M Resources

Coal Quality and Technical Marketing

Capability Sample Pack

2015

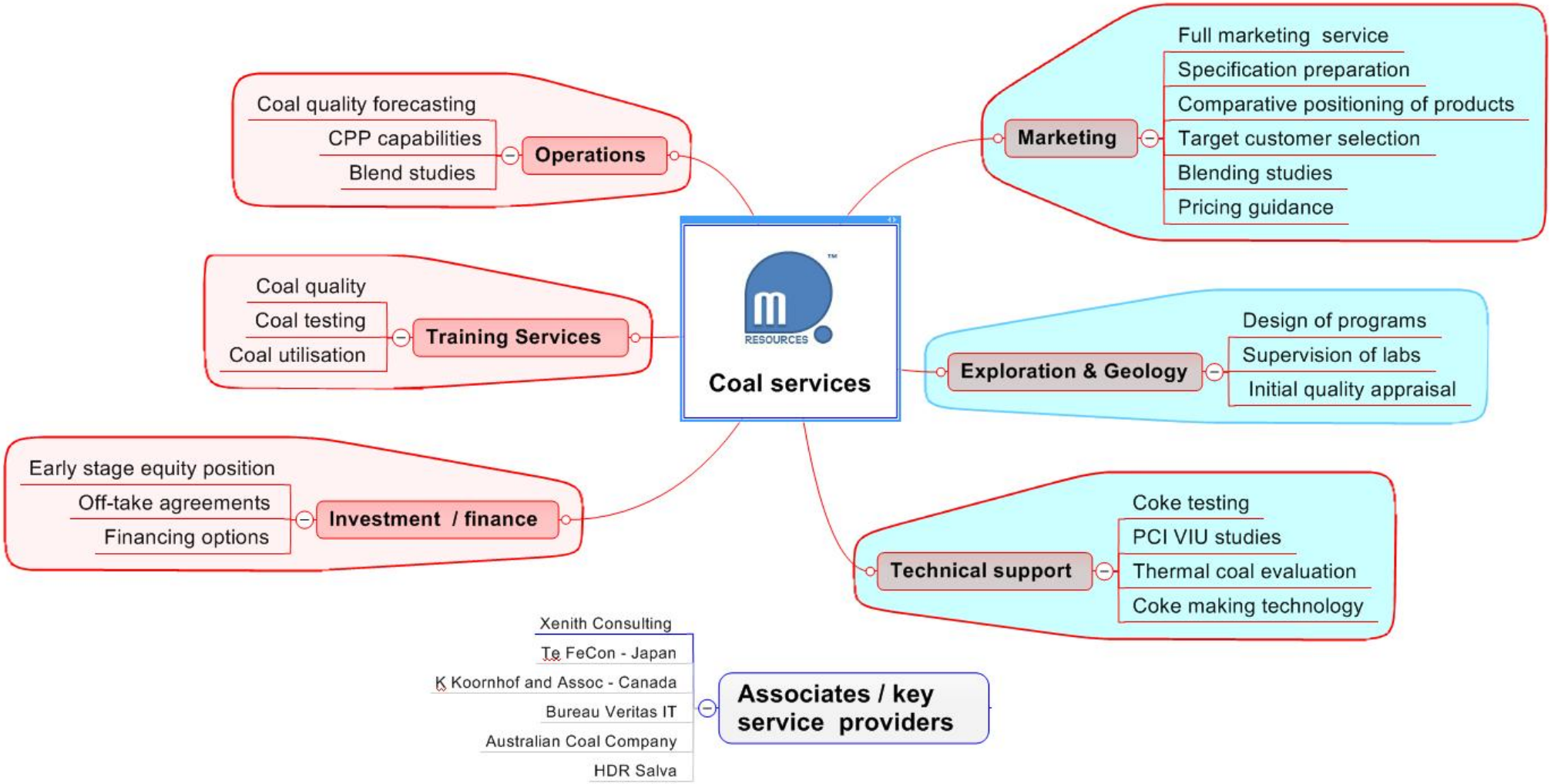
Introduction

Coal technology, along with aspects of *technical marketing support* can cover a wide range of topics – including :

- Bore core programmes
- Data handling and assessment
- Coal washability
- Product specification
- Coal blending and marketing
- *Value-in-use* calculations to support market appraisal

- M Resources have a team of experienced coal technicians and data analysts capable of taking basic bore core, laboratory and product quality data and converting it into valuable output.
- M Resources staff are competent in the areas of *geology – metallurgy – coal technology – coal marketing and data analysis.*
- *Due to continuous coal trading activity, an extensive in-house database of world traded coals is maintained.*

Suite of services



Database Analysis

M Resources has the tools and ability to take a database with thousands of entries and compile results that are customizable to specific needs.

- Database is filterable to create specifications on any basis(e.g. excluding data with ash over 20 % and/or CV under 5,600 kcal/kg gar etc).
- *Weighted average* equation to more accurately model contribution from each component, even when disjointed data is presented.
- Ability to adjust specifications promptly to suit changes in mining area or marketing agenda.

ALL RESULTS:

AVERAGE	1.40	31.2	17.6	11.5	37.2	33.6	0.23	4854	6853
TONNES WEIGHTED AVERAGE	**1.38**	**30.9**	**19.1**	**10.3**	**37.7**	**33.0**	**0.21**	**4857**	**6871**
MIN	1.29	25.6	8.9	3.7	27.9	17.1	0.13	3721	6260
MAX	1.64	37.8	29.7	29.8	53.4	43.6	0.87	5980	7390

SORT	Thickness	T * RD	RD	Moisture holding capacity	Moisture %adb	Ash (%adb)	VM (%adb)	FC (%adb)	TS (%adb)	CV kcal/kg adb	CV kcal/kg daf
1	0.89	1.21	1.36	29.5	21.0	9.0	34.1	35.9	-	4753	6790
4	4.98	6.77	1.36	30.6	26.0	10.3	35.8	27.9	0.19	4374	6867
15	5.78	7.57	1.31	29.6	27.0	8.6	46.1	18.3	0.22	4380	6801
17	5.00	6.55	1.31	28.7	26.7	7.1	35.0	31.2	0.19	4574	6909
23	1.51	2.01	1.33	30.2	28.7	8.1	37.5	25.7	0.20	4475	7081
25	0.78	1.03	1.32	28.9	27.2	7.8	34.2	30.8	0.20	4660	7169
26	0.85	1.17	1.38	27.6	25.3	14.0	31.6	29.1	0.38	4284	7058
28	2.89	3.79	1.31	29.9	28.2	5.0	41.4	25.4	0.15	4694	7027
29	0.31	0.40	1.29	25.6	23.9	4.5	41.0	30.6	0.20	5246	7327

Filtered exclude TS greater than 0.20:

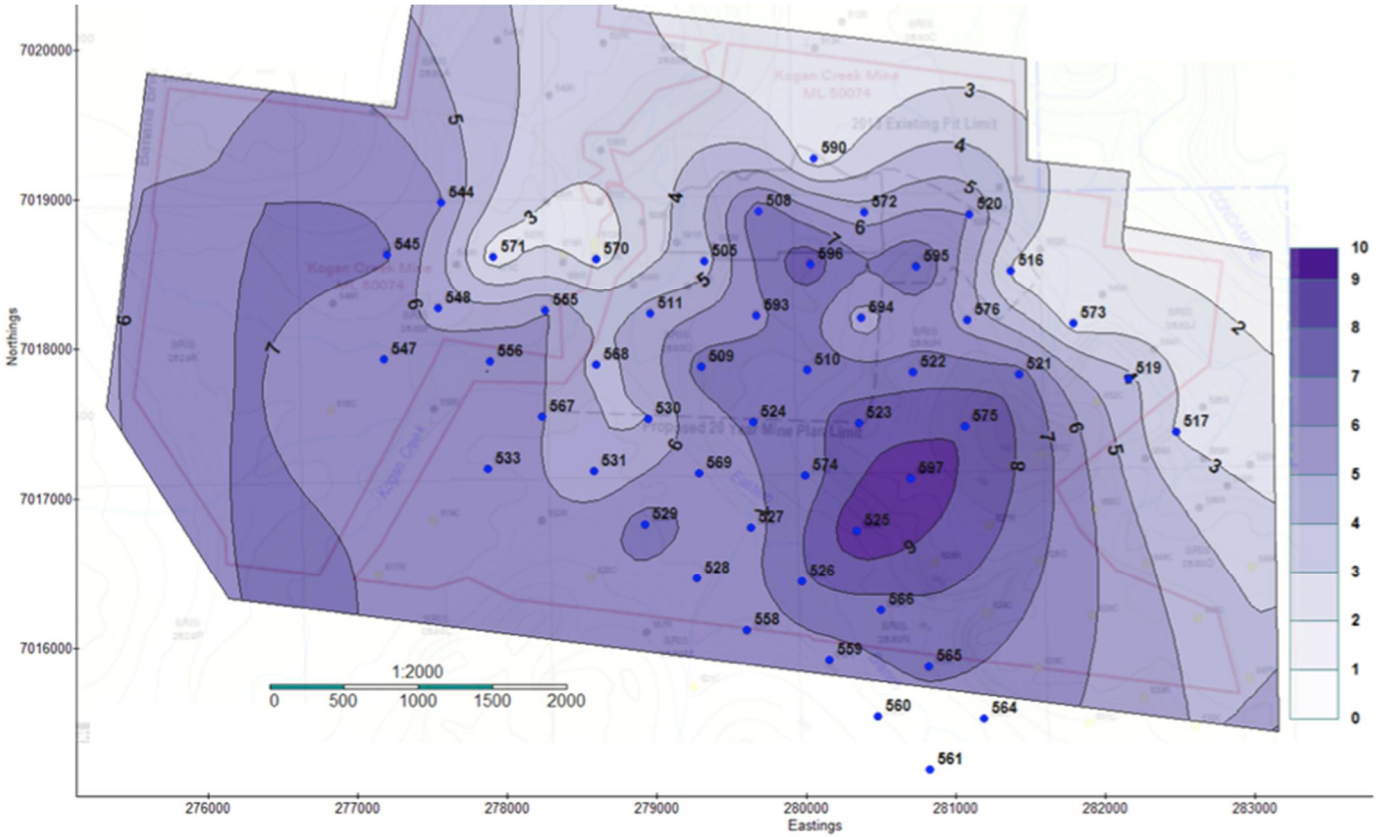
AVERAGE	1.38	30.8	18.8	9.4	37.6	34.3	0.18	4964	6907
TONNES WEIGHTED AVERAGE	**1.36**	**30.6**	**20.9**	**8.7**	**37.5**	**33.1**	**0.18**	**4875**	**6916**
MIN	1.29	25.6	10.8	4.5	32.3	22.3	0.13	4367	6550
MAX	1.46	35.6	29.7	19.3	42.4	43.6	0.20	5728	7327

SORT	Thickness	T * RD	RD	Moisture holding capacity	Moisture %adb	Ash (%adb)	VM (%adb)	FC (%adb)	TS (%adb)	CV kcal/kg adb	CV kcal/kg daf
4	4.98	6.77	1.36	30.6	26.0	10.3	35.8	27.9	0.19	4374	6867
17	5.00	6.55	1.31	28.7	26.7	7.1	35.0	31.2	0.19	4574	6909
23	1.51	2.01	1.33	30.2	28.7	8.1	37.5	25.7	0.20	4475	7081
25	0.78	1.03	1.32	28.9	27.2	7.8	34.2	30.8	0.20	4660	7169
28	2.89	3.79	1.31	29.9	28.2	5.0	41.4	25.4	0.15	4694	7027
29	0.31	0.40	1.29	25.6	23.9	4.5	41.0	30.6	0.20	5246	7327
32	1.51	1.98	1.31	30.8	29.7	4.8	32.8	32.7	0.19	4550	6947
36	4.27	5.64	1.32	29.6	29.4	8.5	32.3	29.8	0.17	4367	7032

Contour Plans

M Resources can prepare basic coal quality contour plans to display lateral variation, highlight trends etc.

- A high level appraisal of key coal properties is possible - as they vary across a mining project or tenement.
- This allows for possible problem or opportunity regions to be identified early on. Blending or exclusion from mining area are some of the options that might ensue.

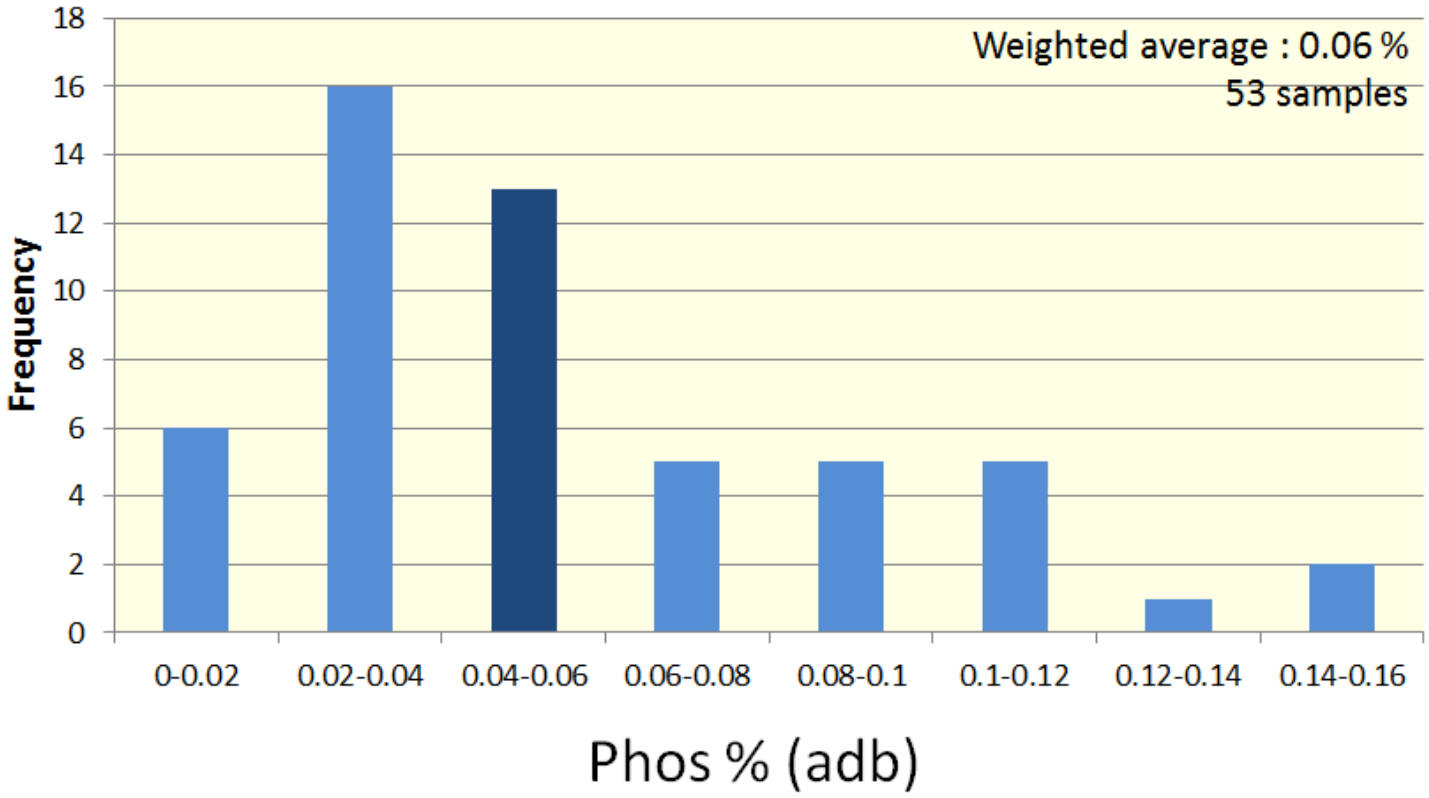


Data Histogram Example

Raw Coal Block Quality

When confronted with large data sets, a very rapid appraisal can be conducted using an M Resources PowerPoint macro as shown

- Data steps are easily configurable
- Distributions of multiple properties can be created quickly and efficiently to allow for early analysis of quality to identify problem areas.



Ply by Ply Analysis

Ply by Ply analysis provides a graphical representation of bore core data in a top down view. Features include:

- Row depth shown relative to ply thickness
- Areas for both raw and washed coal properties
- Weighted averages for all properties summarized at the bottom of the sheet
- Composites and/or separate areas can be combined for a subset of weighted averages
- Colour coded rows provide easy to identify changes in lithography
- Conditional formatting on key properties show greater graphical analysis (bar charts for Ash and red warning cells for high sulphur)
- Number of plies available to be viewed only limited by rows in Excel

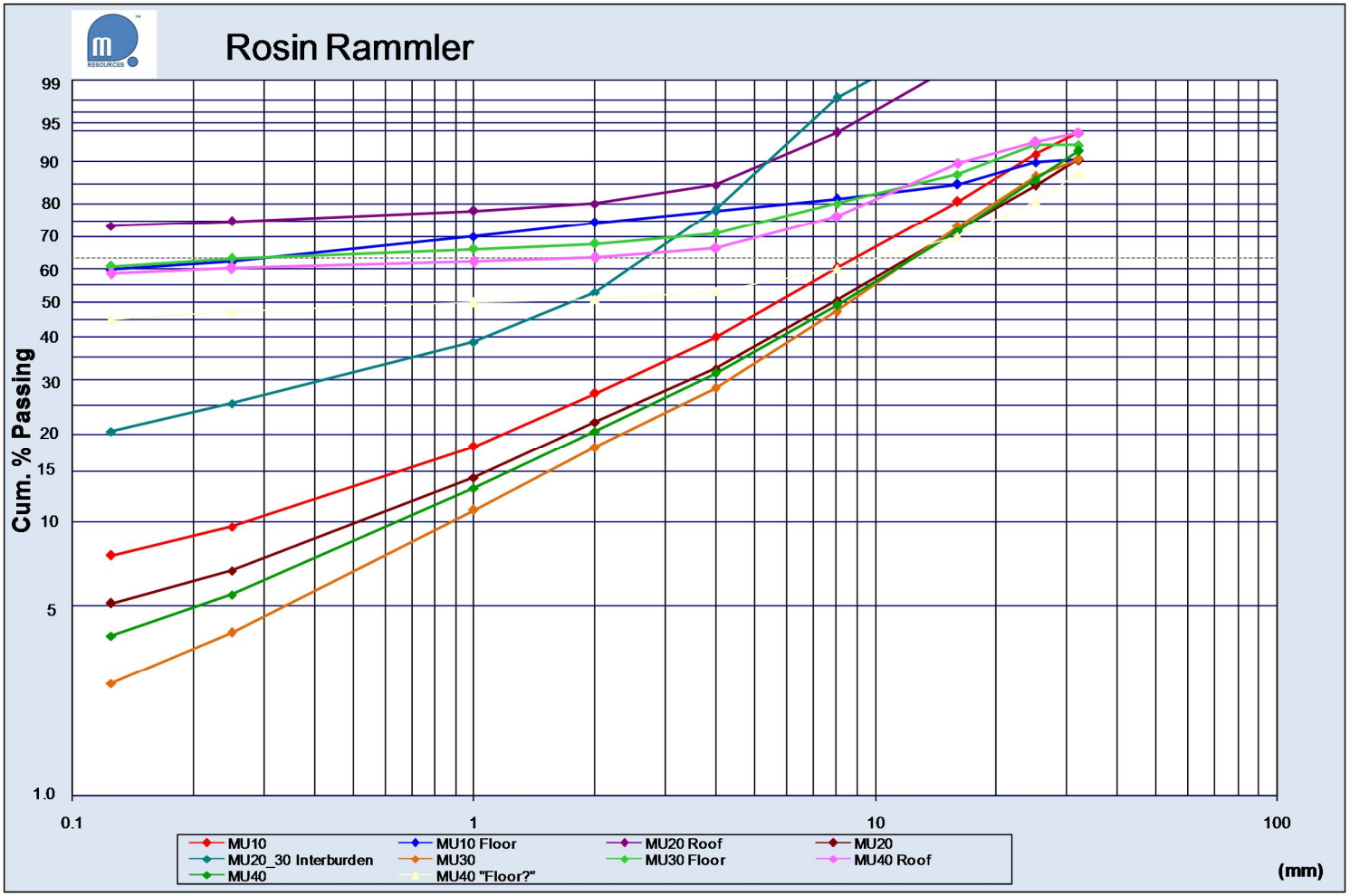
PLY by PLY

Source:

					Raw Coal Properties				
Seam	Type	Thickness (m)	Working Section	RD (imp)	IM %	Ash % adb	Ash % adb	VM % adb	VM % daf
Orion	Coal	2.65	1	1.62	1.3	37.0		19.9	32.3
Orion	Coal	0.80	1	1.97	1.6	55.5		14.2	33.1
Orion	Coal	1.13	1	1.77	1.6	48.3		15.5	30.9
Orion	Coal	3.49	1	1.66	1.2	37.0		20.9	33.8
Castor	Coal	1.80	2	1.55	1.2	31.9		19.3	28.8
Castor	Coal	2.72	2	1.66	1.1	37.7		20.6	33.7
Castor	Coal	3.46	2	1.58	1.2	34.0		18.4	28.4
Castor	Coal	1.51	2	1.64	1.2	37.4		17.8	29.0
Castor	Coal	2.50	2	1.74	1.2	46.9		16.9	32.6
Total Thickness		34.4		1.8	1.2	45.4	45.4	18.5	31.8
Orion Castor		8.1 12.0	1 2		1.3 1.2	40.8 37.8	40.8 37.8	19.0 18.6	32.8 30.7

Rosin-Rammler Analysis

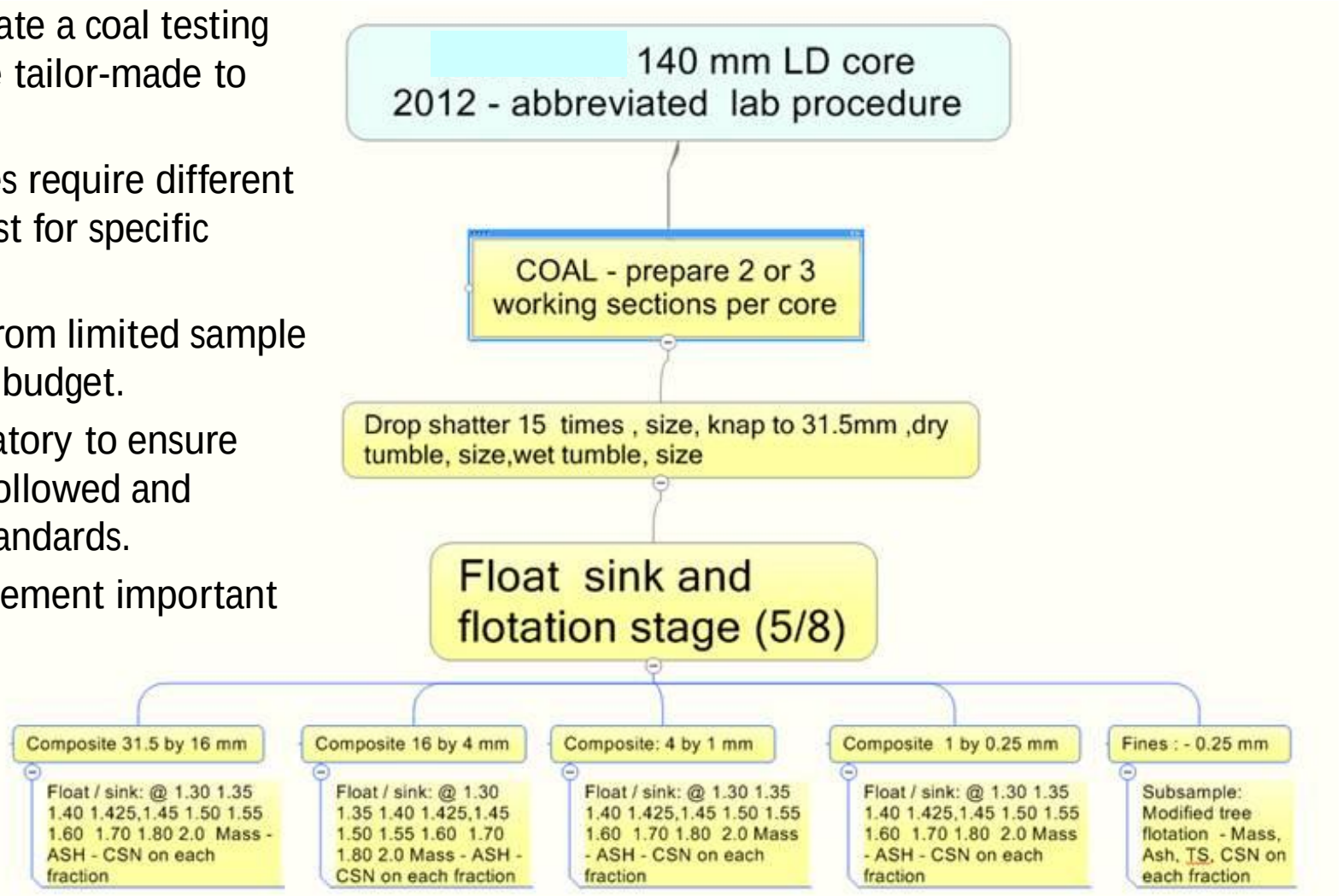
Rosin-Rammler plots are standard across the industry and present particle size distribution in a convenient manner.



Laboratory Procedures

M Resources can create a coal testing laboratory procedure tailor-made to each project.

- Varying coal types require different procedures to test for specific properties.
- Maximum data from limited sample mass - done to a budget.
- Liaise with laboratory to ensure procedures are followed and reporting is to standards.
- Identify and implement important tests.

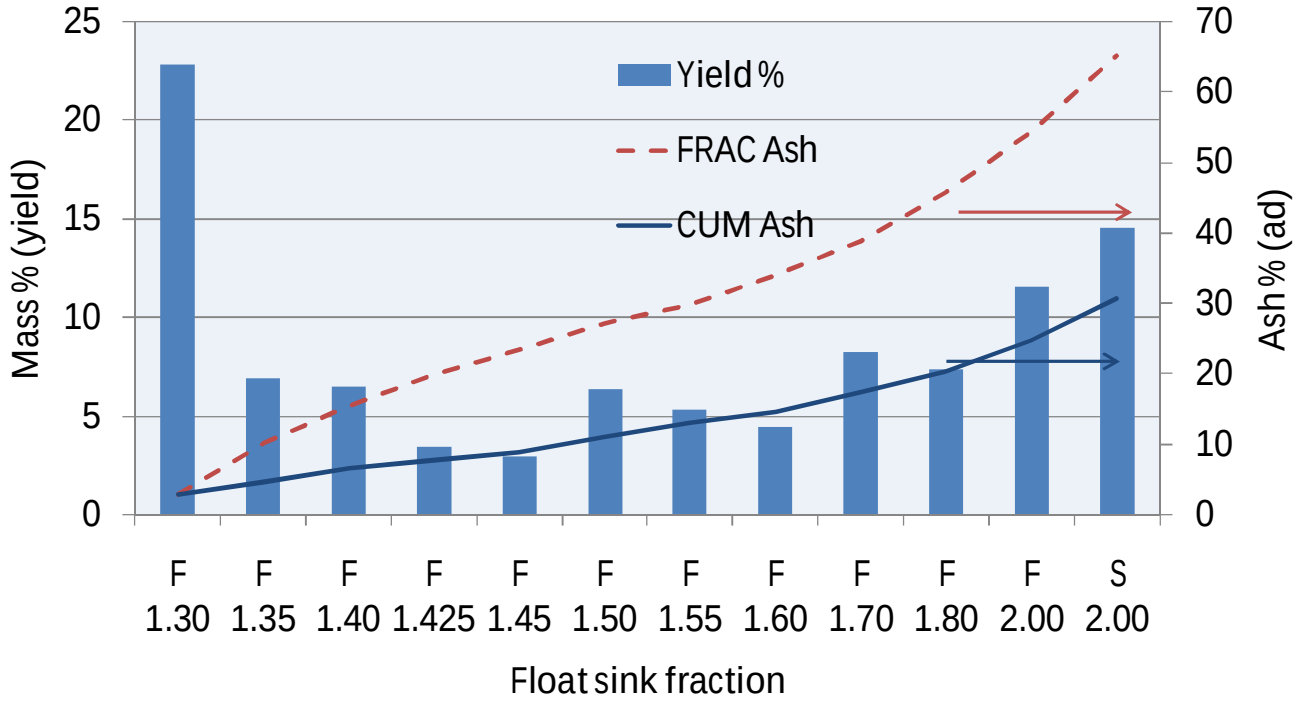


Washability Analysis

Graphical Display 1

Washability analysis provides fundamental yield / ash relationships for raw coal – generally on a size – by - size basis.

- Often washability data is presented as an unwieldy database of numbers with little way to differentiate between plies or seams.
- M Resources uses two graphical displays of washability data to quickly and concisely analyse and compare data. The first (shown below) analyses a single size fraction. Shown are fractional mass yields, cumulative ash (%) and fractional ash (%).

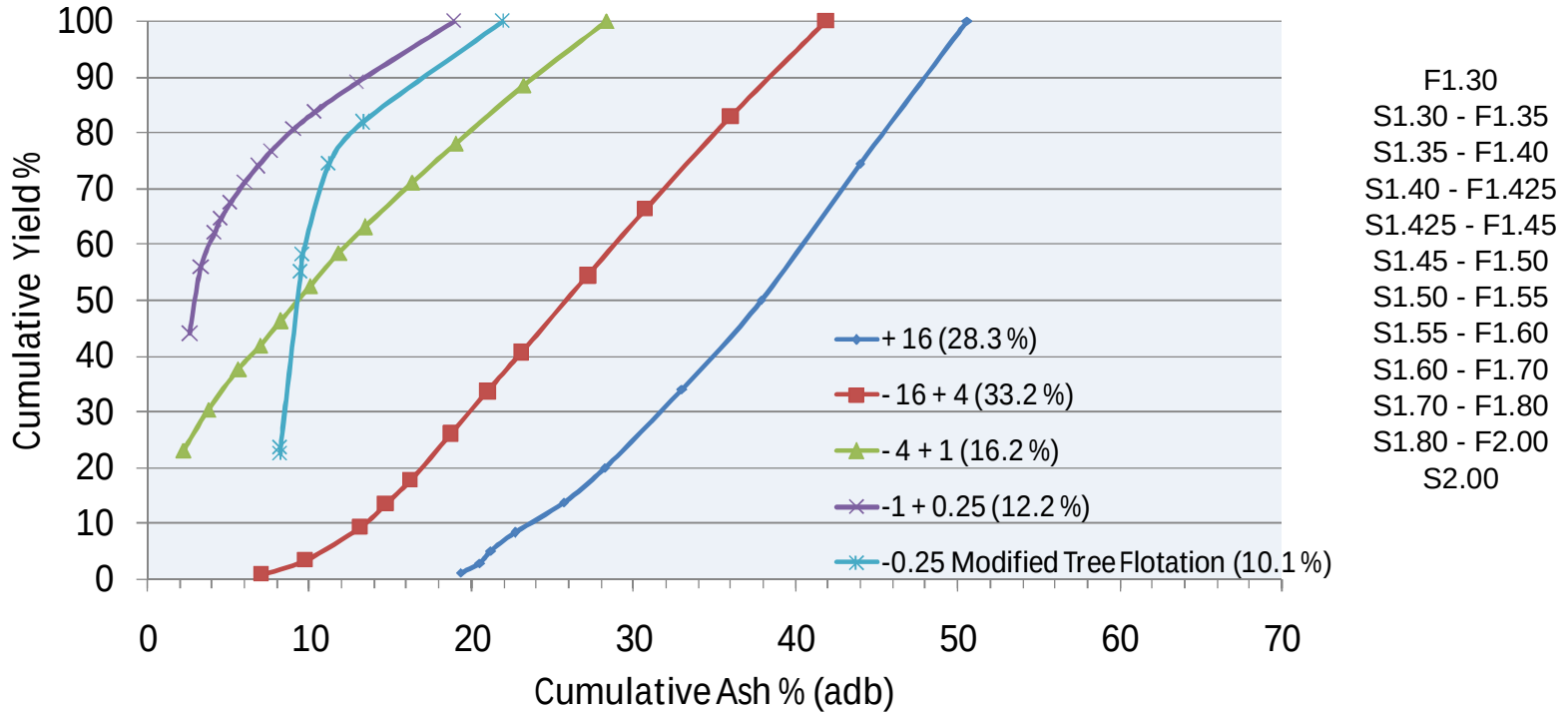


Washability Analysis

Graphical Display 2

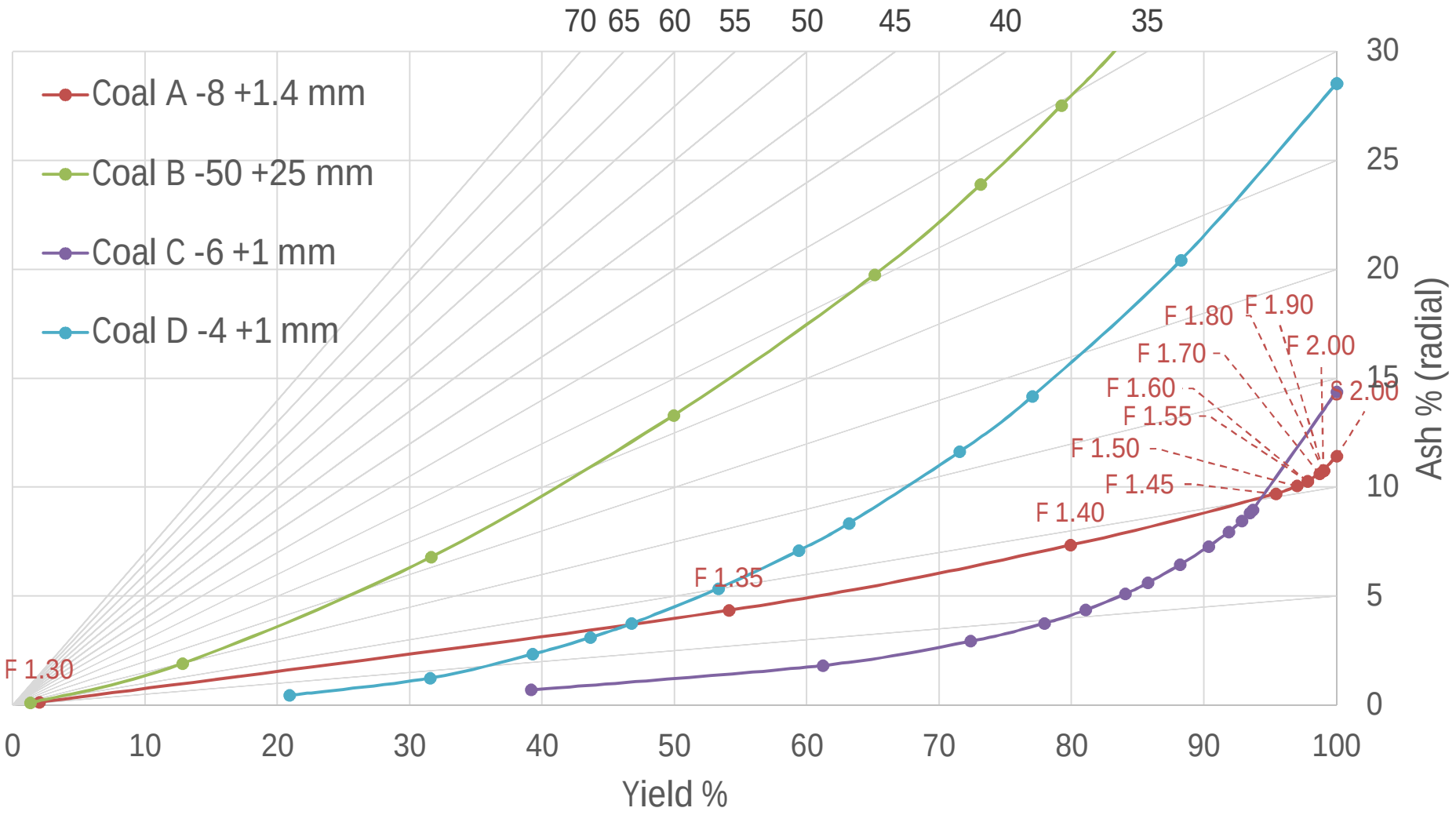
The second graphical display shows the ash / yield curves of all size fractions of a single bore core.

- Size fractions are also displayed with mass percentage components shown.
- When compared to other bore cores in the dataset, trends can be seen and plotted over an entire mining tenement.
- Bypass, secondary and fines products can also be identified using washability analysis.



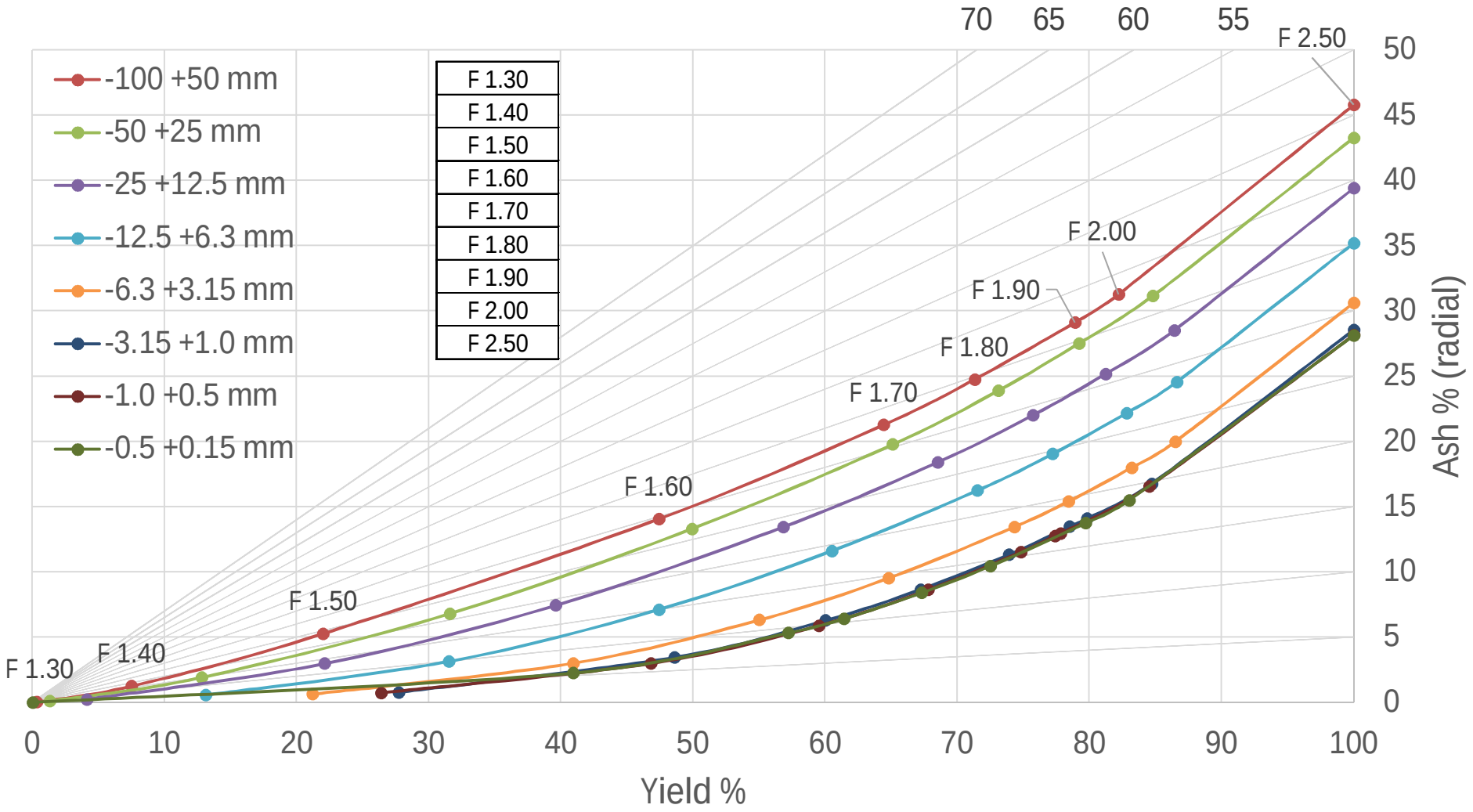
Mayer Curve

Example Four Different Coal Sources



Mayer Curve

Example Single Coal Multiple Size Fractions



Specification Sheet

Preparation of accurate coal specification sheets or indicative property tables are vital.

- M Resources have prepared numerous coal property tables for coals from every major coal producing region.
- Parameters displayed depend on coal type, data availability and other factors.

Indicative Product Specification

May-13

		AS RECEIVED	AIR DRIED	DRY	DRY ASH FREE
Moisture (%):	Total	***9.0***			
Proximate Analysis (%) :	Inherent Moisture		***1.5***		
	Ash	7.9	8.5	8.6	
	Volatile Matter	23.9	25.9	26.2	28.7
	Fixed Carbon	59.3	64.1	65.1	
Total Sulphur (%):		0.65	0.70	0.71	0.78
Phosphorus (%):		0.021	0.023	0.023	0.03
Ultimate Analysis (%) :	Carbon	71.8	77.7	78.9	86.3
	Hydrogen	4.6	4.9	5.0	5.5
	Nitrogen	1.5	1.7	1.7	1.9
	Oxygen by difference	4.6	5.0	5.1	5.54
	Sulphur	0.65	0.70	0.71	0.78

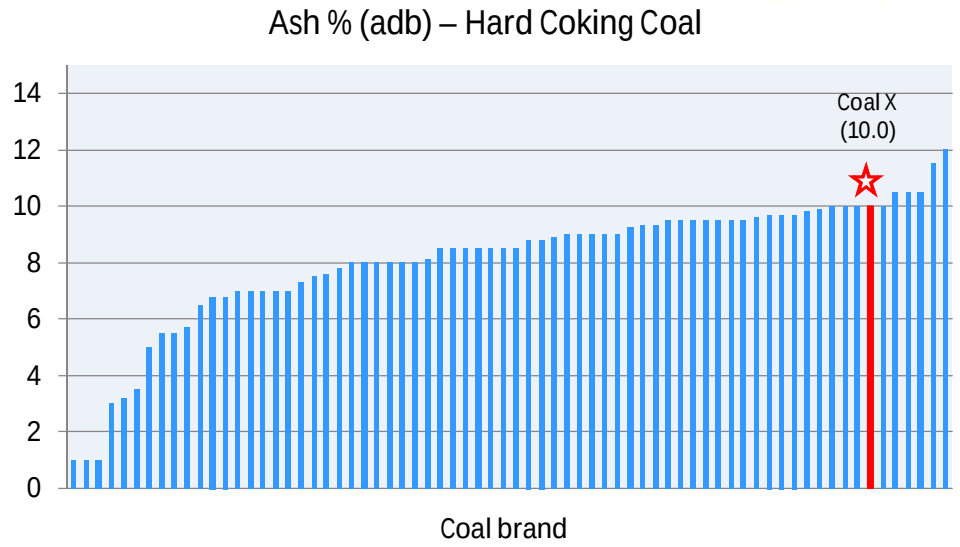
Ash Analysis (% in dry ash)				
	SiO_2	51.6	K_2O	2.3
	Al_2O_3	29.4	TiO_2	1.6
	Fe_2O_3	7.2	Mn_3O_4	0.04
	CaO	2.5	SO_3	1.9
	MgO	1.12	P_2O_5	1.01
	Na_2O	0.65	Total	99

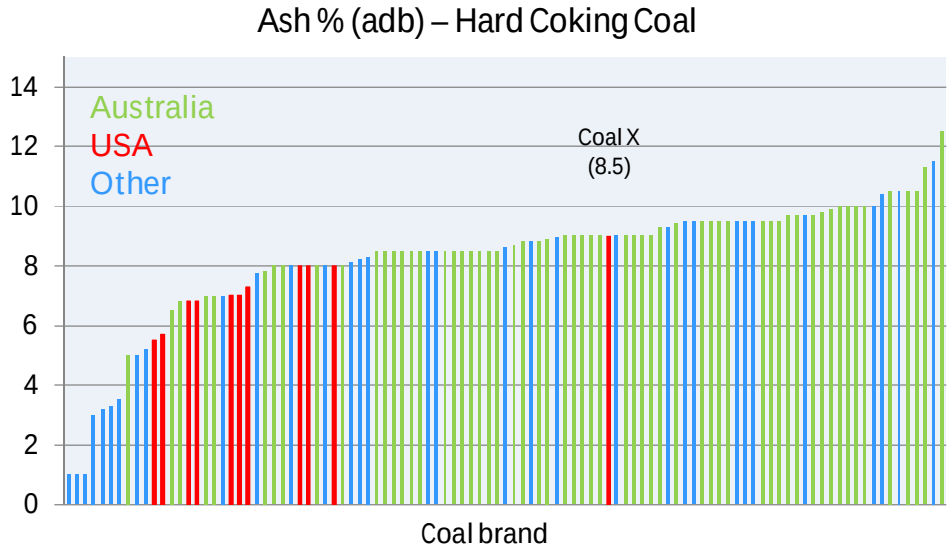
HGI:	79	
Plastic Properties:	CSN	9
Gieseler Plastometer:		
	Plastic Range (Deg C)	89
	Maximum Fluidity (ddpm)	10210
	Log 10	4.01
Dilatation	Max Contraction %	-26
	Max Dilatation %	214
	Total Dilatation %	243
Petrographics (%):		
	Vitrinite	69
	Liptinite	2.7
	Inertinite	25
	Mineral Matter	5.0
	Vitrinite Reflectance (% mean)	1.20
Topsize (mm) nominal:		

World Traded Histograms

M Resources maintains a large database of coal specifications traded throughout the world.

- Every coal property can be ranked against other world-traded coals to highlight advantages or disadvantages the coal could have in the marketplace.
- M Resources' collection of world-traded histograms cover all types of coal (HCC, SSCC, PCI and Thermal).
- Certain properties can also be shown with country of origin.





Blending Analysis

M Resources *MIXMASTER* allows simulated blending analysis between any number of coals.

- Unlimited amount of properties available for blending analysis.
- Customizable for thermal or metallurgical (HCC, PCI and SSCC).
- Directory of over 300 coals from around the world already available for blending opportunities.
- Cost analysis of blended coal available based on current spot and/or contract prices or client supplied forward values.
- Graphical analysis of blended coal shown by percent of coal in blend.

	COAL 1	COAL 2	COAL 3	BLEND (nominal)
Percent in Blend (%)	**50**	**40**	**10**	**100**
Total Moisture (%):	8.0	8.0	10.5	**8.3**
Proximate Analysis:				
Inherent Moisture (% ad):	2.5	2.5	2.5	**2.5**
Ash (% ad):	12.0	5.5	9.5	**9.2**
Volatile Matter (% ad):	28.8	41.0	32.0	**34.0**
Volatile Matter (% daf):	33.7	44.6	36.4	**38.3**
Total Sulphur (% ad):	0.40	2.00	0.50	**1.05**
Calorific Value (kcal/kg ad):	6900	7900	7250	**7340**
Calorific Value (kcal/kg daf):	8070	8587	8239	**8290**
Ultimate Analysis (%) :				
Carbon	83.4	83.6	83.3	**83.5**
Hydrogen	4.9	6.1	5.3	**5.4**
Nitrogen	1.6	1.9	1.9	**1.8**
Oxygen by difference	9.6	7.8	8.9	**8.8**
Sulphur	0.48	1.03	0.57	**0.71**
Ash Analysis (% in dry ash)				
SiO_2	60.0	49.9	52.4	**56.8**
Al_2O_3	30.0	30.0	26.9	**29.7**
Fe_2O_3	2.8	9.1	9.3	**5.0**
CaO	2.7	2.7	3.2	**2.8**
MgO	0.33	0.74	1.20	**0.52**
Na_2O	0.47	1.55	0.40	**0.72**
K_2O	0.38	0.91	2.10	**0.69**
TiO_2	1.22	2.10	1.60	**1.47**
Mn_3O_4	0.08	0.05	0.00	**0.06**
SO_3	0.08	1.65	0.90	**0.54**
P_2O5	0.40	0.81	1.70	**0.63**

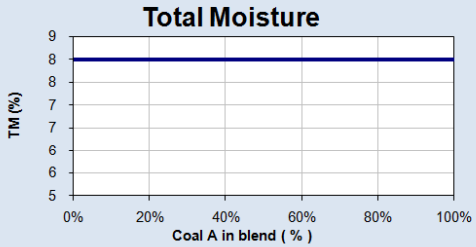
Blending Analysis

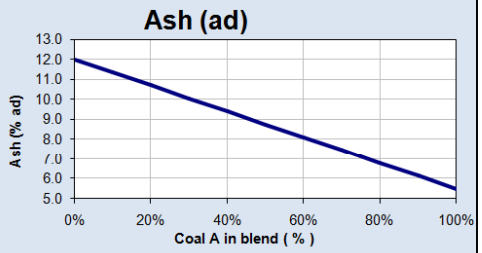
Graphical Display

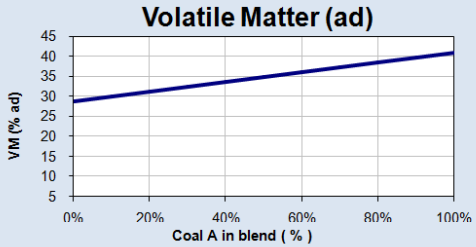
COKING COAL ANALYSIS

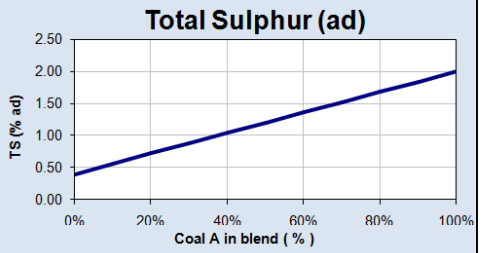
Main Coal: **COAL 1**

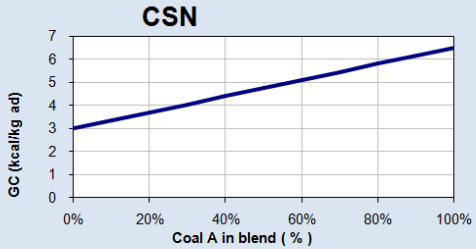
Coal A: **COAL 2**

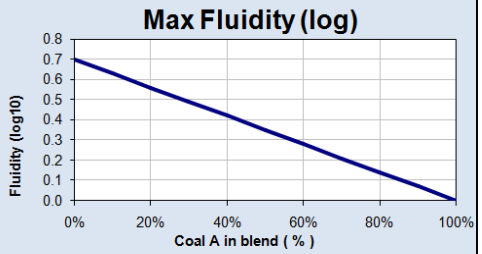








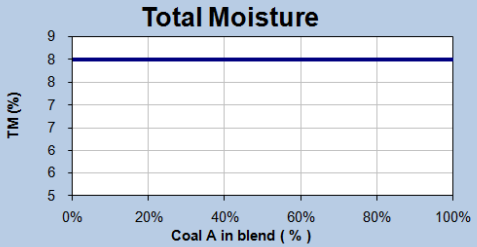


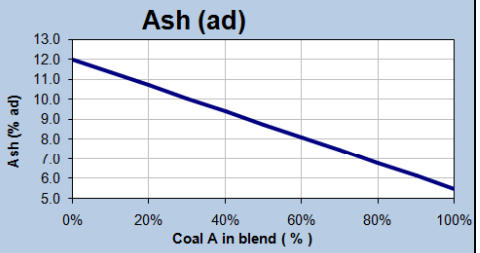


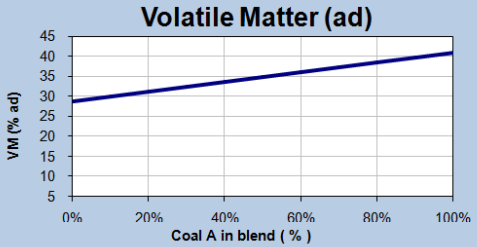
THERMAL COAL ANALYSIS

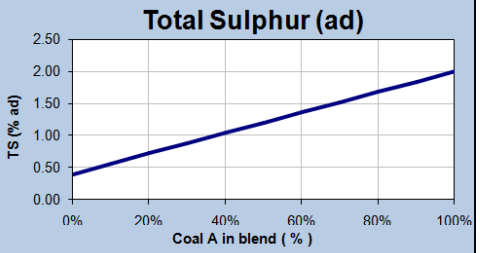
Main Coal: **COAL 1**

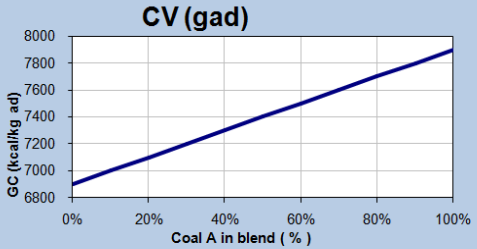
Coal A: **COAL 2**

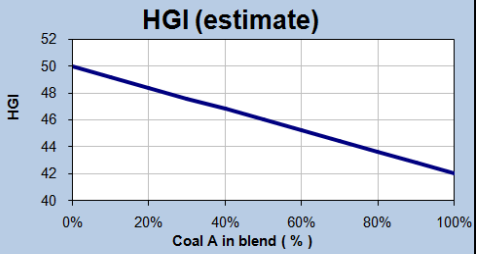












PCI *Value In Use* Analysis

Bennett and Fukushima (2003)[1], pioneered a system to rank and evaluate PCI coals based on *coke replacement ratio* (RR).

- M Resources has access to a model that predicts RR and determines the relative ranking of different coals.
- Singular and blended coals can be synthesized to obtain an equivalent RR which is then fed into a pricing model.

PCI Value Model - Apr 13

3 MTPA HM
150 kg/tonne PCI

Assumptions		BLEND
Coke blend VM	%dry	26.0
Coke blend TM	%ar	8
Coke blend ash	%dry	9
PCI Rate	kg/tHM	150

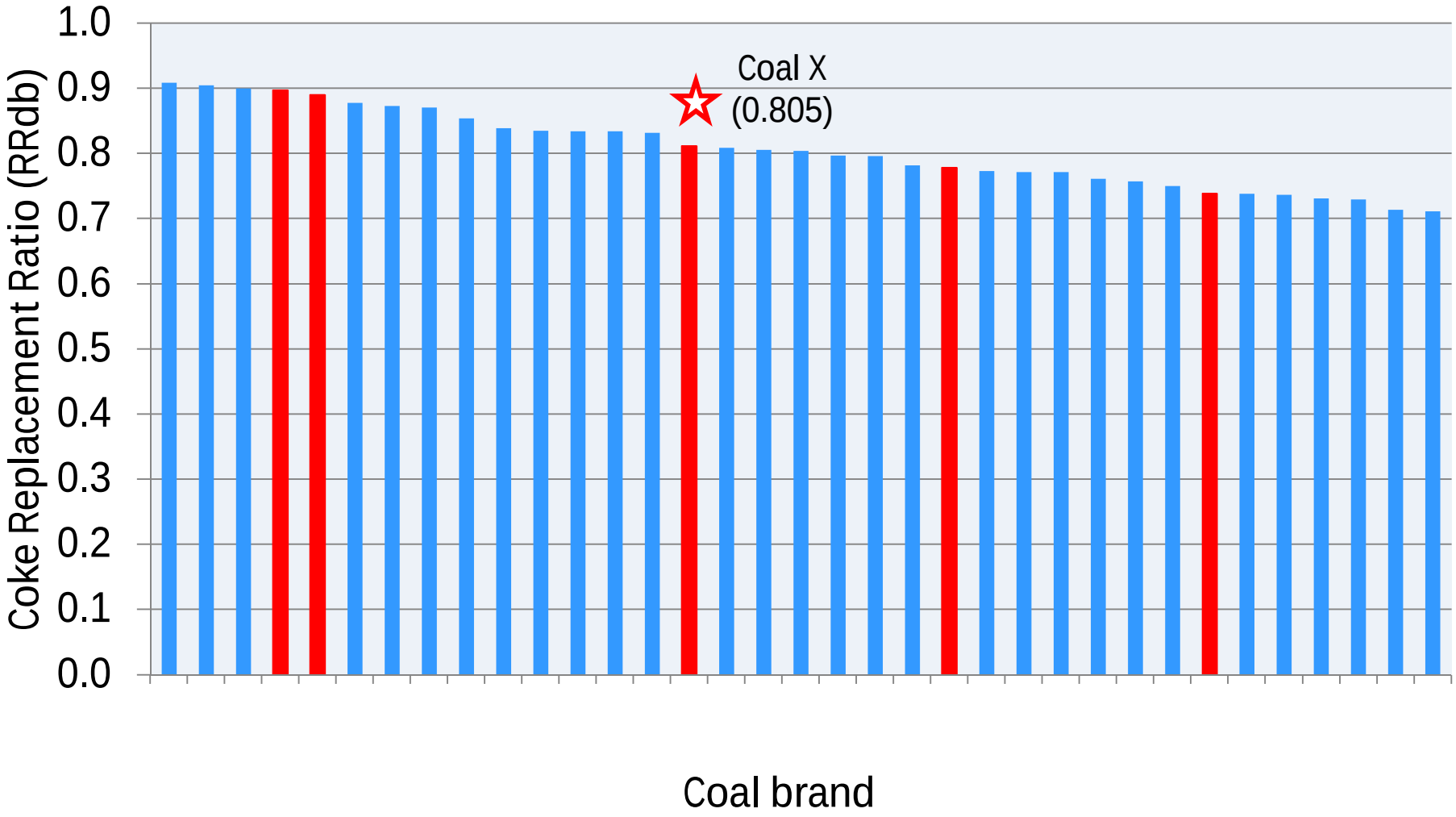
PCI Coal		Reference	Test Coal
Replacement Ratio		0.897	0.868
All Coke Coke Rate	kg/tHM	510	
Coking Coal Cost FOB	US$/t	$ 156.70	
PCI Coal Cost FOB	US$/t	$ 141.00	134.17
Anthracite Cost FOB	US$/t	$ 130.00	
Gas cost	US$/MJ	0.010	
Coke yield db (wharf)	%	77%	
Coke to BF yield	%	72%	
Coke ash	%	11.7	

		Nil PCI	Reference PCI	Test Coal
		CASE 1 All Coke	CASE 2 PCR =150 LV	CASE 3 PCR =150 HV
Coke required	kg/tHM	510	375	380
Coking Coal required dry	kg/tHM	706	520	526
Coking Coal required ar	kg/tHM	767	565	571
Cost of Coking coal	US$/tHM	$ 120.20	$ 88.49	$ 89.51
Cost of PCI coal	US$/tHM	$ -	$ 21.15	$ 20.12
Cost of coal	US$/tHM	$ 120.2	$ 109.6	$ 109.6
$mill at 3 mtpa	US$ mill	$ 360.6	$ 328.9	$ 328.9

1. Impact of PCI Coal Quality on Blast Furnace Operations , Cairns, 2003

PCI *Value In Use* Analysis

Coke Replacement Ratio



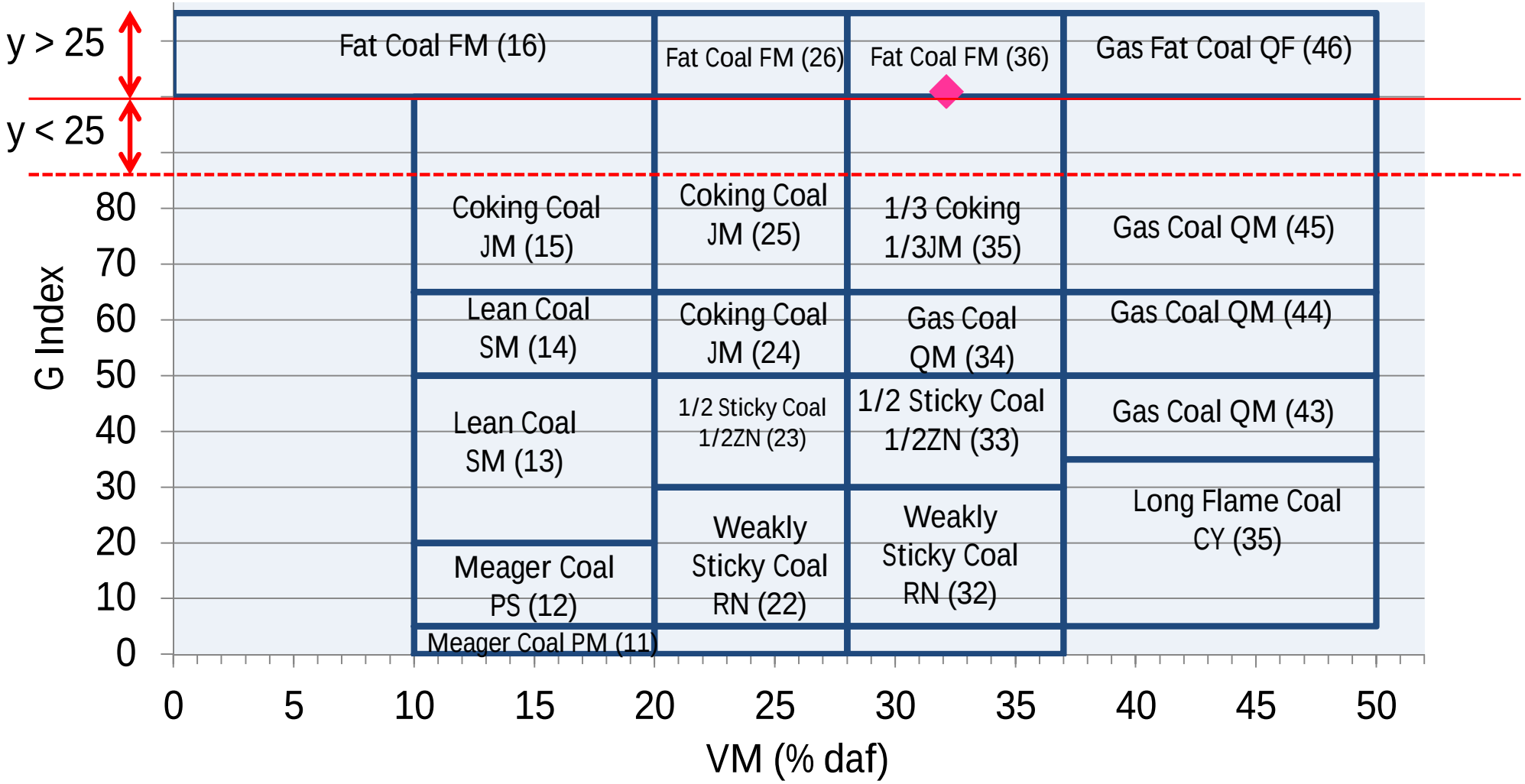
Coke Strength (CSR) prediction

Testing for Coke Strength after Reaction (CSR) was developed by Nippon Steel in the 1970's as an indicator of coking coal performance in the blast furnace.

- CSR is best obtained by testing coke produced in a coke oven. Often this is not practicable.
- M Resources has compiled a collection of peer reviewed equations to model CSR using other plastic and chemical properties.
- This allows M Resources to present a range of modeled CSR values.

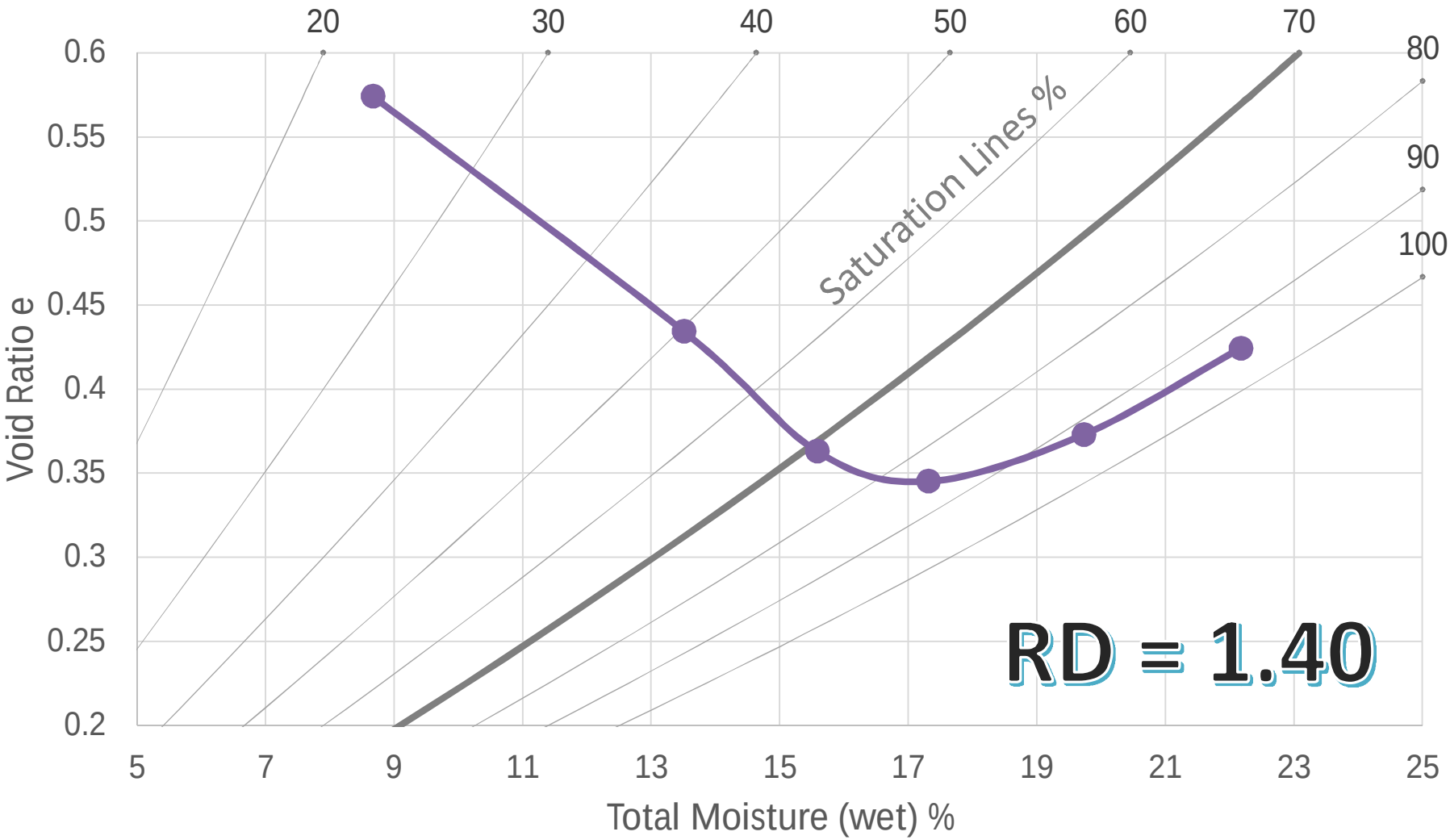
CSR Predictor		CSR #1	CSR #2	CSR #3	CSR #4	CSR #5	CSR #6	CSR #7	CSR #8R	CSR #9	CRI #1	CRI #2
		72	56	72	39	68	68	68	74	66	28	21
CALCULATED VALUES												
Coke Yield	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6
Coke Ash	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
PROXIMATE												
IM (ad)	1											
Ash (db)	8.5	8.5	8.5		8.5			8.5		8.5	8.5	8.5
VM (db)	18							18	18	18		
TS (db)	0.45				0.45							
RoMax												
RoMax	1.60	1.60	1.60				1.60	1.60			1.60	1.60
GF												
Fluidity ddpm	5						5		5	0.7		
Plastic Range	40				40							
TOTAL DIL												
Total Dil	0							0				
INERTINITE												
Total Inertinite	40	40	40						40			
Semifus	12	12	12								12	12
Vitrinite	55									55		
Exinit	1									1		
ASH ANALYSIS (Green Values, % in coke)												
SiO2	59				5.02	59.0	59.0	59.0	59.0	59.0		
Al2O3	26	2.68			2.21	26.0	26.0	26.0	26.0	26.0	2.68	
Fe2O3	3.3		0.34		0.28	3.3	3.3	3.3	3.3	3.3		0.34
CaO	3.5				0.30	3.5	3.5	3.5	3.5	3.5	0.36	
MgO	0.5	0.05	0.05		0.04	0.5	0.5	0.5	0.5	0.5	0.05	0.05
Na2O	0.7				0.06	0.7	0.7	0.7	0.7	0.7		
K2O	0.7	0.07	0.07		0.06	0.7	0.7	0.7	0.7	0.7	0.07	0.07
TiO2	1.2		0.12			1.2	1.2	1.2	1.2	1.2		0.12
Other												
Alkali index	0.87				0.87							
Catalytic index	14.7				14.7							
CBI	0.10					0.10						
RSI	78.3						78.3					
MCI	1.7											
MBI	1.0							1.0				
BI-Base-Acid Ratio	0.10							0.10		0.10		
Ash *Basicity Index	0.9							0.9				

Chinese Coal Classification System



TML Proctor-Fagerberg Test

Transportable Moisture Limit



For additional information regarding:

- Suite of services
- Initial deposit evaluation
- Production optimisation studies
- Ranking in present market place, and
- Technical advice or training

Please contact:
Ross Stainlay rstainlay@mresources.com.au +61 (0) 407 152 315
or
Paul Keleher +61 (0) 419 702 605.