products in two centrifuges. The water recovery system included cyclonic flocculation and inclined settlers to produce clarified water for recirculation.

When operations started in 1974 several problems were encountered. Build-up of slimes in the system, plugging of the two-stage 30.5-cm CWC system, excessive mechanical wear in the fine clean coal centrifuge, and material imbalances were some problems that led to modifications in the plant. These took place in several phases and although the plant was made operable, it was not necessarily at optimum performance. The modified flowsheet in Fig. 2 shows that, as before, the Vissac jig cleans the plus 44.5-mm fraction, the single 61-mm CWC cleans the 44.5 x 0-mm fraction, and the plus 4.8-mm products are dewatered over vibrating screens. However, the 30.5-cm CWC system is now bypassed and all minus 4.8-mm products, including clean coal, are collected in a tank. Partial removal of slimes from process water is effected in a 30.5-cm pulp divider and 15-cm classifier cyclone. The slimes are sent to the drag tank where part of its overflow is bled to a tailings pond. The settled particles are dewatered in a high-speed centrifuge and discharged as fine refuse.

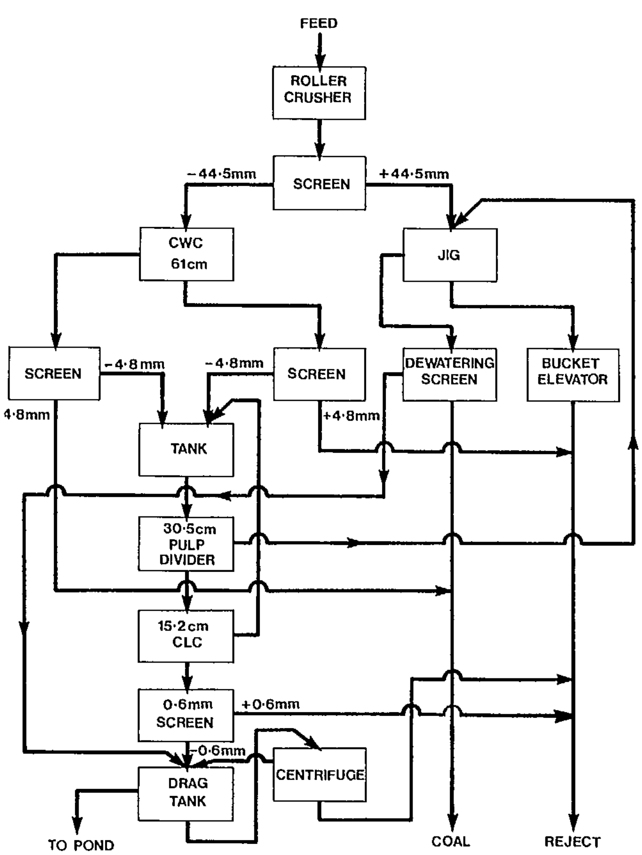


Fig. 2 - Schematic of Stellarton wash plant

Table 1 - Summary of annual coal production - Stellarton wash plant

Year	Dump material processed (t)	Recovered coal (t)	Recovery %	Ash % db*
1974	16 454	4 425	26.9	-
1975	113 242	31 181	27.5	25.2
1976	155 453	43 934	28.3	28.9
1977	152 755	44 298	29.0	29.5
1978	145 839	39 160	27.2	31.6
1979	154 459	41 764	27.0	33.0
Total	738 202	205 212	27.8	29.8

*db = dry basis

After modifications the plant operated relatively smoothly with interruptions due only to breakdown of old equipment and normal wear and tear of other equipment. Because of a surge in coal prices, revenue more than compensated for the operating cost. Annual production figures up to the end of 1979 are summarized in Table 1. Allen and Albion dumps in the process of reclamation near the wash plant were expected to be depleted in 1980. The general success of this operation has led to considering the possibilities of recovering thermal coal from other waste dumps in the province, the most immediate ones being at Westville (Fig. 1).

WASHABILITY CHARACTERISTICS OF WESTVILLE DUMPS

Three dumps in the Westville area are identified in Fig. 1 as the Acadia, West and East Drummond with each containing zones of identifiable differences in ash content. Total recoverable waste material in the three dumps is reported at 1 346 617 t with an average ash content of 53.85% (Table 2) (3). The East Drummond is the largest, containing 69.6% of the total material, and is also the lowest in ash content. Reserve estimates were based on results of a survey and drilling program conducted during the fall of 1979 by DME (3). Split samples from the cores were used for proximate analysis and composites of samples were used for washability analysis for each dump. The top size of the samples used for washability analysis did not necessarily correspond to that of the coal in-situ because of the core pipe diameter of 76.2 mm ID, and to possible degradation, particularly of the coal particles coarser than 76.2 mm. It is reasonable to expect that the waste dump material would be coarser than the size indicated by the core samples.

Acadia Dump

As shown in Table 2, the Acadia dump can be partitioned into two zones, one with a high ash content of 63.8% and the other with a relatively low content of 56.3%. Table 3 shows that the ash content in each of the two zones can be related to differences in particle size and that it decreases with decrease in screen size. This is common in coal waste dumps and is due to the fact that at the time of processing, the coarse coal particles of +6.4 mm were more effectively separated from the refuse than were the finer particles. The high ash content of the plus 19-mm fraction indicates that little coal can be recovered from it.

Table 2 - Recoverable reserves estimate of Westville coal waste dumps

Dump	Zone No.	Recoverable reserves (t)	Ash %*
Acadia	1	79 571	63.81
	2	79 571	56.30
West Drummond	1	125 089	62.03
	2	125 088	53.64
East Drummond	1	380 824	56.22
	2	238 261	49.05
	3	318 213	48.37
Total avg.	-	1 346 617	53.85

*Ash % from washability analysis

Table 3 - Size analysis of Acadia dump

Size fraction mm	Zone 1 *m* %*	Zone 1 Ash %	Zone 2 *m* %	Zone 2 Ash %
+19	28.93	69.58	20.62	70.18
19 - 6.4	31.57	68.89	32.29	60.02
6.4 - 0.6	32.20	59.65	34.38	48.59
- 0.6	15.30	54.16	12.71	45.19
Total avg.	100.00	63.81	100.00	56.30

**m* = mass

Washability data for the plus 0.6-mm fraction of Zone 1 indicate a theoretical recovery of 38% by mass for the 25% ash washed coal (Table 4). The Zone 2 data show a higher theoretical recovery of 51% at the same 25% ash level (Table 5). The corresponding theoretical cutpoints (dp) are 1.87 relative density for Zone 1 and 1.95 for Zone 2.

In practice, the recoveries would be lower than theoretical because of errors of separation that are inherent in any process. The effect of these errors can be seen from the predicted results of washing in Fig. 3 for the plus 0.6-mm fraction. These predictions cover the cutpoint range of 1.60 to 2.00 relative densities. As a measure of the loss in efficiency of a given washing process, the probable error, r, is the parameter used in prediction calculations to convert the theoretical expectation given by the washability curves to practical ones. The range of probable error used for the predictions in Fig. 3 is for separation in a water-only cyclone system. From the curves it appears likely in practice that a washed product with 25% ash would be obtained with a recovery of 41% by mass from Zone 2 (r = 0.20) at dp = 1.85, and a washed pro-

Table 4 - Washing characteristics of Acadia No. 1
high ash: plus 0.6-mm composite

Relative density fraction	Elementary data			Cumulative data: Float			Cumulative data: Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.37	10.09	30 431	0.37	10.09	30 431	100.00	65.54	8572
1.30 - 1.35	5.45	5.27	32 329	5.82	5.58	32 208	99.63	65.75	8490
1.35 - 1.40	7.33	9.66	30 599	13.15	7.85	31 311	94.18	69.25	7111
1.40 - 1.50	6.61	17.35	27 568	19.76	11.03	30 059	86.85	74.28	5129
1.50 - 1.60	4.94	29.08	22 946	24.70	14.64	28 636	80.24	78.97	3280
1.60 - 1.70	2.93	39.33	18 906	27.63	17.26	27 605	75.30	82.24	1990
Sink 1.70	72.37	83.98	1 305	100.00	65.54	8 572	72.37	83.98	1305

Table 5 - Washing characteristics of Acadia No. 2
low ash: plus 0.6-mm composite

Relative density fraction	Elementary data			Cumulative data: Float			Cumulative data: Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.56	6.05	32 022	0.56	6.05	32 022	100.00	57.93	11 576
1.30 - 1.35	9.00	5.70	32 159	9.56	5.72	32 151	99.44	58.22	11 461
1.35 - 1.40	11.71	10.08	30 433	21.27	8.12	31 205	90.44	63.45	9 401
1.40 - 1.50	9.62	17.54	27 493	30.89	11.05	30 049	78.73	71.38	6 273
1.50 - 1.60	3.39	28.72	23 088	34.28	12.80	29 361	69.11	78.88	3 319
1.60 - 1.70	1.97	38.00	19 431	36.25	14.17	28 821	65.72	81.47	2 299
Sink 1.70	63.75	82.81	1 770	100.00	57.93	11 576	63.75	82.81	1 770

duct with 27% ash (25% ash would be difficult to achieve) with a recovery of 28% from Zone 1 at dp = 1.75. The theoretical recoveries at these ash contents are 48.2 and 36.2% respectively as found from the theoretical curves based on the washability data.

West Drummond Dump

As shown in Table 2, the West Drummond dump consists of two equally divided zones with ash contents of 62.03 and 53.64% respectively (3). Data for the zones indicate a decrease in ash with decrease in screen size similar to that for the Acadia dump (Table 6). Because of its very high ash content of 73.68%, the plus 19-mm fraction from Zone 1 could be screened out at the site prior to washing with little loss of recoverable coal.

Washability data in Tables 7 and 8 show that on a percentage basis more coal can be recovered from West Drummond than from the Acadia dump. The Zone 1 high-ash and the Zone 2 low-ash washability data for the plus 0.6-mm fraction indicate theoretical recoveries of 52 and 61% by mass at the 25% ash level and with corresponding

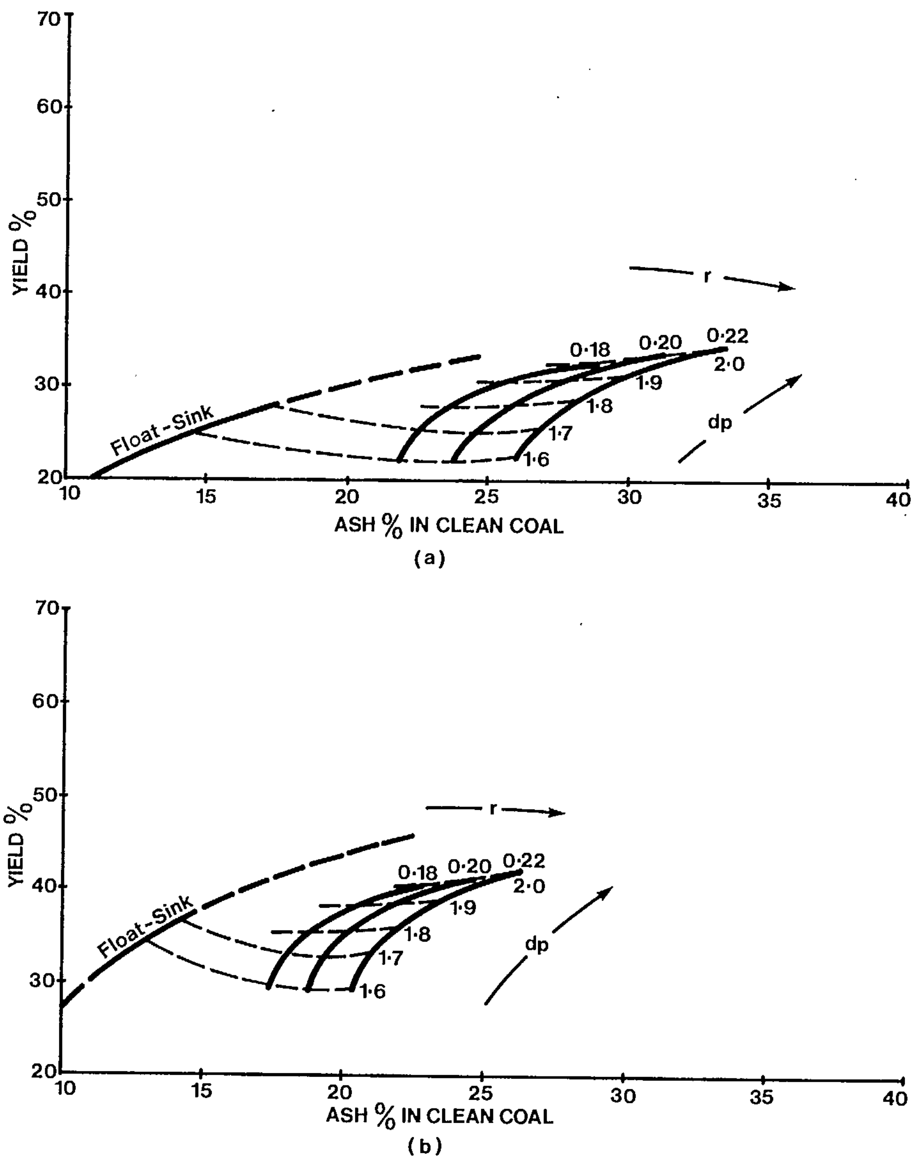


Fig. 3 - Performance evaluation prediction for the +0.6 mm (a) Acadia No. 1 (b) Acadia No. 2

Table 6 - Size analysis of West Drummond dump

Size fraction mm	Zone 1		Zone 2	
	m %*	Ash %	*m* %	Ash %
+19	18.90	73.68	19.75	53.66
19 - 6.4	34.54	67.90	32.67	59.62
6.4 - 0.6	33.13	55.02	32.79	50.35
- 0.6	13.43	47.84	14.79	47.67
Total	100.00	62.03	100.00	53.64

Table 7 - Washing characteristics of West Drummond No. 1
high ash: plus 0.6-mm composite

Relative density fraction	Elementary data			Cumulative data: Float			Cumulative data: Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.29	7.72	31 166	0.29	7.72	31 166	100.00	58.04	11 797
1.30 - 1.35	6.59	5.75	31 924	6.88	5.83	31 892	99.71	58.19	11 740
1.35 - 1.40	13.54	10.14	30 236	20.42	8.69	30 794	93.12	61.90	10 312
1.30 - 1.50	6.83	17.75	27 305	27.25	10.96	29 919	79.58	70.70	6 922
1.50 - 1.60	5.44	28.24	23 267	32.69	13.84	28 812	72.75	75.67	5 008
1.60 - 1.70	1.62	36.45	20 108	34.31	14.90	28 401	67.31	79.51	3 533
Sink 1.70	65.69	80.57	3 124	100.00	58.04	11 797	65.69	80.57	3 124

Table 8 - Washing characteristics of West Drummond No. 2
low ash: plus 0.6-mm composite

Relative density fraction	Elementary data			Cumulative data: Float			Cumulative data: Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.52	10.33	30 161	0.52	10.33	30 161	100.00	52.69	13 846
1.30 - 1.35	9.97	6.23	31 741	10.49	6.43	31 663	99.48	52.91	13 761
1.35 - 1.40	16.10	11.24	29 812	26.59	9.34	30 542	89.51	58.11	11 758
1.40 - 1.50	8.76	18.25	27 114	35.35	11.55	29 693	73.41	68.39	7 799
1.50 - 1.60	4.63	27.28	23 267	39.98	13.37	28 948	64.65	75.18	5 181
1.60 - 1.70	2.10	36.92	19 927	42.08	14.55	28 498	60.02	78.88	3 786
Sink 1.70	57.92	80.40	3 201	100.00	52.69	13 846	57.92	80.40	3 201

cutpoints of 1.76 and 1.77. The predicted washing results in Fig. 4 show that at the 25% ash level, recoveries would be 39 and 49% at r = 0.20 and approximate dp's of 1.87 and 2.10 for the high and low ash zones respectively.

East Drummond Dump

East Drummond is the largest dump and contains more recoverable coal of higher quality than either Acadia or West Drummond. It has 937 298 t divided into three zones having ash contents of 56.22, 49.05 and 48.37% respectively (3). East Drummond contains slightly more recoverable coal in the coarser fractions than in the fine fractions of <0.6 mm (Table 9) making it easier to recover coal by washing than for the other two. Washability data in Tables 10, 11 and 12 indicate theoretical recoveries of 54, 67.5 and 64.4% at cutpoints of 1.75, 1.77 and 1.77 for Zones 1, 2 and 3 respectively. As shown in Fig. 5 and 6, predicted recoveries for washing to the 25% ash level at r = 0.20 would be 39.1, 51.5 and 50.0% at dp's of approximately 1.85, 2.1 and 2.1 for Zones 1, 2 and 3 respectively.

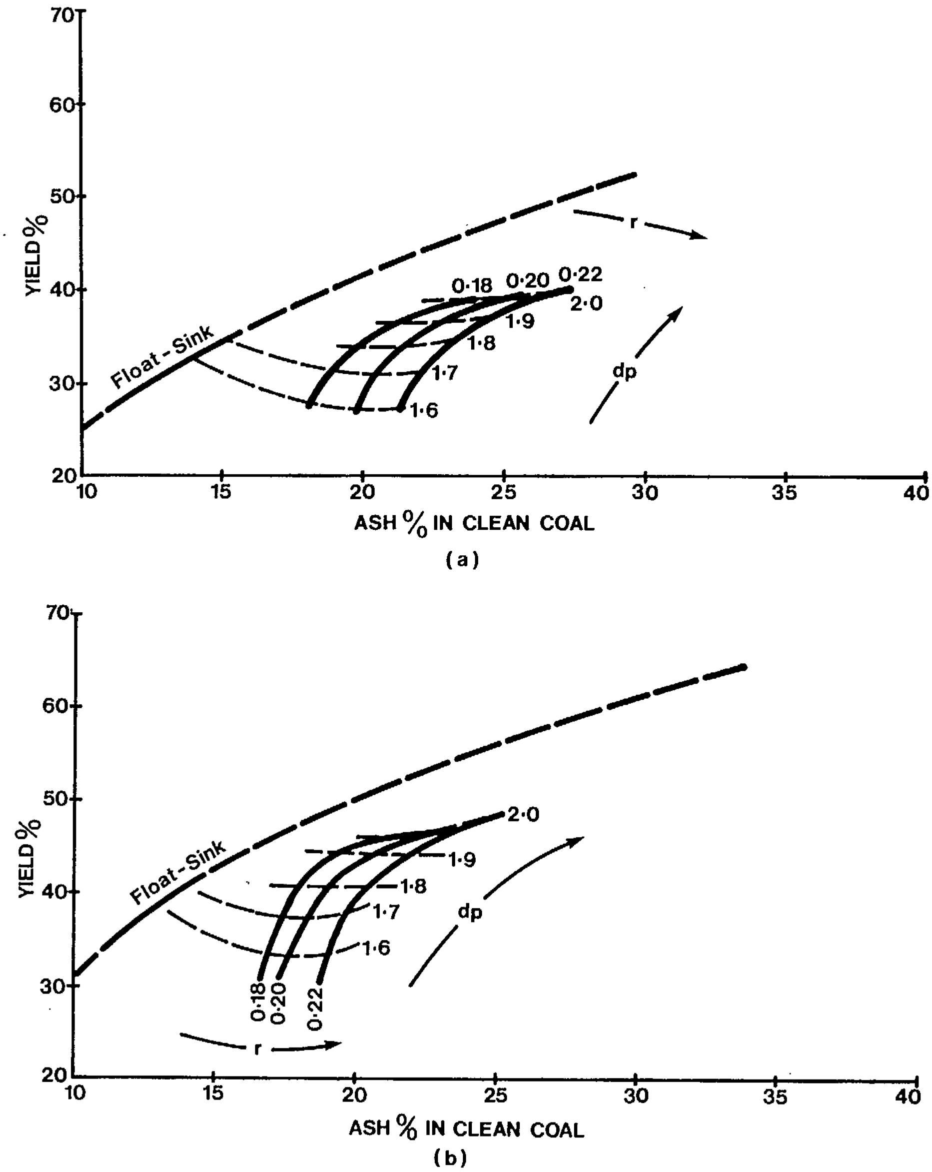


Fig. 4 - Performance evaluation prediction for the +0.6 mm (a) West Drummond No. 1 (b) West Drummond No. 2

Table 9 - Size analysis of East Drummond dump

Size fraction	Zone 1		Zone 2		Zone 3	
mm	*m* %*	Ash %	*m* %	Ash %	*m* %	Ash %
+19	14.86	57.38	17.69	43.50	19.55	46.50
19 - 6.4	29.94	58.05	26.07	47.42	28.38	50.47
6.4 - 0.6	35.44	53.14	33.72	49.77	32.61	46.61
- 0.6	22.76	58.08	22.52	54.23	19.46	50.16
Total	100.00	56.22	100.00	49.05	100.0	48.37

Table 10 - Washing characteristics of East Drummond No. 1 high ash: plus 0.6-mm composite

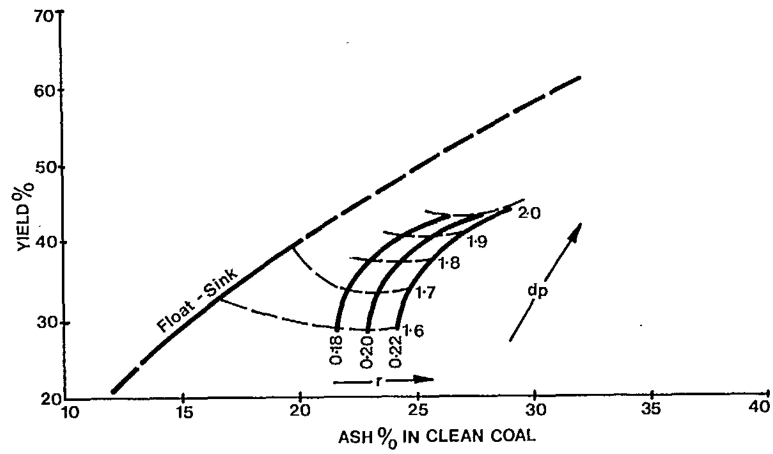
Relative density fraction	Elementary data			Cumulative data: Float			Cumulative data: Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.53	16.28	27 872	0.53	16.28	27 872	100.00	55.20	12 890
1.30 - 1.35	3.49	6.20	31 752	4.02	7.53	31 240	99.47	55.41	12 810
1.35 - 1.40	8.86	10.27	30 185	12.88	9.41	30 514	95.98	57.20	12 121
1.40 - 1.50	11.82	17.39	27 444	24.70	13.23	29 045	87.12	61.97	10 284
1.50 - 1.60	8.25	25.87	24 181	32.95	16.40	27 827	75.30	68.97	7 590
1.60 - 1.70	6.81	36.24	20 187	39.76	19.79	26 519	67.05	74.27	5 549
Sink 1.70	60.24	78.57	3 894	100.00	55.20	12 890	60.24	78.57	3 894

Table 11 -Washing characteristics of East Drummond No. 2 low ash: plus 0.6-mm composite

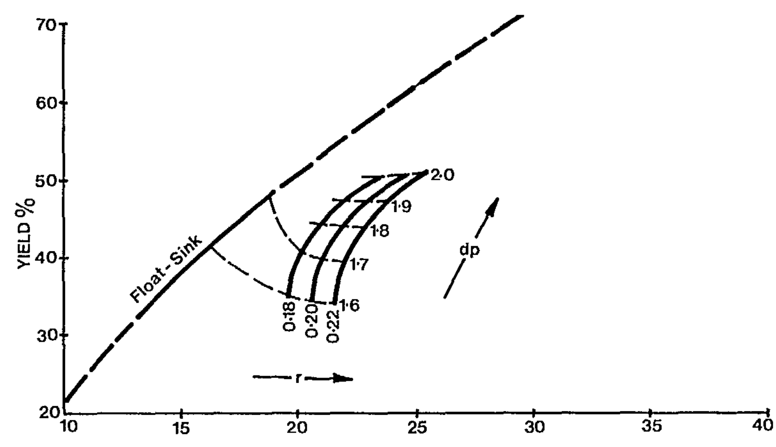
Relative density fraction	Elementary data			Cumulative data: Float			Cumulative data: Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.48	9.09	30 640	0.48	9.09	30 640	100.00	48.88	15 323
1.30 - 1.35	5.00	5.73	31 934	5.48	6.02	31 821	99.52	49.07	15 249
1.35 - 1.40	11.96	10.47	30 108	17.44	9.07	30 646	94.52	51.36	14 367
1.40 - 1.50	14.44	17.89	27 251	31.88	13.07	29 108	82.56	57.28	12 087
1.50 - 1.60	9.74	26.88	23 790	41.62	16.30	27 864	68.12	65.63	8 872
1.60 - 1.70	6.16	35.30	20 550	47.78	18.75	26 921	58.38	72.10	6 383
Sink 1.70	52.22	76.44	4 712	100.00	48.88	15 323	52.22	76.44	4 712

Table 12 - Washing characteristics of East Drummond No. 3: plus 0.6-mm composite

Relative density fraction	Elementary data			Cumulative data: Float			Cumulative data: Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.82	4.46	32 422	0.82	4.46	32 422	100.00	48.80	15 352
1.30 - 1.35	6.34	5.75	31 924	7.16	5.60	31 981	99.18	49.17	15 211
1.35 - 1.40	12.22	11.04	29 889	19.38	9.03	30 662	92.84	52.13	14 070
1.40 - 1.50	14.54	19.32	26 702	33.92	13.44	28 964	80.62	58.36	11 672
1.50 - 1.60	8.11	28.49	23 172	42.03	16.35	27 847	66.08	66.95	8 365
1.60 - 1.70	4.94	36.95	19 915	46.97	18.51	27 013	57.97	72.33	6 293
Sink 1.70	53.03	75.63	5 024	100.00	48.80	15 352	53.03	75.63	5 024



(a)



(b)

Fig. 5 - Performance evaluation for the +0.6 mm (a) East Drummond No. 1 (b) East Drummond No. 2

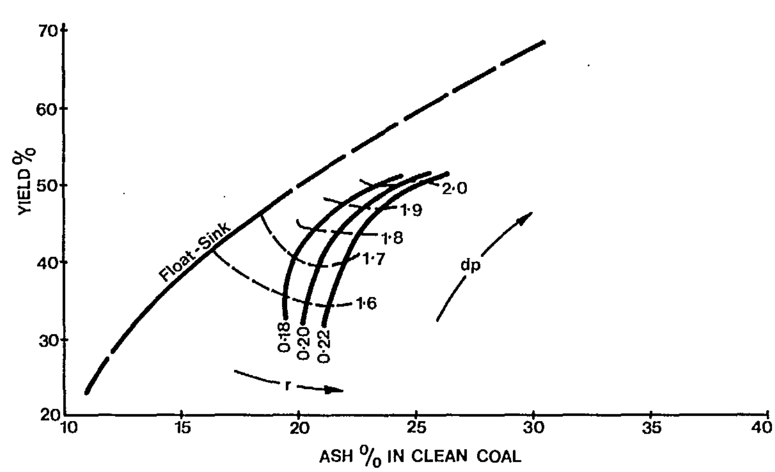


Fig. 6 - Performance evaluation prediction for the +0.6 mm East Drummond Zone 3

BULK TEST IN STELLARTON WASH PLANT

As noted earlier, several changes were made in the original 1972 wash plant flowsheet to overcome operational problems. These made a test run necessary to evaluate the performance of different density and size separators in handling material from the dumps. A bulk sample of approximately 500 t from Acadia was used to evaluate the present wash plant performance. As that material has the highest ash content, results projected for the other two dumps would tend to be conservative. The bulk test was planned to achieve the following objectives:

1. examine reliability of the borehole samples for size representation as questioned earlier and determine whether the total material mined or only certain size ranges should be washed
2. evaluate performance of the Vissac jig and 61-cm CWC for handling the high-ash feed and provide separation parameters to enable accurate projection of recoveries for the Westville dumps
3. evaluate overall plant performance to determine if modifications to the existing plant would be needed
4. examine the effect of slimes build-up on the operation
5. determine recoveries of the fine fractions after washing and dewatering.

Brief Description of the Test

The test duration was 8.5 h with an effective operating time of 5.5 h (3). A few operating problems were encountered during the test including freezing because of the -20°C temperature and plugging of some pipes. This caused interruptions in the run. The plant's effective operating capacity was 91 t/h with a total throughput of 503.8 t of Acadia dump material.

A sampling program was set up to evaluate performance of the Vissac jig and 61-cm CWC washing units and of the water recovery section. Simultaneous incremental samples of the feed, clean coal and reject were collected in a 2 to 5-h period during normal plant operation and placed in plastic-lined 200-L drums.

In the laboratory, the samples were dewatered and air-dried. The plus 6.4-mm fractions were dry-screened and the minus 6.4-mm fractions were wet-screened. Screen fractions of the feed, clean coal and reject products were float-sink tested at relative densities in the range of 1.30 to 2.17. Ash contents were determined for all size fractions for all of the products and from the float-sink fractions of the feed samples to each unit.

Raw Feed to the Plant

The screen analysis given in Table 13 indicates that:

1. The plus 25.4-mm fraction represented 27.9% by mass of the feed and contained 80.3% ash. This size fraction could have been screened out at the dump site and discarded immediately. This would have eliminated the need for a crusher, generally reduced the load on the plant, reduced excess fines resulting from crushing, and reduced ash content of the plant feed to 58.4% which in turn would have resulted in improved separation efficiency of the washing units.

Table 13 - Acadia dump material crushed to 101.6-mm top size

Screen size mm	*m* %	Ash %
+ 101.6	1.4	86.5
101.6 - 50.8	12.1	83.1
50.8 - 25.4	14.4	77.3
25.4 - 12.7	16.5	72.9
12.7 - 6.4	21.5	62.3
6.4 - 3.2	6.3	52.8
3.2 - 0.6	17.8	50.6
0.6 - 0.15	4.4	35.7
- 0.15	5.6	50.3
Total	100.00	64.5

2. The minus 3.2-mm fraction represented 27.8% by mass of the feed and contained 48.2% ash. In the present wash plant operation, the minus 4.8-mm fraction in the clean coal is removed by dewatering and reports to the reject. This reduced the overall recovery of the plant by 11.2% and caused the loss of saleable coal to reject in the 4.8 x 0.15-mm size range.

Vissac Jig

The jig performed well considering that the feed was 74% ash. For the plus 25.4-mm, 78.8% ash product, a recovery of 11.3% was obtained for 26.6 and 85.6% ash contents in the clean coal and reject respectively. The efficiency of separation calculated from the clean coal and reject float-sink analysis and expressed by the probable error was 0.17 at 1.60 cutpoint as shown by the error curve in Fig. 7.

Compound Water Cyclone

Feed to the CWC represented 77.9% by mass of the total feed to the plant and had an ash content of 61.8%. For the plus 0.6-mm (63.8% ash) fraction of this feed, a recovery of 29.3% calculated from the feed and product ash content, was obtained for 16.6 and 83.3% ash in the clean coal and reject respectively. The error curve in Fig. 8 shows that the probable error, r, based on the test run was 0.20 at 1.74 cutpoint for the plus 0.6-mm fraction. Considering the high ash content of 63.8% and the rate of approximately 72 t/h, performance of the cyclone was considered good. However, this was not reflected in the overall performance of the plant because of removal of the minus 4.8-mm fraction from the clean coal in the dewatering process and loss of this material to the fine refuse.

Water Recovery Section

The water recovery section included a 30.5-cm pulp divider and a 15-cm classifier cyclone (Fig. 2). The water recovery circuit allowed unnecessary recirculation and the

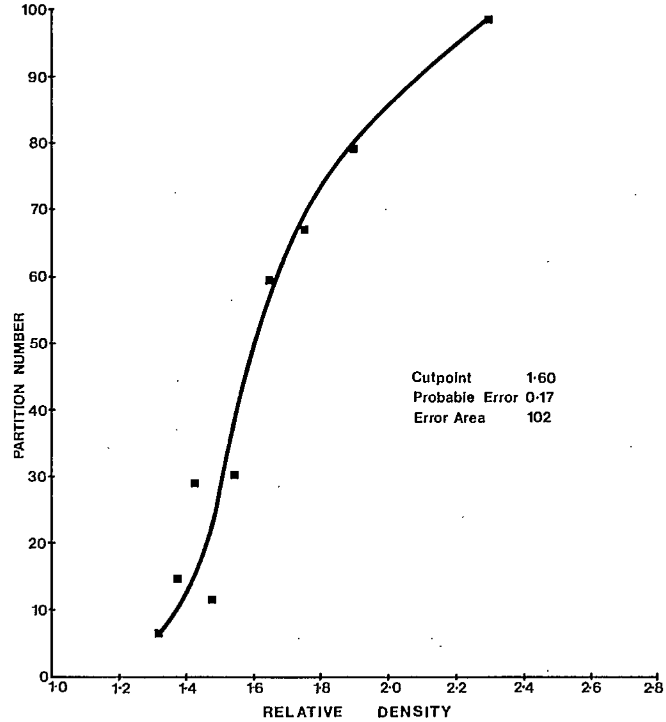


Fig. 7 - Error curve - Vissac jig (+25.4 mm) Stellarton wash plant

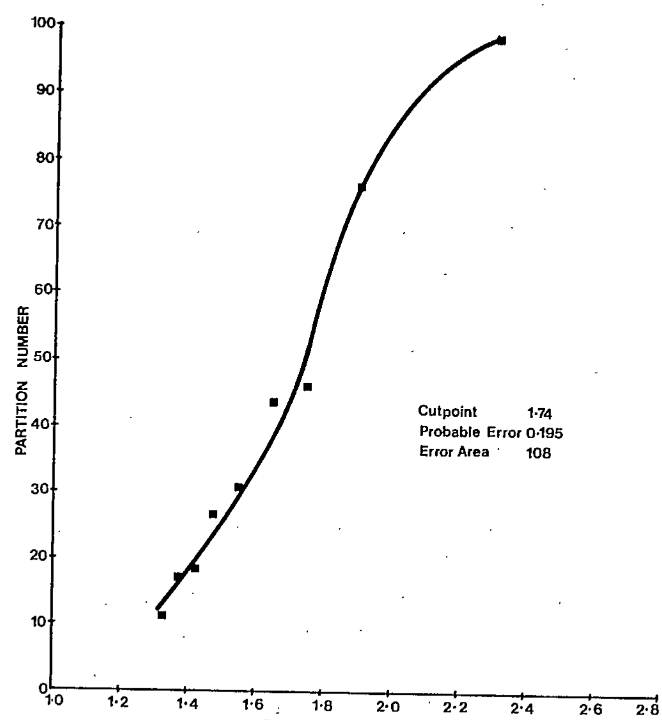


Fig. 8 - Error curve - compound water cyclone (+0.6 mm) - Stellarton wash plant

detrimental feeding of coarser than 0.6-mm fractions to the tailings pond. Based on overflow, underflow, and feed ash contents, the overflow of the classifier cyclone contained 64% by mass of the solids in the feed to the water recovery section which is in turn recirculated to the tank feeding the water recovery circuit. The use of the drag tank in Fig. 2 with limited settling caused some plus 0.6-mm fractions to report to the water recovery circuit. The recirculated slimes, mostly minus 0.07 mm, forced the interruption of the feed for one hour to allow pumping of the slimes to the tailings pond to relieve the system from slimes build-up.

Comments on Bulk Test Results

1. Removal of the plus 50.8-mm size fraction at 86.3% ash content by screening would result in little or no loss in overall recovery and would in turn eliminate the need for crushing in the plant and reduce the amount of fines that create difficulties.
2. Considering the high ash content of the feed, performance efficiencies of the jig and CWC as determined from the test were remarkably good. The partition curves are important for estimating the overall recovery expected from Westville dumps.
3. The effect of discarding the minus 4.8-mm clean coal as reject was to reduce the overall recovery from a possible 25.9% for plus 0.6-mm material only, as shown below, to an actual recovery of 14.7% as shown in Table 14.

	Feed	Clean Coal	
	t/h	*m* %	Ash %
Feed to plant	90.7	-	64.5
Jig (plus 25.4 mm)	20.0	2.5	26.2
CWC (plus 0.6 mm)	72.5	23.4	16.6
Total clean coal	-	25.9	17.5

4. The water recovery circuit requires modification to eliminate or reduce recirculation of slimes and build-up of solids. Only fines of minus 0.6 mm should be sent to the tailings pond. The slurry pumped to the pond during the test contained 20 t of plus 0.6-mm coal with 25.7% ash. The plus 0.6-mm coal should be dewatered mechanically after recovering the low ash coal discarded as solid reject.

Table 14 - Summary of bulk test results on Acadia dump material

	Mass (t)	Yield (%)	Ash (%)
Coarse coal (Jig)	19.64	3.94	19.0
Fine coal (CWC)	53.71	10.78	17.9
Combined rejects	337.88	67.82	81.5
Tailings to pond	86.96	17.46	51.8
Total	*498.19	100.00	67.0
Plant feed	*503.77	-	64.5

* The difference represents the mass of collected samples (4.90 t) + material unaccounted for (0.68 t)

RECOVERY OF THERMAL COAL FROM WESTVILLE DUMPS

On the basis of the bulk test results and evaluation of washability characteristics of the dump materials, the following criteria for wash plant design were formulated:

1. screen out the coarse fractions with greater than 75% ash at the dump site and eliminate crushing unless coal can be liberated and a significant improvement of 3% in recovery is achieved at the 25% ash level, which may be the case for East Drummond
2. simple design is important to reduce capital cost and size of the plant, a consideration when moving to other dump sites in the province
3. employ water only systems - jigs, or cyclones - which have demonstrated capability for producing the required product at cutpoints between 1.70 and 2.00 relative densities at minimum operating cost
4. because significant amounts of recoverable coal occur in the minus 6.4-mm fine size fractions, inclusion of a fines cleaning section is essential for proper plant operation.

There appear to be two routes to consider for washing the Westville waste dumps.

Modified Stellarton Wash Plant

Changes in design are required to improve recovery of fine coal presently lost to the reject, and to eliminate build-up of slimes in the water treatment section. Benefits from these changes would be reflected in an improvement in overall recovery and a smaller tailings pond. The proposed modified flowsheet in Fig. 9 includes the following:

1. plus 10-mm coarse and minus 10-mm fine material cleaning sections using water only cyclones
2. mechanical dewatering of the fine coal with a centrifuge
3. water recovery using a thickener.

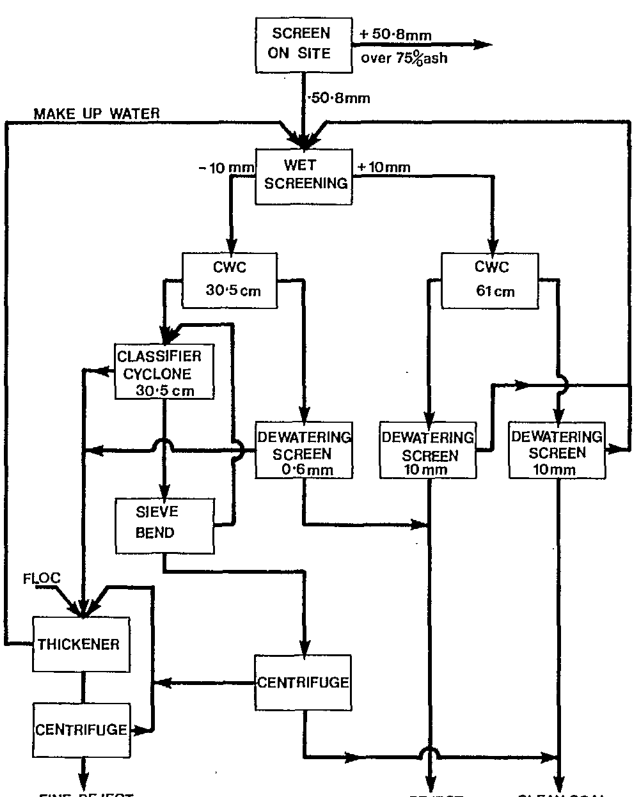


Fig. 9 - Schematic of modified Stellarton wash plant

The basic items that need to be acquired for the proposed modifications are a centrifuge, a thickener and a sieve bend. The advantage of using the existing plant is the minimum capital requirement. The major drawbacks would include the added cost of transporting the dump material about 12 km and increased maintenance for some of the equipment which has been in use for over 30 years.

Modular Plant

The modular plant can be considered a long-term investment as it could be used for dumps other than Westville. Design would have to allow for portability including easy dismantling and erection. The proposed flowsheet shown in Fig. 10 includes the following:

- coarse cleaning of plus 10-mm material using a Batac jig and fine cleaning of minus 10-mm material using a 30.5-cm CWC
- water recovery aided by flocculants using a bottom fed thickener.

The location of the modular plant adjacent to a dump site would reduce transportation costs to a minimum. The new plant would provide a smoother operation than the modified Stellarton plant but the capital investment would be substantially greater.

Overall Predicted Recoverable Thermal Coal

The Westville dumps contain 1 346 617 t of waste material containing recoverable coal. The minus 0.15-mm fraction, estimated to constitute 7% by mass would report to the fine reject. Reserves subject to upgrading by washing would be reduced to 1 252 353 t.

The partition curves in Fig. 7 and 8 representing separation efficiencies of the Vissac jig and 61-cm CWC for the bulk test on high ash Acadia dump material were used to predict recovery of thermal coal from the Westville dumps. The probable error of 0.20 was used for calculating recoveries for cutpoints between 1.60 and 2.00

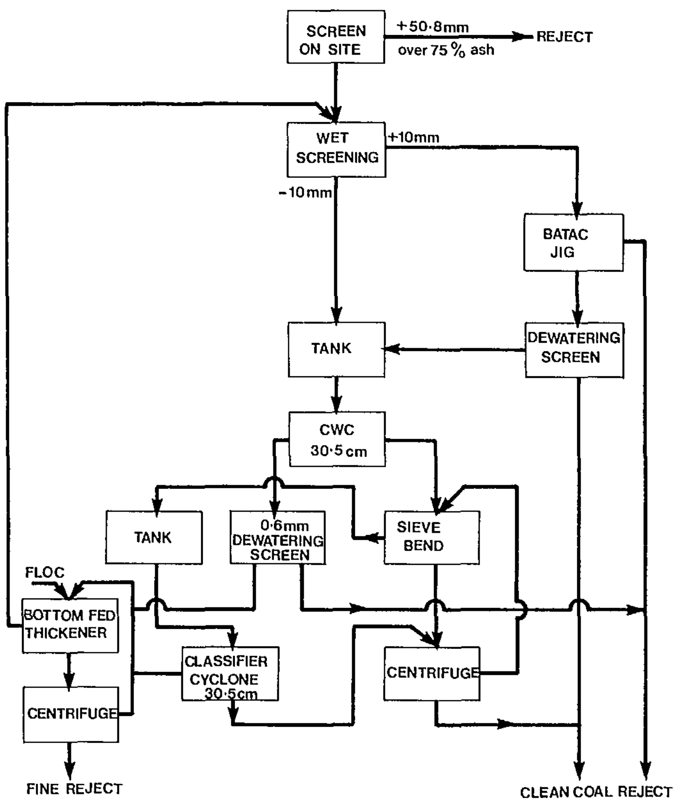


Fig. 10 - Schematic of proposed modular wash plant

relative densities. When applied to better quality waste material such as from East Drummond with a well-controlled operation, the prediction based on r = 0.20 would be on the conservative side.

Washability analysis for the 0.6 x 0.15-mm fractions was not performed and therefore the predicted recoveries based on the plus 0.6-mm fractions have been assumed to be approximately correct for the 0.6 x 0.15-mm fractions also and applicable to the plus 0.15-mm fraction. This assumption should not lead to serious error as the 0.6 x 0.15-mm fraction contains more recoverable coal than the coarser fractions which could possibly compensate for less efficient separation expected on the 0.6 x 0.15-mm fraction.

Expected recoveries of coal at 25% ash for r = 0.20 can be found in Fig. 3,4,5 and 6. As shown in Table 15, the total recoverable 25% ash coal from the three Westville dumps could amount to 551 892 t, equivalent to a yield of 41.2% by mass. Expected recoveries at other ash levels can readily be obtained from the same performance evaluation curves.

Table 15 - Estimated recoverable clean coal from Westville dumps by washing

Dump	Zone No.	* +0.15mm recoverable reserves (t)	Predicted clean coal Ash %	m %	Saleable coal (t)
Acadia	1	74 000	27	28.0	20 720
	2	74 001	23	38.0	28 120
West Drummond	1	116 333	25	39.1	45 486
	2	116 332	25	49.0	57 003
East Drummond	1	354 167	25	39.1	138 479
	2	221 582	25	51.5	114 115
	3	295 938	25	50.0	147 969
Total	-	1 252 353	25	44.1	551 892

* Minus 0.15 mm estimated to be 7% by mass.

CONCLUSIONS

Westville dumps contain recoverable reserves of 1 346 617 t containing 53.85% ash. Of the three dumps, identified as Acadia and West and East Drummond, East Drummond is the largest and contains the highest percentage of recoverable coal as indicated by the washability analysis. At 25% ash the washability data show theoretical recoveries ranging between 38 and 67.5% by mass at cutpoints of 1.75 - 1.95.

A bulk test on high-ash Acadia coal waste performed in the Stellarton wash plant indicated that little or no drop in overall recovery would occur if the plus 50.8-cm sizes containing 86.3% ash were removed by screening. Performance efficiencies as expressed by the probable error were 0.17 and 0.20 for the Vissac jig and Compound Water Cyclone respectively. The minus 4.8-mm fraction of the clean coal discarded on the dewatering screens resulted in a drop in overall recovery of from approximately 25.9% to an actual recovery of 14.7%. The existing dewatering and water recovery circuits in the Stellarton plant require modification to improve coal recovery and to reduce recirculation and slimes build-up.

Based on washability characteristics and bulk test results, two options can be considered for recovery of thermal coal from the Westville dumps. The first is to use the existing Stellarton plant after making changes to improve fine coal recovery and eliminate slimes build-up. This approach would involve low capital investment but high maintenance cost and the additional cost of transporting the dump material 12 km. The second would be to build a modular plant that could be transported for use at any dump site in the province including Westville. This approach would involve high capital investment but a reduction in other costs. Thermal coal recoverable by washing at 25% ash from the three Westville waste dumps was estimated at 551 892 t by either option, equivalent to a recovery by mass of 41%.

ACKNOWLEDGEMENTS

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APPENDIX A

WESTVILLE DUMPS WASHABILITY

Table A-1 - Washing characteristics of Acadia No. 1 - high ash: plus 19.1 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
1.30 - 1.35	2.37	5.75	32 141	2.37	5.75	32 141	100.00	69.58	6984
1.35 - 1.40	4.03	9.84	30 529	6.40	8.33	31 126	97.63	71.13	6374
1.40 - 1.50	4.26	17.32	27 582	10.66	11.92	29 710	93.60	73.77	5334
1.50 - 1.60	10.14	29.28	22 867	20.80	20.38	26 374	89.34	76.46	4273
1.60 - 1.70	3.73	41.00	18 247	24.53	23.52	25 138	79.20	82.50	1892
Sink 1.70	75.47	84.55	1 084	100.00	69.58	6 984	75.47	84.55	1084

Table A-2 - Washing characteristics of Acadia No. 1 - high ash: 19.1 x 6.4 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.21	17.95	27 333	0.21	17.95	27 333	100.00	68.89	7257
1.30 - 1.35	4.23	6.17	31 976	4.44	6.73	31 756	99.79	68.99	7215
1.35 - 1.40	7.06	9.84	30 529	11.50	8.64	31 003	95.56	71.77	6119
1.40 - 1.50	6.23	17.77	27 403	17.73	11.85	29 738	88.50	76.71	4171
1.50 - 1.60	2.83	29.47	22 792	20.56	14.27	28 782	82.27	81.18	2412
1.60 - 1.70	2.68	38.91	19 071	23.24	17.11	27 662	79.44	83.02	1686
Sink 1.70	76.76	84.56	1 079	100.00	68.89	7 257	76.76	84.56	1079

Table A-3 - Washing characteristics of Acadia No. 1 - high ash: 6.4 x 0.6 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.78	8.02	31 245	0.78	8.02	31 245	100.00	59.65	10 898
1.30 - 1.35	8.65	4.76	32 531	9.43	5.03	32 425	99.22	60.05	10 738
1.35 - 1.40	9.74	9.48	30 671	19.17	7.29	31 534	90.57	65.34	8 656
1.40 - 1.50	8.51	17.05	27 686	27.68	10.29	30 351	80.83	72.07	6 004
1.50 - 1.60	3.63	28.41	23 209	31.31	12.39	29 523	72.32	78.54	3 452
1.60 - 1.70	2.66	38.23	19 341	33.97	14.42	28 725	68.69	81.19	2 408
Sink 1.70	66.03	82.92	1 726	100.00	59.65	10 898	66.03	82.92	1 726

Table A-4 - Washing characteristics of Acadia No. 2 - low ash: plus 19.1 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.18	14.55	28 633	0.18	14.65	28 633	100.00	70.18	6747
1.30 - 1.35	2.63	7.10	31 608	2.81	7.85	31 417	99.82	70.28	6707
1.35 - 1.45	6.31	11.12	30 024	9.12	10.03	30 453	97.19	71.99	6033
1.40 - 1.50	6.44	17.80	27 391	15.56	13.25	39 186	90.88	76.22	4368
1.50 - 1.60	1.54	28.63	23 123	17.10	14.63	28 640	84.44	80.68	2612
1.60 - 1.70	0.68	36.05	20 199	17.78	15.45	28 317	82.90	81.64	2231
Sink 1.70	82.22	82.02	2 082	100.00	70.18	6 747	82.22	82.02	2082

Table A-5 - Washing characteristics of Acadia No. 2 - low ash: 19.1 x 6.4 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.39	6.67	31 778	0.39	6.67	31 778	100.00	60.02	10 752
1.30 - 1.35	9.32	6.36	31 901	9.71	6.37	31 896	99.61	60.23	10 670
1.35 - 1.40	11.58	10.74	30 173	21.29	8.75	30 959	90.29	65.79	8 479
1.40 - 1.50	8.76	18.32	27 186	30.05	11.54	29 859	78.71	73.89	5 287
1.50 - 1.60	3.22	30.43	22 413	33.27	13.37	29 138	69.95	80.84	2 544
1.60 - 1.70	1.82	38.96	19 052	35.09	14.69	28 615	66.73	83.28	1 586
Sink 1.70	64.91	84.52	1 096	100.00	60.02	10 752	64.91	84.52	1 096

Table A-6 - Washing characteristics of Acadia No. 2 - low ash: 6.4 x 0.6 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.96	4.85	32 494	0.96	4.85	32 494	100.00	48.59	15 255
1.30 - 1.35	12.52	5.06	32 413	13.48	5.05	32 419	99.04	49.02	15 088
1.35 - 1.40	15.08	9.34	30 726	28.56	7.31	31 525	86.52	55.38	12 581
1.40 - 1.50	12.34	16.93	27 735	40.90	10.21	30 381	71.44	65.10	8 751
1.50 - 1.60	4.66	27.62	23 521	45.56	11.99	29 680	59.10	75.15	4 787
1.60 - 1.70	2.88	37.71	19 545	48.44	13.52	29 077	54.44	79.22	3 184
Sink 1.70	51.56	81.54	2 270	100.00	48.59	15 255	51.56	81.54	2 270

Table A-7 - Washing characteristics of West Drummond No. 1 - high ash: plus 19.1 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
1.30 - 1.35	1.09	7.01	31 441	1.09	7.01	31 441	100.00	73.67	5780
1.35 - 1.40	4.55	10.73	30 008	5.64	10.01	30 285	98.91	74.40	5497
1.40 - 1.50	1.77	17.45	27 421	7.41	11.79	29 601	94.36	77.47	4315
1.50 - 1.60	3.51	27.11	23 702	10.92	16.71	27 705	92.59	78.62	3874
1.60 - 1.70	1.31	35.86	20 334	12.23	18.76	26 915	89.08	80.65	3092
Sink 1.70	87.77	81.32	2 835	100.00	73.67	5780	87.77	81.32	2835

Table A-8 - Washing characteristics of West Drummond No. 1 - high ash: 19.1 x 6.4 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.43	10.47	30 108	0.43	10.47	30 108	100.00	53.86	13 403
1.30 - 1.35	7.27	6.41	31 671	7.70	6.64	31 584	99.57	54.05	13 331
1.35 - 1.40	19.58	10.10	30 250	27.28	9.12	30 626	92.30	57.80	11 887
1.40 - 1.50	7.29	17.73	27 314	34.57	10.94	29 928	72.72	70.65	6 942
1.50 - 1.60	8.08	28.82	23 044	42.65	14.33	28 624	65.43	76.54	4 673
1.60 - 1.70	0.90	38.59	19 283	43.55	14.83	28 431	57.35	83.27	2 084
Sink 1.70	56.45	83.98	1 810	100.00	53.86	13 403	56.45	83.98	1 810

Table A-9 - Washing characteristics of West Drummond No. 1 - high ash: 6.4 x 0.6 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.31	3.74	32 699	0.31	3.74	32 699	100.00	53.46	13 559
1.30 - 1.35	9.02	5.10	32 176	9.33	5.05	32 193	99.69	53.62	13 499
1.35 - 1.40	12.37	10.08	30 259	21.70	7.92	31 091	90.67	58.44	11 641
1.40 - 1.50	9.24	17.80	27 286	30.94	10.87	29 954	78.30	66.08	8 700
1.50 - 1.60	3.80	27.55	23 532	34.74	12.69	29 252	69.06	72.54	6 213
1.60 - 1.70	2.56	35.84	20 341	37.30	14.28	28 640	65.26	75.16	5 205
Sink 1.70	62.70	76.77	4 587	100.00	53.46	13 559	62.70	76.77	4 587

Table A-10 - Washing characteristics of West Drummond No. 2 - low ash: plus 19.1 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg
Float 1.30	0.43	14.61	28 514	0.43	14.61	28 514	100.00	53.66	13 481
1.30 - 1.35	7.27	7.02	31 436	7.70	7.44	31 273	99.57	53.83	13 416
1.35 - 1.40	19.58	11.59	29 677	27.28	10.42	30 127	92.30	57.52	11 997
1.40 - 1.50	7.29	17.76	27 303	34.57	11.97	29 532	72.72	69.89	7 236
1.50 - 1.60	8.08	25.04	24 500	42.65	14.44	28 579	65.43	75.69	5 001
1.60 - 1.70	0.90	33.22	21 350	43.55	14.83	28 429	57.35	82.83	2 253
Sink 1.70	56.45	83.62	1 949	100.00	53.66	13 481	56.45	83.62	1 949

Table A-11 - Washing characteristics of West Drummond No. 2 - low ash: 19.1 x 6.4 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg
Float 1.30	0.53	13.59	28 908	0.53	13.59	28 908	100.00	56.61	12 348
1.30 - 1.35	9.88	6.77	31 534	10.41	7.12	31 400	99.47	56.83	12 260
1.35 - 1.40	15.65	12.06	29 496	26.06	10.09	30 257	89.59	62.36	10 134
1.40 - 1.50	8.05	20.11	26 398	34.11	12.45	29 346	73.94	73.00	6 036
1.50 - 1.60	2.80	30.29	22 478	36.91	13.80	28 825	65.89	79.46	3 549
1.60 - 1.70	1.81	38.14	19 457	38.72	14.94	28 387	63.09	81.65	2 709
Sink 1.70	61.28	82.93	2 214	100.00	56.61	12 348	61.28	82.93	2 214

Table A-12 - Washing characteristics of West Drummond No. 2 - low ash: 6.4 x 0.6 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg
Float 1.30	0.56	5.27	32 110	0.56	5.27	32 110	100.00	48.21	15 580
1.30 - 1.35	11.69	5.47	32 034	12.25	5.46	32 037	99.44	48.45	15 487
1.35 - 1.40	14.45	10.07	30 261	26.70	7.96	31 076	87.75	54.18	13 282
1.40 - 1.50	10.35	17.01	27 591	37.05	10.48	30 102	73.30	62.87	9 935
1.50 - 1.60	4.37	27.85	23 418	41.42	12.32	29 397	62.95	70.41	7 032
1.60 - 1.70	3.11	36.85	19 952	44.53	14.03	28 738	58.58	73.59	5 810
Sink 1.70	55.47	75.65	5 017	100.00	48.21	15 580	55.47	75.65	5 017

Table A-13 - Washing characteristics of East Drummond No. 1 - high ash: plus 19.1 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.28	43.44	17 417	0.28	43.44	17 417	100.00	57.38	12 050
1.30 - 1.35	1.37	12.70	29 249	1.65	17.92	27 241	99.72	57.42	12 035
1.35 - 1.40	5.53	11.05	29 884	7.18	12.63	29 277	98.35	58.04	11 795
1.40 - 1.50	11.90	19.68	26 563	19.08	17.03	27 584	92.82	60.84	10 718
1.50 - 1.60	10.06	28.98	22 983	29.14	21.15	25 996	80.92	66.90	8 388
1.60 - 1.70	8.21	36.25	20 185	37.35	24.47	24 718	70.86	72.28	6 316
Sink 1.70	62.65	77.00	4 498	100.00	57.38	12 050	62.65	77.00	4 498

Table A-14 - Washing characteristics of East Drummond No. 1 - high ash: 19.1 x 6.4 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.44	22.51	25 474	0.44	22.51	25 474	100.00	54.97	12 977
1.30 - 1.35	2.53	7.79	31 140	2.97	9.97	30 301	99.56	55.11	12 922
1.35 - 1.40	11.18	11.18	29 836	14.15	10.93	29 934	97.03	56.35	12 447
1.40 - 1.50	12.22	18.16	27 149	26.37	14.28	28 643	85.85	62.23	10 183
1.50 - 1.60	8.31	26.28	24 023	34.68	17.15	27 536	73.63	69.54	7 367
1.60 - 1.70	7.00	38.04	19 494	41.68	20.66	26 185	65.32	75.05	5 248
Sink 1.70	58.32	79.49	3 538	100.00	54.97	12 977	58.32	79.49	3 538

Table A-15 - Washing characteristics of East Drummond No. 1 - high ash: 6.4 x 0.6 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.71	8.85	30 731	0.71	8.85	30 731	100.00	54.45	13 180
1.30 - 1.35	5.11	4.87	32 264	5.82	5.36	32 077	99.29	54.77	13 055
1.35 - 1.40	8.49	9.15	30 617	14.31	7.61	31 211	94.18	57.48	12 013
1.40 - 1.50	11.49	15.77	28 068	25.80	11.24	29 811	85.69	62.27	10 169
1.50 - 1.60	7.45	23.76	24 993	33.25	14.05	28 732	74.20	69.47	7 398
1.60 - 1.70	6.08	34.65	20 799	39.33	17.23	27 505	66.75	74.57	5 434
Sink 1.70	60.67	78.57	3894	100.00	54.45	13 180	60.67	78.57	3 894

Table A-16 - Washing characteristics of East Drummond No. 2 - medium ash: plus 19.1 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg
Float 1.30	0.16	14.60	28 519	0.16	14.60	28 519	100.00	43.50	17 393
1.30 - 1.35	2.52	7.24	31 352	2.68	7.68	31 183	99.84	43.55	17 375
1.35 - 1.40	11.87	11.78	29 603	14.55	11.02	29 894	97.32	44.49	17 013
1.40 - 1.50	18.65	19.54	26 616	33.20	15.81	28 053	85.45	49.03	15 264
1.50 - 1.60	14.31	28.32	23 237	47.51	19.58	26 602	66.80	57.26	12 095
1.60 - 1.70	8.62	34.84	20 727	56.13	21.92	25 700	52.49	65.15	9 057
Sink 1.70	43.87	71.11	6764	100.00	43.50	17 393	43.87	71.11	6 764

Table A-17 - Washing characteristics of East Drummond No. 2 - medium ash: 19.1 x 6.4 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg
Float 1.30	0.77	11.62	29 666	0.77	11.62	29 666	100.00	50.66	14 635
1.30 - 1.35	4.66	6.89	31 487	5.43	7.56	31 229	99.23	50.97	14 518
1.35 - 1.40	13.38	10.97	29 915	18.81	9.99	30 294	94.57	53.14	13 682
1.40 - 1.50	12.51	19.57	26 605	31.32	13.81	28 821	81.19	60.09	11 007
1.50 - 1.60	9.52	27.34	23 614	40.84	16.97	27 607	68.68	67.47	8 166
1.60 - 1.70	5.84	35.36	20 527	46.68	19.27	26 721	59.16	73.93	5 680
Sink 1.70	53.32	78.15	4 054	100.00	50.66	14 635	53.32	78.15	4 054

Table A-18 - Washing characteristics of East Drummond No. 2 - medium ash: 6.4 x 0.6 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg	m %	Ash %	kJ/kg
Float 1.30	0.42	4.39	32 448	0.42	4.39	32 448	100.00	50.32	14 769
1.30 - 1.35	6.56	4.79	32 294	6.98	4.77	32 303	99.58	50.51	14 694
1.35 - 1.40	10.91	9.25	30 578	17.89	7.50	31 251	93.02	53.73	13 453
1.40 - 1.50	13.72	15.53	28 161	31.61	10.99	29 910	82.11	59.65	11 177
1.50 - 1.60	7.51	24.99	24 518	39.12	13.67	28 875	68.39	68.50	7 770
1.60 - 1.70	5.12	35.66	20 411	44.24	16.22	27 895	60.88	73.86	5 704
Sink 1.70	55.76	77.37	4 354	100.00	50.32	14 769	55.76	77.37	4 354

Table A-19 - Washing characteristics of East Drummond No. 3 - low ash: plus 19.1 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
1.30 - 1.35	1.21	7.43	31 278	1.21	7.43	31 278	100.00	46.50	16 238
1.35 - 1.40	12.03	11.27	29 801	13.24	10.92	29 936	98.79	46.98	16 053
1.40 - 1.50	19.19	19.78	26 523	32.43	16.16	27 916	86.76	51.93	14 147
1.50 - 1.60	10.55	27.97	23 372	42.98	19.06	26 801	67.57	61.06	10 632
1.60 - 1.70	5.03	38.53	19 306	48.01	21.10	26 016	57.02	67.19	8 275
Sink 1.70	51.99	69.96	7 208	100.00	46.50	16 238	51.99	69.96	7 208

Table A-20 - Washing characteristics of East Drummond No. 3 - low ash: 19.1 x 6.4 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	0.34	13.02	29 126	0.34	13.02	29 126	100.00	52.32	13 997
1.30 - 1.35	4.39	6.21	31 748	4.73	6.70	31 560	99.66	52.46	13 946
1.35 - 1.40	13.18	11.18	29 836	17.91	10.00	30 291	95.27	54.59	13 126
1.40 - 1.50	13.58	20.16	26 379	31.49	14.38	28 604	82.09	61.56	10 443
1.50 - 1.60	8.05	29.46	22 797	39.54	17.45	27 422	68.51	69.76	7 284
1.60 - 1.70	4.87	36.28	20 173	44.41	19.51	26 627	60.46	75.13	5 218
Sink 1.70	55.59	78.53	3 908	100.00	52.32	13 997	55.59	78.53	3 908

Table A-21 - Washing characteristics of East Drummond No. 3 - low ash: 6.4 x 0.6 mm

Relative density fraction	Elementary data			Cumulative data					
				Float			Sink		
	m %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg	*m* %	Ash %	kJ/kg
Float 1.30	1.74	3.00	32 985	1.74	3.00	32 985	100.00	47.11	16 003
1.30 - 1.35	11.11	5.48	32 029	12.85	5.14	32 158	98.26	47.89	15 702
1.35 - 1.40	11.50	10.75	30 001	24.35	7.79	31 140	87.15	53.30	13 621
1.40 - 1.50	12.58	18.11	27 168	36.93	11.31	29 787	75.65	59.77	11 131
1.50 - 1.60	6.70	27.96	23 376	43.63	13.86	28 802	63.07	68.08	7 932
1.60 - 1.70	4.95	36.56	20 064	48.58	16.18	27 912	56.37	72.85	6 097
Sink 1.70	51.42	76.34	4 752	100.00	47.11	16 003	51.42	76.34	4 752

APPENDIX B

WASHING UNIT PERFORMANCE

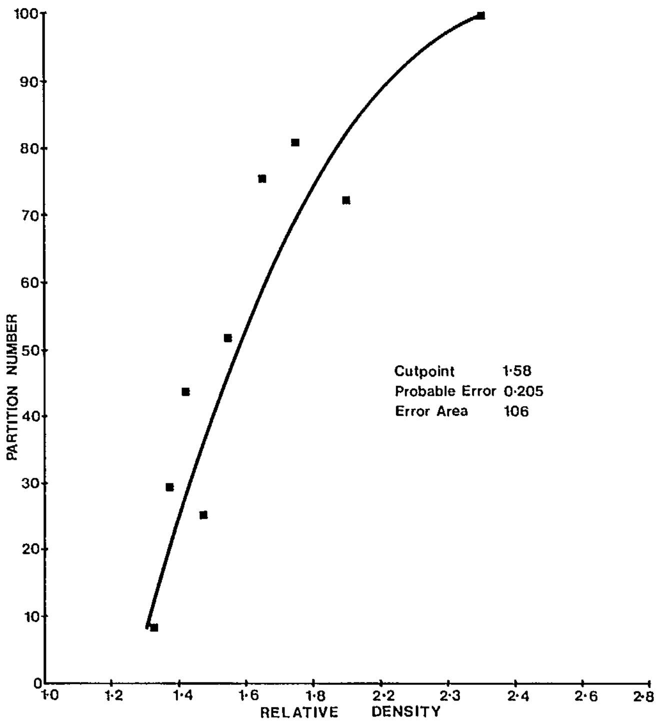

Fig. B-1 - Error curve - Vissac jig (+50.8 mm) Stellarton wash plant

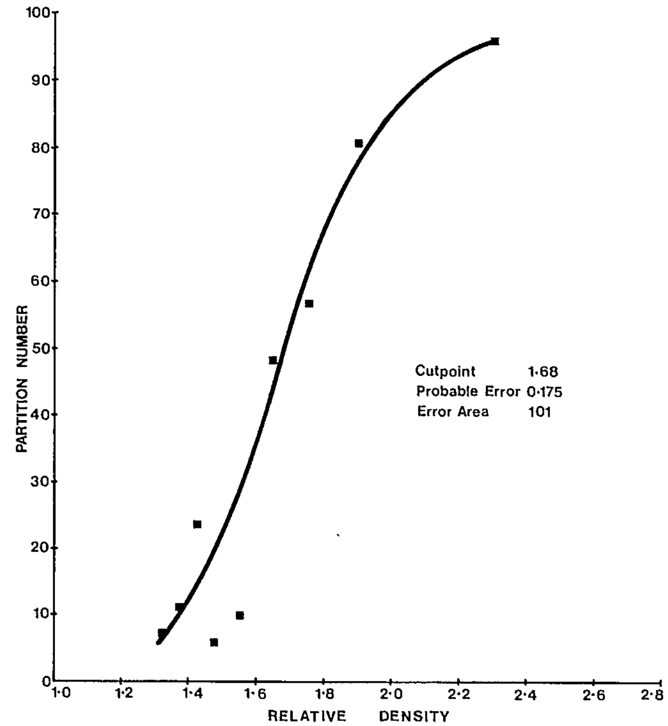

Fig. B-2 - Error curve - Vissac jig (25.8 x 25.4 mm) Stellarton wash plant

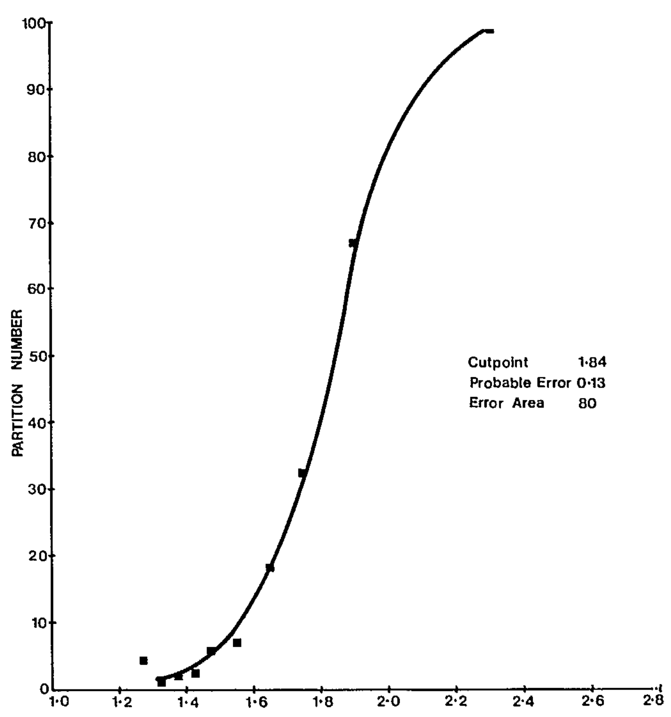

Fig. B-3 - Error curve - compound water cyclone (+12.7 mm) - Stellarton wash plant

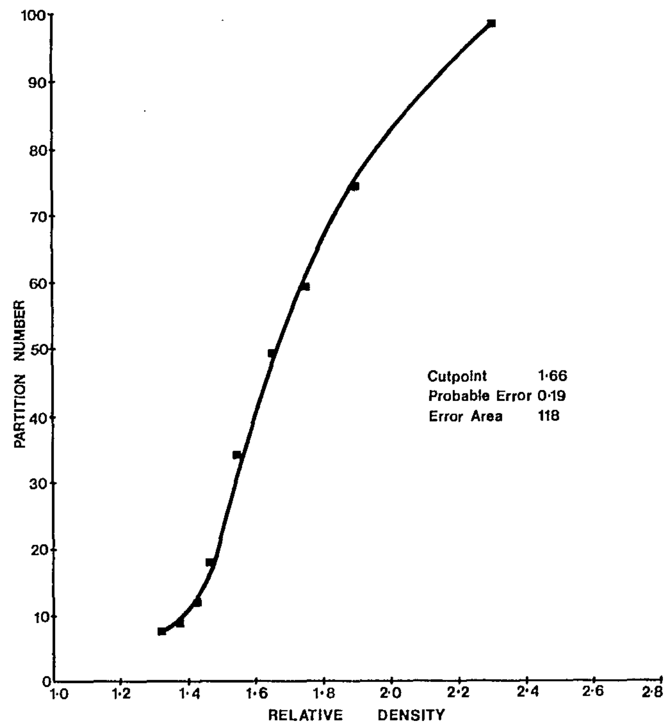

Fig. B-4 - Error curve - compound water cyclone (12.7 x 6.4 mm) - Stellarton wash plant

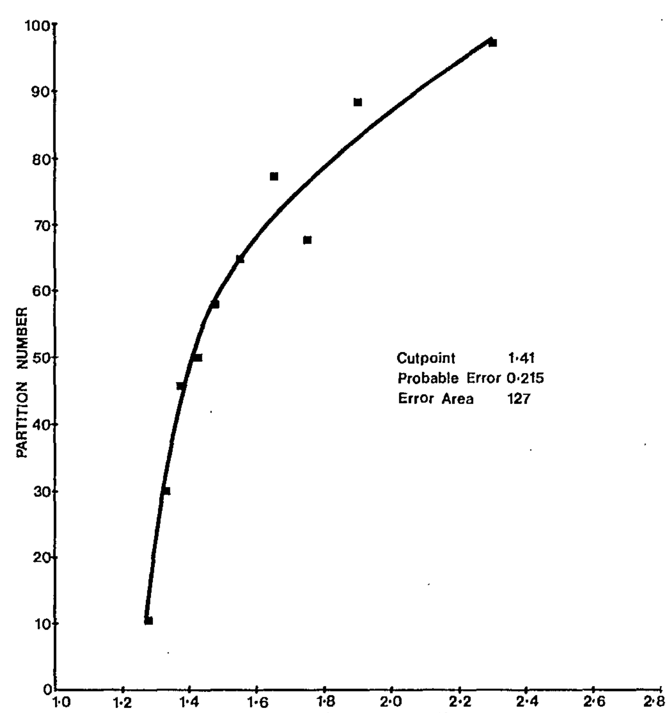

Fig. B-5 - Error curve - compound water cyclone (6.4 x 0.6 mm) - Stellarton wash plant

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