ESTIMATION OF SURFACE MOISTURE IN A COMPOSITE COAL STOCKPILE

Kyle Enslin

A dissertation submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in fulfilment of the requirements for the degree of Master of Science in Engineering.

September 2018

Declaration

I, Kyle Enslin, declare that this dissertation is my own, unaided work. It is being submitted to the Degree of Masters of Science to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

____

28th day of September, 2018

Abstract

This dissertation, through a literature survey, investigated the different types of moisture in coal, what parameters affect coal moisture content as well as technologies and methods for drying coal. It was found that the parameter that affects surface moisture the greatest was particle size and in particular, the -500µm size fraction. Based on this knowledge a hypothesis was developed.

The hypothesis states that each size fraction contributes to the total surface moisture content relative to the size fractions equilibrium surface moisture content and weighting within the overall size distribution. The total surface moisture content is then the sum of these individual contributions.

$$SM_{EST} = \sum_{i=1}^{n} SM_i * f_i = (SM_1 * f_1) + \ldots + (SM_n * f_n) \qquad \text{1-1}$$

Where,

SM_i = relationship (equation) between the equilibrium surface moisture content and the geometric mean of the individual size fraction (%)

f_i= weighting of size fraction in particle size distribution (%)

In order to test this hypothesis the relationship between equilibrium surface moisture and size fraction had to be established first. This was done by performing drainage tests on nine different size fractions and determining the equilibrium surface moisture content for each.

Tests were then done in two stages on composite coal samples to determine the equilibrium surface moisture content. The size distribution for stage one (PSD1) was different to stage two (PSD2). The samples had a fixed +500µm size distribution while the fines fraction (-500µm) increased by 1% for each test from 0% to 10%. Tests were done using a

25L drum and 2m drainage pipe to determine the consistency of the results when scaled up.

Increasing the fines content resulted in a direct linear relationship between the fines fraction and surface moisture content. This was found to be true for the test data as well as the estimated data. Both the test and estimated data showed that for every 1% increase in fines content there was about 0.25% increase in equilibrium surface moisture content. This was true for both size distributions. Although the relationship was consistent, the size distribution did make a difference to the overall result. The finer size distribution resulted in a higher overall surface moisture content.

Finally the model (1-1) was used to estimate the surface moistures of 90 Eskom mill feed samples from five different power stations. Between the 25L drum, drainage pipe tests and Eskom data, the model estimated the Eskom data the best. The Eskom data also showed that in order to reach a minimum surface moisture of 6% the fines content should be kept below 9%.

Acknowledgements

The author would like to thank the following people and institutions for their contribution during the course of this study, without which the research would not have been possible:

Eskom Research, Testing and Development (RT&D) for the use of their laboratory facilities and financial backing.

Eskom Tutuka Power Station for allowing me the time to pursue this research as well as the financial support.

The Eskom Power Plant and Engineering Institute for this opportunity to study further.

My supervisors, Doctor Chris van Alphen and Professor Walter Schmitz, together their relentless encouragement to dig deeper and scrutinise every detail was invaluable.

Bonny Nyangwa, Mark Newby, Rohit Bhagwandas, Jacques Calitz, Basil Potgieter and Joepie Joubert for the financial support, trusting me with the use of their laboratories and equipment, and helping me construct my test rigs.

Table of contents

List of tables

List of figures

List of symbols

Description	Symbol	Units
micron	µm	µm
Uniformity Coefficient	Cu	
The diameter in the particle size distribution curve corresponding to 10% finer. The "effective size".	D_{10}	mm
Geometric Mean	δ	mm
Void ratio	e	
Percentage of Size Fraction (i) in the Size Distribution	f_i	%/100
Mass of fines determined by dry sieve analysis	$Fines_{DRY}$	g
Mass of fines determined by wet sieve analysis	$Fines_{WET}$	g
Lower size of Size Fraction	D_l	mm
Upper Size of Size Fraction	D_u	mm
Mass of Air Dry Coal Sample	M_{AD}	g
Mass of Oven Dry Coal Sample	M_{OD}	g
Mass of Wet Coal Sample	M_W	g
Pendular State	P_e	kg/m^2
Specific Surface Area	SA	m^2/kg

Equilibrium Surface Moisture measured directly (mass balance)	SM_{DIR}	%
Equilibrium Surface Moisture Estimated by Model	SM_{EST}	%
Equilibrium Surface Moisture of Size Fraction (i)	SM_i	%
Surface Moisture Determined in the laboratory	SM_{LAB}	%
Volume	V	m^3

List of acronyms and abbreviations

AASHTO	American Association of State Highway and Transportation
AEV	Air Entry Value
CCGT	Closed Cycle Gas Turbine
CEC	Cation Exchange Capacity
CSP	Concentrated Solar Plant
CSV	Comma Separated Values
CSY	Coal Stockyard
DEA	Department of Environmental Affairs
DoE	Department of Energy
DP	Drainage Pipe
etc	etcetera
FDR	Frequency Domain Reflectrometry
GPS	Global Positioning System
HDPE	High Density Polyethylene
IRP	Integrated Resource Plan
MIT	Massachusetts Institute of Technology
mmf	mineral matter free
OCGT	Open Cycle Gas Turbine
PSD	Particle Size Distribution
PV	Photovoltaic
PVC	Polyvinyl Chloride
Rev	Revision
SABS	South African Bureau of Standards
SWCC	Soil Water Characteristic Curve
TDR	Time Domain Reflectrometry
U.S	United States
USCS	Unified Soil Classification System

USDA	United States Department of Agriculture
VS	Versus
ZLED	Zero Liquid Effluent Discharge

1 Introduction

1.1 Background and motivation

In South Africa coal fired power stations account for 86% of installed power (SAPP, 2015) and presently contribute to 77% of the power produced (Eskom, 2016). This is mainly due to the historic and present levelised cost of coal fired power stations being among the lowest out of all the power producing technologies (See Figure 1-1). That, and the fact that South Africa still has abundant coal resources. It is estimated that South Africa has 53 billion tons of coal which, at the current usage rate, could last for another 200 years (Eskom, 2016).

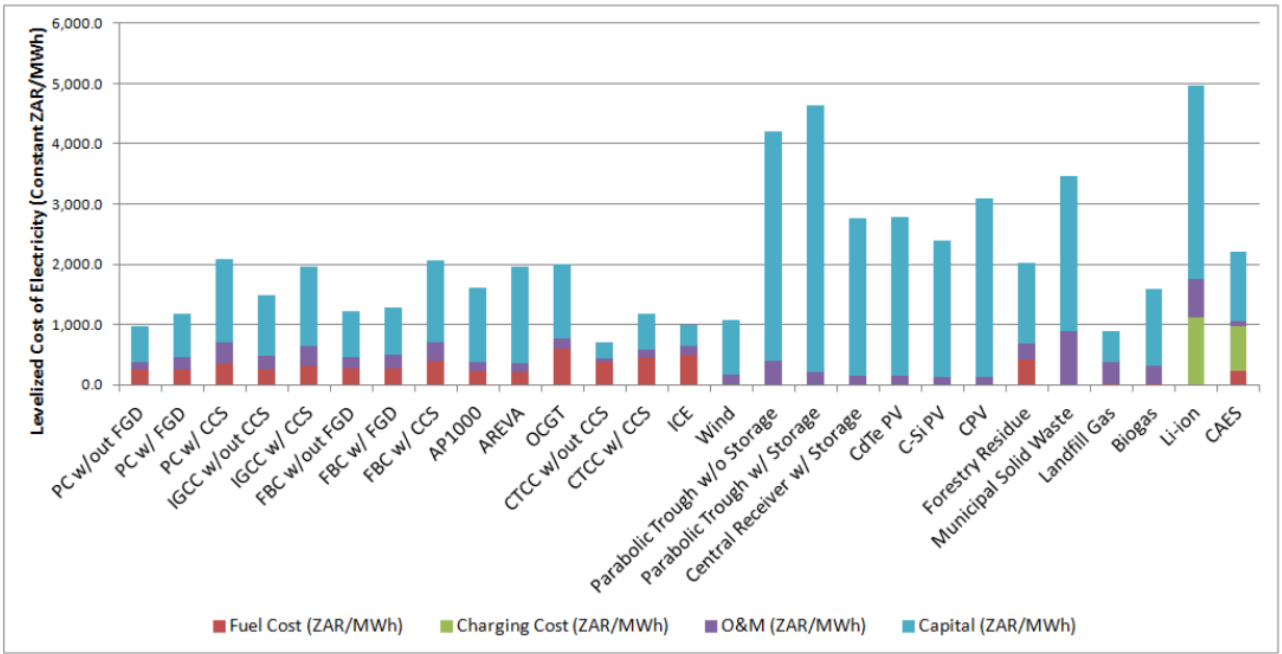


Figure 1-1: Comparison of Representative Levelised Cost of Electricity (EPRI, 2015)

It is anticipated that coal will still be a major presence in South Africa's power grid in 2050 by making up 31.6% of the total energy mix (Republic of South Africa Department of and Energy, 2016). This present and future high dependence on coal requires a keen understanding of it as a fuel for combustion and more specifically to this research, the moisture dynamic of coal.

Wet coal causes numerous problems at the power stations. On the bulk material handling side of the station wet coal causes coal hang ups in the transfer points which can cause blockages. These blockages increase down time and reduce the coal throughput to the mills since the conveyors have to be stopped in order for the blockage to be safely removed. In addition, coal hang ups in transfer points result in skew loading onto the proceeding conveyor belt. Skew loading causes the conveyor belt to track into the structure and greatly reduces the life of the belt. Coal that sticks to the belt may also become deposited under the return side of the conveyor. Large deposits of this coal contribute to misalignment of the belt as well as damage to idlers. An idler running in these coal deposits is a major fire risk.

Probably the most significant effect that wet coal has on a power station is its effect on combustion. Energy that is used to convert the moisture in to vapour is lost in the flue gas. Alphen (2017) states that Eskom online analyser results suggest that a coal fired power station loses 1MW for every 1% increase in moisture content. This effect on the boiler forms the basis for the motivation of this dissertation

Whilst much research and technological development has been put into dewatering fine and ultrafine coal, very little has been put into developing effective coal stockyard and stockpile design and operating strategies that can reduce the surface moisture of coal.

Existing coal dewatering technologies such as mechanical or thermal drying are costly. Since Eskom is looking for an economical solution to wet coal a more viable approach to dewatering coal would be to utilise the existing drainage properties of a composite coal stockpile. Understanding which parameters play the greatest role in surface moisture retention and drainage in stockpiles will aid Eskom to manage the total moisture content of the stockyard coal, especially in times of wet coal.

The general assumption by coal stockpile managers is that a wet coal stockpile, if left long enough, will drain to a moisture content acceptable by the power station. From the literature it has become apparent that this is not the case (Campbell & Le Roux, 2014; Cumming, 2003; Williams & Whitton, 2008). A coal stockpile will drain to an equilibrium moisture content after which no further reduction in moisture can be expected. Knowing what equilibrium moisture content a coal stockpile can drain to is critical for the effective surface moisture management of coal stockpiles.

1.2 Aim of study

Previous research has shown that fines (-500µm) reduce the drainage rate and increase the surface moisture retention of a coal stockpile. While the effect of fines has been qualified, it is yet to be quantified. This research aims at quantifying the effect of fines by empirically determining the relationship (ie: equation) between fines and surface moisture content as well as developing a model that will estimate the surface moisture retention of a coal stockpile based on its particle size distribution and fines content.

1.3 Hypothesis

Moisture retention and permeability of soils is well researched in geotechnical engineering. Factors such as particle size, presence of fine material (clays and silts), and degree of saturation are some of the factors that play a role in how moisture permeates through a soil. It is also known that a small amount of fines (clays and silts) can greatly affect the permeability of soils. Soil permeability models vary from basic, such as Hazen (Carrier, 2003) which solely looks at the D_{10} (The diameter in the particle size distribution curve corresponding to 10% finer. The “effective size”) of a soil specimen, to complicated, such as Fredlund, Xing, & Huang (1994) which uses the entire SWCC (Soil Water Characteristic Curve) to estimate permeability.

It is believed that coals, although different in chemical structure, should behave similarly to soils in terms of permeability and moisture retention. The same factors which affect soils, such as fines, should greatly affect coals.

It was hypothesized that each individual size fraction contributes to the total surface moisture of the coal sample in relation to the equilibrium surface moisture of the size fraction and the weighting of the size fraction that makes up the PSD. Thus,

$$SM_{EST} = \sum_{i=1}^{n} SM_i * f_i = (SM_1 * f_1)+\ldots+(SM_n * f_n) \qquad \text{1-1}$$

Where,

SM_i = relationship (equation) between the equilibrium surface moisture content and the geometric mean of the individual size fraction (%)

f_i= weighting of size fraction in particle size distribution (%)

An example of the calculation is described in Appendix I.

1.4 Objectives

The objective of the research is to determine the following:

1. Develop a model to estimate the equilibrium surface moisture content of an uncompacted composite coal stockpile.
2. Understand the impact fine coal (-500µm) has on drainage rate.

1.5 Scope of study

In order to achieve the above objectives a literature review was first done. This involved searching for similar research into coal stockpile drainage rates and surface moisture retention. Drainage of soils is well researched in geotechnical engineering. It was for this reason the literature review encompassed geotechnical aspects as a way to gather insight into what governs drainage rate and moisture retention of soils. This insight would be used as inspiration for the hypothesis and to develop the model (equation 1-1). The literature review also served as a way of confirming and building onto existing research whilst avoiding duplicating such research.

Small and medium scale drainage equipment was designed and constructed. The inspiration for the equipment was drawn from similar equipment found in literature. The small scale equipment was used to determine the equilibrium surface moisture content of the individual size fractions empirically. This would then be used as input into the model (equation 1-1). The small scale experiments were also used to test uncompacted composite (varying size fraction proportions) coal samples with varying fines content. The results from the composite sample tests were used to verify the model (equation 1-1) estimations. The medium scale experiments were used to determine whether the small scale results would be consistent when scaled up to a medium test size rig. Due to time constraints, no large scale (coal stockpile testing) experiments were executed. However, data from Eskom was used to determine how well the model (equation 1-1) estimated surface moistures of mill feed samples.

2 Literature review

2.1 Introduction

The Department of Energy's latest resource plan (Republic of South Africa Department of and Energy, 2016) indicates that coal will be a significant contributor to the South African power grid up to the year 2050. There is no guarantee that coal will be a major producer of energy in the future. It is predicted that as the cost of alternative power producing technologies decreases the use of coal as a power source will decrease (Kost et al., 2013). In addition there are significant environmental pressures to reduce the reliance on coal fired technologies as a fuel for power generation. The combustion of coal releases large amounts of CO_2 which adds to global warming. The Kyoto protocol is an international commitment for countries to reduce man-made CO_2 emissions (United Nations Framework Convention on Climate Change, 2014). Nuclear and renewable also have their drawbacks. Nuclear, whilst relatively clean to operate compared to coal, has a tarnished reputation due to such events at Chernobyl and Fukushima. To operate a nuclear power station is relatively clean however the waste from nuclear is extremely toxic and is difficult to dispose in a safe manner. The cost to decommission a nuclear power station is also very high. It is estimated that it will cost the United Kingdom $154 Billion to clean up 17 of its historic nuclear sites (World Nuclear, 2016). Renewables are generally expensive to install and require large amounts of land to generate relatively small amounts of power compared to coal or nuclear.

Despite coals abundance, and its low levelised cost (see Figure 1-1) the 2016 integrated resource plan for South Africa shows the new build program aims at introducing more nuclear, gas, CSP, PV and wind energies onto the South African grid by 2050 and thus reducing the reliance on coal. The IRP gives numerous power producing technology options based on different cost scenarios such as high coal cost, high nuclear cost, carbon tax, etc. From Figure 2-1 the dominant power generating technologies by 2050 will be coal, nuclear and wind. Minor contributors such as hydro and landfill gas were omitted from the report. Thus making the total contributions fall shy of 100%.

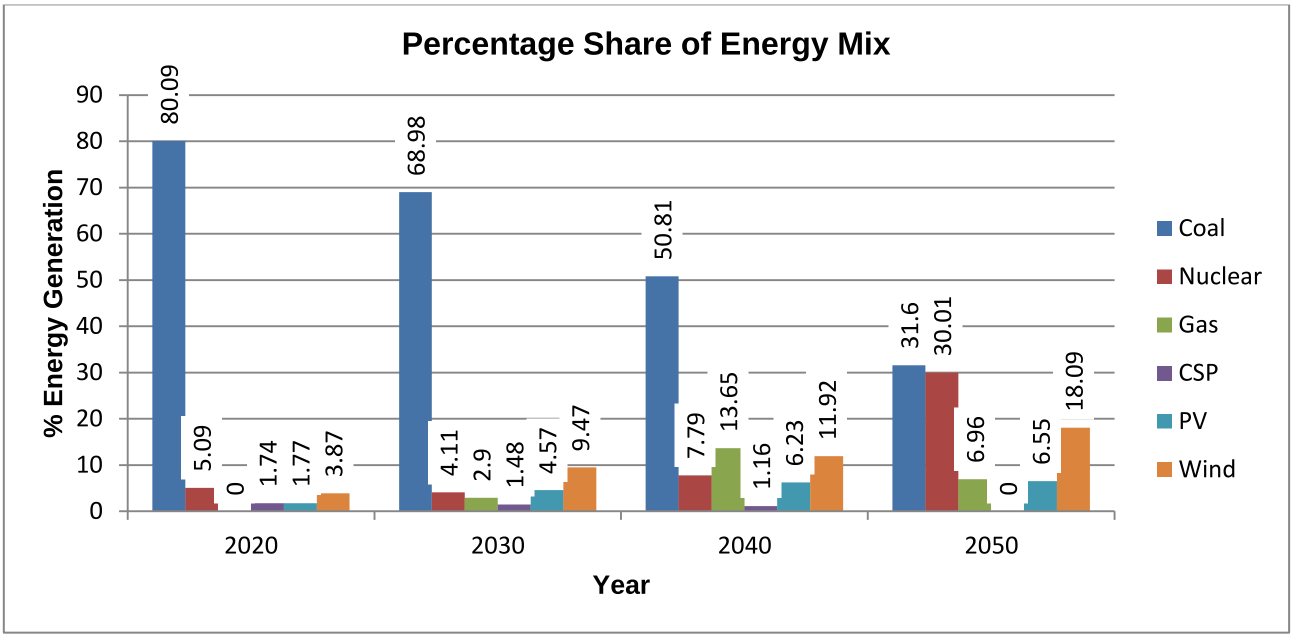


Figure 2-1: 2016 Projected Energy Mix (Republic of South Africa Department of and Energy, 2016)

Despite the anticipated reduction in coal by 2050, coal will still be a major presence in South Africa’s power grid by making up 31.6% of the total installed power.

This present and future high dependence on coal requires a keen understanding of it as a fuel for combustion and more specifically to this research, the surface moisture dynamic of coal.

2.2 South African coal

Coals formed in the Gondwana region (Southern hemisphere) tend to be more rich in minerals, variable in rank and organic composition and more difficult to beneficiate than coals formed in the Laurasian regions (Northern hemisphere). This difference can be attributed to the climatic and geological conditions that the coals were formed in. Coals formed in the Southern Hemisphere experienced a much colder environment compared to the hot and humid equatorial Northern Hemisphere (Falcon & Ham, 1988). During the time of coal formation in the Gondwana region the climate was changing from cold to warmer due to a diminishing ice age as a result of tectonic movement taking the Gondwana region north towards the equator. The vegetation in this area was characterised by deciduous forests (hardwood) to woodlands with reed infested swamps compared to fleshy barked trees and ferns in the Laurasian region. In the Gondwana region some of the coal bearing deposits were washed by seasonal floods and melting ice caps into deltas and shallow seas whilst other vegetation formed in situ. These floods were often accompanied by large amounts of mineral matter adding to the mineral (inorganic) content of the coal deposits.

Figure 2-2 shows where the Gondwana and Laurasian regions were situated relative to earth's latitudinal lines.

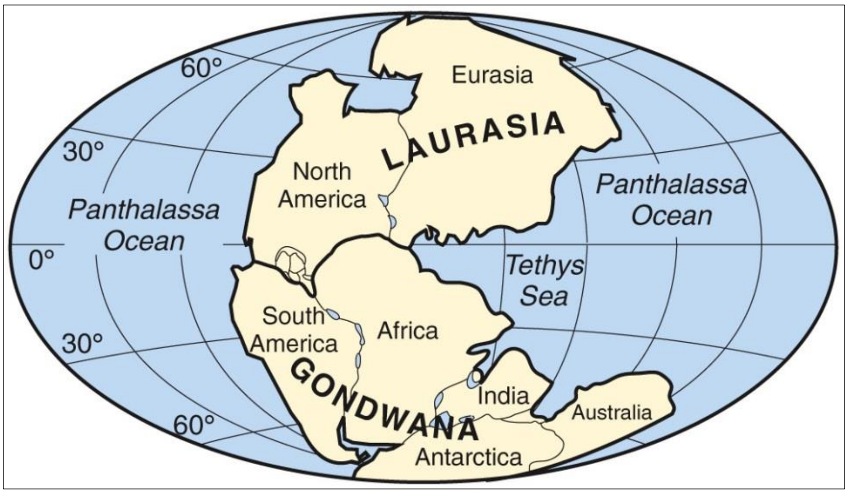


Figure 2-2: Laurasia and Gondwana Regions (Geogrify, 2016)

In South Africa the main coal mining areas are in the Waterberg, Witbank, Highveld, Free State, Vereeniging-Sasol and Ermelo areas (Jeffrey, 2005). Figure 2-3 shows the distribution of coal fields in South Africa.

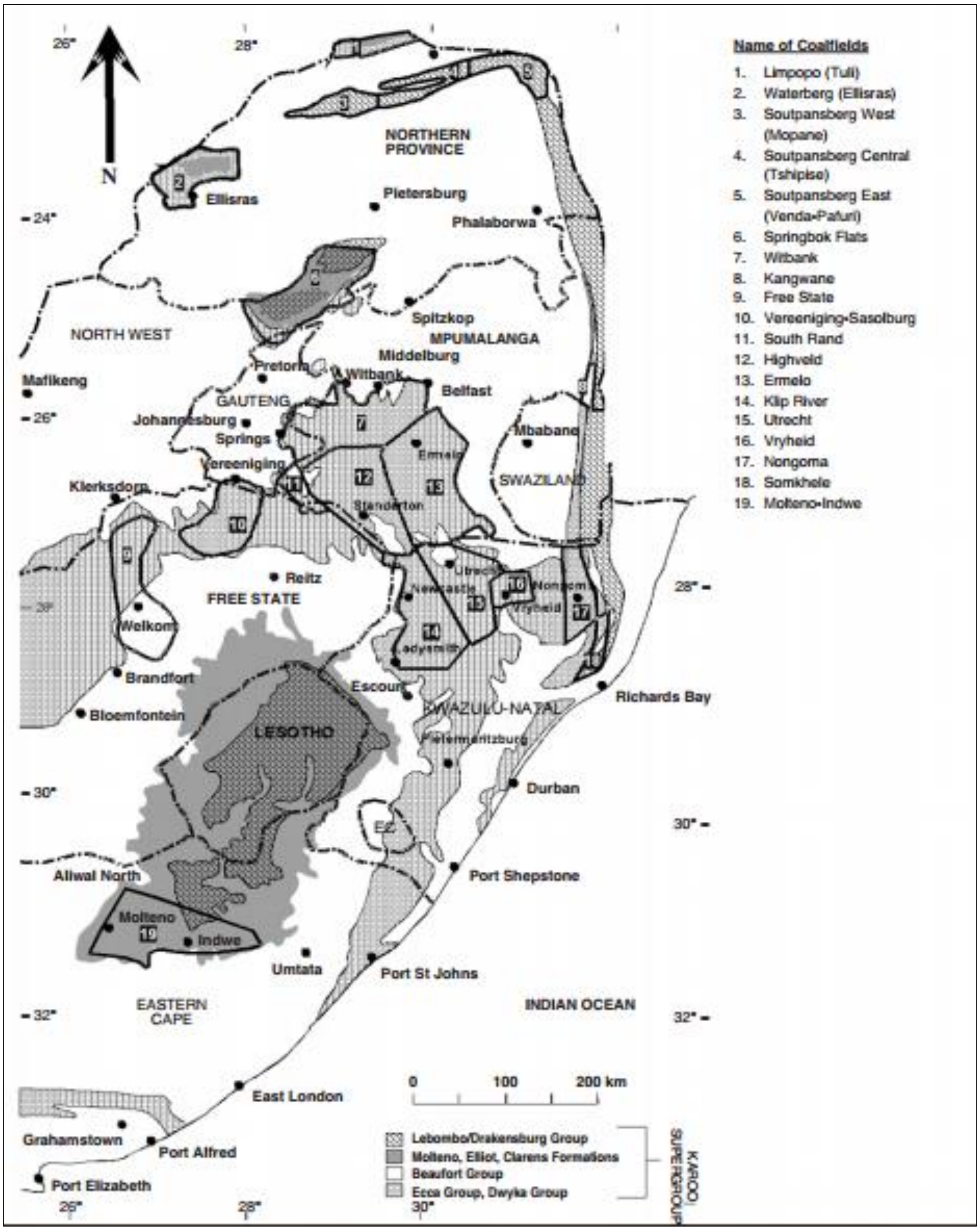


Figure 2-3: South African Coal Fields (Jeffrey, 2005)

Eskom coal fired power stations were designed to combust poorer quality coals with higher ash content compared to the Northern hemisphere power stations. The economic model at the time was to firstly export better quality “export” coal and to send poorer quality “middlings” to Eskom. It meant that the “export” coal “subsidised” the cost of the middlings coal and hence the cost to Eskom. This meant power could be produced and sold for cheaper thus attracting foreign investment into South Africa. The demand for export coal has decreased in the current economic climate thus decreasing the price. The South African coal export market has also changed from exporting to places such as the European Union to India, Japan etc.

2.3 Coal moisture

2.3.1 Types of moisture

Eskom is interested in the total moisture content of the coal reaching their boilers. The total moisture is the sum of the surface and inherent moisture:

- Surface (free) moisture: Water that is held freely on the surface of the coal particles. Surface moisture of fine and ultra-fine coal can exceed 24% (sometimes reaching 43% when coming out of a wash plant), whereas coarse ROM coal can have total moistures as low as 1-3% (Cumming, 2003). Eskom determines the surface moisture content using Eskom method 129, Rev 1 which is based on the South African Bureau of Standards (SABS) method 0135-Part II-1977. The method states that the coal should be dried in “ambient” temperature. Ambient temperature is dependent on the environment and differs from day to day and place to place. Another factor which affects atmospheric drying is humidity. In order to have comparable results these factors should be fixed for all laboratories. When the coal dries in a pan it forms a dry cake layer at the surface and prevents the coal below from drying. Turning the coal at least once a day will expose the wet coal and allow it to dry. (See Appendix A for full description of the method).

- Inherent (residual) moisture: Water that is held in the micro-structure (fractures, pores) of the coal. The inherent moisture cannot be removed by drainage. This moisture can be as high as 6%, and in some cases up to 8% yet will generally fluctuate within a certain range for a certain coal quality (Alphen, 2017). The inherent moisture content of coal used by Espag et al (2016) varied between 2.1-2.8%. Inherent moisture is the mass loss after air dried coal has been heated in an oven at 105°C for 90minutes. Figure 2-4 gives a visual representation of surface and inherent moisture. The inherent moisture content is determined using Eskom method 103, Rev 2, which is based on SABS 925. The temperature of 105°C was chosen as it is just passed the boiling point of water and therefore high enough to liberate the inherent moisture, but low enough to reduce the risk of releasing other volatiles. (See Appendix A for full description of the method).

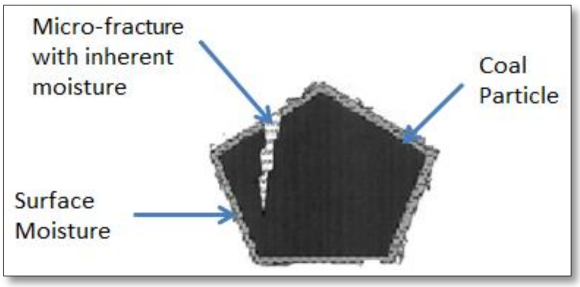


Figure 2-4: Surface and Inherent Moisture (Enslin, 2016)

2.4 Coal stockpile moisture and fines dynamic

Within a compacted soil the moisture content is expected to increase with increasing depth into the soil due to natural drainage and the occurrence of the water table. Due to coal on a coal stockpile being uncompacted the same logic cannot be applied.

Williams & Whitton (2008) performed experiments on a 12m high conical shaped coal stockpile. Samples were taken at different levels from the centre outwards to the face using an auger (Figure 2-5). Figure 2-6 shows the centreline sample, the face sample and the average of all the samples taken at the respective level. Figure 2-6 shows that at 8m the TM was >9%, whereas at the base it was 6%. Williams & Whitton (2008) state that this could be due to “hanging up of fines” in the coal stockpile.

Figure 2-5: Completed level of samples (Williams & Whitton, 2008)

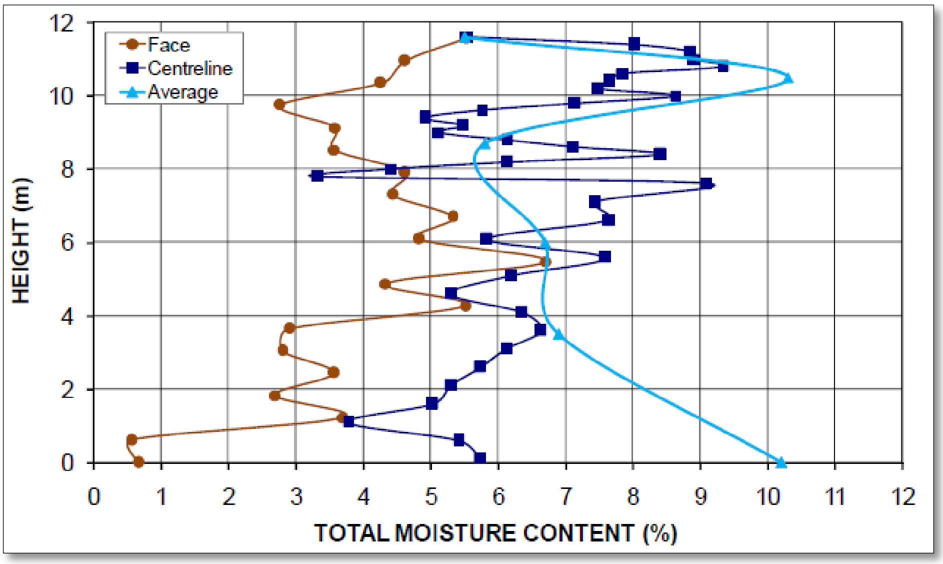


Figure 2-6: Face, centreline and average total moisture content versus height (Williams & Whitton, 2008)

Williams & Whitton (2008) findings were supported by Campbell (2013). Campbell (2013) performed experiments similar to that of Williams & Whitton (2008) but on a smaller scale. A 2m high conical shaped coal stockpile was formed. Above the coal stockpile was a sprinkler system designed to simulate varying rainfall scenarios. After a month the coal stockpile was broken down and samples taken. The sample locations were recorded (vertical height above the ground and horizontal distance from centre) and the moisture content of each sample determined.

Figure 2-7 shows the results from these samples. It can be seen that the moisture content tended to be slightly higher toward the centre of the coal stockpile rather than at the base.

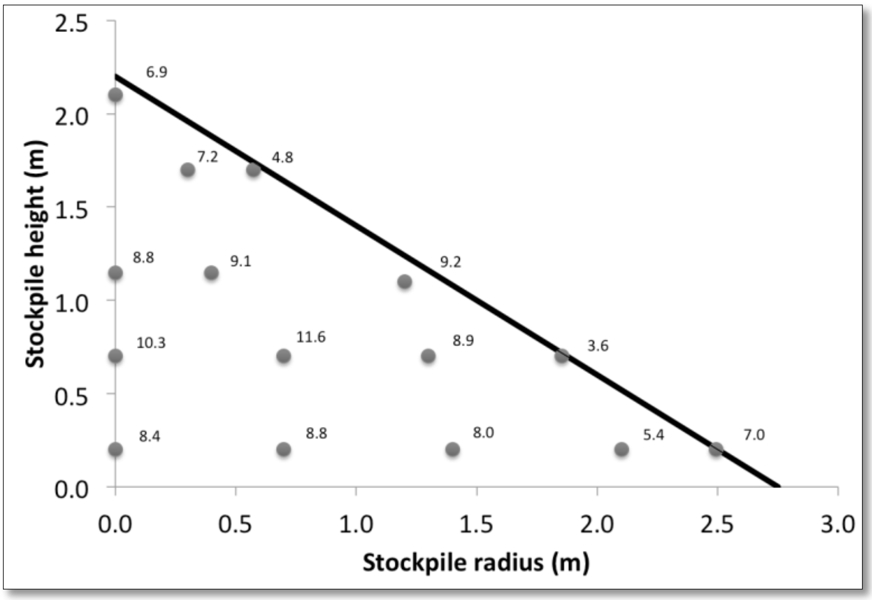


Figure 2-7: Position and values of final moisture samples (Campbell, 2013)

Espag et al. (2016) performed stockpile simulation (Figure 2-8) experiments similar to Campbell (2013). The results were similar in that they showed the final moisture content of the stockpile was independent of rainfall conditions and largely controlled by fines content.

Espag et al. (2016) found that the evaporation from a coal stockpile was considerable and continued long after drainage had ceased, which was about 2 days (Figure 2-9). There were also mass loss and gain cycles which appeared to be from the stockpile absorbing moisture from the atmosphere as the relative humidity increases and the temperature falls through the night.

Figure 2-8: Simulated Coal Stockpile (Espag et al., 2016)

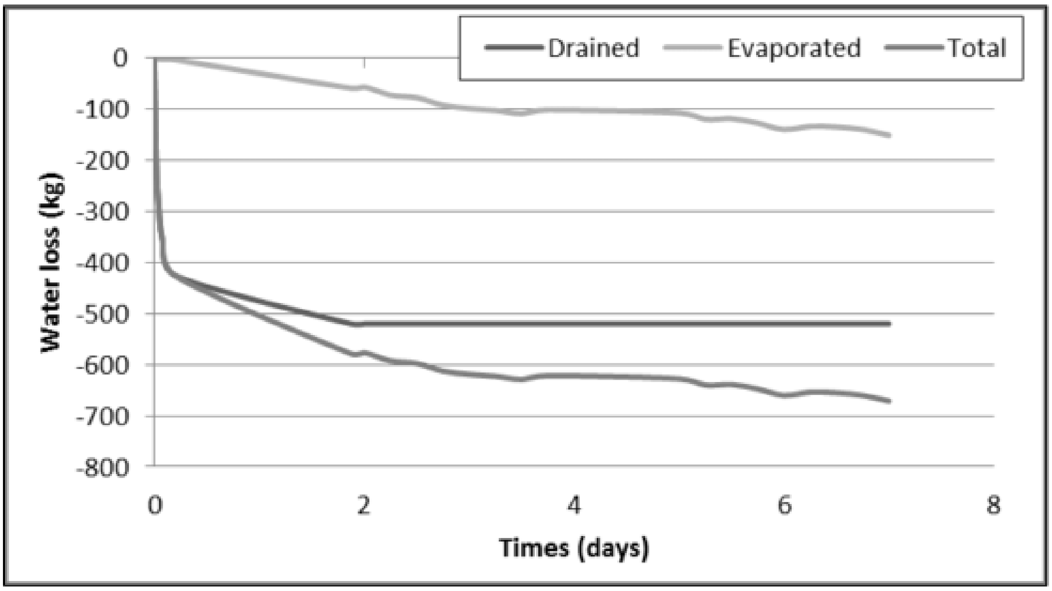


Figure 2-9: Stockpile Simulation water balance (Espag et al., 2016)

From a paper by Bucklen & Meikle (n.d.) on the subject of spontaneous combustion it is briefly discussed how larger coal particles tend to collect at the bottom outside of the stockpile and the finer material towards the top and inside (natural segregation). Figure 2-10 from Bucklen & Meikle (n.d.) gives an exaggeration of this size segregation but does well to demonstrate the concept.

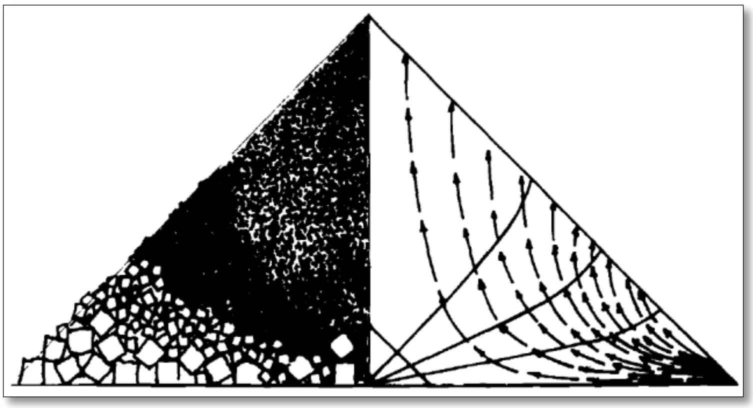


Figure 2-10: Particle Segregation in stockpiles (Bucklen & Meikle, n.d.)

Whilst investigating coal stockpile slope stability Quinn & Partridge (1995) showed by using a large test pipe (900mm diameter, 1.8m long), similar to the pipe constructed by Campbell & Le Roux (2014), how fines would gravitate and then settle in horizontal layers within the pipe. Figure 2-11 shows the drainage pipe used by Quinn & Partridge (1995). Figure 2-12 shows the 450mm diameter, 2m long drainage pipe used by Campbell & Le Roux (2014). Quinn & Partridge (1995) would would flow 1100ml/min (a deliberately exaggerated flow) of water though the pipe for six hours whereas Campbell & Le Roux (2014) would simply add 20litres of water for each experiment.

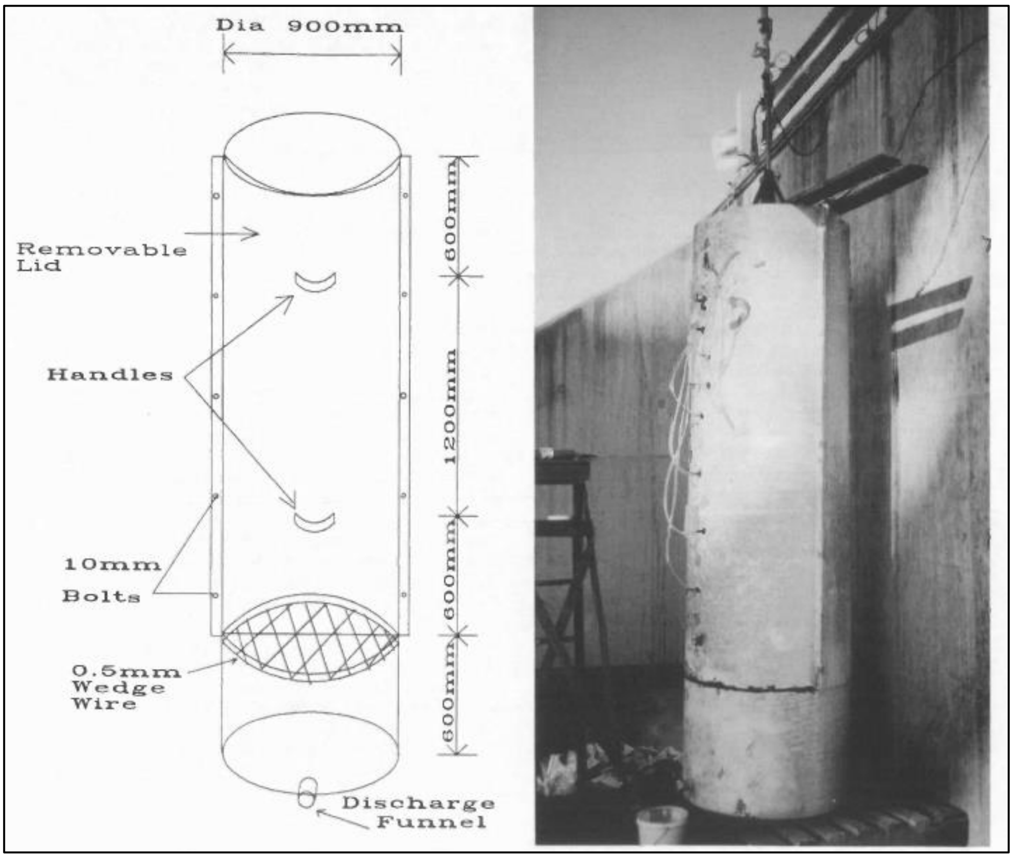


Figure 2-11: Drainage Pipe used by Quinn & Partridge (1995)

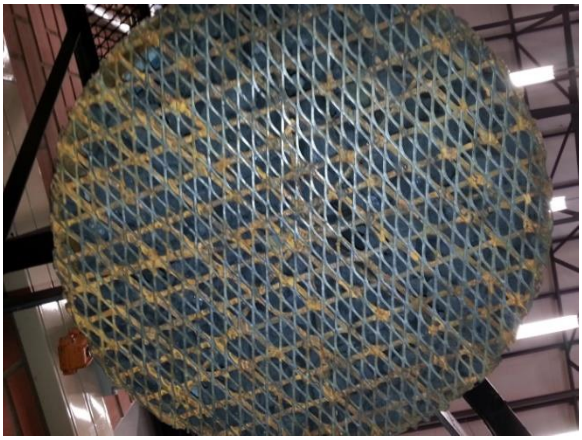


Figure 2-12: Drainage pipe and base used by Campbell & Le Roux (2014)

For the tests an arbitrary size of less than 2.35mm was taken as an indication of fines content. Three runs were done with low (35%), intermediate (39%) and high (43%) fines content.

Figure 2-13 shows percentages of fines in different zones of the pipe. It can be seen that in each case fines migration has taken place with two bands of increased fines content (increased fines concentration) developing below zones with reduced fines content (reduced fines concentration).

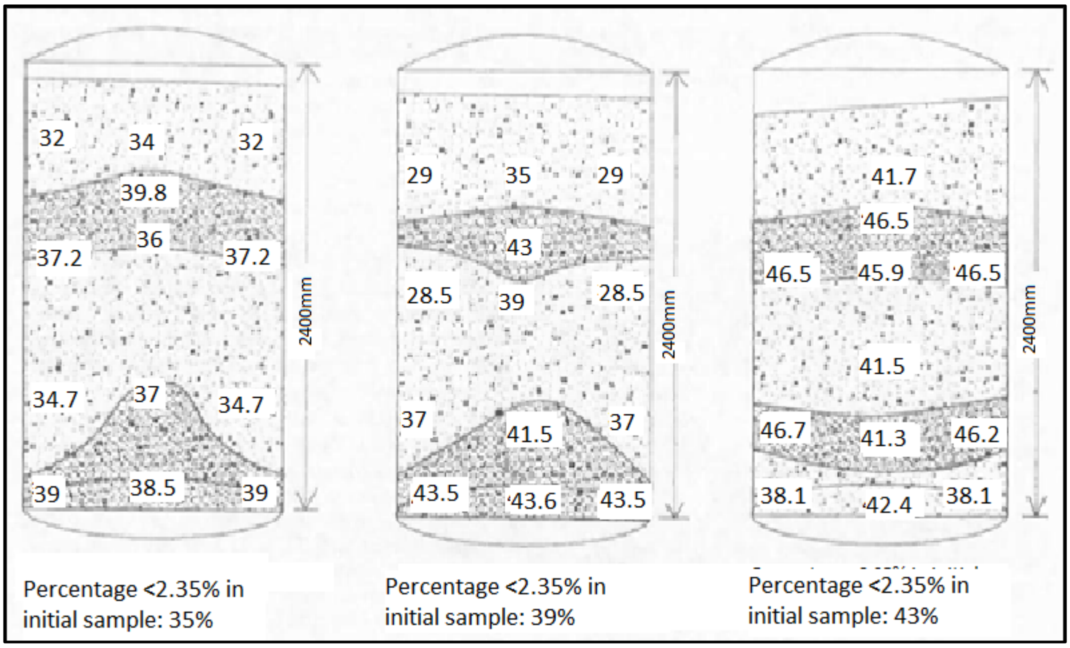


Figure 2-13: Schematic of fines settling (Quinn & Partridge, 1995)

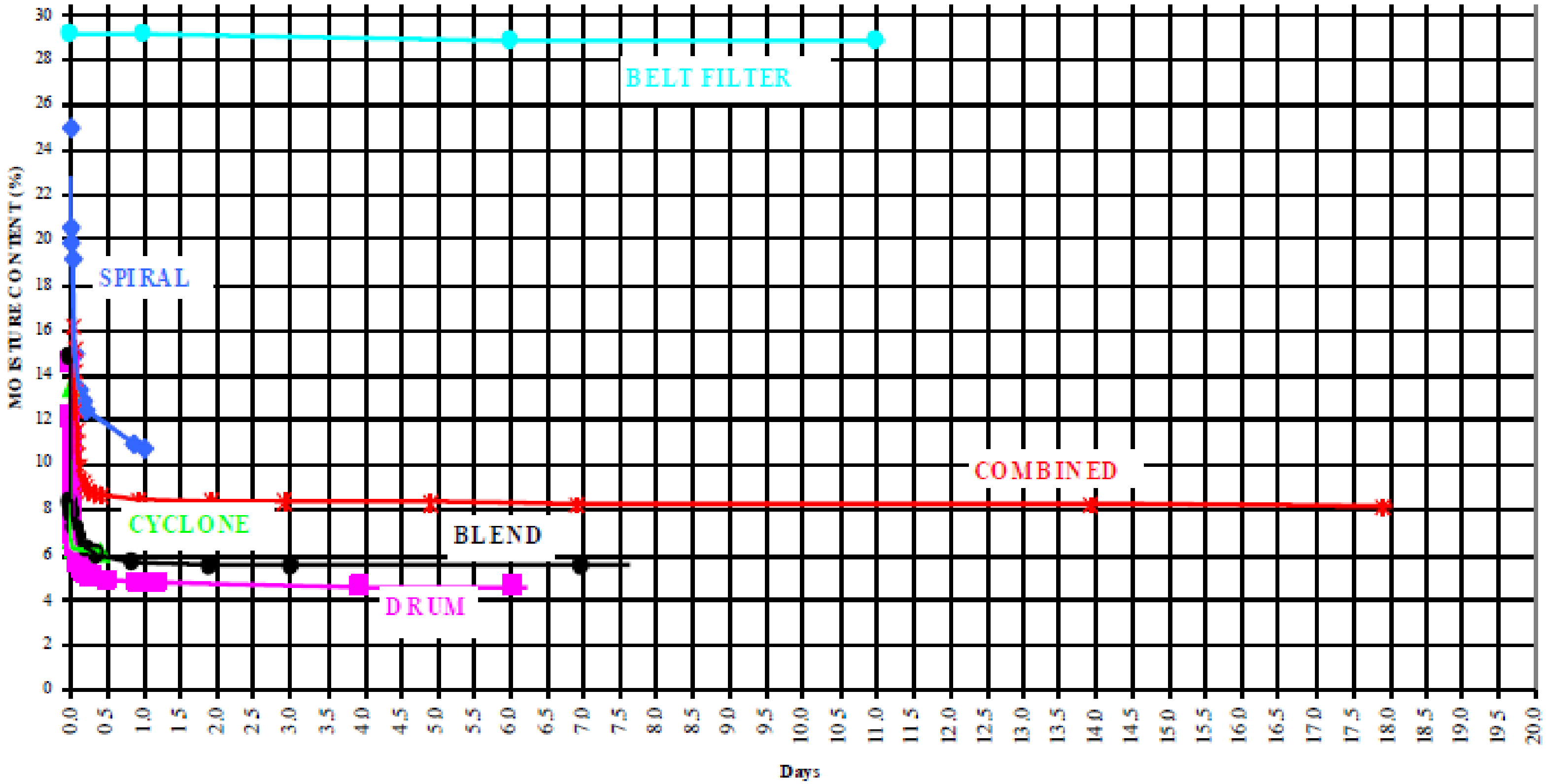
Figure 2-13 unfortunately does not show the exact location where the fines were settling in the pipe. In the study it was postulated that the fines would move through the coal via “percolation trickling”.

This “percolation trickling” together with “size segregation” contributes to the increased fines concentration towards the middle of the coal stockpile and associated elevated surface moistures in this area.

Quinn's postulation was confirmed by Curran, Droppo, & Irvine (2002) who examined flow structure within a simulated coal pile after simulated rainfall and noted that the movement of water and particles through the dry zone of the coal was accomplished by preferential flow of water and fines through macropores or conduits.

Cumming (2003) performed drainage tests on various coal blends to determine their drainage rates. He also used drums similar to those used by Quinn & Partridge (1995) and Campbell & Le Roux (2014) as seen in Figure 2-14. The drums were 1.8m in height and 0.575m in diameter. The base of the drums had funnel shape with a "pen-sized" hole to allow water to pass through and restrict fines from escaping. Figure 2-15 shows the results of these drainage tests. As the blend becomes finer the equilibrium moisture content reached increases. From the figure very little reduction in moisture content is realised after 24-48 hours.

Figure 2-14: Drainage drums used by Cumming (2003)



Cyclone=15 + 1mm
Spiral=1 + 0,3mm
Beltfilter=0,5 mm
Drum=-35 + 1mm

Blend: Drum= 47,8%
Cyclon= 45.6%
Spiral= 6,6%

Combined sample:
Drum = 42,5%Cyclone = 42,5%
Spirals = 5,00%Beltfilter = 10,0%

Figure 2-15: Drainage results (Cumming, 2003)

Espag et al. (2016) modified the pipe used by Campbell & Le Roux (2014) slightly by adding four sample points along the length. Espag et al. (2016) showed that although drainage from the pipe had stopped, moisture would still migrate to the bottom of the pipe (Figure 2-16). The curves "A", "B", "C" and "D" represent the vertical location on the pipe from which samples were taken. "A" being the highest and "D" the lowest point on the pipe.

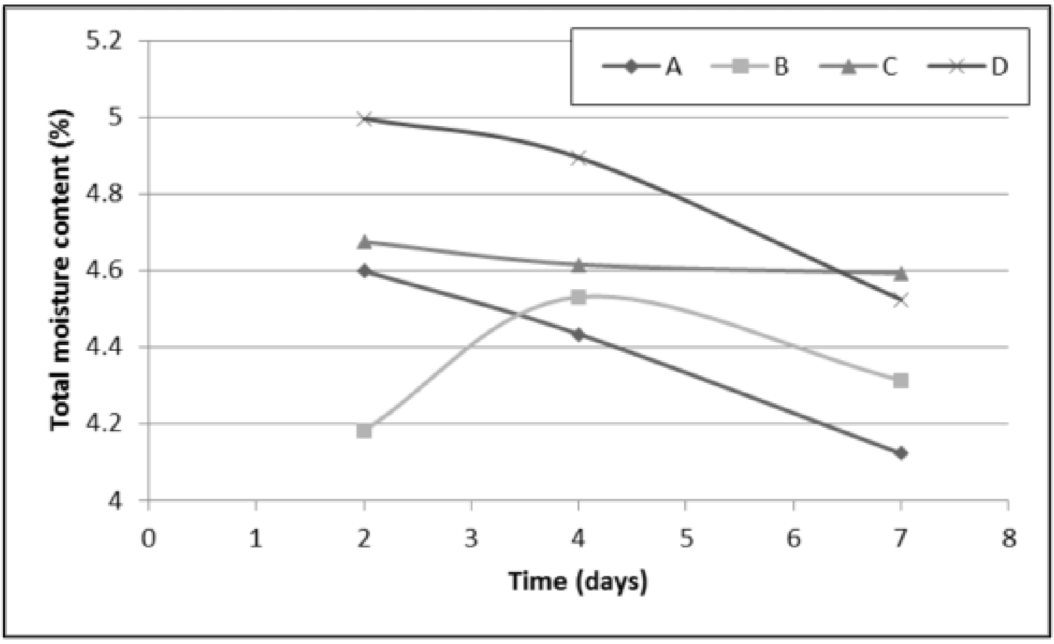


Figure 2-16: Moisture profile over time (Espag et al., 2016)

2.5 Coal stockpile surface moisture level control

2.5.1 Coal composition

Particle size distribution and particle shape

Williams & Whitton (2008) state that when the ultra-fine (-300µm) coal is removed the composite product coal is likely to have a total moisture content of at most 9% (for a 75:25 dry mass ratio of coarse:fine product coal), compared with at most 12.8% for a 60:20:20 dry mass ratio of coarse:fine:ultra-fine (see Table 2-1 for size definitions) product coal.

Dahlstrom (1981) states that 50% of the moisture is found in the ultra-fine fraction (less than 75µm). Run of mine coal surface moisture is as a result of adhesive and cohesive forces between the water and the coal particles. For this research fine coals can be seen as having two types of surface moistures, namely surface liquid and capillary liquid.

Figure 2-17 (a) and (c) illustrates capillary and surface liquid. The fully saturated state could have positive or negative pore pressure. Positive pressure would be in a scenario where the coal is fully submerged (highly unlikely in a practical uncompacted composite situation). Negative pressure would be as a result of surface tension and capillary forces holding the water between the pores spaces. This would be the case in fine product coal with small pore spaces.

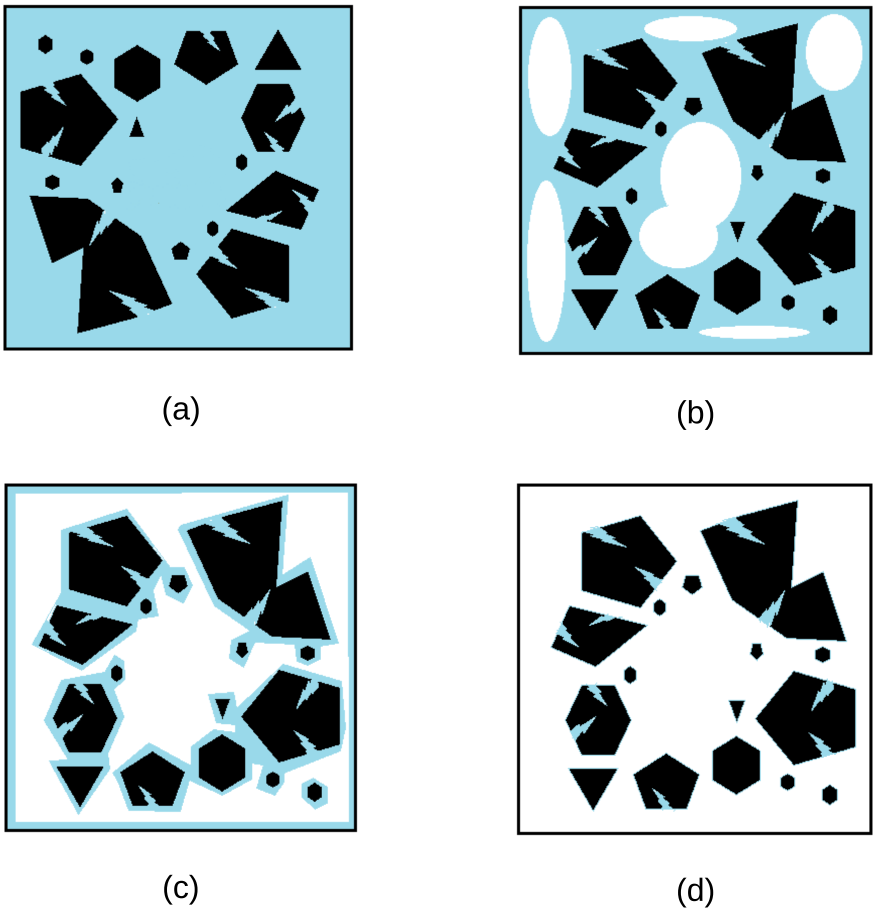


Figure 2-17: Different stages of moisture content (a) Fully Saturated (b) Partially Saturated (c) Surface Moisture and Inherent Moisture (d) Inherent Moisture only

Specific retention is defined as the ratio of the volume of water a soil can retain against gravity to the total volume of the soil. This concept also applies to coals. The finer the coal, the greater the amount of water (surface and capillary liquid) that can be retained against gravity. Figure 2-18 shows the relationship between particle size and specific retention of moisture of soils. As the soil size decreases the amount of moisture that can be retained increases. A similar curve would be obtained for coals. From Figure 2-18 the porosity is the volume of voids over the total volume. Specific yield is the volume of water released from a soil relative to its total porosity.

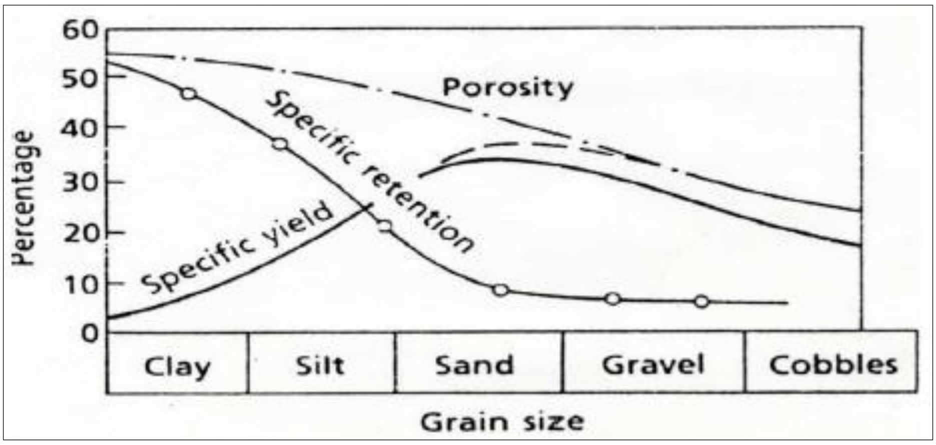


Figure 2-18: Relationship between particle size, porosity, specific retention and specific yield (Bell, 1993)

The definition of various coal size fractions (coarse, fine or ultra-fine product) varies depending on the author. Table 2-1 summarises this. From the table it can be seen that two authors (Cumming, 2003; Hand, 2000) define the upper limit of fines as -500µm.

Table 2-1: Summary of Coal Particle Size Classifications from differing authors

Coal Product Size Fractions	Coal Size (mm)		
	Williams & Whitton (2008)	Cumming (2003)	Hand (2000)
Coarse	-50+0.5	-100+15	+12
Small	-	-15+0.5	-12+0.5
Fine	-2.0+0.125	-0.5+0.1	-0.5+0.15
Ultra-fine	-0.3	-0.1	-0.15

Particle size distribution plays a role in packing density. Both Sohn & Moreland (1968) and Wakeman (1974) agree that a denser packing arrangement is possible with an increase in size range forming the particle distribution. A tighter packing density means a smaller void ratio. By reducing the void ratio the amount of conduits water and fines may gravitate through is decreased. This will then reduce the amount of water entering and passing through a coal stockpile.

Gray (1968) states that any bulk solid has a minimum or maximum packing density or void ratio, e. The packing density of any bulk solid is dependent on its roundness, sphericity and regularity (Cho, Dodds, & Santamarina, 2006). Figure 2-19 from Cho et al (2006) illustrates the difference between sphericity and roundness.

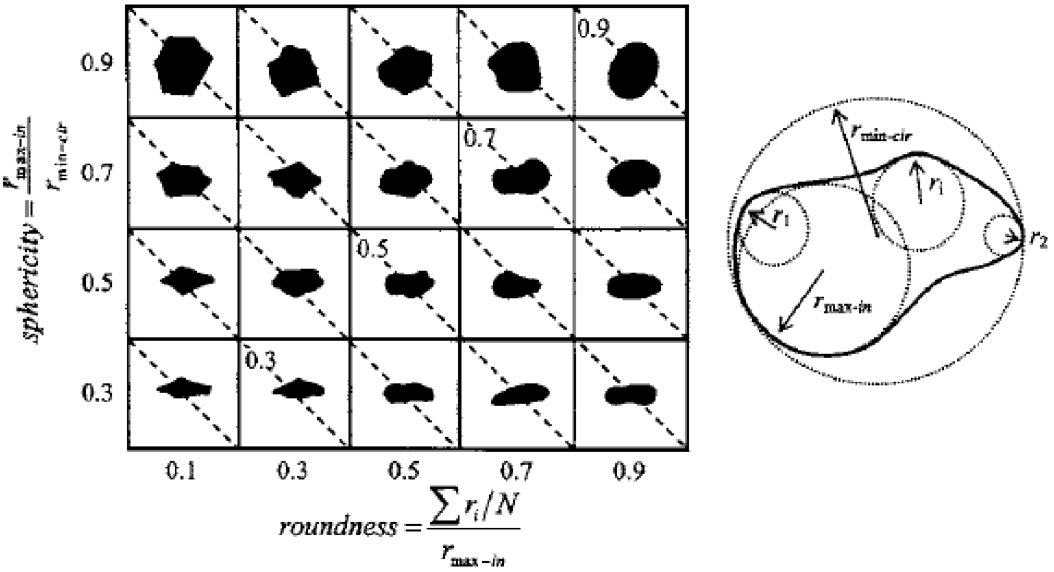
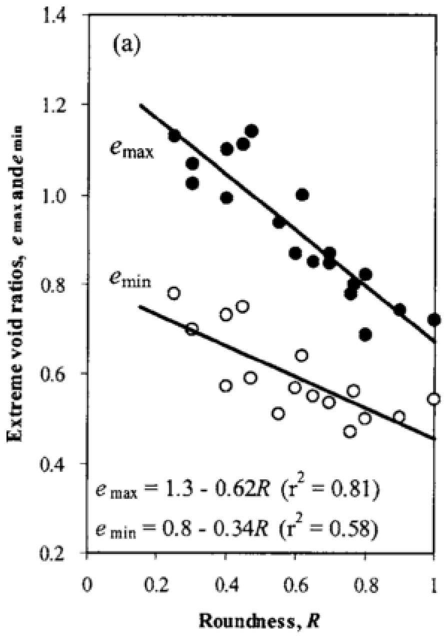


Figure 2-19: Sphericity VS Roundness (Cho et al., 2006)

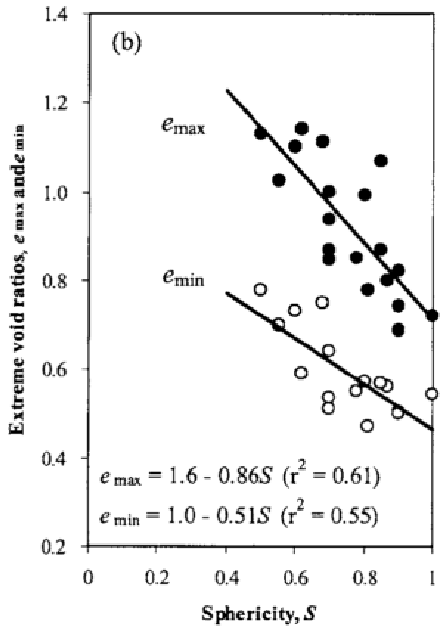
Cho et al (2006) defines sphericity as "the global form of the particle and reflects the similarity between the particle's length, height, and width. Sphericity can be quantified as the diameter of the largest inscribed sphere relative to the diameter of the smallest circumscribed sphere". Cho et al (2006) defines roundness as "the scale of major surface features which are typically one order of magnitude smaller than the particle size. Roundness is quantified as the average radius of curvature of surface features relative to the radius of the maximum sphere that can be inscribed in the particle".

Figure 2-20 shows these relationships for natural sands. The closer to unity these factors are, the smaller the difference between the maximum and minimum porosity is. Sohn & Moreland (1968) claimed that denser packing is possible with angular particles than with spherical particles. Wakeman (1974) disproved this by showing that particles whose shape is closer to unity achieve a denser packing arrangement. This was supported by Cho et al. (2006) who showed that "irregularity hinders particle mobility and the ability to attain dense packing configuration".

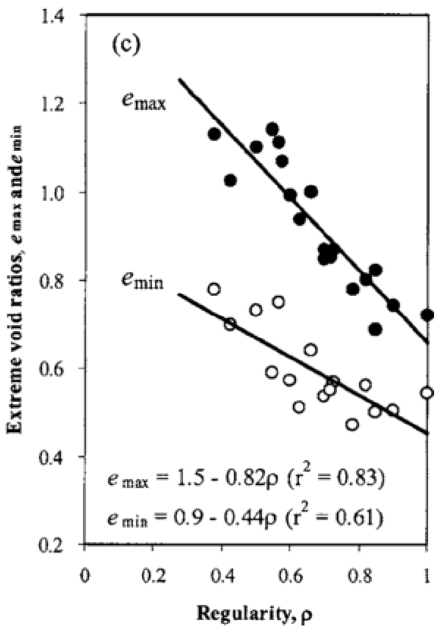
Williams & Whitton (2008) state that "pore size and the inter-connectedness of pores are what govern the saturated permeability of a porous medium". One of the recommendations by Williams & Whitton (2008) was that more work be done to investigate the effects of packing density and compaction on moisture retention of uncompacted composite coal stockpiles.



(a)



(b)



(c)

Figure 2-20: Effect of particle shape on extreme void ratios (natural sands with Cu≤1) (Cho et al., 2006) (a) Roundness (b) Sphericity (c) Regularity

The “pore size distribution and inter connectedness of a given coal is difficult to measure” thus the experiments done by Williams & Whitton (2008) used the particle size distribution, which is fairly simple to determine, as a proxy. Williams & Whitton (2008) showed, by determining the Soil Water Characteristic Curves (SWCC) for different sized coal, that the SWCC is a strong function of the particle size distribution. Figure 2-21 shows these SWCC’s together with the maximum suction that can be applied by various dewatering technologies. The pressure applied to dewater coal is called matric suction. The point on the graph where the moisture content starts to decrease is the Air Entry Value (AEV). For example, from the figure a vacuum filter, which exerts a maximum pressure of 85kPa, can reduce the surface moisture content of an ultra-fine coal to 30.5%. Whereas a filter press, which exerts 1500kPa of pressure, can reduce the moisture content to 23%. The total moisture content of fine and ultra-fine coal is in the region of 43%. This is in line with the value stated by Cumming (2003) of 43% (see section 2.3.1).

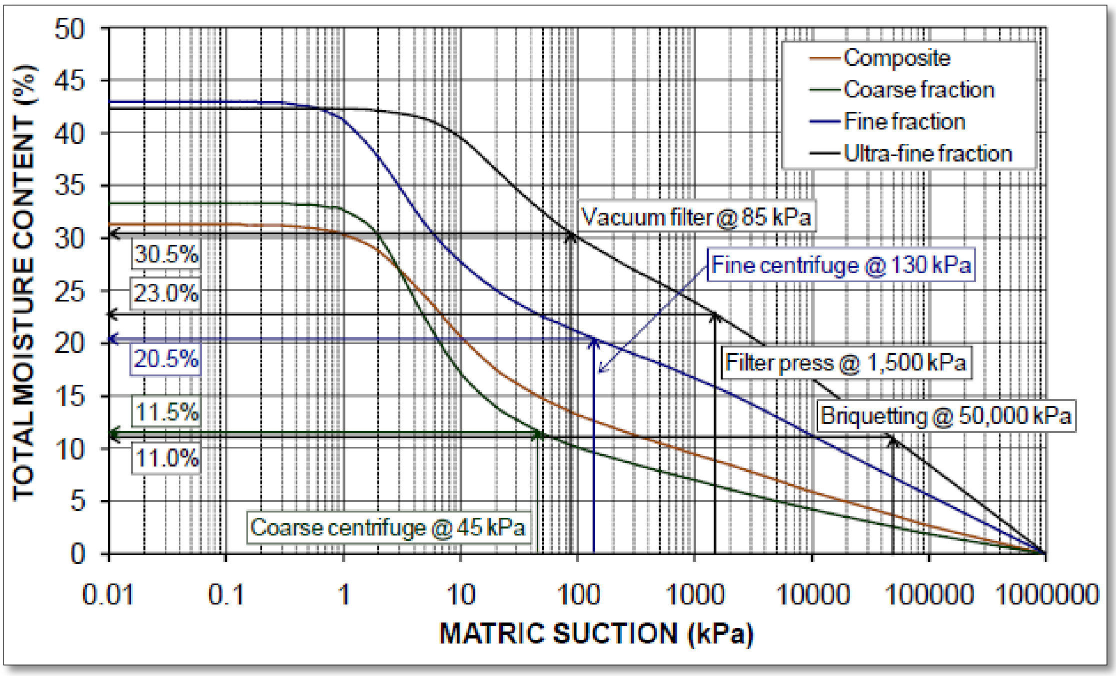


Figure 2-21: Typical SWCC's for different product coal sizes (Williams & Whitton, 2008)

The particle size distribution of Eskom stockpiled coal is dependent on a number of factors. Cumming (2003) states that some of these factors are:

- the properties of the coal, such as hardness, friability, grindability, porosity;
- the mining method (eg: blasting, continuous mining);
- the top size to be processed according to the contract which is unique to Eskom;
- the preparation techniques to be used (crushing, washing, dewatering)

Table 2-2 shows the average particle size distributions for each Eskom power station (Cumming, 2003).

Table 2-2: Average particle size distributions for Eskom power stations (Cumming, 2003)

Station	Sizing mm				Moisture %		
	-50+25	-25+12.5	-12.5+3.5	-3.5	IM	SM	TM
A	2.2	19.7	39.4	38.7	4.2	4.3	8.5
B	10.3	18.3	39.4	38.8	4.0	4.8	8.8
C	11.3	20.7	37.9	30.1	3.8	4.7	8.5
D	10	28.2	23.7	38.1	3.2	4.6	7.8
E	10.8	25.4	30.8	33.0	2.9	3.2	6.1
F	22.6	31.0	20.7	25.7	3.2	4.7	7.9
G	5.3	25.8	38.3	30.6	2.3	4.3	6.6
H	8.0	36.1	18.7	36.2*	5.0	5.8	10.8
I	6.3	14.8	40.6	38.3	4.1	4.4	8.5
J	9.0	30.6	19.6	40.8	2.1	7.2	9.3
Avg %	9.7	28.1	32.6	34.5	3.5	4.8	8.3

*-5.6mm

Wet dense medium beneficiation (wash plants) will increase the total moisture of the washed coal whilst dry beneficiation (x-ray sorters) will not.

In order to meet contractual obligations coal suppliers will use beneficiation/preparation plants. These plants either size the coal by crushing and screening or wash the coal to improve the heat value. The latter process is done by removing non-combustible mineral matter and rock by gravity separation.

Coal rank

Higher rank coals are more hydrophobic than lower rank coals (Williams & Whitton, 2008). This has to do with the way different rank coals fracture which, according to Silbernagel (1989), is due to dramatic changes in coal surface structure with changes in coal rank.

Maceral (organic) content

Rudawska (2012) states that “surface roughness is important in view of the part the mechanical adhesion plays in general adhesion”. Bright coal (high vitrinite content) fractures with smooth surfaces and into small cubic blocks whilst dull coal (mainly inertinite content) fractures unevenly (Falcon & Snyman, 1986). Figure 2-22 shows bright coal (left) compared to dull coal (right). The bright coal on the left is smoother, shinier and has sharper edges compared to the dull coal which has a much rougher surface. This rough surface allows better mechanical adhesion of surface moisture to the coal surface. The uneven fractures also result in larger surface areas for surface moisture to adhere to. .

Figure 2-22: Bright coal (Left –high vitrinite content) compared to dull coal (Right –Low vitrinte content)

Mineral (inorganic) content

Coals with increased mineral content tend to have poorer hydrophobic properties which make them less prone to dewatering. Increased clay and carbonates content, which are common to South African coals, reduces the dewatering ability of coal. This is supported by Williams & Whitton (2008) who state that minerals such as kaolinite (clay) reduce the hydrophobicity of the coal. The reason for this is that clays, for instance, are extremely fine (-2µm) which translates into extremely small pores as well as larger specific surface areas. The significance of these two effects was discussed earlier under “Particle size distribution and particle shape”.

2.5.2 Climate

Solar radiation

Natural drainage will occur up to the equilibrium surface moisture content of the coal. To reduce the surface moisture below equilibrium heat may be applied through solar radiation. Williams (2006) states that although drying due to solar radiation may reduce the moisture content of a coal it is only effective to a depth of 300mm from the surface.

Wind

Williams (2006) states that drying due to wind action is only effective to a depth of 2m from the surface but can help in reducing the overall surface moisture content of coal stockpile. Stockpiles orientated to the prevailing wind direction may take advantage of this although this could lead to dust generation.

Intensity and duration of rainfall

Through the experiments done by (Curran et al., 2002) it was shown that the more intense rainfall resulted in less infiltration and increased surface run off. “Compaction of the coal and breakdown of aggregates into finer grains during rainfall exposure resulted in clogging and reduction of pore space within the coal bed. This reduced water infiltration through the coal pile and increased surface runoff during subsequent storm events.” Curran used a maximum flow of 111mm/hr. This was confirmed by Campbell (2013) who showed, on a larger scale, that longer, less intense rainfall resulted in more moisture penetration into the stockpile. Campbell (2013) used a maximum flow of 40mm/hr.

2.5.3 Coal stockyard design

Existing drainage

Generally coal stockyards are designed so that all the water flows to a dirty dam for recovery. Over time, fine coal transported by the water is deposited along the drainage routes. These deposits then result in blockages of the drainage routes and large pooling of water may occur on the coal stockyard. Williams & Whitton (2008) state that “drainage channels installed at the sloping base of stockpiles has shown to be effective in removing gravity drainage, however, are prone to becoming blocked by coal.” Figure 2-23 shows a coal stockyard with poor drainage.

Figure 2-23: Coal stockyard with poor drainage (Hunterson, 2013)

Generally an impervious clay layer is used as the foundation of the coal stockyard. Although this prevents leachate from contaminating the ground water, it only allows for the horizontal movement of water at the base of the stockpile. Williams & Whitton (2008) state that a layer of sacrificial coal may facilitate gravity drainage and thus prevent pooling of water at the stockpile base.

Angle of stockpile repose

Coal pile rainfall simulation experiments undertaken by Curran et al (2002) have shown that stockpiles with steep slopes facilitates runoff and reduce water infiltration compared to shallow sloped stockpiles. It was suggested that the optimum angle for a coal stockpile is 25°. This angle will allow for minimum runoff contact time thus reducing moisture infiltration into the heap as well as preventing mass slumping and rill erosion. Figure 2-24 shows the experimental set up.

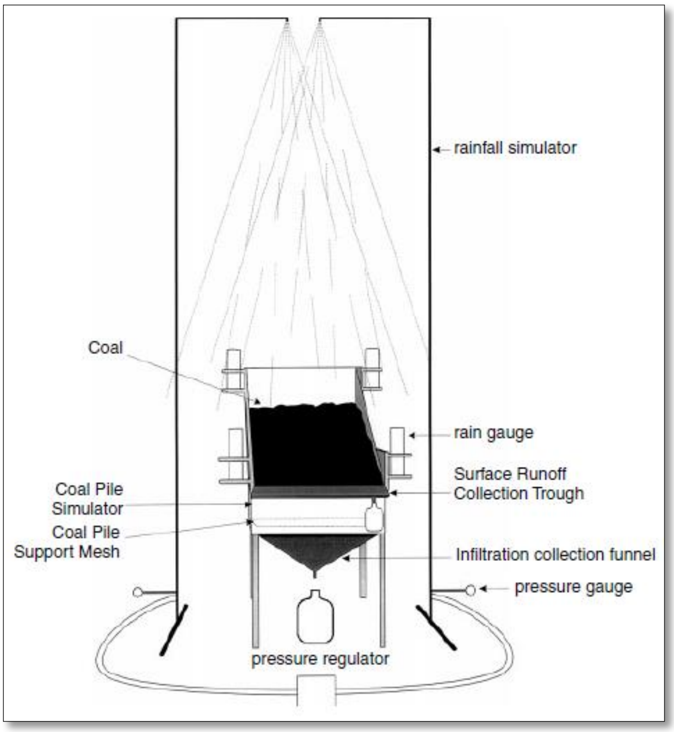


Figure 2-24: Coal pile rainfall simulator (Curran et al., 2002)

Eskom coal stockyard designs

Eskom has 15 coal fired power stations. Coal stockyard design, stacking/reclaiming equipment and stockyard management procedures used to process the coal varies from site to site.

These coal stockyards are generally encompassed by a dirty water channel. The dirty water channels may have “silt traps”. The silt traps are areas within the path of the channel that open up and increase the width of the channel. Since the water now flows through a larger area the velocity is reduced. The reduction in velocity allows any fines being transported with the water to settle. The settled fines are then collected by a front end loader and disposed of on the coal stockyard. After the silt trap the dirty water continues to a dirty water dam where it is then pumped to the power station water treatment plant. The overall gradient of the stockyard is towards the collection point. This helps to reduce pooling of water inside the stockyard. Figure 2-25 shows a typical South African Coal stockyard Layout.

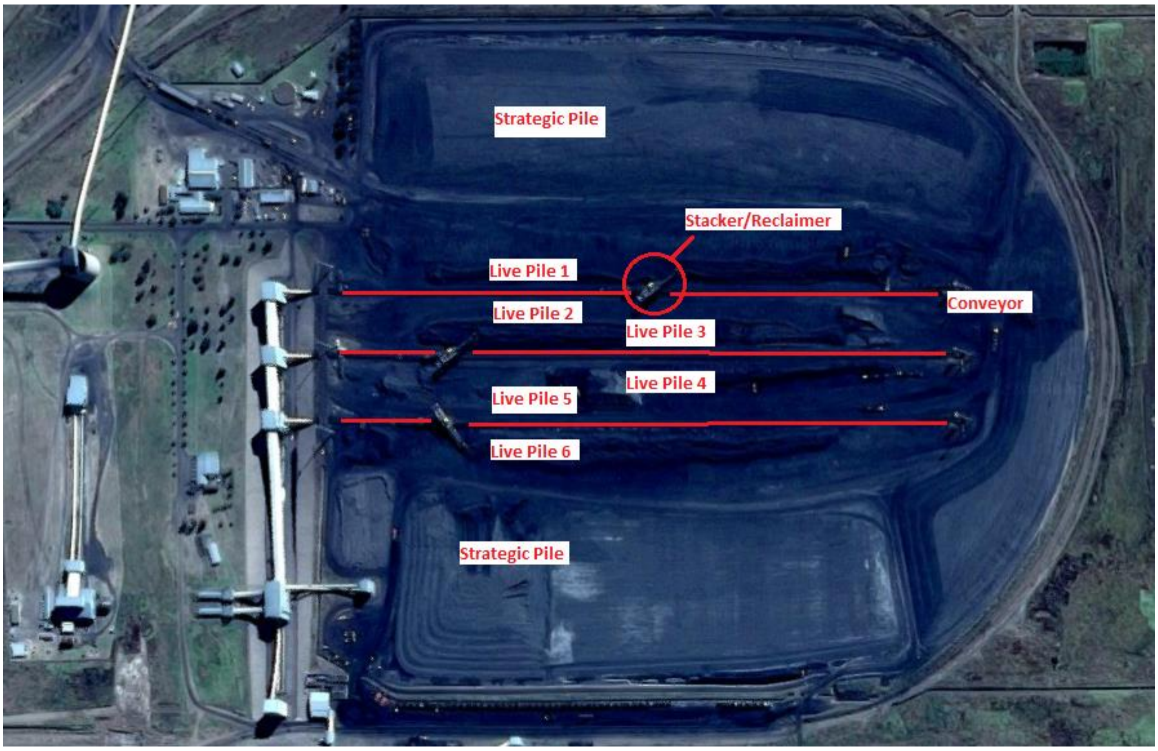


Figure 2-25: Eskom Coal stockyard Layout (Google Maps, 2016)

Initial environmental legislation prescribed an impermeable clay layer be used as the lining for the coal stockyard. A clay layer was used as the base for its low permeability properties and in some cases a sacrificial coal layer was put on top of this clay layer. The low permeability of clay prevented any coal stockyard leachate from polluting the ground water. More stringent environmental legislation has led to the incorporation of zero liquid effluent discharge (ZLED) policies pertaining to the management of possible ground and surface water contamination (Department of Water Affairs et al, 2005). This ZLED policy has led to more complicated CSY design with various layers of clay, geosynthetic liners, large aggregate, perforated piping and a sacrificial coal layer. These new designs are incorporated into more recent Eskom coal stockpiles.

The objective of these designs is to ensure that no leachate from the CSY can enter and contaminate the ground water but at the same time the foundation must be permeable enough for the water to flow through and enter the perforated piping. This new coal stockyard design incorporates the minimum liner requirements as stipulated by DWAF (Savannah Environmental (Pty) Ltd, Naicker, & Thomas, 2012). The functions of the different layers for the lining on the coal stockyard is as follows (refer to Figure 2-26):

- Leachate collection system - Perforated piping that collects leachate and transports it to a sump or bund area.
- Primary clay composite system - Main clay barrier which prevents ground contamination.
- Leak detection system – Has a two-fold function, i.e. detecting and collection. It is the first indication of leakage.
- Secondary compacted clay - The final containment layer. (Savannah Environmental (Pty) Ltd et al., 2012)

Figure 2-26: The different lining layers of the construction of the new Eskom coal stock yards (Savannah Environmental (Pty) Ltd et al., 2012)

From discussions with subject matter experts these designs carry inherent risks such as spontaneous combustion of the coal stockpiles by allowing oxygen to enter through the perforated piping at the base of the stockpile. The level of risk needs to be evaluated with the implementation of measures to reduce the risk as much as possible together with strict monitoring procedures to detect early signs of spontaneous combustion.

2.5.4 Coal stockpile management

Eskom coal stockyards usually have a dedicated mine and some cases coal is imported from other mines. Coal is stacked by a variety of methods. Some stations use stacker/reclaimers (see Figure 2-27) whilst others simply build up the stacks using front end loaders. Reclaiming also varies between using stacker/reclaimers or a combination of buffalo feeders and front end loaders. The coal is reclaimed onto the conveyor belt system and transported to the power station.

Coal stockyard days (days until stockyard coal supply is depleted at demand rate) are monitored annually using aerial based volumetric surveys. Lasers are used to determine the profile of the stockpile. Volume is then calculated and the mass determined using the measured density of the coal. Newer methods involve using a program called QMASTOR©. This product uses GPS technology to monitor the stockpile surface (Keleher, Cameron, & Knijnikov, 1998).

During the rainy season different wet coal strategies are utilised by different stations to prevent wet coal associated load losses. Some of these strategies are:

- Blending the wet coal with drier coal.
- Stockpiling coarse coal during the dry season.
- Reclaiming from the strategic stockpiles. The strategic stockpiles are compacted thus experience little moisture ingress and remain dry during the wet season.
- Reclaiming the coal in a series of shallow lifts rather than full depth cuts. The former takes advantage of atmospheric drying (solar and wind) as the coal is progressively exposed.
- Reclaiming the top of the stockpile only

Figure 2-27: Stacker/reclaimer

Every year Eskom undergoes wet coal readiness surveys at each power station prior to the rainy season. These surveys aim to determine how prepared the coal stockyards and associated bulk materials handling equipment are at handling wet coal. The survey looks at existing drainage; plant health (conveyor capability, scrapers, pulley lagging, etc) and operating procedures (reclaim strategies, blocked chute procedures, etc).

Another strategy (although not employed by Eskom) is to use surfactants and flocculants on the coal stockpiles. Surfactants reduce the surface tension of the water or adsorb to the coal particle surface making it more hydrophobic. Flocculants aggregate the fine coal particles to effectively increase their size. This reduces the specific surface area of the coal and increases the pore size thus increasing the drainage capabilities.

3 Research method

Equilibrium surface moisture content is the point at which surface moisture content does not change over time. Cumming (2003) defined equilibrium moisture content as **"**that moisture level at which no further significant reduction in moisture is achieved with further drainage".

For this research, since time was a consideration for the experiments, a point had to be defined where the experiment could be terminated. Thus the equilibrium surface moisture content was defined as the surface moisture reached when the change in surface moisture is less than 2% over a 12 hour period. For example,

surface moisture After 12hours: 8.55%

surface moisture after 24hours: 8.44%

% change= 1.29%

Thus, Equilibrium surface moisture is 8.44%.

The hypothesis is that the equilibrium surface moisture content of a coal sample is made up of the sum of surface moisture contributions by each size fraction in proportion to its weighting to the overall size distribution:

$$SM_{EST} = \sum_{i=1}^{n} SM_i * f_i = (SM_1 * f_1) + \ldots + (SM_n * f_n) \qquad 1\text{-}1$$

SM_n will be determined empirically in stage 1A.

f_i= percentage of size fraction relative to total sample size.

Table 3-1 shows an example table used for the surface moisture estimation.

Table 3-1: Example of Surface Moisture Estimation

Size Fraction (mm)				
D_l	D_u	Geometric Mean	f_i	SM_if_i
19	30	23.87	5.37	0.15
10	19	13.78	24.93	0.74
6	10	7.75	23.33	0.81
4.75	6	5.34	13.89	0.57
3	4.75	3.77	13.12	0.65
2	3	2.45	8.61	0.53
1	2	1.41	6.93	0.62
0.5	1	0.71	2.83	0.43
0.00	0.50	0.16	1.00	0.29
			$SM_{EST}=\Sigma SM_if_i$	**4.79**

The hypothesis is based on the conclusions by Espag et al (2016) who showed that a composite coal stockpile will reach an equilibrium moisture content. This research assumes the same must hold true for individual size fractions.

For this research the fines fraction was defined as -500µm. This is in line with the definitions by Cumming (2003) and Hand (2000). To test the hypothesis and quantify the effects of fines two stages of testing were done.

Stage one made use of a 25 litre drum which was a smaller version of the drainage pipe used in stage two. The design for the drainage pipe was adapted from similar drainage pipes used by other researchers (Quinn & Partridge, 1995; Campbell & Le Roux, 2014).

The advantage of the drum was fast turnaround time in terms of test duration and sample preparation (coal handling, sample size, etc). The disadvantage being that the fines movement in the short section of the drum could not be simulated. The drainage pipe having a longer length could show these effects.

Stage one consisted of two sub stages, 1A and 1B. Stage 1A involved testing of individual size fractions (see section 3.2.1 for size fractions used). Stage 1B involved testing variable fines content of a composite coal sample (see Table 3-6 for composite samples tested).

Tests were performed on coal from the same source to isolate any effect rank and grade might have on surface moisture retention and drainage. For this research the equilibrium moisture content was defined as the surface moisture reached when the change in surface moisture is less than 2% over a 12 hour period (See section 1.3 for definition).

The data from stage 1A was used to compare how the drainage curves and equilibrium surface moisture changed with size fraction and in particular, the fines fraction.

Stage 1B established the relationship between fines content, drainage curves and equilibrium surface moisture content.

The size fraction/equilibrium surface moisture content relationship from stage 1A was then used as input into the model (equation 1-1) to estimate the equilibrium surface moisture content of the stage 1B samples. The actual data was then compared to the estimated data to verify the model (equation 1-1).

Stage 2 demonstrated the moisture and fines dynamic within an uncompacted composite coal stockpile. Stage 2 surface moisture and drainage curve data was also used to see whether the results would be consistent when scaled up from the 25 litre drum to a larger test rig (drainage pipe) as well as for further verification of the model (equation 1-1). Larger scale testing (actual coal stockyard tests) was not part of this scope. Figure 3-1 illustrates the method used.

Three different types of surface moisture were being considered:

1. SM_{DIR}: Surface Moisture measured using the load cell (mass balance)
2. SM_{LAB}: Surface Moisture measured in the lab
3. SM_{EST}: Surface Moisture estimated using the model (equation 1-1)

For this research the inherent moisture was assumed to be constant and was not evaluated. This assumption was based on discussion with Alphen (2017).

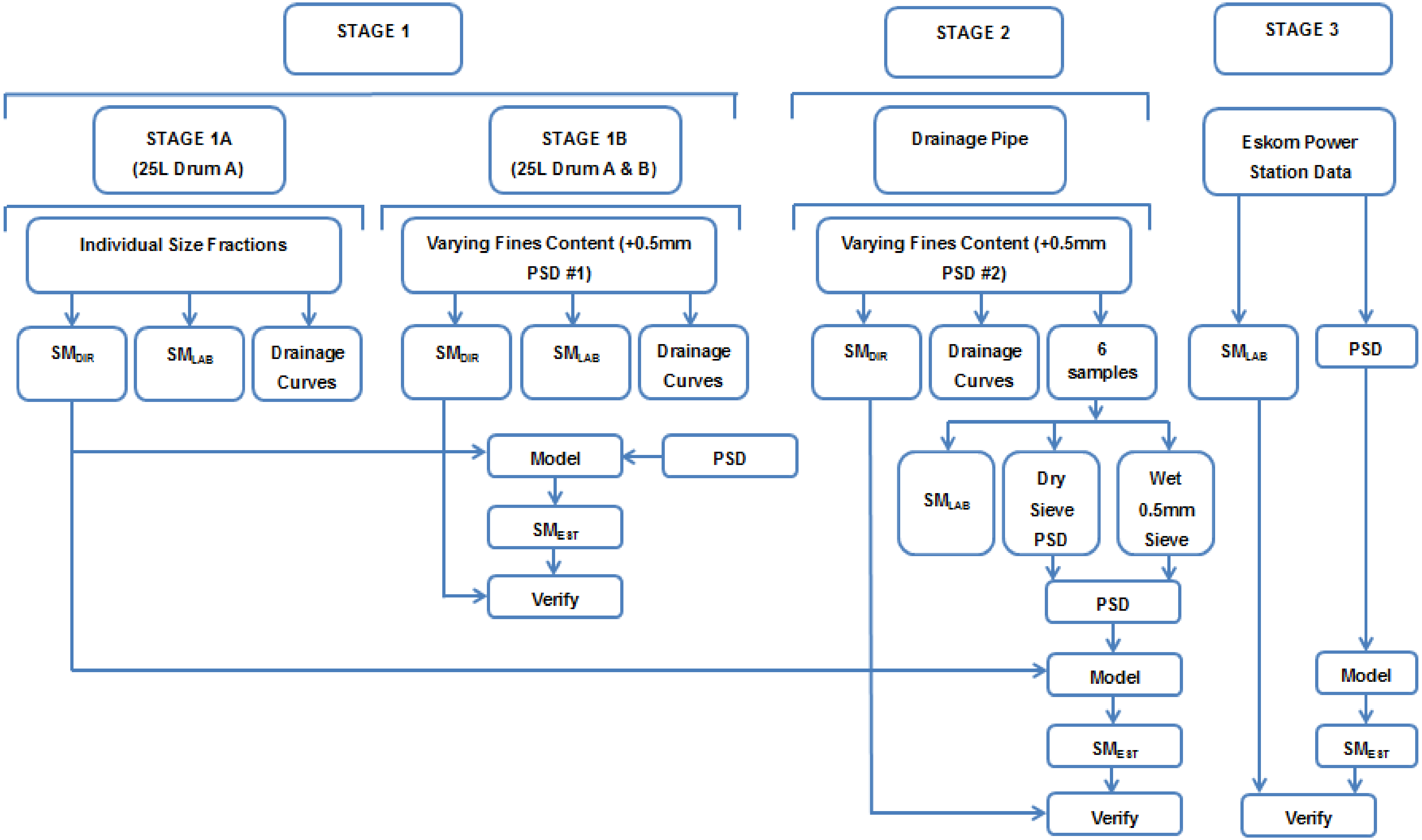


Figure 3-1: Method Diagram

3.1 Experimental equipment

3.1.1 25L drum

The purpose of the 25 litre drum was as follows:

- Compare drainage curves and equilibrium surface moisture content of various size fractions, and more importantly, the fines fraction.
- Establish a relationship between fines content and drainage curves and equilibrium surface moisture content.
- Verify model (equation 1-1) estimates to actual data.

Advantages of the smaller scale experiments were shorter sample preparation time, shorter experimental duration and shorter time needed for sample analysis. While faster turnaround time for experiments was an advantage the question arose of whether the results would hold true when scaled up to the larger drainage pipe. A disadvantage being the fines movement in the short section could not be simulated. Fines movement would be investigated using the drainage pipe.

Two rigs (Drum A and Drum B) were constructed. The rigs were 25L drums each fitted with a 19mm ball valve at the base. The base of each drum was filled with resin at an angle of 1:7 to prevent pooling of moisture at the base. The walls of the drum were lined with 3mm thick polyurethane to prevent corrosion. For Drum A 1mm x 1mm fabric screen was placed over the entrance of the valve so as to reduce the amount of material washing out of the rig. Drum B was built exactly as the first however the fabric screen was not used. This was to determine the effect, if any, the fabric screen had on drainage curves and moisture contents. Figure 3-2 shows the drum suspended from the load cell which is connected to the amplifier which is connected to the data logger. Table 3-2 gives the 25L drum specifications.

Figure 3-2: 25L Drum Set up

Table 3-2: 25L Drum Specifications

Diameter	Height	Volume	Material	Liner	Valve	Empty
287mm	365mm	0.24m^3	Mild Steel	Polyurethane	19mm	6,046kg

3.1.2 Drainage pipe

The purpose of the drainage pipe was as follows:

- Demonstrate fines and equilibrium surface moisture dynamics within an uncompacted composite coal stockpile
- Further verify model (equation 1-1) estimated data to actual data
- Determine scalability from 25 litre drum to drainage pipe

Previous work by other researchers showed that fines movement through a stockpile is not homogenous or linear but occurs in bands or clusters. This effect was not distinguishable in the 25 litre drum.

The design of the drainage pipe (see Figure 3-3) was adopted from experiments done by Quinn & Partridge (1995) and Campbell & Le Roux (2014) and modified slightly. The pipe used by Quinn & Partridge (1995) had an expanded metal base and no sample points (see Figure 2-11). The pipe was purely used to determine fines settling. The pipe used by Campbell & Le Roux (2014) was used to determine moisture retention, vertical moisture profile as well as fines settling (see Figure 2-12). The pipe also utilised an expanded metal base and water passing through the pipe was collected in a bucket sitting on a scale with a data recorder. A known amount of water (20kg) was added to the coal sample inside the pipe. How much surface moisture was retained within the coal was determined by subtracting the amount of water collected in the bucket from the know amount of water added to the coal. The pipe also had three sample points along its length. This allowed samples to be taken to determine the vertical moisture and particle size distribution profile.

Using a pipe design that was used by previous researchers gave the opportunity to build on existing research by confirming their results, expanding the research and improve designs.

The pipe design used by Campbell & Le Roux (2014) was improved in the following ways:

1. The entire pipe plus sample was suspended from a load cell so that the weight could be measured directly (surface moisture could be measured directly). Campbell & Le Roux (2014) determined the water retained in the pipe indirectly by collecting the water in a container resting on a scale connected to datalogger. The amount of water collected was subtracted from the water added to determine the amount of water inside the pipe.

2. Six sample points were used instead of three. This gave a more detailed vertical moisture and fines distribution profile.
3. The base of the pipe was fitted with a cone and ball valve so that the drainage could be controlled if so wished and to better mimic what was used for the 25L drum. Above the cone was an expanded metal base similar to the base used by Campbell & Le Roux (2014).

The pipe was 400mm in diameter, 2m long and made from HDPE. There were six sample points along its length. The base was funnel shaped with a 100mm ball valve at the base. Figure 3-3 shows the drainage pipe set up. The figure shows the six sample points as well as the suspension system. The rig, load cell, amplifier and datalogger are all connected similar to the 25 litre drum (see Figure 3-2). Table 3-3 summarises the drainage pipe specifications.

(a) (b)

Figure 3-3: Drainage Pipe Set Up

When the rig was not in use it rested on its supports. The base of the front supports was hinged at the floor so the rig could rotate. This allowed the pipe to be laid flat if so wished. Figure 3-4 (a) shows the pipe on the floor still connected to its supports and (b) shows a close up of the pipe suspended off its supports.

(a) (b)

Figure 3-4: (a) Pipe on the floor still connect to supports. (b) Pipe suspended off supports

Figure 3-5 shows the perforated steel plate that covered the top of the drainage pipe. The plate ensured that water was distributed evenly through the pipe. Figure 3-6 shows a close up of the suspension bracket.

Figure 3-5: Perforated steel plate

Figure 3-6: Drainage pipe suspension bracket

Coal was added to the top of the pipe whilst the pipe rested on its supports. Roughly 220kg of coal was tested at a time. Once the coal had been added the pipe was unbolted from its supports and suspended from the load cell. A block and tackle was used to raise the pipe off the supports. Water was then added to the pipe from the top. The amount of water added equated to a surface moisture content of 15%. The amount of 15% was chosen after it was noticed from the stage 1A and B results moisture above 15% wasn't retained making completely saturating the sample unnecessary.

When the experiment was completed and samples taken, the base of the pipe (cone and valve) was removed and the coal fell out the bottom. The pipe was then cleaned up and readied for the next test.

Table 3-3: Drainage Pipe Specifications

Diameter	Length	No. Sampling points	Valve Diam.	Material
400mm	2m	6	100mm	HDPE

The logic behind previous researchers using an open base was to not restrict the flow of water through the pipe and best simulate vertical flow through the centre of a coal stockpile. The logic behind the large valve (100mm) used on this pipe was so that water could flow freely but still had the option of closing the valve to control the flow should we wish to. Quinn & Partridge (1995) state that "it was considered that the diameter of the pipe (20 times the maximum particle size) and circular cross section would minimise wall effects, while the bed depth was expected to be sufficient to enable the anticipated fines migration and subsequent concentration into layers to take place". The same logic was applied to the pipe designed for this research.

3.1.3 Load cells

Each rig had its own load cell. This was especially necessary for the 25L drum experiments so that two experiments could be executed simultaneously. For the drums the expected weight range was 18-28kg. Drum A used a 250kg load cell and Drum B used a 100kg load cell. The difference in load cells used was due to availability. For the drainage pipe the expected weight range was 300-350kg. The drainage pipe used a 500kg load cell. The load-voltage calibration was done and found to be accurate. The mass ranges used for the tests were within the mass ranges of the load cells so again little error from the load cell would be expected.

The 100kg and 250kg load cells were calibrated using calibrated weights. Calibrated weights varying from 0.002kg to 33.874kg were suspended from the load cells and the corresponding voltage output recorded. A plot of weight versus voltage output was then plotted to obtain the calibration factor for the load cell. The 100kg and 250kg load cells had sensitivities of 0.01997kg/mV and 0.02515kg/mV respectively.

For the 500kg load cell a tension machine was used. Loads of 50kg increments were applied. At each 50kg increment the corresponding voltage output was recorded. As with the 100kg and 250kg load cells, the millivolt output corresponding to each load increment was then plotted to obtain the calibration coefficient. The 500kg load cell had a sensitivity of 0.051kg/mV. Figure 3-7 shows the load cell with shackles.

Table 3-4 summarises all the load cell calibrations.

See Appendix B for load cell calibration curves.

Table 3-4: Load cell Calibrations

	Drum B	**Drum A**	**Drainage Pipe**
Load Cell	**100kg**	**250kg**	**500kg**
Load Cell calibration	19.97x+70.28	25.15x-505.70	51.00x-0.928
Weight range used for	0.450 to	0.450 to 33.874	50.971 to
Sensitivity (kg/mV)	0.01997	0.02515	0.0051

Figure 3-7: Load Cell with shackles

3.1.4 Amplifier

The same amplifier was used for all tests (see Figure 3-8) and served two purposes:

1. Provide power to the load cell.
2. Convert microstrain reading to a voltage reading.

See Appendix B for amplifier technical specs.

Figure 3-8: Amplifier

3.1.5 Datalogger

The same datalogger was used for all tests (see Figure 3-9). The datalogger was capable of receiving two voltage signals from two load cells simultaneously. This made it possible to execute two tests at the same time using the 25L drums. The recording interval of the datalogger could also be varied. The options were 1sec, 1min and 10min. Data was downloaded in CSV format and then opened in EXCEL.

See Appendix D for datalogger technical specs.

Figure 3-9: Datalogger

3.1.6 Samplers

Six samplers were constructed out of PVC piping. The samplers were used to take samples from the drainage pipe sample points. Each sampler was 100mm in diameter, 500mm in length with handles fitted 100mm from the base. The ends of the samplers were cut at a 45° angle. See Figure 3-10.

(a) (b) (c)

Figure 3-10: Sampler

3.2 Sample preparation

3.2.1 Stage 1

Stage 1A

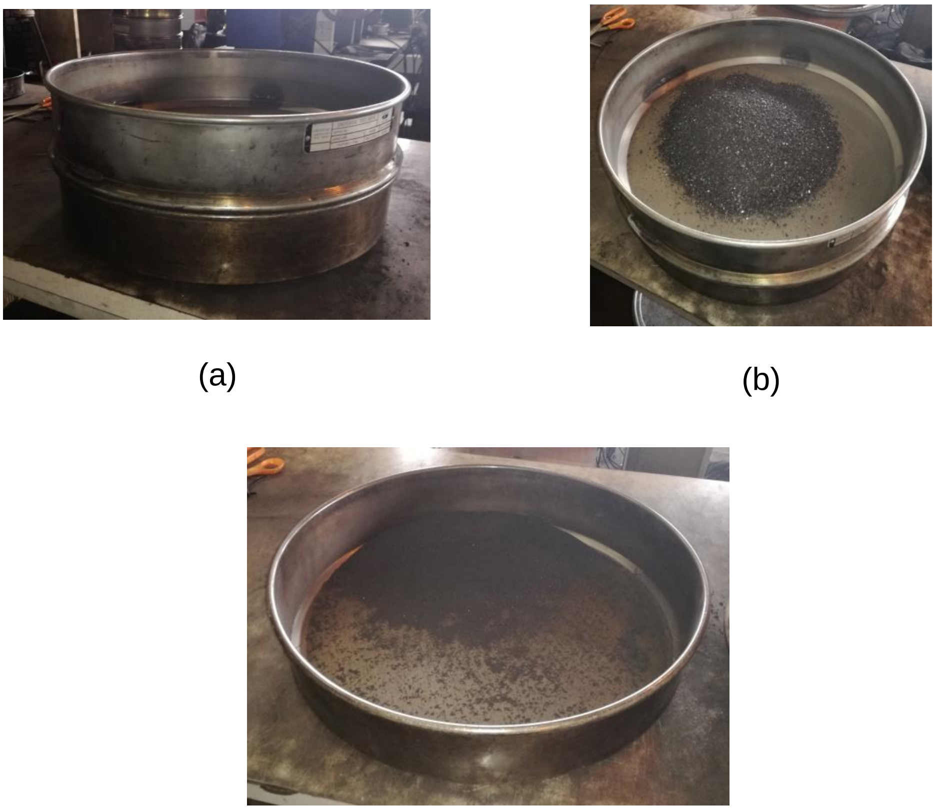
Stage 1A testing was only done using Drum A and the samples were only single size fractions (see Figure 3-1). The coal used in all experiments (Stage 1 and 2) was from the same source to mitigate the effect varying coal qualities might have on surface moisture. The as-received coal was delivered in plastic bags that were closed with cable ties. The as-received coal was a composite mixture of different size fractions. Figure 3-11 shows the as-received coal in bags (a) and the composite mixture of the coal size fractions (b).

(a)

(b)

Figure 3-11: As-recieved coal

For Stage 1 a dry sieve was initially used to remove most of the -500µm material. A dry sieve was done using a 500µm sieve (450mm diameter). All the material less than 500µm in size passed through the sieve and collected in the pan below the sieve. Figure 3-12 (a) shows the 500µm sieve fitted to the pan. Composite coal was added to the top of 500µm sieve (Figure 3-12 (b)) and manually shaken until all the -500µm material has passed through and collected in the pan. Figure 3-12 (c) shows the -500µm material collected in the pan.



(a) (b) (c)

Figure 3-12: Dry Sieve

A wet sieve was then performed on the +500µm material. The purpose of the wet sieve was to remove fines attached to the coarser material as these fines could have an effect on drainage and moisture retention. A wet sieve is the same as a dry sieve except the +500µm material that is left over from the dry -500µm sieve is manually washed with water to remove fines adhering to the coarser material.

The wet sieve was performed by fitting a 500µm sieve over a 200L drum and manually washing 2kg of coal at a time. It was assumed that all the fines had been removed once the water started to run clear (See Figure 3-13). The +500µm washed fine coal was then air dried in the sun until visibly dry (at this point drying according to a standard was not necessary), collected and sized into different size fractions. The size fractions are shown in Table 3-5.

Figure 3-13: Wet Sieve Set up

The wet -500µm fine coal was then dried and collected. A Malvern particle size analysis was done on the washed -500µm material and it was found to be finer than the dry sieve -500µm material. Figure 4-3 shows how the -50µm size fraction increased from about 50% to 65% when combining the fines collected from the wet sieve to the fines collected from the dry sieve. This meant that the combined dry and wet size -500µm PSD (which was the as-received case) was finer than just the dry -500µm sieve alone. The ratio of the mass of fines collected from a dry sieve to the mass of fines collected from a wet sieve was found to be 77:23. It was decided that since the combined dry and wet sieve material was finer than the dry sieve alone, the ratio would be maintained when preparing the composite samples.

Once the +500µm coal had been washed and air dried to remove any surface moisture it was sized into nine different size fractions (see Table 3-5). Each size fraction was used for separate tests to characterise their drainage characteristic and equilibrium surface moisture content. The -500µm size was very difficult to wet and drain and thus no testing was done on the -500µm size fraction. For this reason equilibrium surface moisture content was used from Cumming (2003). The particle size distribution reporting in Eskom only uses four size fractions (Table 2-2). In order to obtain a more comprehensive particle size/equilibrium moisture content relationship it was decided to increase the amount of size fractions used. The sizes chosen were not in accordance with an industry standard for coal particle size classification as reporting varies from place to place. The size of each sample was 20kg.

Table 3-5: 25L Drum Size Fraction Samples

Size Fraction (mm)							
+19	-19+10	-10+6	-6+4.75	-4.75+3	-3+2	-2+1	-1+0.5

Stage 1B

For the Stage 1B sample preparations the same process of cleaning and sizing the coal was used as in Stage 1A.

The individual size fractions were then mixed in constant proportions for each sample to ensure the +500µm size distribution was constant. This was PSD1. To ensure the samples were representative of an as received coal the +500µm PSD used was the same as the PSD of the as received coal.

To prepare each sample the required mass of each size fraction was added to a 30kg plastic bag and then split three times in a 100kg rotary splitter to ensure a homogenous mixture of the different size fractions. Duplicate samples were prepared for Drum A (Net) and Drum B (No Net). Thus, a total of 22 samples were prepared. Table 3-6 shows the samples prepared for stage 1B.

Table 3-7 and Figure 3-14 show the particle size distribution used for the stage 1B samples. For the detailed particle size distributions of each sample see Appendix E.

Table 3-6: Stage 1B Samples

	Fines content used for each sample (%)										
Sample	0	1	2	3	4	5	6	7	8	9	10

Table 3-7: Percentage in size interval for PSD1 (as a fraction of the total +500µm material)

Size fraction (mm)	+19	-19+10	-10+6	-6+4.75	-4.75+3	-3+2	-2+1	-1+0.5
Percentage of +500µm (%)	5.43	25.18	23.56	14.03	13.25	8.69	7.00	2.86

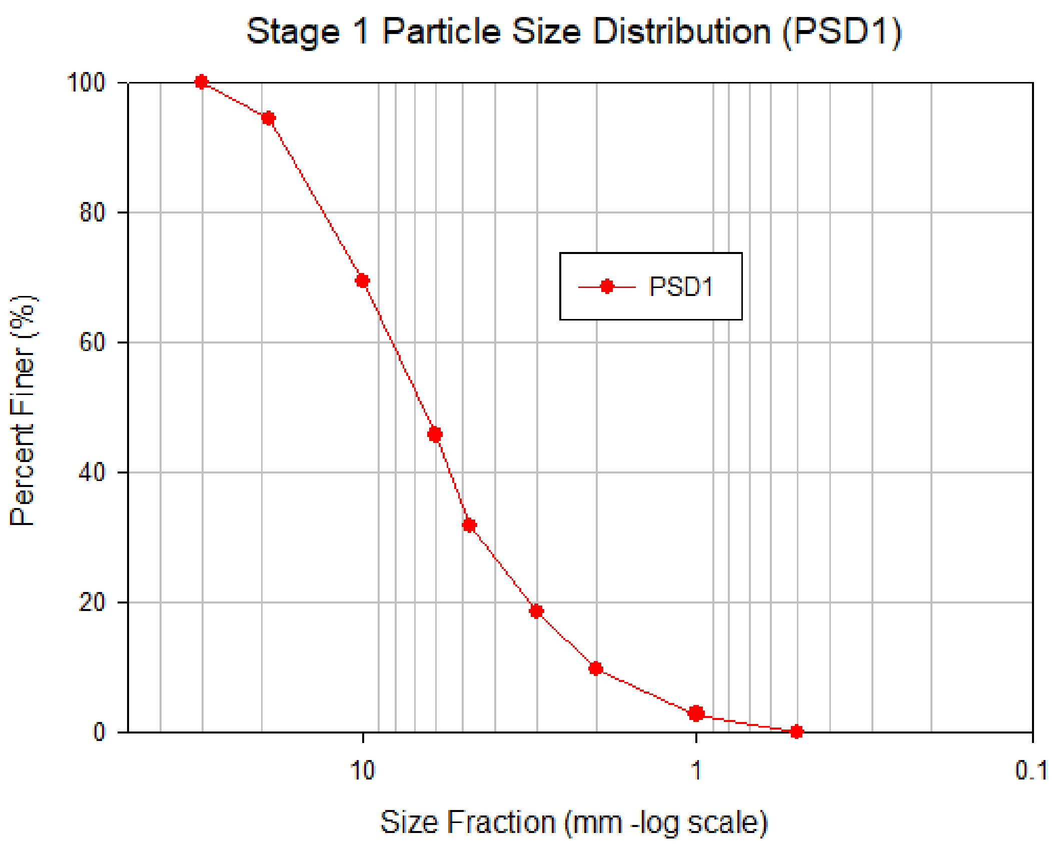


Figure 3-14: Stage 1B Particle Size Distribution (PSD 1)

3.2.2 Stage 2

The Stage 2 method of sample preparation was the same as for Stage 1B except the +500µm PSD2 (excluding the fines content) was used (see Appendix G for PSD1 and PSD2 comparison), the sample size was larger (200kg-230kg) and there were fewer samples (seven in total) each with a different fines fraction.

Since the sample sizes were large, and time consuming to prepare, the available coal was divided so as to reduce the amount of coal that had to be reused. Reusing coal meant washing, drying and sizing which was time consuming. This meant the +500µm PSD changed slightly compared to the PSD used in stage 1B. Since there was 821kg left after stage 1, four samples of roughly 200kg each could be prepared.

Thus, PSD2 was derived by dividing each available size fraction by four, giving the mass of each size fraction required for the sample. This meant coal had to be reused three times to make the seven samples. Each time a sample was prepared the coal was washed to ensure the exact amount of fines was in the sample.

Table 3-8 and Figure 3-15 show the PSD2. For detail size distributions of each sample see Appendix F.

Table 3-8: Percentage in size interval for PSD2(as a fraction of the total +500µm material)

Size fraction (mm)	+19	-19+10	-10+6	-6+4.75	-4.75+3	-3+2	-2+1	-1+0.5
Percentage of +500µm (%)	5.17	19.93	17.67	12.78	13.85	12.54	11.56	6.50

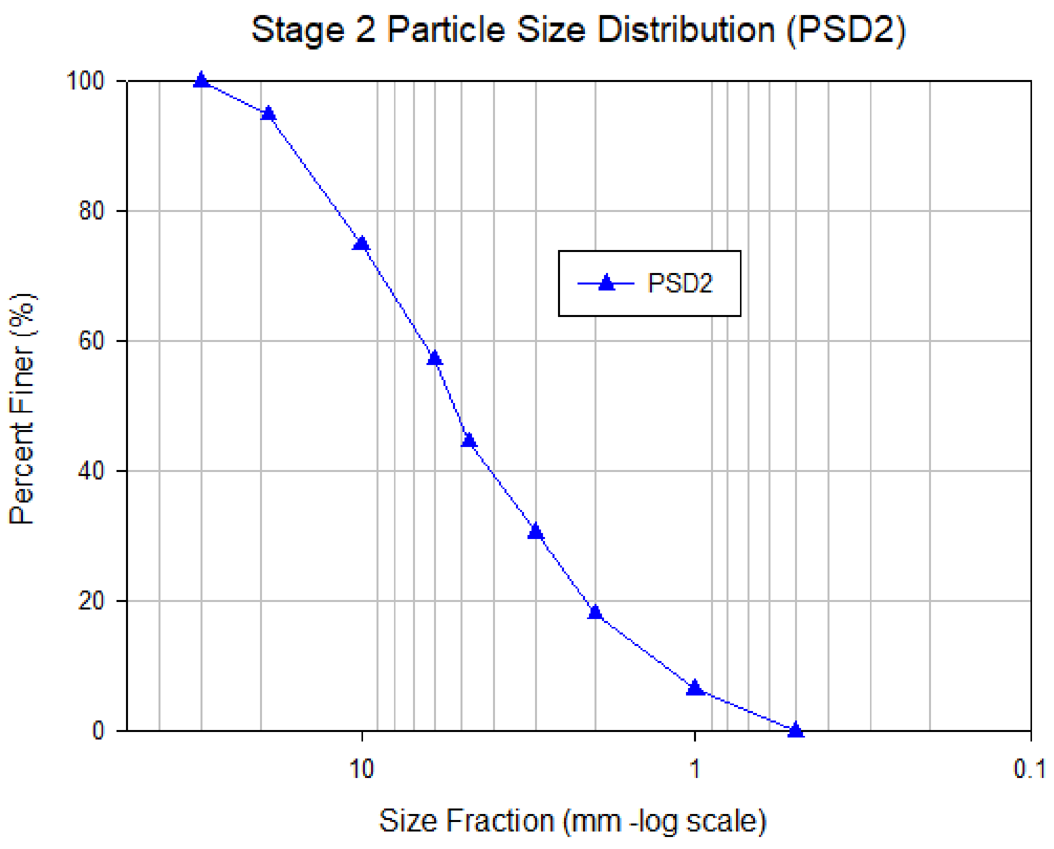


Figure 3-15: Stage 2 Particle Size Distribution

For each sample the required mass of each size fraction was added to ten 30kg plastic bags to make up one roughly 200kg sample. These bags were then split three times in a 100kg rotary splitter to ensure a homogenous mixture of the sample. A total of seven samples were prepared. The samples prepared are shown in Table 3-9.

Table 3-9: Stage 2 Samples

	Fines Content (%)						
Sample	10 (test run)	0	2	4	6	8	10

Unlike Stage One where the samples were completely saturated, the amount of water added to the stage 2 samples was equal to 15% moisture content for each sample. See Appendix F for amount of water added to each sample.

3.3 Test procedure

3.3.1 Stage 1A and 1B

For stage 1 testing the following was analysed (refer to Figure 3-1 for test summary):

- Drainage curves
- Direct equilibrium surface moisture content (SM_{DIR}) (it is assumed that the inherent moisture content does not change throughout each test)
- Surface moisture (SM_{LAB})
- A Malvern analysis was performed on the -500µm material to determine the particle size distribution of the fines (stage 1A only)

(See Appendix I for analysis procedure)

For each test the process was as follows (refer to Figure 3-1 for test summary):

1. The empty drum (Either drum A or B depending on the test) was suspended from the load cell and the datalogger set to record every second. The datalogger was recorded for 60 seconds.
2. Coal was then added to the drum. The drum was again suspended and the datalogger recorded for 60 seconds.
3. Whilst suspended, water was added to the drum filled with the coal. The water was added so as to just cover the top of the coal and completely saturate the sample. Again, the datalogger was set to record for 60 seconds.
4. After the 60 seconds, sometime was allowed before starting the test. This was to place a "marker" in the data to more easily establish during data analysis when the test had started.
5. The datalogger was again set to record every second and started. At the same time the ball valve was fully opened and water allowed to drain into a collection bucket. When the drainage slowed to a drip the datalogger was set to record every ten minutes and allowed to record for a maximum of 72 hours. At this point it was assumed equilibrium moisture had been reached. .

3.3.2 Stage 2

For stage 2 testing the following was analysed (refer to Figure 3-1 for test summary):

- Drainage curves
- Direct equilibrium moisture content (SM_{DIR}) (it is assumed that the inherent moisture content does not change throughout each test)
- Surface moisture (SM_{LAB})

(See Appendix I for analysis procedure)

For each test the process was similar to that of Stage 1. The only difference being the valve was left open and instead of completely saturating the sample, water equating to 15% surface moisture content was added. This differed to the amount of water added by Quinn & Partridge (1995) and Campbell & Le Roux (2014) (see section 2.4). The former continuously ran water through the pipe whereas the latter simply added 20litres of water to the top of the pipe for each test.

3.3.3 Stage 3

For stage 3 the model (equation 1-1) was used to estimate the equilibrium surface moisture of 90 historic mill feed samples from five different power stations and various units. The physical sampling and testing of the 90 samples was not done as part of this research. The data was obtained from the power stations. The dates, units and mills they were taken from are shown in Appendix T.

How a power station typically operates is that coal is received from various mines and then stacked onto live piles at the coal stockyard. The moisture in the live pile coal either comes from the mine or from being exposed to rain. The coal is then reclaimed and transported to the power station via conveyors where it passes through transfer points (chutes), silo's and bunkers. From the bunkers the coal is fed into the mills via the mill feed scraper conveyors. The grab samples, which are routinely taken by the power stations, are roughly 1kg in size. The size distribution and surface moisture of each sample was determined in a laboratory (SM_{LAB}). The size distribution from these samples was used in equation 1-1 to estimate the surface moisture (SM_{EST}).

4 Results

4.1 Stage 1A

For stage 1A nine different size fractions were tested. To ensure no fines were present the samples were washed (wet sieve). Once the change in surface moisture content was less than 2% over 12 hours the sample had reached its equilibrium surface moisture content.

The drainage tests results showed that as the size fraction decreases the equilibrium surface moisture increases. Figure 4-1 shows the surface moisture obtained from a mass balance with the assumption that inherent moisture content remains constant throughout the test.

The laboratory surface moisture was determined by drying the coal outside in the sun on plastic bags. When the coal was visibly dry it was collected and weighed to determine the moisture lost. This was done to reduce the time needed for surface moisture analysis.

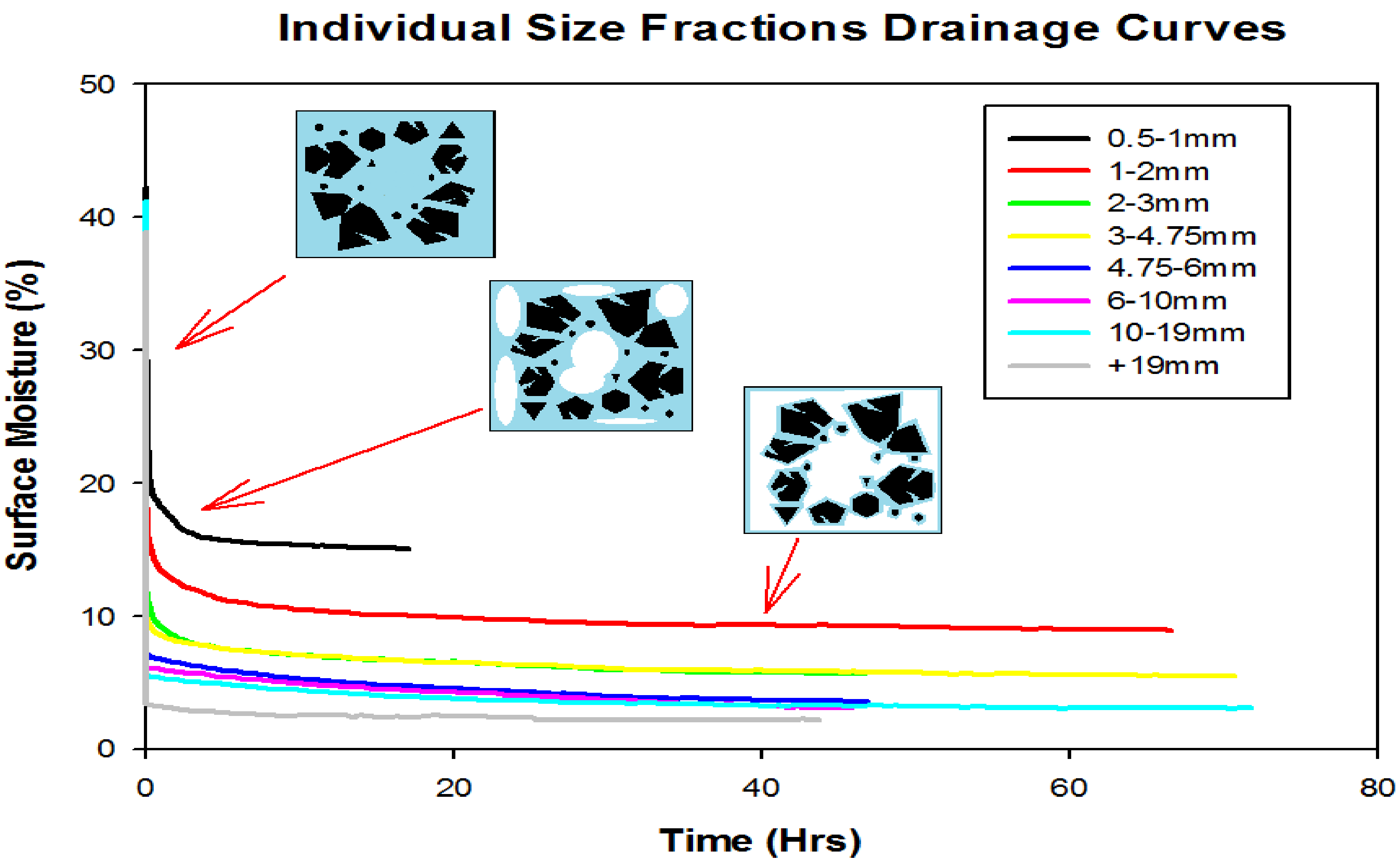


Figure 4-1: Drainage Curves of Individual Size Fractions

The equilibrium surface moisture values were plotted against the geometric mean on the size fractions. Figure 4-2 shows the equilibrium surface moisture (mass balance and laboratory determined surface moisture) tends to reach an asymptote of around 2.3% which implies there is a limit to the lowest equilibrium surface moisture that can be reached as the particle size increases.

The SM_{DIR} was used as it was deemed more reliable than the SM_{LAB} results. The reason for this is that to determine the SM_{LAB} results the samples were handled a lot as well as dried outside. This gave rise to material being lost during handling and different drying conditions due to weather variations at the time of drying. Below a size fraction of 2-3mm there is marked increase in surface moisture. This is due to specific surface area increasing drastically (more surface area for surface moisture to adhere to) as well as pores becoming smaller thus increasing the capillary effect.

Using Sigmaplot 12.5 various regressions were used to determine the best fit. A five parameter exponential decay regression was used as it had the highest R^2 value of one. The size fraction/surface moisture relationship was:

$$SM = 2.88 + 6.5e^{-0.31\delta} + 26.96e^{-1.89\delta} \quad (4\text{-}1)$$

Where,

δ = geometric mean of size fraction

This empirical relationship (equation 4-1) is later used in the model (equation 1-1) to estimate the surface moisture of a coal sample based on its particle size distribution.

Table 4-1 summarises all the moisture results obtained for stage 1A.

Table 4-1: Stage 1A Moisture Results

Size Fraction (mm)	GeoMean (mm)	SM_{LAB} (%)	SM_{DIR} (%)
+19	19.00	1.48	2.59
10-19	13.78	2.48	3.38
6-10	7.75	3.94	3.4
4.75-6	5.34	-	3.83
3-4.75	3.77	5.37	5.5
2-3	2.45	6.64	5.67
1-2	1.41	7.20	9.25
0.5-1	0.71	26.03	15.05
<0.5	-	-	*29

-Data is missing *Adopted from Cumming (2003)

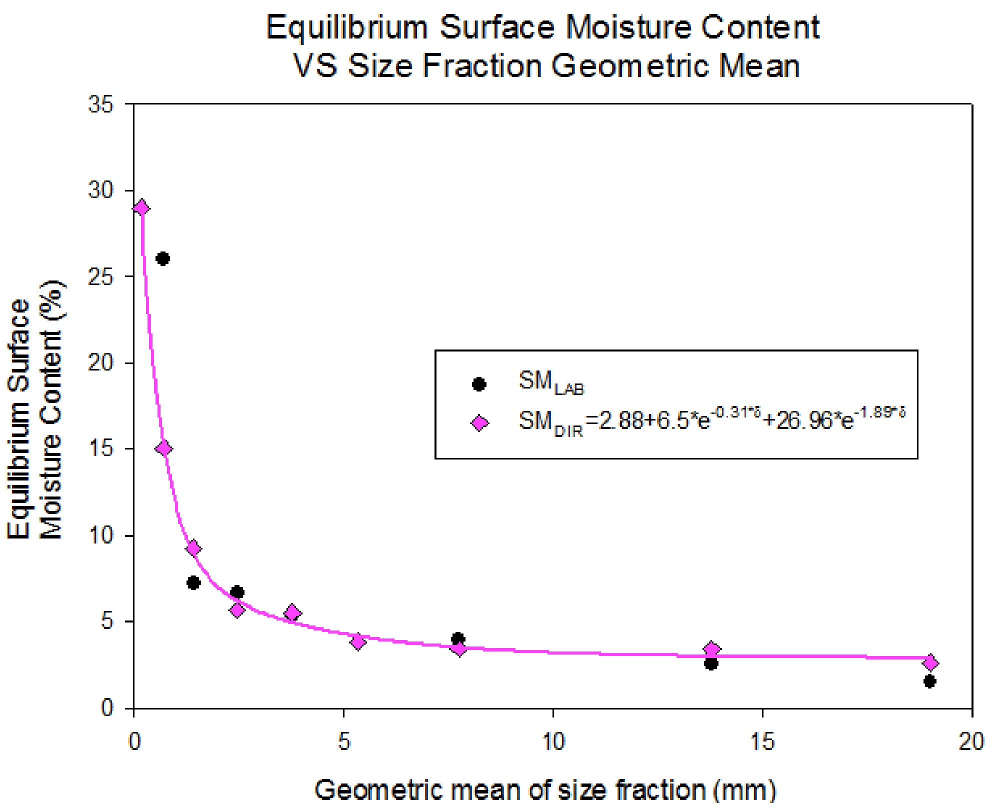


Figure 4-2: Stage One Equilibrium Surface Moisture Content versus Geometric mean of Size Fraction

During the sample preparation process it was noticed that a significant portion of the fines cling to the coarser material. To ensure that these fines did not influence the drainage and equilibrium surface moisture they were removed by washing (wet sieve) and mixed back in during the sample preparation. The proportion of fines obtained from the dry sieve to the fines obtained from a wet sieve was found to be 77:23. The significance of this is that it may have an effect on the results. In order to know the true fines content a wet sieve must also be done. This ratio was determined for all stage 2 samples to see how it varied. The results are shown in section 4.3.3.

A Malvern analysis was done on the fines obtained from a dry sieve and wet sieve and the results plotted on a log scale graph to show the particle size distribution. Figure 4-3 shows how the -50µm size fraction makes up a significant portion of the fines. For the dry sieve the -50µm size fraction makes up 50% of the -500µm size fraction. This increased to about 65% for a wet sieve since all the finer material is washed off the coarser material. The practical significance of the 50µm size fraction is that there are industrial screens which can remove the 50µm size fraction. By implementing these screens Eskom may reduce its fines content by 50-65%.

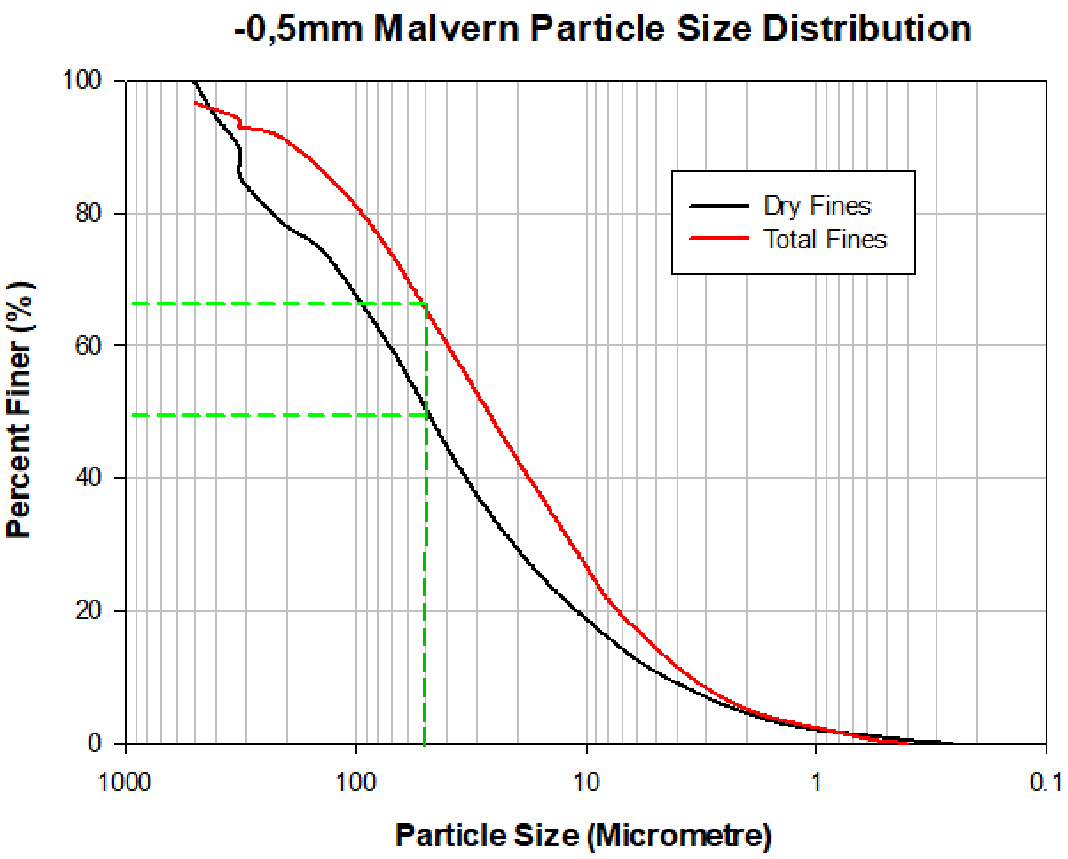


Figure 4-3: -500µm Particle Size Distribution

4.2 Stage 1B

4.2.1 Drainage curves

The drainage curves were determined as in stage 1A where water was added until the coal was completely covered. The discharge was then opened and water allowed to drain. Figure 4-4 and Figure 4-5 show the test results. The figures only show the drainage from 15% onwards and not the actual starting point which was the saturated moisture content. As the fines content increased the drainage curves resulted in a higher equilibrium surface moisture contents. The curves don't follow a perfect expected sequence but do well to demonstrate the effect of fines on drainage. Possibly fines were generated during sample preparation handling which could skew the results. Repeated tests would clarify this. The drum A curves plotted similar to the drum B results. This indicates how the random settling of fine particles can reduce drainage and increase equilibrium surface moisture content. This random settling factor can result in higher equilibrium surface moisture content for samples with lower fines content. The general trend, however, is that an increase in fines results in an increase in equilibrium surface moisture content.

For both drums only the samples with fines content of 5% and less managed to drain to a moisture content of less than 6%.

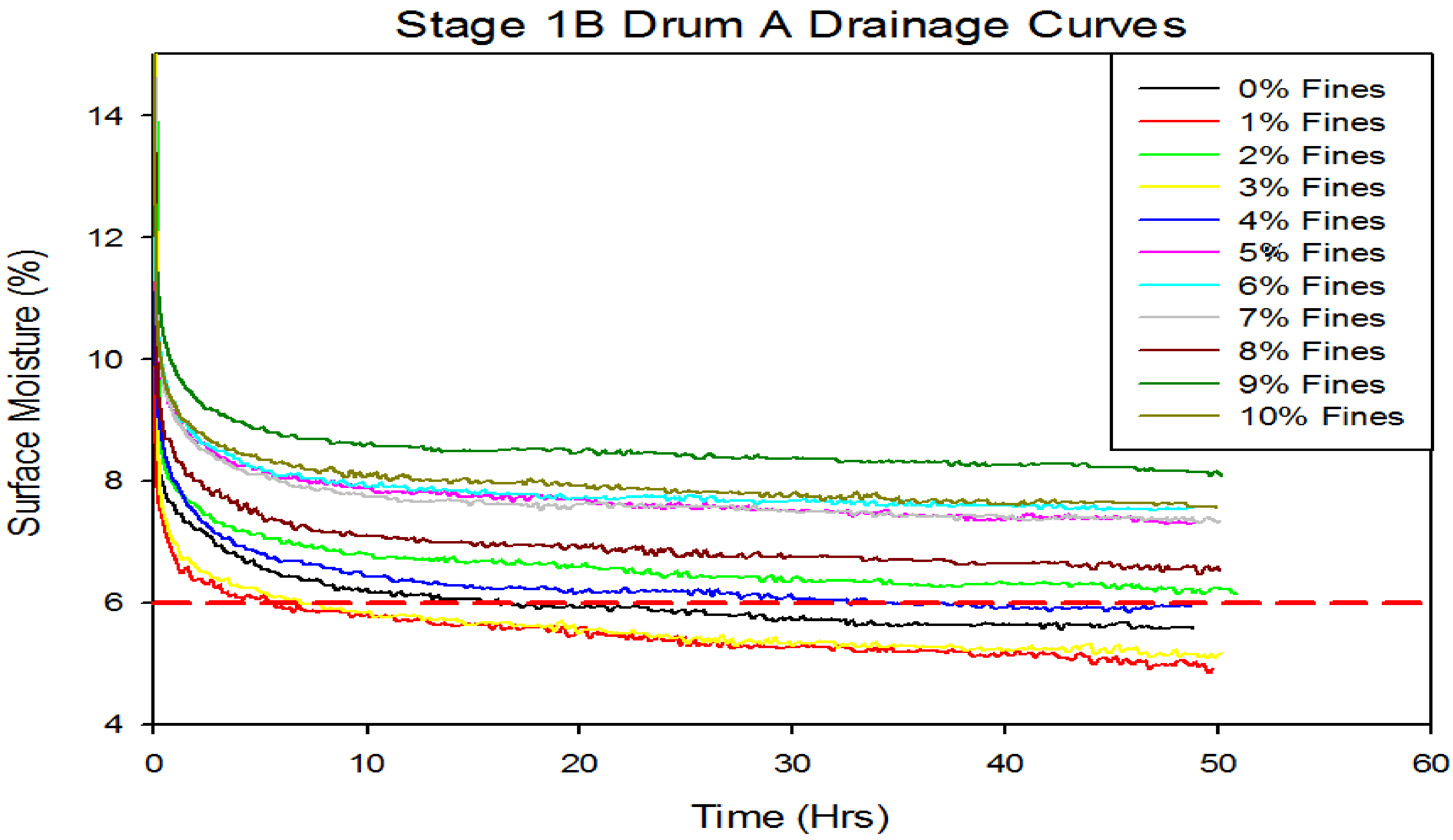


Figure 4-4: Stage 1B Drum A Drainage Curves

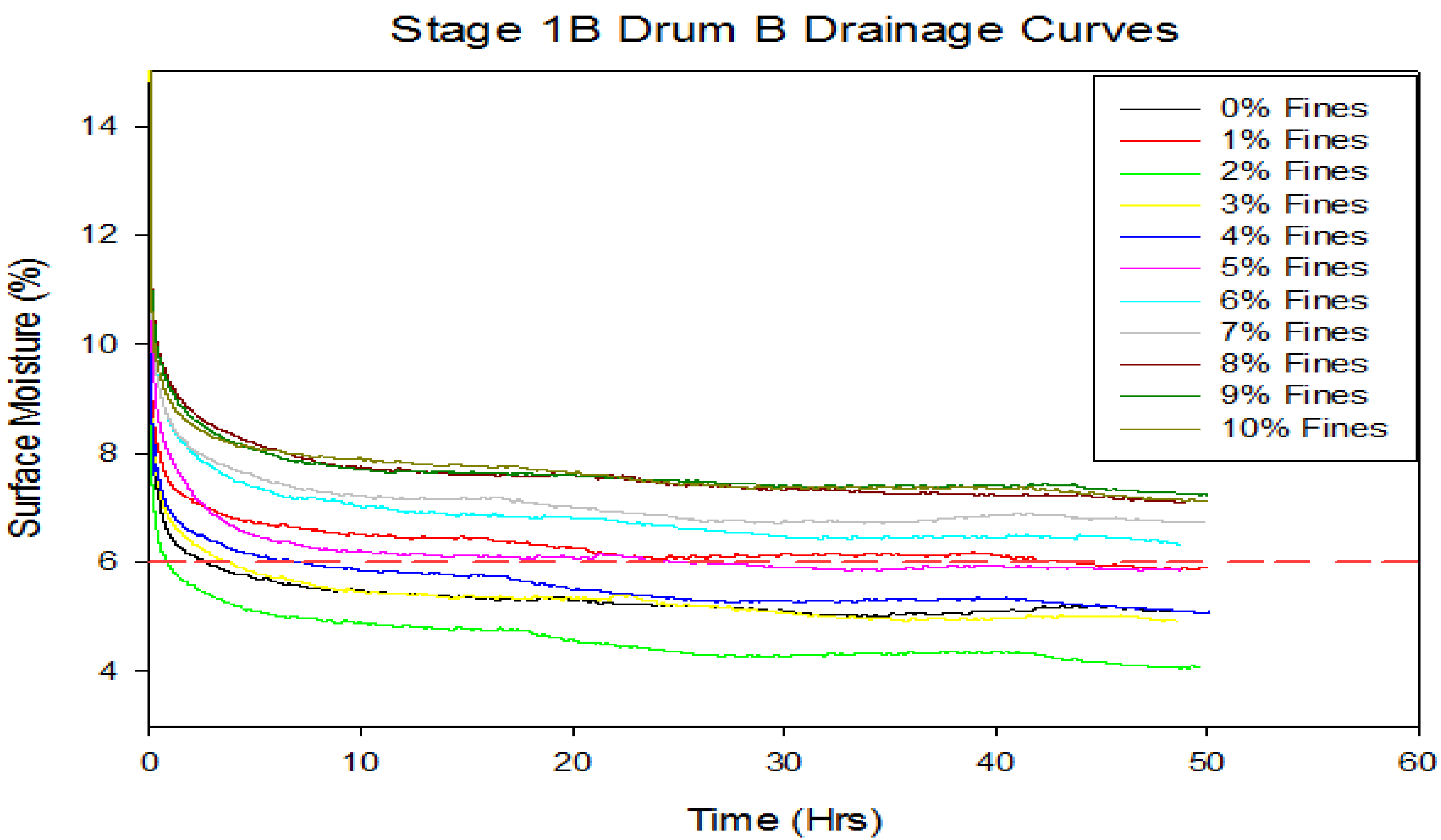


Figure 4-5: Stage 1B Drum B Drainage Curves

4.2.2 Surface moisture

Drum A

For drum A the SM_{LAB} and SM_{DIR} best fit regressions between the surface moisture and fines content were believed to be linear. These regressions were practically the same (see Figure 4-6). For both regressions low R^2 values were obtained (0.52 and 0.67 for SM_{LAB} and SM_{DIR} respectively). The cause for the variability in the SM_{DIR} data is the presence of the net. It is believed the combination of the net and fines increased the final surface moistures by randomly blocking the net and restricting flow. This is discussed further in the discussion section 5.1. The variability in the SM_{LAB} data is due to the way the sample was analysed. In order to fast-track the drying process and obtain a SM_{LAB} result the coal was dried in the sun on plastic packets. This resulted in increased handling of the samples. Excessive handling of coal increases the chances of coal being lost (not all the coal being collected back into the sample bag) and affecting the results. Lost coal would skew the result by increasing the surface moisture that is determined. This is discussed more in section 5.2.

Table 4-2 summarises the moisture results from the stage 1B drum A tests.

Table 4-2: Stage 1B Drum A Moisture Results

Fines (%)	SM_{LAB} (%)	SM_{DIR} (%)	SM_{EST} (%)
10	8.37	7.62	7.00
9	7.06	8.44	6.76
8	7.32	6.53	6.51
7	6.95	7.57	6.27
6	*	7.74	6.02
5	6.56	7.43	5.77
4	*	5.93	5.53
3	5.10	5.23	5.28
2	5.28	6.16	5.04
1	6.47	5.21	4.79
0	6.57	5.58	4.55

*Data Missing

Figure 4-6 shows the SM_{LAB} and SM_{DIR} results.

An important point to take from the figure is the fines content at which equilibrium surface moisture content reaches 6%. From this data, for the coal to be able to drain to a surface moisture of 6% and less it would have to have a maximum fines content of between 1.75-2.57%.

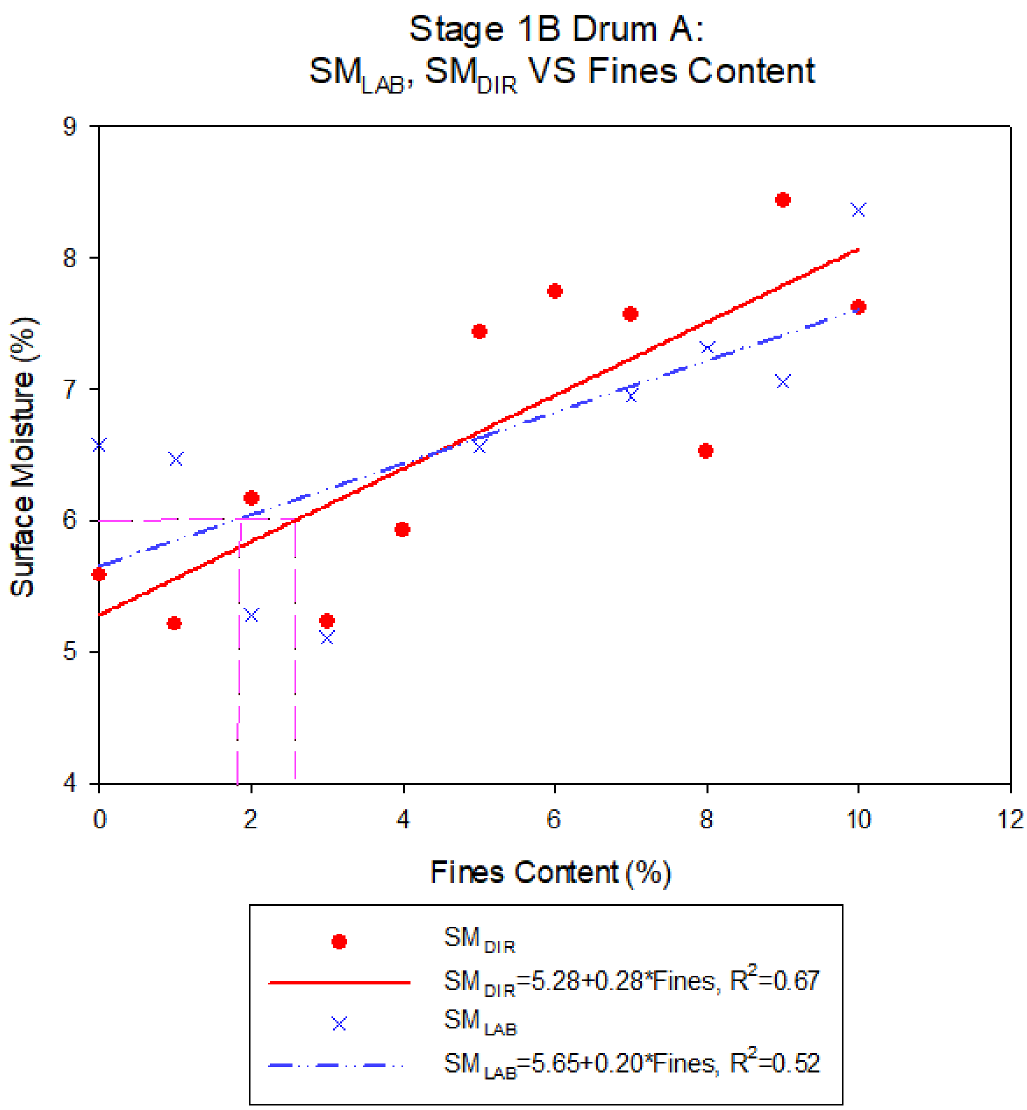


Figure 4-6: SM_{LAB} VS SM_{DIR} (Stage 1B Drum A)

The material that passed through the discharge was collected and quantified. Figure 4-7 shows that on average 24.48g less coal passed through with the net in place (drum A) compared to having no net (drum B). The amount of coal passing through was more consistent with the net than without.

For both drums the amount of coal passing through was negligible with regard to the total sample mass. The largest quantity of material that passed through was 80 grams for the drum B 5% run. This only accounted for 0.55% of the total mass of 14.632kg.

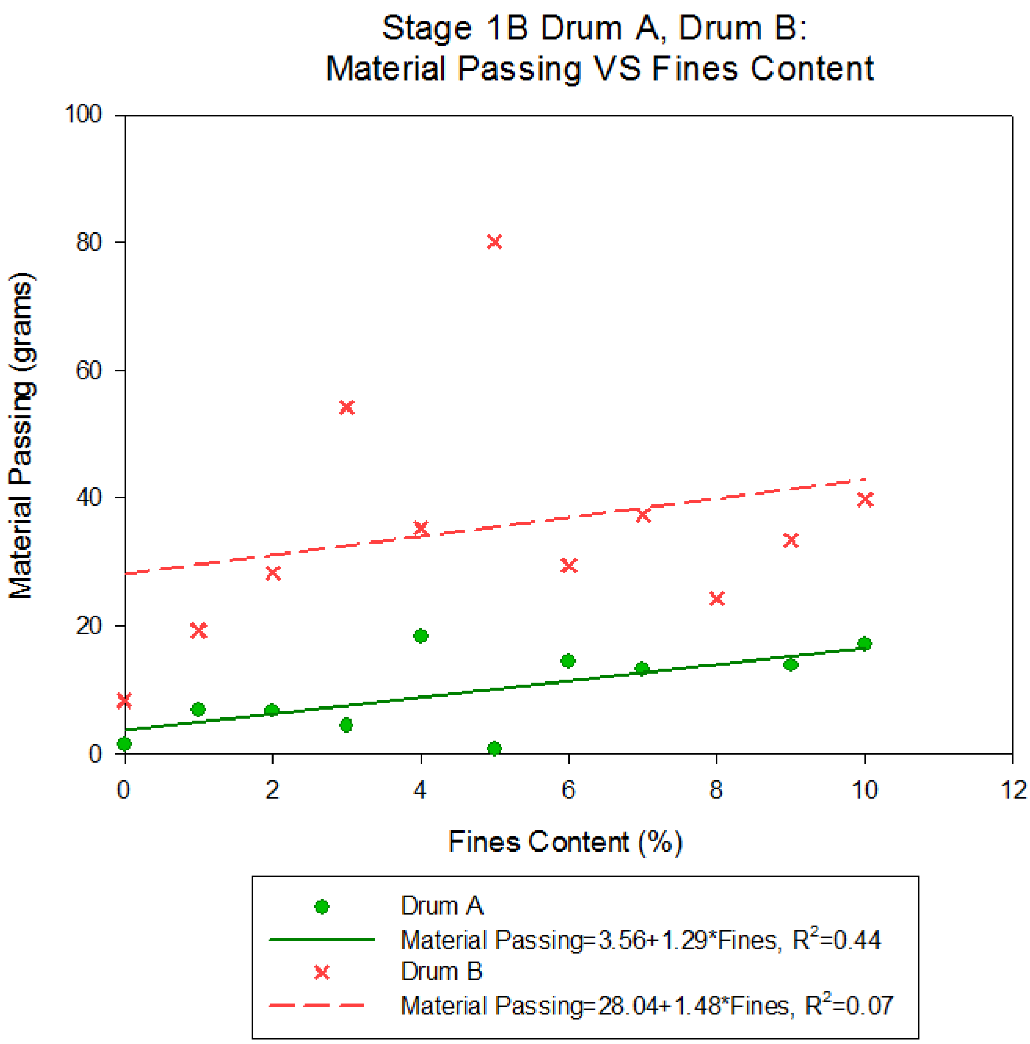


Figure 4-7: Material Passing (Drum A VS Drum B)

Using the empirical relationship (equation 4-1) as input into the model (equation 1-1) the surface moisture content of each sample was estimated. As stated in section 4.1 a maximum surface moisture was defined as 29%. In order for equation 4-1 to produce this value of 29% the lowest size fraction used is +50-500µm (see Table 3-1 as an example). Plotting each estimated surface moisture content value against its corresponding fines content returned a straight line regression very similar to the regressions returned by the lab and directly measured surface moisture contents. Figure 4-8 shows that the estimated regression estimates the surface moisture content about 1% lower than the lab and directly measured values.

For the surface moisture estimation regression a fines content of greater than 6% would not result in a surface moisture content of less than 6%.

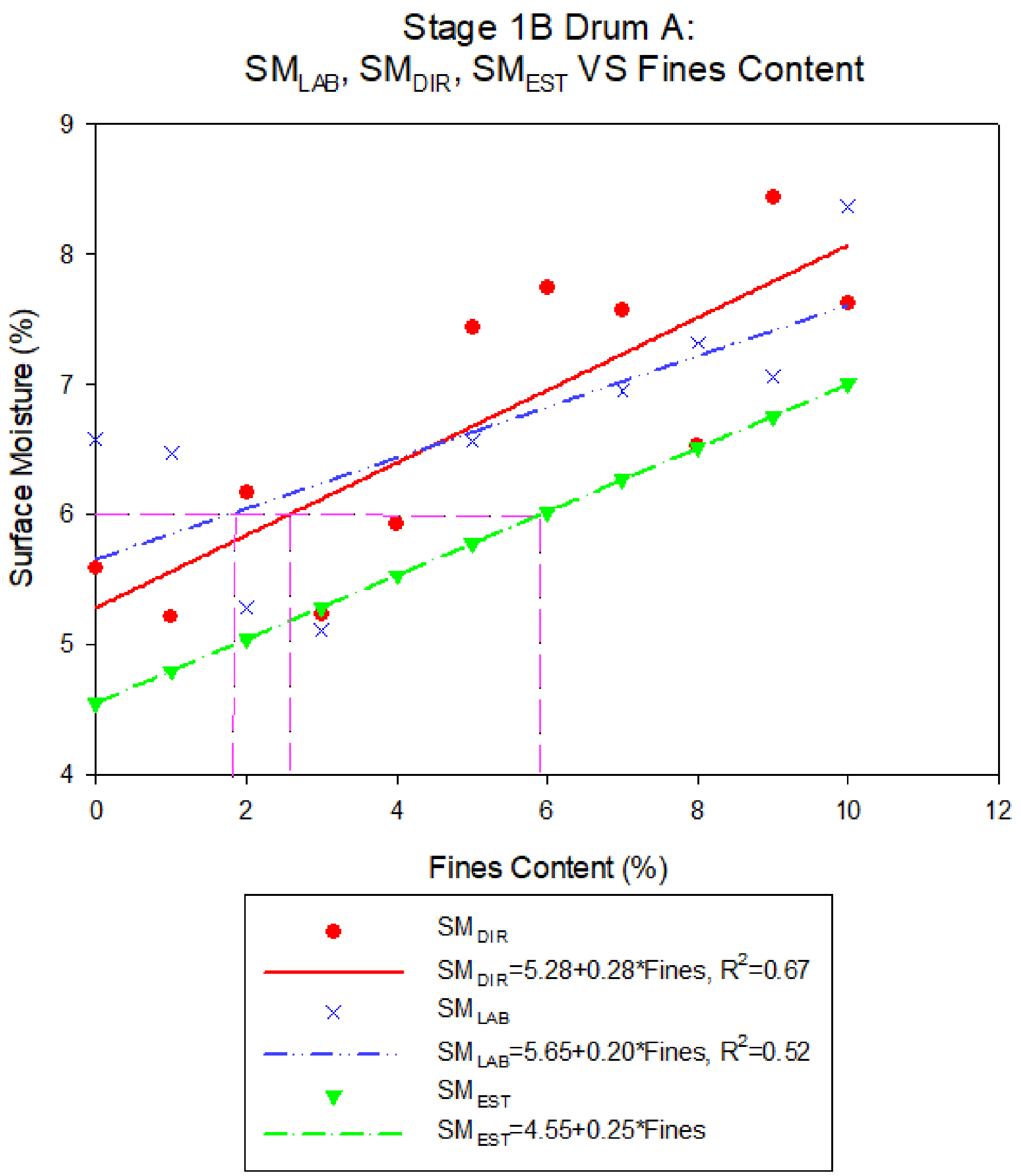


Figure 4-8: Stage 1B Drum A SM_{DIR}, SM_{LAB} and SM_{EST}

Drum B

The SM_{LAB} and SM_{DIR} best fit regressions (Figure 4-9) did not match to each other as well as the results for drum A (Figure 4-6), although the drum B SM_{DIR} data did fit better than the drum A SM_{DIR} data when comparing R^2 values. The better SM_{DIR} R^2 value is attributed to the lack of the net. As previously stated it is believed the combination of fines content and the net increased the final surface moisture by blocking the net and reducing the flow. It is suspected that the blocking of the net would be random and thus result in a greater scatter of results (see section 5.1 for further discussion).

The SM_{LAB} results had a high variability similar to the SM_{LAB} results from drum A (Figure 4-6). Again, this high variability is believed to be as a result of coal being lost during excessive handling.

The data shows for a maximum surface moisture content of 6% the fines content must be less than 3.2-4.63%.

Table 4-3: Stage 1B Drum B Surface Moisture Results

Fines (%)	SM_{LAB} (%)	SM_{DIR} (%)	SM_{EST} (%)
10	7.45	7.36	7.00
9	7.08	7.39	6.76
8	6.65	7.11	6.51
7	7.12	6.75	6.27
6	5.86	6.38	6.02
5	7.70	6.05	5.77
4	5.81	5.32	5.53
3	5.85	4.94	5.28
2	5.31	4.35	5.04
1	5.01	6.12	4.79
0	6.05	5.11	4.55

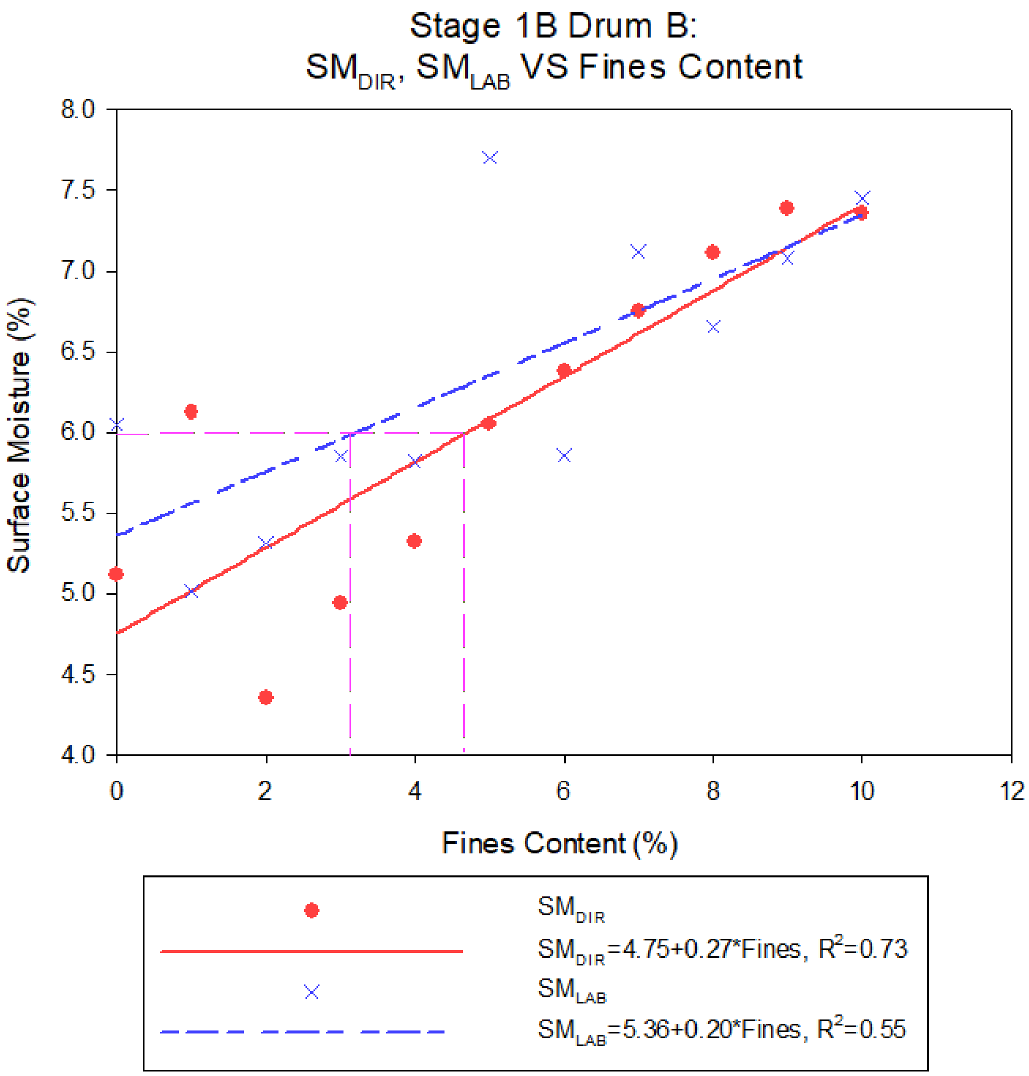


Figure 4-9: SM_{LAB} VS SM_{DIR} (Stage 1B Drum B)

The amount of material passing through the discharge pipe was more than in drum A as seen in Figure 4-7 but still negligible compared to the total sample size.

Figure 4-10 compares the SM_{DIR} of drum A and B. The two regressions run parallel to each other with the drum B values being 0.53% lower than drum A. This indicates that the net in drum A consistently increased the surface moisture by 0.53%.

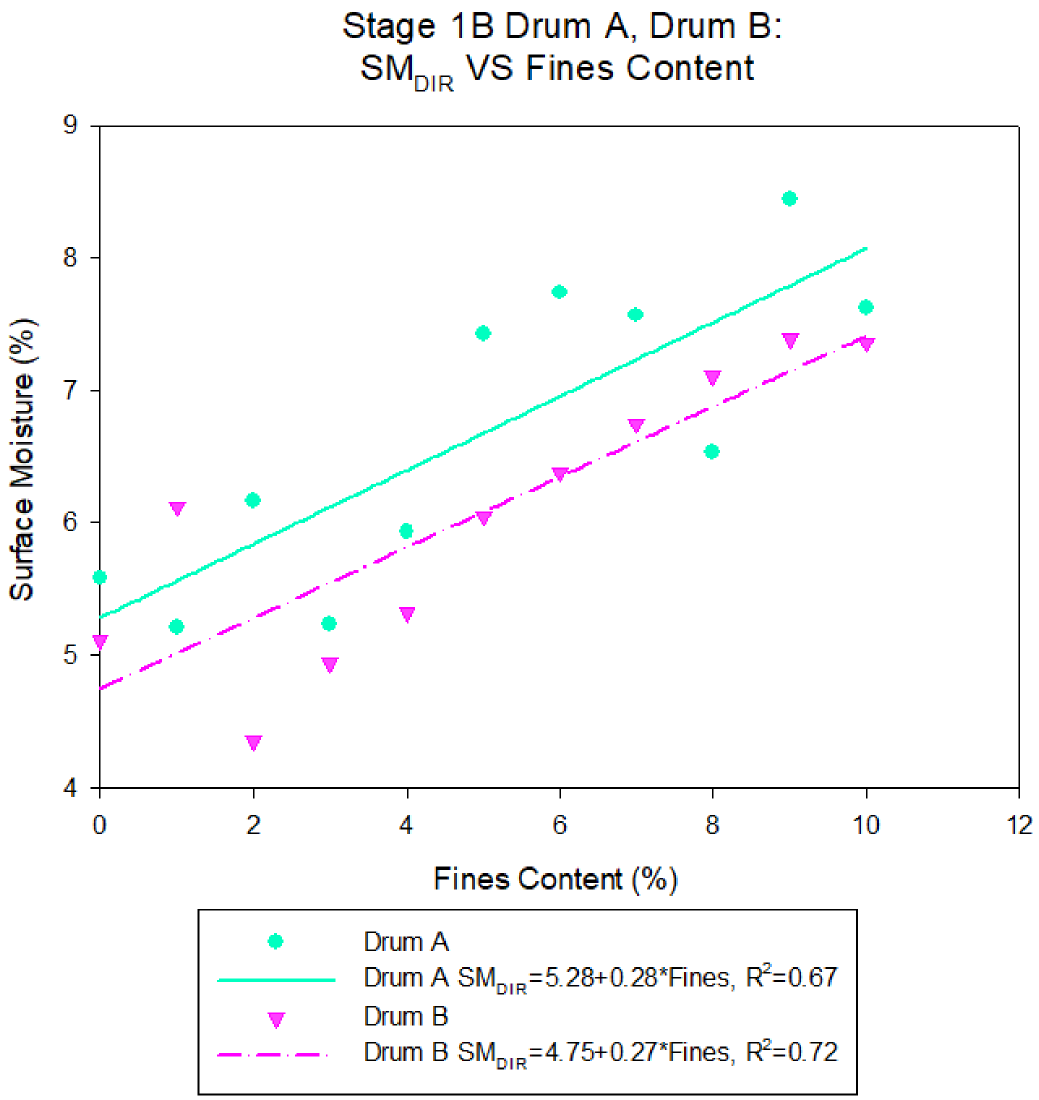


Figure 4-10: Drum A VS Drum B (SM_{DIR})

Due to the effect of the net on the drum A SM_{DIR} results, and the potential error from handling in the drum A and B SM_{LAB} results, it was decided that the drum B SM_{DIR} results were the most reliable. Based on this the stage 2 and 3 results will be compared to the drum B SM_{DIR} results.

Despite the effect of the net on equilibrium moisture and drainage, the empirical data from stage 1A was still used as input into the model (equation 1-1). The coal samples used in stage 1A were washed before testing to remove any fines. This reduced the likelihood of the net becoming blocked and affecting the surface moisture results as with the composite samples. The only time the net could become blocked and potentially affect the result was with the finer particle sizes below 500µm.

Figure 4-11 shows how the SM_{EST} plots just below the SM_{DIR} regression but starts to deviate at higher fines content. The underestimation could be due to the model not factoring in the increased packing density of a homogenous size distribution. This increased packing density could retain more surface moisture. Since the model was based on single size fractions, the packing density was not taken into consideration.

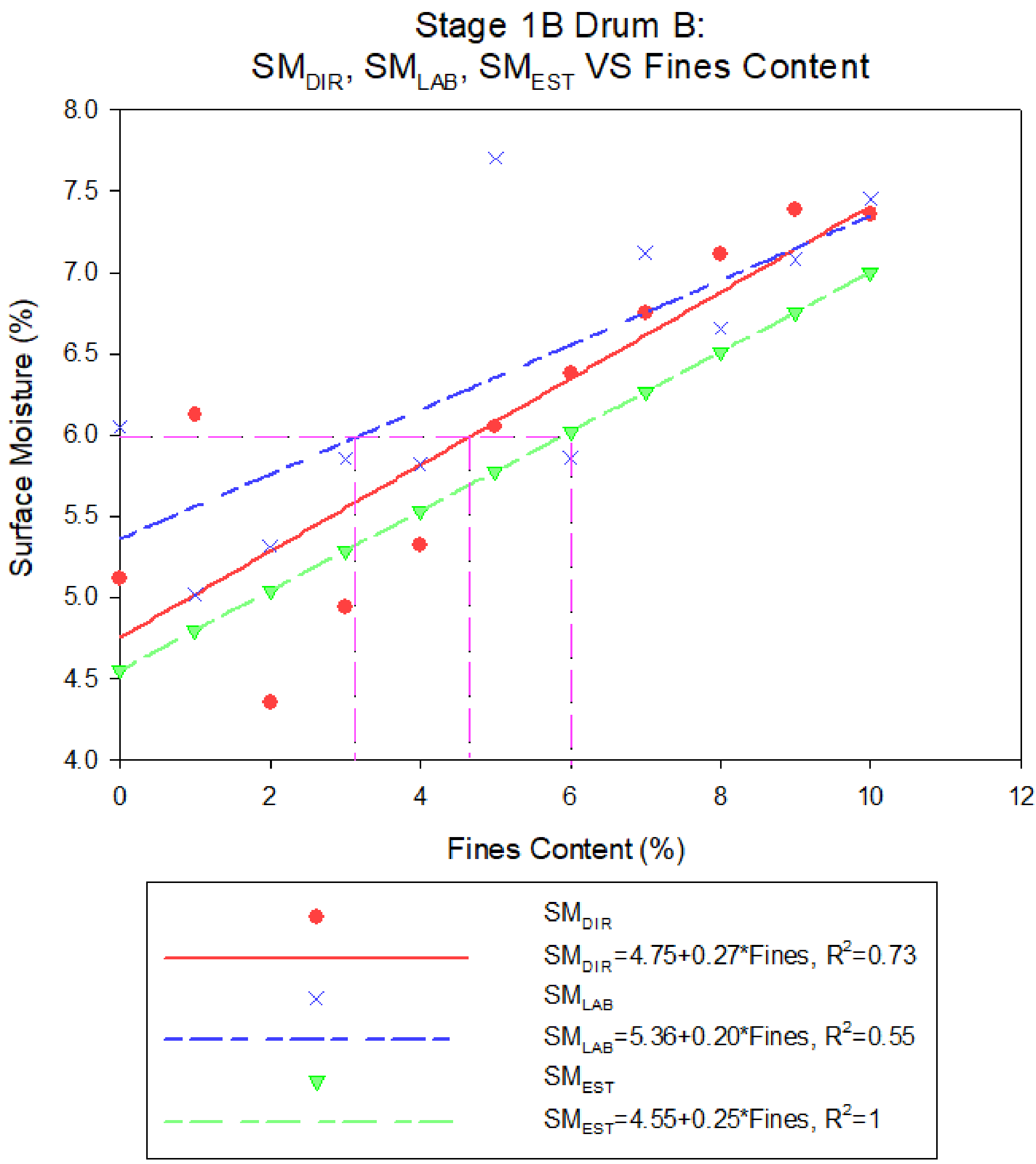


Figure 4-11: Stage 1B Drum B SM_{DIR}, SM_{LAB} and SM_{EST}

4.3 Stage 2

4.3.1 Drainage curves

The objective of stage 2 testing was to determine how the small scale (stage 1B drum B) results would compare to larger scale results. The benefit of the large scale testing was that the fines movement through the pipe could be observed and compared.

The model (equation 1-1) was also used to see how the estimated data compared to actual SM_{DIR} data.

It was realised after the drainage pipe tests that there was a significant increase in the amount of fines during the handling of the coal for sample preparation, transport and testing. This was determined by measuring the fines of each sample after the tests were done.

The fines content of the drainage pipe samples after each test was determined and compared to the fines content prior to testing. Table 4-4 shows how, on average, the fines content increased by 1.16%. This result is better described in section 4.3.3. The decrease in the fines content of the 10% dummy run was as a result of fines lost during the sample preparation. The 10% dummy run sample preparation used a 300kg splitter whereas the other the other samples used a 100kg splitter.

Table 4-4: Pre and post handling fines content

	Fines Content (%)						
Before	0	2	4	6	8	10	10 (Dummy run)
After	1.09	3.13	5.05	7.94	8.49	10.94	8.50
Difference	*1.09*	*1.13*	*1.05*	*1.94*	*0.49*	*0.94*	*-1.50**

*Material lost during sample preparation

Since the small scale and large scale rigs differed in design, particle size distribution (PSD1 VS PSD 2 –see Appendix G) and testing method a direct comparison between drainage curves could not be done. However, the shape of the curves (Figure 4-13 and Figure 4-5) could be compared in that the curves reached an asymptote (equilibrium surface moisture content) fairly soon after the tests had started. As with the stage 1B drum B drainage curves (Figure 4-5) there was a large initial loss of water as the pore moisture drained out. This started to slow down as only surface moisture was left. Similar to stage 1B drum B, as the fines increased the final surface moisture increased. The drainage curves didn't follow an expected sequence (increased surface moistures as fines content increased) but the sequence was better than the stage 1B results in that a more expected sequence was observed. The reason for the non-expected sequence was discussed in section 4.2.1.

Only the 1.09%, 3.13%, 5.05% and 8.5% runs reached a surface moisture of below 6% (Figure 4-13).

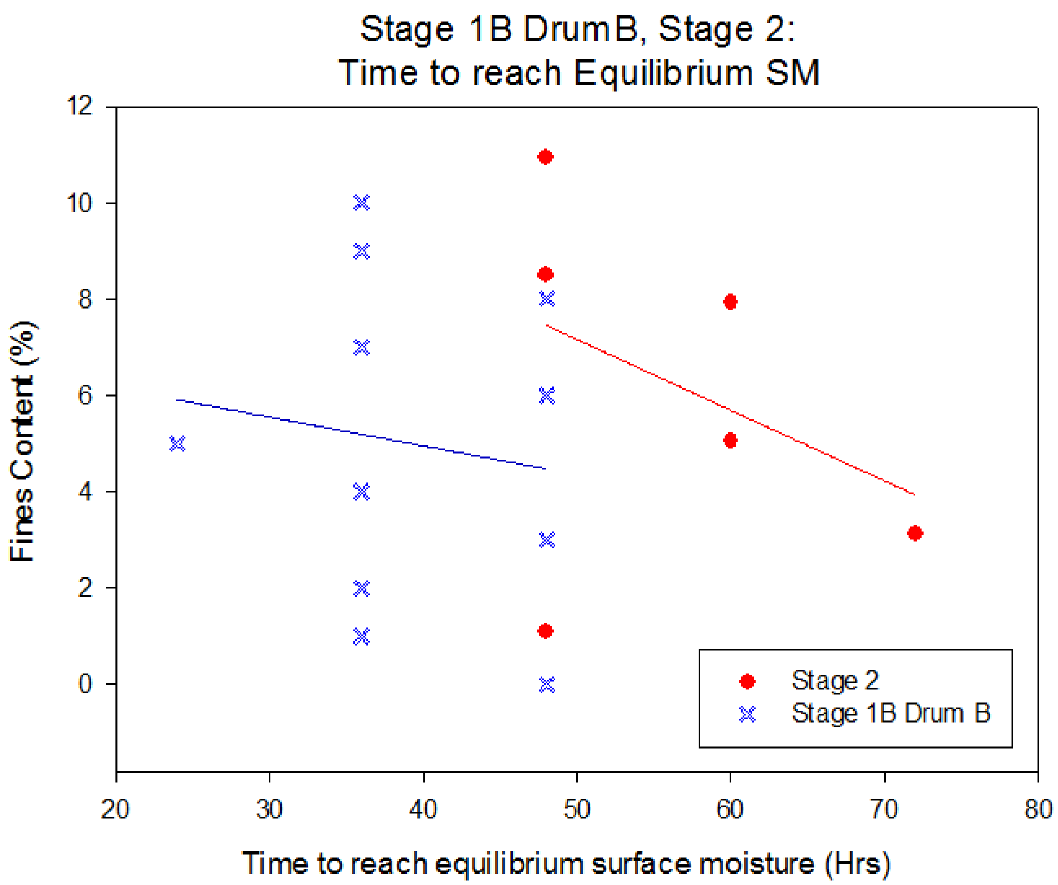


Figure 4-12: Time to reach equilibrium surface moisture (Stage 1B Drum B VS Stage 2)

Table P-2 in Appendix P shows the equilibrium moistures reached and the time taken to reach it.

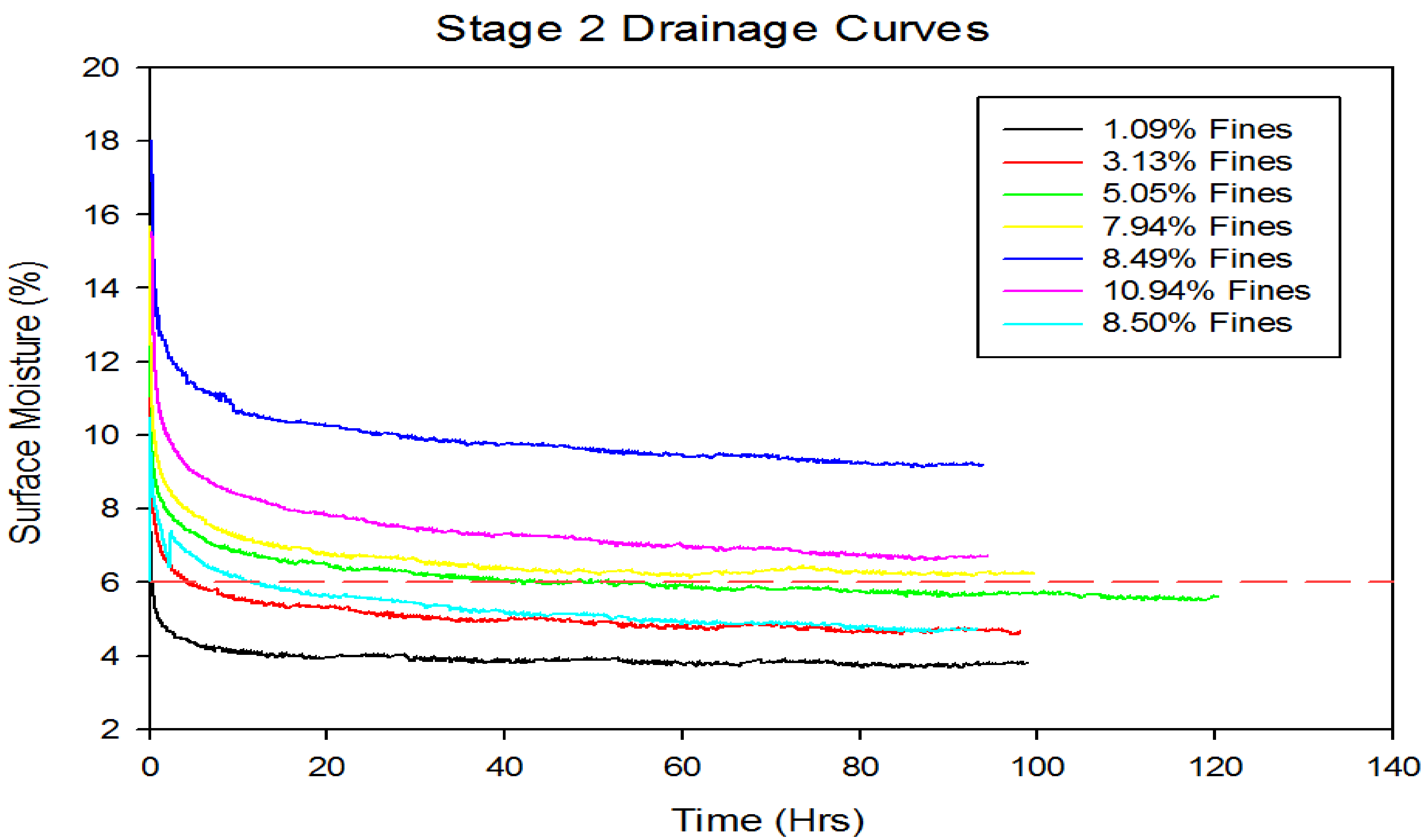


Figure 4-13: Stage 2 Drainage Pipe Drainage Curves

4.3.2 Surface moisture content

Since each test produced six samples and seven drainage pipe tests were done, a total of 42 data points were generated.

Figure 4-14 shows the SM_{LAB} results returned a regression with a gradient twice that of the SM_{LAB} and SM_{DIR} regressions in stage 1 (Figure 4-6 and Figure 4-9). This is believed to be due to the initial degree of saturation the samples were exposed and fines content. This made a big difference in surface moistures at the lower fines content but little difference at the higher fines content values between the stage 1 and 2 results. The reason for this is that the lower fines content sample had many pathways to travel through. The water would quickly find the easiest route and flow to the bottom, only coming into contact with coal along those avenues. The higher fines content would force the water to “seek” different pathways and thus slowly filter through the sample. As this occurred the water would come into contact with more coal, wet a greater surface area and thus increase the surface moisture content. This would bring the surface moisture values in line with the results obtained in stage 1. This is discussed and illustrated in section 4.4 and Figure 4-23. The stage 2 SM_{DIR} regression was more in line with the SM_{DIR} regressions obtained in stage 1B (Figure 4-6 and Figure 4-9).

For the coal to reach a surface moisture of 6% the SM_{EST} regression would require a maximum fines content of 1.7%. The SM_{DIR} and SM_{LAB} require a fines content of 6.08% and 8.26% respectively.

Compared to the stage 1B estimations (Figure 4-8 and Figure 4-11) the model overestimated the surface moisture values. The reason as to why the model overestimated the surface moistures is discussed in section 4.4.

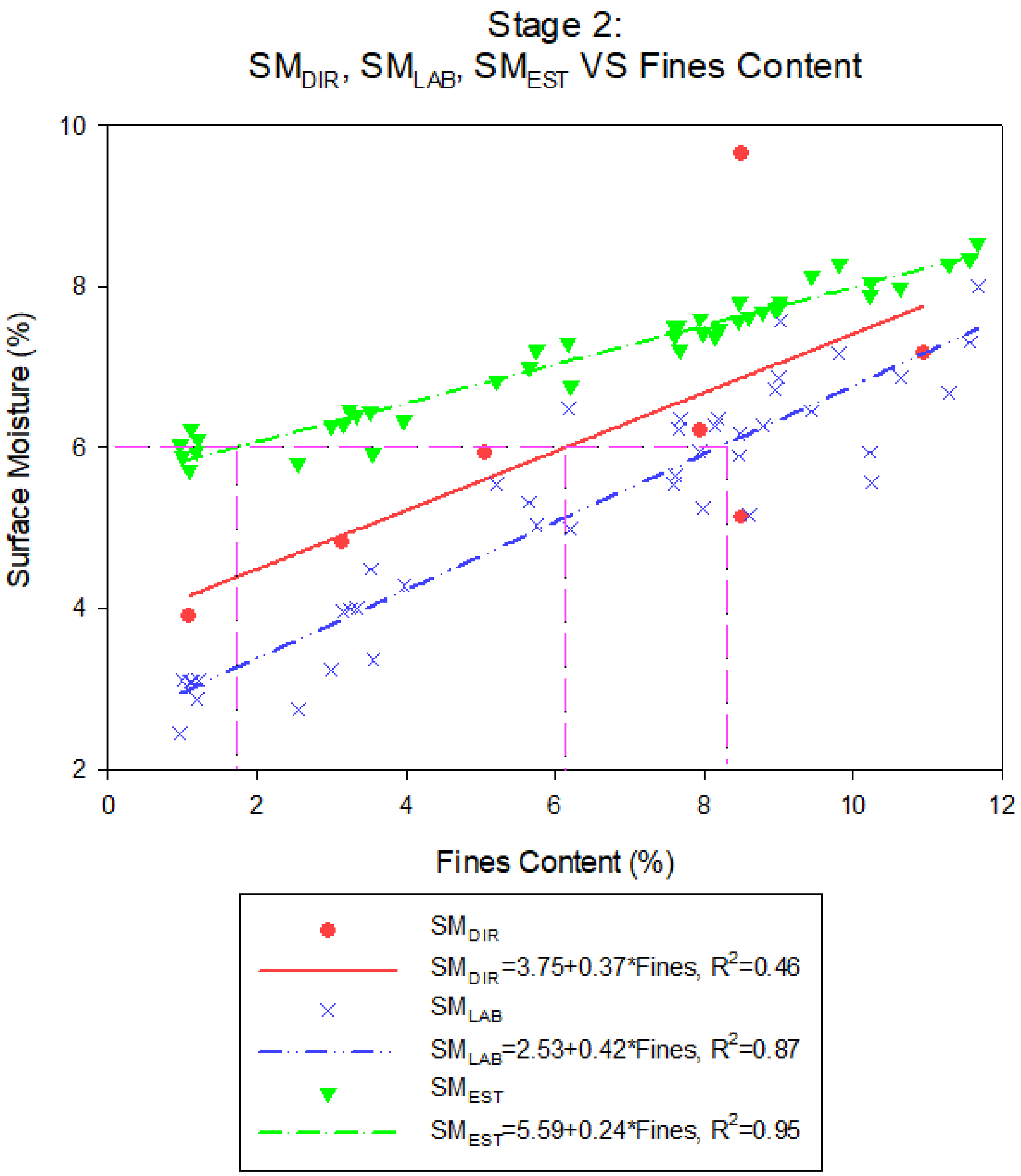


Figure 4-14: Stage 2 SM_{DIR} VS SM_{LAB} VS SM_{EST}

The SM_{DIR} regressions of stage 1B and stage 2 were very similar (Figure 4-15). This is most probably due to the mass balance being a more accurate method of measuring surface moisture. Lab determined surface moisture has increased handling, as discussed, and differing atmospheric conditions which play a role in the final surface moistures. The stage 2 regression had higher variability and returned slightly lower surface moisture values compared to stage 1B.

The overall particle size distribution of the stage 2 samples was finer than stage 1B (Figure G-1) so the equilibrium surface moistures should be higher. This anticipated trend is seen when the stage 1B and stage 2 estimated regressions are plotted against each other (Figure 4-17). This was found not to be the case with the SM_{DIR} results.

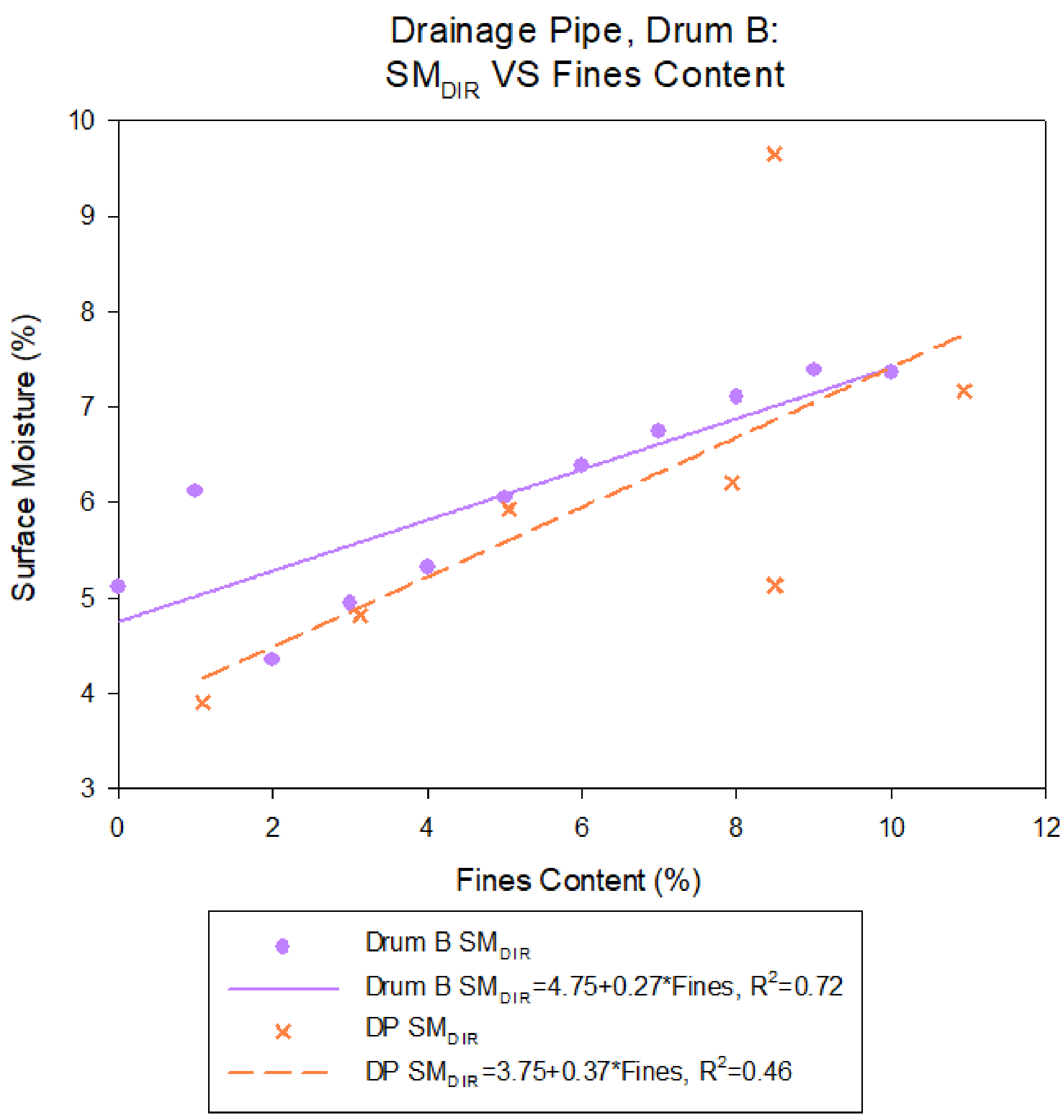


Figure 4-15: SM_{DIR} Stage 2 VS Stage 1B

Unlike the SM_{DIR} results, the SM_{LAB} regressions of stage 1B and stage 2 were very dissimilar (Figure 4-16). The drum B regression plotted far higher than the drainage pipe at the lower fines content. The most plausible reason, as touched on earlier, for this would be the way in which the SM_{LAB} tests were carried out. For stage 1 the samples were completely saturated. For stage 2 only 15% water was added. For the samples with lower fines content there were fewer blocked conduits. This meant the water could find direct pathways to the pipe discharge, spend less time in the pipe, and only wet the coal it came into contact with along the pathways. For the samples with higher fines content the water had to work to either find or create pathways for drainage. This increased the drainage time and gave the water more opportunity to wet more of the coal sample. This is why the stage 1B and stage 2 SM_{LAB} results started to converge at higher fines content.

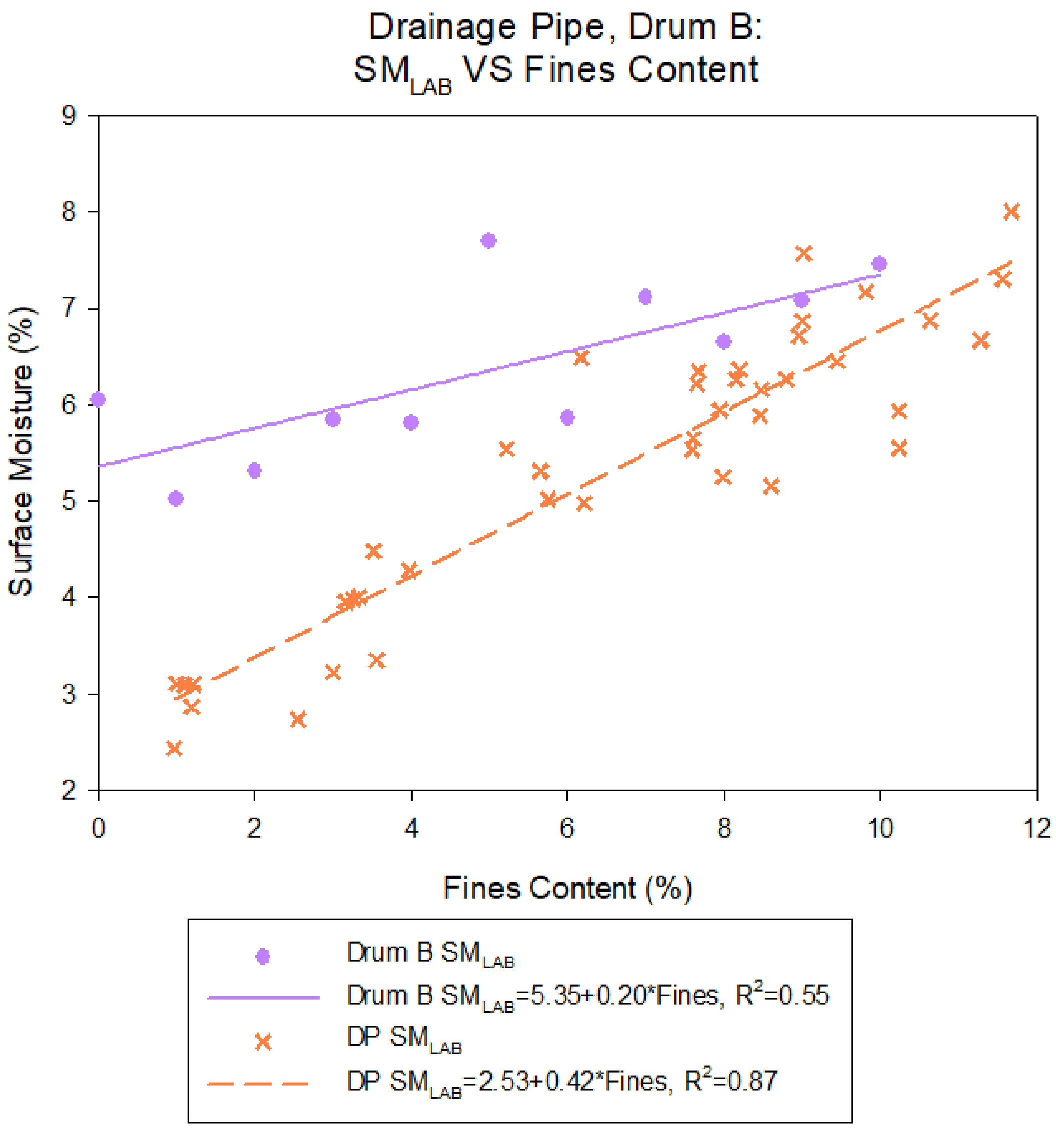


Figure 4-16: SM_{LAB} Stage 2 VS Stage 1B

The stage 2 estimated surface moisture regression (Figure 4-14) plotted higher than the lab and directly measured results. This is in contrast to the stage 1B results (Figure 4-8, Figure 4-11) which plotted below the lab and directly measured results.

The variability in the stage 2 SM_{EST} data comes from the variability in the particle size distributions of the samples. When the samples were prepared, care was taken to homogenise the samples as much as possible by splitting them three times. This didn't prevent the samples from segregating slightly when they were poured into the drainage pipe and would result in slightly different particle size distributions (random settling). The segregation was also as a result of small and fine particles being transported through the pipe with the water. This segregation is evident in Figure 4-18. As shown in section 4.3.3 fines tend to migrate with moisture, further affecting the homogeneity of the coal with respect to coal size. The tables in Appendix S summarise the particle size distributions of each sample taken.

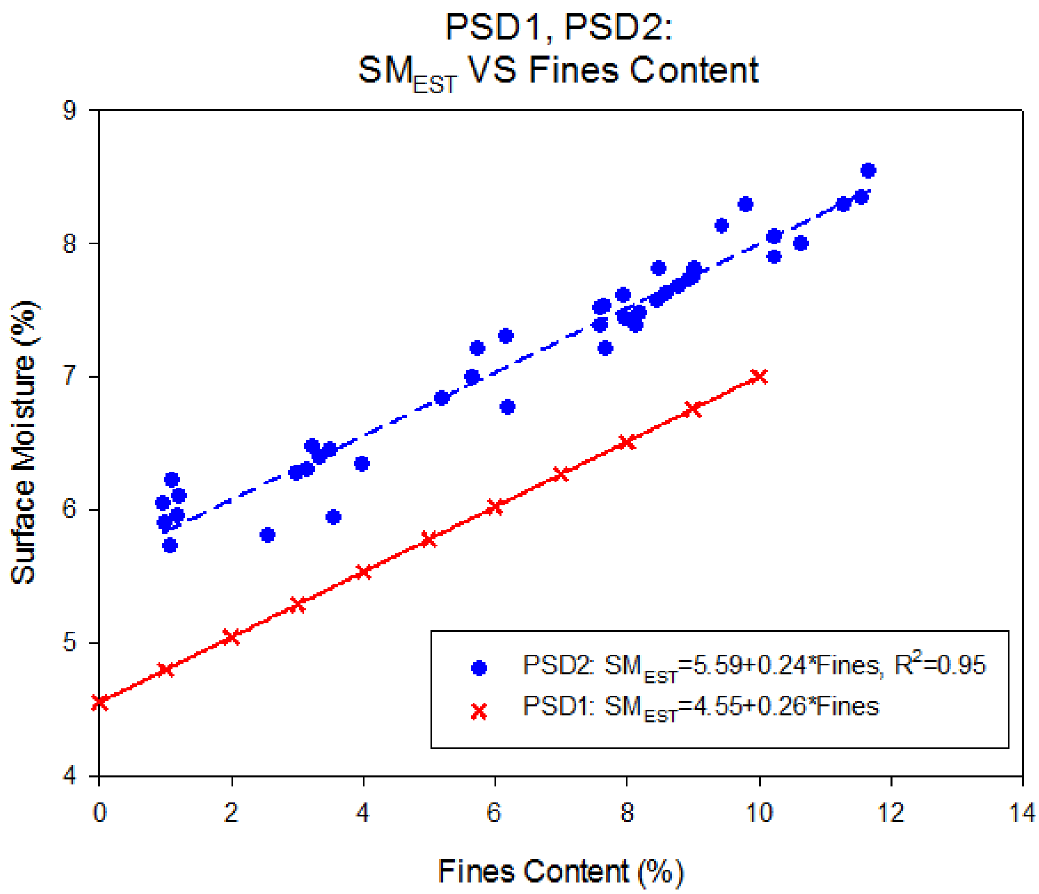


Figure 4-17: Stage 1B VS Stage 2 SM_{EST}

4.3.3 Fines distribution

How the fines content changes with height is shown in Figure 4-18. From the results it appears there are alternating zones of fines depletion and increased fines concentration. The alternating zones were not that pronounced for the 1.09% and 3.13% due to few fines being available for transportation, despite this the surface moisture content still varied with height. Since there wasn't a large enough fines content for the surface moisture to follow the surface moisture distribution was controlled by the next size fraction up (0.5-1mm or 1-2mm).

For the runs with greater fines content, when comparing the fines and surface moisture curves, it is seen that the surface moisture closely follows the fines content. This can be seen in Figure 4-19.

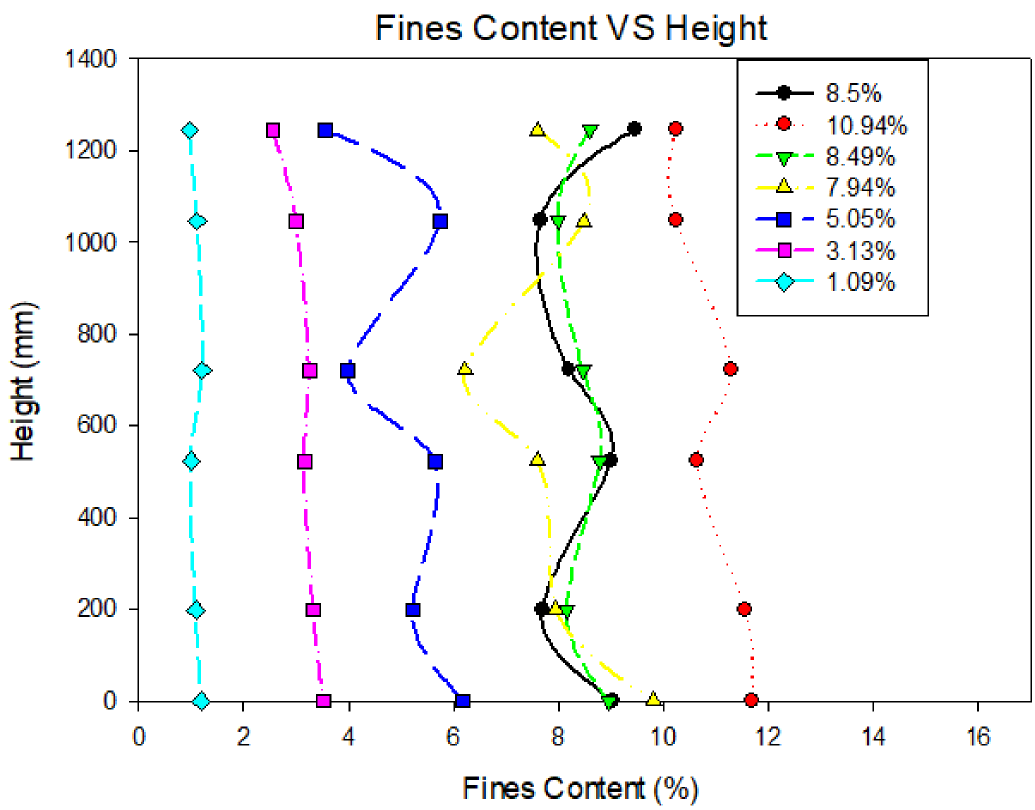


Figure 4-18: Fines Content VS Height

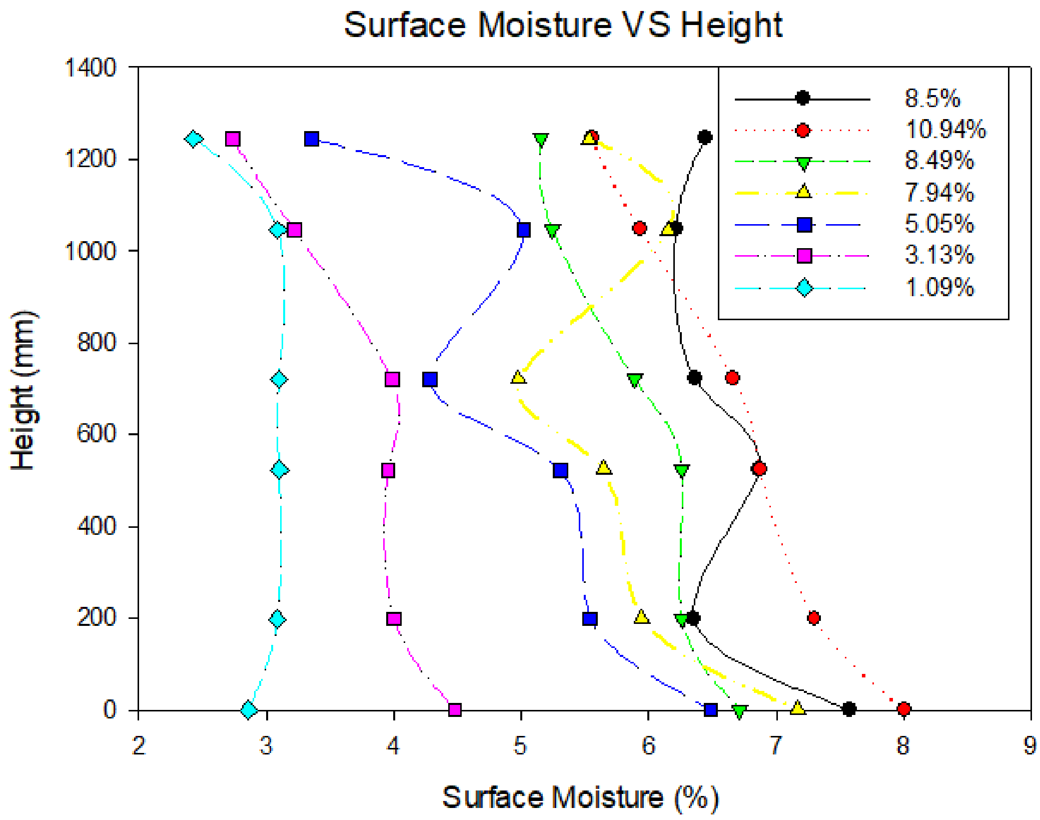


Figure 4-19: Surface Moisture VS Height

In section 3.2.1 and 4.1 it was discussed how the fines adhering to the coarser coal particles seemed to make up a significant portion of the total fines fraction. A dry sieve alone may then give a false determination of the total fines content. To accurately determine the fines content the coarser material must be washed (wet sieve). The washed off fines ($Fines_{WET}$) must then be dried, collected and weighed. To investigate this further each sample that was taken in stage 2 was washed and the $Fines_{WET}$ determined. It was found that the $Fines_{WET}$ may account for up to 45% of the total fines content. This decreased as the total fines increased (Figure 4-20). The tables in Appendix R summarise the $Fines_{WET}$ results. The reason for the decrease is that the coarse material can only hold a certain amount of fines. As the total fines content increases this contribution as a percentage to the total fines content decreases.

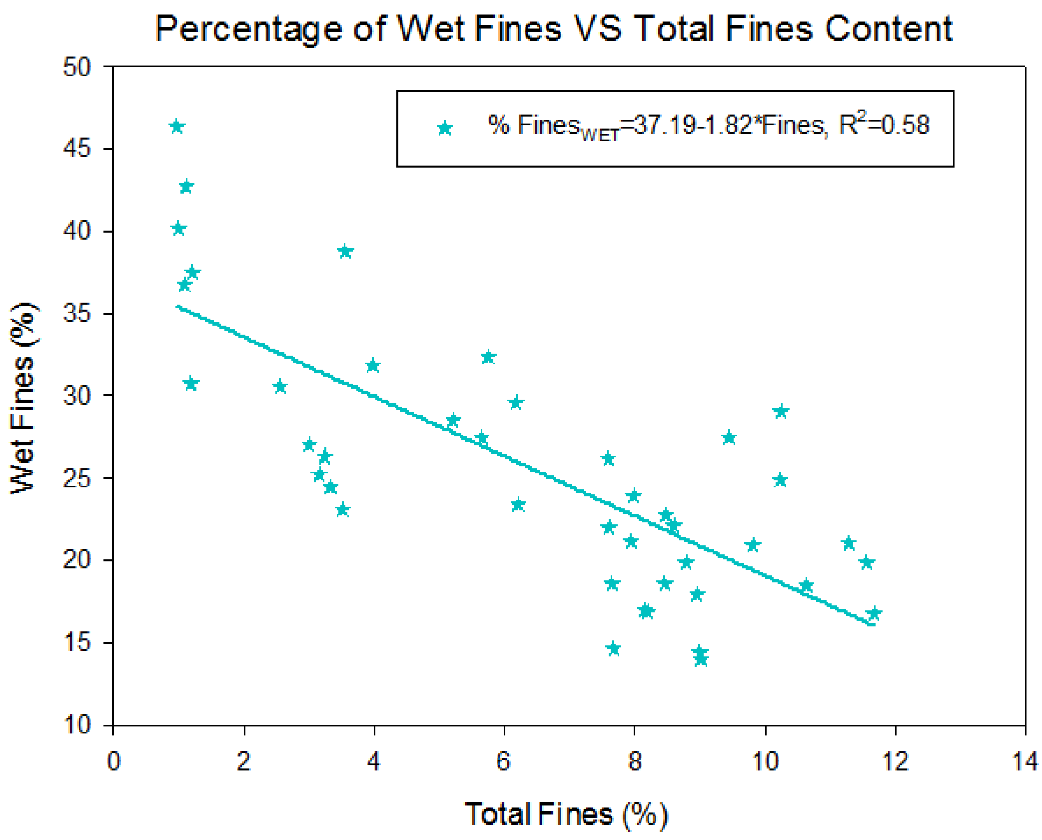


Figure 4-20: Percentage of Wet Fines VS Total Fines

4.4 Stage 3

Stage 3 involved testing the model (equation 1-1) against actual Eskom data. Using the particle size distributions, the model estimated the surface moisture of 90 samples from five different power stations and various units. The SM_{EST} was determined in stage three the same way as in stage one and two. This data is summarised in Appendix T.

Figure 4-21 shows the data for the Eskom SM_{LAB} data and SM_{EST}. Figure 4-22 shows the regressions. The Eskom data has a high variability most likely due to numerous factors such as variable particle size distribution, coal quality, differing degrees of saturation, atmospheric effects and lab error. It must also be remembered that the fines content used in the model was from a dry sieve and is not the true fines content. The true fines content may only be determined by way of a wet sieve. By using the true fines content in the model the estimated surface moisture contents would increase and possibly be more in line with the SM_{LAB} regression.

Figure 4-22 also shows that in order for Eskom to reach a surface moisture content of 6% the fines content may not be greater than 9-10.42%. This is a more realistic figure than what was returned for stage 1B and stage 2.

Given the numerous factors that play a role in surface moisture (size distribution, coal quality, initial degree of saturation, wind, heat, relative humidity, handling, sampling, testing, analysis, etc) the model does well to estimate the average of all the data.

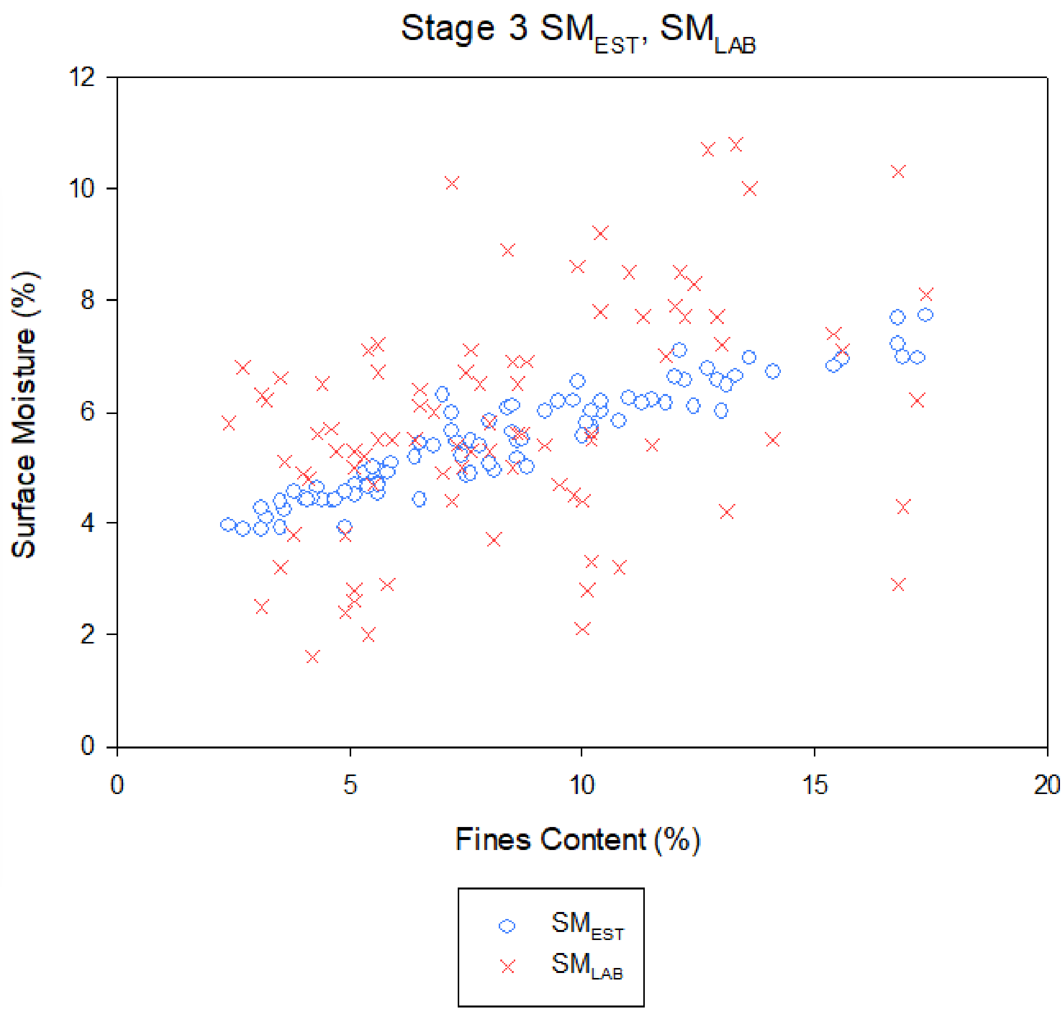


Figure 4-21: Stage 3 SM_{LAB}, SM_{EST} Data

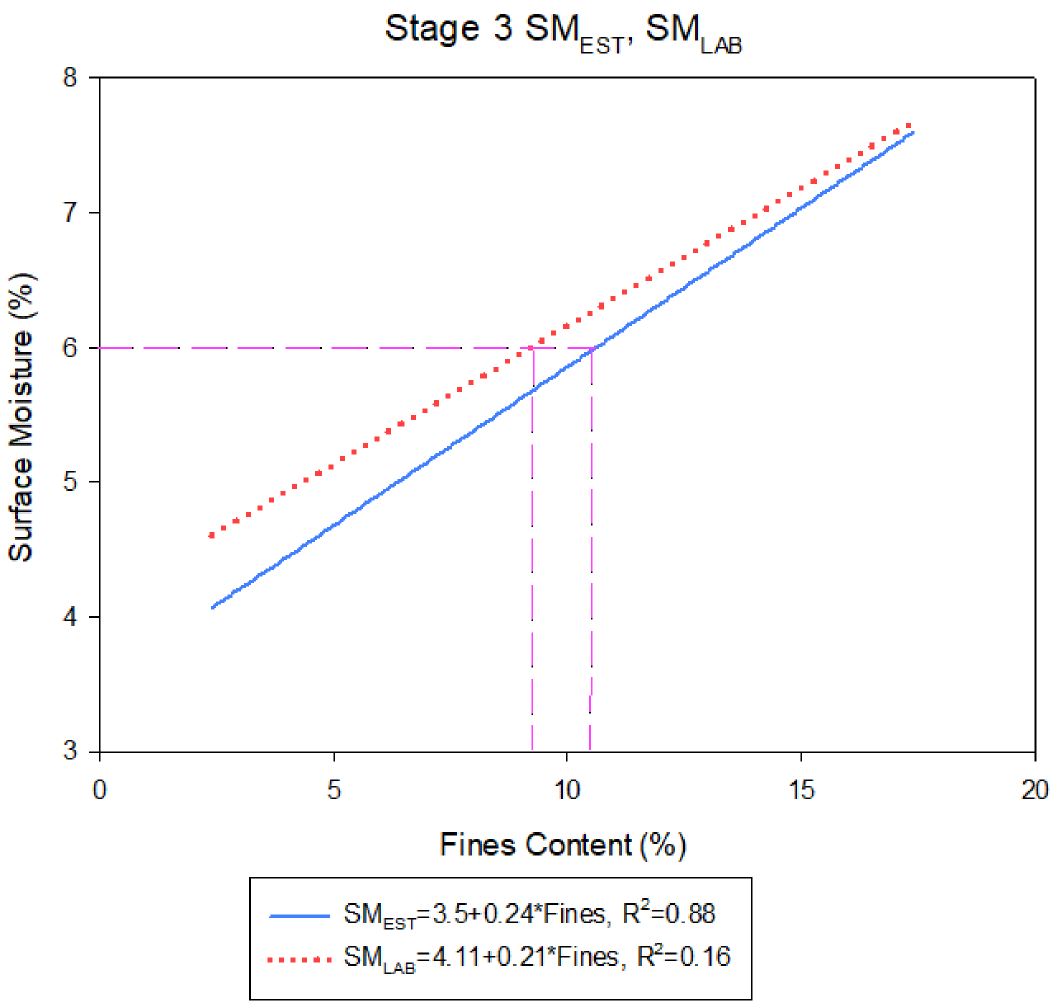


Figure 4-22: Stage 3 SM_{LAB}, SM_{EST} Regressions

Comparing the stage 1B drum B, stage 2 and stage 3 SM_{LAB} regressions in Figure 4-23 we can see how the different initial saturation content for each stage affected the final equilibrium surface moisture results. The stage 1B Drum B regression returns the highest surface moistures since these samples were completely saturated. The stage 2 regression initially plots the lowest due to only 15% water being added but as the fines content increases it starts to align with the stage 1B drum B and stage 3 surface moisture values. The stage 3 plot is very similar to stage 1B drum B in terms of the gradient. Whilst the gradients are the same, stage 3 plots 1.25% lower than stage 1B drum B. As stated, this can be expected since the stage 1B Drum B samples were fully saturated.

Practically, a coal stockpile will never be fully saturated as in the stage 1 tests. Also, a coal stockpile generally won't have as little water added to it from a mine or rain as in stage 2, or have as little fines (<4% fines). This makes the stage 3 regression a more realistic bench mark to compare the model against. With this in mind, and looking at Figure 4-21, the model could possibly be used to estimate the surface moisture of the coal. Even though a statistical analysis wasn't done, given the numerous factors that determine surface moisture, the model does well to estimate the average.

The stage 3 data is summarised in Appendix T.

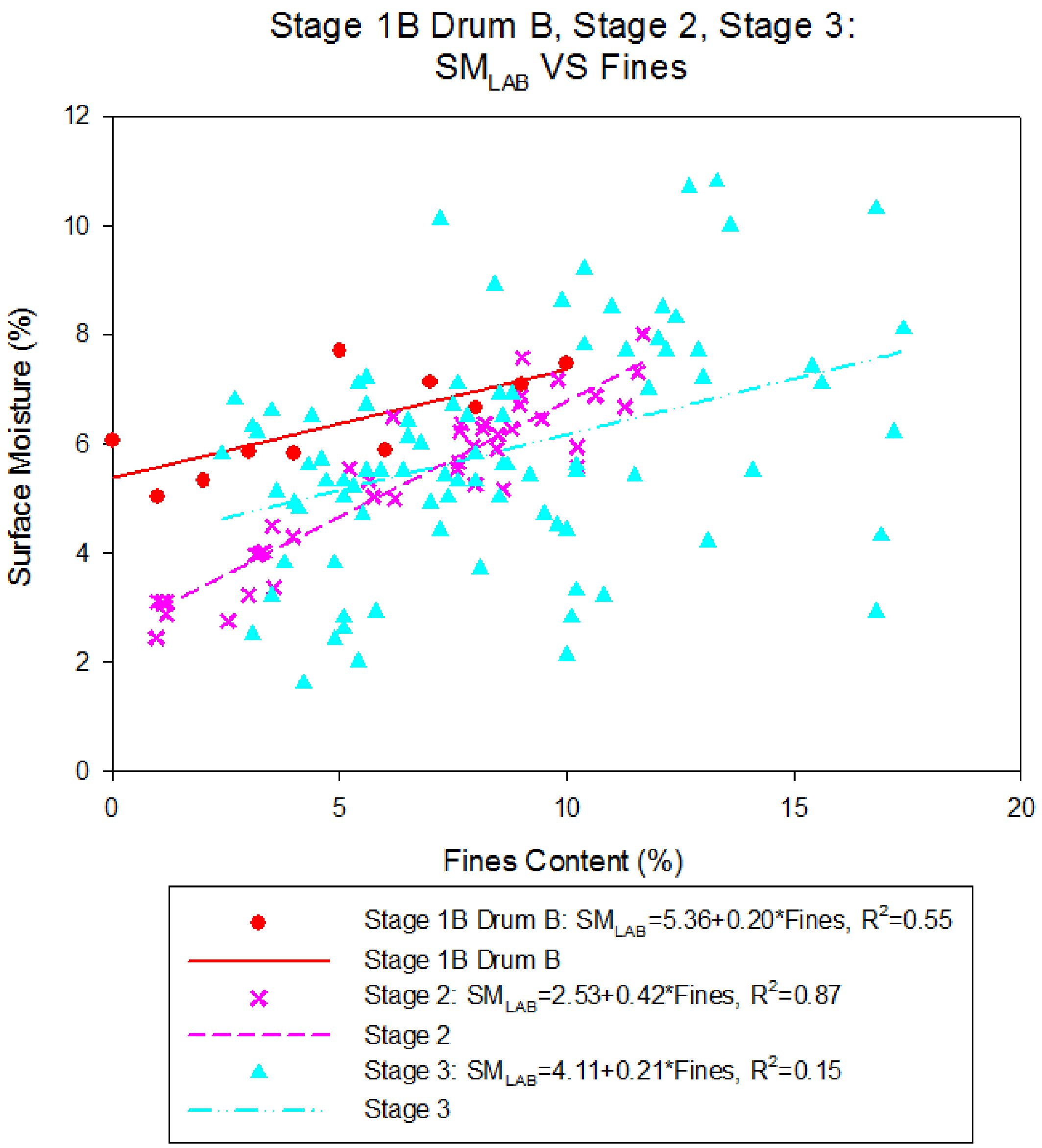


Figure 4-23: SM_{LAB} VS Fines Content (Stage 1B Drum B, Stage 2, Stage 3)

5 Discussion

5.1 Equipment and testing

The drum did well for quick testing although it did have its drawbacks. The net became blocked by fines which reduced the drainage curves and increased the equilibrium surface moistures of the composite samples by 0.53%. This is seen in the drum A and drum B SM_{DIR} comparison results in Figure 4-10. Completely saturating the sample deviated from a practical coal stockyard situation and resulted in higher than expected moisture contents. These higher than expected moisture contents can be seen in the comparison between the drum B and Eskom SM_{LAB} results in Figure 4-23. Contrary to stage 1 testing, the stage 2 tests had very little water added which resulted in far lower surface moistures at lower fines contents. The two test scenarios used in stage 1 and 2 weren't very practical hence the deviation from the actual Eskom results in section 4.4 .

When conceptualising the drum test rig it was thought that excessive coal would drain out of the ball valve. This is the reason the fabric screen was added to the rig. This then raised new concerns as to how the screen would affect surface moistures. Further testing showed that little material passed through the ball valve and the screen did increase the surface moistures. The size fraction/equilibrium surface moisture content relationship from stage 1A was determined using the drum with the net and also completely saturating the samples. However, since there were no fines present in the sample the net did not become blocked nor did the samples retain excessive surface moisture due to random settling of fines. Based on this the size fraction/equilibrium surface moisture content relationship obtained in stage 1A (Figure 4-2) is reliable.

The purpose of the drainage pipe was to try and simulate the centre of a coal stockpile. As with similar research the pipe did well to represent the centre of a coal stockpile and improvements were made to designs used in literature (Quinn & Partridge (1995); Campbell & Le Roux (2014)) (See Figure 2-12). More sample points gave a more detailed vertical profile of fines and moisture distribution. Suspending the pipe from a load cell also gave directly measured surface moisture data. This was less tedious than collecting moisture in a bucket and working backwards to determine surface moisture content. An area of improvement would be to have the pipe located in doors where the surrounding atmospheric conditions could be controlled better. The pipe did well to demonstrate how fines and moisture vary within a coal stockpile and supported results by Quinn & Partridge (1995) and Espag et al. (2016).

5.2 Sample analysis

The laboratory analysis of the surface moisture of coal is a delicate process and strict procedures and requirements should be adhered to. Sample size, size distribution and ambient conditions (temperature and humidity) all affect the end result. This was demonstrated in the different methods used to determine the surface moisture contents between stage 1 and 2.

For the surface moisture large samples were dried outside in the sun compared to stage 2, where the sample size was far smaller and dried in a controlled laboratory environment. Drying large samples outside also resulted in increased handling and chances of losing coal as spillage. This increased the variability of the surface moisture values that were obtained. This is seen when comparing the R^2 values of the drum B and stage 2 SM_{LAB} results (0.55 and 0.87 respectively) in Figure 4-16.

5.3 Drainage curves

Looking at the effect of fines content on drainage curves for stage 1 and 2 the results are similar (Figure 4-1, Figure 4-4, Figure 4-5, Figure 4-13).

For each curve there are essentially three stages of drainage as shown in Figure 4-1. The initial drainage is quick and represents the drainage of pore moisture. The effects of surface tension do not affect this moisture as the pore pressure is positive. Figure 5-1 shows the negative pore pressure. Tension forces are experienced within the water as the water is pulled up the small gaps between the coal and held there due to capillary action. This tension brings about negative pressure. Figure 5-1 shows how this capillary action holds water between coal particles. See Figure 2-17 also for explanation or pore pressure.

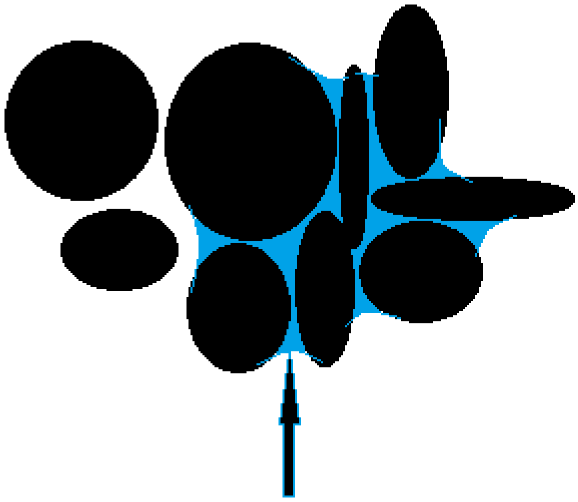
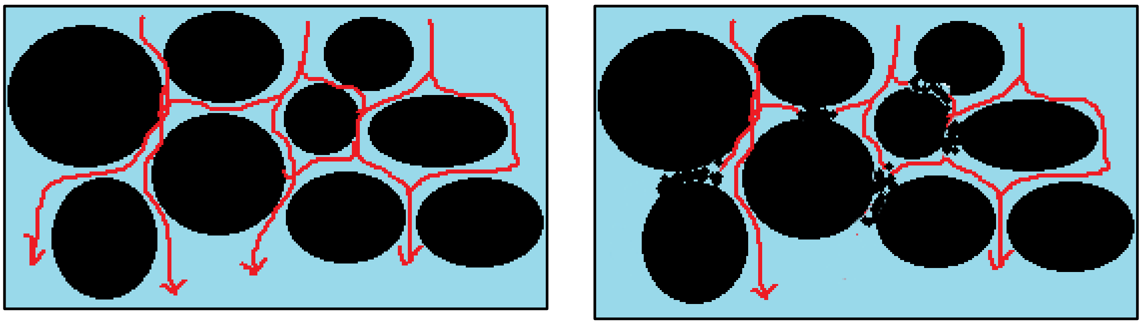


Figure 5-1: Positive versus Negative Pore Pressure

Pore moisture drains freely as it has a positive pressure. As the pore moisture decreases, pore pressure becomes negative, and surface tension effects start to come into play resulting in the rate of discharge decreasing. Drainage decreases to a certain point and ceases. At this point equilibrium surface moisture has been reached and no further significant reduction in surface moisture can be expected. For all size fractions this equilibrium surface moisture content was reached within 48hours (see Table J-2). This corresponds with the drainage tests done by Cumming (2003) in Figure 2-15.

Figure 5-2 (a) illustrates a coal sample with no fines. The water is allowed to move freely through the pores between the coal particles as the pores are interconnected. Figure 5-2 (b) illustrates a coal sample with fines. The fines reduce the size and amount of pathways available for the water to move through thus reducing the drainage rate and increasing the amount of moisture retained.



(a) (b)

Figure 5-2: (a) Flow path with no fines (b) Flow paths reduced by fines

5.4 Surface moisture

Up until this research it has been a long standing assumption by coal stockyard managers that an effective method of reducing the moisture content of a coal stockpile is to allow it to drain naturally (ie: if left long enough, a live coal stockpile will drain to a moisture content acceptable by the power station). What is starting to come to light by this research and others (Campbell & Le Roux (2014), Cumming (2003)) is that the centre of a coal stockpile will drain to an equilibrium surface moisture content. Once this equilibrium surface moisture content is reached, no further reduction in moisture can be expected by natural drainage. In addition, atmospheric drying effects, such as wind and sun, only penetrate 0.3m from the surface making its contribution to the drying of a large coal stockpile relatively small. The greatest contributor to the surface moisture reduction of a coal stockpile is the natural drainage capability of the coal stockpile.

Figure 4-6 and Figure 4-9 show the SM_{LAB} results had high variability for both the stage 1B drum A and B results (0.52 and 0.55 for drum A and B respectively). This is contrasted to the stage 2 results which had a high R^2 value of 0.87.

The high variability of the drum results is from excessive handling of the coal after the test. After the test the wet coal would be collected in a bag then weighed. The wet coal would then be poured onto plastic sheets and air dried in the sun. During this time the coal would be turned to expose wet coal below the dry surface. This was done to speed up the drying process. Once visibly dry the coal would be collected in a plastic bag and weighed again. This constant handling (collecting, pouring and turning) gave opportunity for coal to be lost. This lost coal would be seen as a loss in moisture and thus misleadingly increase the SM_{LAB} result.

The stage 2 SM_{LAB} was determined in a far more controlled manner by using smaller samples that were dried in a tray inside a laboratory.

For the stage 1B results (Figure 4-8 and Figure 4-11) the model underestimated the surface moisture results whereas for stage 2 the model overestimated the surface moisture results. As stated previously, given the numerous factors that play a role in surface moisture (coal quality, initial degree of saturation, wind, heat, relative humidity, handling, sampling, testing, analysis, etc) the model does well to estimate the average of all the data.

For stage 3 the model seemed to perform the best at estimating the surface moistures (Figure 4-21) even though it slightly underestimated the data.

When comparing the SM_{LAB} data for all three stages (Figure 4-23) the differences in the fines content/surface moisture relationship can be best explained by the way in which the tests were done. Stage 1 testing was carried out by completely saturating the sample. This meant that all the coal would come into contact with water and result in a higher equilibrium surface moisture content. For stage 2 only 15% moisture was added. When the water moves through coal it does so through preferential pathways or conduits. When the fines content is low the water will move directly through these conduits and not wet any other coal. When there are fines present the water is forced to seek out different avenues and thus wets more coal. This is in line with what Curran, Droppo, & Irvine (2002) discovered when examining flow structure within a simulated coal pile. This explains the low surface moistures corresponding to low fines content. As the fines content increases the surface moisture values start to align with stage 1 and 3.

The stage 3 fines content/surface moisture regression lay in between stage 1 and 2 at the lower fines content. The stage 3 samples come from the mill feed samples. This means the coal has travelled a long distance over conveyors and through transfer points such as silos and bunkers by the time the sample is taken. This results in fines generation. As the coal moves it mixes with the surface water, giving increased surface moisture values at lower fines contents.

6 Conclusion

This research defines a quantitative relationship between surface moisture and fines content. For every 1% increase in fines content there is a 0.25% increase in the minimum equilibrium surface moisture that the coal will drain to.

Given the numerous factors determining surface moisture, the model did well to estimate the average equilibrium surface moisture of a coal given its particle size distribution. This model is:

$$SM_{EST} = \sum_{i=1}^{n} SM_i * f_i = (SM_1 * f_1) + \ldots + (SM_n * f_n)$$

Where,

$SM = 2.88 + 6.5e^{-0.31\delta} + 26.96e^{-1.89\delta}$ (Determined empirically)

δ = geometric mean of size fraction

f_i= weighting of size fraction in particle size distribution (%)

The model is based on an empirically determined equilibrium surface moisture content and size fraction relationship. This relationship could change if more or less size fractions are used. For this reason it is advisable that when using the model the same or more size fractions be used as in this research. Every size fraction contributes to the overall surface moisture. Thus, by using more size fractions the confidence level of the results will increase due to a better representation of the size distribution being used.

This research used an upper size fraction limit of 30mm. Figure 4-2 shows that the contribution of the larger size fractions to surface moisture reaches an asymptote, and that testing beyond a size fraction of 30mm won't bear much fruit. However, this research defined an upper surface moisture limit of 29%. It is possible that finer fractions could hold more surface moisture.

The model has not been tested on an actual coal stockpile as yet. The moisture dynamics within a coal stockpile could produce different surface moisture results. It is for this reason the model must be tested against actual stockpile data.

The model was also determined using coal from one source. The ability for the model to estimate the surface moistures of different coal qualities must also be investigated.

Additional revelations came to light during this research. For one, a significant amount of fines are generated from minimal handling. It was found in stage 2 that on average an additional 1.16% of fines were generated just from mixing. transporting and pouring.

A relationship between the true total fines and fines adhering to the coarse particles was also established. This was found to be:

$$Fines_{wet\ sieve} = 37.19 - 1.82 \times Fines_{total}$$

The above will give Eskom some foresight into what minimum equilibrium surface moistures a coal stockpile will drain to given the particle size distribution.

By applying the model (equation 1-1) to an incoming coal of known particle size distribution, coal stockpile managers can have an idea of what equilibrium surface moisture content the coal will drain to. By being able to estimate the minimum moisture content of a coal stockpile, a stockpile manager may be able to make real time decisions on which stockpile will be best to reclaim from. Stockpiles that would likely have lower moisture content will be reclaimed first. This model, in conjunction with the knowledge of which areas of the stockpile will have lowest moisture content, can greatly aid stockpile managers in making more informed decisions when reclaiming coal. Based on this knowledge better strategies and procedures may be formulated.

7 Recommendations

This research raised a number of future research topics, such as:

1. Fines generation: Excessive handling can cause a significant increase in fines content (about 1.2% on average). This will affect the moisture retaining ability of the coal (for every 1% increase in fines content results in a 0.25% increase in minimum surface moisture that will be reached). This is an important result from a practical point and shows that coal stockyard operators should keep handling to a minimum. The means in which coal is transported should also be considered. For example, does transporting in trucks produce more fines than a train?
2. Fines adhering to coarse particles may contribute significantly to the total fines content. What is causing these fines to adhere to the coarse particles? How can this be leveraged to make fines part of the usable product instead of discarding it?
3. This research focused on the -500µm size fraction but revealed that up 65% of this size fraction is made up of -50µm. How will removing the -50µm size fraction affect the minimum surface moistures reached?
4. As stated in the conclusion the model was determined empirically using certain size fractions. Using more size fractions, particularly towards the finer size ranges, could produce a different result. The saturated and equilibrium surface moisture content must be investigated further to see if they correlate to the defined upper limit of 29% defined in this research.
5. This research has shown that each size fraction contributes to the overall surface moisture. It will be worthwhile to investigate the reasons why this is the case by looking at the physical effects such as compaction, capillary forces and the hydrophobic/hydrophilic nature of coal. These could be used to determine a model based more on fundamental principles rather than empirical data.

6. Eskom is interested in not only the final surface moisture content but the time it takes to reach this moisture content. The time to reach the equilibrium surface moisture must also be investigated further and a model developed.
7. The random settling of fines plays a large role in moisture retention. So much so that a lower fines content can result in a higher surface moisture content just by the way in which the fines settle. This random settling of fines should be investigated further. If fines are perfectly distributed in a sample does it retain more water than, say, fines collecting together and blocking conduits?

The determination of surface moisture is extremely delicate. The analysis of the samples revealed the importance of a controlled environment. Temperature and humidity needs to be kept constant in order to produce consistent and repeatable results. Eskom would do well to be more specific in its coal analysis standards by specifying these parameters, particularly in the determination of surface moisture.

The sample size and fines content also plays a role in determining the surface moisture content. The Eskom method does reference SANS 18283 (previously SABS 1035) which covers sample size and size distribution. As a suggestion these parameters should be mentioned directly in the Eskom method to reduce potential risk of misinterpreting the SANS standard.

8 References

Alphen, C. van. (2017). Personal Communication.

Bell, F. G. (1993). *Engineering Geology*. Oxford: Blackwell Scientific.

Bucklen, B., & Meikle, P. G. (n.d.). COAL STORAGE AND LOADING US Bureau of Mines.

Campbell, Q. P. (2013). Final report on stockpile drainage tests, (December).

Campbell, Q. P., & Le Roux, M. (2014). Predicting moisture retention and migration in a coal product stockpile. Santiago Chile.

Carrier, W. D. (2003). Goodbye, Hazen; Hello, Kozeny-Carman. *Journal of Geotechnical and Geoenvironmental Engineering*, *129*(November), 1054–1056.https://doi.org/10.1061/(ASCE)1090-0241(2003)129:11(1054)

Cho, G.-C., Dodds, J., & Santamarina, J. C. (2006). Particle Shape Effects on Packing Density, Stiffness, and Strength: Natural and Crushed Sands. *Journal of Geotechnical and Geoenvironmental Engineering*, *132*(5), 591–602. https://doi.org/10.1061/(ASCE)1090-0241(2006)132:5(591)

Cumming, A. G. (2003). Reducing moisture levels in the coal supplied to Eskom ' s Matimba and Lethabo Power Stations with special reference to the management of fines, (October).

Curran, K. J., Droppo, I. G., & Irvine, K. N. (2002). Hydrology of stockpiled industrial coal exposed to rainfall. *Hydrological Processes*, *16*(14), 2781–2790. https://doi.org/10.1002/hyp.1070

Dahlstrom, D. . (1981). Minimizing moisture content of fine coal. *Symposium on Coal Preparation and Utilization*, 199–216.

Department of Water Affairs & Forestry, Ockie Fourie Toxicologists, & Romy van Jaarsveld Consultants cc. (2005). *Department of Water Affairs & Forestry, 2005. Waste Management Series. Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste.* (cc Kathleen Langmore. Jarrod Ball & Assoc, Ed.) (Third). Pretoria: Department of Water Affairs and Forestry.

Enslin, K. (2016). *Estimation of Moisture Dynamics within a Composite Coal Stockpile*. University of Witwatersrand.

Eskom. (2016). Coal Power. Retrieved October 13, 2016, from http://www.eskom.co.za/AboutElectricity/ElectricityTechnologies/Pages/Coal_Power.aspx

Espag, C. B., Campbell, Q. P., Le Roux, M., & Joubert, D. (2016). DYNAMIC WATER DRAINAGE IN A SOUTH AFRICAN COAL PRODUCT STOCKPILE, (2012).

Falcon, R. M. ., & Snyman, C. . (1986). *An Introduction to Coal Petrography: Atlas of Petrographic Constituents in the Bituminous Coals of Southern Africa* (2nd ed.). Johannesburg: The Geological Society of South Africa.

Falcont, R., & Ham, A. J. (1988). The characteristics of Southern African coals *, (5), 145–161.

Fredlund, D. G., Xing, A., & Huang, S. (1994). Predicting the permeability function for unsaturated soils using the soil-water characteristic curve. *Canadian Geotechnical Journal*, *31*(4), 533–546. https://doi.org/10.1139/t94-062

Geogrify. (2016). Pangaea. Retrieved October 13, 2016, from http://geogrify.net/GEO1/Lectures/PlateTectonics/Pangaea.jpg

Google Maps. (2016). No Title. Retrieved October 13, 2013, from https://www.google.co.za/maps/place/Standerton/@-26.741175,29.3534326,1165m/data=!3m1!1e3!4m5!3m4!1s0x1eec9ccc71d96d13:0xabb3a2a74473f149!8m2!3d-26.9438212!4d29.2204548?hl=en

Gray, W. . (1968). *The Packing of Solid Particles*. London, Chapman and Hall.

Hand, P. E. (2000). Dewatering and drying of fine coal to a saleable product by, (March), 1–100.

Hunterson. (2013). Virtual Hunterson. Retrieved February 8, 2017, from http://virtual.hunterston.eu/industry/port/port.htm

Jeffrey, L. S. (2005). Characterization of the coal resources of South Africa. *The Journal of The South African Institute of Mining and Metallurgy*, *105*(2), 95–102. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-16244411695&partnerID=tZOtx3y1

Keleher, P., Cameron, D., & Knijnikov, M. (1998). Improving fundamental stockpile management procedures (pp. 422–428).

Kost, C., Mayer, J. N., Thomsen, J., Hartmann, N., Senkpiel, C., Philipps, S., … Schlegel, T. (2013). *Levelized cost of electricity renewable energy technologies*. FRAUNHOFER.

Merwe, D. Van Der, & Campbell, Q. P. (2002). An investigation into the moisture absorption properties of thermally dried South African fine coal, (October), 417–420.

Quinn, B. A., & Partridge, A. C. (1995). Geotechnical Factors Contributing to Stockpile Slope Stability, (March), 23–26.

Republic of South Africa Department of and Energy. (2016). IRP Update Assumptions & Base Case 22 November 2016 2, 1–29.

Rudawska, A. (2012). Adhesive Properties. In V. Kazmiruk (Ed.), *Scanning Electron Microscopy* (pp. 102–122). InTech. Retrieved from http://www.intechopen.com/books/scanning-electron-microscopy/adhesive-properties

SAPP. (2015). *The Southern African Power Pool 2015*.

Savannah Environmental (Pty) Ltd, Naicker, U., & Thomas, J.-A. (2012). Savannah Environmental (2012) Draft Addendum to the Environmental Management Programme: The proposed coal stockyard on Medupi Ash Dump, Limpopo Province.

Silbernagel, B. . (1989). Physical Characterisation of Coal Surfaces. *Surfactant Science Series*.

Sohn, H., & Moreland, C. (1968). The effect of particle size distribution on packing density. *The Canadian Journal of Chemical Engineering*, *46*(3), 162–167.

United Nations Framework Convention on Climate Change. (n.d.). Kyoto Protocol. Retrieved February 8, 2017, from http://unfccc.int/kyoto_protocol/items/2830.php

Wakeman, R. J. (1974). Short Communication Packing Densities of Particles with Log-Normal Size Distributions, *11*, 297–299.

Williams, D. (2006). *Application of unsaturated soil mechanics to product coal dewatering*. *Australian Mining Technology Conference*. Hunter Valley.

Williams, D., & Whitton, S. (2008). *IMPROVING THE CONTROL OF PRODUCT COAL MOISTURE BASED ON UNSATURATED SOIL MECHANICS PRINCIPLES*. The University of Queensland.

World Nuclear. (2016). UK's nuclear clean-up cost estimate dips to $154 billion. Retrieved February 8, 2017, from http://www.world-nuclear-news.org/WR-UK-nuclear-clean-up-cost-estimate-dips-to-154-billion-15071602.html

Appendix A Total and inherent moisture determination method

METHOD NUMBER 129	PAGE 1 OF 2
REV 1	

THE DETERMINATION OF THE TOTAL MOISTURE CONTENT OF COAL

AIR DRY METHOD

BASIS OF METHOD

Coal is air-dried at room temperature, until a constant mass to obtain the surface moisture. The coal sample is then prepared and analysed for inherent moisture. The total moisture is then calculated from the surface and inherent moistures.

SPECIAL APPARATUS

Balance Top pan balance with an accuracy of at least one gram.

ANALYTICAL PROCEDURE

Weigh

Before the sample container is opened, weigh the container and coal as received. Let this mass be C1.
Weigh a clean and dry tray. Let this mass be T1.
Transfer the coal into the tray and weigh.
Let this mass be T2.
Weigh the sample container.
Let this mass be C2.

Air-dry

Air-dry a) The coal in the tray
and
b) the tin
until the rate of change per hour in the mass of coal is less than 0,1% of the original mass. Let these masses be T3 (tray) and C3(tin).

NOTE: The temperature where the air-drying is taking place should not exceed 40°C.

Sample preparation

Prepare the sample in accordance with SABS 1035 – Part II – 1977 to obtain a coal sample less than 212 micron particle size.

Inherent moisture

Determine the inherent moisture of the sample in accordance with ESKOM method no. 103. Let this value be IM.

METHOD NUMBER 129	PAGE 2 OF 2
REV 1	

Calculate the results as follows:

$$\text{Surface moisture (\% as received)} = \frac{(C2 - C3) + (T2 - T3)}{T2 - T1}$$

* *Multiply above answer by 100*

$$\text{Inherent moisture (\% as received)} = IM \times \frac{100 - \text{Surface moisture}}{100}$$

Total moisture (%as received) = surface Moisture (% as received) + inherent Moisture (% as received)

REFERENCE

SABS 0135 – Part II - 1977

METHOD NUMBER 103	PAGE 1 OF 3
REV 2	

THE DETERMINATION OF THE INHERENT MOISTURE CONTENT OF COAL

GRAVIMETRIC METHOD (AIR-OVEN)

BASIS OF METHOD

Coal is heated in an air-oven at a temperature of 105 - 110°C for 1½ hours and the moisture content is calculated from the loss in mass.

SAMPLE PREPARATION

Coal ground smaller than 212µm, prepared according to SABS 0135 Part II – 1977.

TIME REQUIRED FOR ANALYSIS

For one sample in duplicate
Response time 130 minutes
Operator time 15 minutes

TOLERANCES

	Within laboratory Tolerances
Less than 5%	0,1%
More than 5%	0,2%

NOTE: Limits for tolerances between labs have not yet been established because results obtained in different laboratories depend on the humidity conditions, which may vary from laboratory to laboratory.

SPECIAL APPARATUS

Oven — An air-oven that can maintain a temperature of 105 - 110°C, such that the atmosphere is changed at a rate of at least five times/hour.

Weighing vessel — A shallow cylindrical vessel of at least 30mm diameter and having a well-fitting cover. The vessel and cover shall be of glass and mating surfaces that are ground.

Balance — An analytical balance having a sensitivity of 0,1mg.

Interface — The CP 503 Universal laboratory interface: a microprocessor based data collection and storage device with computational facilities.

METHOD NUMBER 103	PAGE 2 OF 3
REV 2	

Dessicator A suitable desiccator containing fresh (or freshly generated) self indicating silica gel.

ANAYTICAL PROCEDURE

Identification enter GID into CP 503 Universal laboratory interface.

NOTE: GID is an identification code, maximum 7 digits. The submission number of the sample can be entered as GID.

Enter SID into CP 503

NOTE: SID is a unique identification code specific to a particular sample within the group specified by the GID. The sample number can be entered as SID.

Weighing

Tare the balance
Place the clean, dry and empty weighing vessel and cover on the pan and press AUTO.
Press STORE when mass reading is displayed in DATA field.
Remove cover.
Uniformly spread 1 – 1,1g of coal sample in the weighing vessel.
Replace the cover.
Press AUTO
Press STORE when the mass reading is displayed in DATA field.

Insert weighing vessel in oven

Ensure the temperature of the oven is at 105 - 110°C.
Place the cover in the dessicator.
Place the uncovered weighing vessel in the oven for 1½ hours after 1½ hours remove the weighing vessel from the oven.
Replace the cover and allow the vessel to cool on a thick metal plate for 10 minutes.
Transfer to the desiccator and allow to cool for a further period of 10 minutes.

Weigh

Enter the GID.
Enter the SID of the first sample in the batch.
Press FIELD and enter 3.
Tare the balance.
Place the weighing vessel and cover on the pan and press AUTO.
Press STORE when mass reading is displayed in DATA field.

Calculation Press PRINT to get a printout of the calculated inherent moisture content of the coal sample on an air-dried basis.

METHOD NUMBER 103	PAGE 3 OF 3
REV 2	

NOTE: If the volatile matter and ash content are also determined on the same sample, the PRINT command can be given after the weighing of all three tests has been completed.

Report Report the result (preferably the mean of duplicate determinations) to the nearest 0,1% and state the basis (i.e.. inherent moisture content on air-dried basis)

REFERENCE

South African Bureau of Standards: Standard method SABS Method 925.

Appendix B Load cell calibrations

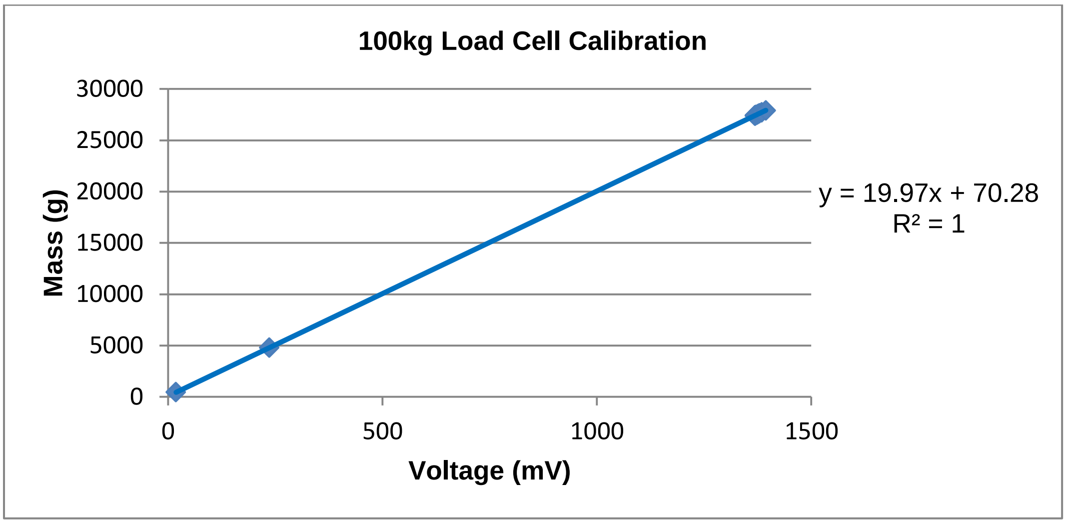


Figure B-1: 100kg Load Cell Calibration Curve

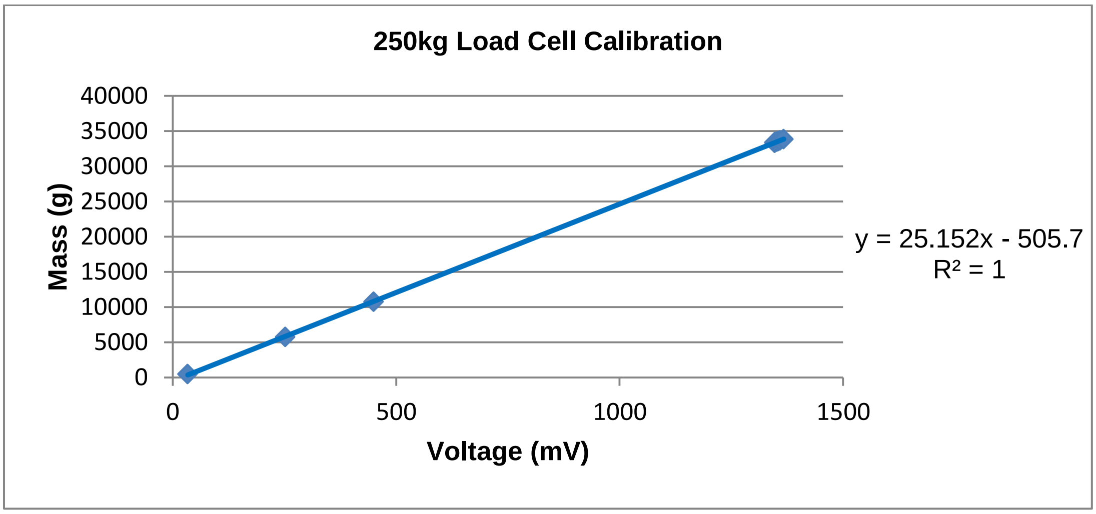


Figure B-2: 250kg Load Cell Calibration Curve

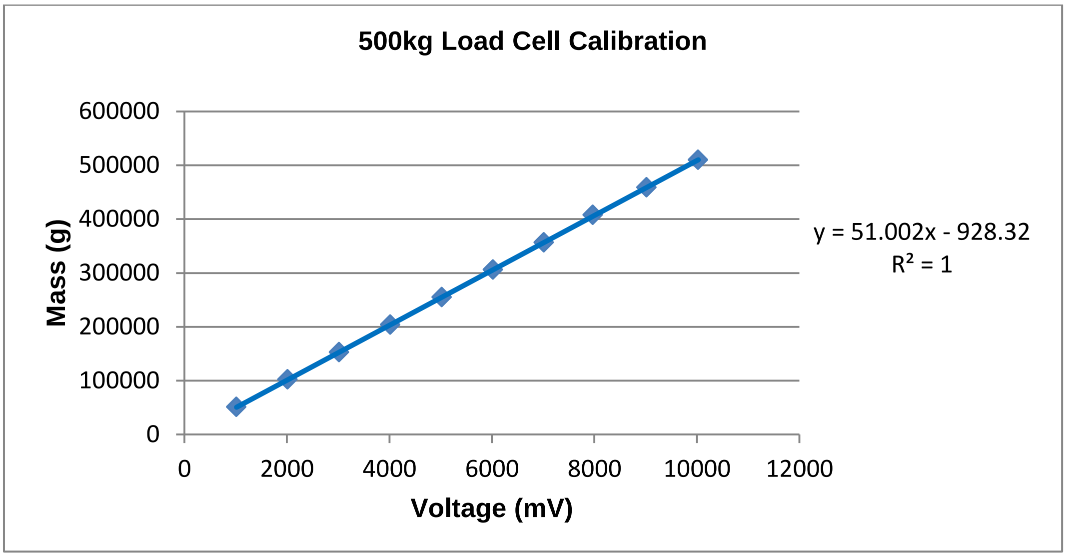


Figure B-3: 500kg Load Cell Calibration Curve

Appendix C Amplifier technical specs

Table C-1: Amplifier technical specifications

Type		MVD 2510
Mains connection/supply voltage	V Hz	115/230; +6 %; -10 % 48...60
Power consumption, max.	VA	8
Fuse link (slow)	mA	200 (115 V) / 100 (230 V)
DC amplifier		
Bridge excitation voltage U_B (±5 %)	V	± 2.5
Transducers that can be connected S/G full bridge	Ω	80...5000
Permissible cable length between transducer and amplifier	m	500
Measuring frequency range, adjustable (-1 dB)	Hz	0.05...5
Measuring range	mV/V	0.2...3.8
Bridge balancing range	mV/V	± 3.8
Measuring frequency range Low pass with Butterworth characteristic (2nd order)		see below

Nom. value f_c (Hz)	-1dB (Hz)	-3dB (Hz)	Run time (ms)	Rise time (ms)	Overs h. (%)
				54	
5	4.9	6.9	100	100	5
2	2.0	3.6	140	196	-
1	1.0	1.8	200	406	-
0.5	0.48	0.86	290	900	-
0.2	0.21	9.39	580	1800	-
0.1	0.105	0.195	1070	3600	-
0.05	0.050	0.099	2140		-

Noise voltage (typ.) without filter with filter	 µV/V_{ss} µV/V_{ss}	 <0,4 <0.2
Max. permissible common-mode voltage	V	± 2
Common-mode rejection	dB	>120
Max. permissible voltage at the input	V	± 5
Linearity deviation	%	<0.02
Longterm drift over 48 hours 15 minutes after power-up	µV/V	<0.3
Permissible relative humidity at 31 °C (non-condensing); reducing linearly to 50 % at 40 °C	%	80
Effect of a 10K change in ambient temperature Zero point Sensitivity	 µV/V %	 < 0.4 < 0.05

Analogue output		
Impressed voltage	V	± 10 V
Permissible load resistance, min.	kΩ	5
Internal resistance, max.	Ω	1. 5
Impressed current	mA	± 20; 4...20
Permissible load resistance, max.	Ω	500
Internal resistance, min.	kΩ	100
The analogue output enables gross and net values to be represented.		
Noise voltage	mV_{SS}	10, typ.
Residual carrier (300 Hz)	mV_{SS}	5
Longterm drift over 48 hours		
(30 minutes after power-up)	mV	< 3
Effect of a 10 K change in ambient temperature		
(effect in addition to digital value)		
Zero point	mV	< 5
Measuring sensitivity	%	< 0.1
Limit-value switch		
Number		2
Reference level		Gross, net value
Reference voltage (independently adjustable)	V	-10 ...+10
Factory setup, hysteresis	V	0.1
Adjustment accuracy	mV	0.33
Response time	ms	25
Control outputs (Limit value 1 and 2, alarm)		
Nominal voltage, external supply	V	24
Permissible supply-voltage range	V	6...30
Output current, max.	A	0.5
Short-circuit current, typ.	A	0.8
Short-circuit duration		unlimited
Isolation voltage, typ.	V_{eff}	350
Control inputs		
Input voltage range, LOW	V	0...5
Input voltage range, HIGH	V	10...24
Input current, typ., HIGH level = 24 V	mA	12
Taring response time	ms	25
Parameter memory (EEPROM)		1 data set
Display		
Number of digits		4 1/2-digit 7-segment display and various special characters
Digit height	mm	14.7
Type		LED display
Keyboard		Foil-type with 7 backgrounded key-elements on the circuit board

Effect of the operating voltage with a change in the specified range, rel. to full scale		
on zero point	%	0.01
on sensitivity	%	0.01
Nominal temperature range	°C	-20...+60
Service temperature range	°C	-20...+60
Storage temperature range	°C	-20...+70
Protection to EN 60 529		IP40 (device) IP51 (front, foil keyboard)
Protection class		I
Dimensions, complete (w x h x d)	mm	153 x 72 x 212
Front-frame dimensions	mm	144 x 72
Frontpanel cutout (to DIN 43 700)	mm	138 x 68
Weight, approx.	kg	1

Appendix D Datalogger technical specs

Table D-1: Data logger technical specifications

Analog Channels

5 analog input channels (expandable to 100*)
Each channel is independent and supports: one isolated 3-wire or 4-wire input, or two isolated 2-wire inputs, or three common referenced 2-wire inputs.
The following maximums apply:
Two wire with common reference terminal: 15 (expandable to 300)*
Two wire isolated: 10 (expandable to 200)*
Three and four wire isolated: 5 (expandable to 100)*
**Expansion requires optional CEM20.*

Fundamental Input Ranges

The fundamental inputs that the DT80M can measure are voltage, current, resistance and frequency. All other measurements are derived from these.

Full Scale	Resolution	Full Scale	Resolution
±30 mVdc	0.25 µV	100 Ω	1.5 mΩ
±300 mVdc	2.5 µV	1000 Ω	15 mΩ
±3 Vdc	25 µV	10,000 Ω	150.00 mΩ
±30 Vdc	250 µV	100 Hz	0.0002 %
±0.3 mA	2.5 nA	10 kHz	0.0002 %
±3 mA	25 nA		
±30 mA	250 nA		

Auto-ranging is supported over 3 ranges.

Accuracy

Measurement at ...	5°C to 40°C	– 45°C to 70°C
DC Voltage	0.1%	0.35%
DC Current	0.15%	0.45%
DC Resistance	0.1%	0.35%
Frequency	0.1%	0.25%

Accuracy table above is % of reading ±0.01% of full scale.

Sampling

Integrates over 50/60Hz line period for accuracy and noise rejection
Maximum sample speed: 25Hz
Effective resolution: 18 bits
Linearity: 0.01%
Common mode rejection: 90dB

Digital Channels

Digital Input/Outputs
8 bi-directional channels
Input Type: 8 logic level (max 20/30V)
Output Type: 4 with open drain FET (max: 30V, 100mA), 4 with logic output.
Relay Output
1 latching relay, contacts (max: 30Vdc, 1A)

Counter Channels

Low Speed Counters
8 counters shared with digital inputs.
Low speed counters do not function in sleep mode.
Size: 32 bit
Max count rate: 10 Hz
Dedicated Counter Inputs
4 high speed inputs or 2 phase encoder (quadrature) inputs
Size: 32 bit
Max count rate: 100 kHz
Input type: 2 logic level inputs (max ±30V), and 2 programmable inputs as either logic level inputs or sensitive inputs (10mV) for magnetic pick-ups (max ±10V)

Serial Channels

SDI-12
4 SDI-12 input shared with digital channels
Each channel supports up to 10 SDI-12 sensors.

Calculated Channels

Combine values from analog, digital and serial sensors using expressions involving variables and functions.
Functions: An extensive range of Arithmetic, Trigonometric, Relational, Logical and Statistical functions are available.

Alarms

Condition: high, low, within range and outside range
Delay: optional time period for alarm response
Actions: set digital outputs, transmit message via SMS or

Modbus Server (Slave)
Access current data and status from any Modbus client
Modbus Client (Master)
Read/write data from Modbus sensors and devices including PLCs, dataTaker dataloggers, modbus displays.
Email Client
Email data or alarms directly from the logger.
DDNS Client
Browse to the logger over the Internet using Dynamic DNS.

System

Display and Keypad
Type: LCD, 2 line by 16 characters, backlight.
Display Functions: channel data, alarms, system status.
Keypad: 6 keys for scrolling and function execution.
Status LEDs: 4 for sample, disk, attention and power.
Firmware Upgrade
Via: Ethernet, USB or USB disk
Real Time Clock
Normal resolution: 200µs
Accuracy: ±1 min/year (0°C to 40°C), ±4 min/year (-40°C to 70°C)
Power Supply
External voltage range: 10 to 30Vdc
Peak Power: 12W
Average Power Consumption (typical)
Using 12Vdc external power source
Values within brackets represent the additional power required by the modem to push data daily to an FTP server.

Schedule Rate	1 analog sample Average Power (mW)	6 analog samples Average Power (mW)
1 sec	540 (9)	840 (27)
5 sec	250 (3)	330 (7)
30 sec	50 (2)	65 (2)
1 min	30 (2)	40 (2)
5 min	15 (2)	15 (2)
30 min	10 (2)	10 (2)
1 hrs	10 (2)	10 (2)

Common mode rejection: >90dB
Line series mode rejection: >35dB
Inputs
Inter-Channel Isolation: 100V (relay switching)
Analog Section Isolation: 100V (opto-isolated)
Input impedance: >100MΩ, 100KΩ (30v range)
Common mode range: ±3.5V or ±30V on 30V range
Sensor Excitation (Supply)
Analog channels: selectable 250µA or 2.5mA precision current source, 4.5V voltage source, or switched external supply.
General Purpose: Switchable 12V regulated supply for powering sensors & accessories (max 150mA).
Switchable 5V regulated supply for powering analog sensors (max 25mA).

Analog Sensors

Supports a wide range of sensors including, but not limited to, those listed below. A wide range of sensor scaling and linearising facilities including polynomials, expressions and functions.
Thermocouples
Types: B, C, D, E, G, J, K, N, R, S, T
Calibration standard: ITS-90
RTDs
Materials supported: Pt, Ni, Cu
Resistance range: 10Ω to 10KΩ
Thermistors
Types: YSI 400xx Series, other types*
Resistance range: <10kΩ**
* Other thermistor types are supported by thermistor scaling and calculated channels.
**Resistance range can be increased with the use of a parallel resistor.
Monolithic Temperature Sensors
Types supported: LM34 - 60, AD590, 592, TMPxx, LM135, 235, 335
Strain Gauge and Bridge Sensors
Configurations: ¼ , ½ & full bridge
Excitation: voltage or current
4-20mA Current Loop
Internal 100Ω shunt or external shunt resistor

Actions: set digital outputs, transmit message via SMS or email, execute any dataTaker command.

Scheduling of Data Acquisition

Number of schedules: 11
Schedule rates: 10ms to days

Data Storage

Internal Store
Capacity: 128MB = approx 10,000,000 data points
Removable USB store device(optional accessory)
Types: compatible with USB 1.1 or USB 2.0 drives, e.g. Flash drive.
Capacity: approx. 90,000 data points per megabyte

Communication Interfaces

Ethernet Port
Interface: 10BaseT (10Mbps)
Protocol: TCP/IP
USB Port
Interface: USB 1.1
Protocol: TCP/IP or ASCII Command
Serial Sensor Port
Interface: RS232, RS422m, RS485
Speed: 300 to 115,200 baud
Flow Control: Hardware (RTS/CTS), Software (XON/XOFF), None
Protocols: Modbus, Serial Sensor

Network (TCP/IP) Services

Uses Ethernet port or integrated modem
Command Interface
Access the ASCII command interface via TCP/IP
Web Server
Access *dEX* to view data or configure the logger.
Define custom dynamic web pages.
Download data in CSV or DBD format.
Command interface window.
Define mimic displays.
FTP Server

Inbuilt Modem

Features
Alarms: Send email or SMS messages
Data: Send data to an email address or FTP server
Remote access: Connect to dEX or Command interface
SIM interface: SIM Socket (1.8V/3V)
Networks and Frequencies
USA Only:
Interfaces: EDGE, GPRS, GSM, CSD
All other places:
Interfaces: EDGE, GPRS, GSM, WCDMA, HSUPA, HSDPA
Frequencies:
EDGE/GPRS/GSM: 850/900/1800/1900 MHz
WCDMA/HSUPA/HSDPA: 850/1900/2100 MHz

Physical and Environment

Construction: Powder coated steel and anodized aluminum.
Dimensions: 300 x 137 x 65mm
Weight: 2.5kg (5kg shipping)
Temperature range: -30°C to 70°C *
Humidity: 85% RH, non-condensing
*reduced LCD operation outside range -15°C to 50°C

Accessories Included

Resource CD: includes software and user manual.
Comms cable: USB cable
Line adaptor: 110/240Vac to 15Vdc, 800mA
Antenna with 2m cable

Optional Accessories

A range of accessories are available.

For full technical specifications download the user's manual from our website www.datataker.com.

Your local distributor

Appendix E Stage 1B samples

Table E-1: Actual Stage 1B Drum A Samples

	Size Fraction (grams)									
Fines Content (%)	**+19mm**	**-19+10mm**	**-10+6mm**	**-6+4.75mm**	**-4.75+3mm**	**-3+2mm**	**-2+1mm**	**-1+0.5mm**	**-0.5_{DRY}mm**	**-0.5_{WET}mm**
0,00	1025	4754	4455	2653	2500	1644	1326	543	-	-
1,01	1024	4757	4456	2654	2508	1645	1326	542	149	44
2,01	1025	4754	4455	2655	2507	1647	1326	545	299	89
3,02	1026	4756	4455	2653	2508	1648	1326	543	454	136
4,01	1024	4755	4454	2653	2508	1648	1327	543	611	180
5,02	1023	4756	4455	2654	2507	1645	1325	545	771	229
6,00	1027	4757	4453	2653	2507	1645	1325	544	931	277
7,01	1024	4756	4453	2652	2506	1646	1327	544	1100	326
8,03	1025	4757	4452	2652	2505	1645	1326	543	1272	378
9,24	1026	4755	4452	2652	2506	1645	1326	543	1445	480
10,01	1026	4757	4452	2652	2506	1645	1325	543	1623	480

Table E-2: Actual Stage 1B Drum B Samples

	Size Fraction (grams)									
Fines Content (%)	**+19mm**	**-19+10mm**	**-10+6mm**	**-6+4.75mm**	**-4.75+3mm**	**-3+2mm**	**-2+1mm**	**-1+0.5mm**	**-0.5_{DRY}mm**	**-0.5_{WET}mm**
0,00	1024	4754	4456	2654	2504	1646	1327	543	-	-
1,00	1023	4757	4455	2655	2505	1648	1326	543	148	43
2,00	1025	4756	4457	2655	2505	1646	1327	542	299	87
3,00	1025	4755	4453	2653	2506	1646	1327	544	451	133
4,00	1027	4753	4453	2654	2506	1655	1325	542	608	180
4,98	1024	4756	4455	2654	2503	1645	1323	543	765	225
6,00	1026	4756	4456	2652	2507	1643	1326	542	930	277
6,99	1026	4757	4457	2652	2508	1645	1328	542	1096	326
7,99	1025	4757	4457	2653	2506	1643	1325	543	1267	375
8,99	1023	4755	4457	2652	2505	1647	1327	545	1442	426
10,00	1024	4756	4456	2652	2506	1648	1327	543	1622	480

Table E-3: Percentage of size fraction in each sample (Stage 1B)

Particle Size (mm)	Stage 1B Percentage of Size Fraction in Sample (%)										
19.00	5.43	5.37	5.32	5.26	5.21	5.15	5.10	5.05	4.99	4.94	4.88
10.00	25.18	24.93	24.67	24.42	24.17	23.92	23.67	23.42	23.16	22.91	22.66
6.00	23.56	23.33	23.09	22.86	22.62	22.39	22.15	21.91	21.68	21.44	21.21
4.75	14.03	13.89	13.75	13.61	13.47	13.33	13.19	13.05	12.91	12.77	12.63
3.00	13.25	13.12	12.99	12.85	12.72	12.59	12.46	12.32	12.19	12.06	11.93
2.00	8.69	8.61	8.52	8.43	8.35	8.26	8.17	8.09	8.00	7.91	7.82
1.00	7.00	6.93	6.86	6.79	6.72	6.65	6.58	6.51	6.44	6.37	6.30
0.50	2.86	2.83	2.80	2.77	2.74	2.71	2.68	2.66	2.63	2.60	2.57
0.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00

Appendix F Actual stage 2 samples

Table F-1: Actual Stage 2 Samples (prior to splitting and testing)

Fines Content (%)	Size Fraction (kg)										H20* (kg)
	+19mm	-19+10mm	-10+6mm	-6+4.75mm	-4.75+3mm	-3+2mm	-2+1mm	-1+0.5mm	-0.5$_{DRY}$mm	-0.5$_{WET}$mm	
0,00	10,62	40,927	36,27	25,397	28,44	25,75	23,74	13,34	-	-	36,231
2,00	10,62	40,91	36,27	26,24	28,44	25,75	23,74	13,34	3,226	0,963	36,97
4,00	10,62	40,91	36,27	26,24	28,44	25,75	23,74	13,34	6,587	1,968	37,74
6,00	10,62	40,91	36,27	26,24	28,44	25,75	23,74	13,34	10,09	3,014	38,543
8,00	10,62	40,91	36,269	26,24	28,438	25,749	23,741	13,341	13,747	4,106	39,382
10,00	10,62	40,912	36,271	26,241	28,443	25,751	23,739	13,341	17,564	5,246	40,257

*Note: Amount of water added was equal to 15% total moisture content

Table F-2: Percentage of size fraction in each sample (Stage 2)

Particle Size (mm)	Stage 2 Percentage of Size Fraction in Each Sample (%)					
19.00	5.17	5.07	4.97	4.86	4.76	4.66
10.00	19.93	19.53	19.13	18.73	18.33	17.93
6.00	17.67	17.31	16.96	16.61	16.25	15.90
4.75	12.78	12.53	12.27	12.01	11.76	11.50
3.00	13.85	13.58	13.30	13.02	12.74	12.47
2.00	12.54	12.29	12.04	11.79	11.54	11.29
1.00	11.56	11.33	11.10	10.87	10.64	10.41
0.50	6.50	6.37	6.24	6.11	5.98	5.85
0.00	0.00	2.00	4.00	6.00	8.00	10.00

Appendix G PSD1 and PSD2 comparison

Table G-1: PSD1 and PSD2 comparison

		+30mm	+19mm	-19+10mm	-10+6mm	-6+4.75mm	-4.75+3mm	-3+2mm	-2+1mm	-1+0.5mm	-0,5mm
Percent Finer (%)	**PSD1**	100	94,57	69,40	45,83	31,80	18,55	9,86	2,86	0,00	0,00
	PSD2	100,00	94,83	74,90	57,24	44,45	30,60	18,06	6,50	0,00	0,00
Percent of total mass (%)	**PSD1**	0,00	5,43	25,18	23,56	14,03	13,25	8,69	7,00	2,86	0,00
	PSD2	0,00	5,17	19,93	17,67	12,78	13,85	12,54	11,56	6,50	0,00
Mass (grams)	**PSD1**	0,00	1024,89	4756,54	4451,73	2650,52	2503,55	1642,40	1322,80	539,57	0,00
	PSD2	0	10620	40910	36270	26240	28440	25750	23740	13340	0,00

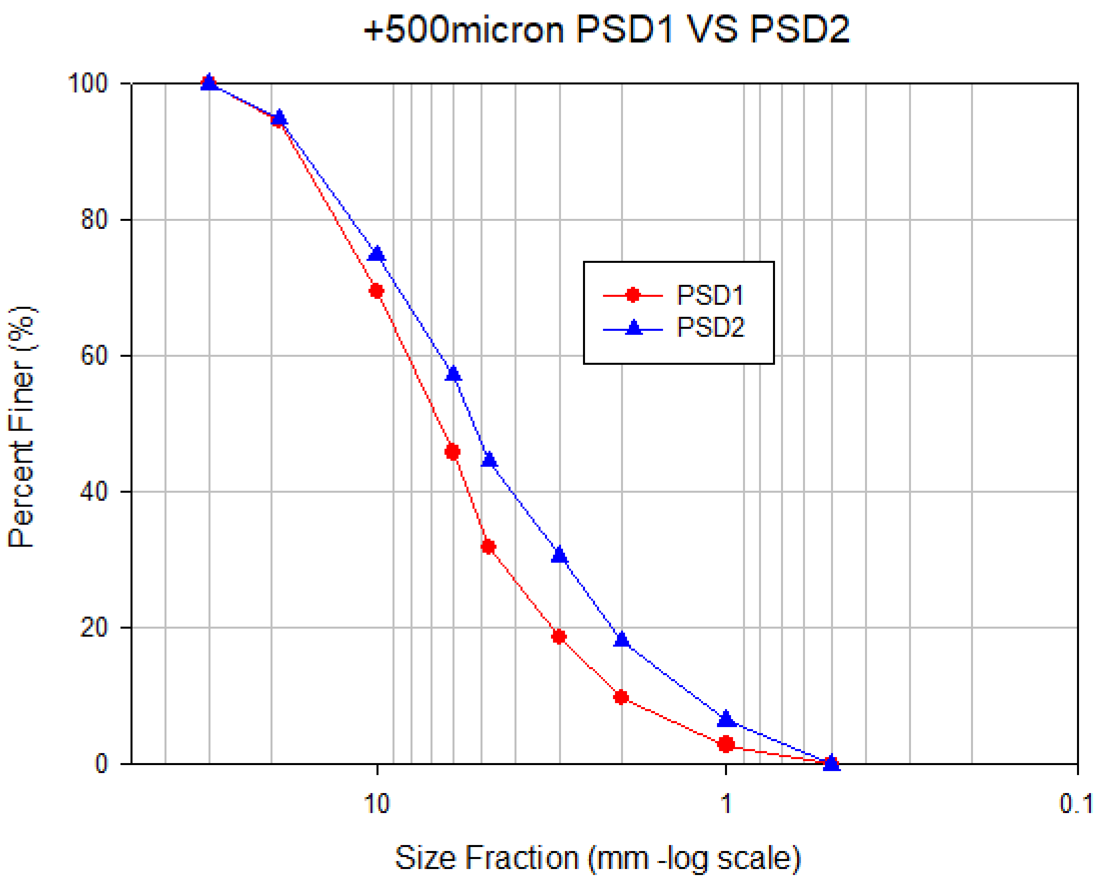


Figure G-1: PSD1 versus PSD2

Appendix H Stage 2 pre and post handling fines content

Table H-1: Stage 2 pre and post handling fines content

	Fines Content (%)						
Before	0	2	4	6	8	10	10 (Dummy run)
Post	1.09	3.13	5.05	7.94	8.49	10.94	8.50
Difference	*1.09*	*1.13*	*1.05*	*1.94*	*0.49*	*0.94*	*-1.50**

*a large amount of fines was lost during the splitting process to homogenise the sample

Appendix I Analysis procedure

Stage 1A

The data from the datalogger was downloaded in CSV format and analysed in EXCEL. From this data the drainage curves and equilibrium Surface moisture content (SM_{DIR}) was determined by direct measurement. SM_{DIR} versus time (hours) was plotted to determine the drainage curves.

Particle size versus equilibrium surface moisture was plotted. This relationship was then used in the equation 1-1.

The lab equilibrium surface moisture content (SM_{LAB}) was compared to the direct equilibrium surface moisture content (SM_{DIR}). The SM_{LAB} was determined by collecting the wet sample from the drum in a 30kg bag, weighing it to get the wet mass (M_W) and then air drying the sample in the sun. Once the sample was visibly dry it was collected and weighed again to get the air dried mass (M_{AD}). The reason for drying in the sun was to decrease the time needed for analysis. Using this method a sample could be dried in a day. The mass loss was assumed to be surface moisture. The SM_{LAB} was determined by dividing the mass loss from air drying by the wet mass (M_W), see equation I-1.

$$SM_{LAB} = \frac{(M_W - M_{AD})}{M_W} \qquad \text{I-1}$$

EXAMPLE:

Fines (%)	SM_{LAB} (%) (y)	SM_{LAB} (%) (ý)	y-ý	(y-ý)^2
10	7,45	7,36	0,09	0,01
9	7,08	7,16	-0,08	0,01
8	6,65	6,96	-0,31	0,09
7	7,12	6,76	0,36	0,13
6	5,86	6,56	-0,70	0,49
5	7,70	6,36	1,34	1,80
4	5,81	6,16	-0,35	0,12
3	5,85	5,96	-0,11	0,01
2	5,31	5,76	-0,45	0,20
1	5,01	5,56	-0,55	0,30
0	6,05	5,36	0,69	0,47
			SSE=	3,64
			std dev(s)=	0,78

Stage 1B

The model (equation 1-1) was used to estimate the surface moisture content (SM_{EST}) of each composite coal sample. The SM_{EST} was then validated against SM_{DIR}. SM_{LAB} was used to confirm results obtained from SM_{DIR}.

$$SM_{EST} = \sum_{i=1}^{n} SM_i * f_i = (SM_1 * f_1) + \ldots + (SM_n * f_n) \qquad \text{1-1}$$

Where, $$SM = 2.88 + 6.5e^{-0.31\square} + 26.96e^{-1.89\square} \qquad \text{4-1}$$

$$\delta = \sqrt[2]{D_l \times D_u} \qquad \text{I-2}$$

Using the +3-4.75mm size fraction with f= 13,25% as an example. Its equilibrium surface moisture is:

$$\square = \sqrt[2]{D_l \times D_u}$$

$$= \sqrt[2]{3 \times 4.75}$$

=3.77

$$SM_i = 2.88 + 6.5e^{-0.31\times3.77} + 26.96e^{-1.89\times3.77}$$

$$= 4.92\%$$

Thus, the contribution of the +3-4.75mm size fraction to the Total surface moisture is:

$$SM_{EST,\delta} = 4.92 \times (\frac{13.25}{100})$$

=0.65%

The above calculation was done for each size fraction and each $SM_{EST,\square}$ added to determine the total surface moisture of the sample.

For stage 1B a plot of fines content versus SM_{DIR} and fines content versus SM_{EST} was also used to determine the relationship between fines and surface moisture. SM_{LAB} was determined in the same manner as stage 1A.

Stage 2

As in the stage 2 analyses, the PSD's obtained were used in the model to estimate the surface moisture contents (SM_{EST}) of the samples. These results were then validated against the directly measured total moisture results (SM_{DIR}).

Again, the correlation coefficient between SM_{DIR} and SM_{EST} was used to verify the model.

The ratio of dry fines to wet fines was also determined to see how much fines adhering to coarser particles contribute to the total fines fraction.

The total fines content from each sample was plotted against drainage pipe height. This was to see how the fines varied within the drainage pipe. These plots are meant to give an idea as to how fines migrate and settle within a composite coal stockpile. The same was done for surface moisture content. The plots are also meant to show how moisture content varies within a coal stockpile.

For the wet sieve analysis the same equipment set up was used as in Figure 3-13. Fines washing off of the coal sample would collect in the 200L drum and allowed to settle overnight. The next morning the excess water was siphoned off. The fines collected in the drum were then dried in the sun and collected and weighed. This mass was then added to the total fines content of the sample.

The determination of SM_{LAB} for stage 2 was different than to stage 1. The SM_{LAB} for stage 2 was done in a laboratory in a controlled environment. The coal samples were poured into a tray and weighed. Every day the tray with coal would be weighed until the difference in mass loss from the previous day was less than 0,1%. At this point it was assumed all the surface moisture had been evaporated. The mass loss divided by the original wet coal mass returned the SM_{LAB}. Using this method it would take up to five days for SM_{LAB} to be reached, far longer than the method used for stage 1.

Appendix J Summary of stage 1A results

Table J-1: Stage 1A SM_{DIR}, IM_{LAB}, SM_{LAB}, TM_{LAB}

Size Fraction (mm)	GeoMean (mm)	SM_{LAB} (%)	IM_{LAB} (%)	TM_{LAB} (%)	Equi SM_{DIR} (%)	M_{SAT}(%)	% Contribution SM_{DIR}
+19	19,00	1,48	2,79	4,27	2,59	36,94	3,33
10-19	13,78	2,48	2,40	4,88	3,38	40,18	4,35
6-10	7,75	3,94	2,46	6,41	3,4	37,17	4,38
4.75-6	5,34	-	-	-	3,83	34,76	4,93
3-4.75	3,77	5,37	2,69	8,06	5,5	34,38	7,08
2-3	2,45	6,64	1,67	8,31	5,67	35,52	7,30
1-2	1,41	7,20	1,82	9,03	9,25	33,93	11,91
0.5-1	0,71	26,03	1,76	27,78	15,05	33,94	19,38
<0,5					*29		37,34

-Data Missing *Adopted from Cumming (2003)

Table J-2: Stage 1A Drum A SM_{DIR} results

	SM_{DIR}															
Time (Hrs)	**0,5-1**	***Diff (%)***	**1-2**	***Diff (%)***	**2-3**	***Diff (%)***	**3-4,75**	***Diff (%)***	**4,75-6**	***Diff (%)***	**6-10**	***Diff (%)***	**10-19**	***Diff (%)***	**+19**	***Diff (%)***
0	39,34		33,93		35,52		34,38		34,76		37,17		40,18		36,94	
12	15,24	61,26	10,34	69,53	6,86	80,69	6,90	79,93	5,10	85,33	4,76	87,19	4,29	89,32	2,49	93,26
24	15,05	1,25	9,66	6,58	6,31	8,02	6,32	8,41	4,27	16,27	4,02	15,55	3,62	15,62	2,31	7,23
36			9,28	3,93	5,81	7,92	5,97	5,54	3,77	11,71	3,39	15,67	3,36	7,18	2,16	6,49
48			9,25	0,32	5,67	2,41	5,76	3,52	3,54	6,10	3,10	8,55	3,23	3,87	2,21	-2,31
60			8,95	3,24			5,53	3,99					3,08	4,64		
72							5,50	0,54					3,07	0,32		

*Yellow highlights indicate equilibrium surface moisture

Appendix K Stage 1A lab results

Table K-1: +19mm SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	+19mm
Surface Moisture (%)	1,48
Inherent Moisture (%)	2,79
Total Moisture	4,27

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	147		
Plastic Bag +H2O+Coal	11768		
Empty Plastic Bag +residual Coal&H2O	147		
Empty Plastic Bag + residual Coal (Air Dried)	147		
Mass of residual coal in bag	0		0
Mass of residual Moisture in Bag	0	0	
Empty Bucket +residual Coal&H2O	4854,503		
Empty Bucket +residual Coal (Air Dried)	4850,699		
Moisture (residual) in bucket	3,804	3,804	
Mass of bucket	4780		
Mass of residual coal in bucket	70,699		70,699
Mass of Bag +Coal (Air dried)	11599		11452
Moisture loss from air drying	169	169	
Total		172,804	11522,699

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3765	8541	8411	130

Tray 2	3767	10443	10253	190
Tray 3				0
Total	7532	18984		320

Table K-2: +10-19mm SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	**10-19mm**
Surface Moisture (%)	2.48
Inherent Moisture (%)	2.40
Total Moisture	4.88

Surface Moisture	**Mass (g)**		
	Mass	**Moisture loss**	**Coal Mass**
New Plastic Bag	96		
Plastic Bag +H2O+Coal	17850		
Empty Plastic Bag +residual Coal&H2O	96		
Empty Plastic Bag + residual Coal (Air Dried)	94		
Mass of residual coal in bag	-2		-2
Mass of residual Moisture in Bag	2	2	
Empty Bucket +residual Coal&H2O	4742		
Empty Bucket +residual Coal (Air Dried)	4774		
Moisture (residual) in bucket	-32	-32	
Mass of bucket	4780		
Mass of residual coal in bucket	-6		-6
Mass of Bag +Coal (Air dried)	17380		17284
Moisture loss from air drying	470	470	
Total		440	17278

Inherent Moisture	**Mass (g)**			
	Empty	**With Coal**	**Oven dried**	**Moisture Loss**

Tray 1	3790	9767	9621	146
Tray 2	3833	9951	9819	132
Tray 3	3881	9142	9004	138
Total	11504	28860		416

Table K-3: +6-10mm SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	**6-10mm**
Surface Moisture (%)	3.94
Inherent Moisture (%)	2.46
Total Moisture	6.41

Surface Moisture	**Mass (g)**		
	Mass	**Moisture loss**	**Coal Mass**
New Plastic Bag	140		
Plastic Bag +H2O+Coal	19454		
Empty Plastic Bag +residual Coal&H2O	153		
Empty Plastic Bag + residual Coal (Air Dried)	143		
Mass of residual coal in bag	3		3
Mass of residual Moisture in Bag	10	10	
Empty Bucket +residual Coal&H2O	4856.983		
Empty Bucket +residual Coal (Air Dried)	4854.181		
Moisture (residual) in bucket	2.802	2.802	
Mass of bucket	4780		
Mass of residual coal in bucket	74.181		74.181
Mass of Bag +Coal (Air dried)	18702		18562
Moisture loss from air drying	752	752	
Total		764.802	18636.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3720	8608	8482	126
Tray 2	3875	10787	10620	167
Tray 3	3862	10617	10453	164
Total	11457	30012		457

Table K-4: +3-4,75mm SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	3-4,75
Surface Moisture (%)	5.37
Inherent Moisture (%)	2.69
Total Moisture	8.06

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	142		
Plastic Bag +H2O+Coal	18542		
Empty Plastic Bag +residual Coal&H2O	149		
Empty Plastic Bag + residual Coal (Air Dried)	145		
Mass of residual coal in bag	3		3
Mass of residual Moisture in Bag	4	4	
Empty Bucket +residual Coal&H2O	6103.439		
Empty Bucket +residual Coal (Air Dried)	6048.82		
Moisture (residual) in bucket	54.619	54.619	
Mass of bucket	4780		
Mass of residual coal in bucket	1268.82		1268.82
Mass of Bag +Coal (Air dried)	17542		17400
Moisture loss from air drying	1000	1000	

Total		1058.619	18668.82

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3762	9815	9654	161
Tray 2	3830	9641	9484	157
Tray 3	3880	9419	9268	151
Total	11472	28875		469

Table K-5: +2-3mm SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	2-3mm
Surface Moisture (%)	6.64
Inherent Moisture (%)	1.67
Total Moisture	8.31

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	96		
Plastic Bag +H2O+Coal	17659		
Empty Plastic Bag +residual Coal&H2O	108		
Empty Plastic Bag + residual Coal (Air Dried)	104		
Mass of residual coal in bag	8		8
Mass of residual Moisture in Bag	4	4	
Empty Bucket +residual Coal&H2O	6136.173		
Empty Bucket +residual Coal (Air Dried)	6171.991		
Moisture (residual) in bucket	-35.818	-35.818	
Mass of bucket	4780		
Mass of residual coal in bucket	1391.991		1391.991
Mass of Bag +Coal	16370		16274

(Air dried)			
Moisture loss from air drying	1289	1289	
Total		1257.182	17665.991

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3761	9862	9761	101
Tray 2	3827	9988	9893	95
Tray 3	3858	7873	7797	76
Total	11446	27723		272

Table K-6: +1-2mm SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	1-2mm
Surface Moisture (%)	7.20
Inherent Moisture (%)	1.82
Total Moisture	9.03

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	144		
Plastic Bag +H2O+Coal	17346		
Empty Plastic Bag +residual Coal&H2O	156		
Empty Plastic Bag + residual Coal (Air Dried)	149		
Mass of residual coal in bag	5		5
Mass of residual Moisture in Bag	7	7	
Empty Bucket +residual Coal&H2O	6073.431		
Empty Bucket +residual Coal (Air Dried)	6170.537		
Moisture (residual) in bucket	-97.106	-97.106	
Mass of bucket	4780		
Mass of residual coal in bucket	1390.537		1390.537

Mass of Bag +Coal (Air dried)	15923		15779
Moisture loss from air drying	1423	1423	
Total		1332.894	17169.537

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3761	8420	8326	94
Tray 2	3827	9267	9166	101
Tray 3	3856	9543	9450	93
Total	11444	27230		288

Table K-7: +0,5-1mm SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	0,5-1mm
Surface Moisture (%)	26.03
Inherent Moisture (%)	1.76
Total Moisture	27.78

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	142		
Plastic Bag +H2O+Coal	19756		
Empty Plastic Bag +residual Coal&H2O	255		
Empty Plastic Bag + residual Coal (Air Dried)	228		
Mass of residual coal in bag	86		86
Mass of residual Moisture in Bag	27	27	
Empty Bucket +residual Coal&H2O			
Empty Bucket +residual Coal (Air Dried)			
Moisture (residual) in bucket	0	0	

Mass of bucket	4780		
Mass of residual coal in bucket	-4780		-4780
Mass of Bag +Coal (Air dried)	15915		15773
Moisture loss from air drying	3841	3841	
Total		3868	10993

Inherent Moisture	**Mass (g)**			
	Empty	**With Coal**	**Oven dried**	**Moisture Loss**
Tray 1	3761	9011	8326	685
Tray 2	3827	9097	9166	-69
Tray 3	3856	9111	9450	-339
Total	11444	27219		277

Appendix L Stage 1B SM_{DIR}

Table L-1: Stage 1B Drum A SM_{DIR} results

	SM																					
Time (Hrs)	**10%**	***Diff***	**9%**	***Diff***	**8%**	***Diff***	**7%**	***Diff***	**6%**	***Diff***	**5%**	***Diff***	**4%**	***Diff***	**3%**	***Diff***	**2%**	***Diff***	**1%**	***Diff***	**0%**	***Diff***
0	24,78		24,16		24,73		24,35		25,24		26,09		27,44		26,52		27,09		25,88		27,73	
12	8,07	67,43	8,55	64,61	7,05	71,49	7,66	68,54	7,84	68,94	7,80	70,10	6,37	76,79	5,78	78,21	6,71	75,23	5,69	78,01	6,13	77,89
24	7,86	2,60	8,44	1,29	6,88	2,41	7,57	1,17	7,74	1,28	7,55	3,21	6,18	2,98	5,47	5,36	6,41	4,47	5,37	5,62	5,86	4,40
36	7,63	2,93	8,29	1,78	6,68	2,91	7,42	1,98	7,60	1,81	7,43	1,59	5,96	3,56	5,28	3,47	6,28	2,03	5,21	2,98	5,64	3,75
48	7,62	0,13	8,16	1,57	6,53	2,25	7,37	0,67	7,54	0,79	7,33	1,35	5,93	0,50	5,23	0,95	6,16	1,91	5,04	3,26	5,58	1,06
60	7,55	0,92	7,95	2,57	6,35	2,76	7,24	1,76							5,03	3,82	6,08	1,30				
72							7,21	0,41							4,96	1,39						
84															5,02	-1,21						
96															4,97	1,00						
108															4,91	1,21						

Cells highlighted in yellow represent the equilibrium moisture content (see section 1.3 for definition).

Table L-2: Stage 1B Drum B SM_{DIR} results

	SM																					
Time (Hrs)	**10%**	***Diff***	**9%**	***Diff***	**8%**	***Diff***	**7%**	***Diff***	**6%**	***Diff***	**5%**	***Diff***	**4%**	***Diff***	**3%**	***Diff***	**2%**	***Diff***	**1%**	***Diff***	**0%**	***Diff***
0	25,26		24,83		23,44		24,83		23,93		24,89		26,46		27,01		26,41		26,35		27,75	
12	7,82	69,04	7,67	69,11	7,69	67,19	7,16	71,16	6,93	71,04	6,15	75,29	5,82	78,00	5,43	79,90	4,85	81,64	6,46	75,48	5,43	80,43
24	7,46	4,60	7,51	2,09	7,50	2,47	6,87	4,05	6,62	4,47	6,05	1,63	5,36	7,90	5,23	3,68	4,39	9,48	6,08	5,88	5,20	4,24
36	7,36	1,34	7,39	1,60	7,25	3,33	6,75	1,75	6,44	2,72	5,90	2,48	5,32	0,75	4,98	4,78	4,35	0,91	6,12	-0,66	5,07	2,50
48	7,15	2,85	7,27	1,62	7,11	1,93	6,75	0,00	6,38	0,93	5,86	0,68	5,12	3,76	4,94	0,80	4,08	6,21	5,89	3,76	5,11	-0,79
60	7,11	0,56	7,17	1,38			6,76						5,15	-0,59					5,98	-1,53		
72			7,06	1,53			6,64						5,03	2,33								
84							6,54						5,07	-0,80								
96													5,13	-1,18								
108																						

Cells highlighted in yellow represent the equilibrium moisture content (see section 1.3 for definition).

Table L-3: Stage 1B Drum A results summary

Fines (%)	SM_{LAB} (%)	IM_{LAB} (%)	TM_{LAB} (%)	SM_{DIR} (%)	M_{SAT} (%)	SM_{EST} (%)
10	8,37	1,12	9,48	7,62	24,78	7,00
9	7,06	1,64	8,70	8,44	24,16	6,76
8	7,32	1,68	9,00	6,53	24,73	6,51
7	6,95	1,29	8,25	7,57	24,35	6,27
6	*	*	*	7,74	25,24	6,02
5	6,56	1,30	7,87	7,43	26,09	5,77
4	*	*	*	5,93	27,44	5,53
3	5,10	1,31	6,41	5,23	26,52	5,28
2	5,28	0,89	6,16	6,16	27,09	5,04
1	6,47	1,23	7,70	5,21	25,88	4,79
0	6,57	1,29	7,86	5,58	27,73	4,55

*Data missing

Table L-4: Stage 1B Drum B results summary

Fines (%)	SM_{LAB} (%)	IM_{LAB} (%)	TM_{LAB} (%)	SM_{DIR} (%)	M_{SAT} (%)	SM_{EST} (%)
10	7,45	1,26	8,72	7,36	25,26	7,00
9	7,08	1,06	8,13	7,39	24,83	6,76
8	6,65	1,47	8,12	7,11	23,44	6,51
7	7,12	0,73	7,85	6,75	24,83	6,27
6	5,86	1,75	7,60	6,38	23,93	6,02
5	7,70	1,94	9,65	6,05	24,98	5,77
4	5,81	1,62	7,43	5,32	26,46	5,53
3	5,85	1,32	7,17	4,94	27,01	5,28
2	5,31	1,10	6,41	4,35	26,41	5,04
1	5,01	0,92	5,93	6,12	26,35	4,79
0	6,05	1,34	7,39	5,11	27,75	4,55

Appendix M Stage 1B (Drum A) lab results

Table M-1: Drum A 0% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	0%
Surface Moisture (%)	6.57
Inherent Moisture (%)	1.29
Total Moisture	7.86

Surface Moisture	Mass (g)			
	Mass	Moisture loss	Coal Mass	
New Plastic Bag	96			
Plastic Bag +H2O+Coal	19445			
H20+Coal-Bag	19349			
Empty Plastic Bag +residual Coal&H2O	114			
Empty Plastic Bag + residual Coal (Air Dried)	105			
Mass of residual coal in bag	9		9	
Mass of residual Moisture in Bag	9	9		
Empty Bucket +residual Coal&H2O	-			
Empty Bucket +residual Coal (Air Dried)	-		-	
Moisture (residual) in bucket	#VALUE!	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	18177		18081	
Moisture loss from air drying	1268	1268		SUM
Total		1277	18155.181	19432.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3824	11955	11840	115
Tray 2	3759	13805	13685	120

Tray 3				0
Total	7583	25760		235

Table M-2: Drum A 1% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	1%
Surface Moisture (%)	6.47
Inherent Moisture (%)	1.23
Total Moisture	7.70

Surface Moisture	Mass (g)			
	Mass	Moisture loss	Coal Mass	
New Plastic Bag	96			
Plastic Bag +H2O+Coal	17801			
H20+Coal-Bag	17705			
Empty Plastic Bag +residual Coal&H2O	116			
Empty Plastic Bag + residual Coal (Air Dried)	107			
Mass of residual coal in bag	11		11	
Mass of residual Moisture in Bag	9	9		
Empty Bucket +residual Coal&H2O	123			
Empty Bucket +residual Coal (Air Dried)	37		37	
Moisture (residual) in bucket	86	86		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	16739		16643	
Moisture loss from air drying	1062	1062		SUM
Total		1157	16717.181	17874.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss

Tray 1	3854	8274	8218	56
Tray 2	3759	9500	9431	69
Tray 3	3628	10206	10125	81
Total	11241	27980		206

Table M-3: Drum A 2% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	**2%**
Surface Moisture (%)	5.28
Inherent Moisture (%)	0.89
Total Moisture	6.16

Surface Moisture	**Mass (g)**			
	Mass	**Moisture loss**	**Coal Mass**	
New Plastic Bag	96			
Plastic Bag +H2O+Coal	20074			
H20+Coal-Bag	19978			
Empty Plastic Bag +residual Coal&H2O	106			
Empty Plastic Bag + residual Coal (Air Dried)	102			
Mass of residual coal in bag	6		6	
Mass of residual Moisture in Bag	4	4		
Empty Bucket +residual Coal&H2O	-			
Empty Bucket +residual Coal (Air Dried)	-		-	
Moisture (residual) in bucket	#VALUE!	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	19020		18924	
Moisture loss from air drying	1054	1054		**SUM**
Total		1058	18998.181	20056.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3278	8508	8461	47
Tray 2	3220	9888	9828	60
Tray 3	3275	10300	10239	61
Total	9773	28696		168

Table M-4: Drum A 3% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	3%
Surface Moisture (%)	5.10
Inherent Moisture (%)	1.31
Total Moisture	6.41

Surface Moisture	Mass (g)			
	Mass	Moisture loss	Coal Mass	
New Plastic Bag	96			
Plastic Bag +H2O+Coal	20421			
H20+Coal-Bag	20325			
Empty Plastic Bag +residual Coal&H2O	116			
Empty Plastic Bag + residual Coal (Air Dried)	106			
Mass of residual coal in bag	10		10	
Mass of residual Moisture in Bag	10	10		
Empty Bucket +residual Coal&H2O	183			
Empty Bucket +residual Coal (Air Dried)	90		90	
Moisture (residual) in bucket	93	93		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	19478		19382	
Moisture loss from air drying	943	943		SUM

Total		1046	19456.181	20502.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3279	10573	10494	79
Tray 2	3221	8390	8297	93
Tray 3	3276	10309	10226	83
Total	9776	29272		255

Table M-5: Drum A 4% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	4%
Surface Moisture (%)	#VALUE!
Inherent Moisture (%)	1.32
Total Moisture	#VALUE!

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	96		
Plastic Bag +H2O+Coal	20344		
H20+Coal-Bag	20248		
Empty Plastic Bag +residual Coal&H2O	119		
Empty Plastic Bag + residual Coal (Air Dried)	111		
Mass of residual coal in bag	15		15
Mass of residual Moisture in Bag	8	8	
Empty Bucket +residual Coal&H2O	108		
Empty Bucket +residual Coal (Air Dried)	-		-
Moisture (residual) in bucket	#VALUE!	#VALUE!	
Mass of bucket	-		
Mass of residual coal in bucket	#VALUE!		74.181
Mass of Bag +Coal	19163		19067

(Air dried)				
Moisture loss from air drying	1181	1181		SUM
Total		#VALUE!	19141.181	#VALUE!

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3785	12054	11937	117
Tray 2	3883	14672	14537	135
Tray 3				0
Total	7668	26726		252

Table M-6: Drum A 5% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	5%
Surface Moisture (%)	6.56
Inherent Moisture (%)	1.30
Total Moisture	7.87

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	96		
Plastic Bag +H2O+Coal	20118		
H20+Coal-Bag	20022		
Empty Plastic Bag +residual Coal&H2O	109		
Empty Plastic Bag + residual Coal (Air Dried)	102		
Mass of residual coal in bag	6		6
Mass of residual Moisture in Bag	7	7	
Empty Bucket +residual Coal&H2O	88		
Empty Bucket +residual Coal (Air Dried)	49		49
Moisture (residual) in bucket	39	39	
Mass of bucket	???		

Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	18842		18746	
Moisture loss from air drying	1276	1276		SUM
Total		1322	18820.181	20142.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3812	13487	13362	125
Tray 2	3881	12950	12831	119
Tray 3				0
Total	7693	26437		244

Table M-7: Drum A 6% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	6%
Surface Moisture (%)	#VALUE!
Inherent Moisture (%)	1.79
Total Moisture	#VALUE!

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	96		
Plastic Bag +H2O+Coal	20128		
H20+Coal-Bag	20032		
Empty Plastic Bag +residual Coal&H2O	129		
Empty Plastic Bag + residual Coal (Air Dried)	113		
Mass of residual coal in bag	17		17
Mass of residual Moisture in Bag	16	16	
Empty Bucket +residual Coal&H2O	126		
Empty Bucket +residual Coal (Air Dried)	-		-

Moisture (residual) in bucket	#VALUE!	#VALUE!		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	18375		18279	
Moisture loss from air drying	1753	1753		SUM
Total		#VALUE!	18353.181	#VALUE!

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3879	12426	12262	164
Tray 2	3825	13906	13737	169
Tray 3				0
Total	7704	26332		333

Table M-8: Drum A 7% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	7%
Surface Moisture (%)	6.95
Inherent Moisture (%)	1.29
Total Moisture	8.25

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	96		
Plastic Bag +H2O+Coal	20951		
H20+Coal-Bag	20855		
Empty Plastic Bag +residual Coal&H2O	118		
Empty Plastic Bag + residual Coal (Air Dried)	109		
Mass of residual coal in bag	13		13
Mass of residual Moisture in Bag	9	9	
Empty Bucket +residual Coal&H2O	91		

Empty Bucket +residual Coal (Air Dried)	-		-	
Moisture (residual) in bucket	#VALUE!	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	19504		19408	
Moisture loss from air drying	1447	1447		**SUM**
Total		1456	19482.181	20938.181

Inherent Moisture	**Mass (g)**			
	Empty	**With Coal**	**Oven dried**	**Moisture Loss**
Tray 1	3811	13395	13262	133
Tray 2	3879	13697	13579	118
Tray 3				0
Total	7690	27092		251

Table M-9: Drum A 8% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	**8%**
Surface Moisture (%)	7.32
Inherent Moisture (%)	1.68
Total Moisture	9.00

Surface Moisture	**Mass (g)**		
	Mass	**Moisture loss**	**Coal Mass**
New Plastic Bag	96		
Plastic Bag +H2O+Coal	21793		
H20+Coal-Bag	21697		
Empty Plastic Bag +residual Coal&H2O	110		
Empty Plastic Bag + residual Coal (Air Dried)	104		
Mass of residual coal in bag	8		8

Mass of residual Moisture in Bag	6	6		
Empty Bucket +residual Coal&H2O	135			
Empty Bucket +residual Coal (Air Dried)	98		98	
Moisture (residual) in bucket	37	37		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	20240		20144	
Moisture loss from air drying	1553	1553		**SUM**
Total		1596	20218.181	21814.181

Inherent Moisture	**Mass (g)**			
	Empty	**With Coal**	**Oven dried**	**Moisture Loss**
Tray 1	3855	9252	9154	98
Tray 2	3762	11259	11147	112
Tray 3	3705	10952	10823	129
Total	11322	31463		339

Table M-10: Drum A 9% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	**9%**
Surface Moisture (%)	7.06
Inherent Moisture (%)	1.64
Total Moisture	8.70

Surface Moisture	**Mass (g)**		
	Mass	**Moisture loss**	**Coal Mass**
New Plastic Bag	96		
Plastic Bag +H2O+Coal	21098		
H20+Coal-Bag	21002		
Empty Plastic Bag +residual Coal&H2O	109		
Empty Plastic	99		

Bag + residual Coal (Air Dried)				
Mass of residual coal in bag	3		3	
Mass of residual Moisture in Bag	10	10		
Empty Bucket +residual Coal&H2O	-			
Empty Bucket +residual Coal (Air Dried)	-		-	
Moisture (residual) in bucket	#VALUE!	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	19620		19524	
Moisture loss from air drying	1478	1478		**SUM**
Total		1488	19598.181	21086.181

Inherent Moisture	**Mass (g)**			
	Empty	**With Coal**	**Oven dried**	**Moisture Loss**
Tray 1	3861	13890	13731	159
Tray 2	3836	13326	13165	161
Tray 3				0
Total	7697	27216		320

Table M-11: Drum A 10% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	**10%**
Surface Moisture (%)	8.37
Inherent Moisture (%)	1.12
Total Moisture	9.48

Surface Moisture	**Mass (g)**		
	Mass	**Moisture loss**	**Coal Mass**
New Plastic Bag	96		
Plastic Bag +H2O+Coal	21995		
H20+Coal-Bag	21899		

Empty Plastic Bag +residual Coal&H2O	113			
Empty Plastic Bag + residual Coal (Air Dried)	103			
Mass of residual coal in bag	7		7	
Mass of residual Moisture in Bag	10	10		
Empty Bucket +residual Coal&H2O	702			
Empty Bucket +residual Coal (Air Dried)	566		566	
Moisture (residual) in bucket	136	136		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	20290		20194	
Moisture loss from air drying	1705	1705		**SUM**
Total		1851	20268.181	22119.181

Inherent Moisture	**Mass (g)**			
	Empty	**With Coal**	**Oven dried**	**Moisture Loss**
Tray 1	3275	10874	10790	84
Tray 2	3262	10371	10303	68
Tray 3	3254	9239	9160	79
Total	9791	30484		231

Appendix N Stage 1B (Drum B) lab results

Table N-1: Drum B 0% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	0%
Surface Moisture (%)	6.05
Inherent Moisture (%)	1.34
Total Moisture	7.39

Surface Moisture	Mass (g)			
	Mass	Moisture loss	Coal Mass	
New Plastic Bag	96			
Plastic Bag +H2O+Coal	19234			
H20+Coal-Bag	19138			
Empty Plastic Bag +residual Coal&H2O	114			
Empty Plastic Bag + residual Coal (Air Dried)	104			
Mass of residual coal in bag	8		8	
Mass of residual Moisture in Bag	10	10		
Empty Bucket +residual Coal&H2O	-			
Empty Bucket +residual Coal (Air Dried)	-		-	
Moisture (residual) in bucket	#VALUE!	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	18082		17986	
Moisture loss from air drying	1152	1152		SUM
Total		1162	18060.181	19222.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3787	12720	12602	118

Tray 2	4096	13211	13087	124
Tray 3				0
Total	7883	25931		242

Table N-2: Drum B 1% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	**1%**
Surface Moisture (%)	5.01
Inherent Moisture (%)	0.92
Total Moisture	5.93

Surface Moisture	**Mass (g)**			
	Mass	**Moisture loss**	**Coal Mass**	
New Plastic Bag	96			
Plastic Bag +H2O+Coal	17599			
H20+Coal-Bag	17503			
Empty Plastic Bag +residual Coal&H2O	107			
Empty Plastic Bag + residual Coal (Air Dried)	103			
Mass of residual coal in bag	7		7	
Mass of residual Moisture in Bag	4	4		
Empty Bucket +residual Coal&H2O	-			
Empty Bucket +residual Coal (Air Dried)	-		-	
Moisture (residual) in bucket	#VALUE!	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	16722		16626	
Moisture loss from air drying	877	877		**SUM**
Total		881	16700.181	17581.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3281	7750	7707	43
Tray 2	3258	8808	8756	52
Tray 3	3276	9878	9820	58
Total	9815	26436		153

Table N-3: Drum B 2% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	2%
Surface Moisture (%)	5.31
Inherent Moisture (%)	1.10
Total Moisture	6.41

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	96		
Plastic Bag +H2O+Coal	20074		
H20+Coal-Bag	19978		
Empty Plastic Bag +residual Coal&H2O	106		
Empty Plastic Bag + residual Coal (Air Dried)	101		
Mass of residual coal in bag	5		5
Mass of residual Moisture in Bag	5	5	
Empty Bucket +residual Coal&H2O	102		
Empty Bucket +residual Coal (Air Dried)	23		23
Moisture (residual) in bucket	79	-	
Mass of bucket	-		
Mass of residual coal in bucket	#VALUE!		74.181
Mass of Bag +Coal (Air dried)	19014		18918

Moisture loss from air drying	1060	1060		SUM
Total		1065	18992.181	20057.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3785	9655	9591	64
Tray 2	3626	10429	10356	73
Tray 3	3766	10107	10035	72
Total	11177	30191		209

Table N-4: Drum B 3% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	3%
Surface Moisture (%)	5.85
Inherent Moisture (%)	1.32
Total Moisture	7.17

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	96		
Plastic Bag +H2O+Coal	20344		
H20+Coal-Bag	20248		
Empty Plastic Bag +residual Coal&H2O	119		
Empty Plastic Bag + residual Coal (Air Dried)	111		
Mass of residual coal in bag	109		109
Mass of residual Moisture in Bag	8	8	
Empty Bucket +residual Coal&H2O	-		
Empty Bucket +residual Coal (Air Dried)	-		-
Moisture (residual) in bucket	#VALUE!	-	
Mass of bucket	-		

Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	19163		19067	
Moisture loss from air drying	1181	1181		**SUM**
Total		1189	19141.181	20330.181

Inherent Moisture	**Mass (g)**			
	Empty	**With Coal**	**Oven dried**	**Moisture Loss**
Tray 1	3785	12054	11937	117
Tray 2	3883	14672	14537	135
Tray 3				0
Total	7668	26726		252

Table N-5: Drum B 4% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	**4%**
Surface Moisture (%)	5.81
Inherent Moisture (%)	1.62
Total Moisture	7.43

Surface Moisture	**Mass (g)**		
	Mass	**Moisture loss**	**Coal Mass**
New Plastic Bag	96		
Plastic Bag +H2O+Coal	20579		
H20+Coal-Bag	20483		
Empty Plastic Bag +residual Coal&H2O	116		
Empty Plastic Bag + residual Coal (Air Dried)	107		
Mass of residual coal in bag	276		276
Mass of residual Moisture in Bag	225	225	
Empty Bucket +residual Coal&H2O	-		
Empty Bucket +residual Coal (Air Dried)	-		-

Moisture (residual) in bucket	#VALUE!	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	19596		19500	
Moisture loss from air drying	983	983		SUM
Total		1208	19574.181	20782.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3062	10145	10048	97
Tray 2	3259	10475	10349	126
Tray 3	3276	8573	8479	94
Total	9597	29193		317

Table N-6: Drum B 5% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	5%
Surface Moisture (%)	7.70
Inherent Moisture (%)	1.94
Total Moisture	9.65

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	96		
Plastic Bag +H2O+Coal	19621		
H20+Coal-Bag	19525		
Empty Plastic Bag +residual Coal&H2O	111		
Empty Plastic Bag + residual Coal (Air Dried)	104		
Mass of residual coal in bag	8		8
Mass of residual Moisture in Bag	7	7	
Empty Bucket +residual	150		

Coal&H2O				
Empty Bucket +residual Coal (Air Dried)	-		-	
Moisture (residual) in bucket	#VALUE!	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	18118		18022	
Moisture loss from air drying	1503	1503		SUM
Total		1510	18096.181	19606.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3876	13376	13203	173
Tray 2	3825	12692	12508	184
Tray 3				0
Total	7701	26068		357

Table N-7: Drum B 6% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	6%
Surface Moisture (%)	5.86
Inherent Moisture (%)	1.75
Total Moisture	7.60

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	96		
Plastic Bag +H2O+Coal	19362		
H20+Coal-Bag	19266		
Empty Plastic Bag +residual Coal&H2O	107		
Empty Plastic Bag + residual Coal (Air Dried)	102		
Mass of residual coal in bag	6		6

Mass of residual Moisture in Bag	5	5		
Empty Bucket +residual Coal&H2O	93			
Empty Bucket +residual Coal (Air Dried)	35		35	
Moisture (residual) in bucket	58	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	18234		18138	
Moisture loss from air drying	1128	1128		**SUM**
Total		1133	18212.181	19345.181

Inherent Moisture	**Mass (g)**			
	Empty	**With Coal**	**Oven dried**	**Moisture Loss**
Tray 1	3879	14555	14380	175
Tray 2	3827	11288	11146	142
Tray 3				0
Total	7706	25843		317

Table N-8: Drum B 7% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	**7%**
Surface Moisture (%)	7.12
Inherent Moisture (%)	0.73
Total Moisture	7.85

Surface Moisture	**Mass (g)**		
	Mass	**Moisture loss**	**Coal Mass**
New Plastic Bag	96		
Plastic Bag +H2O+Coal	19953		
H20+Coal-Bag	19857		
Empty Plastic Bag +residual Coal&H2O	101		
Empty Plastic	98		

Bag + residual Coal (Air Dried)				
Mass of residual coal in bag	2		2	
Mass of residual Moisture in Bag	3	3		
Empty Bucket +residual Coal&H2O	207			
Empty Bucket +residual Coal (Air Dried)	126		126	
Moisture (residual) in bucket	81	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	18537		18441	
Moisture loss from air drying	1416	1416		SUM
Total		1419	18515.181	19934.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3875	12976	12908	68
Tray 2	3825	13233	13165	68
Tray 3				0
Total	7700	26209		136

Table N-9: Drum B 8% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	8%
Surface Moisture (%)	6.65
Inherent Moisture (%)	1.47
Total Moisture	8.12

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass
New Plastic Bag	96		
Plastic Bag +H2O+Coal	20219		
H20+Coal-Bag	20123		

Empty Plastic Bag +residual Coal&H2O	109			
Empty Plastic Bag + residual Coal (Air Dried)	102			
Mass of residual coal in bag	6		6	
Mass of residual Moisture in Bag	7	7		
Empty Bucket +residual Coal&H2O	330			
Empty Bucket +residual Coal (Air Dried)	205		205	
Moisture (residual) in bucket	125	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	18882		18786	
Moisture loss from air drying	1337	1337		SUM
Total		1344	18860.181	20204.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3809	14638	14495	143
Tray 2	3824	11778	11645	133
Tray 3				0
Total	7633	26416		276

Table N-10: Drum 9% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	9%
Surface Moisture (%)	7.08
Inherent Moisture (%)	1.06
Total Moisture	8.13

Surface Moisture	Mass (g)		
	Mass	Moisture loss	Coal Mass

New Plastic Bag	96			
Plastic Bag +H2O+Coal	21319			
H20+Coal-Bag	21223			
Empty Plastic Bag +residual Coal&H2O	108			
Empty Plastic Bag + residual Coal (Air Dried)	103			
Mass of residual coal in bag	7		7	
Mass of residual Moisture in Bag	5	5		
Empty Bucket +residual Coal&H2O	190			
Empty Bucket +residual Coal (Air Dried)	-		-	
Moisture (residual) in bucket	#VALUE!	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	19816		19720	
Moisture loss from air drying	1503	1503		SUM
Total		1508	19794.181	21302.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3876	13441	13326	115
Tray 2	3853	14003	13910	93
Tray 3				0
Total	7729	27444		208

Table N-11: Drum 10% Fines SM_{lab}, IM_{lab}, TM_{lab}

Size Fraction:	10%
Surface Moisture (%)	7.45
Inherent Moisture (%)	1.26
Total Moisture	8.72

Surface Moisture	Mass (g)			
	Mass	Moisture loss	Coal Mass	
New Plastic Bag	96			
Plastic Bag +H2O+Coal	22205			
H20+Coal-Bag	22109			
Empty Plastic Bag +residual Coal&H2O	114			
Empty Plastic Bag + residual Coal (Air Dried)	104			
Mass of residual coal in bag	8		8	
Mass of residual Moisture in Bag	10	10		
Empty Bucket +residual Coal&H2O	464			
Empty Bucket +residual Coal (Air Dried)	348		348	
Moisture (residual) in bucket	116	-		
Mass of bucket	-			
Mass of residual coal in bucket	#VALUE!		74.181	
Mass of Bag +Coal (Air dried)	20561		20465	
Moisture loss from air drying	1644	1644		SUM
Total		1654	20539.181	22193.181

Inherent Moisture	Mass (g)			
	Empty	With Coal	Oven dried	Moisture Loss
Tray 1	3265	10587	10501	86
Tray 2	3273	9831	9742	89
Tray 3	3363	10196	10109	87
Total	9901	30614		262

Appendix O Stage 1B drum A and B SM_{DIR} VS model

Table O-1: Stage 1B Drum A and B SM_{DIR} VS Model

		Size Fraction (mm)					Drum A		Drum B
Fines Content		f_l	f_u	**Geometric Mean**	f_i	SM_iXf_i	SM_{DIR}%	SM_{EST}% $\Sigma(SM_i \times w_i)$	SM_{DIR}%
	A	19,00	30,00	23,87	5,43	0,16			
	B	10	19	13,78	25,18	0,75			
	C	6	10	7,75	23,56	0,82			
	D	4,75	6	5,34	14,03	0,58			
0%	**E**	3,00	4,75	3,77	13,25	0,65	5,58	4,55	5,11
	F	2	3	2,45	8,69	0,54			
	G	1	2	1,41	7,00	0,63			
	H	0,5	1	0,71	2,86	0,43			
	I	0,05	0,50	0,16	0,00	0,00			

		Size Fraction (mm)					Drum A		Drum B
Fines Content		f_l	f_u	**Geometric Mean**	f_i	SM_iXf_i	SM_{DIR}%	SM_{EST}% $\Sigma(SM_i \times w_i)$	SM_{DIR}%
1%	**A**	19,00	30,00	23,87	5,37	0,15	5,21	4,79	6,12
	B	10	19	13,78	24,93	0,74			
	C	6	10	7,75	23,33	0,81			
	D	4,75	6	5,34	13,89	0,57			
	E	3,00	4,75	3,77	13,12	0,65			
	F	2	3	2,45	8,61	0,53			
	G	1	2	1,41	6,93	0,62			
	H	0,5	1	0,71	2,83	0,43			
	I	0,05	0,50	0,16	1,00	0,29			

		Size Fraction (mm)					Drum A		Drum B
Fines Content		f_l	f_u	Geometric Mean	f_i	SM_iXf_i	SM_{DIR}%	SM_{EST}% $\Sigma(SM_i \times w_i)$	SM_{DIR}%
2%	A	19,00	30,00	23,87	5,32	0,15	6,16	5,04	4,35
	B	10	19	13,78	24,67	0,73			
	C	6	10	7,75	23,09	0,80			
	D	4,75	6	5,34	13,75	0,57			
	E	3,00	4,75	3,77	12,99	0,64			
	F	2	3	2,45	8,52	0,53			
	G	1	2	1,41	6,86	0,61			
	H	0,5	1	0,71	2,80	0,43			
	I	0,05	0,50	0,16	2,00	0,58			

		Size Fraction (mm)					Drum A		Drum B
Fines Content		f_l	f_u	Geometric Mean	f_i	SM_iXf_i	SM_{DIR}%	SM_{EST}% $\Sigma(SM_i \times w_i)$	SM_{DIR}%
3%	A	19,00	30,00	23,87	5,26	0,15	5,23	5,28	4,94
	B	10	19	13,78	24,42	0,73			
	C	6	10	7,75	22,86	0,79			
	D	4,75	6	5,34	13,61	0,56			
	E	3,00	4,75	3,77	12,85	0,63			
	F	2	3	2,45	8,43	0,52			
	G	1	2	1,41	6,79	0,61			
	H	0,5	1	0,71	2,77	0,42			
	I	0,05	0,50	0,16	3,00	0,87			

		Size Fraction (mm)					Drum A		Drum B
Fines Content		f_l	f_u	Geometric Mean	f_i	SM_iXf_i	SM_{DIR}%	SM_{EST}% $\Sigma(SM_i \times w_i)$	SM_{DIR}%
4%	A	19,00	30,00	23,87	5,21	0,15	5,93	5,53	5,32
	B	10	19	13,78	24,17	0,72			
	C	6	10	7,75	22,62	0,78			
	D	4,75	6	5,34	13,47	0,56			
	E	3,00	4,75	3,77	12,72	0,63			
	F	2	3	2,45	8,35	0,52			
	G	1	2	1,41	6,72	0,60			
	H	0,5	1	0,71	2,74	0,42			
	I	0,05	0,50	0,16	4,00	1,16			

		Size Fraction (mm)					Drum A		Drum B
Fines Content		f_l	f_u	Geometric Mean	f_i	SM_iXf_i	SM_{DIR}%	SM_{EST}% $\Sigma(SM_i \times w_i)$	SM_{DIR}%
5%	A	19,00	30,00	23,87	5,15	0,15	7,43	5,77	6,05
	B	10	19	13,78	23,92	0,71			
	C	6	10	7,75	22,39	0,78			
	D	4,75	6	5,34	13,33	0,55			
	E	3,00	4,75	3,77	12,59	0,62			
	F	2	3	2,45	8,26	0,51			
	G	1	2	1,41	6,65	0,59			
	H	0,5	1	0,71	2,71	0,41			
	I	0,05	0,50	0,16	5,00	1,45			

		Size Fraction (mm)					Drum A		Drum B
Fines Content		f_l	f_u	Geometric Mean	f_i	SM_iXf_i	SM_{DIR}%	SM_{EST}% $\Sigma(SM_i \times w_i)$	SM_{DIR}%
6%	A	19,00	30,00	23,87	5,10	0,15	7,74	6,02	6,38
	B	10	19	13,78	23,67	0,70			
	C	6	10	7,75	22,15	0,77			
	D	4,75	6	5,34	13,19	0,54			
	E	3,00	4,75	3,77	12,46	0,61			
	F	2	3	2,45	8,17	0,51			
	G	1	2	1,41	6,58	0,59			
	H	0,5	1	0,71	2,68	0,41			
	I	0,05	0,50	0,16	6,00	1,74			

		Size Fraction (mm)					Drum A		Drum B
Fines Content		f_l	f_u	Geometric Mean	f_i	SM_iXf_i	SM_{DIR}%	SM_{EST}% $\Sigma(SM_i \times w_i)$	SM_{DIR}%
7%	A	19,00	30,00	23,87	5,05	0,15	7,57	6,27	6,75
	B	10	19	13,78	23,42	0,70			
	C	6	10	7,75	21,91	0,76			
	D	4,75	6	5,34	13,05	0,54			
	E	3,00	4,75	3,77	12,32	0,61			
	F	2	3	2,45	8,09	0,50			
	G	1	2	1,41	6,51	0,58			
	H	0,5	1	0,71	2,66	0,40			
	I	0,05	0,50	0,16	7,00	2,03			

		Size Fraction (mm)					Drum A		Drum B
Fines Content		f_l	f_u	**Geometric Mean**	f_i	SM_iXf_i	$SM_{DIR}\%$	$SM_{EST}\%\ \Sigma(SM_i \times w_i)$	$SM_{DIR}\%$
8%	**A**	19,00	30,00	23,87	4,99	0,14	6,53	6,51	7,11
	B	10	19	13,78	23,16	0,69			
	C	6	10	7,75	21,68	0,75			
	D	4,75	6	5,34	12,91	0,53			
	E	3,00	4,75	3,77	12,19	0,60			
	F	2	3	2,45	8,00	0,49			
	G	1	2	1,41	6,44	0,58			
	H	0,5	1	0,71	2,63	0,40			
	I	0,05	0,50	0,16	8,00	2,33			

		Size Fraction (mm)					Drum A		Drum B
Fines Content		f_l	f_u	Geometric Mean	f_i	SM_iXf_i	SM_{DIR}%	SM_{EST}% $\Sigma(SM_i \times w_i)$	SM_{DIR}%
9%	A	19,00	30,00	23,87	4,94	0,14	8,44	6,76	7,39
	B	10	19	13,78	22,91	0,68			
	C	6	10	7,75	21,44	0,74			
	D	4,75	6	5,34	12,77	0,53			
	E	3,00	4,75	3,77	12,06	0,59			
	F	2	3	2,45	7,91	0,49			
	G	1	2	1,41	6,37	0,57			
	H	0,5	1	0,71	2,60	0,39			
	I	0,05	0,50	0,16	9,00	2,62			

		Size Fraction (mm)					Drum A		Drum B
Fines Content		f_l	f_u	Geometric Mean	f_i	SM_iXf_i	SM_{DIR}%	SM_{EST}% $\Sigma(SM_i \times w_i)$	SM_{DIR}%
10%	A	19,00	30,00	23,87	4,88	0,14	7,62	7,00	7,36
	B	10	19	13,78	22,66	0,67			
	C	6	10	7,75	21,21	0,74			
	D	4,75	6	5,34	12,63	0,52			
	E	3,00	4,75	3,77	11,93	0,59			
	F	2	3	2,45	7,82	0,48			
	G	1	2	1,41	6,30	0,56			
	H	0,5	1	0,71	2,57	0,39			
	I	0,05	0,50	0,16	10,00	2,91			

Appendix P Stage 2 SM_{DIR} results summary

Table P-1: Stage 2 Drainage results

	surface moisture													
Time (Hrs)	**8.50%**	***Diff***	**10.94%**	***Diff***	**8.49%**	***Diff***	**7.94%**	***Diff***	**5.05%**	***Diff***	**3.13%**	***Diff***	**1.09%**	***Diff***
0			0,00		0,00		0,00		0,00		0,00		0,00	
12	5,95		8,25		10,56		7,09		6,70		5,52		4,12	
24	5,57	6,39	7,72	6,42	10,09	4,45	6,71	5,36	6,38	4,78	5,16	6,52	4,00	2,91
36	5,20	6,64	7,28	5,70	9,78	3,07	6,48	3,43	6,16	3,45	5,04	2,33	3,83	4,25
48	5,13	1,35	7,17	1,51	9,65	1,33	6,33	2,31	6,02	2,27	4,93	2,18	3,90	-1,83
60	4,97	3,12	7,02	2,09	9,44	2,18	6,21	1,90	5,93	1,50	4,79	2,84	3,77	3,33
72	4,92	1,01	6,92	1,42	9,35	0,95	6,43	-3,54	5,83	1,69	4,82	-0,63	3,88	-2,92
84	4,70	4,47	6,68	3,47	9,25	1,07	6,21	3,42	5,69	2,40	4,63	3,94	3,74	3,61
96	4,76	-1,28	6,69	-0,15	9,20	0,54	6,24	-0,48	5,70	-0,18	4,70	-1,51	3,78	-1,07
108									5,58	2,11				
120									5,60	-0,36				

Table P-2: Stage 2 SM_{DIR} Summary

Fines Content (%)	Equi SM_{DIR} (%)	Time (Hrs)
8.50%	5,13	48
10.94%	7,17	48
8.49%	9,65	48
7.94%	6,21	60
5.05%	5,93	60
3.13%	4,82	72
1.09%	3,9	48

Appendix Q Stage 2 lab results

Table Q-1: Stage 2 1,09% Fines SM_{lab}, IM_{lab}, TM_{lab}

Sample Point	1	Day 1	Day 2	Day 3
Item	Mass (g)			
Empty Bag	93			
Empty Tray	3258			
Bag + Wet Coal	3137			
Coal in Bag	3044			
Tray + Wet Coal	6300	6225	6226	
Coal Mass on tray	3042	2967	2968	
% Moisture Loss		2.465483	-0.0337	
Empty Bag + res Wet Coal	94			
Empty Bag + res Dry Coal	94			
Res coal in bag	1			
Moisture lost from bag	0			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6130			
Oven Dry Coal	2872			
Total Coal	3043.00			
Surface Moisture lost	74.00			
Inherent Moisture lost	96.00			
Surface Moisture %	**2.43**			
Inherent Moisture %	**3.23**			
Total Moisture %	**5.67**			
Sample Point	**2**	**Day 1**	**Day 2**	**Day 3**
Item	Mass (g)			
Empty Bag	93			
Empty Tray	3289			
Bag + Wet Coal	3074			
Coal in Bag	2981			
Tray + Wet Coal	6268	6177	6177	
Coal Mass on tray	2979	2888	2888	
% Moisture Loss		3.054716	0	
Empty Bag + res Wet Coal	94			
Empty Bag + res Dry Coal	93			

Res coal in bag	0			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6083			
Oven Dry Coal	2794			
Total Coal	2979.00			
Surface Moisture lost	92.00			
Inherent Moisture lost	94.00			
Surface Moisture %	**3.09**			
Inherent Moisture %	**3.25**			
Total Moisture %	**6.34**			
Sample Point	**3**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3271			
Bag + Wet Coal	3453			
Coal in Bag	3360			
Tray + Wet Coal	6626	6521	6522	
Coal Mass on tray	3355	3250	3251	
% Moisture Loss		3.129657	-0.03077	
Empty Bag + res Wet Coal	93			
Empty Bag + res Dry Coal	93			
Res coal in bag	0			
Moisture lost from bag	0			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6421			
Oven Dry Coal	3150			
Total Coal	3355.00			
Surface Moisture lost	104.00			
Inherent Moisture lost	101.00			
Surface Moisture %	**3.10**			
Inherent Moisture %	**3.11**			
Total Moisture %	**6.21**			
Sample Point	**4**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			

Empty Tray	3300			
Bag + Wet Coal	3287			
Coal in Bag	3194			
Tray + Wet Coal	6491	6393	6393	
Coal Mass on tray	3191	3093	3093	
% Moisture Loss		3.071138	0	
Empty Bag + res Wet Coal	94			
Empty Bag + res Dry Coal	93			
Res coal in bag	0			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6304			
Oven Dry Coal	3004			
Total Coal	3191.00			
Surface Moisture lost	99.00			
Inherent Moisture lost	89.00			
Surface Moisture %	**3.10**			
Inherent Moisture %	**2.88**			
Total Moisture %	**5.98**			
Sample Point	**5**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3270			
Bag + Wet Coal	3287			
Coal in Bag	3194			
Tray + Wet Coal	6634	6531	6531	
Coal Mass on tray	3364	3261	3261	
% Moisture Loss		3.061831	0	
Empty Bag + res Wet Coal	98			
Empty Bag + res Dry Coal	97			
Res coal in bag	4			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6441			
Oven Dry Coal	3171			
Total Coal	3368.00			
Surface Moisture lost	104.00			
Inherent Moisture lost	90.00			
Surface Moisture %	**3.09**			

Inherent Moisture %	**2.76**			
Total Moisture %	**5.85**			
Sample Point	**6**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3203			
Bag + Wet Coal	4288			
Coal in Bag	4195			
Tray + Wet Coal	7396	7277	7277	
Coal Mass on tray	4193	4074	4074	
% Moisture Loss		2.838063	0	
Empty Bag + res Wet Coal	94			
Empty Bag + res Dry Coal	93			
Res coal in bag	0			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	7194			
Oven Dry Coal	3991			
Total Coal	4193.00			
Surface Moisture lost	120.00			
Inherent Moisture lost	83.00			
Surface Moisture %	**2.86**			
Inherent Moisture %	**2.04**			
Total Moisture %	**4.90**			

Table Q-2: Stage 2 3,13% SM_{lab}, IM_{lab}, TM_{lab}

Sample Point	**1**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3202			
Bag + Wet Coal	**2544**			
Coal in Bag	2451			
Tray + Wet Coal	5650	5585	5581	5583
Coal Mass on tray	2448	2383	2379	2381
% Moisture Loss		2,655229	0,167856	-0,08407
Empty Bag + res Wet Coal	94			

Empty Bag + res Dry Coal	94			
Res coal in bag	1			
Moisture lost from bag	0			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	5523			
Oven Dry Coal	2321			
Total Coal	2449,00			
Surface Moisture lost	67,00			
Inherent Moisture lost	60,00			
Surface Moisture %	**2,74**			
Inherent Moisture %	**2,52**			
Total Moisture %	**5,26**			
Sample Point	**2**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3288			
Bag + Wet Coal	**3140**			
Coal in Bag	3047			
Tray + Wet Coal	6332	6240	6234	6235
Coal Mass on tray	3044	2952	2946	2947
% Moisture Loss		3,022339	0,203252	-0,03394
Empty Bag + res Wet Coal	94			
Empty Bag + res Dry Coal	93			
Res coal in bag	0			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6158			
Oven Dry Coal	2870			
Total Coal	3044,00			
Surface Moisture lost	98,00			
Inherent Moisture lost	77,00			
Surface Moisture %	**3,22**			
Inherent Moisture %	**2,61**			
Total Moisture %	**5,83**			
Sample Point	**3**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass**			

	(g)			
Empty Bag	93			
Empty Tray	3270			
Bag + Wet Coal	**3558**			
Coal in Bag	3465			
Tray + Wet Coal	6730	6605	6596	6593
Coal Mass on tray	3460	3335	3326	3323
% Moisture Loss		3,612717	0,269865	0,090198
Empty Bag + res Wet Coal	96			
Empty Bag + res Dry Coal	95			
Res coal in bag	2			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6521			
Oven Dry Coal	3251			
Total Coal	3462,00			
Surface Moisture lost	138,00			
Inherent Moisture lost	72,00			
Surface Moisture %	**3,99**			
Inherent Moisture %	**2,17**			
Total Moisture %	**6,15**			
Sample Point	**4**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3298			
Bag + Wet Coal	**3663**			
Coal in Bag	3570			
Tray + Wet Coal	6856	6731	6720	6718
Coal Mass on tray	3558	3433	3422	3420
% Moisture Loss		3,51321	0,320419	0,058445
Empty Bag + res Wet Coal	103			
Empty Bag + res Dry Coal	100			
Res coal in bag	7			
Moisture lost from bag	3			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6627			
Oven Dry Coal	3329			
Total Coal	3565,00			

Surface Moisture lost	141,00			
Inherent Moisture lost	91,00			
Surface Moisture %	**3,96**			
Inherent Moisture %	**2,66**			
Total Moisture %	**6,62**			
Sample Point	**5**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3269			
Bag + Wet Coal	**3692**			
Coal in Bag	3599			
Tray + Wet Coal	6856	6727	6716	6714
Coal Mass on tray	3587	3458	3447	3445
% Moisture Loss		3,59632	0,318103	0,058021
Empty Bag + res Wet Coal	103			
Empty Bag + res Dry Coal	101			
Res coal in bag	8			
Moisture lost from bag	2			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6627			
Oven Dry Coal	3358			
Total Coal	3595,00			
Surface Moisture lost	144,00			
Inherent Moisture lost	87,00			
Surface Moisture %	**4,01**			
Inherent Moisture %	**2,52**			
Total Moisture %	**6,53**			
Sample Point	**6**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3258			
Bag + Wet Coal	**3692**			
Coal in Bag	3599			
Tray + Wet Coal	6846	6702	6690	6688
Coal Mass on tray	3588	3444	3432	3430
% Moisture Loss		4,013378	0,348432	0,058275

Empty Bag + res Wet Coal	102			
Empty Bag + res Dry Coal	99			
Res coal in bag	6			
Moisture lost from bag	3			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6586			
Oven Dry Coal	3328			
Total Coal	3594,00			
Surface Moisture lost	161,00			
Inherent Moisture lost	102,00			
Surface Moisture %	**4,48**			
Inherent Moisture %	**2,97**			
Total Moisture %	**7,45**			

Table Q-3: Stage 2 5,05% Fines SM_{lab}, IM_{lab}, TM_{lab}

Sample Point	**1**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3258			
Bag + Wet Coal	**2931**			
Coal in Bag	2838			
Tray + Wet Coal	6090	5997	5998	5996
Coal Mass on tray	2832	2739	2740	2738
% Moisture Loss		3,283898	-0,03651	0,072993
Empty Bag + res Wet Coal	96			
Empty Bag + res Dry Coal	95			
Res coal in bag	2			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	5917			
Oven Dry Coal	2659			
Total Coal	2834,00			
Surface Moisture lost	95,00			
Inherent Moisture lost	79,00			
Surface Moisture %	**3,35**			
Inherent Moisture %	**2,88**			
Total Moisture %	**6,24**			

Sample Point	**2**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3289			
Bag + Wet Coal	**3533**			
Coal in Bag	3440			
Tray + Wet Coal	6724	6558	6552	6551
Coal Mass on tray	3466	3300	3294	3293
% Moisture Loss		4,789383	0,181818	0,030358
Empty Bag + res Wet Coal	96			
Empty Bag + res Dry Coal	95			
Res coal in bag	2			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6459			
Oven Dry Coal	3170			
Total Coal	3468,00			
Surface Moisture lost	174,00			
Inherent Moisture lost	92,00			
Surface Moisture %	**5,02**			
Inherent Moisture %	**2,79**			
Total Moisture %	**7,81**			
Sample Point	**3**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3270			
Bag + Wet Coal	**3646**			
Coal in Bag	3553			
Tray + Wet Coal	6818	6673	6667	6666
Coal Mass on tray	3548	3403	3397	3396
% Moisture Loss		4,086809	0,176315	0,029438
Empty Bag + res Wet Coal	95			
Empty Bag + res Dry Coal	95			
Res coal in bag	2			
Moisture lost from bag	0			
Fine Coal Collected from				

Sampler				
Oven Dry Coal + Tray	6575			
Oven Dry Coal	3305			
Total Coal	3550,00			
Surface Moisture lost	152,00			
Inherent Moisture lost	91,00			
Surface Moisture %	**4,28**			
Inherent Moisture %	**2,68**			
Total Moisture %	**6,96**			
Sample Point	**4**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3289			
Bag + Wet Coal	**3342**			
Coal in Bag	3249			
Tray + Wet Coal	6542	6375	6371	6369
Coal Mass on tray	3272	3105	3101	3099
% Moisture Loss		5,103912	0,128824	0,064495
Empty Bag + res Wet Coal	97			
Empty Bag + res Dry Coal	96			
Res coal in bag	3			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6289			
Oven Dry Coal	3000			
Total Coal	3275,00			
Surface Moisture lost	174,00			
Inherent Moisture lost	80,00			
Surface Moisture %	**5,31**			
Inherent Moisture %	**2,58**			
Total Moisture %	**7,89**			
Sample Point	**5**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3270			
Bag + Wet Coal	**3886**			

Coal in Bag	3793			
Tray + Wet Coal	7058	6863	6850	6849
Coal Mass on tray	3788	3593	3580	3579
% Moisture Loss		5,147835	0,361815	0,027933
Empty Bag + res Wet Coal	96			
Empty Bag + res Dry Coal	95			
Res coal in bag	2			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6747			
Oven Dry Coal	3477			
Total Coal	3790,00			
Surface Moisture lost	210,00			
Inherent Moisture lost	102,00			
Surface Moisture %	**5,54**			
Inherent Moisture %	**2,85**			
Total Moisture %	**8,39**			
Sample Point	**6**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3203			
Bag + Wet Coal	**3771**			
Coal in Bag	3678			
Tray + Wet Coal	6874	6661	6644	6643
Coal Mass on tray	3604	3391	3374	3373
% Moisture Loss		5,9101	0,501327	0,029638
Empty Bag + res Wet Coal	99			
Empty Bag + res Dry Coal	96			
Res coal in bag	3			
Moisture lost from bag	3			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6537			
Oven Dry Coal	3334			
Total Coal	3607,00			
Surface Moisture lost	234,00			
Inherent Moisture lost	106,00			
Surface Moisture %	**6,49**			
Inherent Moisture %	**3,14**			

Total Moisture %	**9,63**			

Table Q-4: Stage 2 7,94% Fines SM_{lab}, IM_{lab}, TM_{lab}

Sample Point	1	Day 1	Day 2	Day 3	Day 4
Item	**Mass (g)**				
Empty Bag	93				
Empty Tray	3258				
Bag + Wet Coal	2985				
Coal in Bag	2892				
Tray + Wet Coal	6145	6002	5991	5986	5985
Coal Mass on tray	2887	2744	2733	2728	2727
% Moisture Loss		4,953239	0,400875	0,182949	0,036657
Empty Bag + res Wet Coal	96				
Empty Bag + res Dry Coal	96				
Res coal in bag	3				
Moisture lost from bag	0				
Fine Coal Collected from Sampler					
Oven Dry Coal + Tray	5886				
Oven Dry Coal	2628				
Total Coal	2890,00				
Surface Moisture lost	160,00				
Inherent Moisture lost	99,00				
Surface Moisture %	**5,54**				
Inherent Moisture %	**3,63**				
Total Moisture %	**9,17**				
Sample Point	**2**	**Day 1**	**Day 2**	**Day 3**	**Day 4**
Item	**Mass (g)**				
Empty Bag	93				
Empty Tray	3289				
Bag + Wet Coal	3343				
Coal in Bag	3250				
Tray + Wet Coal	6535	6382	6343	6337	6335
Coal Mass on tray	3246	3093	3054	3048	3046
% Moisture Loss		4,713494	1,260912	0,196464	0,065617
Empty Bag + res Wet Coal	96				

Empty Bag + res Dry Coal	96				
Res coal in bag	3				
Moisture lost from bag	0				
Fine Coal Collected from Sampler					
Oven Dry Coal + Tray	6233				
Oven Dry Coal	2944				
Total Coal	3249,00				
Surface Moisture lost	200,00				
Inherent Moisture lost	102,00				
Surface Moisture %	**6,16**				
Inherent Moisture %	**3,35**				
Total Moisture %	**9,50**				
Sample Point	**3**	**Day 1**	**Day 2**	**Day 3**	**Day 4**
Item	**Mass (g)**				
Empty Bag	93				
Empty Tray	3270				
Bag + Wet Coal	3791				
Coal in Bag	3698				
Tray + Wet Coal	6964	6820	6780	6783	6780
Coal Mass on tray	3694	3550	3510	3513	3510
% Moisture Loss		3,898213	1,126761	-0,08547	0,085397
Empty Bag + res Wet Coal	96				
Empty Bag + res Dry Coal	96				
Res coal in bag	3				
Moisture lost from bag	0				
Fine Coal Collected from Sampler					
Oven Dry Coal + Tray	6688				
Oven Dry Coal	3418				
Total Coal	3697,00				
Surface Moisture lost	184,00				
Inherent Moisture lost	92,00				
Surface Moisture %	**4,98**				
Inherent Moisture %	**2,62**				
Total Moisture %	**7,60**				
Sample Point	**4**	**Day 1**	**Day 2**	**Day 3**	**Day 4**
Item	**Mass**				

	(g)				
Empty Bag	93				
Empty Tray	3299				
Bag + Wet Coal	3884				
Coal in Bag	3791				
Tray + Wet Coal	7085	6925	6881	6872	6871
Coal Mass on tray	3786	3626	3582	3573	3572
% Moisture Loss		4,226096	1,213458	0,251256	0,027988
Empty Bag + res Wet Coal	96				
Empty Bag + res Dry Coal	96				
Res coal in bag	3				
Moisture lost from bag	0				
Fine Coal Collected from Sampler					
Oven Dry Coal + Tray	6769				
Oven Dry Coal	3470				
Total Coal	3789,00				
Surface Moisture lost	214,00				
Inherent Moisture lost	102,00				
Surface Moisture %	**5,65**				
Inherent Moisture %	**2,86**				
Total Moisture %	**8,50**				
Sample Point	**5**	**Day 1**	**Day 2**	**Day 3**	**Day 4**
Item	**Mass (g)**				
Empty Bag	93				
Empty Tray	3270				
Bag + Wet Coal	3895				
Coal in Bag	3802				
Tray + Wet Coal	7068	6908	6852	6846	6843
Coal Mass on tray	3798	3638	3582	3576	3573
% Moisture Loss		4,212744	1,539307	0,167504	0,083893
Empty Bag + res Wet Coal	96				
Empty Bag + res Dry Coal	95				
Res coal in bag	2				
Moisture lost from bag	1				
Fine Coal Collected from Sampler					
Oven Dry Coal + Tray	6734				
Oven Dry Coal	3464				
Total Coal	3800,00				

Surface Moisture lost	226,00				
Inherent Moisture lost	109,00				
Surface Moisture %	**5,95**				
Inherent Moisture %	**3,05**				
Total Moisture %	**9,00**				
Sample Point	**6**	**Day 1**	**Day 2**	**Day 3**	**Day 4**
Item	**Mass (g)**				
Empty Bag	93				
Empty Tray	3203				
Bag + Wet Coal	3904				
Coal in Bag	3811				
Tray + Wet Coal	7010	6831	6752	6742	6739
Coal Mass on tray	3807	3628	3549	3539	3536
% Moisture Loss		4,701865	2,177508	0,28177	0,08477
Empty Bag + res Wet Coal	96				
Empty Bag + res Dry Coal	94				
Res coal in bag	1				
Moisture lost from bag	2				
Fine Coal Collected from Sampler					
Oven Dry Coal + Tray	6640				
Oven Dry Coal	3437				
Total Coal	3808,00				
Surface Moisture lost	273,00				
Inherent Moisture lost	99,00				
Surface Moisture %	**7,17**				
Inherent Moisture %	**2,79**				
Total Moisture %	**9,96**				

Table Q-5: Stage 2 8,49% Fines SM_{lab}, IM_{lab}, TM_{lab}

Sample Point	**1**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3265			
Bag + Wet Coal	**3179**			
Coal in Bag	3086			

Tray + Wet Coal	6344	6209	6186	6187
Coal Mass on tray	3079	2944	2921	2922
% Moisture Loss		4,38454	0,78125	-0,03423
Empty Bag + res Wet Coal	98			
Empty Bag + res Dry Coal	96			
Res coal in bag	3			
Moisture lost from bag	2			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6126			
Oven Dry Coal	2861			
Total Coal	3082,00			
Surface Moisture lost	159,00			
Inherent Moisture lost	61,00			
Surface Moisture %	**5,16**			
Inherent Moisture %	**2,09**			
Total Moisture %	**7,25**			
Sample Point	**2**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3242			
Bag + Wet Coal	**3623**			
Coal in Bag	3530			
Tray + Wet Coal	6764	6607	6581	6581
Coal Mass on tray	3522	3365	3339	3339
% Moisture Loss		4,457694	0,77266	0
Empty Bag + res Wet Coal	99			
Empty Bag + res Dry Coal	97			
Res coal in bag	4			
Moisture lost from bag	2			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6535			
Oven Dry Coal	3293			
Total Coal	3526,00			
Surface Moisture lost	185,00			
Inherent Moisture lost	46,00			
Surface Moisture %	**5,25**			
Inherent Moisture %	**1,38**			
Total Moisture %	**6,62**			

Sample Point	**3**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3271			
Bag + Wet Coal	**3732**			
Coal in Bag	3639			
Tray + Wet Coal	6901	6719	6690	6691
Coal Mass on tray	3630	3448	3419	3420
% Moisture Loss		5,013774	0,841067	-0,02925
Empty Bag + res Wet Coal	99			
Empty Bag + res Dry Coal	95			
Res coal in bag	2			
Moisture lost from bag	4			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6624			
Oven Dry Coal	3353			
Total Coal	3632,00			
Surface Moisture lost	214,00			
Inherent Moisture lost	67,00			
Surface Moisture %	**5,89**			
Inherent Moisture %	**1,96**			
Total Moisture %	**7,85**			
Sample Point	**4**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3278			
Bag + Wet Coal	**3945**			
Coal in Bag	3852			
Tray + Wet Coal	7119	6918	6882	6881
Coal Mass on tray	3841	3640	3604	3603
% Moisture Loss		5,233012	0,989011	0,027747
Empty Bag + res Wet Coal	102			
Empty Bag + res Dry Coal	99			
Res coal in bag	6			
Moisture lost from bag	3			
Fine Coal Collected from				

Sampler				
Oven Dry Coal + Tray	6836			
Oven Dry Coal	3558			
Total Coal	3847,00			
Surface Moisture lost	241,00			
Inherent Moisture lost	45,00			
Surface Moisture %	**6,26**			
Inherent Moisture %	**1,25**			
Total Moisture %	**7,51**			
Sample Point	**5**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3277			
Bag + Wet Coal	**4027**			
Coal in Bag	3934			
Tray + Wet Coal	7196	6994	6955	6954
Coal Mass on tray	3919	3717	3678	3677
% Moisture Loss		5,154376	1,049233	0,027189
Empty Bag + res Wet Coal	106			
Empty Bag + res Dry Coal	102			
Res coal in bag	9			
Moisture lost from bag	4			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6884			
Oven Dry Coal	3607			
Total Coal	3928,00			
Surface Moisture lost	246,00			
Inherent Moisture lost	70,00			
Surface Moisture %	**6,26**			
Inherent Moisture %	**1,90**			
Total Moisture %	**8,17**			
Sample Point	**6**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3248			
Bag + Wet Coal	**3942**			

Coal in Bag	3849			
Tray + Wet Coal	7083	6865	6829	6829
Coal Mass on tray	3835	3617	3581	3581
% Moisture Loss		5,684485	0,9953	0
Empty Bag + res Wet Coal	104			
Empty Bag + res Dry Coal	100			
Res coal in bag	7			
Moisture lost from bag	4			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6771			
Oven Dry Coal	3523			
Total Coal	3842,00			
Surface Moisture lost	258,00			
Inherent Moisture lost	58,00			
Surface Moisture %	**6,72**			
Inherent Moisture %	**1,62**			
Total Moisture %	**8,33**			

Table Q-6: Stage 2 10,94% Fines SM_{lab}, IM_{lab}, TM_{lab}

Sample Point	1	Day 1	Day 2	Day 3
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3247			
Bag + Wet Coal	**3217**			
Coal in Bag	3124			
Tray + Wet Coal	6360	6207	6197	6193
Coal Mass on tray	3113	2960	2950	2946
% Moisture Loss		4,914873	0,337838	0,135593
Empty Bag + res Wet Coal	102			
Empty Bag + res Dry Coal	96			
Res coal in bag	3			
Moisture lost from bag	6			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6113			
Oven Dry Coal	2866			
Total Coal	3116,00			
Surface Moisture lost	173,00			

Inherent Moisture lost	80,00			
Surface Moisture %	**5,55**			
Inherent Moisture %	**2,71**			
Total Moisture %	**8,26**			
Sample Point	**2**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3214			
Bag + Wet Coal	**3873**			
Coal in Bag	3780			
Tray + Wet Coal	6981	6782	6766	6762
Coal Mass on tray	3767	3568	3552	3548
% Moisture Loss		5,282718	0,44843	0,112613
Empty Bag + res Wet Coal	104			
Empty Bag + res Dry Coal	99			
Res coal in bag	6			
Moisture lost from bag	5			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6672			
Oven Dry Coal	3458			
Total Coal	3773,00			
Surface Moisture lost	224,00			
Inherent Moisture lost	90,00			
Surface Moisture %	**5,94**			
Inherent Moisture %	**2,53**			
Total Moisture %	**8,47**			
Sample Point	**3**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3283			
Bag + Wet Coal	**4137**			
Coal in Bag	4044			
Tray + Wet Coal	7311	7075	7055	7050
Coal Mass on tray	4028	3792	3772	3767
% Moisture Loss		5,858987	0,527426	0,132556
Empty Bag + res Wet Coal	107			

Empty Bag + res Dry Coal	99			
Res coal in bag	6			
Moisture lost from bag	8			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6954			
Oven Dry Coal	3671			
Total Coal	4034,00			
Surface Moisture lost	269,00			
Inherent Moisture lost	96,00			
Surface Moisture %	**6,67**			
Inherent Moisture %	**2,55**			
Total Moisture %	**9,21**			
Sample Point	**4**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3228			
Bag + Wet Coal	**3700**			
Coal in Bag	3607			
Tray + Wet Coal	6819	6600	6585	6581
Coal Mass on tray	3591	3372	3357	3353
% Moisture Loss		6,09858	0,44484	0,119154
Empty Bag + res Wet Coal	105			
Empty Bag + res Dry Coal	96			
Res coal in bag	3			
Moisture lost from bag	9			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6500			
Oven Dry Coal	3272			
Total Coal	3594,00			
Surface Moisture lost	247,00			
Inherent Moisture lost	81,00			
Surface Moisture %	**6,87**			
Inherent Moisture %	**2,41**			
Total Moisture %	**9,29**			
Sample Point	**5**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass**			

	(g)			
Empty Bag	93			
Empty Tray	3830			
Bag + Wet Coal	**3909**			
Coal in Bag	3816			
Tray + Wet Coal	7627	7373	7360	7356
Coal Mass on tray	3797	3543	3530	3526
% Moisture Loss		6,689492	0,366921	0,113314
Empty Bag + res Wet Coal	110			
Empty Bag + res Dry Coal	103			
Res coal in bag	10			
Moisture lost from bag	7			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	7256			
Oven Dry Coal	3426			
Total Coal	3807,00			
Surface Moisture lost	278,00			
Inherent Moisture lost	100,00			
Surface Moisture %	**7,30**			
Inherent Moisture %	**2,83**			
Total Moisture %	**10,14**			

Sample Point	**6**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3732			
Bag + Wet Coal	**3714**			
Coal in Bag	3621			
Tray + Wet Coal	7332	7070	7056	7052
Coal Mass on tray	3600	3338	3324	3320
% Moisture Loss		7,277778	0,419413	0,120337
Empty Bag + res Wet Coal	112			
Empty Bag + res Dry Coal	103			
Res coal in bag	10			
Moisture lost from bag	9			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6956			
Oven Dry Coal	3224			
Total Coal	3610,00			

Surface Moisture lost	289,00			
Inherent Moisture lost	96,00			
Surface Moisture %	**8,01**			
Inherent Moisture %	**2,89**			
Total Moisture %	**10,89**			

Table Q-7: Stage 2 8,5% Dummy Run Fines SM_{lab}, IM_{lab}, TM_{lab}

Sample Point	**1**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3258			
Bag + Wet Coal	3336			
Coal in Bag	3243			
Tray + Wet Coal	6499	6299	6296	6294
Coal Mass on tray	3241	3041	3038	3036
% Moisture Loss		6,170935	0,098652	0,065833
Empty Bag + res Wet Coal	97			
Empty Bag + res Dry Coal	93			
Res coal in bag	0			
Moisture lost from bag	4			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6234			
Oven Dry Coal	2976			
Total Coal	3241,00			
Surface Moisture lost	209,00			
Inherent Moisture lost	60,00			
Surface Moisture %	**6,45**			
Inherent Moisture %	**1,98**			
Total Moisture %	**8,42**			
Sample Point	**2**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3289			
Bag + Wet Coal	3697			
Coal in Bag	3604			

Tray + Wet Coal	6891	6676	6669	6667
Coal Mass on tray	3602	3387	3380	3378
% Moisture Loss		5,968906	0,206673	0,059172
Empty Bag + res Wet Coal	94			
Empty Bag + res Dry Coal	94			
Res coal in bag	1			
Moisture lost from bag	0			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6599			
Oven Dry Coal	3310			
Total Coal	3603,00			
Surface Moisture lost	224,00			
Inherent Moisture lost	68,00			
Surface Moisture %	**6,22**			
Inherent Moisture %	**2,01**			
Total Moisture %	**8,23**			
Sample Point	**3**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3270			
Bag + Wet Coal	3881			
Coal in Bag	3788			
Tray + Wet Coal	7057	6823	6818	6816
Coal Mass on tray	3787	3553	3548	3546
% Moisture Loss		6,179034	0,140726	0,05637
Empty Bag + res Wet Coal	94			
Empty Bag + res Dry Coal	94			
Res coal in bag	1			
Moisture lost from bag	0			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6760			
Oven Dry Coal	3490			
Total Coal	3788,00			
Surface Moisture lost	241,00			
Inherent Moisture lost	56,00			
Surface Moisture %	**6,36**			
Inherent Moisture %	**1,58**			
Total Moisture %	**7,94**			

Sample Point	**4**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3298			
Bag + Wet Coal	3734			
Coal in Bag	3641			
Tray + Wet Coal	6939	6699	6693	6690
Coal Mass on tray	3641	3401	3395	3392
% Moisture Loss		6,591596	0,176419	0,088365
Empty Bag + res Wet Coal	94			
Empty Bag + res Dry Coal	93			
Res coal in bag	0			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6621			
Oven Dry Coal	3323			
Total Coal	3641,00			
Surface Moisture lost	250,00			
Inherent Moisture lost	69,00			
Surface Moisture %	**6,87**			
Inherent Moisture %	**2,03**			
Total Moisture %	**8,90**			
Sample Point	**5**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3270			
Bag + Wet Coal	4127			
Coal in Bag	4034			
Tray + Wet Coal	7303	7059	7052	7048
Coal Mass on tray	4033	3789	3782	3778
% Moisture Loss		6,050087	0,184745	0,105764
Empty Bag + res Wet Coal	94			
Empty Bag + res Dry Coal	93			
Res coal in bag	0			
Moisture lost from bag	1			
Fine Coal Collected from				

Sampler				
Oven Dry Coal + Tray	6966			
Oven Dry Coal	3696			
Total Coal	4033,00			
Surface Moisture lost	256,00			
Inherent Moisture lost	82,00			
Surface Moisture %	**6,35**			
Inherent Moisture %	**2,17**			
Total Moisture %	**8,52**			
Sample Point	**6**	**Day 1**	**Day 2**	**Day 3**
Item	**Mass (g)**			
Empty Bag	93			
Empty Tray	3204			
Bag + Wet Coal	4255			
Coal in Bag	4162			
Tray + Wet Coal	7363	7059	7052	7049
Coal Mass on tray	4159	3855	3848	3845
% Moisture Loss		7,309449	0,181582	0,077963
Empty Bag + res Wet Coal	95			
Empty Bag + res Dry Coal	94			
Res coal in bag	1			
Moisture lost from bag	1			
Fine Coal Collected from Sampler				
Oven Dry Coal + Tray	6960			
Oven Dry Coal	3756			
Total Coal	4160,00			
Surface Moisture lost	315,00			
Inherent Moisture lost	89,00			
Surface Moisture %	**7,57**			
Inherent Moisture %	**2,31**			
Total Moisture %	**9,89**			

Appendix R Stage 2 results summary

Table R-1: Stage 2 1.09% Fines Results Summary

Point	Height (mm)	SM_{LAB} (%)	IM (%)	TM (%) Actual	Fines Content (%)	% Wet Fines of Total	SM_{EST} (%)	Diff (%)
1	1244,45	2,43	3,23	5,67	0,97	46,38	6,04	-6,25
2	1046,30	3,09	3,25	6,34	1,12	42,68	6,22	1,92
3	721,30	3,10	3,11	6,21	1,21	37,50	6,10	1,79
4	523,15	3,10	2,88	5,98	1,00	40,16	5,89	1,50
5	198,15	3,09	2,76	5,85	1,09	36,76	5,72	2,20
6	0,00	2,86	2,04	4,90	1,19	30,72	5,95	-17,61

Table R-2: Stage 2 3,13% Fines Results Summary

Point	Height (mm)	SM_{LAB} (%)	IM (%)	TM (%) Actual	Fines Content (%)	% Wet Fines of Total	SM_{EST} (%)	Diff (%)
1	1244,45	2,74	2,52	5,26	2,55	30,58	5,80	-9,43
2	1046,30	3,22	2,61	5,83	3,00	27,02	6,27	-7,04
3	721,30	3,99	2,17	6,15	3,25	26,31	6,47	-4,87
4	523,15	3,96	2,66	6,62	3,16	25,23	6,30	4,94
5	198,15	4,01	2,52	6,53	3,33	24,43	6,39	2,15
6	0,00	4,48	2,97	7,45	3,52	23,01	6,44	15,69

Table R-3: Stage 2 5,05% Fines Results Summary

Point	Height (mm)	SM_{LAB} (%)	IM (%)	TM (%) Actual	Fines Content (%)	% Wet Fines of Total	SM_{EST} (%)	Diff (%)
1	1244,45	3,35	2,88	6,24	3,56	38,76	5,94	4,94
2	1046,30	5,02	2,79	7,81	5,75	32,33	7,21	8,33
3	721,30	4,28	2,68	6,96	3,97	31,78	6,34	9,72
4	523,15	5,31	2,58	7,89	5,65	27,40	6,99	12,85
5	198,15	5,54	2,85	8,39	5,21	28,48	6,83	22,89
6	0,00	6,49	3,14	9,63	6,17	29,60	7,30	31,86

Table R-4: Stage 2 7,94% Fines Results Summary

Point	Height (mm)	SM_{LAB} (%)	IM (%)	TM (%) Actual	Fines Content (%)	% Wet Fines of Total	SM_{EST} (%)	Diff (%)
1	1244,45	5,54	3,63	9,17	7,59	26,18	7,51	22,08
2	1046,30	6,16	3,35	9,50	8,48	22,73	7,81	21,75
3	721,30	4,98	2,62	7,60	6,21	23,35	6,76	12,38
4	523,15	5,65	2,86	8,50	7,61	21,99	7,38	15,19
5	198,15	5,95	3,05	9,00	7,94	21,15	7,61	18,24
6	0,00	7,17	2,79	9,96	9,81	20,88	8,29	20,09

Table R-5: Stage 2 8,49% Fines Results Summary

Point	Height (mm)	SM_{LAB} (%)	IM (%)	TM (%) Actual	Fines Content (%)	% Wet Fines of Total	SM_{EST} (%)	Diff (%)
1	1244,45	5,16	2,09	7,25	8,60	22,06	7,62	-4,86
2	1046,30	5,25	1,38	6,62	7,98	23,94	7,43	-10,85
3	721,30	5,89	1,96	7,85	8,46	18,54	7,57	3,67
4	523,15	6,26	1,25	7,51	8,79	19,84	7,68	-2,14
5	198,15	6,26	1,90	8,17	8,15	16,95	7,38	10,67
6	0,00	6,72	1,62	8,33	8,96	17,95	7,73	7,77

Table R-6: Stage 2 10,94% Fines Results Summary

Point	Height (mm)	SM_{LAB} (%)	IM (%)	TM (%) Actual	Fines Content (%)	% Wet Fines of Total	SM_{EST} (%)	Diff (%)
1	1244,45	5,55	2,71	8,26	10,24	29,01	8,05	2,62
2	1046,30	5,94	2,53	8,47	10,23	24,88	7,90	7,28
3	721,30	6,67	2,55	9,21	11,28	21,07	8,29	11,16
4	523,15	6,87	2,41	9,29	10,63	18,50	7,99	16,20
5	198,15	7,30	2,83	10,14	11,56	19,86	8,35	21,40
6	0,00	8,01	2,89	10,89	11,67	16,77	8,54	27,49

Table R-7: Stage 2 8,5% Fines Results Summary

Point	Height (mm)	SM_{LAB} (%)	IM (%)	TM (%) Actual	Fines Content (%)	% Wet Fines of Total	SM_{EST} (%)	Diff (%)
1	1244,45	6,45	1,98	8,42	9,45	27,40	8,13	3,58
2	1046,30	6,22	2,01	8,23	7,65	18,59	7,52	9,39
3	721,30	6,36	1,58	7,94	8,20	16,87	7,47	6,27
4	523,15	6,87	2,03	8,90	9,00	14,41	7,75	14,91
5	198,15	6,35	2,17	8,52	7,67	14,57	7,21	18,22
6	0,00	7,57	2,31	9,89	9,02	13,96	7,81	26,57

Appendix S Stage 2 sample particle size distribution

Table S-1: Stage 2 1.09% Fines Sample PSD

	% Passing						
Particle Size	Original	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
30	100,00	100,00	100,00	100,00	100,00	100,00	100,00
19	95,34	95,92	94,81	93,03	95,90	95,27	94,71
10	77,41	80,95	80,85	77,71	79,87	76,15	78,09
6	61,51	64,45	65,78	62,86	62,70	59,04	61,21
4,75	50,01	52,70	55,09	52,39	51,34	46,97	50,03
3	37,54	37,27	39,28	37,88	35,62	32,46	35,58
2	26,26	23,24	25,06	24,07	21,95	20,30	22,75
1	15,85	9,40	10,32	9,72	8,24	7,92	8,83
0,5	10,00	0,97	1,12	1,21	1,00	1,09	1,19
0	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table S-2: Stage 2 3.13% Fines Sample PSD

	% Passing						
Particle Size	Original	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
30	100,00	100,00	100,00	100,00	100,00	100,00	100,00
19	95,34	96,20	95,66	97,97	93,69	96,40	96,94
10	77,41	76,63	79,20	80,17	77,84	78,53	77,28
6	61,51	57,22	62,72	65,09	61,58	61,68	61,66
4,75	50,01	44,78	50,88	52,98	50,07	50,10	50,74
3	37,54	30,10	34,77	37,42	34,61	35,94	36,18
2	26,26	18,33	22,29	23,92	22,84	23,54	23,82
1	15,85	7,74	10,05	10,72	10,33	10,67	10,90
0,5	10,00	2,55	3,00	3,25	3,16	3,33	3,52
0	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table S-3: Stage 2 5.05% Fines Sample PSD

	% Passing						
Particle Size	Original	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
30	100,00	100,00	100,00	100,00	100,00	100,00	100,00
19	95,34	96,94	95,43	95,74	95,73	94,32	95,89
10	77,41	77,45	80,92	78,61	77,91	78,12	82,91

6	61,51	58,92	66,40	61,36	63,63	63,24	67,74
4,75	50,01	44,05	55,81	49,80	52,96	52,00	55,99
3	37,54	28,91	41,11	34,07	38,25	37,03	40,93
2	26,26	17,77	28,08	21,49	25,94	24,81	27,87
1	15,85	8,06	13,93	9,81	13,10	12,33	14,27
0,5	10,00	3,56	5,75	3,97	5,65	5,21	6,17
0	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table S-4: Stage 2 7.94% Fines Sample PSD

	% Passing						
Particle Size	**Original**	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**
30	100,00	100,00	100,00	100,00	100,00	100,00	100,00
19	95,34	93,73	96,34	94,03	95,82	96,74	95,96
10	77,41	80,51	79,41	74,50	79,63	80,78	83,02
6	61,51	63,47	65,48	57,85	62,39	64,32	68,26
4,75	50,01	54,71	56,83	48,53	53,58	56,24	60,69
3	37,54	40,45	43,26	34,97	39,48	41,78	46,05
2	26,26	27,94	29,90	22,83	26,90	28,52	33,48
1	15,85	15,32	16,26	11,63	14,22	15,28	17,86
0,5	10,00	7,59	8,48	6,21	7,61	7,94	9,81
0	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table S-5: Stage 2 8,49% Fines Sample PSD

	% Passing						
Particle Size	**Original**	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**
30	100,00	100,00	100,00	100,00	100,00	100,00	100,00
19	95,34	97,20	96,16	93,46	93,20	95,14	95,97
10	77,41	80,57	80,41	79,67	79,61	78,95	78,46
6	61,51	64,46	64,07	65,65	65,05	62,73	65,37
4,75	50,01	51,12	51,15	51,93	52,12	49,05	52,04
3	37,54	38,98	38,68	39,14	39,96	36,88	39,55
2	26,26	27,31	26,35	27,00	27,72	25,68	28,23
1	15,85	15,68	14,62	15,30	15,81	14,62	16,22
0,5	10,00	8,60	7,98	8,46	8,79	8,15	8,96
0	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table S-6: Stage 2 10.94% Fines Sample PSD

	% Passing

Particle Size	Original	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
30	100,00	100,00	100,00	100,00	100,00	100,00	100,00
19	95,34	95,96	93,95	94,40	91,12	94,18	96,89
10	77,41	81,31	77,42	80,59	76,55	76,96	82,55
6	61,51	67,17	63,32	65,36	62,33	64,73	69,02
4,75	50,01	55,07	52,19	54,14	51,96	54,50	57,88
3	37,54	41,00	38,66	41,36	39,03	41,78	43,93
2	26,26	28,90	27,58	30,03	28,24	30,38	31,68
1	15,85	17,08	16,76	18,35	17,26	18,77	19,29
0,5	10,00	10,24	10,23	11,28	10,63	11,56	11,67
0	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table S-7: Stage 2 8.50% Fines Sample PSD

	% Passing						
Particle Size	**Original**	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**
30	100,00	100,00	100,00	100,00	100,00	100,00	100,00
19	95,34	96,62	98,57	95,56	98,07	96,23	95,52
10	77,41	83,89	82,17	80,72	82,24	78,00	80,37
6	61,51	69,88	66,79	64,09	66,12	62,24	65,40
4,75	50,01	58,89	56,81	53,58	55,65	51,59	56,72
3	37,54	45,54	40,62	37,04	38,36	35,16	40,34
2	26,26	31,59	27,95	26,26	27,53	24,32	28,68
1	15,85	17,06	14,57	14,87	15,99	13,64	16,23
0,5	10,00	9,45	7,65	8,20	9,00	7,67	9,02
0	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Appendix T Stage 3 samples and SM_{EST}

Table T-1: Stage 3 Power Station A Samples

Unit 1 - 17 July 2014				
Mill A				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	1,5	0,04
31,5	40	35,50	8,7	0,25
25	31,5	28,06	8,9	0,26
19	25	21,79	12,9	0,37
12,5	19	15,41	17,9	0,52
11,2	12,5	11,83	3,5	0,11
6	11,2	8,20	9,9	0,31
4,75	6	5,34	4,9	0,19
3	4,75	3,77	5,1	0,22
2	3	2,45	5,3	0,29
1	2	1,41	6,6	0,46
0,5	1	0,71	5,5	0,64
0,05	0,5	0,16	5,6	1,06
		SM_{ACT}	5,5	
		SM_{EST}		4,72

Unit 2 - 10 December 2014				
Mill A –No Data				
f_l	f_u	Geomean	f_i	SM_iXf_i
		SM_{ACT}		
		SM_{EST}		

Mill B				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	0,9	0,03
31,5	40	35,50	4,5	0,13
25	31,5	28,06	5,1	0,15
19	25	21,79	8,2	0,24
12,5	19	15,41	13,6	0,39
11,2	12,5	11,83	3,2	0,10
6	11,2	8,20	13,7	0,42
4,75	6	5,34	8,3	0,32
3	4,75	3,77	9,5	0,42
2	3	2,45	8,1	0,45
1	2	1,41	8,9	0,62
0,5	1	0,71	6,2	0,73
0,05	0,5	0,16	6,4	1,21
		SM_{ACT}	5,5	
		SM_{EST}		5,20

Mill B				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	0,7	0,02
31,5	40	35,50	2,6	0,07
25	31,5	28,06	2,2	0,06
19	25	21,79	3,8	0,11
12,5	19	15,41	8,7	0,25
11,2	12,5	11,83	7,9	0,24
6	11,2	8,20	10,3	0,32
4,75	6	5,34	12,9	0,50
3	4,75	3,77	11	0,48
2	3	2,45	10,8	0,60
1	2	1,41	10,1	0,71
0,5	1	0,71	7,9	0,93
0,05	0,5	0,16	7,2	1,36
		SM_{ACT}	4,4	
		SM_{EST}		5,65

Mill C				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	4,7	0,14
40	50	44,72	0	0,00
31,5	40	35,50	4,5	0,13
25	31,5	28,06	5	0,14
19	25	21,79	15,1	0,44
12,5	19	15,41	22,6	0,65
11,2	12,5	11,83	4,4	0,13
6	11,2	8,20	11,9	0,37
4,75	6	5,34	5	0,19
3	4,75	3,77	4,8	0,21
2	3	2,45	4	0,22
1	2	1,41	5,4	0,38
0,5	1	0,71	4,8	0,56
0,05	0,5	0,16	3,6	0,68
		SM_{ACT}	5,1	
		SM_{EST}		4,25

Mill C				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	1,5	0,04
40	50	44,72	1,5	0,04
31,5	40	35,50	4,5	0,13
25	31,5	28,06	4,4	0,13
19	25	21,79	10,3	0,30
12,5	19	15,41	15,2	0,44
11,2	12,5	11,83	3,8	0,11
6	11,2	8,20	14,7	0,45
4,75	6	5,34	8,4	0,33
3	4,75	3,77	8,4	0,37
2	3	2,45	7,1	0,39
1	2	1,41	7,5	0,52
0,5	1	0,71	5	0,59
0,05	0,5	0,16	3,8	0,72
		SM_{ACT}	3,8	
		SM_{EST}		4,56

Mill D				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	0	0,00
31,5	40	35,50	0	0,00
25	31,5	28,06	1,4	0,04
19	25	21,79	1,5	0,04
12,5	19	15,41	4,6	0,13
11,2	12,5	11,83	1,8	0,05
6	11,2	8,20	11,6	0,36
4,75	6	5,34	10	0,39
3	4,75	3,77	15,6	0,68
2	3	2,45	17,6	0,97
1	2	1,41	18,4	1,29
0,5	1	0,71	8,7	1,02
0,05	0,5	0,16	7	1,32
		SM_{ACT}	4,9	
		SM_{EST}		6,31

Mill D				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	5,4	0,16
31,5	40	35,50	6,9	0,20
25	31,5	28,06	6,9	0,20
19	25	21,79	11,1	0,32
12,5	19	15,41	16,5	0,48
11,2	12,5	11,83	3,9	0,12
6	11,2	8,20	11,2	0,35
4,75	6	5,34	5,7	0,22
3	4,75	3,77	8,7	0,38
2	3	2,45	4,1	0,23
1	2	1,41	4,6	0,32
0,5	1	0,71	4	0,47
0,05	0,5	0,16	8,1	1,53
		SM_{ACT}	3,7	
		SM_{EST}		4,97

Mill E				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00

Mill E				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00

40	50	44,72	0,7	0,02
31,5	40	35,50	0,9	0,03
25	31,5	28,06	3,4	0,10
19	25	21,79	5,9	0,17
12,5	19	15,41	11,3	0,33
11,2	12,5	11,83	4,1	0,12
6	11,2	8,20	12,3	0,38
4,75	6	5,34	10,2	0,40
3	4,75	3,77	12,2	0,53
2	3	2,45	12,1	0,67
1	2	1,41	9,3	0,65
0,5	1	0,71	4,4	0,52
0,05	0,5	0,16	5,3	1,00
		SM_{ACT}	5,2	
		SM_{EST}		4,91

40	50	44,72	1,5	0,04
31,5	40	35,50	2,6	0,07
25	31,5	28,06	5,3	0,15
19	25	21,79	6,1	0,18
12,5	19	15,41	14,7	0,43
11,2	12,5	11,83	4	0,12
6	11,2	8,20	14,2	0,44
4,75	6	5,34	7,8	0,30
3	4,75	3,77	8	0,35
2	3	2,45	7,1	0,39
1	2	1,41	7,8	0,55
0,5	1	0,71	6,8	0,80
0,05	0,5	0,16	10,2	1,93
		SM_{ACT}	3,3	
		SM_{EST}		5,75

Mill F – No Data				
f_l	f_u	Geomean	f_i	SM_iXf_i
		SM_{ACT}		
		SM_{EST}		

Mill F				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	2,6	0,07
40	50	44,72	0	0,00
31,5	40	35,50	2,5	0,07
25	31,5	28,06	5,2	0,15
19	25	21,79	8,4	0,24
12,5	19	15,41	14,2	0,41
11,2	12,5	11,83	2,9	0,09
6	11,2	8,20	12,8	0,39
4,75	6	5,34	7,7	0,30
3	4,75	3,77	8,3	0,36
2	3	2,45	7,3	0,40
1	2	1,41	8,2	0,57
0,5	1	0,71	6,1	0,71
0,05	0,5	0,16	10,8	2,04
		SM_{ACT}	3,2	
		SM_{EST}		5,83

Unit 5 - 16 July 2014				
Mill A				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	2,3	0,07
31,5	40	35,50	5,6	0,16

Unit 4 - 17 July 2014				
Mill A – No Data				
f_l	f_u	Geomean	f_i	SM_iXf_i

25	31,5	28,06	4,7	0,14
19	25	21,79	11,7	0,34
12,5	19	15,41	15,6	0,45
11,2	12,5	11,83	3,7	0,11
6	11,2	8,20	13,2	0,41
4,75	6	5,34	6,8	0,26
3	4,75	3,77	6,5	0,28
2	3	2,45	5,7	0,32
1	2	1,41	6,1	0,43
0,5	1	0,71	5	0,59
0,05	0,5	0,16	8,6	1,63
		SM_{ACT}	5,6	
		SM_{EST}		5,18

		SM_{ACT}		
		SM_{EST}		

Mill B				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	0	0,00
31,5	40	35,50	2,4	0,07
25	31,5	28,06	4,8	0,14
19	25	21,79	7	0,20
12,5	19	15,41	14,1	0,41
11,2	12,5	11,83	4	0,12
6	11,2	8,20	14,9	0,46
4,75	6	5,34	8,1	0,32
3	4,75	3,77	9	0,39
2	3	2,45	7,5	0,42
1	2	1,41	8,6	0,60
0,5	1	0,71	6,3	0,74
0,05	0,5	0,16	8,6	1,63
		SM_{ACT}	6,5	
		SM_{EST}		5,49

Mill B				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	2,3	0,07
40	50	44,72	4,6	0,13
31,5	40	35,50	6	0,17
25	31,5	28,06	8,9	0,26
19	25	21,79	14,2	0,41
12,5	19	15,41	16,7	0,48
11,2	12,5	11,83	3,5	0,11
6	11,2	8,20	11,2	0,35
4,75	6	5,34	5,6	0,22
3	4,75	3,77	5,2	0,23
2	3	2,45	4	0,22
1	2	1,41	4,5	0,31
0,5	1	0,71	4,4	0,52
0,05	0,5	0,16	5,6	1,06
		SM_{ACT}	5,5	
		SM_{EST}		4,53

Mill C – No Data				
f_l	f_u	Geomean	f_i	SM_iXf_i

Mill C				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	1,4	0,04
40	50	44,72	11,2	0,32
31,5	40	35,50	16,6	0,48
25	31,5	28,06	15,9	0,46
19	25	21,79	17,2	0,50
12,5	19	15,41	14,9	0,43
11,2	12,5	11,83	2,4	0,07

		SM_{ACT}		
		SM_{EST}		

6	11,2	8,20	5,6	0,17
4,75	6	5,34	1,8	0,07
3	4,75	3,77	1,4	0,06
2	3	2,45	1,1	0,06
1	2	1,41	1,4	0,10
0,5	1	0,71	2	0,23
0,05	0,5	0,16	4,9	0,93
		SM_{ACT}	3,8	
		SM_{EST}		3,92

Mill D				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	0	0,00
31,5	40	35,50	0	0,00
25	31,5	28,06	4,4	0,13
19	25	21,79	8	0,23
12,5	19	15,41	15,1	0,44
11,2	12,5	11,83	3,8	0,11
6	11,2	8,20	15,6	0,48
4,75	6	5,34	8,6	0,33
3	4,75	3,77	9,1	0,40
2	3	2,45	7,9	0,44
1	2	1,41	8,1	0,57
0,5	1	0,71	6,3	0,74
0,05	0,5	0,16	8,7	1,65
		SM_{ACT}	5,6	
		SM_{EST}		5,51

Mill D				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	0	0,00
31,5	40	35,50	4,2	0,12
25	31,5	28,06	3	0,09
19	25	21,79	8,3	0,24
12,5	19	15,41	14,5	0,42
11,2	12,5	11,83	3,8	0,11
6	11,2	8,20	14,3	0,44
4,75	6	5,34	7,8	0,30
3	4,75	3,77	8,8	0,38
2	3	2,45	8,2	0,45
1	2	1,41	9,1	0,64
0,5	1	0,71	7,8	0,91
0,05	0,5	0,16	6,8	1,29
		SM_{ACT}	6	
		SM_{EST}		5,40

Mill E				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	1,6	0,05
40	50	44,72	3,6	0,10
31,5	40	35,50	6,2	0,18
25	31,5	28,06	8,3	0,24
19	25	21,79	10,1	0,29
12,5	19	15,41	18,8	0,54
11,2	12,5	11,83	2,8	0,08
6	11,2	8,20	12	0,37
4,75	6	5,34	5,9	0,23
3	4,75	3,77	5,4	0,24
2	3	2,45	4,6	0,25

Mill E				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	2,6	0,07
40	50	44,72	1,4	0,04
31,5	40	35,50	3,5	0,10
25	31,5	28,06	7,9	0,23
19	25	21,79	11,6	0,33
12,5	19	15,41	23,5	0,68
11,2	12,5	11,83	5,3	0,16
6	11,2	8,20	14,4	0,44
4,75	6	5,34	5,9	0,23
3	4,75	3,77	4,2	0,18
2	3	2,45	2,5	0,14

1	2	1,41	4,9	0,34
0,5	1	0,71	4,5	0,53
0,05	0,5	0,16	7,5	1,42
		SM_{ACT}	6,7	
		SM_{EST}		4,87

1	2	1,41	2,4	0,17
0,5	1	0,71	3,4	0,40
0,05	0,5	0,16	6,5	1,23
		SM_{ACT}	6,1	
		SM_{EST}		4,41

Mill F				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	1,6	0,05
40	50	44,72	3,6	0,10
31,5	40	35,50	6,2	0,18
25	31,5	28,06	8,3	0,24
19	25	21,79	10,1	0,29
12,5	19	15,41	18,8	0,54
11,2	12,5	11,83	2,8	0,08
6	11,2	8,20	12	0,37
4,75	6	5,34	5,9	0,23
3	4,75	3,77	5,4	0,24
2	3	2,45	4,6	0,25
1	2	1,41	4,9	0,34
0,5	1	0,71	4,5	0,53
0,05	0,5	0,16	7,6	1,44
		SM_{ACT}	5,3	
		SM_{EST}		4,89

Mill F				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	0	0,00
40	50	44,72	1,1	0,03
31,5	40	35,50	0	0,00
25	31,5	28,06	2,1	0,06
19	25	21,79	4,3	0,12
12,5	19	15,41	8,7	0,25
11,2	12,5	11,83	3,3	0,10
6	11,2	8,20	14,8	0,46
4,75	6	5,34	9,5	0,37
3	4,75	3,77	11,3	0,49
2	3	2,45	11,3	0,63
1	2	1,41	11,3	0,79
0,5	1	0,71	8,9	1,04
0,05	0,5	0,16	9,8	1,85
		SM_{ACT}	4,5	
		SM_{EST}		6,20

Unit 6 - 16 July 2014				
Mill A				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	3	0,09
40	50	44,72	1,7	0,05
31,5	40	35,50	4,1	0,12
25	31,5	28,06	9	0,26
19	25	21,79	7,7	0,22
12,5	19	15,41	15	0,43
11,2	12,5	11,83	4,2	0,13
6	11,2	8,20	14	0,43
4,75	6	5,34	7,2	0,28
3	4,75	3,77	7,5	0,33
2	3	2,45	6,3	0,35
1	2	1,41	6,5	0,45
0,5	1	0,71	5,9	0,69

0,05	0,5	0,16	4,3	0,81
		SM_{ACT}	5,6	
		SM_{EST}		4,64

Mill B				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	1,4	0,04
40	50	44,72	2,8	0,08
31,5	40	35,50	1,2	0,03
25	31,5	28,06	3,9	0,11
19	25	21,79	7,1	0,20
12,5	19	15,41	14,7	0,43
11,2	12,5	11,83	4	0,12
6	11,2	8,20	13,4	0,41
4,75	6	5,34	7,4	0,29
3	4,75	3,77	8,2	0,36
2	3	2,45	8,1	0,45
1	2	1,41	8,7	0,61
0,5	1	0,71	8,1	0,95
0,05	0,5	0,16	7,3	1,38
		SM_{ACT}	5,4	
		SM_{EST}		5,47

Mill C – No Data				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
		SM_{ACT}		
		SM_{EST}		

Mill D				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	2,1	0,06
40	50	44,72	2,1	0,06
31,5	40	35,50	3,7	0,11
25	31,5	28,06	2,9	0,08
19	25	21,79	5,1	0,15
12,5	19	15,41	13,4	0,39
11,2	12,5	11,83	3,2	0,10
6	11,2	8,20	10,9	0,34
4,75	6	5,34	6,5	0,25
3	4,75	3,77	8,2	0,36
2	3	2,45	9	0,50
1	2	1,41	11,1	0,78
0,5	1	0,71	7,4	0,87
0,05	0,5	0,16	11,5	2,18
		SM_{ACT}	5,4	
		SM_{EST}		6,21

Mill E				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	3,4	0,10
40	50	44,72	1,1	0,03
31,5	40	35,50	4,7	0,14
25	31,5	28,06	4,7	0,14
19	25	21,79	7,3	0,21
12,5	19	15,41	10,8	0,31
11,2	12,5	11,83	3,5	0,11
6	11,2	8,20	12	0,37
4,75	6	5,34	7,7	0,30
3	4,75	3,77	9	0,39
2	3	2,45	8,6	0,48
1	2	1,41	8,9	0,62
0,5	1	0,71	8,7	1,02
0,05	0,5	0,16	6,5	1,23
		SM_{ACT}	6,4	
		SM_{EST}		5,44

Mill F				
f_l	f_u	Geomean	f_i	SM_iXf_i

50	75	61,24	0	0,00
40	50	44,72	4,8	0,14
31,5	40	35,50	3,9	0,11
25	31,5	28,06	5	0,14
19	25	21,79	9,1	0,26
12,5	19	15,41	19,8	0,57
11,2	12,5	11,83	5,6	0,17
6	11,2	8,20	15,6	0,48
4,75	6	5,34	6,2	0,24
3	4,75	3,77	5,4	0,24
2	3	2,45	3,9	0,22
1	2	1,41	4	0,28
0,5	1	0,71	7,1	0,83
0,05	0,5	0,16	4	0,76
		SM_{ACT}	4,9	
		SM_{EST}		4,44

Table T-2: Stage 3 Power Station B Samples

Unit 2				
Mill A				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	0	0,00
40	50	44,72	0	0,00
31,5	40	35,50	6,1	0,18
25	31,5	28,06	8,7	0,25
19	25	21,79	20,9	0,60
12,5	19	15,41	20,1	0,58
11,2	12,5	11,83	4,2	0,13
6	11,2	8,20	11,7	0,36
4,75	6	5,34	5,2	0,20
3	4,75	3,77	5,3	0,23
2	3	2,45	4,6	0,25
1	2	1,41	4,5	0,31
0,5	1	0,71	2,3	0,27
0,05	0,5	0,16	2,7	0,51
		SM_{ACT}	6,8	
		SM_{EST}		3,88

Mill B				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**

50	75	61,24	0	0,00
40	50	44,72	3,2	0,09
31,5	40	35,50	1,2	0,03
25	31,5	28,06	5,7	0,16
19	25	21,79	10,4	0,30
12,5	19	15,41	19,5	0,57
11,2	12,5	11,83	5	0,15
6	11,2	8,20	17,5	0,54
4,75	6	5,34	8,3	0,32
3	4,75	3,77	8,7	0,38
2	3	2,45	6,6	0,37
1	2	1,41	5,2	0,36
0,5	1	0,71	2	0,23
0,05	0,5	0,16	2,4	0,45
		SM_{ACT}	5,8	
		SM_{EST}		3,97

Mill C –	**No**	**Data**		
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
		SM_{ACT}		
		SM_{EST}		

Mill D				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	1,4	0,04
40	50	44,72	1,4	0,04
31,5	40	35,50	1,9	0,05
25	31,5	28,06	5	0,14

19	25	21,79	6,8	0,20
12,5	19	15,41	14,9	0,43
11,2	12,5	11,83	4,1	0,12
6	11,2	8,20	15,1	0,47
4,75	6	5,34	7,9	0,31
3	4,75	3,77	8,7	0,38
2	3	2,45	8,1	0,45
1	2	1,41	9,2	0,64
0,5	1	0,71	5,4	0,63
0,05	0,5	0,16	5,6	1,06
		SM_{ACT}	7,2	
		SM_{EST}		4,97

Mill E				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	0	0,00
40	50	44,72	0	0,00
31,5	40	35,50	2,6	0,07
25	31,5	28,06	7,8	0,22
19	25	21,79	13	0,37
12,5	19	15,41	22	0,64
11,2	12,5	11,83	4,2	0,13
6	11,2	8,20	15,1	0,47
4,75	6	5,34	7,2	0,28
3	4,75	3,77	6,9	0,30
2	3	2,45	5,6	0,31
1	2	1,41	5,3	0,37
0,5	1	0,71	2,7	0,32
0,05	0,5	0,16	3,2	0,61
		SM_{ACT}	6,2	
		SM_{EST}		4,09

Mill F				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	4,3	0,12
40	50	44,72	1,9	0,05
31,5	40	35,50	3,8	0,11
25	31,5	28,06	7,6	0,22
19	25	21,79	11,2	0,32
12,5	19	15,41	21,9	0,63
11,2	12,5	11,83	4,7	0,14
6	11,2	8,20	14,6	0,45

4,75	6	5,34	6	0,23
3	4,75	3,77	5,6	0,24
2	3	2,45	4,3	0,24
1	2	1,41	3,8	0,27
0,5	1	0,71	2,2	0,26
0,05	0,5	0,16	3,1	0,59
		SM_{ACT}	6,3	
		SM_{EST}		3,88

Table T-3: Stage 3 Power Station C Samples

Unit 1 - 11 September 2014

Mill A				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	1,4	0,04
31,5	40	35,50	3,4	0,10
25	31,5	28,06	3,9	0,11
19	25	21,79	7	0,20
12,5	19	15,41	11	0,32
11,2	12,5	11,83	3,1	0,09
6	11,2	8,20	11	0,34
4,75	6	5,34	5,7	0,22
3	4,75	3,77	6,4	0,28
2	3	2,45	5,9	0,33
1	2	1,41	12,5	0,87
0,5	1	0,71	12,7	1,49
0,05	0,5	0,16	13,6	2,57
		SM_{ACT}	10	
		SM_{EST}		6,97

Mill B				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	4,6	0,13
40	50	44,72	3	0,09
31,5	40	35,50	3,7	0,11
25	31,5	28,06	3,7	0,11
19	25	21,79	5,2	0,15
12,5	19	15,41	11,5	0,33
11,2	12,5	11,83	3	0,09
6	11,2	8,20	10	0,31

Unit 2 - 11 September 2014

Mill A				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	0	0,00
31,5	40	35,50	7,5	0,22
25	31,5	28,06	6,1	0,18
19	25	21,79	8,1	0,23
12,5	19	15,41	12,1	0,35
11,2	12,5	11,83	2,7	0,08
6	11,2	8,20	10,3	0,32
4,75	6	5,34	5,9	0,23
3	4,75	3,77	6,6	0,29
2	3	2,45	9,9	0,55
1	2	1,41	8,7	0,61
0,5	1	0,71	8,5	1,00
0,05	0,5	0,16	10,4	1,97
		SM_{ACT}	7,8	
		SM_{EST}		6,01

Mill B				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0,9	0,03
40	50	44,72	9,7	0,28
31,5	40	35,50	6,1	0,18
25	31,5	28,06	6,4	0,18
19	25	21,79	7,5	0,22
12,5	19	15,41	12,9	0,37
11,2	12,5	11,83	2,5	0,08
6	11,2	8,20	9,2	0,28

4,75	6	5,34	4,9	0,19
3	4,75	3,77	5,5	0,24
2	3	2,45	5,3	0,29
1	2	1,41	10,7	0,75
0,5	1	0,71	13,5	1,58
0,05	0,5	0,16	12,7	2,40
		SM_{ACT}	10,7	
		SM_{EST}		6,77

4,75	6	5,34	5	0,19
3	4,75	3,77	5,2	0,23
2	3	2,45	5	0,28
1	2	1,41	7,6	0,53
0,5	1	0,71	4,3	0,50
0,05	0,5	0,16	8,8	1,67
		SM_{ACT}	6,9	
		SM_{EST}		5,01

Mill C				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	0	0,00
40	50	44,72	1,5	0,04
31,5	40	35,50	3	0,09
25	31,5	28,06	5,1	0,15
19	25	21,79	9	0,26
12,5	19	15,41	12,8	0,37
11,2	12,5	11,83	3,2	0,10
6	11,2	8,20	10,7	0,33
4,75	6	5,34	5,6	0,22
3	4,75	3,77	5,8	0,25
2	3	2,45	5,3	0,29
1	2	1,41	9,6	0,67
0,5	1	0,71	11,6	1,36
0,05	0,5	0,16	13,3	2,52
		SM_{ACT}	10,8	
		SM_{EST}		6,65

Mill C				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	0	0,00
40	50	44,72	1,7	0,05
31,5	40	35,50	3,5	0,10
25	31,5	28,06	6,7	0,19
19	25	21,79	9,1	0,26
12,5	19	15,41	14,8	0,43
11,2	12,5	11,83	3,3	0,10
6	11,2	8,20	12,4	0,38
4,75	6	5,34	6,2	0,24
3	4,75	3,77	6,6	0,29
2	3	2,45	6,2	0,34
1	2	1,41	8,5	0,59
0,5	1	0,71	9	1,05
0,05	0,5	0,16	8,5	1,61
		SM_{ACT}	6,9	
		SM_{EST}		5,65

Mill E				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	0	0,00
40	50	44,72	1,6	0,05
31,5	40	35,50	4,3	0,12
25	31,5	28,06	4	0,12
19	25	21,79	5,3	0,15
12,5	19	15,41	9,2	0,27
11,2	12,5	11,83	2,4	0,07
6	11,2	8,20	9,6	0,30
4,75	6	5,34	5,2	0,20
3	4,75	3,77	5,8	0,25
2	3	2,45	6	0,33
1	2	1,41	11	0,77

Mill E				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	5,5	0,16
40	50	44,72	6	0,17
31,5	40	35,50	3,9	0,11
25	31,5	28,06	7,9	0,23
19	25	21,79	8,4	0,24
12,5	19	15,41	12,3	0,36
11,2	12,5	11,83	3,1	0,09
6	11,2	8,20	9,8	0,30
4,75	6	5,34	5	0,19
3	4,75	3,77	5,4	0,24
2	3	2,45	4,8	0,27
1	2	1,41	7	0,49

0,5	1	0,71	16	1,88
0,05	0,5	0,16	16,8	3,18
		SM$_{ACT}$	10,3	
		SM$_{EST}$		7,68

0,5	1	0,71	10,2	1,20
0,05	0,5	0,16	7,6	1,44
		SM$_{ACT}$	7,1	
		SM$_{EST}$		5,49

Mill F				
f_l	f_u	Geomean	f_i	SM$_i$Xf_i
50	75	61,24	0	0,00
40	50	44,72	4,4	0,13
31,5	40	35,50	4,3	0,12
25	31,5	28,06	5	0,14
19	25	21,79	4,4	0,13
12,5	19	15,41	11,2	0,32
11,2	12,5	11,83	3,1	0,09
6	11,2	8,20	10,5	0,32
4,75	6	5,34	5,5	0,21
3	4,75	3,77	5,8	0,25
2	3	2,45	7,3	0,40
1	2	1,41	18	1,26
0,5	1	0,71	10,5	1,23
0,05	0,5	0,16	7,2	1,36
		SM$_{ACT}$	10,1	
		SM$_{EST}$		5,99

Mill F				
f_l	f_u	Geomean	f_i	SM$_i$Xf_i
50	75	61,24	0	0,00
40	50	44,72	6,3	0,18
31,5	40	35,50	9,8	0,28
25	31,5	28,06	10,2	0,29
19	25	21,79	9,5	0,27
12,5	19	15,41	12,5	0,36
11,2	12,5	11,83	2,7	0,08
6	11,2	8,20	8,3	0,26
4,75	6	5,34	4,8	0,19
3	4,75	3,77	5	0,22
2	3	2,45	4,5	0,25
1	2	1,41	6,6	0,46
0,5	1	0,71	9,2	1,08
0,05	0,5	0,16	7,8	1,48
		SM$_{ACT}$	6,5	
		SM$_{EST}$		5,40

Unit 3 - 12 September 2014					Unit 4 - 15 September 2014				
Mill A					Mill A				
f_l	f_u	Geomean	f_i	SM$_i$Xf_i	f_l	f_u	Geomean	f_i	SM$_i$Xf_i
50	75	61,24	9,3	0,27	50	75	61,24	0	0,00
40	50	44,72	7,3	0,21	40	50	44,72	2,2	0,06
31,5	40	35,50	5	0,14	31,5	40	35,50	3,1	0,09
25	31,5	28,06	7,3	0,21	25	31,5	28,06	6,5	0,19
19	25	21,79	11,8	0,34	19	25	21,79	6,4	0,18
12,5	19	15,41	15,1	0,44	12,5	19	15,41	9	0,26
11,2	12,5	11,83	3,3	0,10	11,2	12,5	11,83	2,9	0,09
6	11,2	8,20	9,7	0,30	6	11,2	8,20	8,8	0,27
4,75	6	5,34	4,3	0,17	4,75	6	5,34	4,7	0,18
3	4,75	3,77	4,6	0,20	3	4,75	3,77	5,2	0,23
2	3	2,45	4,1	0,23	2	3	2,45	5,1	0,28
1	2	1,41	5,3	0,37	1	2	1,41	11,2	0,78
0,5	1	0,71	4,8	0,56	0,5	1	0,71	15,5	1,82

0,05	0,5	0,16	4,6	0,87	0,05	0,5	0,16	17,4	3,29
		SM_{ACT}	5,7				**SM_{ACT}**	8,1	
		SM_{EST}		4,41			**SM_{EST}**		7,73

Mill B					**Mill B**				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**	**f_l**	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	5,1	0,15	50	75	61,24	3,6	0,10
40	50	44,72	4,1	0,12	40	50	44,72	2,2	0,06
31,5	40	35,50	4,9	0,14	31,5	40	35,50	1,9	0,05
25	31,5	28,06	5,5	0,16	25	31,5	28,06	2,3	0,07
19	25	21,79	5,1	0,15	19	25	21,79	4,5	0,13
12,5	19	15,41	11,3	0,33	12,5	19	15,41	9	0,26
11,2	12,5	11,83	3,7	0,11	11,2	12,5	11,83	2,2	0,07
6	11,2	8,20	12,1	0,37	6	11,2	8,20	9,1	0,28
4,75	6	5,34	7,5	0,29	4,75	6	5,34	5	0,19
3	4,75	3,77	8,5	0,37	3	4,75	3,77	5,5	0,24
2	3	2,45	8,4	0,47	2	3	2,45	5,8	0,32
1	2	1,41	8,6	0,60	1	2	1,41	19,8	1,38
0,5	1	0,71	6,1	0,71	0,5	1	0,71	14	1,64
0,05	0,5	0,16	5,9	1,12	0,05	0,5	0,16	12,1	2,29
		SM_{ACT}	5,5				**SM_{ACT}**	8,5	
		SM_{EST}		5,09			**SM_{EST}**		7,10

Mill C					**Mill C**				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**	**f_l**	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	1,2	0,03	50	75	61,24	0	0,00
40	50	44,72	6,5	0,19	40	50	44,72	7,1	0,20
31,5	40	35,50	5,9	0,17	31,5	40	35,50	3,8	0,11
25	31,5	28,06	8,2	0,24	25	31,5	28,06	4,5	0,13
19	25	21,79	10,2	0,29	19	25	21,79	6,8	0,20
12,5	19	15,41	14,6	0,42	12,5	19	15,41	11,1	0,32
11,2	12,5	11,83	3,7	0,11	11,2	12,5	11,83	3,2	0,10
6	11,2	8,20	12,5	0,39	6	11,2	8,20	8,9	0,27
4,75	6	5,34	5,5	0,21	4,75	6	5,34	4,8	0,19
3	4,75	3,77	5,8	0,25	3	4,75	3,77	5,6	0,24
2	3	2,45	4,8	0,27	2	3	2,45	5,4	0,30
1	2	1,41	7	0,49	1	2	1,41	14,3	1,00
0,5	1	0,71	5,1	0,60	0,5	1	0,71	12,1	1,42
0,05	0,5	0,16	5,4	1,02	0,05	0,5	0,16	8,4	1,59
		SM_{ACT}	7,1				**SM_{ACT}**	8,9	
		SM_{EST}		4,68			**SM_{EST}**		6,07

Mill E				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	1,6	0,05
40	50	44,72	6,2	0,18
31,5	40	35,50	8,5	0,24
25	31,5	28,06	12,4	0,36
19	25	21,79	11	0,32
12,5	19	15,41	13,9	0,40
11,2	12,5	11,83	3,7	0,11
6	11,2	8,20	9,6	0,30
4,75	6	5,34	5,3	0,21
3	4,75	3,77	4	0,17
2	3	2,45	6,1	0,34
1	2	1,41	5	0,35
0,5	1	0,71	4,9	0,57
0,05	0,5	0,16	4,4	0,83
		SM_{ACT}	6,5	
		SM_{EST}		4,43

Mill E				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	3,9	0,11
40	50	44,72	3,5	0,10
31,5	40	35,50	2,4	0,07
25	31,5	28,06	4,3	0,12
19	25	21,79	7	0,20
12,5	19	15,41	8,5	0,25
11,2	12,5	11,83	5,5	0,17
6	11,2	8,20	8,2	0,25
4,75	6	5,34	4,5	0,18
3	4,75	3,77	4,7	0,21
2	3	2,45	4,8	0,27
1	2	1,41	13,9	0,97
0,5	1	0,71	15,2	1,78
0,05	0,5	0,16	9,9	1,87
		SM_{ACT}	8,6	
		SM_{EST}		6,55

Mill F				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	3,1	0,09
40	50	44,72	2,6	0,07
31,5	40	35,50	7,4	0,21
25	31,5	28,06	8	0,23
19	25	21,79	10,9	0,31
12,5	19	15,41	15,4	0,45
11,2	12,5	11,83	3,9	0,12
6	11,2	8,20	12,2	0,38
4,75	6	5,34	5,7	0,22
3	4,75	3,77	5,4	0,24
2	3	2,45	4,6	0,25
1	2	1,41	6,2	0,43
0,5	1	0,71	5,4	0,63
0,05	0,5	0,16	5,6	1,06
		SM_{ACT}	6,7	
		SM_{EST}		4,70

Mill F				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	6,7	0,19
31,5	40	35,50	4,9	0,14
25	31,5	28,06	1,5	0,04
19	25	21,79	4,3	0,12
12,5	19	15,41	9	0,26
11,2	12,5	11,83	2,6	0,08
6	11,2	8,20	8,7	0,27
4,75	6	5,34	4,9	0,19
3	4,75	3,77	5,3	0,23
2	3	2,45	5,6	0,31
1	2	1,41	13,5	0,94
0,5	1	0,71	8,3	0,97
0,05	0,5	0,16	12,4	2,35
		SM_{ACT}	8,3	
		SM_{EST}		6,10

Unit 5 - 16 September 2014					Unit 6 - 16 September 2014				
Mill A					Mill A				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00	50	75	61,24	1	0,03
40	50	44,72	1,8	0,05	40	50	44,72	10,3	0,30
31,5	40	35,50	3,9	0,11	31,5	40	35,50	10,4	0,30
25	31,5	28,06	6,7	0,19	25	31,5	28,06	10,2	0,29
19	25	21,79	7,1	0,20	19	25	21,79	8,4	0,24
12,5	19	15,41	11	0,32	12,5	19	15,41	10,9	0,32
11,2	12,5	11,83	3	0,09	11,2	12,5	11,83	2,6	0,08
6	11,2	8,20	10,7	0,33	6	11,2	8,20	8,1	0,25
4,75	6	5,34	6,7	0,26	4,75	6	5,34	4,7	0,18
3	4,75	3,77	7,6	0,33	3	4,75	3,77	4,9	0,21
2	3	2,45	8,1	0,45	2	3	2,45	4,6	0,25
1	2	1,41	10,6	0,74	1	2	1,41	6,3	0,44
0,5	1	0,71	9,7	1,14	0,5	1	0,71	7,8	0,91
0,05	0,5	0,16	10,4	1,97	0,05	0,5	0,16	7,4	1,40
		SM_{ACT}	9,2				SM_{ACT}	5	
		SM_{EST}		6,19			SM_{EST}		5,21
Mill B					Mill B				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	4,5	0,13	50	75	61,24	2,8	0,08
40	50	44,72	5,2	0,15	40	50	44,72	4	0,12
31,5	40	35,50	3,9	0,11	31,5	40	35,50	2,6	0,07
25	31,5	28,06	4,7	0,14	25	31,5	28,06	5,6	0,16
19	25	21,79	6,7	0,19	19	25	21,79	9,8	0,28
12,5	19	15,41	9,7	0,28	12,5	19	15,41	12,4	0,36
11,2	12,5	11,83	2,6	0,08	11,2	12,5	11,83	2,5	0,08
6	11,2	8,20	9,7	0,30	6	11,2	8,20	10,3	0,32
4,75	6	5,34	5,7	0,22	4,75	6	5,34	5,9	0,23
3	4,75	3,77	7,2	0,31	3	4,75	3,77	6,4	0,28
2	3	2,45	7,5	0,42	2	3	2,45	6,3	0,35
1	2	1,41	10,9	0,76	1	2	1,41	8,5	0,59
0,5	1	0,71	10	1,17	0,5	1	0,71	10	1,17
0,05	0,5	0,16	9,2	1,74	0,05	0,5	0,16	10,2	1,93
		SM_{ACT}	5,4				SM_{ACT}	5,6	
		SM_{EST}		6,01			SM_{EST}		6,02
Mill C					Mill C				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i

50	75	61,24	2	0,06	50	75	61,24	5,1	0,15
40	50	44,72	3,5	0,10	40	50	44,72	11,2	0,32
31,5	40	35,50	4,3	0,12	31,5	40	35,50	7,5	0,22
25	31,5	28,06	3,2	0,09	25	31,5	28,06	7,6	0,22
19	25	21,79	8,3	0,24	19	25	21,79	7,7	0,22
12,5	19	15,41	10,9	0,32	12,5	19	15,41	12,9	0,37
11,2	12,5	11,83	2,5	0,08	11,2	12,5	11,83	3,1	0,09
6	11,2	8,20	10,4	0,32	6	11,2	8,20	8,7	0,27
4,75	6	5,34	6,6	0,26	4,75	6	5,34	4,9	0,19
3	4,75	3,77	8,3	0,36	3	4,75	3,77	4,9	0,21
2	3	2,45	8,3	0,46	2	3	2,45	4,2	0,23
1	2	1,41	10,4	0,73	1	2	1,41	6	0,42
0,5	1	0,71	10,1	1,18	0,5	1	0,71	5,5	0,64
0,05	0,5	0,16	8	1,51	0,05	0,5	0,16	8	1,51
		SM_{ACT}	5,3				**SM_{ACT}**	5,8	
		SM_{EST}		5,83			**SM_{EST}**		5,08
Mill E					**Mill E**				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**	**f_l**	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	2,7	0,08	50	75	61,24	3,8	0,11
40	50	44,72	3,7	0,11	40	50	44,72	8,3	0,24
31,5	40	35,50	5,7	0,16	31,5	40	35,50	7,8	0,22
25	31,5	28,06	5	0,14	25	31,5	28,06	6	0,17
19	25	21,79	5,8	0,17	19	25	21,79	8,8	0,25
12,5	19	15,41	8,7	0,25	12,5	19	15,41	11,9	0,34
11,2	12,5	11,83	2,5	0,08	11,2	12,5	11,83	3,1	0,09
6	11,2	8,20	10,1	0,31	6	11,2	8,20	9,8	0,30
4,75	6	5,34	5,8	0,23	4,75	6	5,34	5,4	0,21
3	4,75	3,77	7,4	0,32	3	4,75	3,77	5,5	0,24
2	3	2,45	8,3	0,46	2	3	2,45	5	0,28
1	2	1,41	10	0,70	1	2	1,41	9	0,63
0,5	1	0,71	11,9	1,39	0,5	1	0,71	7,5	0,88
0,05	0,5	0,16	9,5	1,80	0,05	0,5	0,16	5,5	1,04
		SM_{ACT}	4,7				**SM_{ACT}**	4,7	
		SM_{EST}		6,20			**SM_{EST}**		5,02
Mill F					**Mill F**				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**	**f_l**	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	5	0,14	50	75	61,24	11,4	0,33
40	50	44,72	5,2	0,15	40	50	44,72	5,6	0,16
31,5	40	35,50	2,9	0,08	31,5	40	35,50	9,7	0,28
25	31,5	28,06	4,5	0,13	25	31,5	28,06	7,1	0,20

19	25	21,79	6,6	0,19	19	25	21,79	9,4	0,27
12,5	19	15,41	8,8	0,26	12,5	19	15,41	14,1	0,41
11,2	12,5	11,83	2,1	0,06	11,2	12,5	11,83	3,1	0,09
6	11,2	8,20	9,8	0,30	6	11,2	8,20	9,7	0,30
4,75	6	5,34	6	0,23	4,75	6	5,34	5,1	0,20
3	4,75	3,77	7,6	0,33	3	4,75	3,77	4,6	0,20
2	3	2,45	8,5	0,47	2	3	2,45	4,3	0,24
1	2	1,41	9,9	0,69	1	2	1,41	4,8	0,34
0,5	1	0,71	12,5	1,47	0,5	1	0,71	4,3	0,50
0,05	0,5	0,16	8,5	1,61	0,05	0,5	0,16	4,7	0,89
		SM_{ACT}	5				SM_{ACT}	5,3	
		SM_{EST}		6,12			SM_{EST}		4,41

Unit 1 - 18 September 2014					Unit 2 - 18 September 2014				
Mill B					Mill B				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00	50	75	61,24	1,7	0,05
40	50	44,72	2,8	0,08	40	50	44,72	2,6	0,07
31,5	40	35,50	4,8	0,14	31,5	40	35,50	4,7	0,14
25	31,5	28,06	3,9	0,11	25	31,5	28,06	6,2	0,18
19	25	21,79	6,6	0,19	19	25	21,79	7,8	0,22
12,5	19	15,41	11,1	0,32	12,5	19	15,41	11,7	0,34
11,2	12,5	11,83	2,9	0,09	11,2	12,5	11,83	2,9	0,09
6	11,2	8,20	11	0,34	6	11,2	8,20	10,5	0,32
4,75	6	5,34	6,3	0,25	4,75	6	5,34	5,5	0,21
3	4,75	3,77	6,8	0,30	3	4,75	3,77	5,9	0,26
2	3	2,45	6,8	0,38	2	3	2,45	5,7	0,32
1	2	1,41	10,3	0,72	1	2	1,41	9,2	0,64
0,5	1	0,71	11,5	1,35	0,5	1	0,71	11,3	1,32
0,05	0,5	0,16	12,2	2,31	0,05	0,5	0,16	11	2,08
		SM_{ACT}	7,7				SM_{ACT}	8,5	
		SM_{EST}		6,57			SM_{EST}		6,25
Mill D					Mill D				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	3,8	0,11	50	75	61,24	0	0,00
40	50	44,72	3,6	0,10	40	50	44,72	1,7	0,05
31,5	40	35,50	7,6	0,22	31,5	40	35,50	4,8	0,14
25	31,5	28,06	5,9	0,17	25	31,5	28,06	3	0,09
19	25	21,79	8,4	0,24	19	25	21,79	5,9	0,17

12,5	19	15,41	10,4	0,30	12,5	19	15,41	9,4	0,27
11,2	12,5	11,83	2,7	0,08	11,2	12,5	11,83	2,6	0,08
6	11,2	8,20	9,5	0,29	6	11,2	8,20	11,8	0,36
4,75	6	5,34	4,9	0,19	4,75	6	5,34	6,8	0,26
3	4,75	3,77	5,3	0,23	3	4,75	3,77	7,7	0,34
2	3	2,45	5,1	0,28	2	3	2,45	7,8	0,43
1	2	1,41	8,3	0,58	1	2	1,41	11,3	0,79
0,5	1	0,71	10,3	1,21	0,5	1	0,71	11,8	1,38
0,05	0,5	0,16	11,3	2,14	0,05	0,5	0,16	12	2,27
		SM_{ACT}	7,7				SM_{ACT}	7,9	
		SM_{EST}		6,15			SM_{EST}		6,64

Mill E					Mill E				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	7,2	0,21	50	75	61,24	0	0,00
40	50	44,72	7,9	0,23	40	50	44,72	1,3	0,04
31,5	40	35,50	4,9	0,14	31,5	40	35,50	3,8	0,11
25	31,5	28,06	4,5	0,13	25	31,5	28,06	0	0,00
19	25	21,79	6,2	0,18	19	25	21,79	8,1	0,23
12,5	19	15,41	11,5	0,33	12,5	19	15,41	12,4	0,36
11,2	12,5	11,83	3,2	0,10	11,2	12,5	11,83	3,2	0,10
6	11,2	8,20	10,8	0,33	6	11,2	8,20	11,7	0,36
4,75	6	5,34	5,4	0,21	4,75	6	5,34	6,3	0,25
3	4,75	3,77	5,7	0,25	3	4,75	3,77	0	0,00
2	3	2,45	5,1	0,28	2	3	2,45	6	0,33
1	2	1,41	6,7	0,47	1	2	1,41	8,6	0,60
0,5	1	0,71	7,5	0,88	0,5	1	0,71	10,1	1,18
0,05	0,5	0,16	10,2	1,93	0,05	0,5	0,16	13	2,46
		SM_{ACT}	5,5				SM_{ACT}	7,2	
		SM_{EST}		5,67			SM_{EST}		6,02

Mill F					Mill F				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0,8	0,02	50	75	61,24	1,8	0,05
40	50	44,72	6	0,17	40	50	44,72	4,5	0,13
31,5	40	35,50	7,7	0,22	31,5	40	35,50	4,8	0,14
25	31,5	28,06	6,9	0,20	25	31,5	28,06	5,6	0,16
19	25	21,79	12	0,35	19	25	21,79	6,7	0,19
12,5	19	15,41	8,2	0,24	12,5	19	15,41	10,6	0,31
11,2	12,5	11,83	3,7	0,11	11,2	12,5	11,83	3	0,09
6	11,2	8,20	8,6	0,27	6	11,2	8,20	11,3	0,35
4,75	6	5,34	5,5	0,21	4,75	6	5,34	6,2	0,24

3	4,75	3,77	6,1	0,27	3	4,75	3,77	6,8	0,30
2	3	2,45	6	0,33	2	3	2,45	6,5	0,36
1	2	1,41	10,1	0,71	1	2	1,41	8,4	0,59
0,5	1	0,71	5,4	0,63	0,5	1	0,71	8,8	1,03
0,05	0,5	0,16	5,1	0,97	0,05	0,5	0,16	11,8	2,23
		SM_{ACT}	5,3				SM_{ACT}	7	
		SM_{EST}		4,69			SM_{EST}		6,17

Table T-4: Stage 3 Power Station D Samples

UNIT 1 - 21/10/2015					UNIT 2 - 2/11/2015				
Mill A					Mill A – No Data				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00					
40	50	44,72	3,2	0,09					
31,5	40	35,50	4,4	0,13					
25	31,5	28,06	6,2	0,18					
19	25	21,79	11,7	0,34					
12,5	19	15,41	22,6	0,65					
11,2	12,5	11,83	5,8	0,17					
6	11,2	8,20	15,5	0,48					
4,75	6	5,34	6,2	0,24					
3	4,75	3,77	5,6	0,24					
2	3	2,45	4	0,22					
1	2	1,41	3,8	0,27					
0,5	1	0,71	2	0,23					
0,05	0,5	0,16	3,5	0,66					
		SM_{ACT}	6,6				SM_{ACT}		
		SM_{EST}		3,91			SM_{EST}		
Mill B					Mill B				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	3,9	0,11	50	75	61,24	0	0,00
40	50	44,72	4,3	0,12	40	50	44,72	1	0,03
31,5	40	35,50	9,2	0,26	31,5	40	35,50	5,6	0,16
25	31,5	28,06	5,4	0,16	25	31,5	28,06	4,6	0,13
19	25	21,79	7,7	0,22	19	25	21,79	6	0,17
12,5	19	15,41	13,6	0,39	12,5	19	15,41	8,2	0,24
11,2	12,5	11,83	3,9	0,12	11,2	12,5	11,83	1,7	0,05
6	11,2	8,20	12,8	0,39	6	11,2	8,20	8,2	0,25
4,75	6	5,34	7,3	0,28	4,75	6	5,34	6,3	0,25

3	4,75	3,77	7,5	0,33	3	4,75	3,77	7,9	0,35
2	3	2,45	6,2	0,34	2	3	2,45	9,4	0,52
1	2	1,41	6	0,42	1	2	1,41	13,9	0,97
0,5	1	0,71	3,3	0,39	0,5	1	0,71	7,9	0,93
0,05	0,5	0,16	5,1	0,97	0,05	0,5	0,16	16,8	3,18
		SM_{ACT}	2,8				**SM_{ACT}**	2,9	
		SM_{EST}		4,51			**SM_{EST}**		7,23

Mill C – No Data					**Mill C**				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**	**f_l**	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
					50	75	61,24	3,9	0,11
					40	50	44,72	4,3	0,12
					31,5	40	35,50	9,2	0,26
					25	31,5	28,06	5,4	0,16
					19	25	21,79	7,7	0,22
					12,5	19	15,41	13,6	0,39
					11,2	12,5	11,83	3,9	0,12
					6	11,2	8,20	12,8	0,39
					4,75	6	5,34	7,3	0,28
					3	4,75	3,77	7,5	0,33
					2	3	2,45	6,2	0,34
					1	2	1,41	6	0,42
					0,5	1	0,71	3,3	0,39
					0,05	0,5	0,16	5,1	0,97
		SM_{ACT}					**SM_{ACT}**	2,6	
		SM_{EST}					**SM_{EST}**		4,51

Mill D					**Mill D**				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**	**f_l**	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	0	0,00	50	75	61,24	2,2	0,06
40	50	44,72	4,2	0,12	40	50	44,72	2,5	0,07
31,5	40	35,50	8	0,23	31,5	40	35,50	4,7	0,14
25	31,5	28,06	6,4	0,18	25	31,5	28,06	6,4	0,18
19	25	21,79	4,7	0,14	19	25	21,79	11,4	0,33
12,5	19	15,41	15,5	0,45	12,5	19	15,41	17,1	0,50
11,2	12,5	11,83	4,2	0,13	11,2	12,5	11,83	3,6	0,11
6	11,2	8,20	14,2	0,44	6	11,2	8,20	13	0,40
4,75	6	5,34	7,8	0,30	4,75	6	5,34	7,8	0,30
3	4,75	3,77	9,2	0,40	3	4,75	3,77	7,5	0,33
2	3	2,45	6,8	0,38	2	3	2,45	5,4	0,30
1	2	1,41	7,1	0,50	1	2	1,41	6,9	0,48
0,5	1	0,71	4	0,47	0,5	1	0,71	3,9	0,46

0,05	0,5	0,16	3,5	0,66	0,05	0,5	0,16	4,2	0,79
		SM_{ACT}	3,2				SM_{ACT}	1,6	
		SM_{EST}		4,39			SM_{EST}		4,45

Mill E					Mill E				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	3,1	0,09	50	75	61,24	0	0,00
40	50	44,72	1,8	0,05	40	50	44,72	2,4	0,07
31,5	40	35,50	4,7	0,14	31,5	40	35,50	5,3	0,15
25	31,5	28,06	5,7	0,16	25	31,5	28,06	5,4	0,16
19	25	21,79	7,6	0,22	19	25	21,79	7,9	0,23
12,5	19	15,41	15,8	0,46	12,5	19	15,41	12,9	0,37
11,2	12,5	11,83	3,7	0,11	11,2	12,5	11,83	3,7	0,11
6	11,2	8,20	15,9	0,49	6	11,2	8,20	12,5	0,39
4,75	6	5,34	8,3	0,32	4,75	6	5,34	7,4	0,29
3	4,75	3,77	7,9	0,35	3	4,75	3,77	8	0,35
2	3	2,45	6,8	0,38	2	3	2,45	7,3	0,40
1	2	1,41	6,5	0,45	1	2	1,41	8	0,56
0,5	1	0,71	3,5	0,41	0,5	1	0,71	5,2	0,61
0,05	0,5	0,16	5,4	1,02	0,05	0,5	0,16	10	1,89
		SM_{ACT}	2				SM_{ACT}	2,1	
		SM_{EST}		4,65			SM_{EST}		5,58

UNIT 2 - 2/11/2015					UNIT 2 - 3/11/2015				
Mill A - No Data					Mill A – No Data				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i

		SM_{ACT}					SM_{ACT}		
		SM_{EST}					SM_{EST}		

Mill B					Mill B				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	1,6	0,05	50	75	61,24	8,3	0,24
40	50	44,72	1,8	0,05	40	50	44,72	3,1	0,09
31,5	40	35,50	3,1	0,09	31,5	40	35,50	4,4	0,13
25	31,5	28,06	5,2	0,15	25	31,5	28,06	2,1	0,06
19	25	21,79	7	0,20	19	25	21,79	6,2	0,18
12,5	19	15,41	9,1	0,26	12,5	19	15,41	8,1	0,23
11,2	12,5	11,83	2,5	0,08	11,2	12,5	11,83	3,7	0,11
6	11,2	8,20	9,6	0,30	6	11,2	8,20	10,5	0,32
4,75	6	5,34	6,3	0,25	4,75	6	5,34	7	0,27
3	4,75	3,77	8,2	0,36	3	4,75	3,77	8,1	0,35
2	3	2,45	9,3	0,51	2	3	2,45	8,6	0,48
1	2	1,41	11,5	0,80	1	2	1,41	9,8	0,69
0,5	1	0,71	8,2	0,96	0,5	1	0,71	6,3	0,74
0,05	0,5	0,16	14,1	2,67	0,05	0,5	0,16	10,1	1,91
		SM_{ACT}	5,5				SM_{ACT}	2,8	
		SM_{EST}		6,73			SM_{EST}		5,80

Mill C					Mill C				
f_l	f_u	Geomean	f_i	SM_iXf_i	f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	3,9	0,11	50	75	61,24	8,7	0,25
40	50	44,72	4,3	0,12	40	50	44,72	2,6	0,07
31,5	40	35,50	9,2	0,26	31,5	40	35,50	4	0,12
25	31,5	28,06	5,4	0,16	25	31,5	28,06	3,1	0,09
19	25	21,79	7,7	0,22	19	25	21,79	7,9	0,23
12,5	19	15,41	13,6	0,39	12,5	19	15,41	12,8	0,37
11,2	12,5	11,83	3,9	0,12	11,2	12,5	11,83	3,3	0,10
6	11,2	8,20	12,8	0,39	6	11,2	8,20	12,6	0,39
4,75	6	5,34	7,3	0,28	4,75	6	5,34	6,9	0,27
3	4,75	3,77	7,5	0,33	3	4,75	3,77	8	0,35
2	3	2,45	6,2	0,34	2	3	2,45	7,6	0,42
1	2	1,41	6	0,42	1	2	1,41	8,3	0,58
0,5	1	0,71	3,3	0,39	0,5	1	0,71	4,9	0,57
0,05	0,5	0,16	5,1	0,97	0,05	0,5	0,16	5,8	1,10
		SM_{ACT}	5				SM_{ACT}	2,9	
		SM_{EST}		4,51			SM_{EST}		4,91

Mill D				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	2,2	0,06
40	50	44,72	2,5	0,07
31,5	40	35,50	4,7	0,14
25	31,5	28,06	6,4	0,18
19	25	21,79	11,4	0,33
12,5	19	15,41	17,1	0,50
11,2	12,5	11,83	3,6	0,11
6	11,2	8,20	12,9	0,40
4,75	6	5,34	7,8	0,30
3	4,75	3,77	7,5	0,33
2	3	2,45	5,4	0,30
1	2	1,41	6,9	0,48
0,5	1	0,71	3,9	0,46
0,05	0,5	0,16	4,1	0,78
		SM_{ACT}	4,8	
		SM_{EST}		4,43

Mill D				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	3,2	0,09
40	50	44,72	3	0,09
31,5	40	35,50	4,2	0,12
25	31,5	28,06	3,1	0,09
19	25	21,79	5,4	0,16
12,5	19	15,41	12,7	0,37
11,2	12,5	11,83	4,4	0,13
6	11,2	8,20	18,9	0,58
4,75	6	5,34	9,2	0,36
3	4,75	3,77	8,8	0,38
2	3	2,45	7	0,39
1	2	1,41	6,6	0,46
0,5	1	0,71	3,6	0,42
0,05	0,5	0,16	4,9	0,93
		SM_{ACT}	2,4	
		SM_{EST}		4,57

Mill E				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	0	0,00
40	50	44,72	2,4	0,07
31,5	40	35,50	5,3	0,15
25	31,5	28,06	5,4	0,16
19	25	21,79	7,9	0,23
12,5	19	15,41	12,9	0,37
11,2	12,5	11,83	3,7	0,11
6	11,2	8,20	12,5	0,39
4,75	6	5,34	7,4	0,29
3	4,75	3,77	8	0,35
2	3	2,45	7,3	0,40
1	2	1,41	8	0,56
0,5	1	0,71	5,2	0,61
0,05	0,5	0,16	10	1,89
		SM_{ACT}	4,4	
		SM_{EST}		5,58

Mill E				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	1,8	0,05
40	50	44,72	5,1	0,15
31,5	40	35,50	6	0,17
25	31,5	28,06	6,1	0,18
19	25	21,79	8,7	0,25
12,5	19	15,41	14,6	0,42
11,2	12,5	11,83	3,6	0,11
6	11,2	8,20	12,9	0,40
4,75	6	5,34	7,1	0,28
3	4,75	3,77	7,9	0,35
2	3	2,45	7,3	0,40
1	2	1,41	7,5	0,52
0,5	1	0,71	3,6	0,42
0,05	0,5	0,16	3,1	0,59
		SM_{ACT}	2,5	
		SM_{EST}		4,29

Table T-5: Stage 3 Power Station E Samples

UNIT 2 - 3/11/2015				
Unit 1 - Mill B,C,D,E Composite				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	2,3	0,07
40	50	44,72	0,4	0,01
31,5	40	35,50	3,4	0,10
25	31,5	28,06	4,6	0,13
19	25	21,79	8	0,23
12,5	19	15,41	1,5	0,04
11,2	12,5	11,83	14,9	0,45
6	11,2	8,20	8,4	0,26
4,75	6	5,34	9,2	0,36
3	4,75	3,77	4,6	0,20
2	3	2,45	3,8	0,21
1	2	1,41	16,8	1,17
0,5	1	0,71	6,5	0,76
0,05	0,5	0,16	15,6	2,95
		SM_{ACT}	7,1	
		SM_{EST}		6,95

Unit 2 - Mill B,C,D,E Composite				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	1,2	0,03
40	50	44,72	3,7	0,11
31,5	40	35,50	1,2	0,03
25	31,5	28,06	8,4	0,24
19	25	21,79	6,2	0,18
12,5	19	15,41	5	0,14
11,2	12,5	11,83	12,7	0,38
6	11,2	8,20	7,1	0,22
4,75	6	5,34	5,9	0,23
3	4,75	3,77	2,8	0,12
2	3	2,45	10,2	0,56
1	2	1,41	16,5	1,15
0,5	1	0,71	6,2	0,73
0,05	0,5	0,16	12,9	2,44
		SM_{ACT}	7,7	
		SM_{EST}		6,58

Unit 3 - Mill B,C,D,E Composite

f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	2,7	0,08
40	50	44,72	1,9	0,05
31,5	40	35,50	0,8	0,02
25	31,5	28,06	8,3	0,24
19	25	21,79	8	0,23
12,5	19	15,41	3,4	0,10
11,2	12,5	11,83	14,8	0,45
6	11,2	8,20	6,80	0,21
4,75	6	5,34	8	0,31
3	4,75	3,77	2,7	0,12
2	3	2,45	9,8	0,54
1	2	1,41	10,2	0,71
0,5	1	0,71	7,2	0,84
0,05	0,5	0,16	15,4	2,91
		SM_{ACT}	7,4	
		SM_{EST}		6,82

Unit 4 - Mill B,C,D,E Composite				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	2,9	0,08
40	50	44,72	9,8	0,28
31,5	40	35,50	1,6	0,05
25	31,5	28,06	5,4	0,16
19	25	21,79	4,1	0,12
12,5	19	15,41	5,1	0,15
11,2	12,5	11,83	11,7	0,35
6	11,2	8,20	5,7	0,18
4,75	6	5,34	7,6	0,30
3	4,75	3,77	6,7	0,29
2	3	2,45	4,1	0,23
1	2	1,41	12,4	0,87
0,5	1	0,71	5,7	0,67
0,05	0,5	0,16	17,2	3,26
		SM_{ACT}	6,2	
		SM_{EST}		6,97

Unit 5 - Mill B,C,D,E Composite				
f_l	f_u	Geomean	f_i	SM_iXf_i
50	75	61,24	2,5	0,07
40	50	44,72	5,6	0,16

31,5	40	35,50	8,4	0,24
25	31,5	28,06	6,6	0,19
19	25	21,79	3,1	0,09
12,5	19	15,41	8	0,23
11,2	12,5	11,83	8,7	0,26
6	11,2	8,20	5,6	0,17
4,75	6	5,34	7	0,27
3	4,75	3,77	6	0,26
2	3	2,45	9,7	0,54
1	2	1,41	7	0,49
0,5	1	0,71	8,7	1,02
0,05	0,5	0,16	13,1	2,48
		SM_{ACT}	4,2	
		SM_{EST}		6,48

Unit 6 - Mill B,C,D,E Composite				
f_l	**f_u**	**Geomean**	**f_i**	**SM_iXf_i**
50	75	61,24	1,40	0,04
40	50	44,72	3,60	0,10
31,5	40	35,50	3,20	0,09
25	31,5	28,06	8,10	0,23
19	25	21,79	7,70	0,22
12,5	19	15,41	3,60	0,10
11,2	12,5	11,83	9,00	0,27
6	11,2	8,20	5,90	0,18
4,75	6	5,34	11,30	0,44
3	4,75	3,77	5,90	0,26
2	3	2,45	7,20	0,40
1	2	1,41	9,90	0,69
0,5	1	0,71	6,30	0,74
0,05	0,5	0,16	16,90	3,20
		SM_{ACT}	4,30	
		SM_{EST}		6,97