TECHNICAL REPORT

ON

ECONOMIC FEASIBILITY OF COAL RESERVES IN 5086C MOATIZE COALFIELD, MOZAMBIQUE

2024

Prepared By

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Submitted to

Midwest Africa Limitada, AV 25 de Setembro No. 1230, 3 Andhar, Block 5, Maputo, Mozambique

Effective Date: 31st August 2024

Volume - I:

Technical Report on Economic Feasibility of Coal Reserves in 5086c Tenement, Mecondezi Sub-Basin, Moatize Coalfield, Mozambique

Volume - II:

Annexures to the report

Foreword

The '**MGPL Exploration& Mining**' is a 'competent agency' recognized by the Ministry of Mines, Government of India vide Notification No 4/1/2016-NMET to undertake various levels of exploration activities for coal &lignite Resource and Reserve estimates. The principals in MGPL have been credited with rich experience in implementation of JORC/SAMREC/UNFC guidelines for assessment of coal projects in India. Besides, the agency conducted study of coal projects in Indonesia, Russia, Mozambique and Madagascar for stock market listing and also Bankable Feasibility study reports on Industrial Minerals in India.

The competent agency has been entrusted the task of preparation of the present report entitled "Technical study on Economic Assessment of Coal Reserve in 5086C, Mecondezi sub-basin of the Moatize Coalfield" by the Midwest Africa Limitada. This is a team work of several qualified persons/ consulting companies, whose work was accomplished under my overall guidance and supervision. Besides, this project had undergone Technical auditing on exploration results and resource estimates independently at various stages by the Geos Mining consultants- Australia, M/s. Behre Dolbear-USA and Peet Meyer consulting- South Africa.

Inputs on mine plan have been provided by Mr. Ajababu, and K.Mallikarjuna Rao who have had four decades rich experience in coal mine planning and mine development; Messers A.Mukhopadhyay Associates, Kolkata, and Mr. T.Gowricharan, principal Scientist (Retd) of CIMFR (Central Institute of mine planning and fuel research) had conducted Coal Preparation studies, CHPP flow sheet design machinery planning and cost estimates; the GSMC Lda. Maputo, are consultants for Environmental Impact& Management studies: RR geophysics company, India is a service provider on down-the-hole multi-probe geophysical sonic logs interpretations. Field operation niceties, Data synthesis, Statistical analysis, QA/QC and Minex modeling have been executed by well experienced exploration team comprising Mr. Y.Arun Kumar, D.Vijay Kumar and P.V.Satish, Geologists. The task of the Economic assessment and finance model has been undertaken by Mr. G.V. Krishna Rao, BE (Mech); MBA.

I certify that this report has been designed on the SANAS 2004 procedures and UNFC methodology and complies with the themes of Adequacy, transparency and competency as enshrined in Australian JORC-2012.

Some of the observations and inferences presented in this report are subject to change with the addition of new information w.e.f. 31st August, 2024.

Dr. G. Lakshminarayana, MAusImm (CP)

Competent person

Competent Person's Consent Form

Pursuant to the requirements of ASX Listing rules 5.6, 5.22, and 5.24 and clause 9 of the JORC code 2012 Edition (Written Consent Statement).

Name of company releasing the report: MIDWEST AFRICA LIMITADA, MOZAMBIQUE

Name of the deposit to which this report refers to: Tenement No. 5086C, MOATIZE COAL BASIN, MOZAMBIQUE.

Date of the Report: 31st August, 2024.

Statement

I Dr. Guddanti. Lakshminarayana

Confirm that I am the Competent Person for the report and:

- I have read and understood the requirements of the 2012 edition of the Australasian Code for reporting of Exploration Results, Mineral resource and Ore Reserves (JORC Code, 2012 Edition)
- I am a competent person as defined by the JORC Code 2012 Edition, having eighteen years' experience that is relevant to the style of Mineralization and type of deposit described in the Report, and to the activity for which I am accepting responsibility.
- I am a Member and Chartered Professional of the Australasian Institute of Mining and Metallurgy
- I have compiled and reviewed the report to which this consent Statement applies.

I am an Independent consultant and have been engaged by

Midwest Africa Limitada

To prepare the documentation for

Technical report on Economic Feasibility Pre-feasibility of Coal Reserves in 5086C tenement, Mecondezi sub-basin, Moatize coalfield, Mozambique.

On which the Report is based, for the period ended 31st August, 2024.

I have disclosed to the reporting company the full nature of the relationship between myself and the company, including any issue that could be perceived by investors as a conflict of interest.

I verify that the Report is based on and fairly and accurately reflects in the form and context in which it appears, the information in my supporting documentation relating to Resource and Reserves.

Consent

I consent to the release of the Report and this Consent Statement by the Directors of:

MIDWEST AFRICA LIMITADA

Signature of Competent Person: Date: 31st August, 2024.

Professional Membership: **MAusImm (CP)** Membership Number: **305538**

Signature of Witness

Witness Name and Residence:

B Ramakrishna

11-8-19/1, Saroor Nagar

Hyderabad – 500035

CERTIFICATE OF QUALIFICATIONS

G.LAKSHMINARAYANA

- I Guddanti. Lakshminarayana, residing at Padmaja courts-I, Flat No: 401, Srinagar Colony, Hyderabad, Telangana, India, do hereby certify that.
- I have been engaged as a consultant by the MGPL Exploration & Mining, Road no.12, Banjara hills, Hyderabad-34, India to prepare documentation on the coal Reserves
- My educational qualifications: M.Sc. Geology (1978) Andhra University, India; Ph.D. in Mineral Exploration, (1991), Nagarjuna University, India: AusImm certificate course on Coal Quality, Brisbane, Australia-2011, Coal Preparation course – 2011, Rutherford, Australia and Whittle Mine Optimization course – 2012, Perth, Australia.
- I am a chartered professional of good standing in Australian Institute of Mining and Metallurgy (No.305538). I am a competent person for estimation and reporting of ore resources and reserves (coal).
- I am a member of Mining Engineers Association of India (MEAI)-No.277.
- I have read Australasian code for Reporting of Exploration Results, Mineral Resources and Ore resources-JORC code – 2012 edition.
- I certify that the relevant contents in Technical report on Economic Feasibility of Coal Reserves in 5086C tenement, Mecondezi sub-basin, Moatize coalfield, Mozambique are true to the best of my knowledge with effective date 31st August, 2024.

AJABABU

- I M. Aja Babu residing at Sai sasikala Awas, Flat 304, SR Nagar, Hyderabad, Telangana, India, do hereby certify that
- I have been engaged as a consultant by MGPL Exploration & Mining to conduct mining study and to prepare conceptual mine plan as a part of pre-feasibility study of 5086C coal property of Midwest Africa Limitada located in Moatize coal basin, Mozambique.
- I graduated in Bachelor of Engineering (Mining) in 1969 from Osmania University, Hyderabad, India. I am a recognized qualified person (RQP) of the Government of India, holding First class certificate of competency to manage coal mines. I am a member of Mining Engineers Association of India.
- I am credited with 40 years of experience in open cast and underground coal mines planning & operations.
- I have prepared all the aspects included: Mine plan of the Technical Report. I certify that the Mining parameters and cost estimates comply with the industry practices.
- I had personally inspected the 5086C coal property in 2009 and 2014, three weeks duration in each visit.
- I am an independent person of MAL

- As on the effective 20-1-24.All scientific and technical information included in the report on mine plan are transparent and adequate at this level of study and I hold responsibility for the contents included in the relevant part.

MALLIKARJUNA RAO

- I K. Mallikarjuna Rao residing at Lancohills Residential Towers, Flat 2704, Manikonda, Hyderabad, Telangana, India, do hereby certify that.
- I am qualified Mining Engineer and working as Chief Operating Officer for Midwest Group of mines. Besides Mining Operations I have had adequate experience in Mine Planning exercises and operational aspects of the coal mines.
- I have reviewed the Mine Plan prepared by Mr Aja Babu which is incorporated in the Pre-Feasibility study report dated 12.04.2028 on 5086 C coal property of Midwest Africa Limitada located in Moatize coal basin, and incorporated modification as required. .
- I am holder of First Class Mine Managers Certificate of Competency and a Diploma in Mining Engineering from State Board of Technical Education, Andhra Pradesh. I am a full-fledged member of Mining Engineers Association of India which is recognized by International Mining Institutes.
- I am credited with 43 years of experience in planning & operations of open cast and underground Coal and Non coal mines in India and abroad.
- I have reviewed and modified all the aspects included in Mine plan part of the Technical Report. I certify that the Mining parameters and cost estimates comply with industry practices and state-of-art mining niceties.
- I am currently the Project In-charge and had personally executed development of Trail (pilot) Mining Pit in the 5086C coal property during 2022-23.
- As on the effective date 20-1-2024-, all scientific and technical information included in the report on mine plan is transparent and adequate at this level of study and I hold responsibility for the reviewed contents included in the relevant part.

ABHIK MUKHOPADHAYA

- I Abhik Mukhopadhaya residing at Abhik Mukhopadhaya Consultant Ltd. East Calcutta, India do hereby certify that.
- I have been involved in the synthesis of float-sink data, Regressive analysis and estimated theoretical coal yields of the laboratory data supplied by the Midwest Africa Limitada.
- I have designed conceptual flow sheet of the coal preparation plant and made cost estimations based on information collected from the potential suppliers.
- I have had about 45 years' experience in the concerned field.
- The Abhik Mukhopadahya consultant company is headed by me in which a team of flow sheet designers and estimators whose output is presented in the report.

T.GOWRI CHARAN

- I Dr. T.Gowri Charan residing at Flat No. 401, Sri Balaji Enclave, Shipyard layout – Simhachalam, Visakhapatnam, Andhra Pradesh, India, do hereby certify that.
- I am a Post graduate in Mineral Beneficiation and Ph.D. in Mineral processing Engineering and over 30 years of experience in coal preparation.
- I am a member of coal preparation society of India and South Africa.
- I am an honorary adviser for coal preparation of the Midwest Africa Limitada for the study of bulk sample float-sink analysis. Prepared float-sink derivative graphs and gravity separation curves.
- Information presented in the coal preparation is relevant to the best of my knowledge.

G.V.KRISHNA RAO

- I G.V.Krishna Rao residing at Marigold Apartment, Sainikpuri colony, Hyderabad, India, do hereby certify that.
- I was employed as Project Manager and Business Analyst in the MGPL. My services are provisionally requested by the company for the modification of the financial model incorporated in the PFS report dt.12/4/2023.
- My educational qualifications are i) Bachelor of Technology in Mechanical Engineering (2005) ii) Degree in MBA- Master of Business Administration (2007), from Institute of Public Enterprises, Hyderabad, India.
- I am specialized in Logistics, Operations Management, Business analysis and strategic account management. I possess adequate experience in Mechanical design, Microsoft and SAP applications. I am credited with more than eight years' experience in preparation of financial model of mining projects.
- Prior to MGPL, I worked in HCL (Hindustan Computers Limited), Chennai, India, a listed company in BSE and NSE as logistics manager. My total experience in Business Administration amounts to 12(Twelve) years
- I have inspected the 5086C coal property in 2013 to study logistics and operational management. I have discussed with the logistics management companies located in Tete on costing and cost-effectiveness of the operations.
- I have prepared a chapter on coal market study, cost estimates and financial model presented in the Technical Report on Economic Feasibility study of coal reserves in 5086C of Midwest Africa Limitada. I am responsible for relevance and transparency of the above cited aspects at the Economic feasibility level.

T.HANUMANTH REDDY

- I T.Hanumanth Reddy resided at Tete, Mozambique.
- I have served as operational manager for 12 years for the Midwest Africa Limitada.
- Information furnished on infrastructure and allied aspects has been gathered by me from various service providers and true the best of knowledge.

JORC Table-1. Section4. Estimation and Reporting of Ore reserves.

Section 4. Estimation and reporting of ore reserves	
Criteria	Explanation
Mineral Resource estimate for conversion to Ore Reserves	Measured and Indicated categories of resources have been used as a basis for conversion to coal reserves.
Site visits	The CP has made several site visits to assess mine lay out area, Infrastructure facilities. Visited other operating coal mines in regard to mine plan and operational practices in the Moatize coalfield. Discussed with the potential mining contractors and service providers for cost estimate assumptions and Government agencies on licensing
Study status	Pre-feasibility level study. Infill drilling and pilot mine operations formed basis for conversion of resource into reserve. Salient components include, determined mine plan, mining method, scheduling, machinery planning, cost estimates, coal preparation, coal product specification, marketability, EIA&EMP and economic viability through a finance model.
Cut-off parameters	Basis for cut-off parameters are outlined in chapter on Resource and reserve estimation. Market and Trade specifications are kept in mind for working out the cut off parameters.
Mining factors or assumptions	Preliminary pit design and optimization Chosen mining method is appropriate to nature of mineralization (mine out bar code type coal seams by Surface Miner to keep control on mine dilution). Pit slope angles are proposed at 60^{o} on lithological and geotechnical considerations. Grade control will be maintained through shallow core drilling in grid pattern; mining out and mixing of coal from sections with different ash grades. Dilution factor estimated is 7% which includes contaminants Coal Seam recovery factor considered by Surface Miner is 90%. Minimum mining width used is 100m in 300x100 mining cell, flexible when warranted. Minimum mining height is 0.3m. Inferred resource is not used in the present study. Infrastructure requirement of selective mining method are detailed.

Metallurgical factors or assumptions	Coal preparation by washing is universal way of coal beneficiation. Metallurgical tests conducted so far are indicative in nature. Recovery factor for saleable products looks more appropriate. Metallurgical high temperature coking test yielded positive results. Bulk samples from large dia borehole and bulk samples collected from pilot mine and tested so far would suffice at this level of study.
Environmental	Coal mining and CHPP impacts on environment have been studied. Appropriate provisions are made in mine plan for soil preservation, waste dump sites, waste water recycling, air and dust control. Etc.
Infrastructure	Infrastructure status at project site was reviewed. A provisional amount of 10 million USD pre-production infrastructure development is proposed which includes, plant site, project site up gradation, personnel accommodation, ware houses, workshops, water, power rail siding and coal hauling facilities etc.,
Costs	Vendor/ contractor quotations as well as MGPL experience. Prevailing market rates. Allowances are made at FOB penalties and premiums against bench mark coal. USD vs. Metica – Mozambique currency is taken into consideration. Transportation costs are derived at prevailing rates with service providers like LALJI. Refining charges are provisional Royalties have been listed
Revenue factors	Main source of revenue is proceeds from coal sales in both seaborne trade and local trade. Metallurgical coal price realization is taken as 266$, while for thermal coal it is 96$ on f.o.b.
Market assessment	Long term and short-term coal demand and supply cyclical have been taken into consideration since the year 2008. Metallurgical coal has demand for iron & steel manufacturing. Market window is primarily from Indian and Chinese and other regions. MAL coal product specifications (metallurgical; and thermal) have been assessed against global coal market indexes.
Economic	Financial model developed as a part of economic analysis

	is positive and coal mining in 5086C is viable.
Social	Mining license was received from Government of Mozambique. An understanding was reached with the local Government communities living in and around the mining area on CSR. Local community's involvement and response to the project has been very much positive and affirmative.
Other	Consultations on legal agreements and marketing arrangements are in progress Statutory approvals required for the project have been received. EMP approval is awaited. Approval permits for water, power use and bridge construction shall be obtained in due course to enable mine construction.
Classification	The coal reserve definition presented in this report reflects the competent person's view of the deposit.
Audits or reviews	Audit was conducted on G2 level Geological study and resource estimation by Peet Meyer consulting of South Africa whose result was very positive.
Discussion of relative accuracy/confidence	The accuracy and confidence level of the coal reserve estimates is +/- 10 %.

Report Name: TECHNICAL REPORT ON ECONOMIC FEASIBILITY OF COAL RESERVES IN 5086C TENEMENT, MECONDEZI SUB-BASIN, MOATIZE COALFIELD, MOZAMBIQUE.

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Preface

The present Technical report on “Economic Feasibility study of Coal Reserves in 5086 C, Mecondezi sub-basin, Moatize coalfield, Mozambique” is a comprehensive document covering whole gamut of the coal deposit as required for the Economic Feasibility study.

Executive Summary provides a glimpse of the work conducted by the MAL.

Part-I: The report begins with an introduction chapter of the deposit followed by the presentation of Detailed (G1 level) exploration data on, coal quality, Resources and mine outlay and Reserves.

PART- II: The second part of the report deals with feasibility aspects viz. Detailed mine plan, coal processing, mine infrastructure, costing, environment and land rights.

PART_III: The economic analysis is synthesis of the above two parts of the report passing through the costing, marketing and ultimately converging into an economic model. Conclusion of the report and other appendices are enclosed.

TECHNICAL REPORT ON
ECONOMIC FEASIBILITY OF COAL RESERVES IN
ML No 5086C, MOATIZE COALFIELD, MOZAMBIQUE
2024

Executive Summary

INTRODUCTION

- The Technical Report on the Economic Feasibility study of coal reserves in 5086C tenement of Midwest Africa Limitada (MAL), AV 25 de Setembro No. 1230, 3 Andhar, Block 5 Maputo, Mozambique has been prepared by the MGPL exploration & Mining, company, an agency recognized by the Government of India. Coal Resource and Reserve estimates incorporated in the report have been guided by JORC code-2012 of Australasian Institute of Mining and Metallurgy, AusImm Monograph 23 on Good Practices of Reserve Estimation and also guidelines given in South African National Standards (SANS): 10320-2004.
- The Competent Person (CP) to this report is Dr. G.Lakshminarayana, Member Australian Institute of mining and metallurgy, Charted Professional (CP) with a professional membership of no. 30553 of good standing. His Educational qualification is M.Sc. (Geology) and Ph.D (coal exploration) and experience for 40 years in Coal exploration. Other qualified persons on Resource modeling, Mining, Coal Preparation, Finance and Infrastructure provided valuable inputs to the report. Accuracy level of the technical report is +/- 10%.

Location:

- The MAL coal property (5086C) forms a part of the Mecondezi sub-basin of the Moatize coalfield, Tete, Mozambique. The property is bound by Lat: 15° 42' 00'' S – 15° 48' 00'' S and Long: 33° 47' 45'' – 33° 56' 00''E. Areal extent of the license area is 15840 ha.

DEPOSIT DEFINITION

Geology & Structure:

- Geological formations in 5086C belong to the Lower Karoo (Late Carboniferous to Triassic) sedimentary succession and the underlying Precambrian crystalline basement. The Karoo sediments are classified in ascending order into Vuzi, Moatize (late carboniferous to Permian); Matinde (Triassic) and Muchena (Quaternary) Formations. Structural setting of the project area is a half graben in the Gondwana rift of the Zambezi valley. This part of the coal basin is devoid of younger intrusive like dykes and sills.

Mineralization:

- Coal occurs in the Moatize Formation. The coal deposit is 'Thick bedded Multi-seam' type. There are six major coal seams contained in a 900 m thick stratum. Coal seam elongation is NW-SE and dip is 8-100 towards northeast. Coal seam classification in ascending order from bottom to top shows SausoPinto, Chipanga, Bananeiras, Intermedia, Grande Falesia and Andre. The SausoPinto seam is interbedded with the glaciogenic diamictite – rhythmite-sandstone assemblage at the Vuzi-Moatize formational contact zone, whereas the remaining five seams occur in Moatize Formation. The Chipanga seam is 25 to 40 m thick and has been targeted for coal exploitation by coal companies operating in the Moatize coal basin. The 'Grande Falesia' seam has attained a maximum thickness of over 200 m in 5086C and has been designated as one of the thickest coal seams of this type in the world. It also offers a scope for eventual exploitation by open pit mining in 5086C. Coal seams are complex and marked by 'barcode' morphology made of alternate beds of coal and shale. Based on ash contained in the coaly layers, these coal seams are further sub-divided into sub-seams and potentially mineable sections.

Exploration:

- The conventional geological mapping was carried out by ground surveys aided by Aster image interpretation. Drilling campaigns conducted on grid pattern by the MAL since 2009 have built up robust exploration database captured from 153 (104 cored & 49 open) boreholes with a cumulative meterage of 40,014 m supported by multi probe down-the-hole geophysical logging in 110 holes and coal assay and coking coal tests. It included 17 numbers of open holes drilled 2022 to test the up dip continuation of the coal seams. Core to open hole ratio is 70:30.

COAL QUALITY

- The MAL had conducted coal analytical tests including proximate analysis and coking coal tests on 14,137 samples in accredited laboratories of South Africa, India and Mozambique. Samples are classified on visual basis as coal, shaly coal, carb shale and shale plies. These are reconciled on ash percentages after lab analysis as coal- up to 45%; shaly coal=55%, carbonaceous shale- 65to 75% ash and Dirt >75% ash.

Raw Coal Quality:

- Coal is of bituminous-B type. Raw Coal (coal/shaly coal) quality characterization based on statistical analysis of core bores at deposit level shows the following values on adb. RD=1.7; Mo= 1.66%; Ash = 45 %; VM= 23. % = FC: 30%, GCV= 4825 kcal/kg; CSN= 0-3; AFT= 1200-1500oC; HGI=65 S = 1+ 0.2%; P= 0.03%; Cl= 0.01%.Composite coal samples excavated from pilot mine has been separately analyzed at CMPDI and SAIL labs, India. It shows on adb: - Moist, 1.6; Ash, 25%; VM=27%, FC= 46%. GCV=5200-5500Kcal/kg (cal).

Coking Coal Profile:

- CSN/FSI was conducted on all raw coal samples. Comprehensive Coking coal tests have been conducted on the whole seam level composite samples. Coking coal profile @ 10% coal ash recovered during float-sink tests shows on adb as follows:- Moist= 2%; Ash= 10% ; CSN = 9 ; GK= G6–G8 ; Vitrinite= ~80% Total Inerts = 16- 18%; VM= 31% ; FC= 61% ; MMR= 0.98; CSR= 54 (61 max);Fluidity = 1455 ddpm ; phosphorous : <0.03%, Sulfur: 1.0+/-0.2. Vitrinoid profile (coal petrography) shows V9, V10, V11 & and V12 together amounting to 71%. RoMax of coking coal is 0.98. Metallurgical coal testing by high temperature carbonation (HTC) has shown 67% coke yield@0.9 density.

Thermal Coal Profile:

- Coal quality tests at various ash levels have revealed a decline in swelling property as well as fluidity with increase in ash content. It is observed that the coal is suitable for burning in boilers at or above 21% ash and is also suitable as a sweet blend to low ash, high moisture Indonesian coals. Exportable thermal coal specifications are (on adb) Moist: 1.3%, Ash: 21-25%, VM: 27%, FC: 51% and GCV: ~6000Kcal; whereas at 28% ash levels, the GCV is ts to ~5800 Kcal. The Midwest thermal coal is compared with the RB1-RB3 (Richards's Bay) export thermal coal of South African standards.

GEOLOGICAL MODEL

- The Midwest geological model for coal deposit has focused on seam continuity, physical continuity and grade continuity both along strike and dip and fault modeling for mining purposes.

COAL RESOURCE

- Resource has been estimated at 55% ash cut-off. Input csv files were developed for computing resource estimates on MINEX software. At the entire property level toal In-situ resources (GTIS) : 5367 MMT after allowing discounts for GLp and GLm the TTIS works out to be 4294 MMT. Say 4.3 Billion tons. From this,the JORC coal reserves are defined as shown below.

Total In-situ Coal Resources in 5086C

NEW			Area
Total Area in Million Tons (5086C) EFS		Old(PFS)	Ha
MEASURED	868	381	1436.33
INDICATED	1942	1839	2610.55
INFERRED	2557	1975	3861.19
Total	5367(GTIS) 4294(TTIS)	4195(TTIS)	

Categorization of Resources:

- Coal Resources are categorised in to three types of confidence levels based on borehole density i.e. spacing of the boreholes i.e. 500m interval for Measured ; 1000m for indicated and >1000m for inferred category . Please see the following table. JORC Resorcs in coal. Mining Block-A & B = 868(Measured) + 1942(Indicated)= 2810 (Demonstrated).

RESERVES

Mine Layout and Mining Method for Coal Reserves:

- Mining method is of open cast type, hybrid- dumper-shovel for OB removal and surface miner for coal extraction.Workable mining depth is 300 m with a maximum stripping ratio of <1:4 and ash cut off of 55% and a minimum mining height of 0.2m by using surface miner. MGPL has estimated the coal reserves from the resources in a sequential manner from mine layout as per the procedures outlined in SANS 10320:2004. It includes the following steps.
- Delineation of mine out lay area involves the; 1) Estimation of GTIS coal reserves; 2) Estimation of Mine lay out loss; 3) Estimation of GTIS coal reserves at theoretical mining height; 4) Determination of dilution percentage & contaminants; 5) Estimation of GTIS reserves as per practical bench height adopted; 6) Extractable coal reserves. Mine lay out area is 12.62 sq.km. Mine elongation is about 6km and progression width is 2.2km, mine lay out area is oriented in NW-SE along formation strike.
- This mine layout area contains an extractable coal reserves of 714MMT and has been designated as PIT-I. For planning purpose, the mine lay out area has been sub-divided into five mining modules namely Mb-A, Mb-B1, Mb-B2, Mb-B3 and Mb-B4. Detailed mine plan is prepared for Mining Block Mb-A which is subdivided in to west and East blocks.
- Synthesis of washability curves developed during the study has revealed two types of saleable coal products i.e. metallurgical coal and thermal coal whose theoretical coal

yield has been estimated 20% and 15-18% respectively. The in-situ saleable coal product tonnages have been estimated at 142 MMT of metallurgical coal and 128MMT of thermal coal whose extraction is found economical at the time of reporting.

Uptrend:

- The reserves of 714 MMT pertains to the explored area (marked as A &B). The area marked as ‘C’ need further exploration which on completion is likely to contribute another 300 MMT of shallow coal which is likely to take up the coal reserves to the tune of One Billion ton.

Geotechnical Studies:

- Geotechnical studies have been conducted to a reasonable level of adequacy to support conceptual mine plan and mining methods including pit slope angle and stability They include determination of soil cover & weathered zone thickness, water table level, Rock property studies, RQD determinations compressive strength and shear strength determinations of roof and floor rocks as well as coal. Sonic logs of mine lay out area have been studied to determine various geotechnical attributes. Outcome of geotechnical studies presented in this report.

Mine Operation Model & Cost Estimates:

- The License holder is having long experience and high level of expertise in open cast mining and is capable of taking up the mining operations by itself which will result in substantial savings. However, for the purpose of all financial computations, operations by contractor and the resultant costs have been used.
- The MAL has proposed contractor model of operation. The role of contractor is removal of soil cover, OB and to mine coaland its delivery at CHPP. A provisional negotiated price is 5$ per BCM..
- Nevertheless, MGPL made its own independent cost estimates on mining. The cost estimate is based on estimates received from Suppliers, Consultants, and Machinery manufacturers. The cost estimate is considered reasonable accurate to within +/- 10-15% at the summary level and is expressed in US dollars.

Capital Cost of Machinery:

- The capital cost of machinery is estimated on price quotation for 3 Million tons is 20 Million USD and 6 Million tons is 34 Million USD.

Operating Cost of Mining:

- The operating cost is the cost of running the mine; items which are included in the model are based on contract pricing.
- Cost per ton of ROM is 14.8 USD say 15$: washing cost per ton of ROM is 4 USD.
- Product cost per ton at mine per ton is 53.8 USD: Transportation cost per ton is 48.7 USD.
- Total Operating cost is perceived at FOB = 102.5 USD.

COAL PREPARATION

Targeted Coal Products:

- The targeted saleable coal products include (1)Hard Coking Coal at 10% ash for export, (2) export thermal coal at 25% ash with 6000 kcal/kg for export or for use in steel and local cement plants.

Theoretical Coal Yields:

- Size fraction analysis and coal liberation potential are presented. Washability curves have been developed. RD of separation has been presented. Instantaneous ash curve and density curves of +/-0.1% have been developed to identify 'ease of washing' whose results have indicated that this type of coal is 'difficult' to wash. A theoretical product yield at 47% ROM ash works out to be 20% metallurgical coal and 15-18 % thermal coal.The Midwest has conducted float sink analysis collected for samples from exploratory core bores, large dia boreholes and bulk sample from Trail pit. Laboratory level float-Sink analysis have formed base for coal preparation and processing plant flow sheet preparation.
- Detailed note on Float-Sink analysis and derivative graphs are presented in the report.
- Cost Estimation for CHPP is 39 Million Dollars for Coal preparation plant.

INFRASTRUCTURE

- MGPL has reviewed existing infrastructure facilities at 5086C project site and conducted assessment of further facilities required for ensuring smooth functioning of mining activities and evacuation of coal. Summary of cost estimates derived from enquiries with the Paramount Pvt limited (Brodge) and ANE (Road)–Government of Mozambique are furnished below.

Summary of Cost estimates: Road Bridge, Camp,Culverts

Sl No.	Description	Amount in USD
1	Bridge @ Nkondezi	943190
2	Road Work	948649
3	Pipes Culverts - 900 MM DIA / BOX CULVERT - 2.5MX2.5MX1.7M	210153
4	Camp	1151000
5	Preliminary & General Expenses	455428
	SUBTOTAL	3708420
	IVA (17%)	630431
	GRAND TOTAL - USD	4338851

Say 4.4 Million USD

Details of Water, Power, Haul Roads, Coal hauling and rail loading is given in the report.

ECONOMIC ANALYSIS

Market study analysis is presented.

Saleable coal product specifications:

Saleable Coal products from 5086C property are two types

1) Coking coal and 2) Thermal coal

Coking coal:

Coking coal produced from Moatize coal basin has been a part of sea borne trade since 2011. It has been indexed as Chipanga and Moatize brands, the source for both being the coal from Chipanga seam.

Price Realization:

Australian coking coal prices averaged USD 301 per metric ton in September, up 18.6% from August’s 2023 price and 13.0% higher year on year.

Realizable Prices for Metallurgical Coal

Particulars	Price/Discount	Remarks
Current Price	301 $ per ton	HCC-64, US High Vol-A. reference
Quality adjustment at market	30 $ per ton	Index reference price due to different product characteristics as well as value in use adjustments which may have a negative affect (10%)
Other adjustments like sales, penalties	5 $ per ton	3%
FOB Realized price	266$ per ton	

CP has envisioned a price realization for Midwest metallurgical coal on f.o.b basis to be in the range of 250-280 $ at the time of reporting.

However, economic assessment has been computed at 266 $..

Thermal coal specifications:

Thermal coal specifications and pricing in Southern Africa are governed by Richards Bay index. Penalties are imposed for high ash and low thermal heat value.

A comparative statement of MAL Thermal coal with RB1 and RB3 bench mark coals is shown below.

Comparative statement of Richard bay bench mark coals and MAL coal specifications

Specifications	RB1	RB3	MAL
Calorific Value Basis (kcal/kg NCV)	6,000	5,500	6,000
Calorific Value Min (kcal/kg NCV)	5,850	5,300	5,980
Total Moisture (ARB)	12% max	14.0% max	2.0%(adb)
Volatile Matter (ARB)	22% Min	20.0% min	28.0%(adb)
Ash (ARB)	15.0% Max	23.0% max	23-25(adb)
Sulphur (ARB)	1.0% Max	1.0% max	1.0%(ADB)
Hardgrove Grindability Index (HGI)	45-70	45 – 70	54-68%
Nominal Top size	50mm	50 mm	50mm
IDT	Min 1,250 °C in reducing atmosphere	Min 1,150 °C in reducing atmosphere	1500°C In reducing atmosphere
Calcium Oxide in Ash (DB)	1.2% max		0.9-1.2%

MAL= Midwest Africa Limitada, Mozambique, RB= Richard Bay

Thermal coal price realization on f.o.b basis:

Price realization of Thermal coal

Particulars	Price/Discount	Remarks
Current Price	110 $ per ton	Thermal coal
Quality adjustment	12 $ per ton	Index reference price due to different product characteristics as well as value in use adjustments associated with ash content, which has a negatively affect (15%)
Other adjustments l	2 $ per ton	3%
Realizable price FOB	96 $ per ton	

MARKETING STRATEGY

Midwest shall adopt a mixed strategy of sale of coal through long term supply contract as well as partly through spot sales. Midwest will strive for least cost delivery of products to ensure continued viability / profitability of the project. However, the MAL has been advised to engage marketing agency in the light of large in-situ coal product tonnages identified in 5086C license. A review of global coal outlook, Mozambique scenario and constraints are documented in the report.

SUMMARY OF COST ESTIMATES

Capital expenditure is the money spent on project development; mine site infrastructure development, coal processing plant (washery) and contractor advance for mining. Coal processing plant shell be developed in modular basis there will be 5 modules, each with a capacity of 6 Mtpa.

Capital Cost (CAPEX):

The capital cost for 3 Mtpa for First year and ramp up to 30 Mtpa ROM coal productions which is segmented into different modules (Mines) developed in a sequential manner to achieve the desired targets and objectives. Capital and operational cost estimates are presented below.

Capital Costs (in USD Million)		Initial Capital for 3 MTPA (2024)	Total Capital cost over life of Mine (30 MTPA)
	Mine Equipment - Advance	5.0	5.0
	Washery equipment	33.9	335.6
	Mine Infrastructure & Development	6.3	31.3
	Contingency (5%)	2.3	18.6
	Working capital margin	0.7	0.7
	Total Capital Cost	48.1	391.3

Operating Cost (OPEX):

The operating cost is the cost of running the mine; items included in the model are.

Coal Mining price to contactor	$13.2 per ton of ROM
Washing/Processing (USD/t RoM)	$4 per ton of ROM
Coal Transport& port handling charges	$48.7 per ton of FOB product
Management & Support Expenses	$0.5 per ton of ROM
Mine closure	$0.5 per ton of ROM
Environment Related Costs	$0.4 per ton of ROM
CSR	1% of capital expenditure

Product Cost Estimate Per ton of Saleable coal Product

Operating costs	**US$/ROM ton**
Mining Costs (Strip ratio of 1:2.5)	13.2
Management & Support Expenses	0.5
Average mine closure cost per tone	0.5
Environment Related Costs	0.4
CSR	0.1
Cost per ton of ROM	14.7
Washing cost per ton of ROM	4.0
Mining + Washing cost per ton of ROM	18.7
	US$/Product t
Cost per ton of Saleable Coal Product	49.3
Royalty (3% Ex mine revenue)	4.1
Total Cost per ton of product	53.4
Transport Costs	US$/Product t
Road Transport to Rail sliding	4.2
Rail transport to Port cost	35.0
Port Charges	9.5
Export product transport cost	48.7
	US$/Product t
Total Operating cost at FOB	102.1

Assumptions and basis for cost estimates are described in the report.

Financial Model:

Midwest has prepared a financial model, incorporating technical and cost input parameters which have been derived from the current level of technical studies.

The following is deemed to be appropriate for the current level of economic assessment.

- Discount Rate: 10%

The model is prepared for 21 years including ramp up period of nine years to achieve 30 Mtpa scale of full production. In this process we can mine out only 327 MMT of ROM coal. Coal production which is expected to yield saleable coal product of 65.4 MMT of metallurgical coal and 58.9 MMT of thermal coal in 21 years. It translates into saleable coal of 6mtpa metallurgical type and 5.4 Mtpa thermal coal per year at peak production. Price realization at FOB is 266$ for metallurgical coal and 96$ for thermal coal taking into consideration of coal cyclical and present market value (details are provided in section on market analysis).

The Financial Model has been prepared on Microsoft Excel.

Periodicity is presented in the model on annualized basis.

Financial Model is presented in US Dollars.

The corporate income tax rate assumed is 32%. Midwest is aware that various tax related benefits may exist and/or to be negotiated. However, in the absence of better defined terms, these benefits (corporate income tax rate and the depreciation allowances etc.) are not incorporated in the model.

Input Parameters:

The technical input parameters and commodity prices driving the revenue stream primarily consist of the following:

- The coal products are saleable in the current overseas market.

The operating cost input parameters impacting the revenue stream include:-

Mining costs of ROM coal; Washing cost of coal; Transport and port handling charges; Administration and miscellaneous cost; Mine closer cost.

Financial model detailed has been prepared and illustrated in the report.

Internal Rate of Return (IRR):

NPV	US$m	1795
IRR	%	115.1%

Sensitive Analysis (NPV):

The forecasted cash flows depend on the expected revenue and costs.

NPV (million USD)

		Operating cost		
Revenue /Sales	% of Change	10% increase	No Change	10% decrease
	20% increase	2784	3160	3536
	10% increase	2102	2478	2853
	No Change	1419	1795	2171
	10% decrease	736	1112	1488
	20 % decrease	54	430	805

ENVIRONMENTAL STUDIES & COMMUNITY CONSULTATIONS

MAL has commissioned GMSC Lda, a consulting company recognized by Government of Mozambique to prepare an Environmental Impact Assessment Report and Environmental Management Plan. The work involves two phases of study 1) EPDA 2) EIA.

In partial fulfillment of environmental licensing mandate, the GMSC Lda has conducted EPDA (Pre-environmental feasibility and definition of scope) study along with community consultation and a detailed report was submitted to MICOA (Ministry for the co-ordination of environmental action) for approval.

EPDA: The EPDA report has been prepared for the proposed coal mining operation and CHPP activity. The report thus prepared and submitted has been approved by MICOA, who has approved the report to proceed for stage-2 i.e. EIA study. Agreement between MAL and GMSC Lda is in force to complete the EIA study.

EIA: Procedures and practices envisaged in next level of EIA have been defined.

CSR Activities:

The MAL has undertaken CSR activities in consultation with the Mozambique government.

Social Acceptance:

There is no human habitation in the vicinity of the proposed mining project or within (AID) five-kilometer radius. However, there are few habitations within ten-kilometer radius (AII). People living in those habitations have been appraised about the proposed coal mining activities. The CP has participated in community consultation meetings and found that the social acceptance of the mining project is very positive.

Risk Analysis: Overall, Risk rating of the Project is Low to Medium. Item-wise risk assessment is presented in the report.

INTERPRETATIONS & CONCLUSIONS

Based on the outcome of the present Economic Feasibility Study, the MGPL has arrived at the following interpretations and conclusions

The coking coal mining project 5086 C is economically viable. For,

RECOMMENDATIONS

- The MAL may proceed to obtain public /private funding to move further on Engineering drawings and start mining operation.
- Working mine plan is immediate need of the hour.
- Coal processing and CHPP flow sheet may be developed by reputed Consulting Company like Minopex etc. Construction activity for CHPP may be started
- Infrastructure up gradation and bridge construction need immediate attention.

Coal transport and handling: Negotiations with the coal transport authorities like VALE and CFM of Mozambique as well may be continued for securing the capacity and to determine coal transport and handling costs.

Marketing Strategy: A suitable agency may be engaged to work out effective marketing strategies including the identification of potential customers, market linkages for better price realization.

Permits, Licenses and CSR activities:

- The MAL should ensure renewal of existing permits on hiring of Manpower, water, Land use, power utilities etc.
- GMSC should speed up approval of Environment Management plan (EMP) from MICOA and obtain license to operate.
- Health, Safety Environment and social license shall be maintained.
- CSR activities may be planned as per the latest guidelines issued by the Government of Mozambique.

PART--I

1 INTRODUCTION

1.1 PURPOSE

The technical report on Economic Feasibility study of coal Reserves deals with Mining, Metallurgical (coal preparation), Marketing, Economical, environmental aspects, risk & sensitive assessment. This report is an extension of the Pre-feasibility study of Coal reserves released in 2018.It has taken into account of the subsequent In-fill drilling undertaken, Trail pit (Pilot Pit) excavated during 2022 and follow-up laboratory/technical studies. Besides it has taken into account the changing coal market scenario to formulate financial model. Accordingly, The MGPL exploration & Mining synthesized relevant information and prepared this technical report on ‘**Economic Feasibility study of Coal reserves’** in 5086C as on 31st August 2024.

TERMS OF REFERENCE & SCOPE OF WORK

The Terms of Reference include

- Review and update of Geological model, Coal quality and Resource estimates, mine outlay and attendant Reserve estimation conducted up to end of 2023.The data generated in infill boreholes has been integrated with the pre-feasibility geological model.
- Evaluation of options on opencast mining methods based on the experience of Trail pit (Pilot Pit) to arrive at cost-effective viable mining method relevant to mineralization pattern in the MAL property.
- Prepare a reserve statement for the portion of resources which are mineable and economically viable.
- Develop conceptual Mine plan covering Pit outlay, operating procedures which include scheduling, machinery planning, mine lay out, mine facility systems i.e., man power requirements and a proposal for mine closure plan and to prepare cost estimation. This report deals with the mine plan of four sq.km that focuses 3 million tonnes of ROM coal production to begin with, to be extendable to 12.62 sq.km mine lay out area to realize the 30 MMT (ROM) coal productions in the peak production stage in due course.
- Refinement of coal processing methods including coal crushing pattern and liberation(float-sink data)so as to evolve functional flow sheet for CHPP(Coal Handling and Processing Plant) and cost estimates.
- Planning on mine site infrastructure including water, power, ware houses, workshops, and administrative units and to evolve suitable models. Availability of labor and review of labor laws in mining sector.
- Mode of coal transportation, Negotiations with service providers. Coals marketing on coking coal thermal coal aspects are aptly pursued.

- Review of Environmental Impact Assessment study, Community consultations, Environmental Management Plan to ensure Health, Safety &Environment of local communities.
- Prepare capital costs (CAPEX) and operating costs (OPEX) estimates for the life of mine as well as CHPP plant and other supporting systems.
- Develop financial model including DCF and sensitivities.
- Conduct Risk analysis
- To highlight areas that requires further refinement/fortification in the next level of engineering study.

1.2 SOURCES OF INFORMATION

Prime source of information for the present technical report being the Exploration data generated since the beginning (i.e. 2010) and stored in digital format in the MAL data room. The Competent Person (CP) has taken cognizance of progress reports issued from time to time and audited technical reports viz.1) Resource report issued by Geos Mining, Australia in 2011, 2) the scoping study report prepared by Ms. Behre Dolbear, USA, in 2012 3) G2 level resource report validated by PC Meyer consulting of South Africa (see references) in 2014) Time to time annual reports submitted by Midwest Africa Limitada to INAMI of the Mozambique government up to December 2023.

The MGPL Mining team conducted field study in operating coal mines in India viz. SCCL(Singareni Coal Mines Company Limited), in Mozambique such as ICVL(Indian Coal Ventures Limited), JSPL Mines (Jindal Steel and Power limited) with a view to assessing efficiency of various types of mine operational procedures relevant to southern Africa.

Held detailed discussions with contract mining companies' i.e. BGR mining, Sushee Mining &Infra (India) and Equestra (South Africa), ALUMER-Prestacao de Servicos Lda, Tete Information and quotations provided by them have been evaluated. All of them have adequate experience on coal mining in Mozambique and India.

Messers Abhik Mukhopadhyay coal preparation consultant and T.Gouri Charan, principal coal processing scientist of CIMFR (Central Institute of Mining and Fuel Research) provided valuable inputs on coal washability as well as conceptual CHPP flow sheet and other relevant aspects.

The MAL has built up a reasonable infrastructure at its project site. The MAL's past experience and information and quotations gathered from its service providers form source of information on the concerned subject. They are PARAMOUNT ENHARIA LDA (Bridge), ANE (National Authority of Roads), CFM (Railways), and EDM (Electrical)

Report on EIA & EMP. by GMSC consultants, Maputo has been considered. Progress of DUAT has been reviewed.

Contemporaneous market trends and price fluctuations available in open source files form source for projection of coal price trends and a source for market study.

SANS 10320: 2004; AusImm Monographs 23 - Guide on to Good practice to Reserve Estimation and Guidelines on JORC code -2012 have guided the present report preparation.

1.3 CP SITE VISITS AND RELEVANT EXPERIENCE

The CP and his team had conducted several site visits between 2009 to2022 and have been familiar with the *modus operandi* of exploration activities in 5086C (old license number 1151) tenement. Mining operations of VALE, ICVL, JSPL and Minas Moatize have been visited to substantiate the efficacy of Mining operations. Coal processing facilities of ICVL, JSPL have been visited. Examined coal yards at Beria Port. Coal loading facility is identified at Mpassi village for loading coal by rail to Beria port. The loading facility is located at 10km from the Mpassi village. The CP and his team have exercised considerable skill and diligence to conduct comprehensive assessment of the coal project during site inspection visits.

1.4 PROPERTY OWNERSHIP&RIGHTS

The license 5086C and the project is owned and operated exclusively by the Midwest Africa Limitada, Mozambique with its registered office located at AV 25 de Setembro No. 1230, 3Andhar, Maputo, Mozambique.

The major shareholders of Midwest Africa Limitada are

Midwest Africa Limitada – 91%

Shapoorji Pallonji – 8%

Others – 1%

The Mining License, title deed has been issued in the name of Mr. Kollareddy Ramachandra, Mandatario (authorized person). He is also the CEO of the project.

The Mining contract has been executed between the Government of Mozambique and the MAL. It confers exclusive right of land use, coal mining and export subject to clauses mentioned in the contract. The project is not yet listed on any stock exchange and is continuing as a private limited enterprise. The Mining License was issued on **01 October 2013**and is valid until **01 October 2038**.A copy of the Mining License document is shown in Annex-I.

1.5 PROJECT LOCATION

Boundary coordinate points for 5086C tenement include Lat. 15° 42’ 00’’ to 15° 48’ 00’’ S and Long. 33° 47’ 45’’to 33° 56’ 00’’E. Total area covered under the mining project is 15,840 ha. It is located about 60km northeast of Tete, capital city of the province of the same name (Fig.1-1). Nearby coal mining projects in Moatize coal basin belong to VALE (867C), Rio Tinto, now ICVL (3365C) and Minas Moatize (1163C) (Fig.1-1). Other coal mining project in Tete province belongs to JSPL at Songo, located west of Zambezi River.

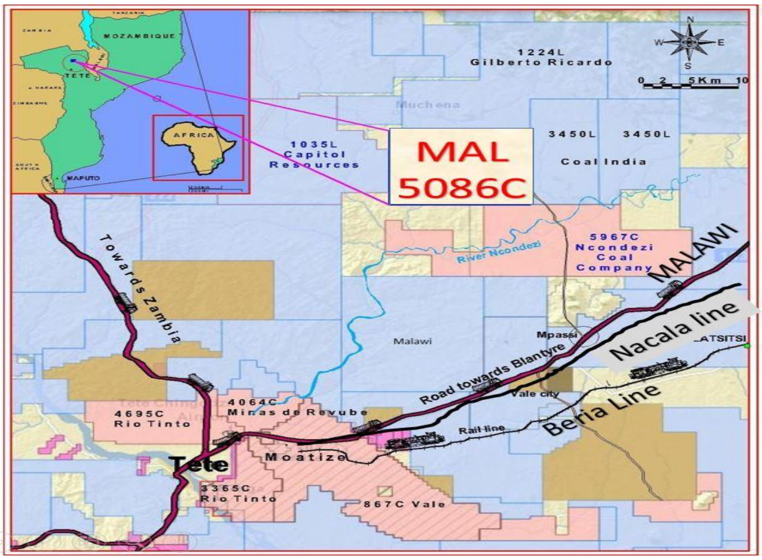


Fig. 1-1: Location Map Of 5086C Coal Project in Moatize coalfield

1.6 CONNECTIVITY & TRANSPORT SYSTEMS

Road connectivity to the5086C project area is through the Tete-Zobue-Malawi Highway No.103 which passes through a coal mining town by name Moatize at a distance of ~15km east of Tete. Moving another 30km east along the same highway, there is a hamlet named Mpassi (S15°57’41’’ and E 34°0’12.01”) from where a 23km long un-metaled but all season motorable road runs in northerly direction which leads to 5086C tenement, after crossing Nkondezi River (Fig.1-2). This road supports round the year movement of 45-ton long haul trucks. Out of 17 km, a stretch of 14kms road between Mpassi and the Nkondezi River was strengthened by Ncondezi Coal Company Limited (NCCL) to facilitate the movement of their coal mining machinery and their thermal plant equipment in 2014.This road now needs refurbishment. The MAL has natural access to this road. Road distance between Ncondezi River to the 5086C MAL property is about 6 km. which needs further strengthening. Vehicle movement across the Nkondezi River is restricted during rainy season i.e. December to March. To overcome this connectivity constraint, a cause way/bridge has been planned across the Nkondezi River, whose cost is estimated to be around 1.2million USD.

1.6.1 Air Transport:

The nearest airport to 5086C project is Tete international airport situated at 11km north-east of Tete, which provides daily flights Maputo, Beira and Quelimane The LAM airlines of Mozambique and Air link of South Africa provide international connecting flights to Johannesburg, Nairobi, Addis Ababa and Lisbon. The distance between the Tete airport and 5086C tenement is about 50km by road and the traveling time is approximately one and half hour.

1.6.2 Rail Transport:

Moatize is the nearest railway terminal to the Moatize coalfield. Rail line between Moatize and Beira Pori is called Sena rail line. The rail line between Moatize and Nacal port is known as the Nacala rail line the 5086C tenement has an advantage of reasonable connectivity to multiple rail transport lines i.e. currently operating Nacala and Sena lines as well as the proposed Macuse line (Fig.1-2). Road distance between the coal mine and the nearest point on Nacala rail line is at Mpassi village i.e. ~23.5 km to the Mine site.

Coal loading on the Sena railway line is 10 km south of Mpassi village (Fig.1-2). The sena railway line connects the coal mining town of Moatize with the port of Beira at a distance of 570km. The railway line was refurbished for transporting coal from Moatize to Beira Port in 2010. The southwest railway terminal is Moatize located at a distance of about 45km.It is the railway terminal on sena line. Cambuletsitsi is the historic rail loading point developed during the Portuguese time and distance to it is 34km to southeast of 5086C project area.

Sena railway line is meant to transport coal from Moatize coalfields to Beira port for onward shipping to overseas destinations. Rated haulage capacity of rail line is in the range of 10 mtpa. VALE had started coal export through this line in 2011 and Rio Tinto in 2012.As per records, actual coal transported by three coal producing companies viz VALE, Rio Tinto (now ICVL) and Beacon Hill resources on this line amounted to ~ 3mtpa since 2012. Coal mining companies have their own railway rolling stocks. All the coal mining companies except VALE have discontinued coal mining and transportation during 2015 to 2017 due to nose diving of coal prices in international markets and also for other reasons. This sena railway line is dogged insurgency problems in certain sectors affecting the coal movement.

Nevertheless, the VALE continued coal mining and transportation but switched over to its own Nacala line in 2016 on cheaper transport costs and better loading facilities. In its 2017 annual statement, Vale announced significant reduction in transport costs and port handling by using Nacala line; distance between 5086C to Nacala port is ~ 1030km. At the time of writing this report, coal transport and port handling charges together are tentatively indicated to be 40$/ton. MGPL examined rail transport options and recommended MAL to start engagement with the VALE consortium to utilize the Nacala coal transport facility.

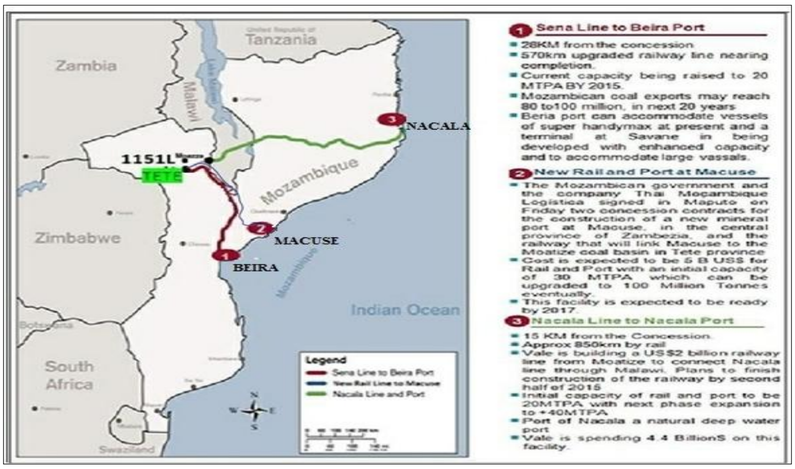


Fig. 1-2: Rail and Port Connectivity to Midwest Coal Mining Project, 5086C. The 1151L is the old number of 5086C

1.6.3 Ports:

Beira: Coal produced from the Moatize coalfield had been exported through the Beira port until 2014.Moatize and Cambuletsi are historic rail loading points. The distance between Moatize and Cambuletsitsi to Beira port is around 570 and 540km respectively. The CP had visited Beira port and found that it could handle cargo on Minimax size vessels only. Plans are afoot to load Panamax size vessels at a specified offshore loading point. Coal transported by rail is stocked in designated yards before loading into ships by using conveyor belt system. Regular docking of ships is restricted at the port due to dredging constraints.

Nacala: It is a natural deep-water port capable of handling 'cape size' vessels. The distance between Moatize and Nacala is about 1030km. The Brazilian mining company Vale-Matsui consortium remained to be a major stake holder with 1.6 billion USD investments in the newly constructed Nacala – Moatize rail system as well as coal handling facilities at the port. The targeted coal transport capacity through Nacala–Moatize corridor is 20 MTPA; it can handle cape size vessels.

Macuse: In order to meet the increasing demand for material transport, another port at Macuse (Fig.1-2) with a connecting link to Moatize are under construction by a consortium led by Thai operator. The project was expected to be completed by 2021, however, construction work is still going on. The Mozambique Government is committed to provide cheap transport for Moatize basin coal and expects that the transport and port handling to be ~ 30 $/ton.

1.7 TELECOMMUNICATION

Mozambique is rapidly catching up with the fast-growing wireless telecommunication needs of modern economies. The Tete province is covered by mobile services operators' viz. Mcel and Vodacom. High speed broadband internet, 4G/5G is of the order of the day in the Tete-Moatize area. Mobile and internet facilities can be accessed directly from the Midwest project area as well through satellite phone operated by Vodacom receiver.

1.8 PROJECT INFRASTRUCTURE, PERMITS/LICENCES

The MGPL has reviewed existing infrastructure facilities at MAL property. A separate chapter on Infrastructure has been provisioned in this report (see Part-II/III of this report).

2 GEOLOGY

2.1 REGIONAL GEOLOGY

The Permian Karoo coal basins are developed along the Zambezi rift Valley in Mozambique. It is over 400km long and cuts across the Zambezi mobile belt. The latter is a tectonic join of the Precambrian ancestry developed along interface between the Zambian and Zimbabwe cartons. The Zambezi rift basin had witnessed multiple pulses of volcanic eruptions punctuating the Permo-Triassic and Jurassic terrestrial sedimentation.

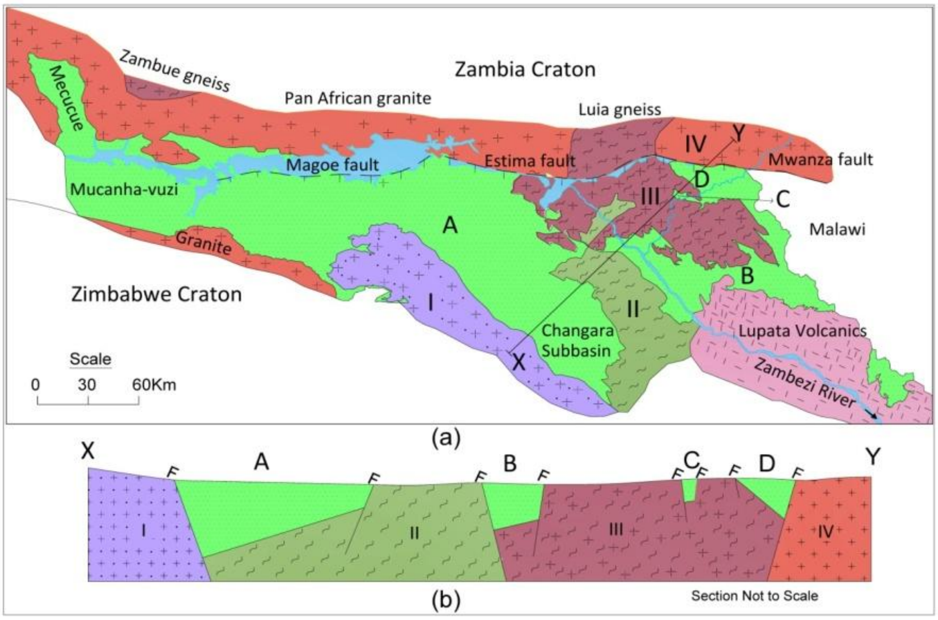


Fig. 2-1: a. Outline map showing tectonic setting of Karoo Basin along Zambezi valley in Mozambique. and b) Schematic geological cross section along X–Y. A: Sanangoe–Changara–Mefidezesub-basin, B: Moatize–Minjova sub basin, C: Nkondezisub basin, and D: Mecondezi

The Karoo coal basin inversion had occurred in early Cretaceous as a cause and effect of basement reactivation and faulting- a corollary to Gondwanaland break-up. The Rishinga, Barue and Tete ridges were uplifted. An otherwise continuous stretch of the Zambezi valley Karoo coal basin had been dissected by faults resulting in the development of horst and graben blocks. Coal bearing Karoo sediments are now preserved in down thrown(graben) blocks viz. Mecucue, Mucanha-Vuzi, Chicoa, Mafidezi, Sanangoe, Changara, Moatize-Minjova and Mecondezi which are now disposed in an enechelon pattern. The 5086Ctenement forms northern part of the Mecondezi sub-basin, which is a tectonic half graben of the Zambezi rift (Fig.2-1). Interlinked grabens viz. Moatize-Minjova and Mecondezi sub basins located east of the Zambezi River and form continuous stretch representing the Moatize coal basin. The 5086C coal deposit forms part of the Mecondezi Sub-basin.

2.2 GEOLOGY OF PROJECT AREA

Out crops of the Karoo sedimentary rocks are sporadically distributed in project area. Yet, the geological succession has been carved out mainly on the coal drilling data. Sediment fill in the basin is about a kilometer thick and has been classified in ascending order into Vuzi, Moatize and Matinde Formations.

Geological map of the project area and stratigraphic succession are shown in (Fig.2-2a &b). A brief description of various stratigraphic units follows.

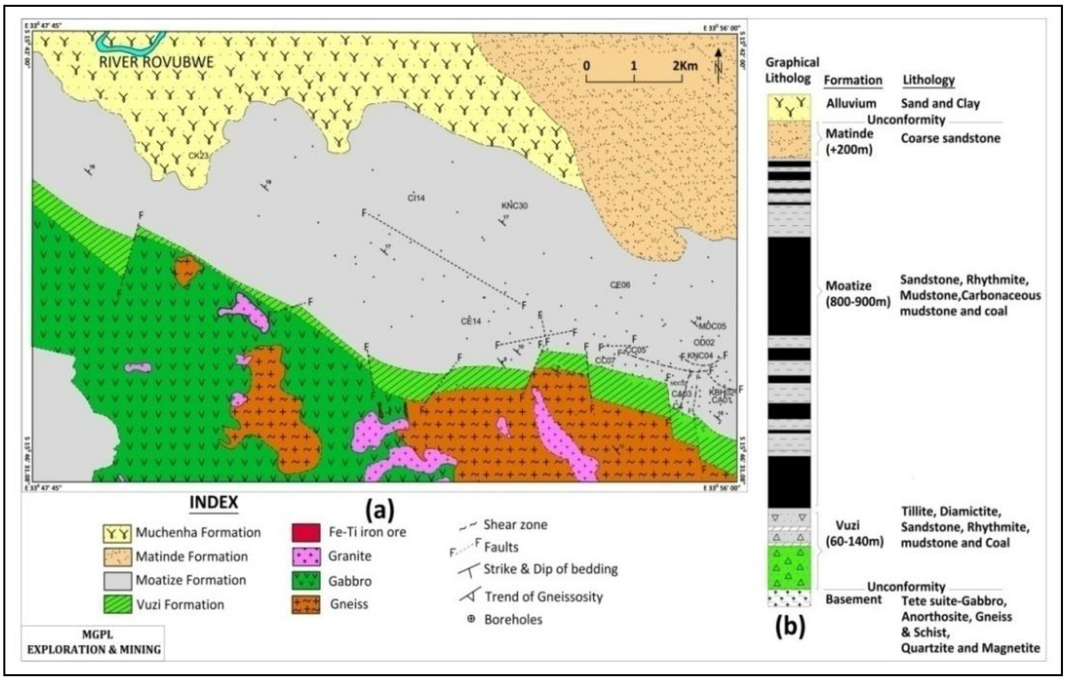


Fig. 2-2: a) Geological map and b) stratigraphic succession in Mecondezi sub basin. Dots in Moatize Formation indicate drilled borehole locations.

Basement: The Proterozoic Tete suite consists of an ensemble of gabbro, anorthosite, quartz-feldspathic augen gneiss, quartz veins and titaniferous magnetite veins constitute basement to the Karoo sediments. Iron ore vein patters and their chemical attributes are presented in Annexure-II

Karoo Sediments: The argillite dominated Karoo sediments the basement. The contact between the basement and the Karoo basin is faulted with varying amount of throw towards north. The fault bounding the basement and the basin is oriented NW-SE. It is transected by transverse faults whose dispacent pattern has impared horst and graben structures (Fig. 2-2 a)

The oldest basin sediments are designated as the Vuzi Formation. It consists of tillite, diamictite, rhythmite, mudstone and coal. Thickness of the Vuzi Formation ranges from 50 to over 120m. Tillite and diamictite are prominent in lower, whereas diamictite interbedded with the coal and carbonaceous mudstone beds are prominent in the upper horizons.

The coal bearing argillite dominated succession that succeeds the Vuzi Formation along a gradational contact is termed as the Moatize Formation. Thickness of the Moatize Formation increases from <70m along basin margin to over 900m in the central part and abuts against a major basin marginal in the north. Besides coal and carbonaceous mudstone, other rock units present in this Formation are rhythmite, siltstone, mudstone and sandstone. There are multiple Coal seamsin the Moatize Formation (Fig. 2-2 b). Thickness of the coal bearing formation recorded in exploratory boreholes is over 700 m. Maximum thickness contemplated is over 900m. Topographic configuration is gently undulating plains.

Thick bedded sandstone of Triassic Matinde Formation is exposed along the WNW-ESE oriented mounds inthe north-eastern quadrant of5086C (Fig.2-2 a). This Formation is devoid of coal.

A 5 to 20m thick semi consolidated Quaternary sand, gravel sand and salty sand constitutes the Muchena Formation. It occurs in Rivube River terraces and also as one to two-meter-thick carpet over the Karoo sediments

2.3 GEOMORPHOLOGY AND DRAINAGE

Topographic expression of 5086C area is gently undulating plain with a gradient of <10° towards south. About 4km away from the northern boundary of the tenement lie the Precambrian Chiriza hills, along whose foot hills an easterly flowing Rivube River tributary marks a topographic break defining the northern limit of the Karoo basin. Whereas in southern shoulder, a low elevated terrain of Precambrian Tete Suite of crystalline rocks constitutes basement to the coal basin. Most of the Karoo basin area is covered by 2 to 6 m thick Quaternary/alluvium. Sporadic occurrence of karoo sediments is present here and there.

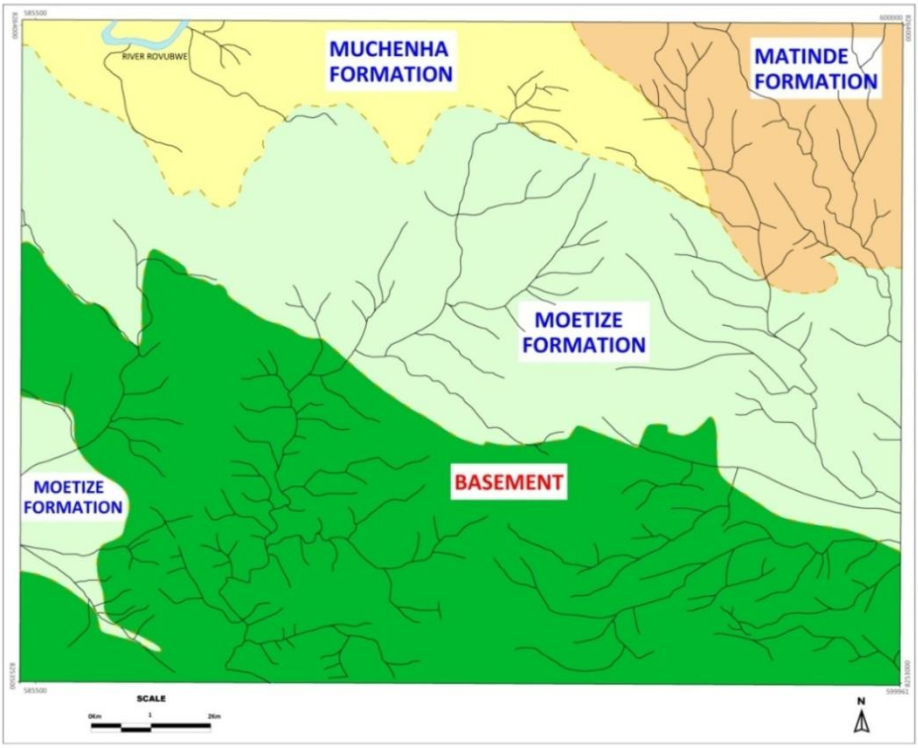


Fig. 2-3: Drainage pattern in 5086C tenement

Drainage pattern is low density sub-dendritic (Fig.2-3). Streams are first/ second order category, shallow and remain dry for most part of the year. There are a couple of high order streams to be tackled during Mine construction. The higher order streams, namely the Rovube in northwest and the Nkondezi in southeast are perennial streams and offer unlimited source of water supply for the coal mining project.

2.4 RAINFALL & TEMPERATURE

The area receives mean annual rainfall of 700mm in the rainy season that spans from December to March while remaining months of the year seldom receive noticeable rain. January and February are peak rainy months. Climate of the area is hot rainy summer and cool dry winter type. Maximum and minimum temperatures recorded are 40° and 18°C respectively. Mean monthly rainfall in Moatize coal basin is given in Fig.2-4.

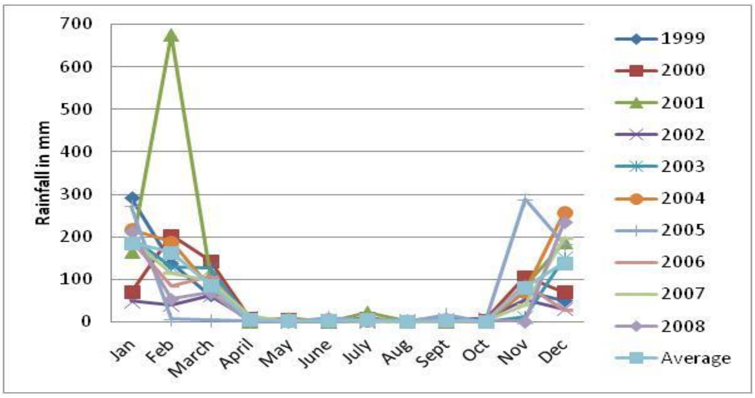


Fig. 2-4: Rainfall pattern in project area

2.5 FLORA & FAUNA

Flora in the area is typical Deciduous Savanna vegetation represented by an undergrowth of 1 to 1.5 m tall African grass in a realm of wide trunked tall trees as well as trees with flat topped canopy. The tall trees support lumbering activity (Fig.2-5). Prominent species is Grandiose Umunyum ("Adansonia Digitata Baobab") followed by "Colophospermum Mopane" "Kirkia Acuminate", "Cordyla Africana" and "Acacia Nigrescens".

Fig. 2-5: Vegetation type in 5086C tenement

Wild life in the area is scarce, though snakes and scorpions are occasionally seen. Common snake found is Africa Rock Python ("Python Sebae Natalensis") and Mozambique Spitting Cobra. Common birds seen in the area include White Stork (“Ciconia Ciconia"), the AfricanSkimmer ("Rhyncoper Flavirostris") and Rock Prantincole ("Glarcola Nuchalis"). Crocodiles ("Crocodylus Niloticus") are occasionally sighted in the Nkondezi and Rivube Rivers.

The 5086C tenement is devoid of human settlements. The nearest hamlet is located about 4km away from the license boundaries. People live in hamlets comprising 15 to 20 thatched hutments supported by walls made of closely spaced tree trunks. Population density in the area is 8/sq.km. Village people have started encroaching the small parcels of mining lands for agriculture. The agricultural crops are maize, vegetables and beans. The household supporting activity is poultry, cattle and sheep rearing.

Bicycle is the main means of transport for local people. People living in hamlets are hardworking nature and form a valuable source of unskilled labor to 5086C coal mining project.

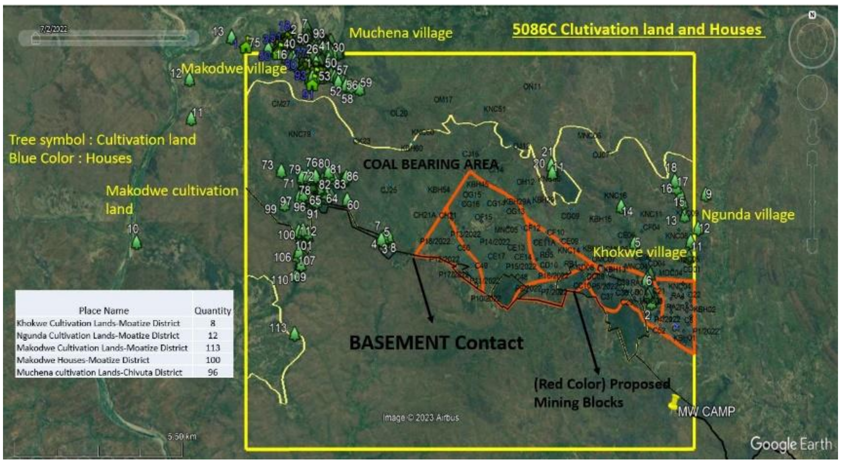


Fig. 2-6: Status quo agricultural land encroachment into 5086C(shown as dots)

2.6 GEOLOGICAL STRUCTURE

The Karoo sediments in the environs of 5086C project area are preserved in a fault bounded half-graben. Along the southern boundary the contact between basement and the basin is partly unconformable and partly faulted- a NW-SE trending fault with throws ranging from< 10m to 45m. Whereas the northern extent of the Karoo sediments is delimited by an E-W oriented fault (Muwanza fault) which is located along the foothill of Chiriza Mountain a southern extension of the Zambia carton.

General trend of sediment bedding is NW-SE with 5 to 10o dip towards north. Faults identified in the project area are of two types (1) NW-SE Longitudinal and (2) NE-SW transverse set. The longitudinal faults are present along the basin margin as well as within the Karoo tract and controlled the deposition and preservation of Karoo sediments (see Fig.2-7). Longitudinal fault No.2 controlled sediment accumulation and coal deposition during basin development. The coal zones thicknesses have increased enormously up to 300m along the hanging wall side of the fault while the coal zones are up to 40 to 50m thick only along the footwall side in south.

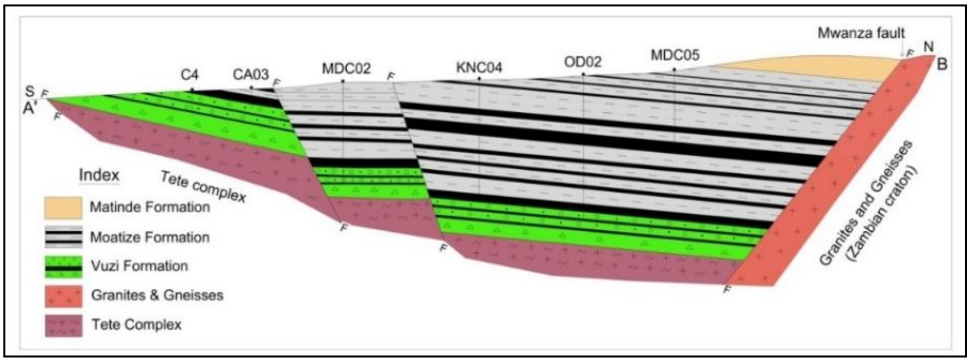


Fig. 2-7: Schematic geological cross section across the Mecondezi sub basin showing half graben frame work (not to scale).(Lakshminarayana,2015)

The NE-SW transverse faults are post-depositional faults that imparted lateral shift to formation contacts whose uneven throws have given rise to the development of secondary horst and graben structures. These are high angle faults, oblique slips along these faults have resulted faulted in the formation of wedge shaped blocks and basement highs. Schematic geological showing the fault pattern is shown in Fig, 2-7

2.7 NATURE OF MINERALISATION

There are six coking coal seams in Moatize basin. It is a thick interbeddeed coal seam deposit. The 5086C tenement showcases all six known bituminous coking coal seams of the Moatize coal basin. All the 153 boreholes drilled in 5086C have invariably intersected one or other coal seams depending on the stratigraphic position, thereby indicating comprehensive coal development in the tenement. Coal thickness trend map is shown in (Fig.2-8).

Coal seam thickness increases from margin towards center of the basin. Coal depositional trends are parallel to basin elongation and shaped by a couple of basement highs.

Depocenters are areas of maximum coal deposition controlled by faults and attendant basin subsidence.

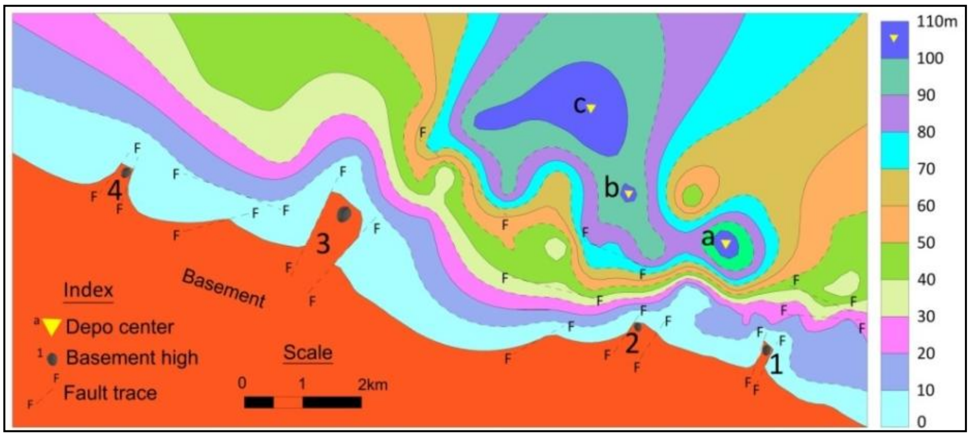


Fig. 2-8: Net coal thickness trend map of 5086C.

Nature of mineralization has been described under three sub-heads namely coal seam stratigraphy, coal seam type and coal seam morphology.

2.7.1 Coal Seam Stratigraphy:

There are six major seams i.e. Sousa Pinto, Chipanga, Bananeiras (Inferior & Superior), Intermedia, Grande Falesia and Andre in the Mecondezi sub-basin. These are correlatable with those of the Moatize basin type area, but attained more thickness (Fig.2-9). For example, the Grande Falesia seam has attained a maximum recorded thickness of 108 to 250 m thickness thereby making it one of the thickest coal seams of this kind in the world.

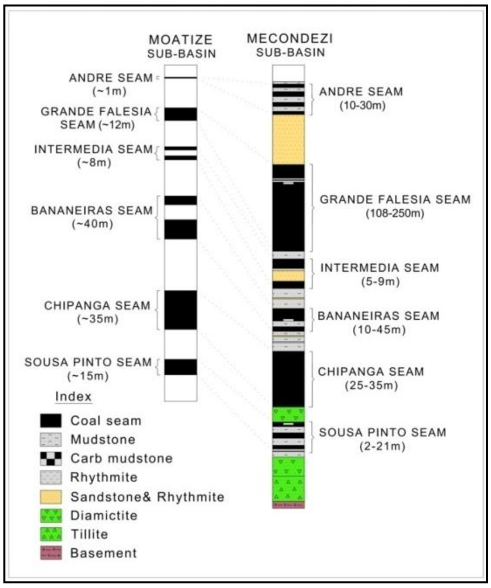


Fig. 2-9: Coal seams in Moatize formation.Comparison between Moztize and Mecondezi area (5086C)

The above fig shows that the coal seam thickness is more in the in the Mecondezi area.

2.7.2 Coal seam Type:

The South African coal guidelines document (SANS-10320, 2004) has categorized coal seams of the Southern African basins into two types namely a) multiple seam type and b) thick inter-bedded type. The multiple seam type deposits contain well defined coal seams with a thickness of up to 10m and inter seam partings thicker than the coal seams. Whereas, the thick inter bedded type seams are complex type consisting of cyclic beds of coal, carbonaceous mudstone and mudstone, whose whole seam thickness attaining up to 75m. Coal seams in the Moatize Coal basin in Mozambique are thick inter-bedded type and also known as Barcode type coal seams.

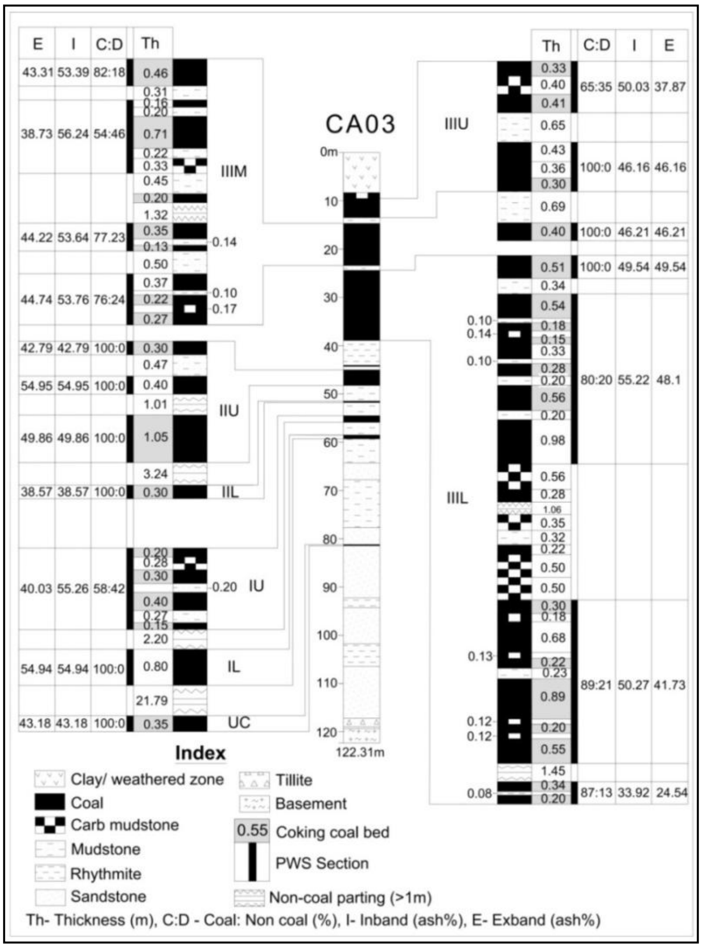


Fig. 2-10: Barcode morphology of coal seams. I&II: Sousa Pinto seam, III: Chipanga seam, L M U, lower, middle and upper sub-seams. Figs in boxes: bed thickness. Thick vertical lines: potentially workable sections—PWS.

2.7.3 Coal Seam Morphology:

Coal seam morphology shows cyclic beds of coal, carbonaceous mudstone and mudstone whose disposition on vertical section looks like Barcode (Fig.2-10). Hence, these seams are termed as Barcode type coal seams. Each coal seam is a composite whole seam as per (SANS-10320, 2004) terminology. Each whole seam consists of a hierarchy of units, i.e. whole seam → sub seams → sections → beds (Fig.2-10).

Thickness and distribution pattern of carbonaceous mudstone and mudstone are similar to that of coal beds. The net coal component at whole seam level varies from 25 to 55%, and the remaining 45 to 75% is either carbonaceous mudstone or mudstone. Seam-wise Coal (C) and non-coal ratios are presented in Table 2.1.

Table 2.1: Coal: Non-Coal Ratio and Coal Quality in Different Composite whole Seams.

Seam	**Thickness(m)**	**Coal: Non-coal**	**M%**	**Ash%**	**VM%**	**FC%**	**GCV Kcal/kg**
Andre	10-30	25:75	3.5	51	24	21.5	3300
Grande Falesia	108-249	30:70	2.7	54	20	23.3	3148
Intermedia	5-9	55:45	2.6	49	23	25.4	3551
Bananeiras	10-45	35:65	2.2	48	21	28.8	3800
Chipanga	25-35	45:55	1.6	42	23	33.4	4400
Sousa Pinto	2-21	35:65	1.3	40	23.7	35.0	4630

Taking more than a meter thick intra seam parting into consideration, each composite seam has been divided into sub seams numbered as Lower (L) Middle (M) and Upper (U) etc. thin coal beds which do not stratigraphically fit into whole seam classification are designated as UC(unclassified)

The coal component in each sub seam amounts to 55.45%. Each sub seam can be further divided into 2 to 4 coal sections separated by >0.5 m thick mudstone partings. These sections are designated as potentially workable/mineable sections (PWS) whose thickness ranges from 0.2 to >6.5 m and contain 65 to 95% of coal beds and 5 to 35% of non-coal beds. Ash content in each PWS works out to be <55% whereas net coal ash in PWS works out to be <50% with mean value being 44%. Each PWS contain two or more coal beds.

The thickness of coal beds ranges from 10 to 150 cm, with average thickness being ~40 cm. However, a few coal beds are present in a thickness range of 150 to 300 cm. There is a marginal lateral variation in number of coal beds with in whole seam.

Older seems like Souso Pinto and Chipanga occur at shallow depths along the basin margin; middle seams i.e. Bananeiras, and Intermedia occur at shallow levels in middle part whereas Grande Falesia and Andre seams occur at shallow depth in central part of the basin As a result, boreholes located towards central part of the basin have revealed all six coal seams. A corollary to this type of seam disposition is that the net coal content increases from basin margin towards central part of the basin. An empirical count of coal beds has revealed a total number of ~54 coal beds along marginal part and 160 coal beds towards central part thereby denoting more coal deposition and preservation towards central part of the basin.

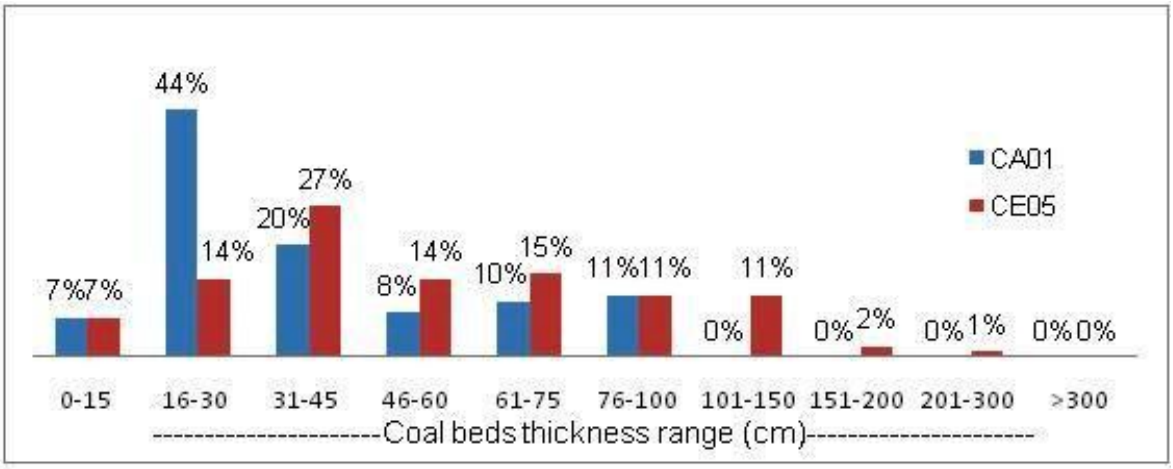


Fig. 2-11: Bar diagram showing thickness wise distribution of coal beds identified at the points of observation—Borehole CA01 located along basin margin and CE05 central part of the basin

Along the basin margin, only about 30% of coal beds exceed 50 cm thickness, whereas the remaining 70% coal beds are <50 cm thick. Towards central part of the basin, the proportion of coal beds of >50 cm thickness increases to 40%. About 15% of the coal beds have attained thicknesses of more than a meter each, with the remaining 45% being <50 cm thick (Fig.2-11). However, there are few coal beds, of 1.5 to 3 m thickness in the central part of the basin, mostly found in the upper stratigraphic levels of the Grande Falaise seam.

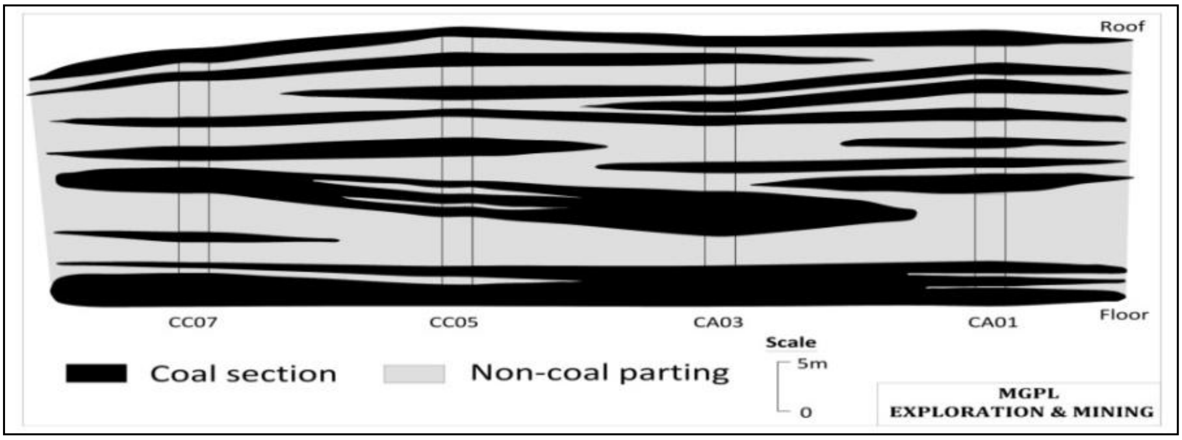


Fig. 2-12: Schematic diagram showing lateral continuity /discontinuity of potentially workable sections due to splitting and merging

Coal seams display a reasonable geological continuity at whole seam level and also sub seam level along dip and strike directions to facilitate the formation of benches during mine planning (Fig.2-12).

2.7.4 Mineralization constraints and solutions:

It is difficult to establish lateral continuity of potentially workable coal sections within the seam due to their pinching/swelling and also merging/splitting nature (Fig.2-12), which is likely to become a major constraint in large-scale conventional dumper and shovel type of open pit mining.

Another constraint on the exploitation of Barcode coal seams is that the coal occurs as thin beds of less than one-meter thickness separated by intra seam partings as shown in Fig.2-12. When such Barcode type coal sections are mined out by conventional method, using blasting and shovel, a significant amount of non-coal material will be mixed with coal leading to increase in ash content >55%. When such high ash samples were subjected to float sink analysis, the yield of saleable coal products are on decline. On the other hand, the ex-band coal at 44% ash has shown a theoretical yield of prime saleable metallurgical is going up to 23% with low ash (~10% primary coking coal product, which contributes significantly to the economics of the coal mining project.

Therefore, constraints on exploitation of Barcode seams are linked to seam morphology and lateral variation of coal component in mining sections. In order to overcome these constraints, and to maintain economic viability and sustainability of mining project, coal should be mined out as clean as possible, as little out of seam dilution as possible, by separately mining out coal and non-coal material. Selective mining of coal is possible by using Surface Miner mining equipment instead of conventional blasting and shovel. Selective open pit coal mining by using Surface Miner mining equipment has been widely practiced for more than a decade in the Permian coal deposits of Indian Gondwana coal fields and VALE Company has recently switched over to coal extraction by Surface Miner.

3 COAL EXPLORATION

3.1 HISTORICAL DATA

Historical data of the 5086C coal project was derived from the swede coal to start the geological activities. The report dealt with mainly basic geological aspects. The MAL coal mine development phases are outlined below.

3.2 PROJECT DEVELOPMENT PHASES-5086C

When the project was acquired by the Midwest Africa Limitada it was a green field area. Comprehensive coal exploration as commenced at the end of 2008.

Chronology of project development phases include

Phase-1: 2008-2009: Target generation study.

Phase-2: 2010-2012: Resource definition and Scoping study.

Phase-3: 2012-2014: In-fill drilling and G2 level Resource Reporting.

Phase-4: 2015-2017: Technical studies for Pre-feasibility assessment.

Phase-5: 2018 Release of PFS report.

----------: 2019-21: Corona Interregnum.

Phase -6:2022-23: Infill drilling, Trail pit (Pilot pit), Laboratory studies and Modeling.

2023/24: Release of Economic feasibility report.

Note: The MAL operations were slowed down between phase-3 and phase-4 interval due to worldwide decline in coal markets and uncertainty looming over upcoming coal projects.

3.3 NATURE& QUANTUM OF EXPLORATION WORK DONE UP TO 2023

- The quantum of work accomplished so far is as follows:
- Total area under coal bearing lower Karoo Formations: 8203 ha.
- Area covered by drilling so far: 5028 ha.
- Drilling: 39,991 m (25877.7m coring and 14113.3m non- coring).It includes in-fill drilling.
- No of boreholes: 153 (104 coring and 49 non-coring).
- Geophysical studies: 110 holes (77 coring and 33 non- coring).
- Geotechnical studies: 45 boreholes.
- Coal plies sampled, photo documented and analyzed: 12,137.
- Boreholes analyzed for coking coal tests: 95 (90 coring and 5 non-coring).
- Borehole composites tested for screen size and washability tests: 101.
- Two large diameter boreholes for bulk sampling.

- Trail pit (Pilot mine).

The database is stored in digital format can be accessed from MGPL data room "\\ns2\GEO_DEPT-2\MIDWEST DATAROOM-2014 and 2015\5086C-2018".

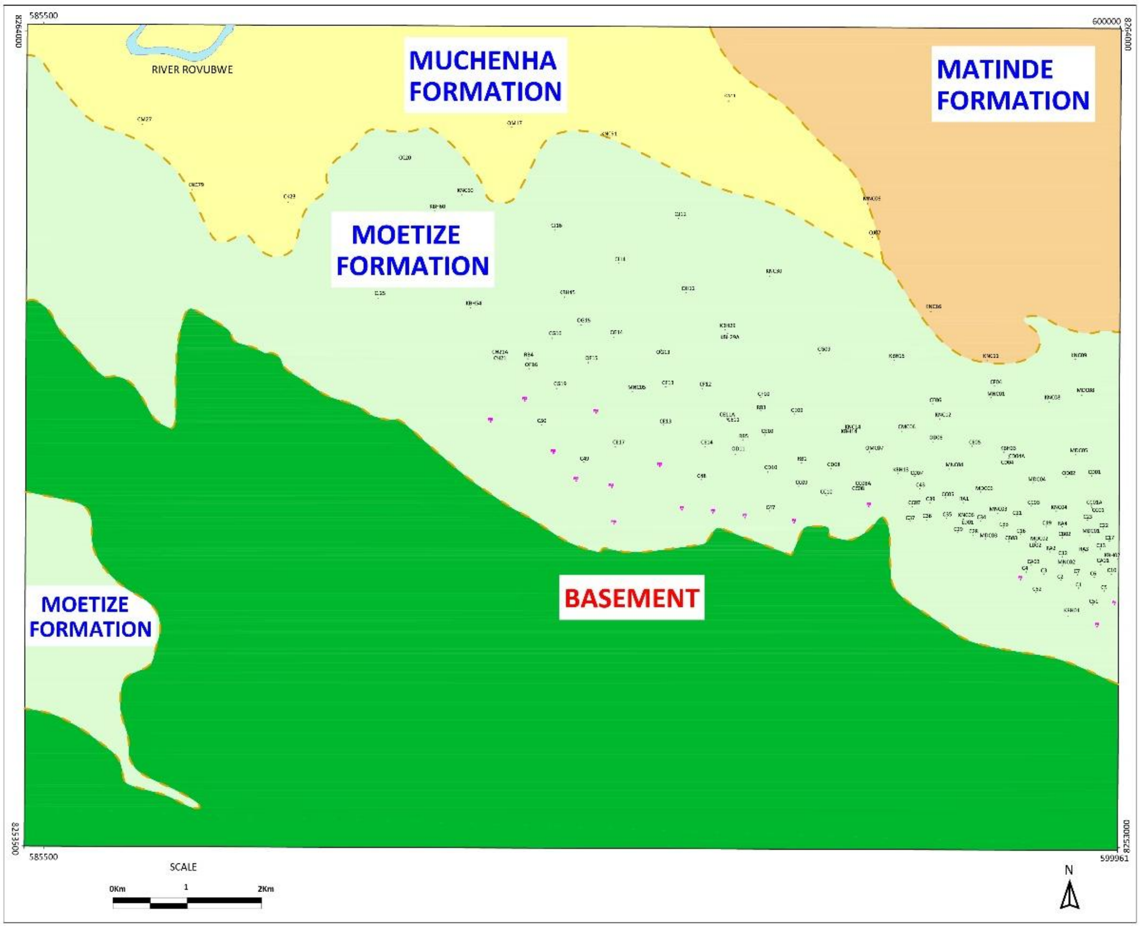


Fig. 3-1: Outline Geological Map Showing Borehole Locations, 5086C

3.4 BOREHOLE PLANNING

At the time of commencement of the project in 2008, the entire project area was a green-field area. There were no coal outcrops in 5086 C. Therefore between 2009 and 2014 prime objectives was coal exploration with a view to delineate the coal seams and to establish the lateral continuity. Geological map showing borehole locations is shown in Fig. 3-1.

3.5 BOREHOLE COLLAR & TOPOGRAPHIC SURVEYING

3.5.1 Borehole Collar Survey:

WCSTS (Willem Coetzee Survey and Technical Services) of South Africa conducted borehole color survey by DGPS. The RML Tete survey stations have been utilized to establish the network and to calculate the co-ordinates of all the bore holes drilled in the project area. The location of survey stations has been selected in the vicinity of uplands.

The coordinate of the reference stations is given as:

RML-TETE

Easting: 566012.8281

Northing: 8217544.5473.

Elevation: 172.5256 m.

The survey system used is: UTM36STH.

Datum: WGS 84(IRTF2008).

Geoidal model: EGM2008.

Controls were fixed with Trimble R8 receivers from a known RML base station in Tete and checked for the precise point positioning values of IRTF2008 EGM2008. The minimum and maximum ground levels vary from 304.461MSL (Bh.no.CM27) to 349.236m MSL (Bh.no.KNC30) within the Karoo Formation. X, Y, Z of borehole collors are given in Annex.III

3.5.2 Topographic Survey:

SMC (Southern Mapping Company) of South Africa has conducted topographic survey by using LIDAR system over shallow coal areas with a reasonably high density of boreholes in the southern part of the lower Karoo tract. The area covered was about 15.26 sq.km which forms most of the newly designated mining PIT-I. Rectified color images and Digital Terrain Model (DTM) of the project area was developed. Aircraft mounted 70 kHz LIDAR system scanned the ground below from a height of about 800m and an image pixel size of 10m was obtained. Ground check points were set out using differential GPS survey methods, and are used as check of the flight data. The Survey equipment deployed for topographical survey is as follows

Aircraft – Partenavia P68 Observer.

LiDAR Scanner – Optech ALTM 3100(maximum 100000 LIDAR ranges per second).

Camera – Rollei AIC with a 40 mega-pixel p45 phase one digital CCD.

GPS – Trimble and Topcon dual frequency receivers.

The survey stations already established by the triangulation are utilized as reference stations in the above survey. The coordinates of base and control stations are:

RML-TETE	566012.8281(E), 8217544.5473(N), 172.5256(H)
SMCA111801	592877.7593(E), 8259309.7159(N), 311.2309(H)
SMCA111802	596395.3265(E), 8258787.4294(N), 321.6800(H)
SMCA111803	599107.7972(E), 8256933.2980(N), 299.9746(H)

The Lidar Survey data is incorporated in Annex-IV.

3.6 DRILLING AND LOGGING

3.6.1 Non-Core Drilling (Open Holes):

Open hole drilling was carried out by using a compressor propelled truck mounted Smith Capital RC Rig of South Africa. The RC rig could drill effectively only up to 250m depths and was used for drilling in shallow areas along the basin margin. Deep hole drilling was done by deploying mud rotary HANJIN D&B P7000RC and a Boart Longyear LF90D rigs. The RC rigs returned rock material in the form of fine dust and millimeter to centimeter size chips of rock cuttings, which were arranged in the form of heaps representing one-meter interval at rig site (Fig.3-2 a & e). Representative samples are collected from heaps by coning and quartering method for laboratory studies. Lithological logs were prepared from open hole rock chipsGeophysical logging was done in all the open holes and the data were used to reconcile lithology, coal seam intersections and other relevant aspects.

3.6.2 Core Drilling (Diamond-Core Holes):

Core drilling was carried out by diamond impregnated drill bits using wire line double tube HQ barrel fitted to Boart Longyear and Atlas Copco rigs. Borehole diameter was 96mm and core diameter was 64mm (HQ). All the drilling was done in a single shift starting from 8 a.m. to 6 p.m. The average rate of drilling was 36m/day against the planned target of 40m/day.

Core recoveries were very good and often exceeded 96%. The core recovery and core caring procedures was monitored by the on-site geologist (Fig.3-2 a, b & d). The entire coal core was properly wrapped in polythene sheets, at the drill site, as soon as they were recovered from the core barrel to avoid moisture loss and destruction of coking properties. Care was taken to avoid core loss in fragile vitrinite portions during coal core handling. Drill site core handling procedures are shown in (Fig.3-2b).

3.6.3 Large Diameter Core Drilling:

Large diameter core drilling was completed in two boreholes namely LD01 and LD02 which are the twin holes of KNC06 and MDC02 respectively. Core diameter was 180 mm. A Boart Longyear LF 90D rig was deployed for the large diameter drilling (Fig.3-2d). Core handling and sampling procedures were undertaken following the protocol provided by Dolbear, USA

3.6.4 Lithological Core Logging:

Core recovered from the barrel was gently washed or flushed immediately with water to remove the drilling fluids and mud. The core was perfectly reconstructed, measured and placed in core boxes in book format. Core recovery percentage is arrived at by dividing the length of the recovered core with total length of the drilling by using the following equation:

Recovery (%) = Lr/Ld x 100. Lr = Length of core recovered, Ld = Length of the core drilled.

Core recovery percentage of core bores is over 96%.

Fig. 3-2: Photo mosaic showing exploration procedures and practice by MAL

3.6.5 Lithology & Core logging and safety:

Lithological attributes were studied and marked with piece of chalk. The core marking was made by chalk or paint according to the run by keeping small wooden/plastic pegs duly indicating the depth and recovery of that core. The entire core boxes were numbered and labeled with details of the borehole & concession. Physical properties of rocks including textural attributes, sedimentary structures and secondary structures such as fractures, joints and faults were recorded in detailed lithological data sheets which are preserved in Midwest data room (Annex-VII). All the core boxes were photographed and soft copies are stored in Midwest Data room (Annex-V). The coal intersections were sampled and bagged. The marked and sampled core boxes with the selected core were systematically stacked in the core library set up at the Midwest project site office.

3.6.6 Rock Quality Designation (RQD):

Besides lithological information, RQD of selected core was also determined at the drill site following the procedure laid down in ASTM Manual 11.This shows that the RQD expressed as a percentage of solid core greater than 10cm, recovered from given drilled length. Core loss, weathered and soft zones are accounted for. Mechanical and artificial fractures are not considered. RQD is calculated by the formula:

$$RQD = \frac{L_r - \sum P}{L_d} X100$$

Where: L_r = Length of core recovered.

L_l = Length of core loss.

L_d = Length of core drilled.

P = Sum of the core recovered ≥ 10cm.

Quality	Excellent	Good	Fair	Poor	Very poor
RQD	90-100%	75-90%	50-75%	25-50%	25%

Summary of RQD recorded in 5086C core bores is excellent to good. Detailed loss showing borehole wise RQD have been presented.

3.7 COAL SAMPLING PROTOCOL

The MAL has followed band-by-band sampling protocol as the coal seams are made of multiple coal beds stratified with carbonaceous mudstone and siltstone. All the coal and carbonaceous shale beds are sampled separately denoting as ‘C’ and ‘D’ plies respectively. The ultimate objective of this type of sampling is to analyze all coal beds and dirt beds separately, so that the real assay of given coal section can be estimated. This type sampling is more preferred to explain coal seam morphology as well as its suitability to bulk mining or selective mining methods. The coal seam plies were prepared for band-by-band analysis as per the protocol given in Table.3.1.

Table 3.1: Sampling protocol

Description	Interval	Interval Thickness	Sample No.	Sampling Procedure used
Roof	Bed	Bed wise		
Coal		Bed wise		Sample entire coal ply.
Parting		<0.10m		If parting is less than 0.10 m, then include with the coal ply.
Parting		>0.10m and <0.30m		Sample as a single sample.
Coal				Sample the body of coal as a single or series of samples.
Parting		>30 cm		If parting thickness is >0.30m sampled as a separate unit depending on overlying and underlying coal.
Floor	Bed	Bed-wise		

3.7.1 Duplicate Samples:

Duplicate samples were created by breaking the full coal core vertically with a core splitter into two halves. One half of the split part of the sample is submitted to the ACT Laboratory (now part of Bureau Veritas) in Tete for basic coal analysis and the other half of the same split is sent to different laboratories in India and South Africa for further coal analysis to validate assay values.

3.7.2 Blind Samples:

Blind samples are prepared by splitting coal core into two halves from every borehole, one half was retained with original running ply number and another half by different (blind) number and both are submitted to the same laboratory. After receiving the analysis, the values of original sample are compared with the blind sample to ensure repeatability.

3.7.3 Soil cover, Depth of Weathering and water table levels:

Soil cover and depth of weathering were also recorded at drill site. The unconsolidated sediment (including brownish-grey loamy soil and loose terrace alluvium) extending from surface to the depth of consolidated sediment is taken as soil cover. The depth ranges from less than 1m to 4m. Depth of weathering implies the level or line at the contact between faintly weathered rock and fresh rock. Faintly weathered rock is the one which shows stains or de-coloration along discontinuities like bedding planes or fracture planes whereas the fresh rock is the parent rock which does not show any de-coloration or does not loose strength due to weathering. Depth of weathering extends up to 12m. However, influence of oxidation in the form of localized strains is recoded up to 25m in holes located in the vicinity of fault zones. Depth of weathering and oxidation zones are given below in Table 3.2.

Table 2.2: Borehole-Wise Thickness of Soil, Weathered Zone and Water Table details.

Borehole ID	**Soil zone**	**Weathered zone**	**Water table level**	**Borehole ID**	**Soil zone**	**Weathered zone**	**Water table level**
CA01	2.14	17.14	21.26	C33	5.18	8.18	-
CA03	2.61	8.31		C34	5.14	11.14	-
CB02	2	47	24.04	C35	2.19	14.19	-
CB03	1.8	11.26	10.49	C36	2.16	20.16	-
CC01A	2.1	16.28	23.85	C37	2.72	26.24	-
CC03	1	29.24	29.31	C39	2.14	23.14	-
CC05	5	35	34.39	C4	5.3	6.91	-
CC07	4.5	20.16	37.98	C43	1.6	20.7	-
KBH02	2.43	10.89	-	C5	3.15	8.75	-
RA01	2	6.5	-	C51	2.96	6.4	-
RA02	5.5	12.5	-	C52	4.4	5.4	-
RA03	1.9	9.4	-	C6	2.19	23.19	-
RA04	1.95	25.36	-	C7	0.54	17.67	-
C1	0.9	10.95	-	MDC01	1.5	11.72	-
C10	0.68	18.23	-	MDC02	1.5	19.32	-
C12	1.9	13.64	-	MDC06	2.41	23	33.33
C13	2.12	8.12	-	LD01	-	-	30.92
C16	2.15	6.03	-	LD02	-	-	16.71
C17	2.15	11.97	-	OD02	-	-	43.3
C19	5.15	25.15	-	KNC04	-	-	31.24

C2	2.18	8.38	-
C21	5.13	14.13	-
C22	3.16	10.95	-
C23	4.15	12.43	-
C28	5.16	13.58	-
C29	3.2	14.19	-
C3	1.59	4.17	-

MNC02	-	-	17.18
MNC03	-	-	25.42
MNC04	-	-	38.01
CD01	1.75	29.74	35.04
CD07	3.73	29.63	45.53
CE05	-	-	34.04

3.7.4 Down-The-Hole Geophysical Logging:

Weatherford and GAP geophysics companies of South Africa were conducted down-the-hole geophysical logging. It was undertaken as far as possible at all the points of observation i.e., coring and non-coring boreholes. Multi probe logging was conducted in 98 boreholes. Sonic logging was conducted in representative borehole (Fig.3-2 c & f).

Parameters recorded are natural Gamma, Gamma-Gamma (SSD, LSD) and caliper. Later, sonic and resistivity components were added for down the hole logging in 2013. Besides these, verticality of boreholes was also tested. LAS files are stored in Midwest data room (Annex-IX).

3.8 IN-FILL DRILLING

a) Location plan of infill bore holes is given in Fig.3-3.The total 80 sq. km coal bearing of the license has been explored by drilling 136 boreholes with a cumulative meterage of 38,280m. Based on this exploration data, a mine lay out could be made for 12.62 sq.km area. Boreholes already drilled within this mine lay out area were 78 nos. In order to enhancing the confidence level of the Reserves, another 17 nos of in-fill borehole have been drilled in 2022 which makes the total number of boreholes to 95 nos (Figs.3-1 & 3-3) as prescribed by the SAMEC(South Africa) for delineation of the mineable coal Reserves. Drilling type = RC Drilling; Service Provider=Spartan Drilling Lda, Tete

b) All the seventeen bore holes have been logged for lithology by site geologist (Fig.3-4). Each borehole was subjected to multi-probe down hole geophysical logging by Wire-Line Africa LDA. Logs prepared from geological studies are calibrated with the GP log to work out the actual depth of seam intersections and thickness. Such coal intersection are given in Fig.3-4.Detailed/ calibrated seam structures are given Annexure-IX.

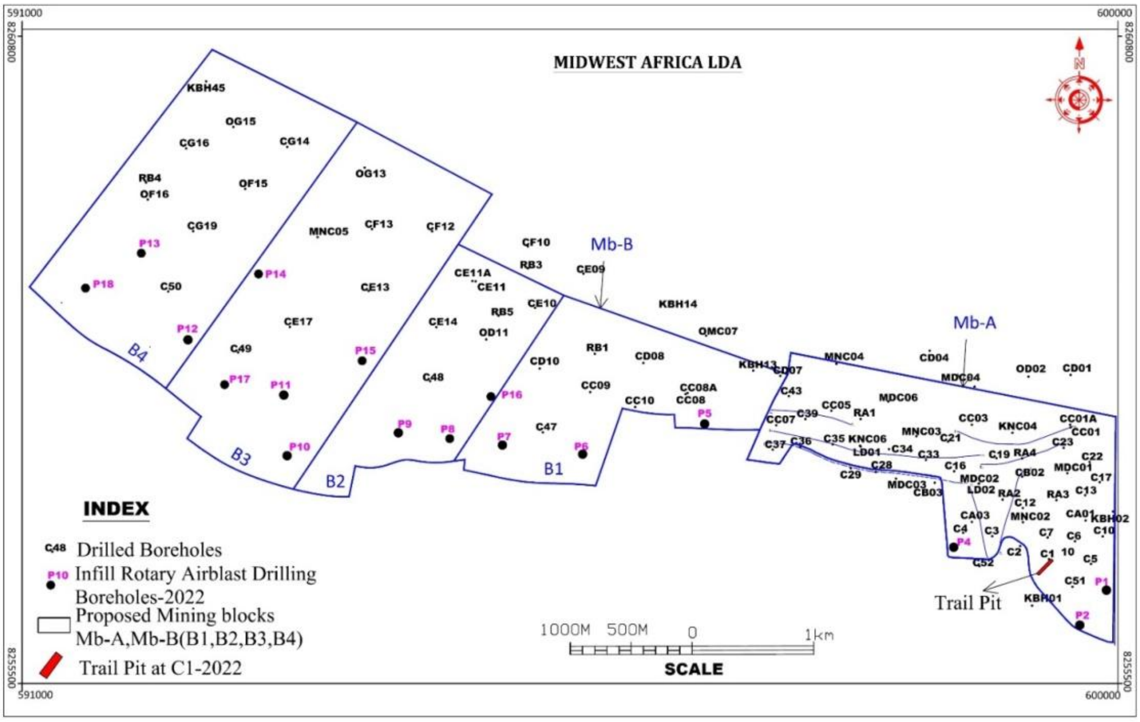


Fig. 3-3: Scetch showing location of Infilled Boreholes and Trail pit

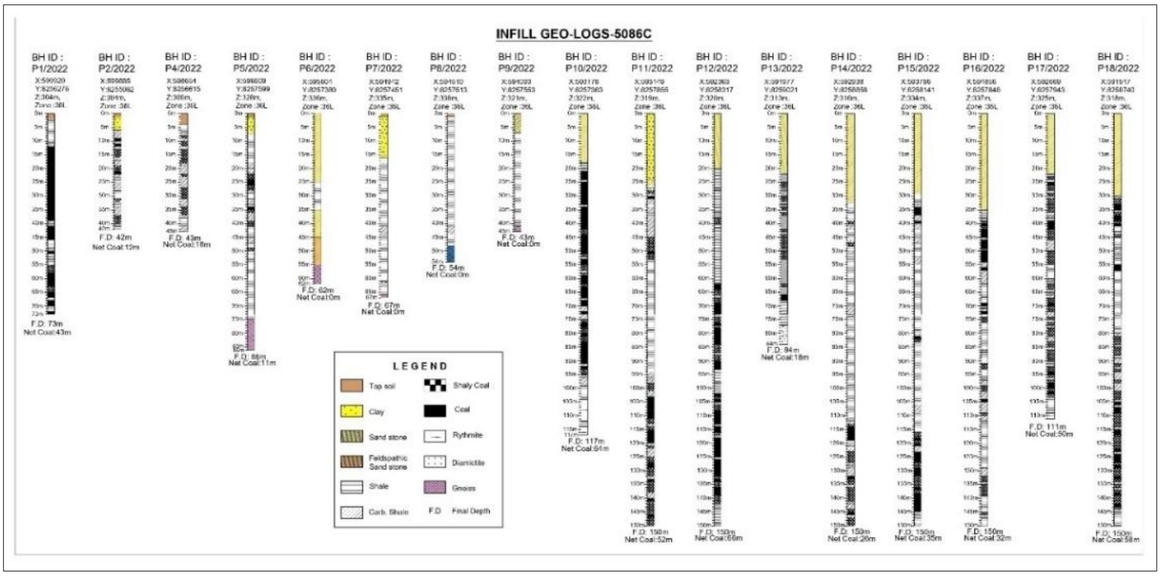


Fig. 3-4: Lithologs of Infilled Boreholes of 5086C

3.9 TRAIL PIT (PILOT MINE):

The Trail pit (Fig.3-5) is a prelude to assess viable mining method, machinery and man power planning.

The mining area in the license is shown in Fig.3-3. It is divided into two major mining blocks name it Mb-A and Mb-B. The latter is sub-divided into four blocks B1, B2, B3 and B4.Trail pit is located in Mb-A shown in red color and infill bore holes in Magenta color.

Geographic coordinates of the trail mining pit are given in Table 3.3.

Table 3.3: Geographic coordinates of the trail mining pit

WGS-84				**UTM Zone =36L**		
ID	**Latitude**	**Longitude**		**ID**	**X(E)**	**Y (S)**
A	15°46'8.96"S	33°55'38.85"E		A	599347	8256381
B	15°46'5.04"S	33°55'41.83"E		B	599436	8256501
C	15°46'5.61"S	33°55'42.53"E		C	599457	8256483
D	15°46'9.41"S	33°55'39.67"E		D	599371	8256367

3.9.1 Pit Dimensions:

Pit Surface Dimensions: 1 acre or 0.40 ha

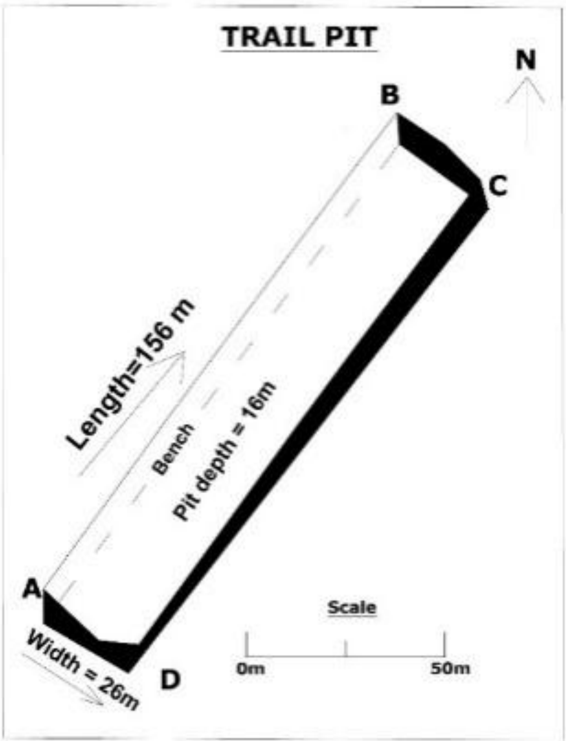


Fig. 3-5: Drawing depicting pit outline

3.9.2 Pit Geometry:

Trail pit geometry is Box shape rectangular. Walls are vertical. Ramp angle is1 in 15.

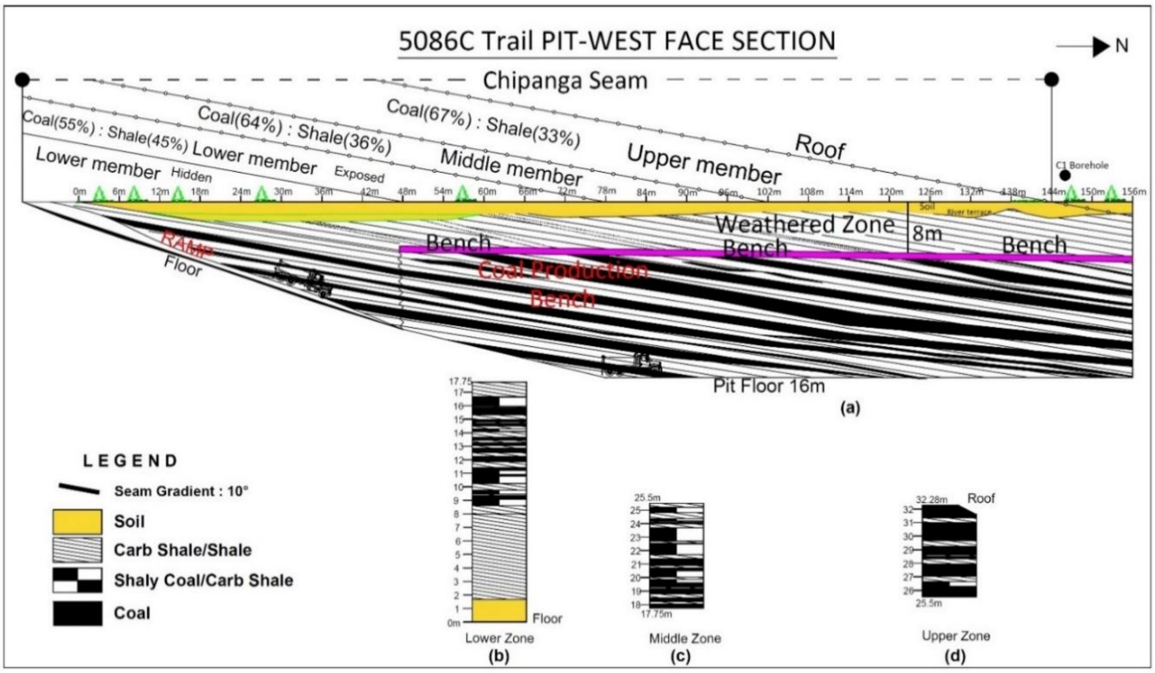


Fig.3-6: Field sketch showing pit geometry. Seam structure. b,c& d are lower, middle and upper members

Two benches have been made. The top bench is OB bench (8m height), followed downwards by the coal bench (8m). Bed dip is 10^0 Seam overall gradient 1 in 6.In addition, information on the in-situ 3-D configuration of coal seams, structural fatalities, viz. fault pattern, joints, lithology and their geotechnical attributes .ground water levels have been collected. OB is clay and weathered silt stone/Sandstone in seam parting mainly shale/grey shale. Besides bulk sample for pilot scale testing has been collected. Salient aspects are as given below.

3.9.3 Coal Seam Parameters:

Target Coal Seam -Chipanga Seam. Its thickness is ~23.68 mts. It is divided into three informal members namely Lower, Middle, Upper whose thickness and structure(Coal: shale) stacking pattern are given in Fig.3-6 and Table 3.4.

Table 4.4: Coal seam parameters

Chipanga Seam	Thickness	Coal : Shale Ratio
Upper Member	9.15	67:33
Middle Member	8.9	64:36
Lower Member	5.63	55:45

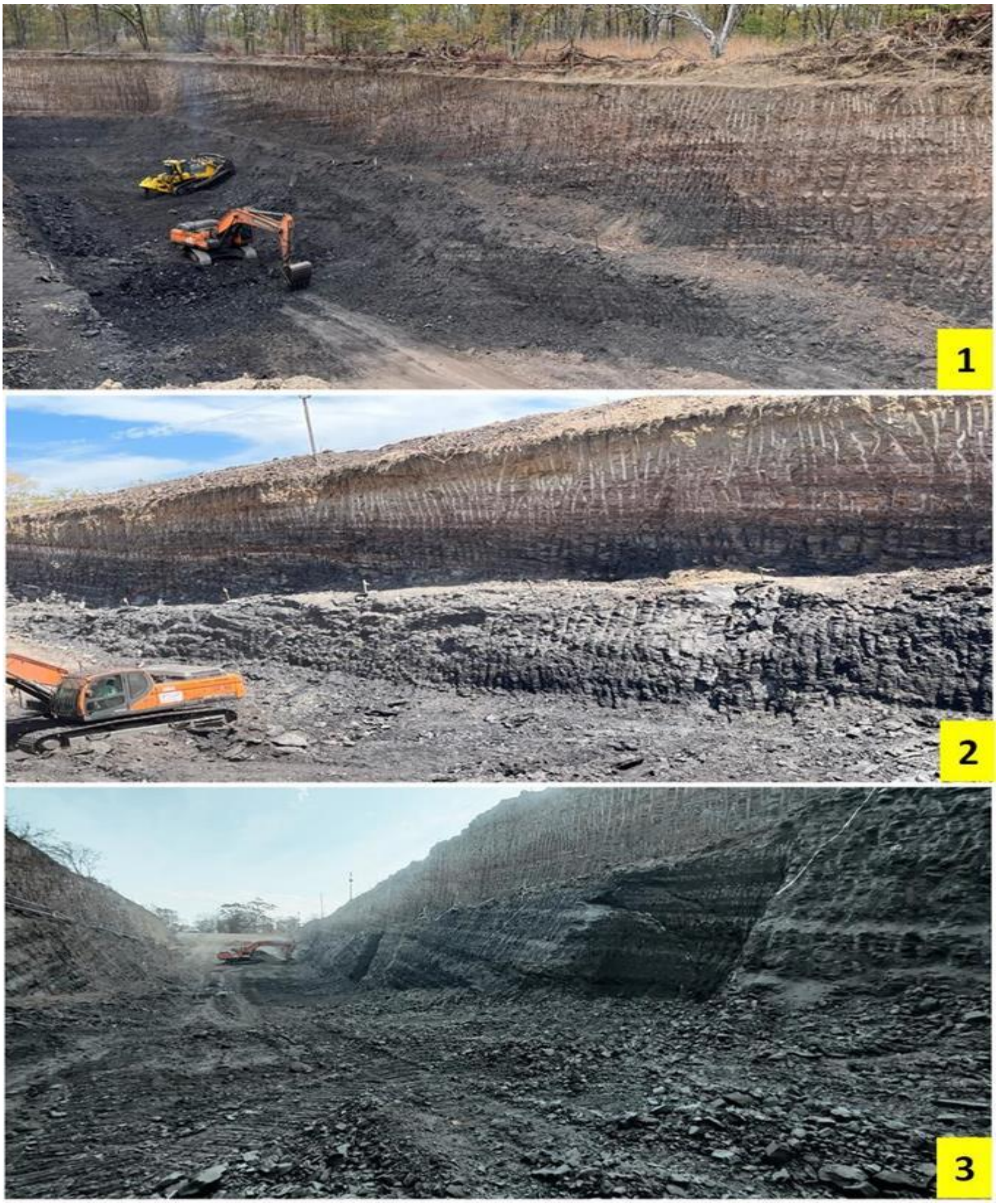


Fig.3-7: (1) Overview of the Trail pi showing theweathered coal bench top 8m followed down wards by un-weathered coal. Bench height 8m. (2) Safety bench for operational convenience between OB and coal sections (3) Chipanga seam structure in 3D along the pit gradient. (Excavator standing of the lower member) the middle member in the middle part and upper member in upper right hand side of the picture. Light coloured layers broadly coincide with lithological contacts in between the seam members.

Fig.3-8: (4) Dump truck transporting coal to stock pile (5) un-weathered bulk sample collection from coal bench 6) coal stacked in (6) Coal dumps in stockyard

3.9.4 Volumes Extracted:

Coal volumes are extracted from the whole seam

OB volume excavated= 26500 cbm
Coal volume excavated= 16,500 cbm.

4 GEOLOGICAL MODEL

Geological model present in the report has focused on lateral continuity of coal seams and their sub surface geometrical configuration including gradient of coal seams as well as fault disposition modeling in resource blocks A & B shown in Fig. 4-1.

GEOLOGICAL MODEL: Due to barcode nature of coal bands, Correlation of seams have been established on horizon basis. Total Six horizons (namely Sauso Pinto, Chipinga, Bannaneris, Intermedia, Grande Felsi, and Andre) has been established within the concession. On the basis of floor contours of all horizons, structure of the block has been established and fault & grade modeling done with the help of Minex Geological Modeling Software to establish lateral and grade continuity of coal. The model has been verified with the floor contours of all horizons and cross-sections and the same has been produced in plates (FC plans, Isochore, Isopach, IsoGCV, IsoAsh, cross-sections, etc). For resource estimation, the effective thickness and grade (weighted average) of the horizon has been taken based on the Cut-off Ash 55% and greater than 0.20m individual coal bands.

4.1 COAL SEAM CONTINUITY

MGPL has reviewed borehole data and put up adequate efforts to establish the geological continuity of complex thick interbedded seams of Mozambique type. Seam nomenclature and correlation are vital to establish geological continuity which in turn is of paramount importance during resource and reserve estimates as well as mining. Coal seam nomenclature from bottom to top shows Souso Pinto, Chipanga, Bananeiras, Intermedia, Grande Falesia and Andre. To demonstrate whole seam continuity, resource area of 5023 ha (Fig.4-1) has been divided into seven resource blocks numbered as Rb-A, Rb-B, Rb-C, Rb-D, Rb-E, Rb-F, Rb-G.

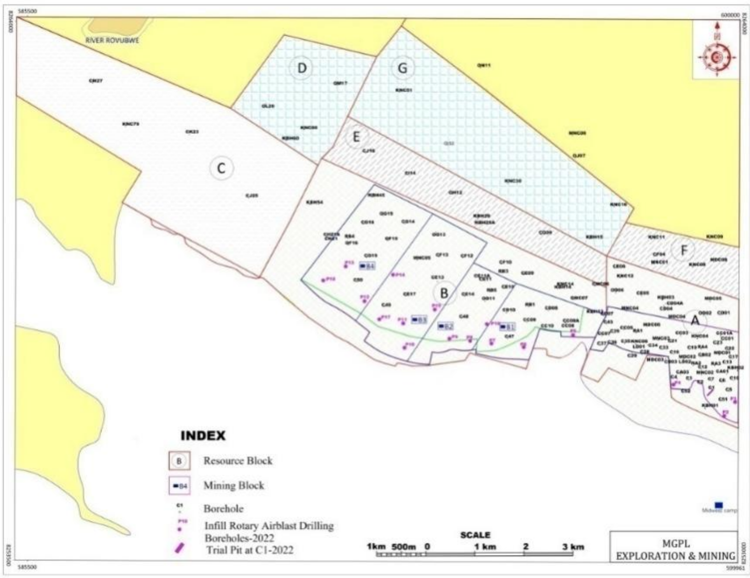


Fig. 4-1: 5086C Map with Resource Boundaries with Borehole Locations

Total length of drilled/resource area is 16.2km with widths is varying from 2.8 to 5.7km. This is unwieldy and could lead to generalizations.

Blocks A, B, B1, and C are located in up dip side i.e. along the basin margin and contain coal present in Souso Pinto, Chipanga, Bananeiras and Intermedia seams at shallow depths, whereas the Grande Falesia and Andre seams are top seams occurring at shallow depths in central part of the basin.

4.1.1 Coal seam continuity Rb-A:

Souso Pinto seam forms part of Vuzi Formation and contain thin coal beds and display numerous splits as well as thickening and thinning stratigraphy. Some of these coal beds show upward continuity into lower levels of the Chipanga seam, which is the main coal bearing horizon having a thickness of 30 to 80m. and it offers a good deal of mineablilty in open cast mining block A (See section) There is a lateral variation in the thickness of sub seams in the Chipanga whole seam. Gradient of coal seams in Rb-A is shown below Figs.4-2, 4-3, 4-4, 4-5 & 4-6.

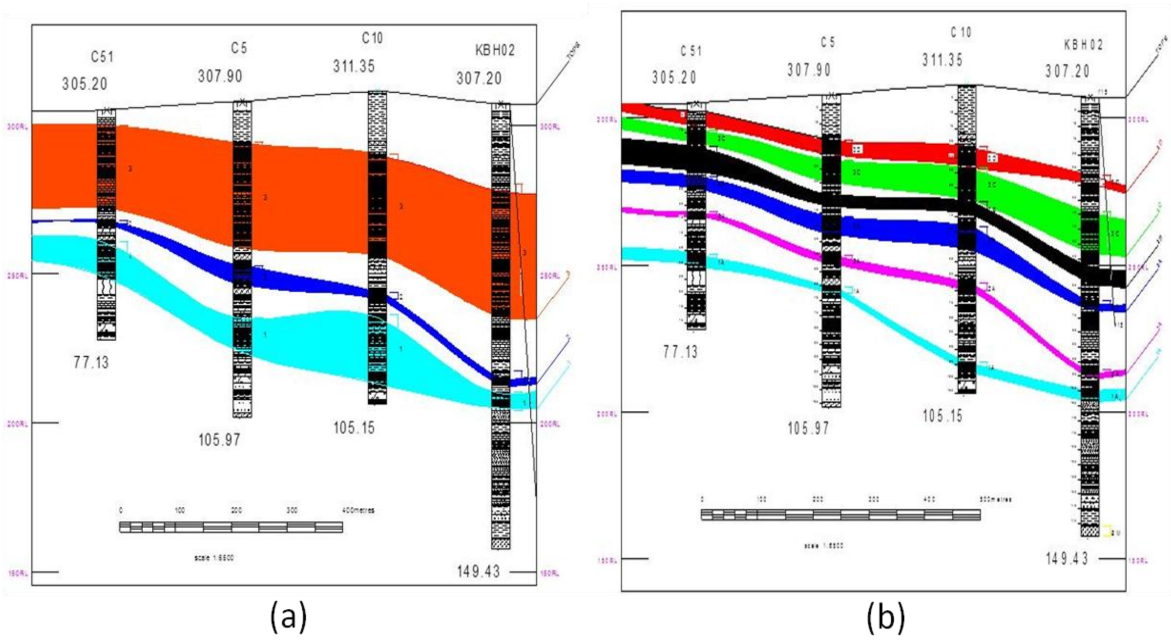


Fig. 4-2: a) Geological section showing seam gradient at seam level bottom two belong to SousPinto and top thick one is Chipanga seam b) Continuity at sub seam level.Top two zones are part parcel of Upper Chipanga seam.

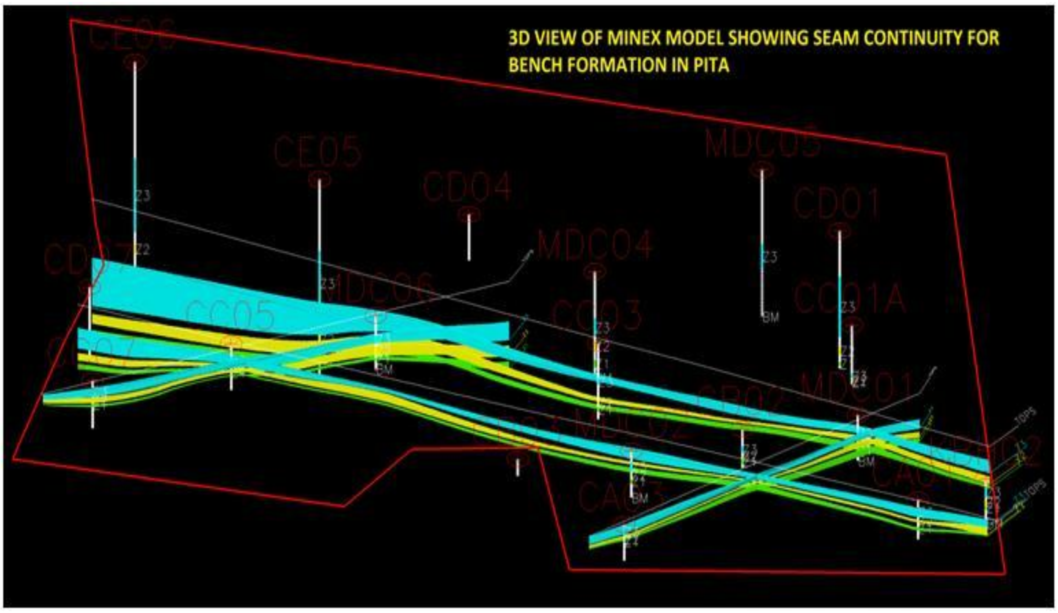


Fig. 4-3: An extract from Minex showing sub-surface geometry of coal seams.Bottom two (yello and green) represent Sousa Pinto seam and light blue is Chipanga seam

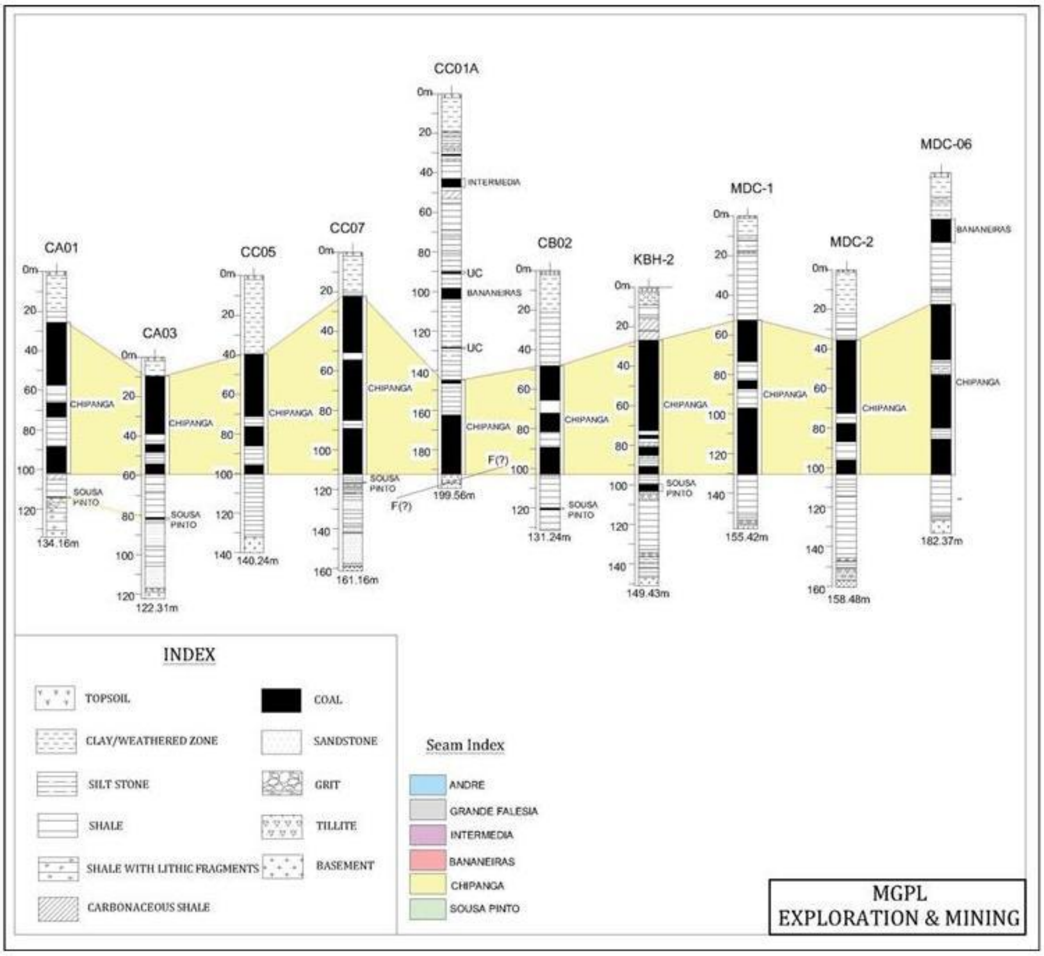


Fig. 4-4: Whole seam level lateral continuity in Rb-A (For Shallow boreholes <200m)

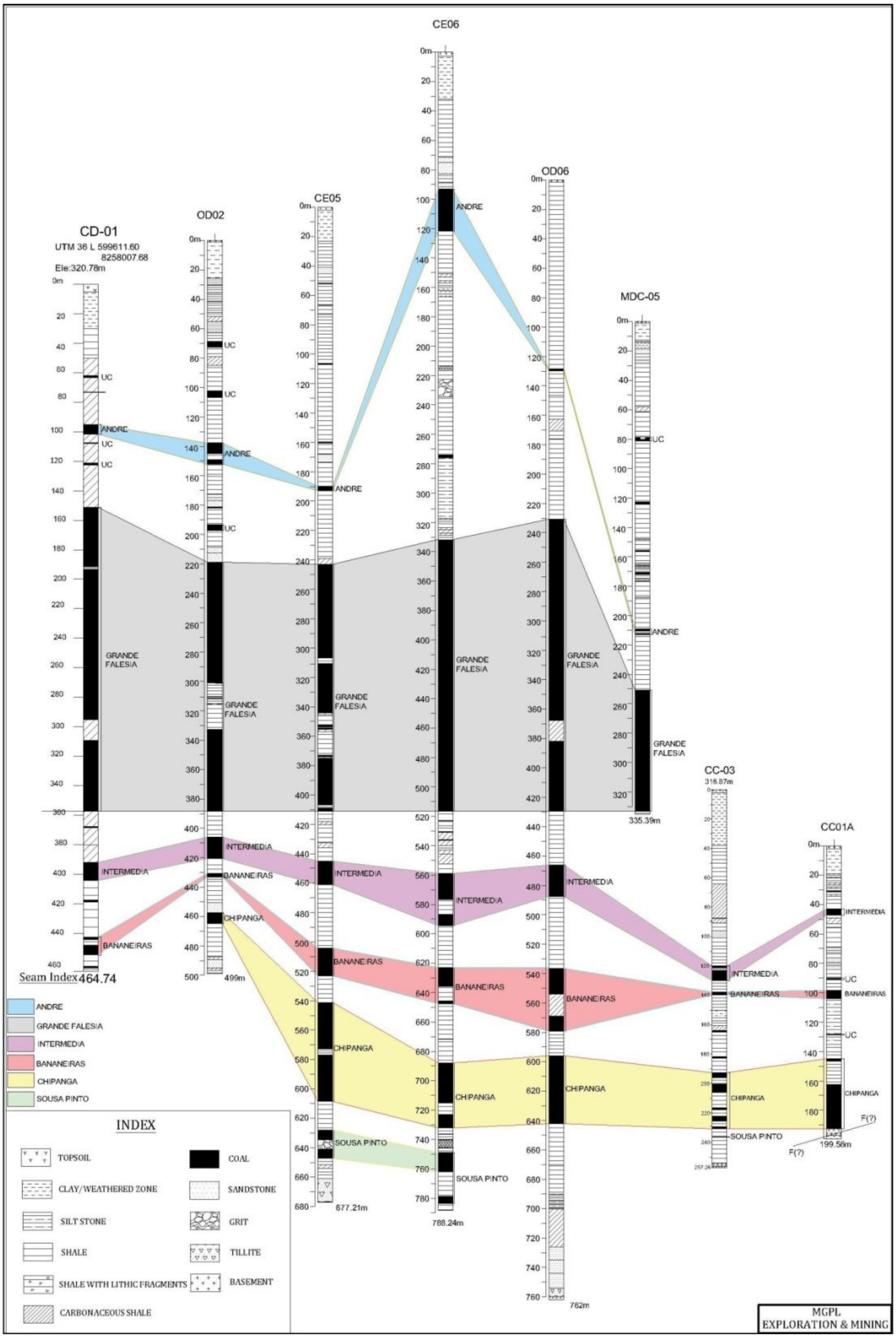


Fig. 4-5:Whole seam level lateral continuity in Rb-A (For deep boreholes UPTO 600M depth)

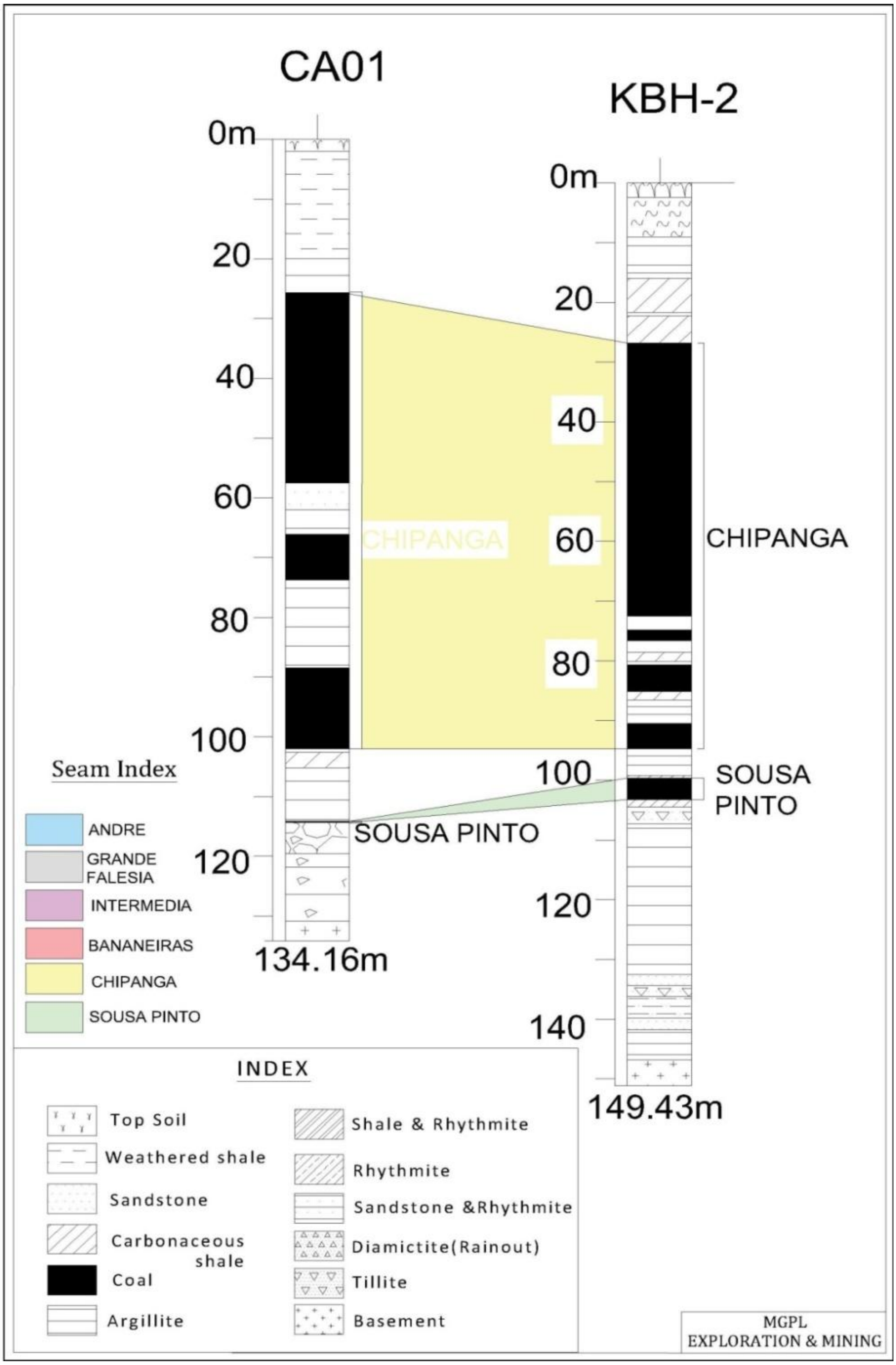


Fig. 4-6: Whole seam level lateral continuity in Rb-A (For Shallow boreholes <200m). Sousa pinto seam showing pinching nature whereas Chipanga seam showing consistency in thikness.

4.1.2 Coal seam continuity in Rb –B:

Coal seam correlation and continuity is shown in Figs 4-7 to 4-13. In this block all six coal seams are exploitable by open pit mining at one stage or other. It contains maximum amount of mineable coal with in a depth of 280m from surface as documented in depth-wise borehole data.

Two boreholes in central part of (Fig 4-7 & 4-8) are located along basin margin and two boreholes each on either side are located in down dip side

Lateral Geological continuity of coal seams in other resource blocks has been demonstrated in following Figs.

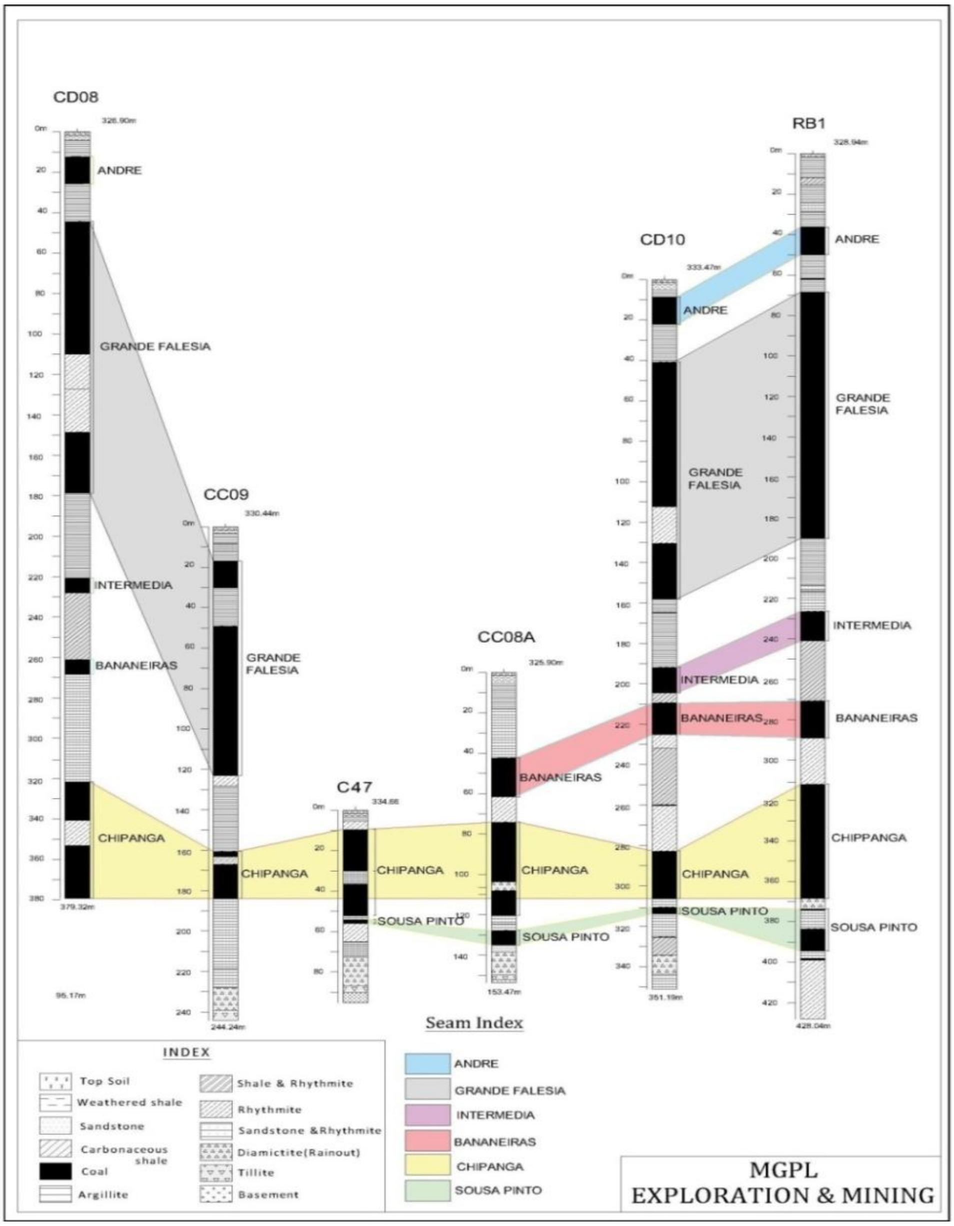


Fig. 4-7: Geological continuity of coal seams in Rb-B1

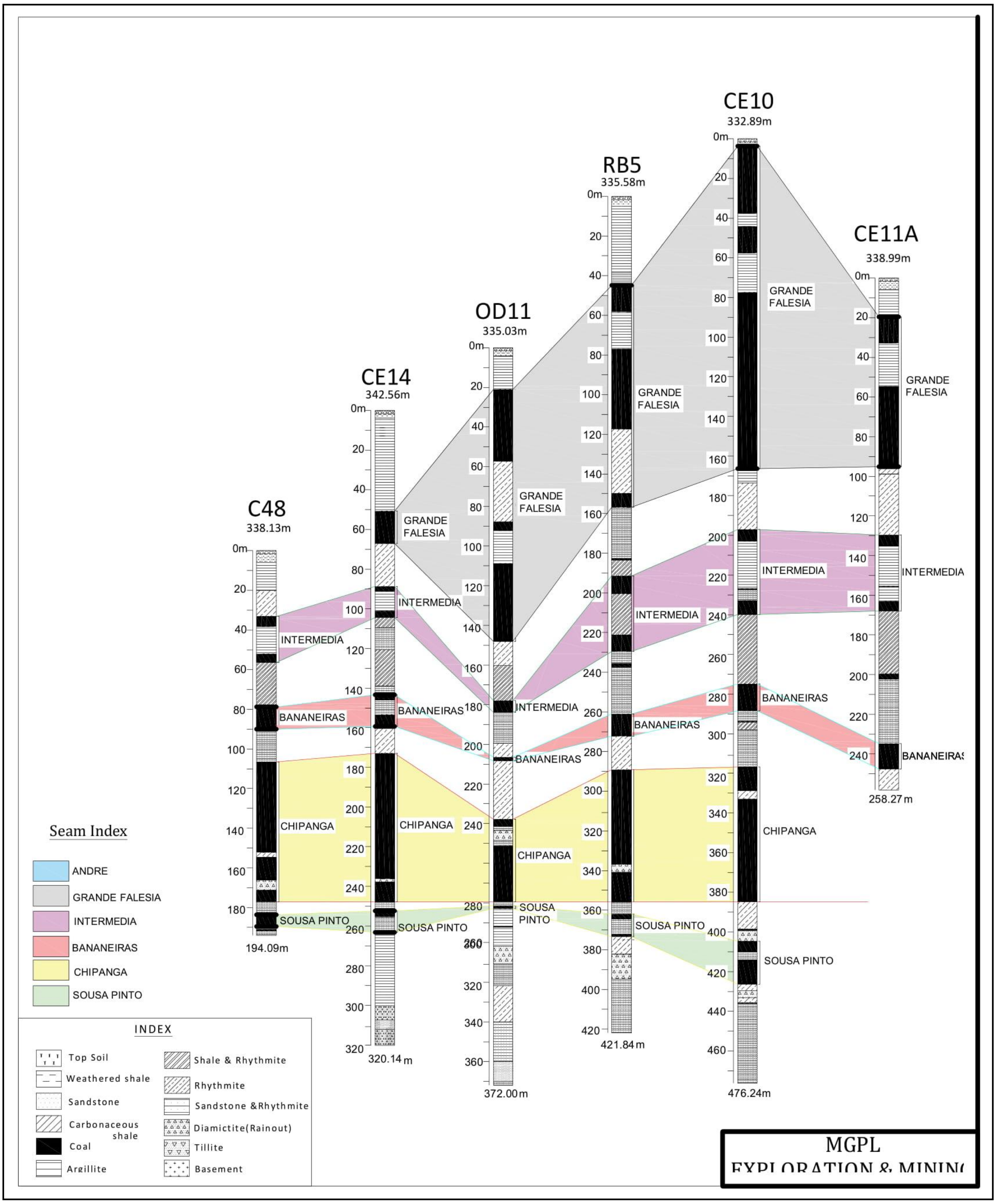


Fig. 4-8: Geological continuity of coal seams in Rb-B and Rb-E together in down dip

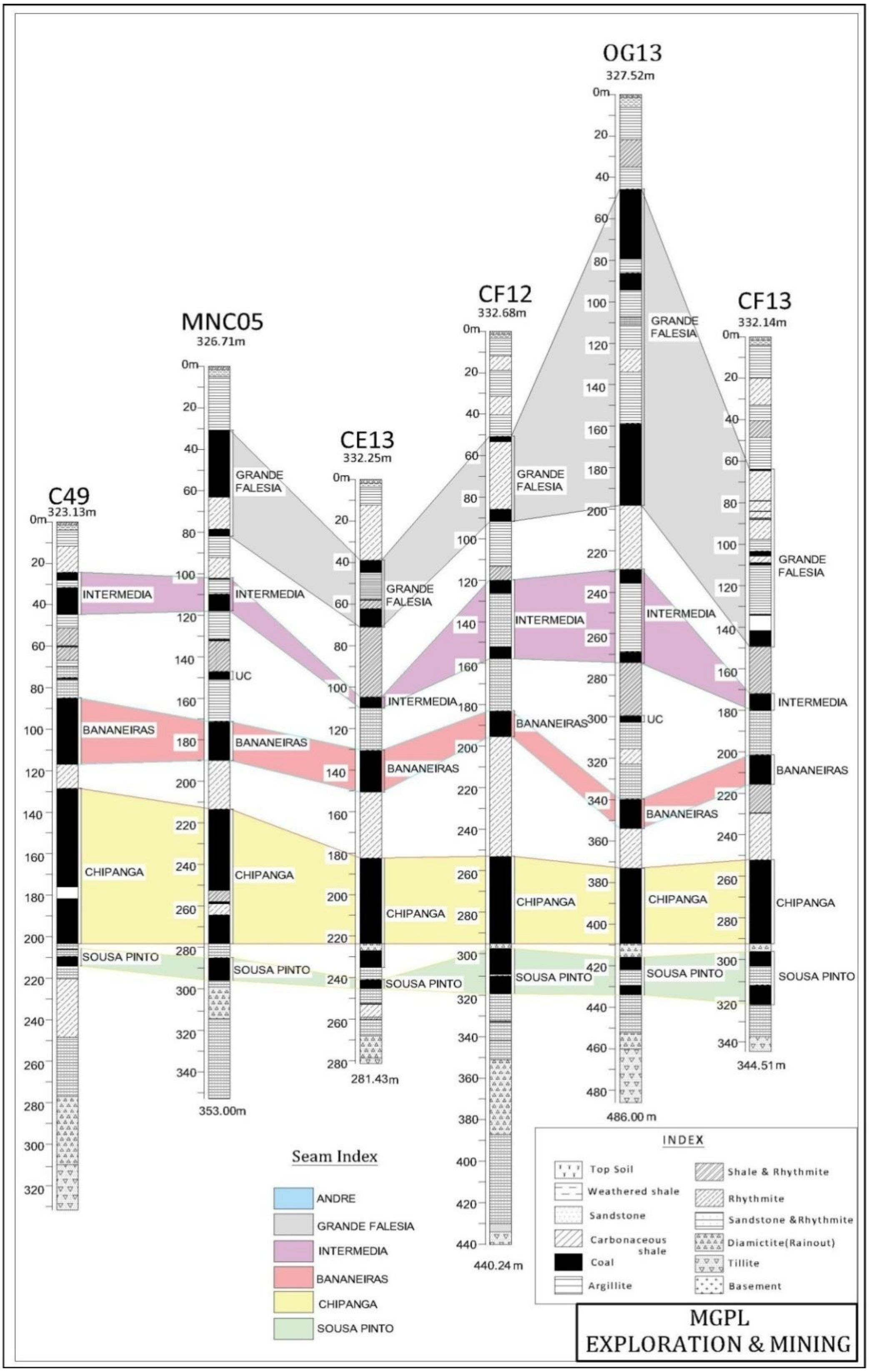


Fig. 4-9: Geological continuity of coal seams in part of Rb-B and Rb-E together(down dip)

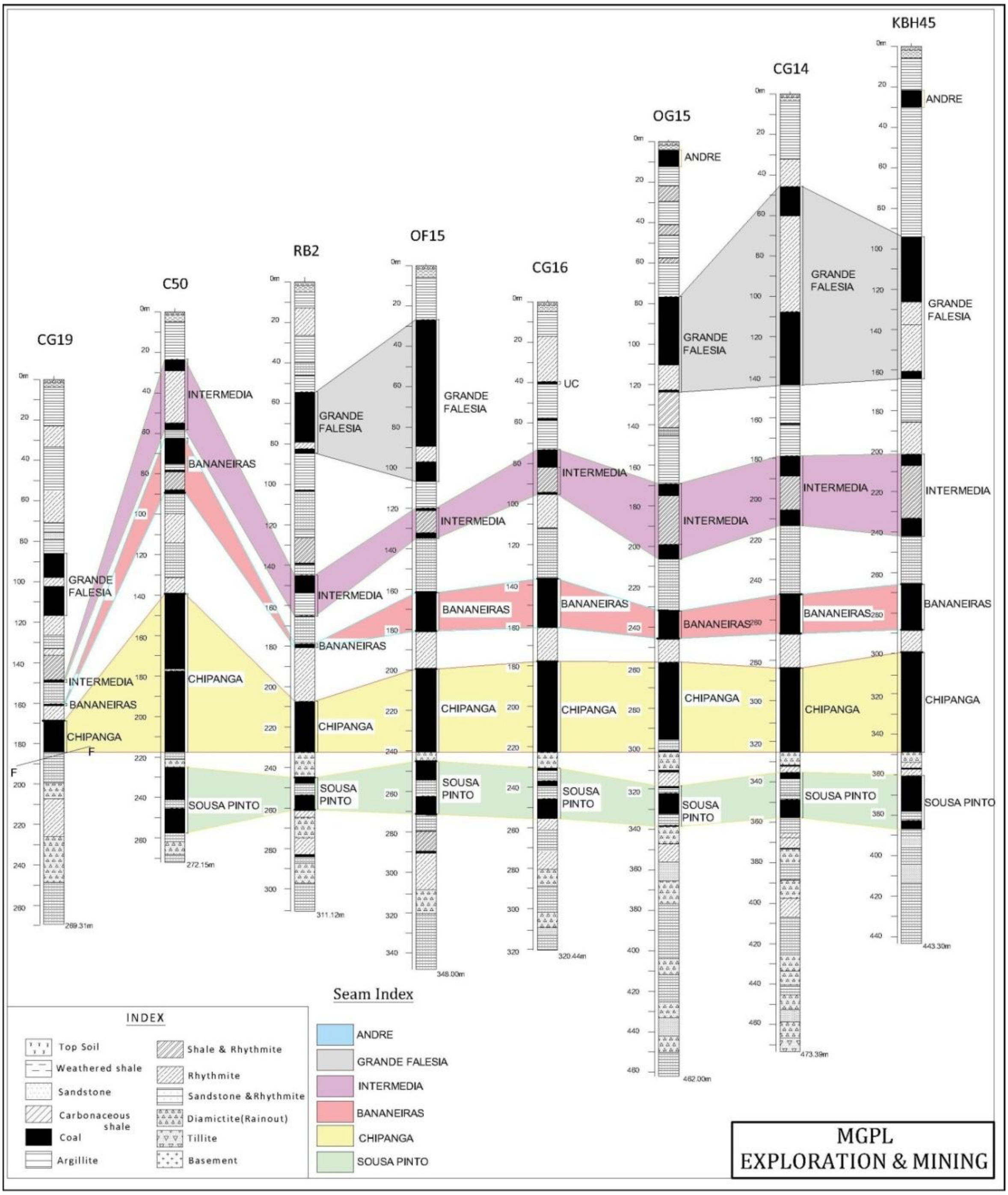


Fig. 4-10: Geological continuity of coal seams in part of Rb-B(strike-ise)

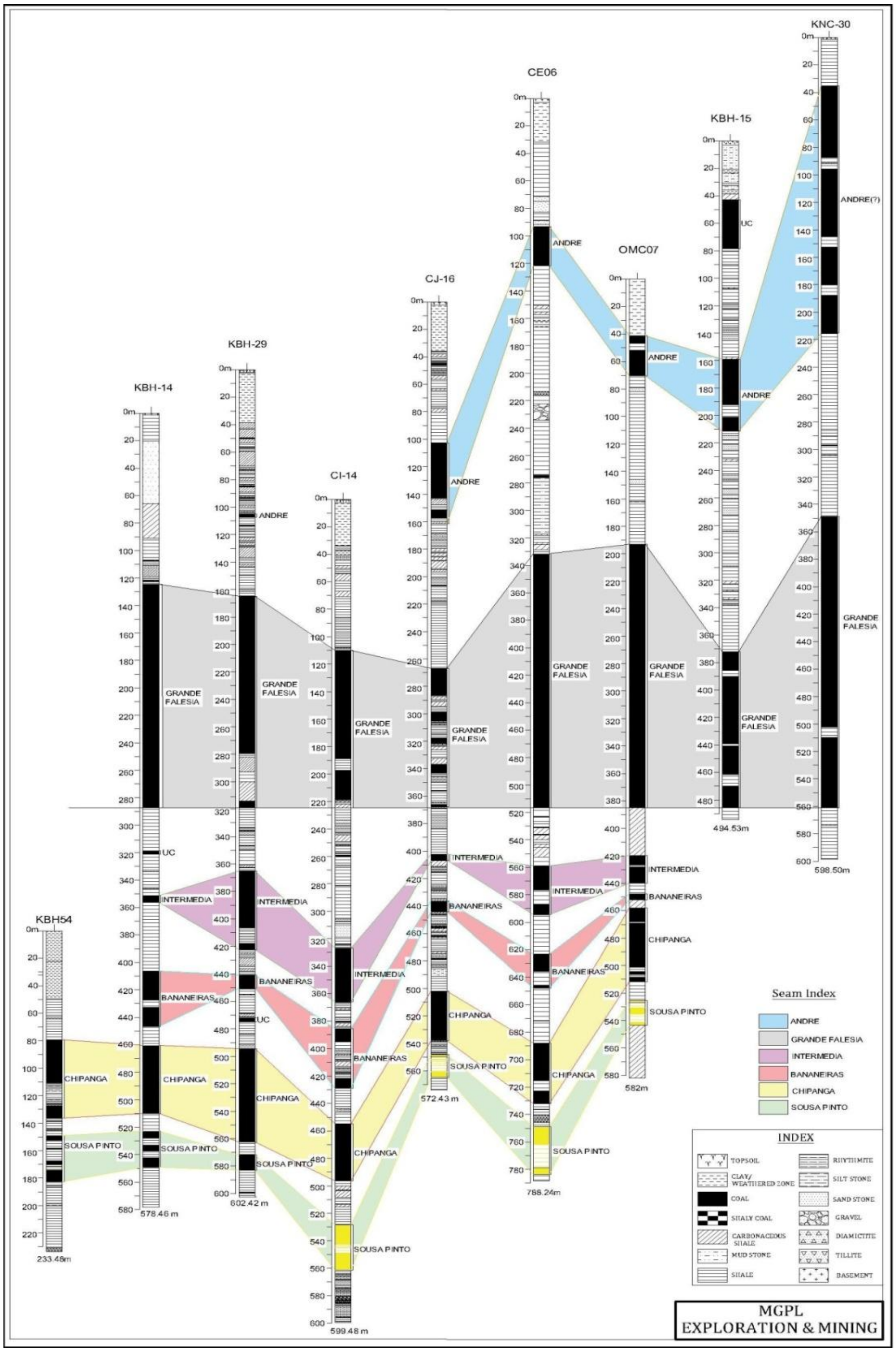


Fig. 4-11: Geological continuity of coal seams in part of Rb-B

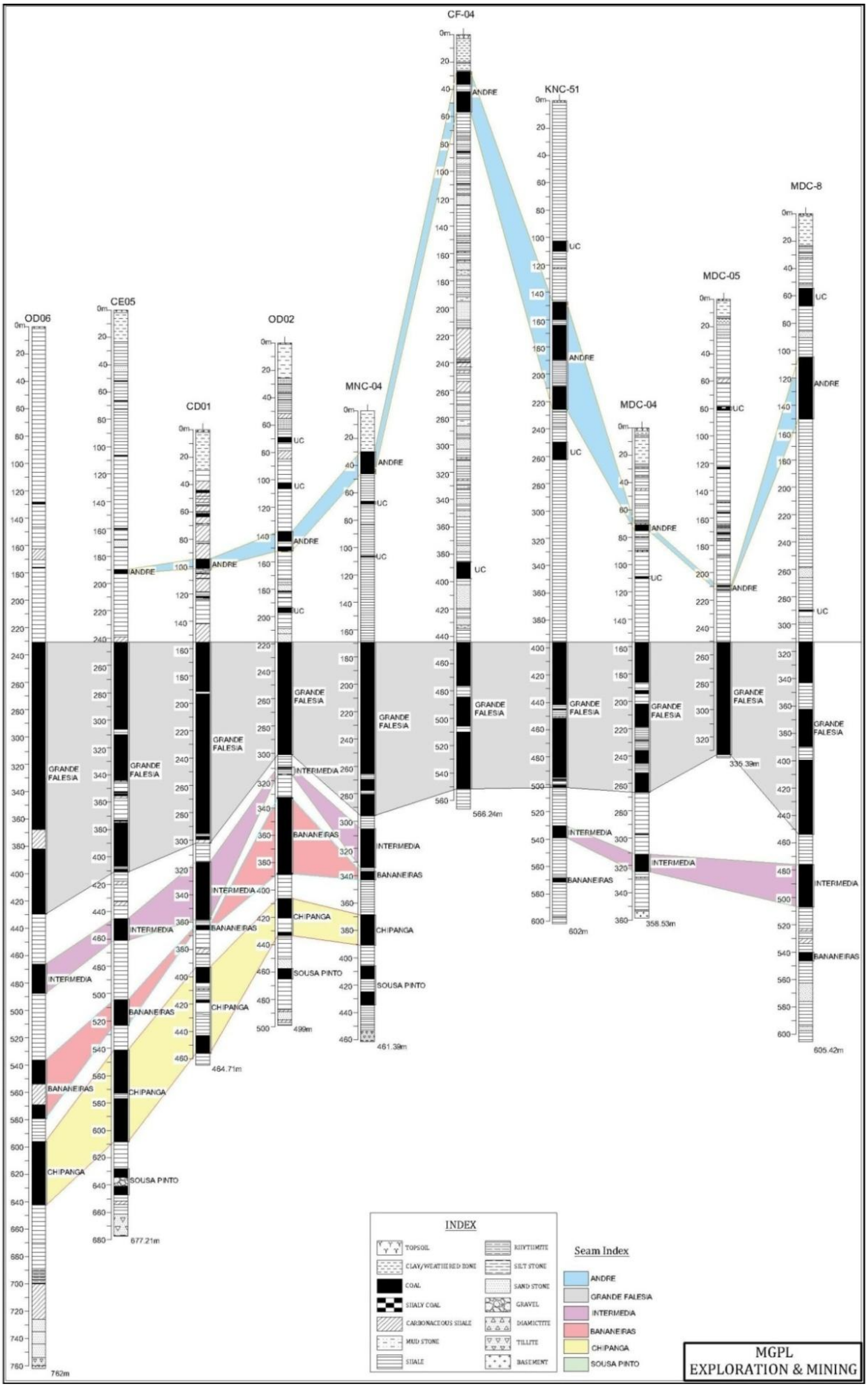


Fig. 4-12: Geological continuity of coal seams in part of Rb-f

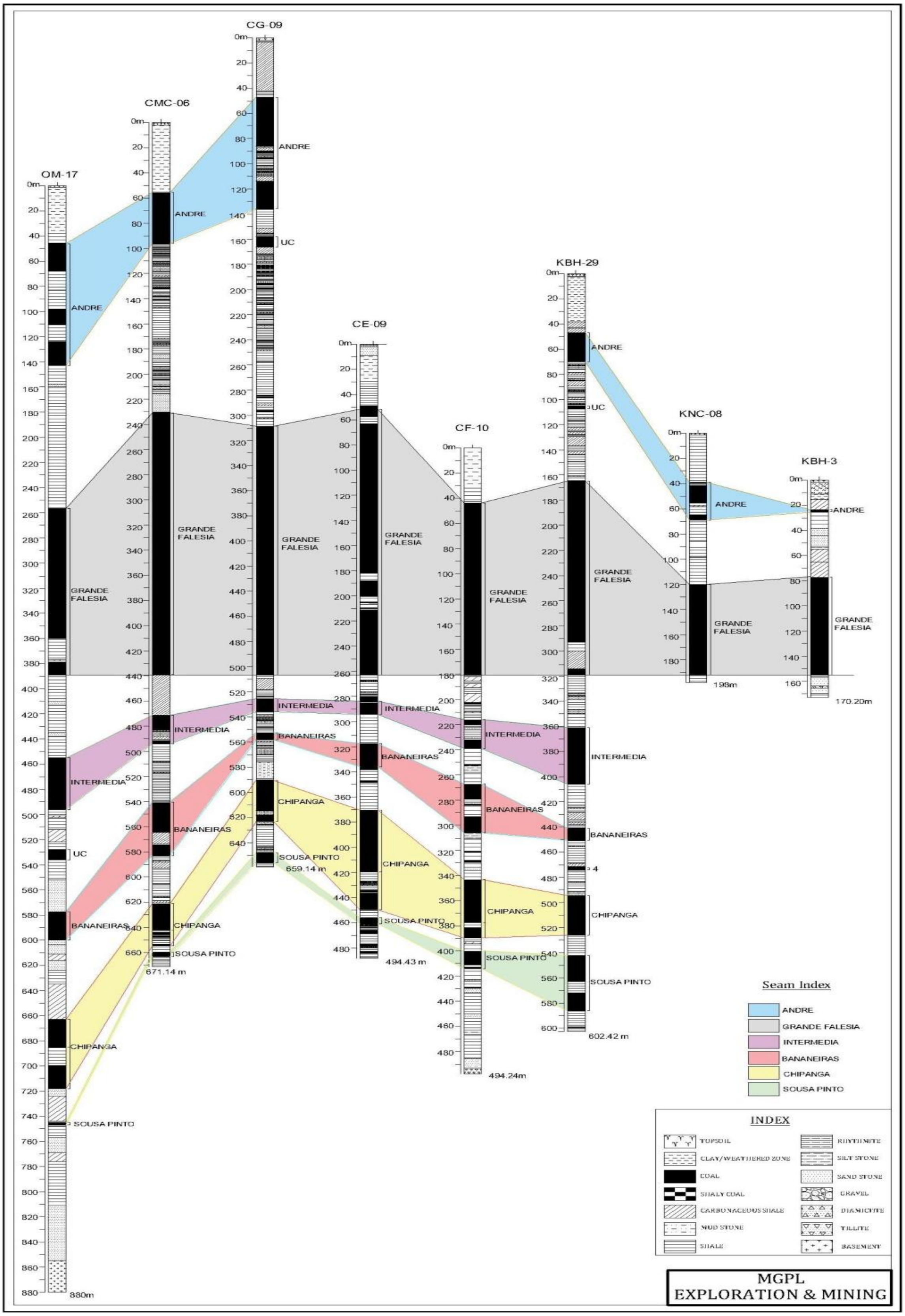


Fig. 4-13: Geological continuity of coal seams in part of Rb-A and Rb-F togethr

4.2 FAULTS AND FAULT MODELS(Figs. 4-14, 4-15, 4-16 & 4-17):

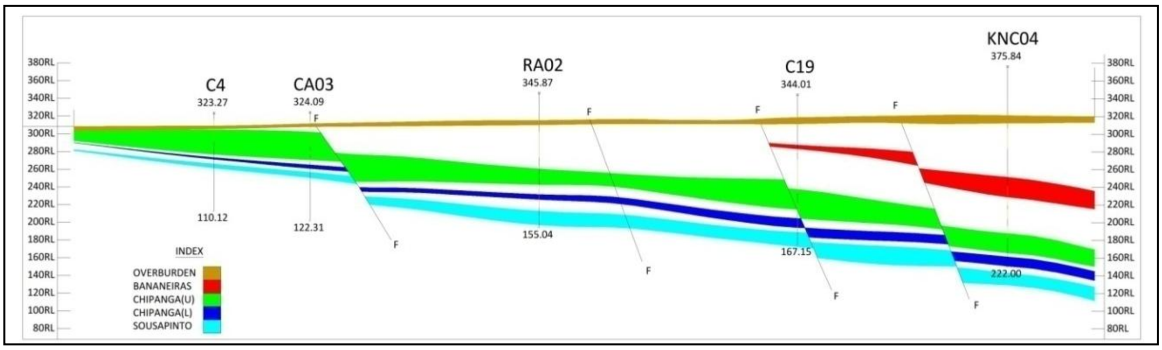


Fig. 4-14: Transverse section along the projected boreholes in Mb-A showing impact of faults and throwpattern

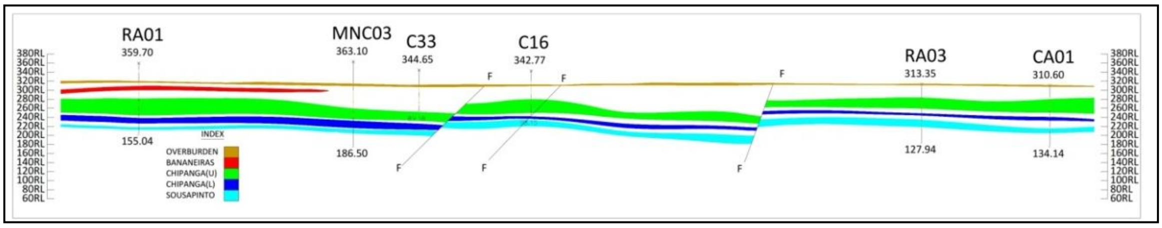


Fig. 4-15: Longitudinal section along the projected boreholes in Mb-A

Major faults identified in the present level of fault modelling are shown in Fig.4-14 and Fig.4-15 respectively.

In 2023 after completion of in-fill drilling, with the data accrued there upon a revised minex model has been prepared in this stage fault models have been drawn as shown in Fig.4-16. This model has focused on fault controlled models. The revised model several longitudinal and transverse sections have prepared to re-assured the coal seam continuity (Figs. 4-18 to 4-29).

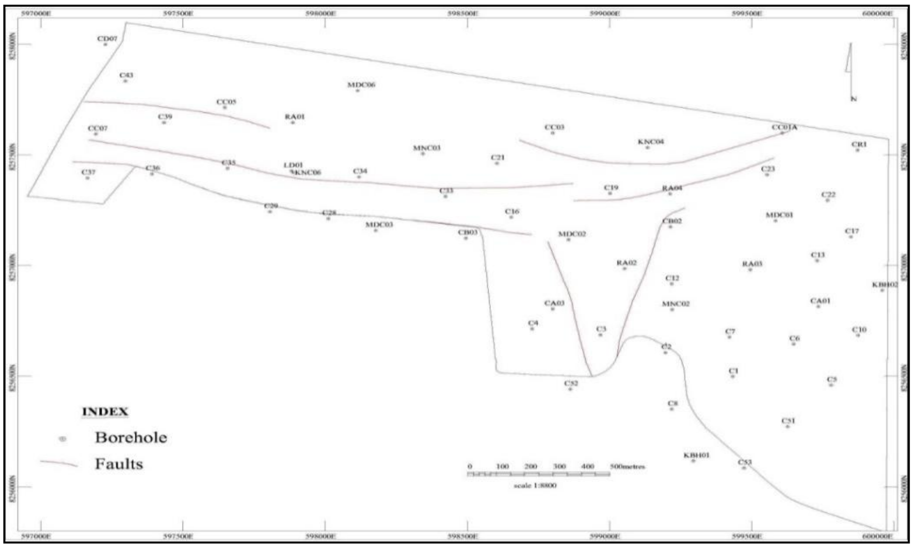


Fig.4-16: Fault controlled model

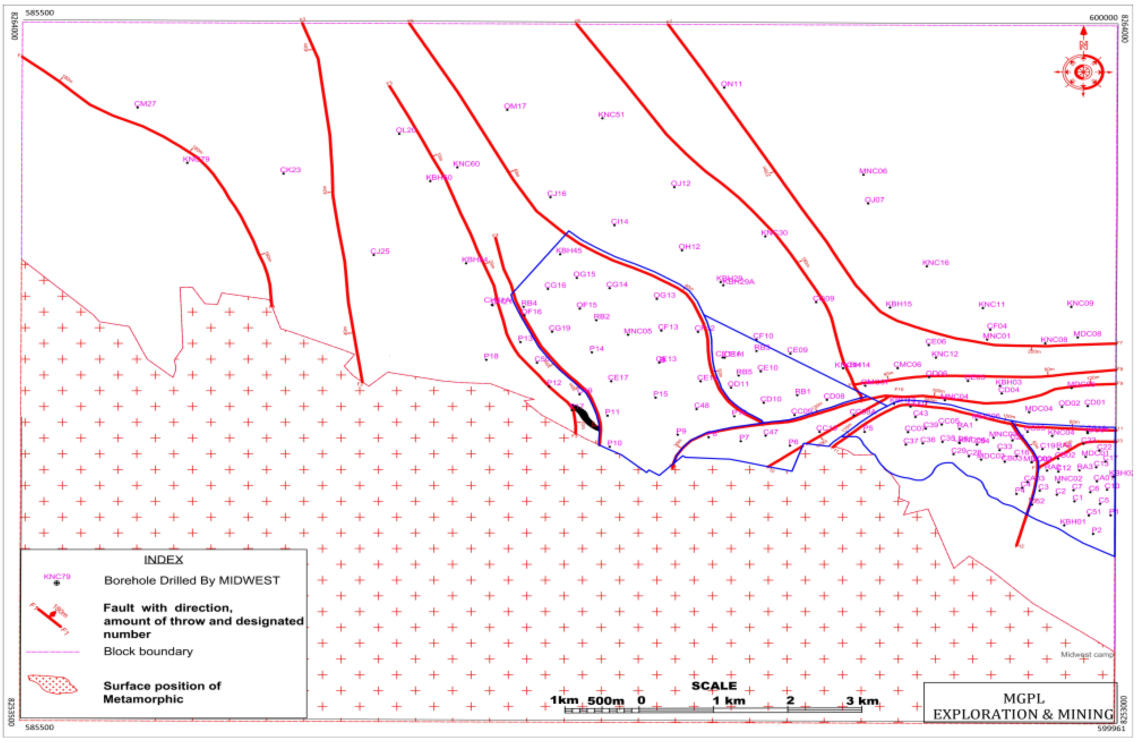


Fig.4-17: Fault model

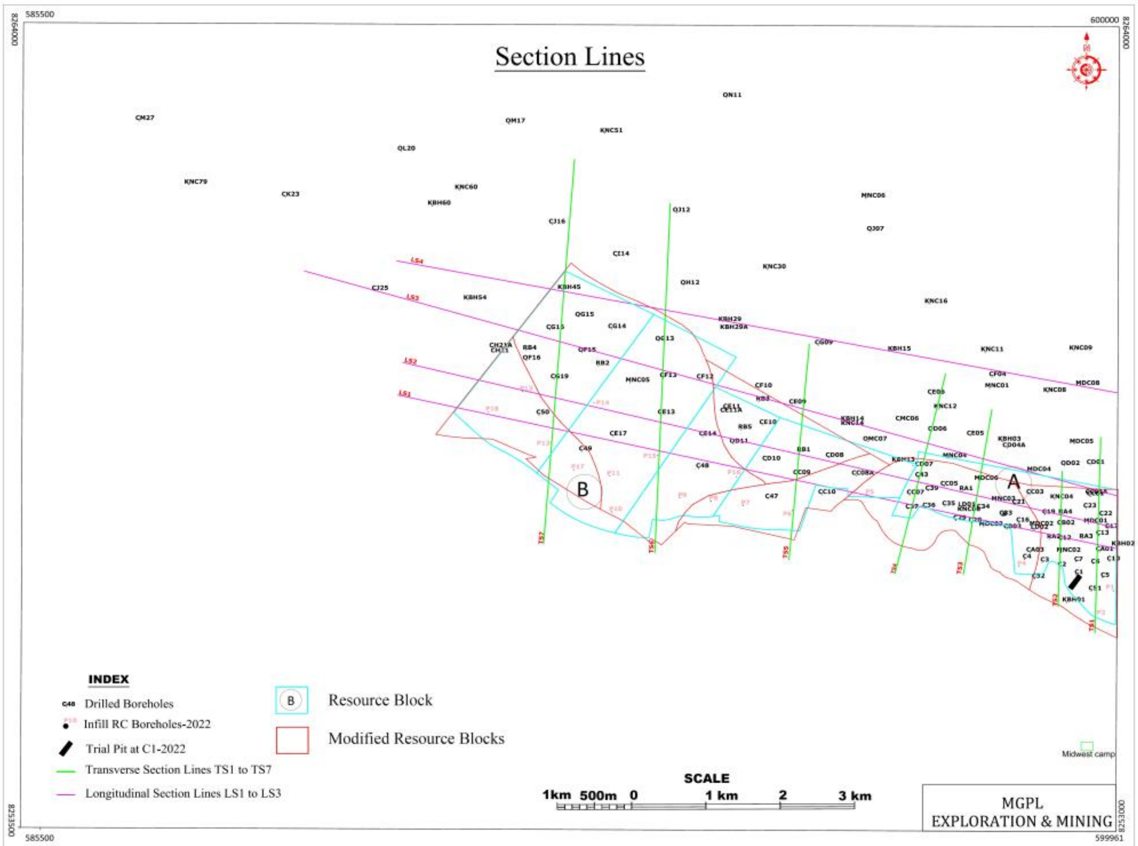


Fig. 4-18: Section lines

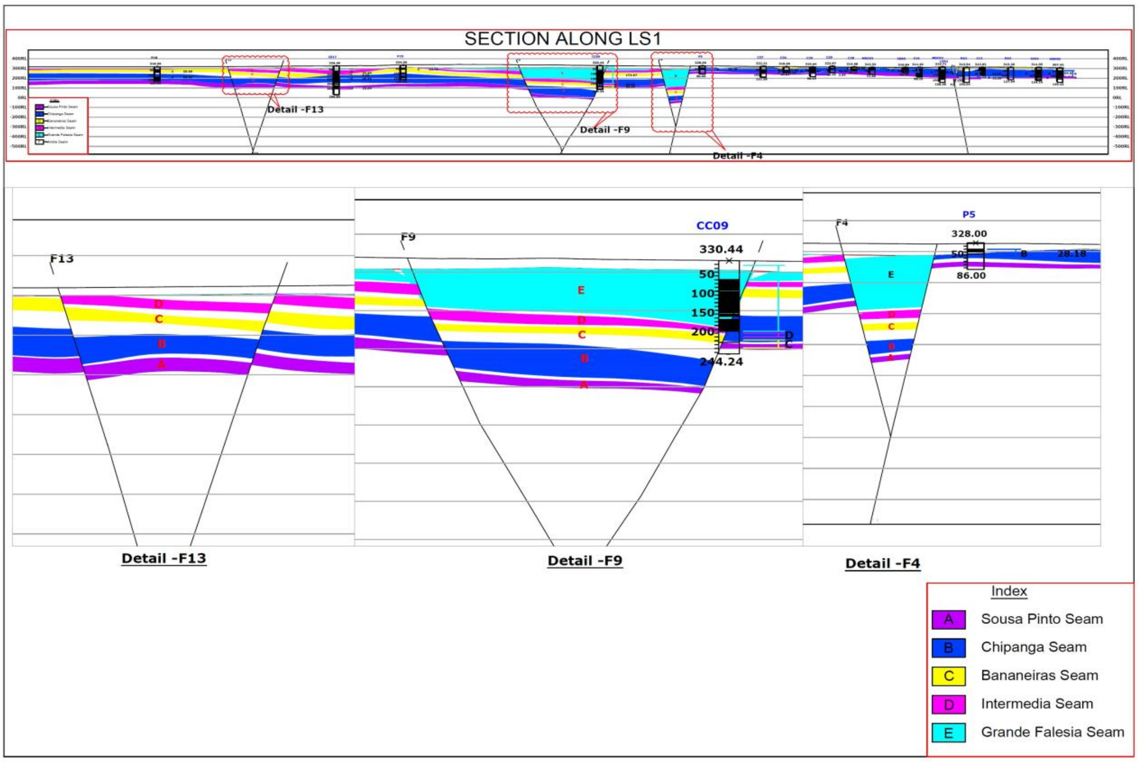


Fig. 4-19: Longitudinal Section LS1

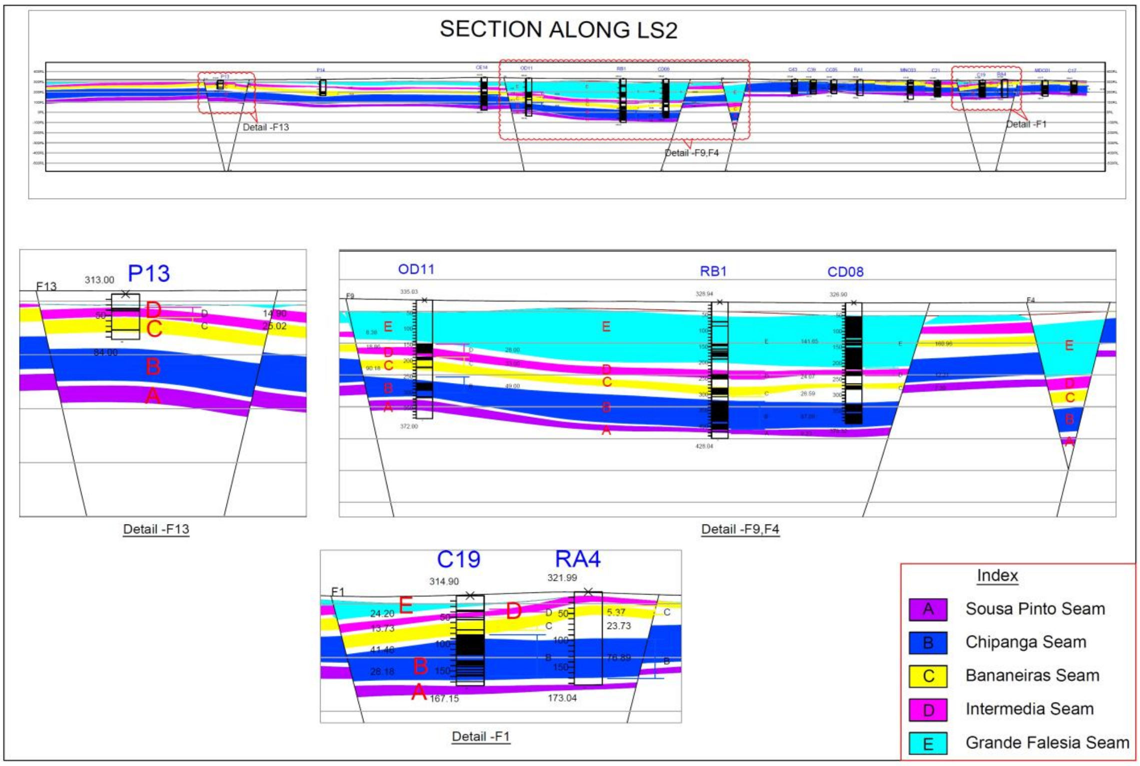


Fig.4-20: Longitudinal Section LS2

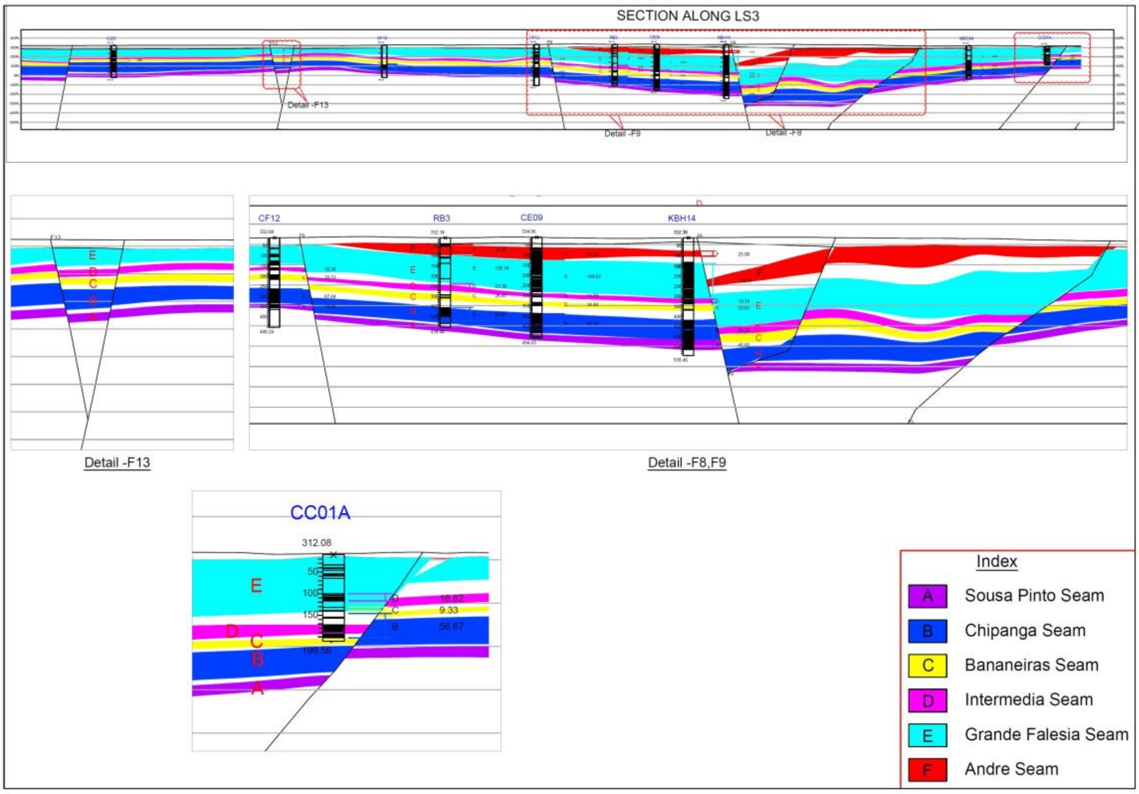


Fig.4-21: Longitudinal Section LS3

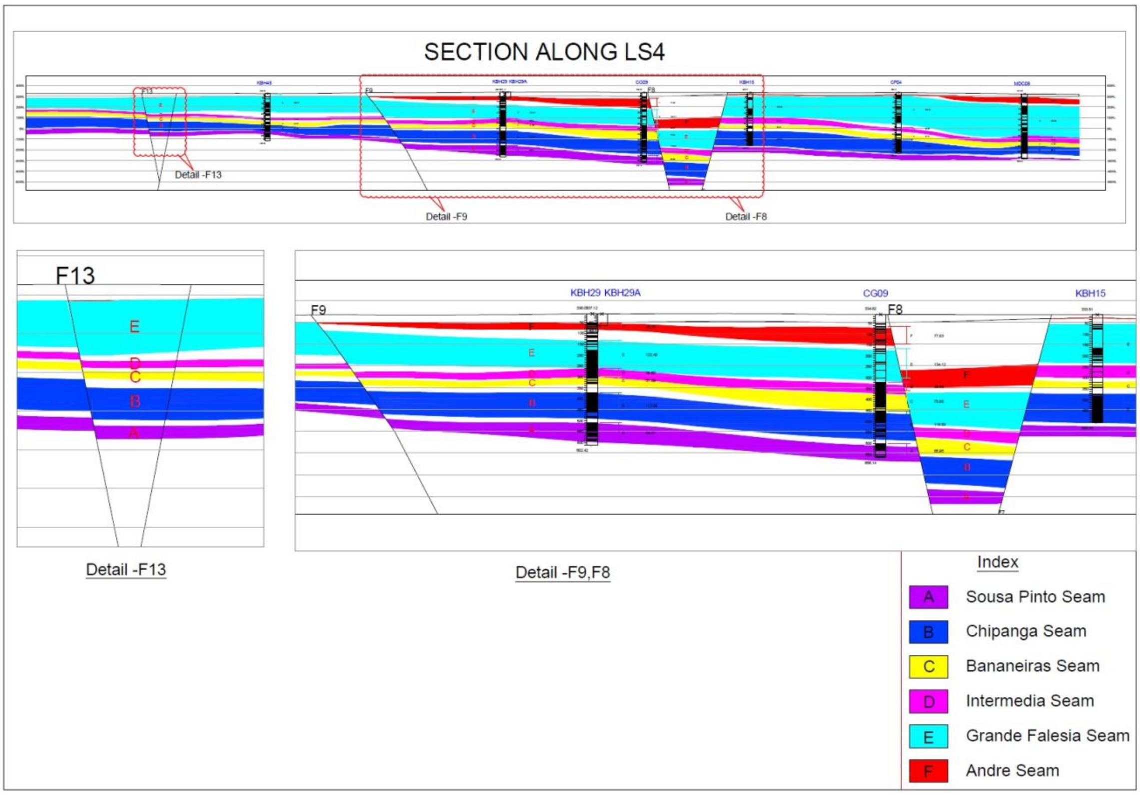


Fig. 4-22: Longitudinal Section LS4

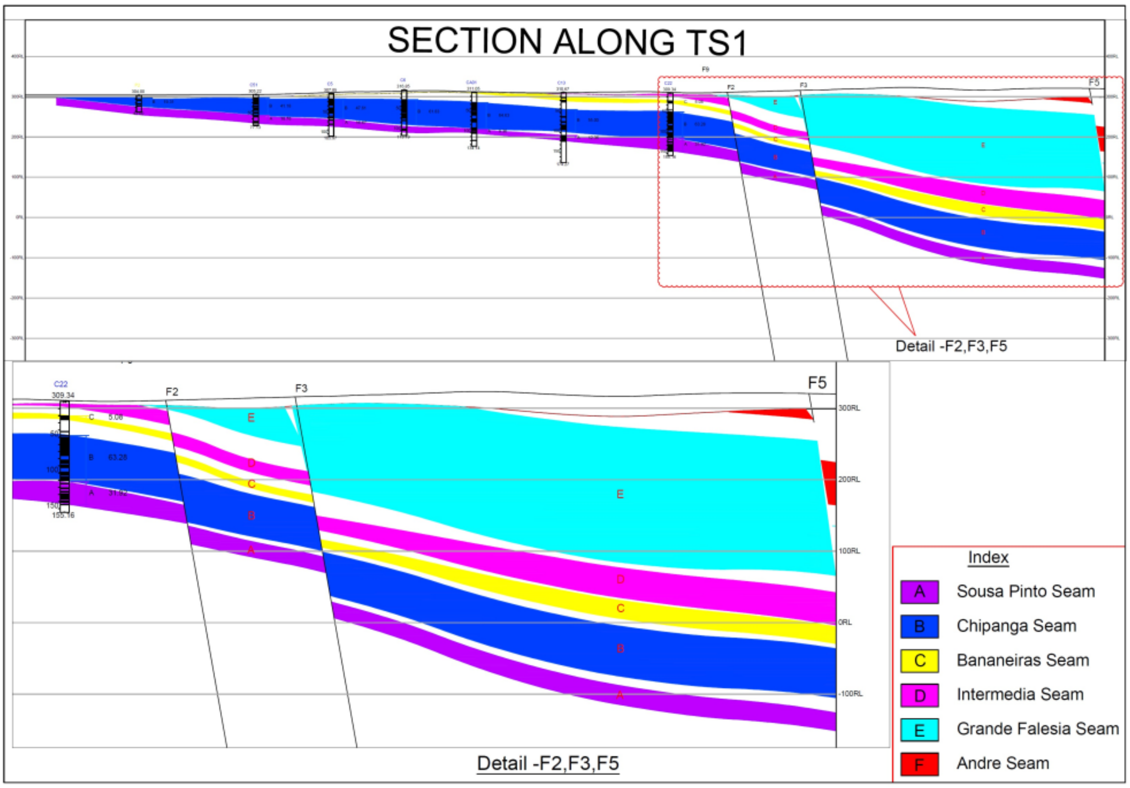


Fig. 4-23: Transverse Section TS1

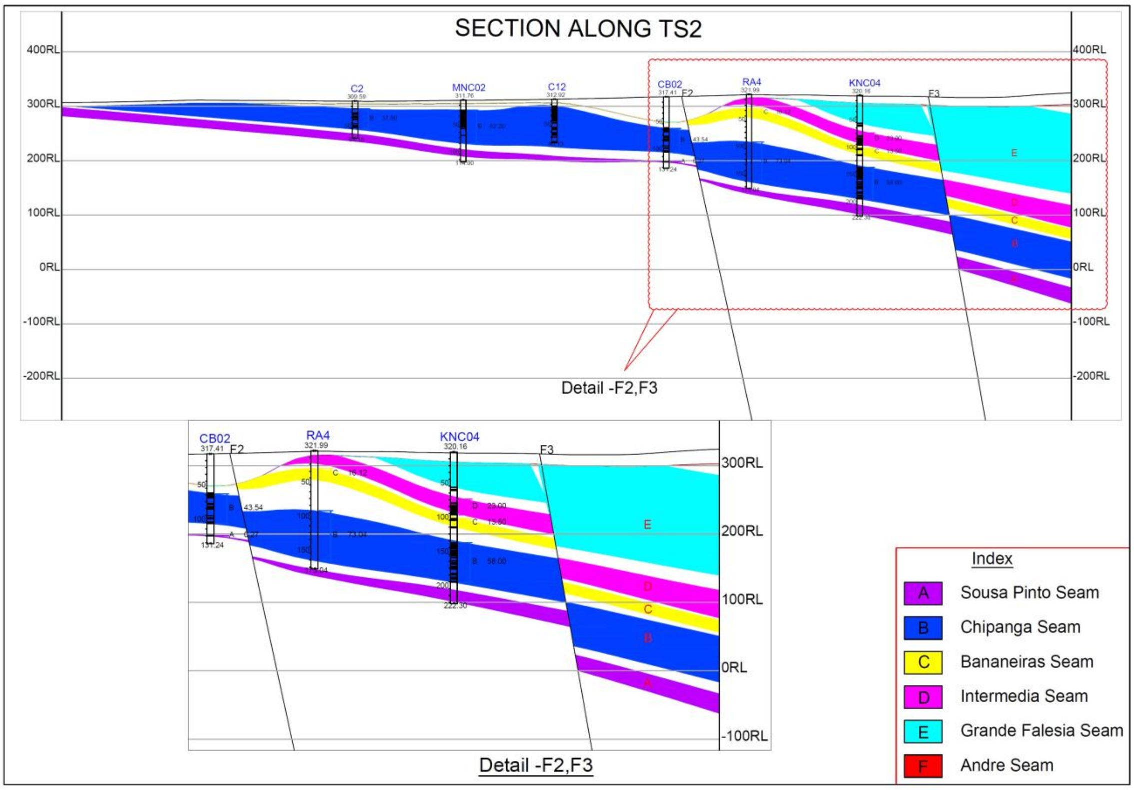


Fig. 4-24: Transverse Section TS2

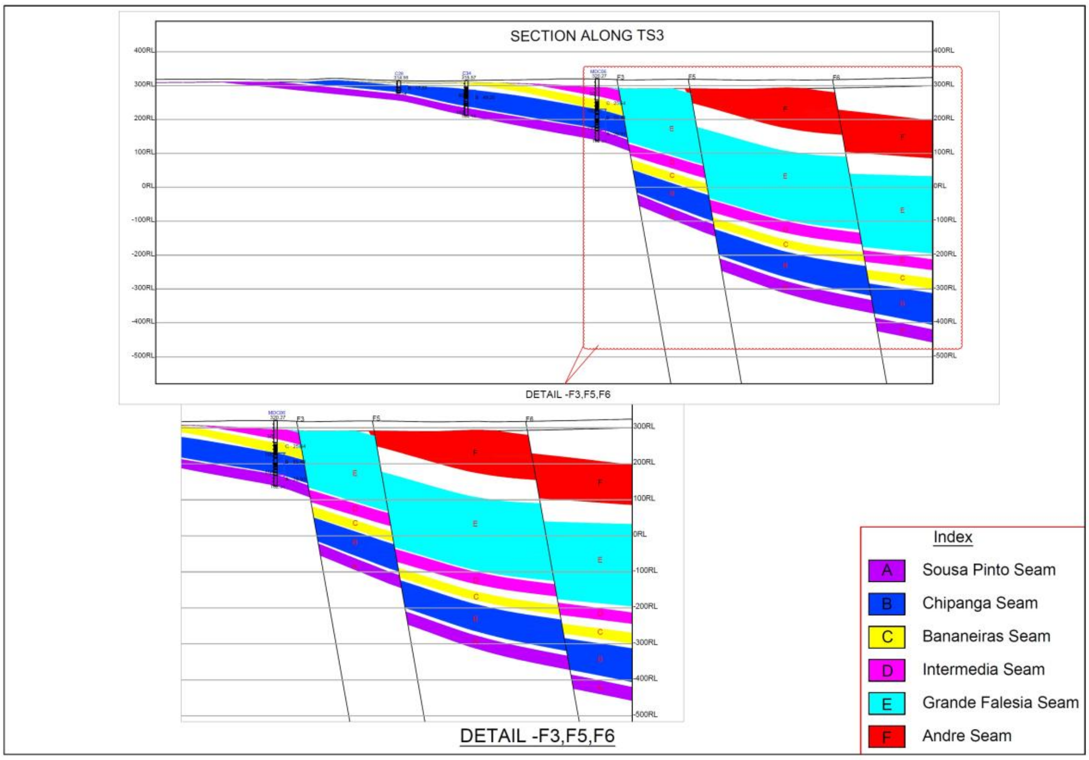


Fig. 4-25: Transverse Section TS3

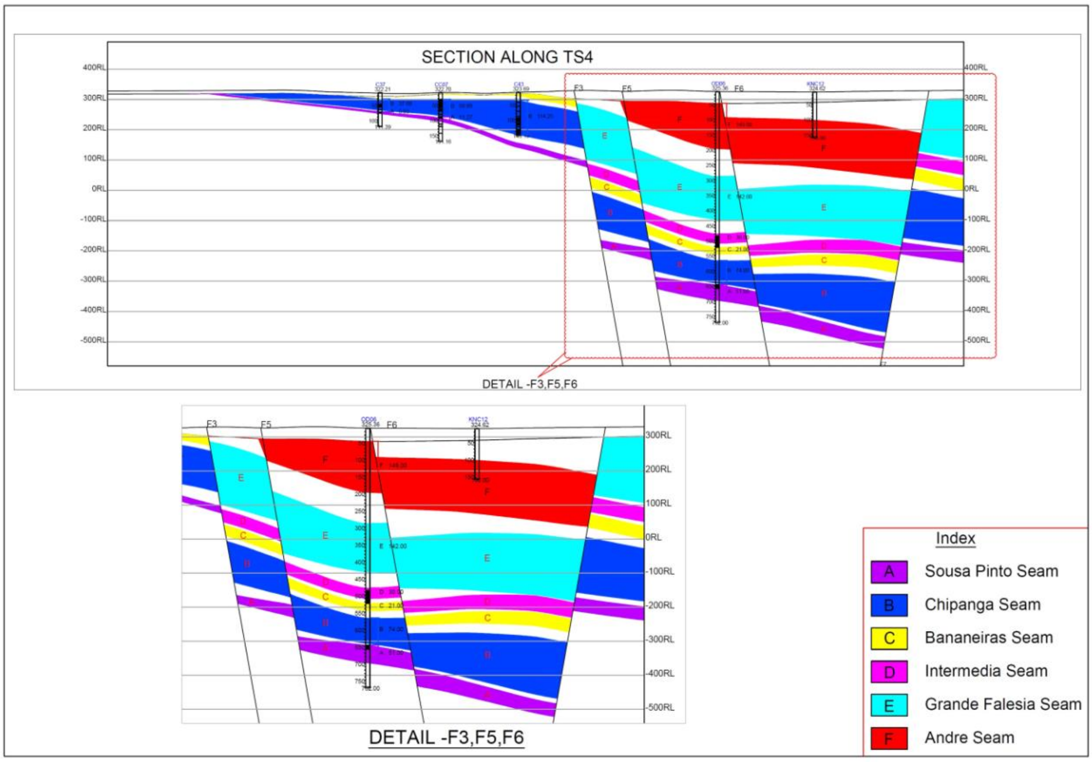


Fig. 4-26: Transverse Section TS4

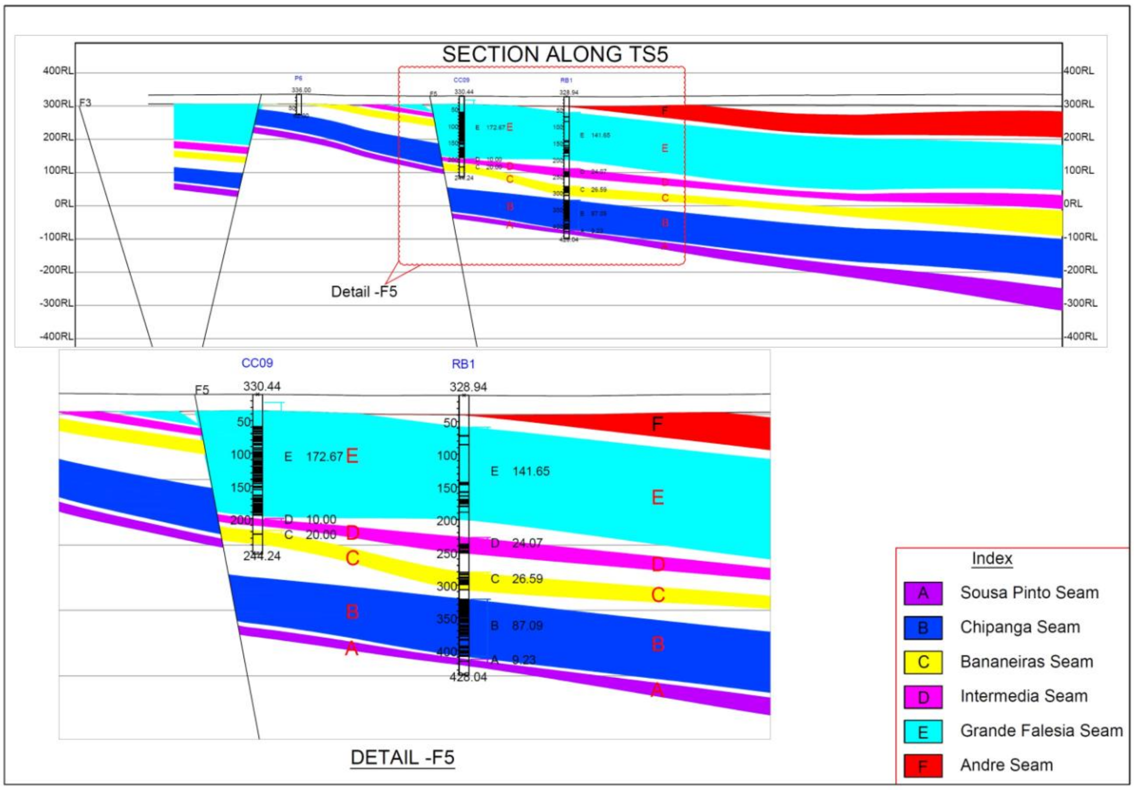


Fig.4-27: Transverse Section TS5

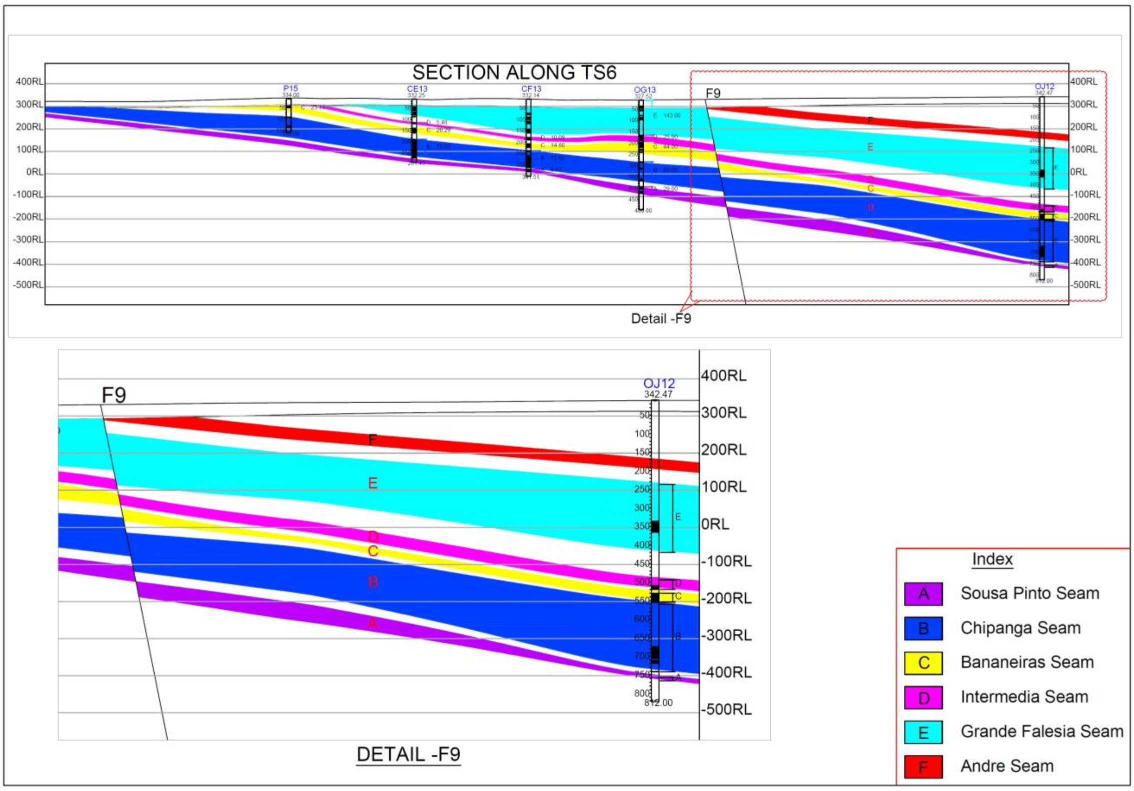


Fig. 4-28: Transverse Section TS6

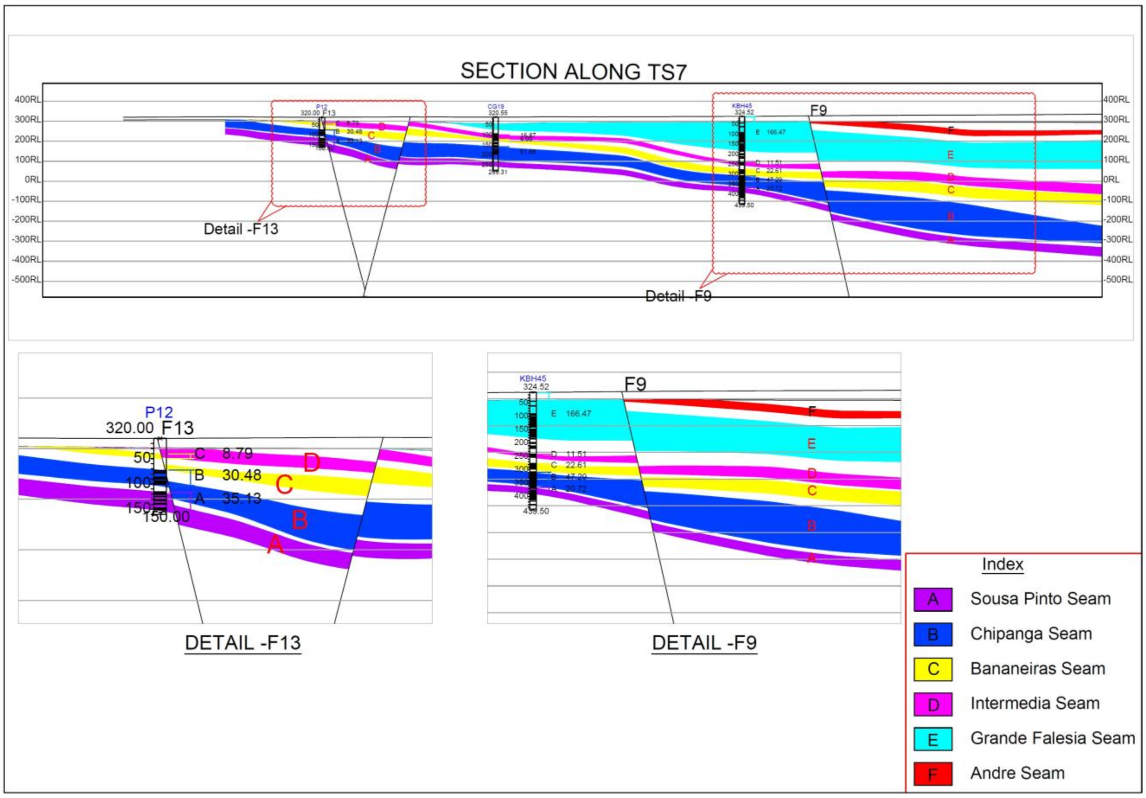


Fig. 4-29: Transverse Section TS7

5 RESOURCE&RESERVES

5.1 CUT -OFF PARAMETERS

- **Coal:** Coal is defined as carbonaceous bed whose total ash + moisture component does not exceed 55% as per Indian standards; SANS, 2004 prescribes 50% ash to define coal in case of multi seam type of deposits and 65% in case of thick interbedded type of deposits. In the present study ash cut off is taken as 55%.
- **Carbonaceous Shale/mudstone:** It is that part of carbonaceous bed inter-stratified with coal beds and contains 55 to 75% ash and carries some calorific value.
- **Parting:** It is a mudstone bed interstratified with coal and carbonaceous mudstone beds. Ash content in parting beds is over 75%. It is considered as overburden or inter-burden/intra-burden as the case may be.
- **True Thickness:** Coal Seams in this deposit are sub-horizontal i.e. 5 to $10^{o.}$ True thickness is derived from core bores perpendicular to dip of beds.
- **Net coal thickness:** Net coal thickness is the summation of the thickness of coal beds at each point of observation in whole seam. For working out net coal thickness at each point of observation, the minimum coal bed thickness considered is taken as 10 cm. The reasons being the Surface Miner is designed to effectively mine out the coal beds of 10cm and above.
- **Potentially workable sections (PWS):** A PWS is that part of whole seam (see Fig.3-18) which analyses <55% ash including clean coal and/or carbonaceous shale beds on weighted average basis when mined together. Minimum thickness of PWS is 0.2 m and maximum height recorded is 6.5m. To estimate minable coal reserves, PWS with <50% ash has been considered.
- **Theoretical Mining height.** It is the height of full seam or optimum selected part of the seam based on a geological assessment that is expected to be mined. Theoretical mining height considered is 10 cm for the Surface Miner mining method.
- **Justification**: -Thickness of composite coal seams is very high and characterized by the presence of multiple separately mineable waste bands. The CP opinions that any estimation from roof to bottom of whole seam may be cumbersome at whole seam level for thick interbedded type composite seams. Therefore, resource is estimated and reported for all (one or multiple) PWS of full seam at block level in case of GTIS and TTIS; Number of PWS varies from seam to seam. Thickness of PWS is considered as theoretical mining height. Minimum height is 10cm, effective height 20cm, ideal height 30 cm, therefore it is flexible. Justification to this is that the proposed open pit coal mining deploys surface miner which can effectively mine coal beds of 10 cm thickness and above.
- **Relative Density**: Relative density considered for estimating the GTIS is 1.7 g/cm^3; and 1.67 g/cm^{3}for PWS of <50% ash. Minex feed data has been composed from laboratory determination of every coal sample in case of core boreholes or as derived from calibrated geophysical logs in case of open holes.

- **Points of observation**: Point of observation is the coordinated position of borehole where characterization of full coal seam was achieved either by direct or indirect methods. The direct observation is cored boreholes with quality and down-hole geophysical log. The indirect point of observation is an open hole where the coal seam identification is invariably supported by down-hole geophysical log (see Appendex-1 for coordinates for point of observation).
- Spacing/interval between points of observation.
- Spacing between points of observation consider for various categories of resource estimation are as follows
- Measured: Spacing between points of observation is 250m - 500m radius.
- Indicated: Spacing between points of observation is 500m - 1000m radius.
- Inferred: spacing between points of observation is 1000 - 3000m radius.

5.2 RESOURCE BLOCKS

RESOURCE & RESERVES:

During PFS study the Resource has been estimated at 55% ash cut-off. Input csv files were developed for computing resource estimates on MINEX software. Total area covered by drilling for resource delineation amounts to 5028 ha. With a view to ensure clarity, the total resource area, where drilling has been conducted at either closer or wider spacing, has been divided into seven resource blocks designated as Rb-A, Rb-B, Rb-C, Rb-D, Rb-E, Rb-F and Rb-G (see Fig.5-1)The criteria adopted here is strike continuation and dip wise persistence of the seams. Resource estimates have been presented for whole resource area as well as block level. Coordinates of the resource area is given below.

Table 5.1: Coordinates of Total Resource Area

TOTAL RESOURCE AREA			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	599989	8259391
2	36 L	597679	8259896
3	36 L	597849	8260192
4	36 L	593111	8263901
5	36 L	592608	8263273
6	36 L	590723	8263719
7	36 L	589631	8262226
8	36 L	585276	8264088
9	36 L	585270	8262487
10	36 L	587815	8260939
11	36 L	587425	8260307
12	36 L	590230	8258775
13	36 L	591309	8257907
14	36 L	592278	8257291
15	36 L	592571	8257099
16	36 L	592989	8256978
17	36 L	593027	8257035
18	36 L	593327	8256979
19	36 L	593633	8256984
20	36 L	594410	8257094
21	36 L	594507	8257243
22	36 L	595654	8256916
23	36 L	595791	8257332
24	36 L	595960	8257334
25	36 L	596056	8257321
26	36 L	596069	8257307
27	36 L	596074	8257203
28	36 L	596184	8257167
29	36 L	596355	8257141
30	36 L	596503	8257203
31	36 L	596670	8257343
32	36 L	596760	8257446
33	36 L	596792	8257457
34	36 L	596840	8257412
35	36 L	596882	8257287
36	36 L	596896	8257163
37	36 L	596760	8256807
38	36 L	597116	8256651
39	36 L	597330	8256935
40	36 L	597880	8256683
41	36 L	598117	8257199
42	36 L	598545	8257168
43	36 L	598609	8256336
44	36 L	598704	8256261
45	36 L	599038	8256102
46	36 L	599973	8255709
47	36 L	599989	8259391

COORDINATES OF RESOURCE BLOCK

Rb-A			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	599974	8255708
2	36 L	599986	8258334
3	36 L	597294	8259215
4	36 L	597287	8258011
5	36 L	596761	8256806
6	36 L	597117	8256651
7	36 L	597331	8256935
8	36 L	597881	8256683
9	36 L	598118	8257198
10	36 L	598552	8257169
11	36 L	598610	8256336
12	36 L	598704	8256261

Rb-B			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	590236	8258777
2	36 L	591620	8257692
3	36 L	592613	8257086
4	36 L	592989	8256978
5	36 L	593032	8257035
6	36 L	593480	8256982
7	36 L	594410	8257094
8	36 L	594507	8257243
9	36 L	595654	8256916
10	36 L	595791	8257332
11	36 L	596056	8257321
12	36 L	596074	8257203
13	36 L	596355	8257141
14	36 L	596792	8257457
15	36 L	596896	8257163
16	36 L	597053	8257542
17	36 L	597290	8258033

Rb-C			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	589631	8262226
2	36 L	585276	8264088
3	36 L	585270	8262487
4	36 L	587815	8260939
5	36 L	587425	8260307
6	36 L	590213	8258767
7	36 L	590822	8259887
8	36 L	591414	8261062
9	36 L	589631	8262226

Rb-D			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	591414	8261062
2	36 L	589631	8262226
3	36 L	590723	8263719
4	36 L	592608	8263273
5	36 L	592019	8262063
6	36 L	591714	8261434
7	36 L	591486	8261205
8	36 L	591414	8261062
9	36 L	591414	8261062

Rb-E			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	591486	8261205
2	36 L	591714	8261434
3	36 L	592019	8262063
4	36 L	597293	8259215
5	36 L	597283	8258575
6	36 L	591486	8261205
7	36 L	591486	8261205

Rb-F			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	597679	8259896
2	36 L	599989	8259391
3	36 L	599985	8258334
4	36 L	597293	8259215
5	36 L	597679	8259896

Rb-G			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	597293	8259215
2	36 L	597679	8259896
3	36 L	597849	8260192
4	36 L	594811	8262609
5	36 L	594811	8262609
6	36 L	593111	8263901
7	36 L	592608	8263273
8	36 L	592019	8262063
9	36 L	597293	8259215

5.3 RESOURCE ESTIMATE (ELABORATION)

Method: The following input files were used during the resource modeling and estimation. Database (Input) for Minex application:

1. Collar_data.csv - Consists of X, Y, Z coordinates (Annex- X).

2. Litho_data.csv - Consists of lithologies of all boreholes (Annex- X).

3. Quality_data.csv - Band by band analysis file (Annex- X).

4. Seam_data.csv - Correlated Seam Pick file (Annex- X). (PWS)

5. Boundary coordinates in UTM for resource blocks Dwg file (Annex- X).

6. Topographic survey files Dwg (Annex- IV).

5.4 INSITU COAL RESOURCES

5.4.1 Gross Total In-Situ Resources (GTIS):

GTIS is tonnage and coal quality at specified moisture content, contained in the full seam above the minimum thickness cut off of 0.3 m as well as quality cut off of Moisture 2%, ash <55% and Rd 1.7. GTIS estimate for whole resource area of 5028 ha is shown in Table 5.6.

Table 5.2: Seam wise GTIS – Gross in-situ coal resource for 5028ha (seam-wise)

.

CATEGORY/SEAM NAME	A	B	C	D	E	F	Grand Total
MEASURED	139,226,806	400,644,221	69,301,733	78,542,028	161,667,836	18,789,840	**868,172,464**
INDICATE	235,536,925	780,920,233	166,207,209	225,686,817	486,956,433	46,852,482	**1,942,160,099**
INFERRED	275,404,520	1,149,066,406	220,816,237	298,627,773	577,687,005	35,838,704	**2,557,440,645**
Grand Total	**650,168,251**	**2,330,630,860**	**456,325,179**	**602,856,618**	**1,226,311,274**	**101,481,026**	**5,367,773,208**
	A- Sauso Pinto	**B= Chipanga**	**C= Bananeiras**	**D=Intermedia**	**E= Grande felsia**	**F=Andre Seam**	

Say total GTIS= 5367 MMT

GTIS (Gross Total in-situ resources) for 5028ha = 5367 MMT.

TTIS (Total in-situ tones): After accounting for geological loss and model estimation error from GTIS, the total in-situ resource (TTIS) is estimated and presented in (Table 5.3).

4294 MMT (rounded off to 4.2 Bt) with a raw coal assay of

RD: 1.69; Moist: 1.66%; Ash: 45.03%; VM: 23.42%; FC: 29.89%; GCV: 4172 kcal/kg; CSN: 0-5. The reported TTIS occurs within depths of 8m to ~600m from the surface.

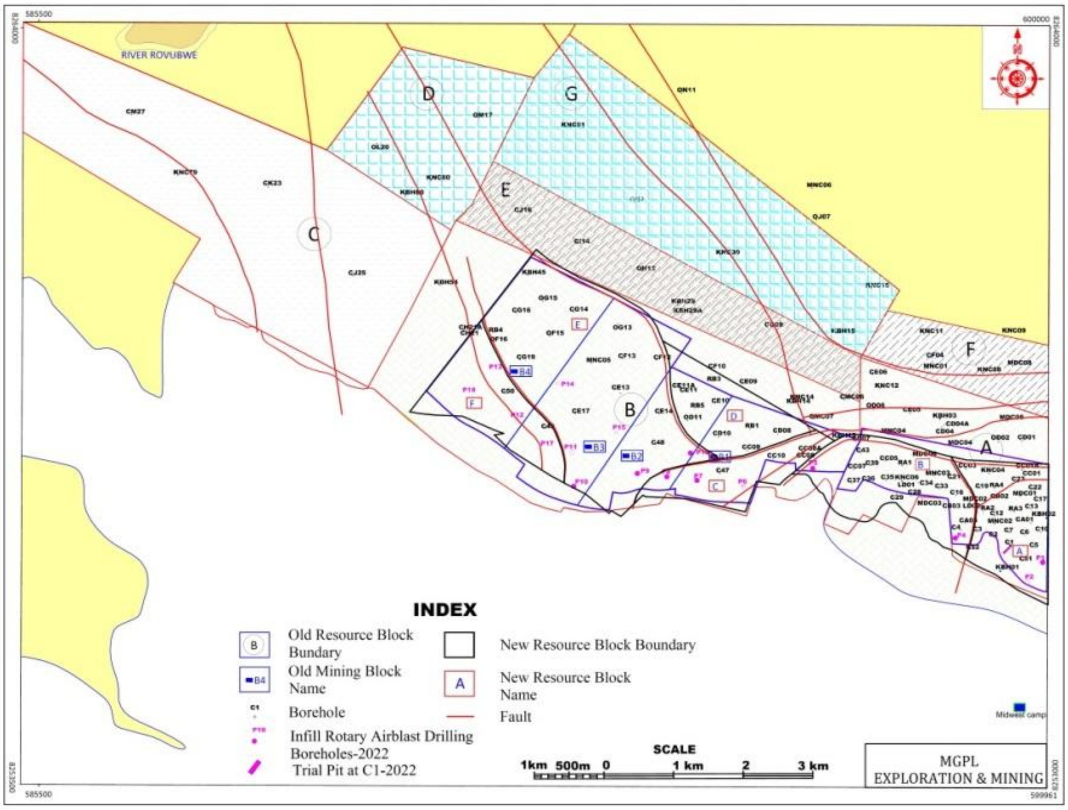


Fig.5-1: Geological map of 5086C showing resource blocks

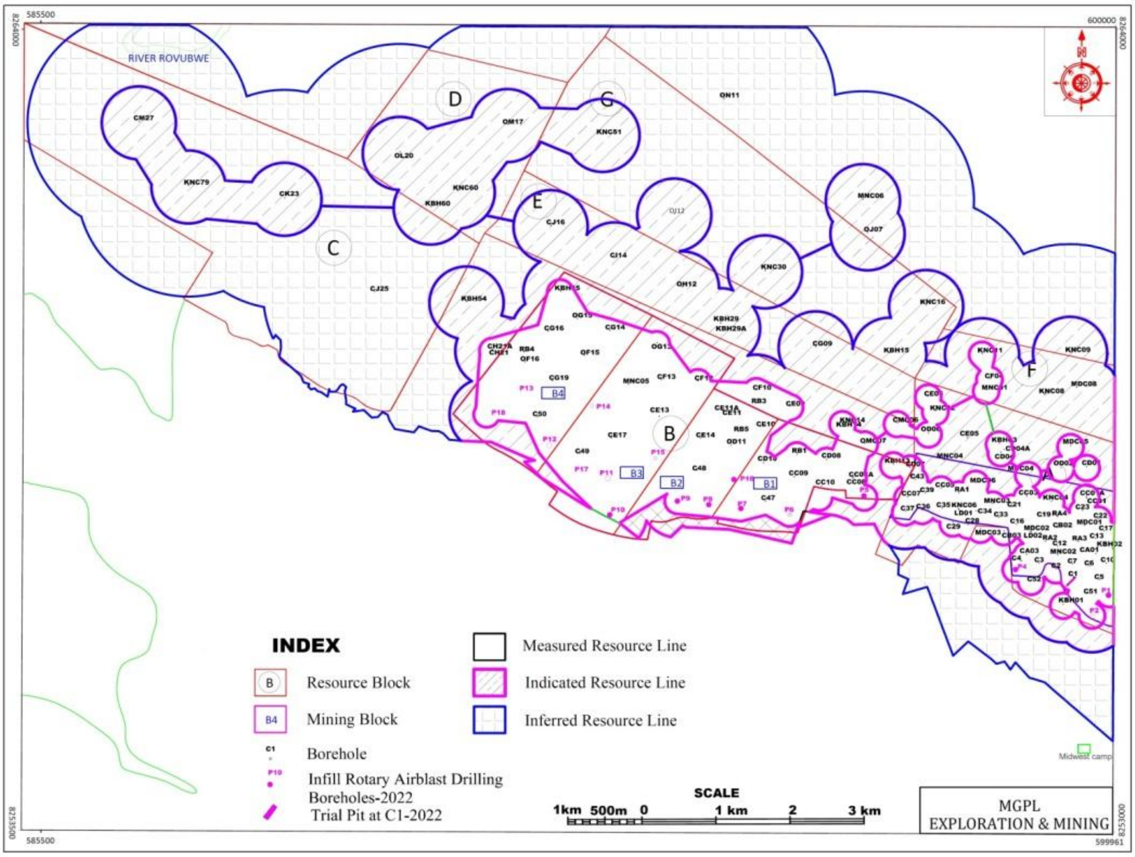


Fig.5-2: Coal resource categories in blocks

Toal In-situ resources (GTIS) : 5367 MMT after allowing discounts for GLp and GLm the TTIS works out to be 4294 MMT. The TTIS reported in PFS was 4.2 Billion Tons,which after in fill data and remodeling ,it works out be 4.5 Billion Tonnes. PFS Resource status and the present position are shown Table 5-3.

Table 5.3: Total In-situ resources

Total Area in Million Tons (5086C) EFS		Area Ha
MEASURED	868	1436.33
INDICATED	1942	2610.55
INFERRED	2557	3861.19
Total	5367(GTIS) 4294(TTIS)	

Accordingly, the CP has proceeded to delimit the area for variation in confidence level of the resource blocks areas. A map showing category-wise resource blocks is presented in Fig.5-4. It indicates most of the area shown as Indicated category of resource is now brought under the measured category. In the light of updated /refined modeling, the CP has opined it appropriate to retain the pre-feasibility mining blocks in the current Economic Feasibility report.

5.4.2 JORC COAL RESOURCES:

JORC coal resource defined in this report represents the part of coal resource which finds eventual economic viability on the basis of open cast mining up to a depth of 280m from surface with a stripping ratio of < 1:4 and cut off ash of 55%.

Coal resource estimation has been carried out at higher confidence levels in resource blocks Rb-A and Rb-B to qualify for Measured and Indicated categories and the coal from remaining resource blocks comes under Indicated and Inferred category for which mining conceptualization either by open cast or underground methods is not made at this stage but will be undertaken in due course.

The JORC coal resource reported by CP is as follows.

Measured category = 868 MMT

Indicated category = 1942 MMT.

Inferred category = 2557 MMT

The Demonstrated coal resource thus reported amounts to (i.e. 868+1942 = 2810MMT for which coal quality works out on adb basis as. RD: 1.69, Moisture: 1.66, Ash: 45.03%, VM: 23.42%, FC: 29.89% and GCV: 4172 k/cal, corresponding to mineable in-situ coal resource and quality vide. SANS 10320-2004. Geological continuity and grade continuity of seams has been demonstrated.

Based on borehole spacing and geological continuity the resource estimated area of 5086C has been divided into resource blocks namely Rb- A, B, B1.C, D, E, F and G as shown in Fig.5-4 and Table 5.4.

Table 5.4: Surface area and number of boreholes in each resource block

Block No	Area (ha)	Points of observation
RB-A	541	65
RB-B	985	43
RB-B1	163	1
RB-C	1106	4
RB-D	443	4
RB-E	563	6
RB-F	231	5
RB-G	996	5
Outside	---	3(Not include in resource)
TOTAL	**5028**	**136**

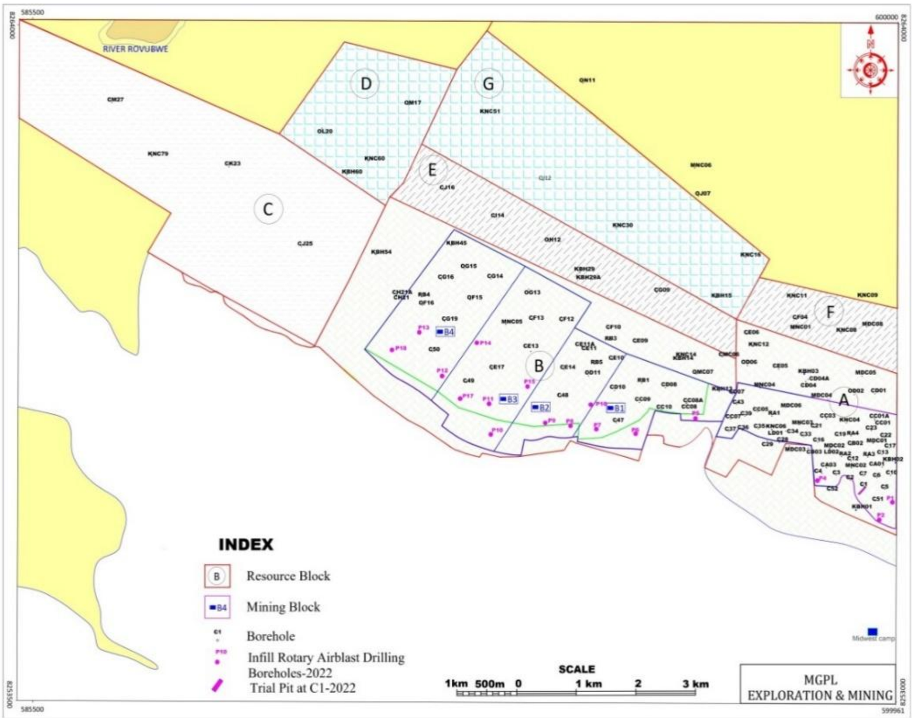


Fig. 5-3: Resource Blocks In 5086C Tenement

Table 5.5: Coordinates of mine layout area

COORDINATES OF MINING BLOCKS

Mb-A			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	599983	8257878
2	36 L	599973	8255709
3	36 L	599417	8255939
4	36 L	599304	8255986
5	36 L	599038	8256102
6	36 L	598704	8256261
7	36 L	598609	8256336
8	36 L	598551	8257169
9	36 L	598117	8257199
10	36 L	597880	8256683
11	36 L	597330	8256935
12	36 L	597116	8256651
13	36 L	596760	8256807
14	36 L	596953	8257312
15	36 L	597076	8257596
16	36 L	597135	8257723
17	36 L	597169	8257795
18	36 L	597287	8258011
19	36 L	597283	8258575
20	36 L	597293	8259215
21	36 L	599985	8258334
22	36 L	599983	8257878

Mb-B

BLOCK-B1			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	594545	8257302
2	36 L	594925	8257166
3	36 L	595315	8257120
4	36 L	595710	8257100
5	36 L	595930	8257733
6	36 L	596171	8257691
7	36 L	596356	8257683
8	36 L	596364	8257575
9	36 L	596695	8257563
10	36 L	597060	8257559
11	36 L	597168	8257796

BLOCK-B2			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	595449	8258659
2	36 L	594581	8259077
3	36 L	593226	8257072
4	36 L	593447	8257027
5	36 L	593685	8257009
6	36 L	593735	8257262
7	36 L	593945	8257256
8	36 L	594122	8257309
9	36 L	594362	8257290
10	36 L	594545	8257302

BLOCK-B3			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	594859	8259488
2	36 L	593751	8260077
3	36 L	592179	8257897
4	36 L	592469	8257666
5	36 L	592355	8257486
6	36 L	592732	8257244
7	36 L	593099	8257107
8	36 L	593226	8257072

BLOCK-B4			
S.NO	ZONE	LATITUDE	LONGITUDE
1	36 L	593751	8260077
2	36 L	592560	8260672
3	36 L	591061	8258729
4	36 L	591531	8258308
5	36 L	591869	8258116
6	36 L	592179	8257897
7	36 L	593751	8260077

TTIS (Total in-situ tonnes) thus estimated amounts to**4294 MMT** with a raw coal assay of RD: 1.70, Moist: 1.66%, Ash: 45.03%, VM: 23.42%, FC: 29.89%, GCV: 4172 kcal/kg and CSN 0-5.

Fig. 5-4: Mine lay out area in Rb-A & Rb-B

5.5 COAL RESERVE ESTIMATE

MGPL has conducted coal reserve estimate from demonstrated coal resource in a sequential manner beginning with mine layout as per the procedures outlined in SANS 10320:2004. Mine layout area for demonstrated resource is shown in Fig.5.5 and its Tete datum coordinates are mentioned in Table 4-5. The reserve estimation process includes a) Delineation of mine out lay area → b) Estimation of GTIS coal reserves → c) Estimation of Mine lay out loss →d) Estimation of GTIS coal reserves at theoretical mining height → e) Determination of dilution percentage & contaminants → f) Estimation of GTIS reserves at practical mining height → g) Extractable coal reserves and → h) ROM coal reserves.

5.6 MINEABLE INSITU RESOURCE (MTIS) FOR REPORTING PURPOSE

MTIS of Measured and Indicated category together are termed as Demonstrated coal resource which amounts to 925 MMT. It will allow the preparation of mine plan by open cast mining method up to a depth of 280m and stripping ratio of ~1:3. Reserve estimate has been made in two parts one for Rb-A and another for Rb-B.

5.7 COAL RESERVE ESTIMATE IN RB-A.

5.7.1 Resource Block A (Mb-A):

Areal extent of Rb- A is 541ha; it contains coal amenable for open cast mining up to a depth of 200m. Based on depth wise coal resource estimates, surface extent of the area corresponding to 200m depth has been determined for which GTIS is presented in Table 4-8. Areal extent of open cast coal mining block works out to be 377ha. It contains 125 MMT of mineable coal by open cast mining at a stripping ratio of ~1:3.

Table 5.6: Coal resource up to 200m depth in Rb-A

DEPTH	COAL TONNAGES	DIRT VOLUMES
<50m	4,26,08,663	16,75,63,790
5-100	4,33,53,829	16,34,51,214
100-150	1,51,76,754	12,49,57,267
150-200	2,38,59,717	9,12,60,633
TOTAL (up to200m Depth)	12,49,98,963	54,72,32,904

GTIS coal resource which is converted into MTIS by using formula

$MTIS_{\text{resource mh theo}} = GTIS_{\text{mh theor x}}$ (1-GLp/100) x (1-GLm/100)

i.e. 125 x 0.95 x 0.95= 112 MMT……………. Step-1.

5.7.2 Mine lay out loss (MLL):

Mine layout loss factor is a measure of the practical extraction of the efficiency of practical extraction of coal reserves with in a defined coal resource block and can be calculated using the equation

Areal extent of MTIS area is 377ha on consideration seam dip, coal; waste and likely slopes in east, Mine lay out area is taken as 303ha

MLL = (1-(A_{layout} / A_{horz})) X 100

Where

A_{layout} is the horizontal mineable area,

/ A_{horz} is the horizontal area of the coal resource block,

The mine lay out loss factor works out to be (1- (3.03/3.77)) x100= 12.5…..**Step-2**.

5.7.3 Mineable in-situ coal reserves (theoretical mining height):

The mineable coal reserves estimation is based on the theoretical mining height with in the area defined by mine plan. The mining lay out loss factors represent the expected losses that are caused by not reaching the extremities of the practical/theoretical lay out.

MTIS in situ coal reserves = MTIS in step 2 x (1-MLL/100).

112 X 0.875 = 98 MMT with coal quality Ash-45%, Moist-1.36% RD-1.68………….**Step -3**

Table 5.7: MTIS reserves in Mb-A

MTIS Reserves in Pit-A										
SEAM_NAME	PWS	COAL_AREA	COAL_VOLUME	INSITU_TONNES	WASTE_THICK	WASTE_VOLUME	ASH	RD	INCR	ACC
BANANEIRAS	2.16	1,211,089	1,802,683	3,048,622	62.78	86,663,832	44.1	1.68	28.4	28.4
CHIPANGA	18.6	3,043,346	46,121,353	75,322,498	52	156,320,500	44.6	1.66	2.1	3.1
SOUSA PINTO	5.58	3,062,718	11,505,394	19,673,378	19.32	59,748,176	46.1	1.73	3.0	3.1
TOTAL	**26.34**		**59,429,430**	**98,044,498**		**302,732,508**	**44.9**	**1.68**		**3.1**

The 98 MMT reserves reported here represent minable coal reserves.

5.7.4 Dilution material tonnage for Mb-A:

Impact of dilution material has been determined on additional thickness converted into parentage basis for the mine lay out area referred here after as mining Mb-A. Density of dilution material has been measured / assumed, wherever necessary. The coal quality of the mineable coal at the practical mining height shall be calculated by weighing the coal quality and the quality of the dilution material on a tonnage basis.

$T_{dilution} = th_{dilution\ roof} + th_{dilution\ floor}$

$rd_{dilution} = (rd_{dilution\ roof} \times th_{dilution\ roof} + rd_{dilution\ floor} \times th_{dilution\ floor}) / (th_{dilution\ roof} + th_{dilution\ floor})$

$T_{dilution} = th_{dilution} \times rd_{dilution} \times$ Alayout (after MLL)

The planned dilution from waste by volume worked out at – 7%.............................. **Step-4**

5.7.5 Mineable in situ coal reserves (at practical mining height):

The mineable in situ coal reserves are the discounted practical mineable in situ coal reserves with in a practical mining lay out, calculated after applying the theoretical mining lay out lay out loss percentage. It includes planned dilution.

The mineable in situ coal reserve has been estimated based on the theoretical mining height with planned dilution material along roof and floor.

Table 5.8: Mineable in situ coal reserves of Mb-A

	THEORITICAL MINING HEIGHT	**DILUTION MATERIAL ADDEDAT 7% (ROOF & FLOOR)**	**PRACTIAL MINING HEIGHT**
INSITU COAL VOLUMES (Cub.m)	59,429,430	4,160,060	63,589,490
RD	1.69	1.90	1.70
RESOURCE IN TONNES	98,044,498	7,904,114	105,948,612
ASH %	45.00	70.00	46.87

Coal reserve estimate at practical mining height 105 MMT……………………….…..**Step-5**

5.7.6 Extractable coal Reserves:

MTIS coal reserve at practical mining height (105 MMT) has been considered for Mine plan of Mb-A.

The extractable coal reserves are the discounted practical minable insitu coal reserves within a practical mining layout, calculated after applying the theoretical mining layout factor.

The extractable coal reserve includes dilution material but exclude any contamination material.

ETIS reserve mh pract = (MTIS reserve mh pract x (MLE/100)

and associated area can be calculated as

A extractable = Ahorz x (1-MLL/100) x MLE/100

For each seam we extracted mineable insitu coal reserves at practical mining height and multiplied with the percentage of mining layout extraction area to derive the extractable reserves (see Table 5.9).

Table 5.9: Extractable RoM coal reserves in Rb-A

SEAM ID	EXTRACTIABLE AREA	SEAM INCROP AREA	% OF AREA AVAILABLE FOR PRACTIAL MINING HEIGHT	MINEABLE INSITU COAL RESERVES AT THEORITICAL MINING HEIGHT(@ 1.69RD & ASH -45%)	MINEABLE INSITU COAL RESERVES AT PRACTIAL MINING HEIGHT (@ 1.7RD & ASH -46.9%)	EXTRACTIABLE RESERVES (@ 1.7RD & ASH -46.9%)
BANANEIRAS	11,38,424	12,11,089	90.3	30,48,622	32,94,395	29,74,838
CHIPANGA	27,99,878	30,43,346	89.1	7,53,22,498	8,13,94,818	7,25,22,783
SOUSA PINTO	27,60,000	30,62,718	87.53	1,96,73,378	2,12,59,399	1,86,09,023
PIT-A AREA	**33,00,000**	**37,70,000**	**87.53**	**9,80,44,498**	**10,59,48,612**	**9,41,06,645**

Extractable/ROM coal reserve estimate of 94 MT has been considered as proved coal reserve in Rb-A…………**Step-6.**

Accordingly this block hereafter termed as mining block -A (Mb-A).

Note: The CP has opined that the determination of contaminants separately by surface miner mining method is not required as it forms part of forced dilution already accounted for in practical mining height. The reason being that in this method roof of seam is fully exposed to make ready for coal extraction.

5.8 COAL RESERVES ESTIMATION IN RB-B

5.8.1 Resource Block B (Mb-B):

Areal extent of Rb- B is 11.38km$^{2.}$ It contains coal resource to the tune of 800 MMT up to a depth of 300m. (Table 5.12). It contains 799.6MMT of coal at a stripping ratio of ~1:3

Table 5.10: GTIS coal Resource estimate in Rb-B

SEAM_NAME	PWS	COAL_AREA	COAL_VOLUME	INSITU_TONNES	WASTE_THICK	WASTE_VOLUME	PRD	PAS	INCR	ACC
GRANDE FALESIA	15.95	86,63,607	8,10,77,190	12,81,89,554	99	84,08,47,648	1.65	46.13	6.6	6.6
INTERMEDIA	8.56	94,96,802	5,92,04,376	9,51,99,656	44	42,71,25,328	1.64	44.81	4.5	5.7
BANANEIRAS	17.8	99,62,742	12,23,97,032	20,28,92,176	30.63	32,93,93,120	1.67	44.56	1.6	3.7
CHIPANGA	28.01	91,17,680	19,17,61,832	31,74,94,880	41	40,00,65,832	1.66	44.39	1.3	2.7
SOUSA PINTO	3.21	81,96,418	2,30,21,042	3,83,81,880	9.64	8,20,47,280	1.67	43.67	2.1	2.7
UC	1.74	77,66,704	90,04,615	1,75,34,434	8.58	7,04,73,600	1.98	49.32	4.0	2.7
				79,96,92,580		2,14,99,52,808	**1.69**	**45.25**		**2.7**

Based on depth –wise coal resource estimates, surface extent of the area corresponding to 280 m depth has been determined and superimposed on surface extent of Rb-B (Fig.5-6).

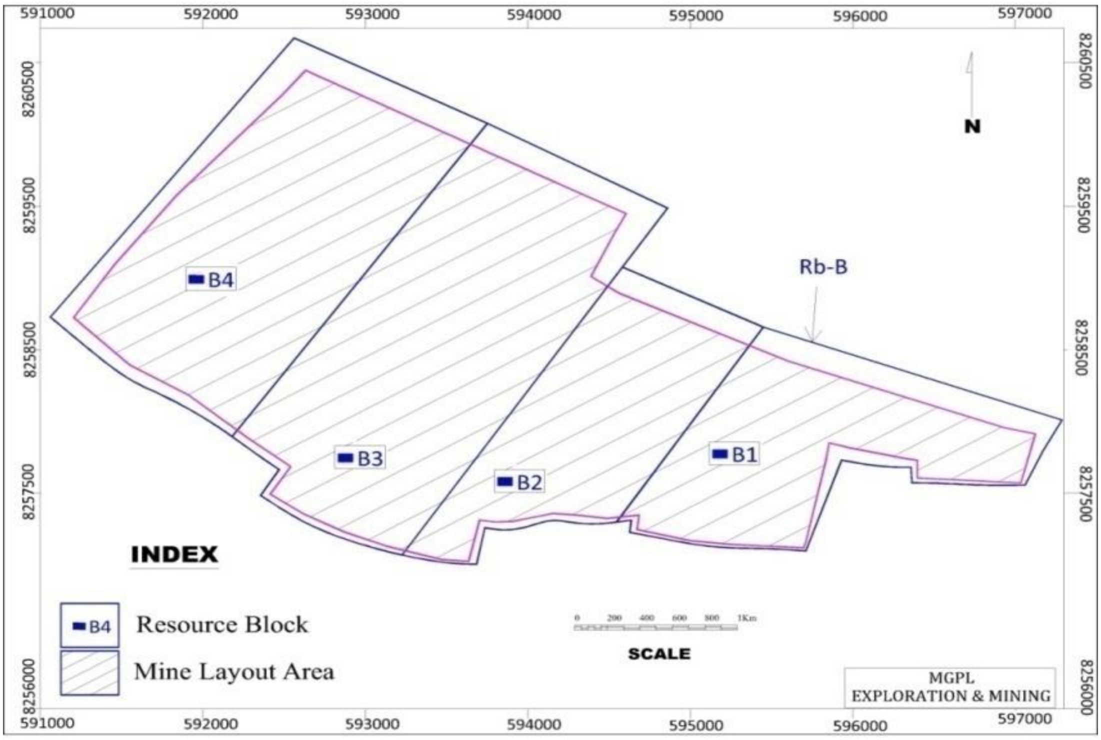


Fig.5-5: Mine Layout area with resource boundary, Rb-B

The calculation of coal reserves has been undertaken in a sequence beginning with GTIS (Gross total in-situ resource up to 300m depth)

Estimated MTIS resource in Rb-B is calculated as follows:

Coal resource which is converted into MTIS by using formula

$MTIS_{\text{resource mh theo}} = GTIS_{\text{mh theor}} \times (1\text{-}GLp/100) \times (1\text{-}GLm/100)$

i.e. **799.6** x 0.95 x 0.95 = 722 **MMT……………… Step-1**

5.8.2 Mining lay out loss (MLL):

Mining layout loss factor is a measure of the practical extraction of the efficiency of practical extraction of coal reserves with in a defined coal resource block and can be calculated using the equation

Areal extent of MTIS area is 11.38km^2 on consideration seam dip, coal; waste and likely slopes in east, Mine lay out area is taken as 10.31km^2

$MLL = (1- (MTIS_{\text{mh theor lay out}} / MTIS_{\text{resource mh theor}})) \times 100$

$MLL = (1-(A_{\text{layout}} / A_{\text{horz}})) \times 100$

Where

A_{layout} is the horizontal mineable area, in Square meters

A_{horz} is the horizontal area of the coal resource block, in Square meters.

The mine lay out loss factor works out to be ((1- (10.31 / 11.38)) x 100= 9.4

Accordingly, MLL factor = 9.4 …………………………………..**Step-2.**

5.8.3 Mineable in-situ coal reserves (theoretical mining height) (for reporting purpose):

The mineable coal reserves estimation is based on the theoretical mining height with in the area defined by mine plan. The mining lay out loss factors represent the expected losses that are caused by not reaching the extremities of the practical/theoretical lay out.

MTIS in situ coal reserves = MTIS in step 2 x (1-MLL)/100).

722 X 0.906 = 654 MMT with coal quality Ash 45%, Moist.2% RD 1.69.

Table 5.11: MTIS coal reserves at theoretical mining height in Rb-B

SEAM NAME	NC	COAL AREA	COAL VOLUME	INSITU TONNES	WASTE TH	WASTE VOLUME	ASH	RD	INCR SR	ACC SR
GRANDE FALESIA	15.03	86,62,453	9,25,34,178	13,39,07,871	97	83,20,00,448	45.8	1.70	6.2	6.2
INTERMEDIA	8.4	94,16,190	5,73,15,956	8,29,41,735	44	42,26,02,768	46	1.70	5.1	5.8
BANANEIRAS	17.6	93,38,203	11,66,88,656	16,67,68,558	29.65	30,84,06,784	45.6	1.68	1.8	4.1
CHIPANGA	27.35	85,34,584	16,98,83,328	24,13,52,080	40	37,40,23,232	44.6	1.67	1.5	3.1
SOUSA PINTO	3.02	76,26,098	2,03,54,294	2,90,52,177	9.6	7,79,70,696	44.6	1.68	2.7	3.1
				65,40,22,422		**2,01,50,03,928**	**45.3**	**1.69**		**3.1**

Mineable reserve at theoretical mining height is 654 MMT ………….**Step-3**.

5.8.4 Dilution material tonnage for Mb-B:

Impact of dilution material has been determined on additional thickness converted into parentage basis for the mine lay out area referred here after as mining Mb-B. Density of dilution material has been measured / assumed, wherever necessary. The coal quality of the mineable coal at the practical mining height shall be calculated by weighing the coal quality and the quality of the dilution material on a tonnage basis.

$T_{dilution} = th_{dilution\ roof} + th_{dilution\ floor}$

$rd_{dilution} = (rd_{dilution\ roof} \times th_{dilution\ roof} + rd_{dilution\ floor} \times th_{dilution\ floor}) / (th_{dilution\ roof} + th_{dilution\ floor})$

$T_{dilution} = th_{dilution} \times rd_{dilution} \times$ Alayout (after MLL)

The planned dilution from waste by volume worked out at 7% …..**Step-4**.

5.8.5 Mineable in situ coal reserves (at practical mining height):

The mineable in situ coal reserves are the discounted practical mineable in situ coal reserves with in a practical mining lay out, calculated after applying the theoretical mining lay out lay out loss percentage. It includes planned dilution.

The mineable in situ coal reserve at practical mining height has been estimated based on the theoretical mining height with planned dilution material along roof and floor.

Table 5.12: Mineable in situ coal reserves of Mb-B

	THEORITICAL MINING HEIGHT	**DIRT BANDS ADDED at7% (roof& floor)**	**PRACTIAL MINING HEIGHT**
INSITU COAL VOLUMES (Cub.m)	456,776,412	27,406,584.72	484,182,996.7
RD	1.69	1.9	1.7
RESOURCE IN TONNES	654,022,422	52,072,510.97	706,094,933
ASH %	45.28	70	46.91

Mineable coal reserve estimate at practical mining height shows 706 MMT……**step-5**.

5.8.6 Extractable coal Reserves Mb-B:

MTIS coal reserve at practical mining height (706 MT) has been considered for Mine plan of Mb-B.

The extractable coal reserves are the discounted practical minable insitu coal reserves within a practical mining layout, calculated after applying the theoretical mining layout factor.

The extractable coal reserve includes dilution material but exclude any contamination material.

ETIS reserve mh pract = (MTIS reserve mh pract x (MLE/100)

and associated area can be calculated as

$A_{extractable} = A_{horz}$ x (1-MLL/100) x MLE/100

For each seam we extracted mineable insitu coal reserves at practical mining height and multiplied with the percentage of mining layout extraction area to derive the extractable reserves (Table 5.15).

Table 5.13: Extractable / coal reserves in Mb-B

SEAM ID	EXTRACTIABLE AREA	SEAM INCROP AREA	% OF AREA AVAILABLE FOR PRACTIAL MINING HEIGHT	MINEABLE INSITU COAL RESERVES AT THEORITICAL MINING HEIGHT(@ 1.69RD & ASH -45.3%)	MINEABLE INSITU COAL RESERVES AT PRACTIAL MINING HEIGHT (@ 1.7RD & ASH -46.91%)	EXTRACTIABLE RESERVES(@ 1.7RD & ASH -46.91%)
GRANDE FALESIA	78,30,858	86,62,453	90.4	13,39,07,871	14,45,69,461.48	13,06,90,793
INTERMEDIA	83,07,904	94,16,190	88.23	8,29,41,735	8,95,45,460.51	7,90,05,960
BANANEIRAS	81,72,795	93,38,203	87.52	16,67,68,558	18,00,46,478.70	15,75,76,678
CHIPANGA	73,85,829	85,34,584	86.54	24,13,52,080	26,05,68,254.71	22,54,95,768
SOUSA PINTO	65,06,587	76,26,098	85.32	2,90,52,177	3,13,65,278.04	2,67,60,855
PIT-B AREA	**1,03,10,000**	**1,13,80,000**	**90.6**	**65,40,22,422**	**70,60,94,933**	**61,95,30,054**

An extractable coal reserve estimate at practical mining height shows 620 MT. **Step-6**.

Note: CP justification for contaminants given for Mb-A is applicable to Mb-B as well.

5.9 ROM COAL RESERVES IN PIT-I (MB-A + MB-B)

The Resource Blocks 'Rb-A & Rb-B' have been combined into a single unit for mining purpose and designated as mining PIT-I as shown in Fig.5-5, for which the summary of ROM coal reserve estimate follows.

1) RoM coal reserve estimate in Mb-A shows 98 MMT.

2) RoM coal reserve estimate in Mb-B shows 620 MMT.

Therefore, the total ROM coal reserve estimate for PIT_I amounts to **98+620= 718MMT (proved Reserves)** with a coal quality RD- 1.69, Moist.1.4%, Ash- 46.91%, VM-21.69%, FC- 30% and GCV- 4012k/cal.

5.9.1 In-situ coal product tonnages in mining PIT-I:

Coal preparation studies have brought out two types of saleable coal products i.e. metallurgical coal and thermal coal whose theoretical coal yield has been estimated 20% and 15-18% respectively (see chapter -10 on coal preparations). Accordingly, in-situ saleable coal product tonnages estimated works at 142 MMT metallurgical coal and 128 MMT of thermal coal whose extraction is economical at the time of reporting.

Therefore, The CP has considered 718 MMT of ROM coal as JORC coal reserve of proved category in Pit-I, 5086C tenement.

6 COAL QUALITY

6.1 ANALYTICAL PROCEDURES & STANDARDS

MAL has undertaken coal analysis of a total 12,137 samples. Coal analysis was carried out in accredited laboratories at South Africa, India and Mozambique. It includes proximate analysis, coking coal tests including carbonation tests, ultimate analysis, ash analysis, trace element analysis, float–sink analysis and other related tests in accredited laboratories of South Africa, India and Mozambique. Borehole wise analyzed C & D pile numbers is given below (Table 6.1).Analytical data are given in Annex XI, XII and XIII

Table 6.1: Showing bore-hole wise status of coal sample analysis

BOREHOLE WISE STATUS OF COAL SAMPLES ANALYSED, 5086C

S.No	Borehole	C-Plies	D-Plies	No.of samples
1	KBH02	46	24	70
2	KBH03	63	43	106
3	MDC01	54	34	88
4	MDC02	66	45	111
5	MDC04	140	67	207
6	MDC05	110	50	160
7	MDC06	59	45	104
8	KBH13	26	8	34
9	KBH14	333	201	534
10	KBH45	214	162	376
11	KBH54	21	9	30
12	KBH15	117	117	234
13	KBH29	178	128	306
14	KBH60	105	56	161
15	MDC08	166	81	247
16	CA01	46	59	105
17	CA03	44	45	89
18	CB02	29	29	58
19	CC01A	67	54	121
20	CC03	45	43	88
21	CC05	52	40	92
22	CC07	49	56	105
23	CD01	164	189	353
24	CD07	41	29	70
25	CE05	305	238	543
26	CE06	293	300	593
27	LD01	3	---	3
28	LD02	3	---	3
29	CC08A	47	44	91
30	CC09	85	73	158
31	CD08	201	153	354
32	CD10	202	141	343
33	CE09	206	170	376
34	CE10	212	181	393
35	CE11A	87	76	163
36	CE13	138	121	259
37	CE14	143	154	297
38	CE17	78	65	143
39	CF10	245	204	449
40	CF12	170	145	315
41	CF13	135	122	257
42	CG14	170	158	328
43	CG16	167	124	291
44	CG19	31	30	61
45	CH21A	67	51	118
46	CMC06	241	191	432

S.No	Borehole	C-Plies	D-Plies	No.of samples	Composit samples			
					Proximate			Float-Sink
					C-Plies	D-Plies	Total	S-Plies
47	CF04	137	95	232				
48	CG09	234	160	394				
49	CI14	205	147	352				
50	CJ16	119	94	213				
51	CJ25	112	89	201				
52	CK23	132	115	247				
53	CM27	87	35	122				
54	C1	30	18	48	12	6	18	5
55	C2	9	5	14	5	2	6	2
56	C3	38	16	54	38	16	54	---
57	C4	21	4	25	11	4	15	5
58	C5	38	9	47	15	8	8	6
59	C6	70	19	89	12	4	4	6
60	C7	33	15	48	11	4	4	5
61	C10	61	15	76	12	7	7	6
62	C12	29	11	40	9	5	5	3
63	C13	46	16	62	15	8	8	7
64	C16	67	18	85	9	5	5	7
65	C17	50	11	61	11	3	3	6
66	C19	81	21	102	16	6	6	8
67	C21	97	39	136	22	15	15	16
68	C22	57	30	87	22	14	14	8
69	C23	75	25	100	15	6	6	9
70	C33	50	21	71	11	7	7	7
71	C34	52	20	72	9	5	5	7
72	C35	18	3	21	8	2	2	3
73	C37	21	5	26	5	3	3	4
74	C39	61	27	88	16	13	13	9
75	C43	44	12	56	11	6	6	4
76	C47	23	7	30	6	3	3	3
77	C48	106	53	159	13	11	11	11
78	C49	156	57	213	21	14	14	13
79	C50	154	64	218	19	12	12	12
80	C51	41	29	70	9	5	5	3
81	RA1	---	---	---	103	140	243	---
82	RA2	---	---	---	55	44	99	---
83	RA3	---	---	---	48	71	119	---
84	RA4	---	---	---	72	112	184	---
85	RB1	---	---	---	217	366	583	---
86	RB2	---	---	---	94	168	262	---
87	RB3	---	---	---	189	289	478	---
88	RB4	---	---	---	10	16	26	---
89	RB5	---	---	---	185	317	502	---
	Total	8018	5660	**13678**	1336	1717	**2755**	**175**

ACT-UIS Laboratories of South Africa and Mozambique have followed SA standards; whereas the Indian Laboratories followed IS Standards.

6.2 REPRODUCIBILITY & REPEATABILITY (QA/QC)

The MAL has implemented Quality Assurance (QA) / Quality Control (QC) proceeding in order to ensure dependable coal assays. Reproducibility denotes maximum acceptable difference between the mean of acceptable replicate determinations carried out in one laboratory verses the mean of acceptable replicate determinations carried out in any other laboratory. Repeatability is the maximum difference, duplicate determinations carried out with different items in the same laboratory on the same sample by the same operator using the same apparatus.

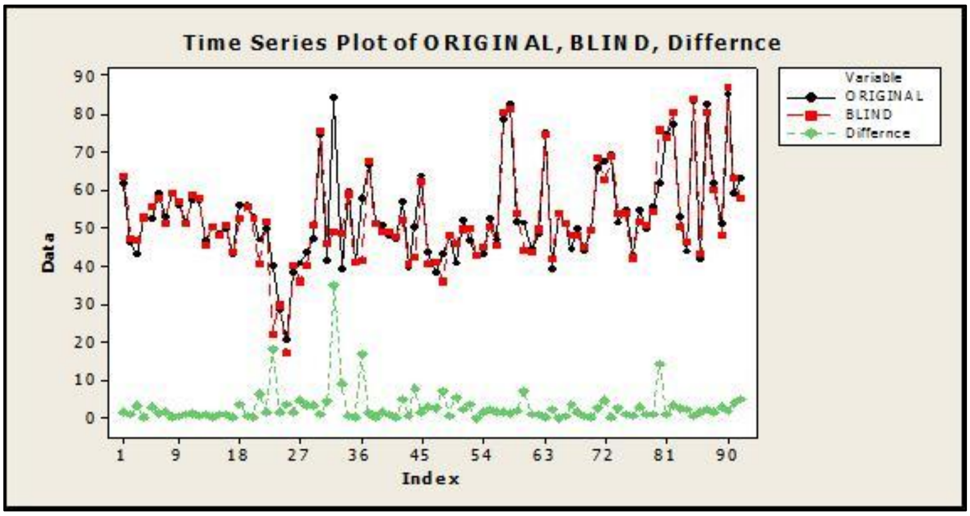


Fig.6-1: Statistical Graph Repeatability of Coal Analysis

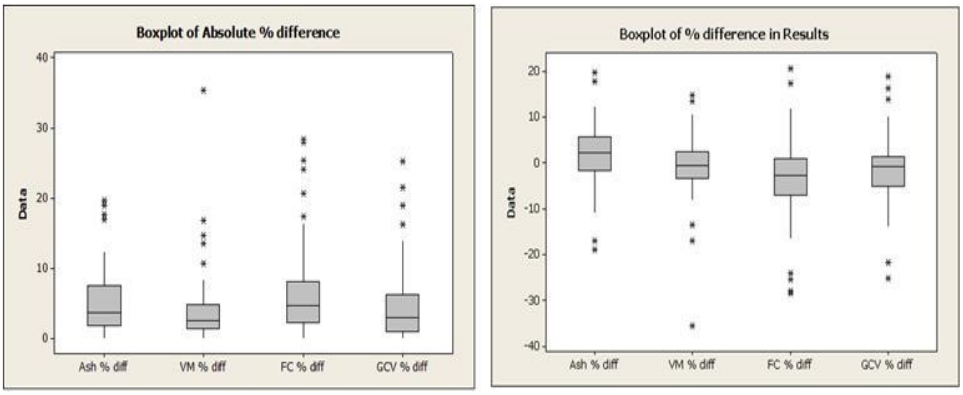


Fig.6-2: Representation of Reproducibility between ACT and CIMFR Laboratories

MAL had undertaken study of duplicates for repeatability in the same lab in the name of blind samples and reproducibility by analyzing the same sample in two different laboratories

The percent difference is calculated by dividing the difference between the two results by their average as follows:

% difference = (x - y) / ((x + y)/2) x 100%

Where x = result of first analysis and y = result of second analysis

Statistical analysis of coal quality is primarily based on proximate analysis constituent's viz. Moisture, ash, volatile matter and RD.

6.2.1 Determination of Random Assay Error / variation:

An attempt is made to evaluate the reliability of chemical assays of various proximate component determined in the laboratory by sending a duplicate of predetermined number of samples from boreholes drilled in the area. The following table summarizes the results of statistical analysis of 49 samples. Separate data sheets giving details of borehole-wise samples and sample-wise statistics are provided in Annex-XII. The difference between the value of duplicate sample and original sample gives the magnitude and sign of deviation (Table 6.2).

Table 6.2: Statistical analysis of coal assay to determine random assay variation

Determined Statistical Analysis	RD	IM	Ash	VM	FC	CV
1.Mean absolute random error (a) %	1.24/49 0.025	-2.5/49 0.051	-48.8/49 0.996	37.63/49 0.768	15.20/49 0.310	186/49 3.80
2.Mean content of Principle /Original sample (b) %	89.41/49 1.83	83.90/49 1.712	2647/49 54.20	969.6/49 19.79	1199.3/49 24.47	168562/49 3440.04
3.Mean content of Check/ Blind sample %	89.30/49 1.82	81.40/49 1.66	2598/49 53.02	1007.23/49 20.56	1214.5/49 24.79	168748/49 3443.84
4.Mean relative random error a/b *100	0.03/1.83 1.37%	0.051/1.71 2.98%	0.99/54.02 1.84%	0.77/19.79 3.88%	0.310/24.48 1.27%	3.80/3440.04 0.11%

The CP has reviewed QA/QC practices and statistical analysis of coal assay and found it satisfactory.

6.3 SUMMARY OF PROXIMATE ANALYSIS

Raw Coal characterization has been made based on proximate analysis of 12,137 coal samples generated during the exploration (see Annex- XII) Basic raw coal quality of 5086C be defined as statistical analysis of proximate attributes of Midwest deposit is shown in (Fig.6-3).

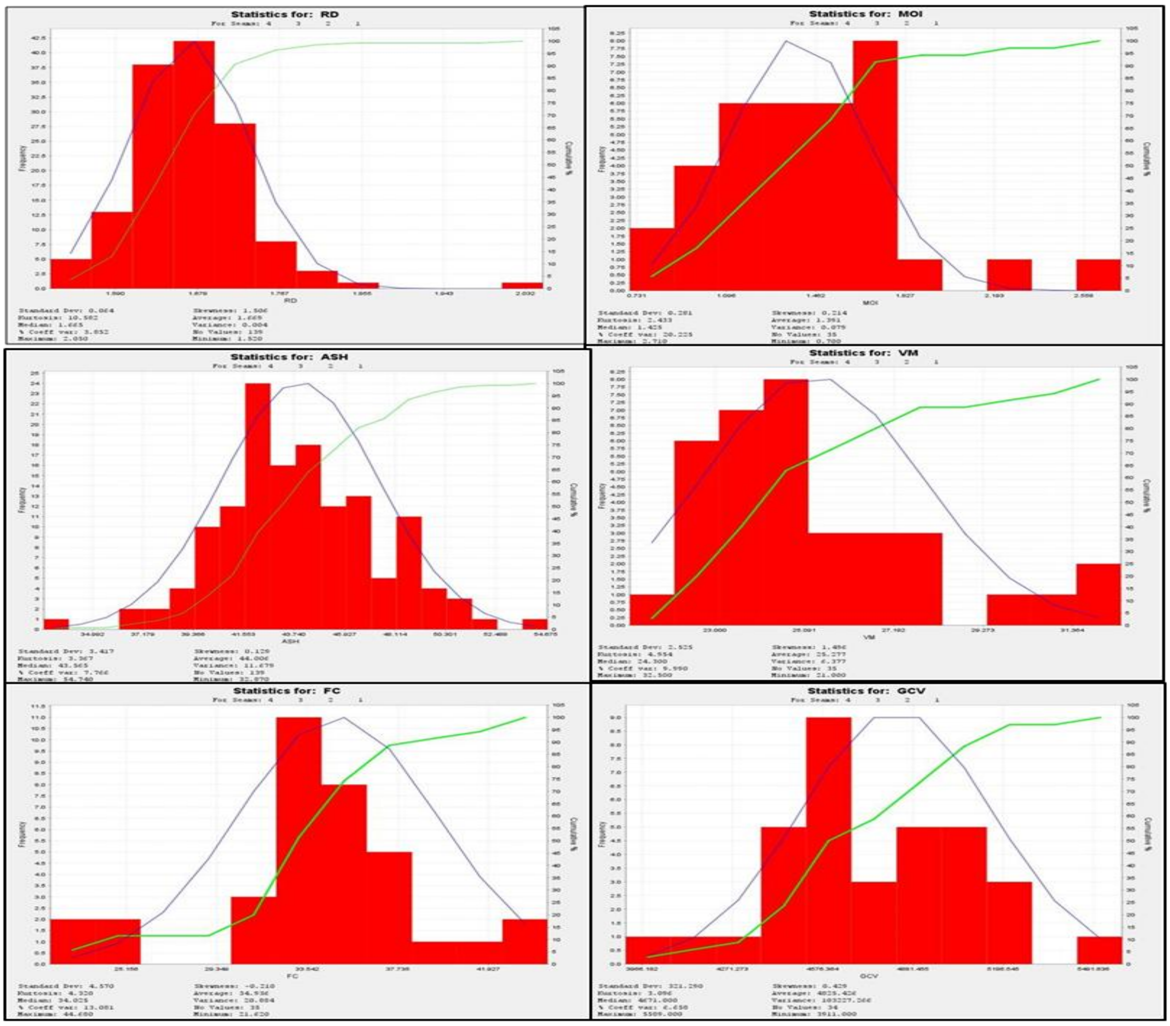


Fig. 6-3: Bar graphs showing coal quality

Summary of Proximate analysis for raw coal, 5086C coal property.

RD=1.67, Moisture=1.39%; Ash=44% VM= 25% FC=30-35% GCV= 4825 Kcal/kg.

6.4 ULTIMATE ANALYSIS

Ultimate analysis of coal is expressed in terms of carbon, hydrogen, nitrogen, and oxygen. Besides, other inorganic elements like sulfur, phosphorus, and chlorine have also been presented. Nitrogen is useful in deciphering ammonium salts and sodium gases and liquors. (See Tables 6.3 &6.4)

Sulfur is an undesirable element responsible for corrosion, atmospheric pollution and impact on iron produced from blast furnaces. Chlorine in coal occurs as NaCl or KCl. Chlorine has negative effect in coke oven refractoriness, slagging and corrosion. Phosphorous in coal occurs as apatite. It has negative effect on steel manufacturing as the phosphorous has tendency to enter the molten metal easily and degrades the product.

Table 6.3: Ultimate Analysis of Raw Coal

Sample No.	Sample Id	Carbon %	Hydrogen %	Nitrogen %	Sulfur %	Oxygen % (by diff)
1	MDC-06/C3	55.90	4.00	0.77	0.38	4.21
2	MDC-06/C24	55.80	4.00	0.70	0.67	5.23
3	MDC-06/C36	62.10	4.10	0.84	0.52	6.24
4	MDC-06/C50	50.80	3.30	0.77	1.17	4.54
5	MDC-06/C56	64.85	4.50	0.91	0.56	7.40

Ultimate analysis on daf basis =**C – 81%, H - 5 %, O-7%.**

Table 6.4: Ultimate analysis (P, Cl and TS %)

S.No	Sample ID	Phosphorous (%)	Chlorine (%)	Total Sulfur (%)
1	KBH-29/C134	0.017	0.1	0.81
2	KBH-29/C135	0.003	0.13	1
3	KBH-29/C136	0.01	0.1	0.65
4	KBH-29/C137	0.016	0.13	0.73
5	KBH-29/C138	0.002	0.09	0.46
6	KBH-29/C139	0.05	0.03	0.55
7	KBH-29/C140	0.015	0.07	0.61
8	KBH-29/C141	0.012	0.14	0.66
9	KBH-29/C142	0.003	0.02	1.03
10	KBH-29/C143	0.011	0.04	0.49
11	KBH-29/C144	0.003	0.28	0.77
12	KBH-29/C145	0.06	0.23	0.48
13	KBH-29/C146	0.014	0.03	0.68
14	KBH-29/C147	0.06	0.03	0.36
15	KBH-29/C148	0.007	0.11	0.81
16	KBH-29/C149	0.008	0.11	1

17	KBH-29/C150	0.09	0.03	0.59
18	KBH-29/C151	0.01	0.03	0.63
19	KBH-29/C152	0.04	0.1	0.75

Inferences that may be drawn from Ultimate analysis of 5086C coal include:

The carbon and oxygen proportion indicate that the coal is bituminous.

Phosphorous, sulfur and chlorine values are well within the tolerance limits for industrial uses.

6.5 SULFUR VARIATION

Sulfur is analyzed on regular basis for all coal ply samples, as far as possible. Seam wise weighted average of Sulfur of individual boreholes on raw coal is presented in Table 6.5.

Table 6.5: Seam wise sulfur in different boreholes of coal reserves area

SEAM NAME	BOREHOLE WISE AVG.TOTAL SULPHUR VALUES											
	CD08	CD10	CE10	CE11A	CE13	CE14	CE17	CF12	CF13	CG14	CG16	CG19
GRAND FALESIA	1.53	1.07	0.94	1.63		0.82	1.76	2.1	1.16	1.5		2.46
	0.78	0.79	0.78	1.65	0.95	0.87	0.71	0.73	0.88	0.74	0.77	1.07
INTERMEDIA	0.77	1.12	0.93	0.9	1.06	1.56		0.87	1.23	0.9	1.56	
	0.92	0.77	1.16	1.59	1.28	1.8		1.08	0.92	0.78	1.98	1.12
BANANEIRAS	1.57	0.69	1	1.42	1.44	1.3	0.97	1.51	1.13	2.17	2.85	2.55
CHIPANGA	2.2	1.37	1.05		1.59	1.72	1.75	1.24	0.81	1.56	3.54	1.6
SOUSA PINTO		1.07	0.86		1.7	1.76		1.07	0.66	2.28	1.77	
		1.74	1.45		1.5	2.35		1.27	0.84	2.26	1.77	
UC	0.56	0.59	1.64	1.18	1.33	2.47	0.93	0.94	0.6	1.68	3.41	

Sulfur content varies from borehole to borehole. Pyrite and other sulphides are observed along fractures in coal cores of boreholes located near basement or fault zones. These sulphides are secondary additions which can usually be removed at the time of washing. Midwest carried out analysis of various forms of sulfur such as Pyritic sulfur, sulphate sulfur and organic sulfur (Table 6.6).

Table 6.6: Forms of Sulfur in raw coal

Types	**MDC01**
	comp – 1(raw coal)
Total Sulfur % (ad)	1.6
Pyritic Sulfur % (ad)	0.94
Sulphate Sulfur %(ad)	0.05
Organic Sulfur % (ad)	0.61

Pyritic sulfur and sulphatic sulfur are secondary additions to coal after its formation and is liberated during coal processing while organic sulfur is inherent in coal and does not liberate from the coal. There is a marginal variation in sulfur content determination from one laboratory to another probably due to variation in standards. The deleterious sulfur that can be reported is ~1 with ±0.2% variation which is within the acceptable limit of export coking coal and thermal coal market specifications.

The CP has reviewed coal specifications, analysis standards, QA/QC procedures and statistical study and found them comply with industry standards.

6.6 SUMMARY OF RAW COAL QUALITY

Summary of raw coal quality for the resources presented in this report is as follows.

Coal is sub-bituminous to bituminous, coking type and contains low moisture and high ash. Statistical average of coal, proximate analysis, on ad basis

Moisture (M): 1.66%;
Ash: 45.03%;
Volatile Matter (VM): 23.42%;
Fixed Carbon: 29.89%;
Gross Calorific Value (GCV): 4825 kcal/kg,
Crucible Swelling Number (CSN): 1 to 7.
Hard Grove Index (HGI): 54 to 62,
Ash Fusion Temperature (AFT): ~1500 °C.
Ultimate Analysis on daf basis
Carbon (C): 81%,
Hydrogen (H): 5 to 6% and
Oxygen (O): 4 to 7%.

Sampling for Coal Characterisation and Coal Petrography: From the Coal seam cuttings, two samples weighing 10kg each were collected, preserved in air tight plastic bags and shipped to SAIL & CMPDI laboratory India.

Table 6.7: Summary of Coal characterisation results

Coal characterization study			
S.No		**CMPDI**	**SAIL**
1	PETROGRAPHY		
1.1	Maceral Composition %		
1.1.1	Vitrinite %	66.4	64.3
1.1.2	Semi Vitrinite %		0.6
1.1.3	Liptinite%	4.2	3.1
1.1.4	Inertinite%	9.8	16.9
1.1.5	VMM%	19.6	15.1
1.2	Maceral Composition Vmmf%		
1.2.1	Vitrinite %	82.6	
1.2.2	Liptinite%	5.2	
1.2.3	Inertinite%	12.2	
1.3	MMR%	0.96	0.8
1.4	RoR %		0.76
1.5	V Type %		
1.5.1	V5		4
1.5.2	V6		14
1.5.3	V7		56
1.5.4	V8	16	23
1.5.5	V9	60	3
1.5.6	V10	24	

2	PROXIMATE ANALYSIS			
		AR	60%RH 40°C	ADB
2.1	Moisture %	1.6	1.6	1.5
2.2	Ash %	25	25	24.9
2.3	VM%	27.1	27.1	27.5
2.4	FC%	46.3	46.3	
3	ULTIMATE ANALYSIS			
3.1	Total Sulphur %(AR Basis)	1.69		
3.1.1	Total Sulphur %(Dry Basis)	1.72		1.89
3.1.2	Total Sulphur %(DMF Basis)	1.91		
3.2	Carbon%(Dry Basis)			63.15
3.3	Hydrogen %(Dry Basis)			4.46
3.4	Nitrogen%(Dry Basis)			0.86
4	PLASTOMETER			
4.1	Initial soft Temp at 1.0 ddpm	383°C		391°C
4.2	Final fluid Temp at 1.0 ddpm	467°C		
4.3	Solidification temp	470°C		483°C
4.4	Plastic range	87°C		92°C
4.5	Fluidity area	DD		
4.6	Max fluidity (ddpm)	2654 ddpm		13157 ddpm
4.7	Max.fluid temp	437°C		443°C
4.8	Swelling Index	5.5-6		5
4.9	LTGK	G-7		G-5

6.7 GRADE CONTINUITY

MGPL has adopted the following methods to work out the grade continuity and consistency of the deposit (1) Empirical method and (2) Geostatistical method.

6.7.1 Empirical method:

Empirical method was adopted at whole seam level to determine grade continuity/lateral variation using coal Ash%, GCV values (Fig 6-4).

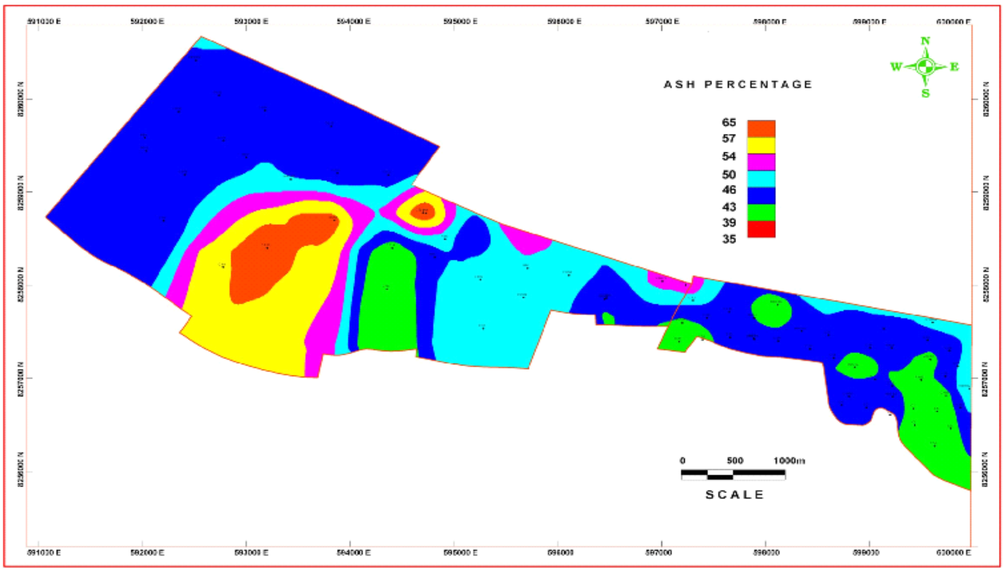


Fig. 6-4: MinexModel Showing Grade Continuity and Variation in Ash% in Coal Reserve Area (Pit-I)

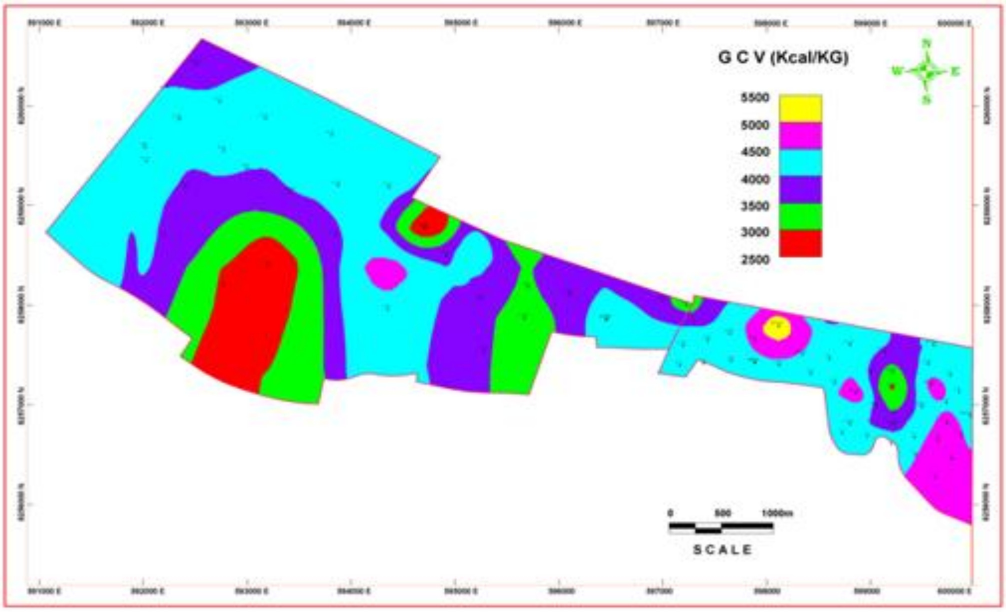


Fig. 6-5: Minex Model Showing Grade Continuity and Variation in GCV (Kcal/Kg) In Coal Reserve Area (Pit-I)

6.7.2 Geo-statistical study of coal assay for consistency in between points of observation (Figs. 6-6 to 6-15):

In this method, basic coal assay values viz. RD, Ash, GCV and FC are subjected to statistical treatment to identify their borehole wise variation along strike and dip sections has been worked out. Borehole location in map is shown (in Fig 6-5.). Grade consistency is represented in Figs and Tables.

C/S **line CA01 - CA03** Frequency distribution graphs for different assay values are as follows.

Table 6.8: Mean Coal Assay Values Along the LineCA-1 - CA03

Parameters	**Mean**	**Std Dev**	**Variance**	**3rd Quartile i.e.75% values are below**	**95% Confidence Interval Mean**	**95% Confidence Interval Median**	**95% Confidence Interval Std Dev**
RD	1.6390	0.0899	0.0081	1.700	1.6213 1.6568	1.6018 1.6568	0.0790 0.1044
Ash	42.655	6.963	48.484	46.920	41.280 44.030	41.094 43.310	6.117 8.082
GCV	4545.2	668.3	446625.1	4903.4	4413.30 4677.20	4466.50 4721.50	587.10 775.70
FC	33.078	4.354	18.961	36.090	32.219 33.938	32.181 34.682	3.826 5.054

The Regression Analysis RD vs. Ash show that the relationship is sympathetic i.e. a rise in value of ash there is a concomitant rise in the value of RD the regression equation is

RD= 1.16+0.0113Ash

The regression analyses of RD vs. GCV, RD vs. FC and Ash vs. GCV shows that the relationship is antipathetic *i.e.* A rise in value of the former there is decrease in the value of the latter. The regression equations are

RD=2.17-0.000117GCV; RD= 2.25-0.178FC; Ash= 87.60-0.00989; GCV:

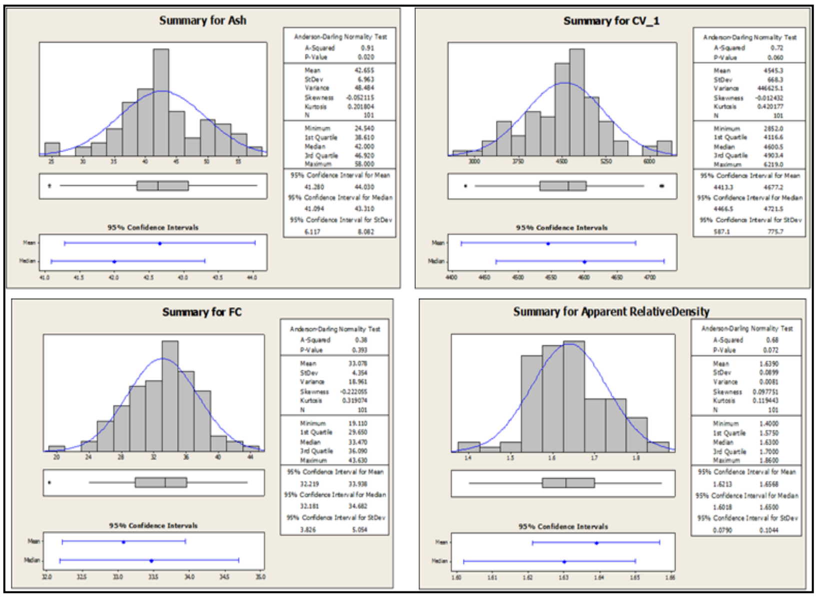


Fig. 6-6: Histogram Showing Coal Assay Population/Variation along the Section Line CA01-CA03

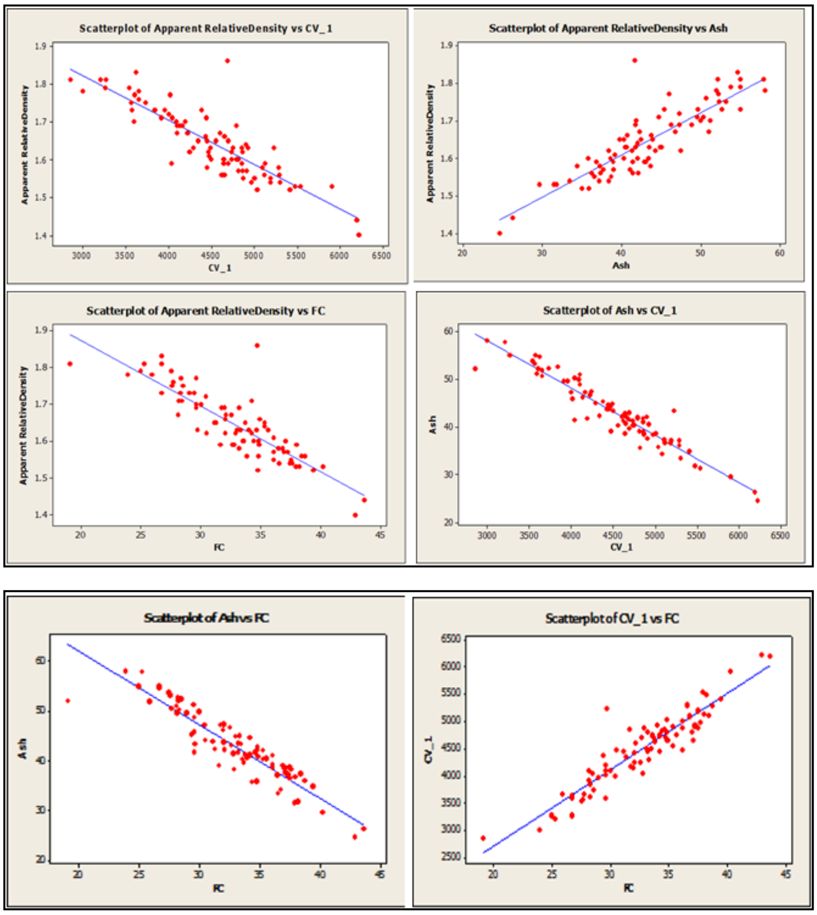


Fig. 6-7: Scatter Plot Showing Grade Variation in Coal Assay alongCA01-CA03

Table 6.9: Mean Coal Assay along the C/S Line KBH02, MDC01, CB02, MDC02, CC05, AND CC07

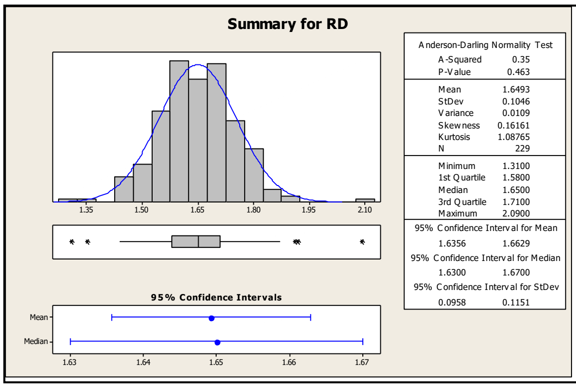
	Mean	**Std Dev**	**Variance**	**3rd Quartilei.e.75%values are below**	**95% Confidence Interval Mean**	**95% Confidence Interval Median**	**95% Confidence Interval Std Dev**
RD	1.6493	0.1046	0.0109	1.7100	1.6356, 1.6629	1.6300, 1.6700	0.0958, 0.1151
Ash	43.683	9.617	92.482	50.366	42.540, 44.827	42.074, 45.337	8.873, 10.497
GCV	4506.0	930.6	866025.3	5228.10	4395.3, 4616.7	4383.1, 4649.0	858.7, 1015.8
FC	31.927	6.222	38.710	36.866	31.187, 32.667	31.358, 32.972	5.741, 6.761

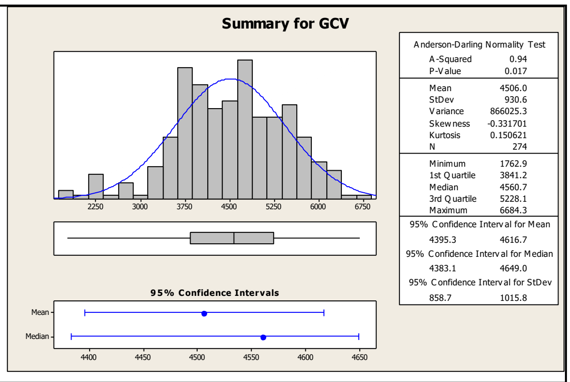
The Regression Analysis RD vs. Ash shows that the relationship is sympathetic i.e. A rise in value of ash there is a concomitant rise in the value of RD the regression equation is

RD= 1.23+0.00976Ash

The regression Analyses RD vs. GCV, RD vs. FC, and Ash vs. GCV shows that the relationship is antipathetic i.e. A rise in value of the former there is decrease in the value of the latter. The regression equations are

RD=2.04-0.000085GCV; RD= 2.11-0.141FC; Ash= 86.60-0.00951GCV





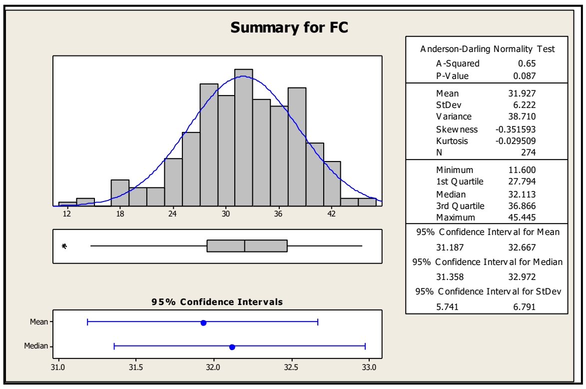


Fig.6-8: Histogram Showing Coal Assay Population/Variations

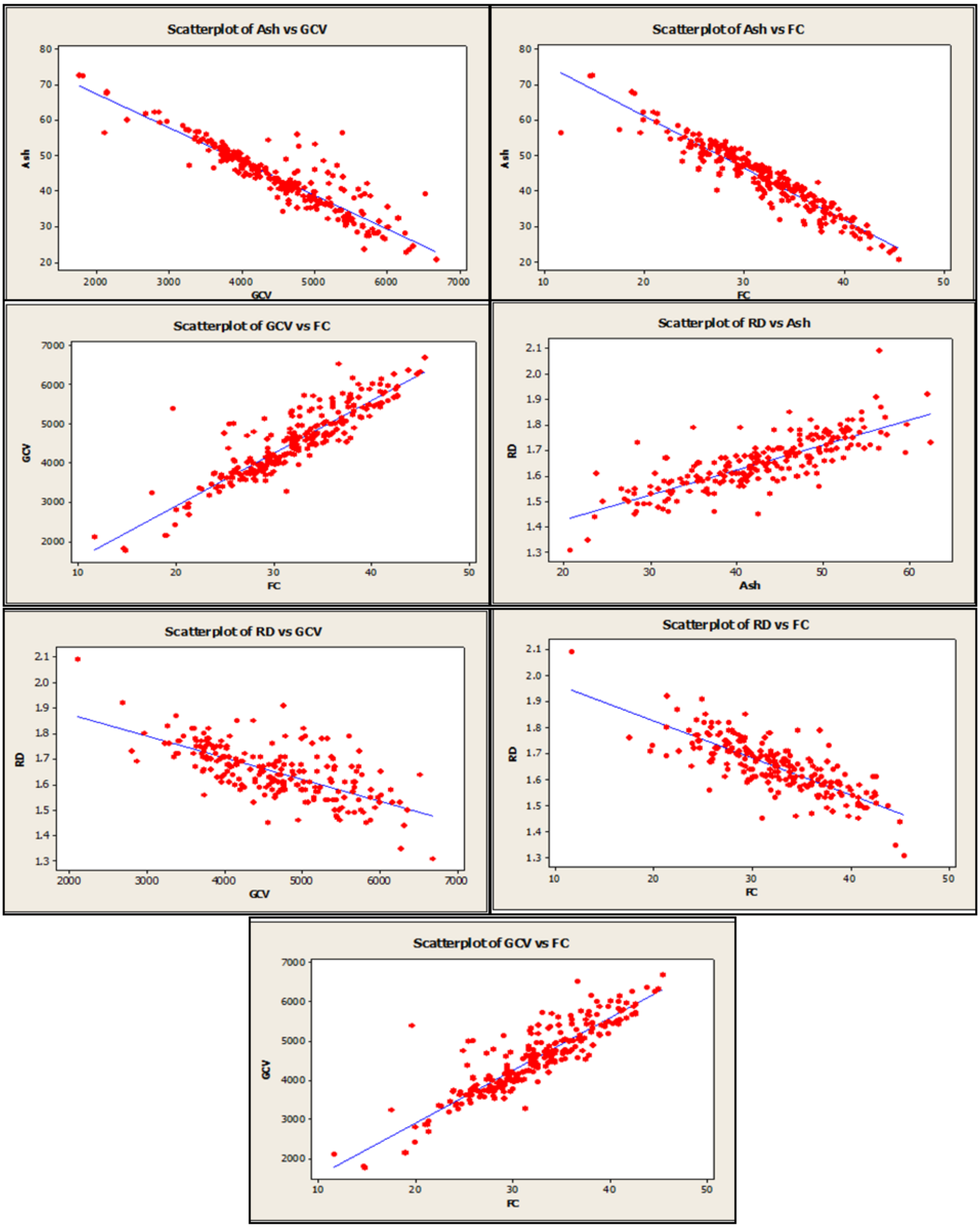


Fig. 6-9: Scatter Plot Showing Grade Variations

Table 6.10: Mean Coal Assay along the C/S Line CD1, MDC05, CE5, AND CE6

	Mean	Std Dev	Variance	3rd Quartile i.e.75% values are below	95% Confidence Interval Mean	95% Confidence Interval Median	95% Confidence Interval Std Dev
RD	1.7062	0.1269	0.0161	1.7800	1.6890 1.7235	1.6900 1.7300	0.1158 0.1403
Ash	45.754	8.356	69.823	51.980	44.617 46.891	44.860 48.052	7.626 9.242
GCV	3902.2	591.5	349842.4	4274.0	3821.20 3983.30	3812.50 4008.80	539.5 654.7
FC	29.949	6.730	45.291	34.160	29.033 30.864	27.965 31.391	6.142 7.443

The Regression Analysis RD vs. Ash shows that the relationship is sympathetic i.e. A rise in value of ash there is a concomitant rise in the value of RD the regression equation is

RD= 1.09+0.00135Ash

The regression analyses RD vs. GCV, RD vs. FC and Ash vs. GCV shows that the relationship is antipathetic i.e. a rise in value of the former there is decrease in the value of the latter. The regression equations are

RD=2.33-0.000161GCV; RD= 2.20-0.0166FC; Ash= 90.9-0.0117GCV

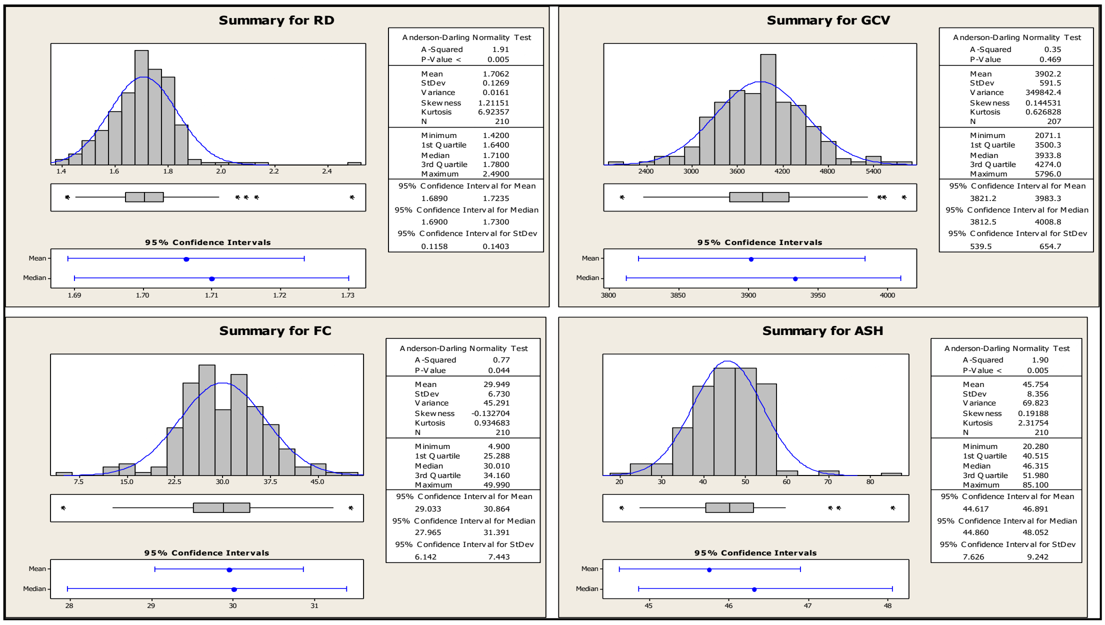


Fig. 6-10: Histogram Showing Coal Assay Variations

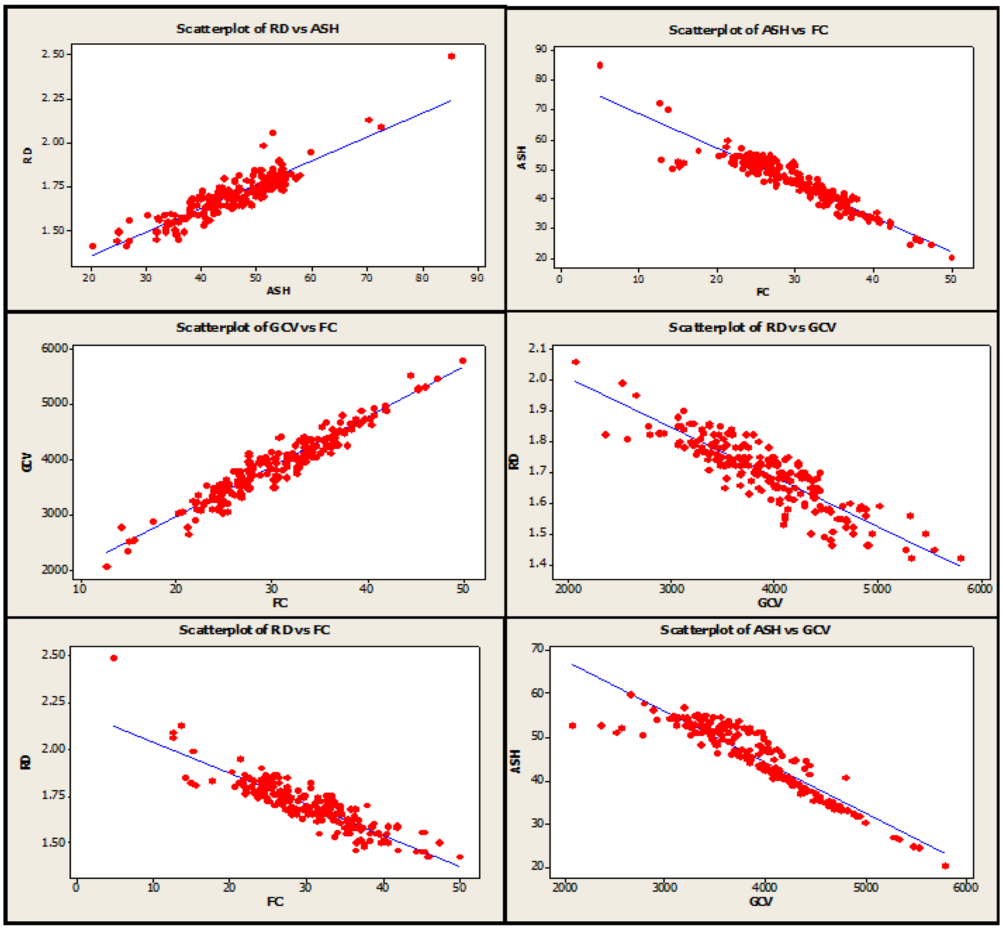


Fig. 6-11: Scatter Plot of Coal Assay

Table 6.11: Mean Coal Assay along C/S LINE CA01, MDC04

	Mean	Std Dev	Variance	3rd Quartile i.e.75% values are below	95% Confidence Interval Mean	95% Confidence Interval Median	95% Confidence Interval Std Dev
RD	1.7432	0.1329	0.0177	1.81	1.707 1.7658	1.7200 1.7600	0.1188 0.1509
Ash	47.526	6.845	46.855	53.075	46.365 48.687	46.381 50.471	6.117 7.772
GCV	4571.2	623.3	388488	4909.5	4402.7 4739.7	4437.4 4822.7	524.7 767.8
FC	27.976	6.213	38.589	32.720	26.922 29.030	26.750 28.879	5.552, 7.054

The Regression Analysis RD vs. Ash show that the relationship is sympathetic i.e. a rise in value of ash, there is a concomitant rise in the value of RD the regression equation is

RD= 1.04+0.0148Ash. Population

The regression analyses RD vs. GCV, RD vs. FC and Ash vs. GCV shows that the relationship is antipathetic i.e. a rise in value of the former there is decrease in the value of the latter. The regression equations are

RD=2.19-0.000116GCV; RD= 2.28-0.0193FC; Ash= 86.80-0.0972GCV

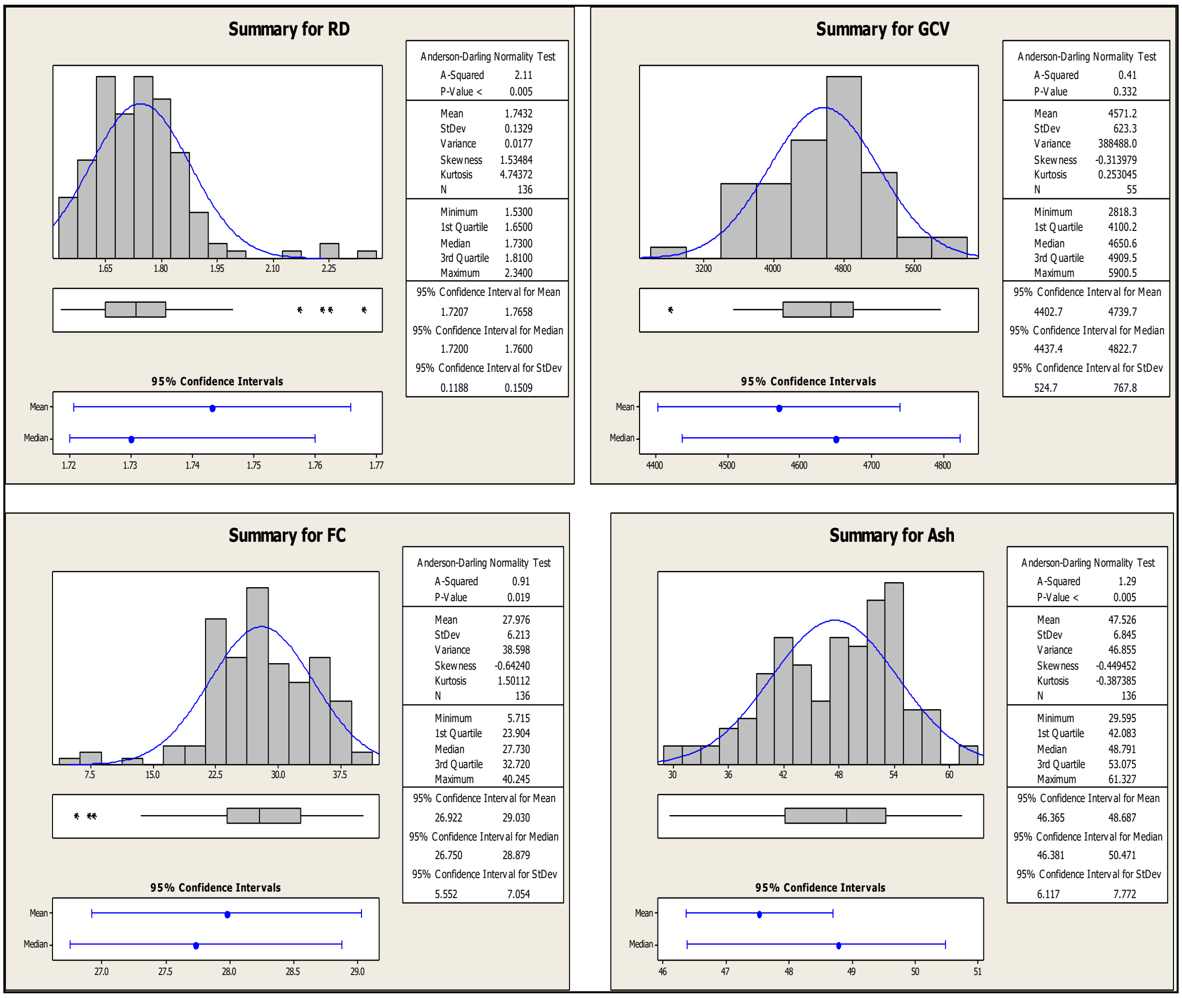


Fig. 6-12: Histogram of Coal Assay Population

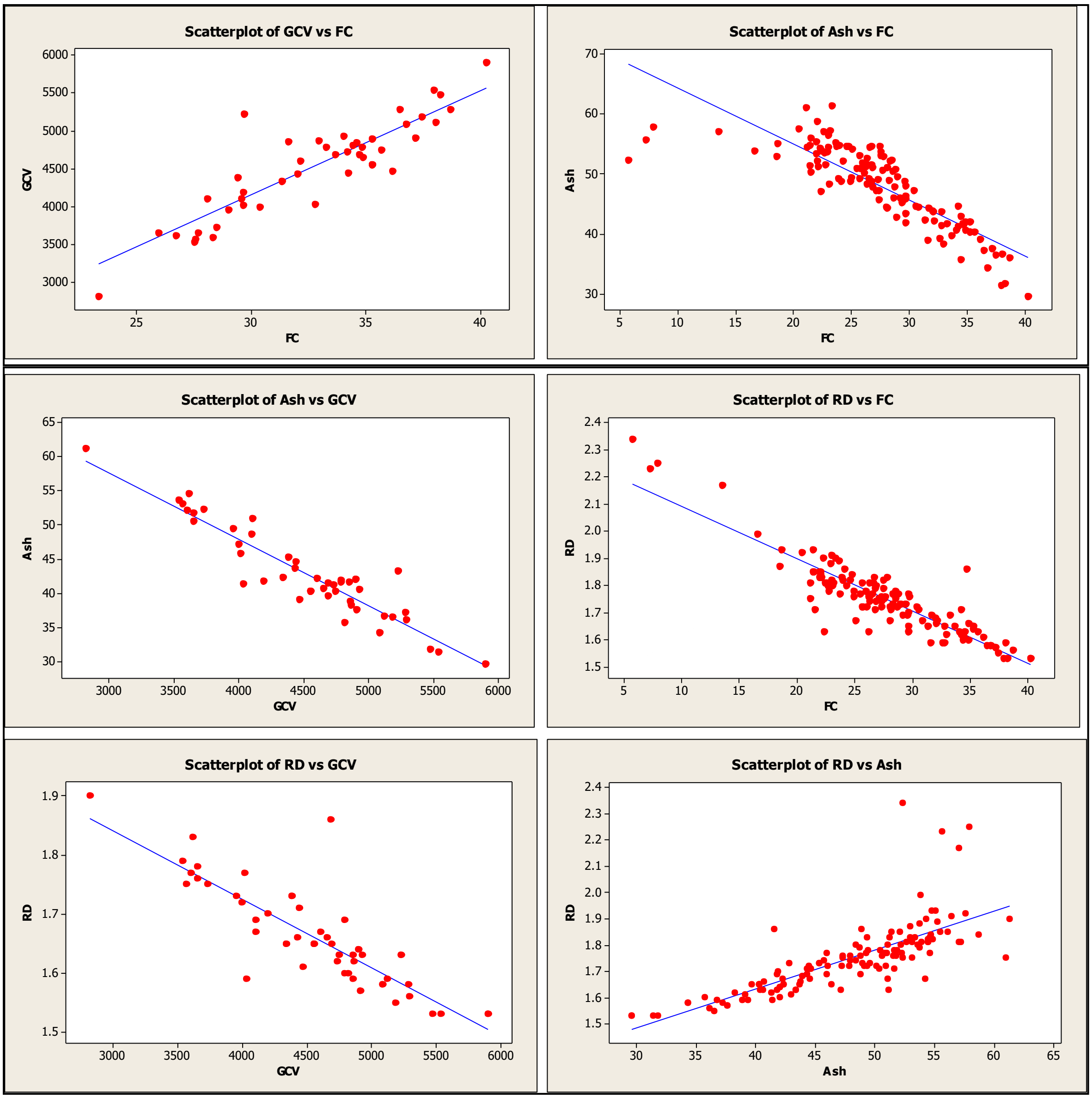


Fig. 6-13: Graphical Representation of Grade Consistency

Table 6.12: Total Rb- A (Combined for all 4 C/S line along strike in Rb-A)

	Mean	Std Dev	Variance	3rd Quartile i.e.75% values are below	95% Confidence Interval Mean	95% Confidence Interval Median	95% Confidence Interval Std Dev
RD	1.6843	0.1224	0.0150	1.7600	1.6751 1.6936	1.6700 1.6900	0.1162 0.1293
Ash	44.867	8.581	73.638	51.210	44.240 45.495	43.806 45.927	8.160 9.049
GCV	4321.70	820.7	673479.5	4851.50	4257.80 4385.50	4191.70 4394.70	777.90 868.40
FC	30.767	6.374	40.623	35.30	30.301 31.233	30.131 31.723	6.061 6.721

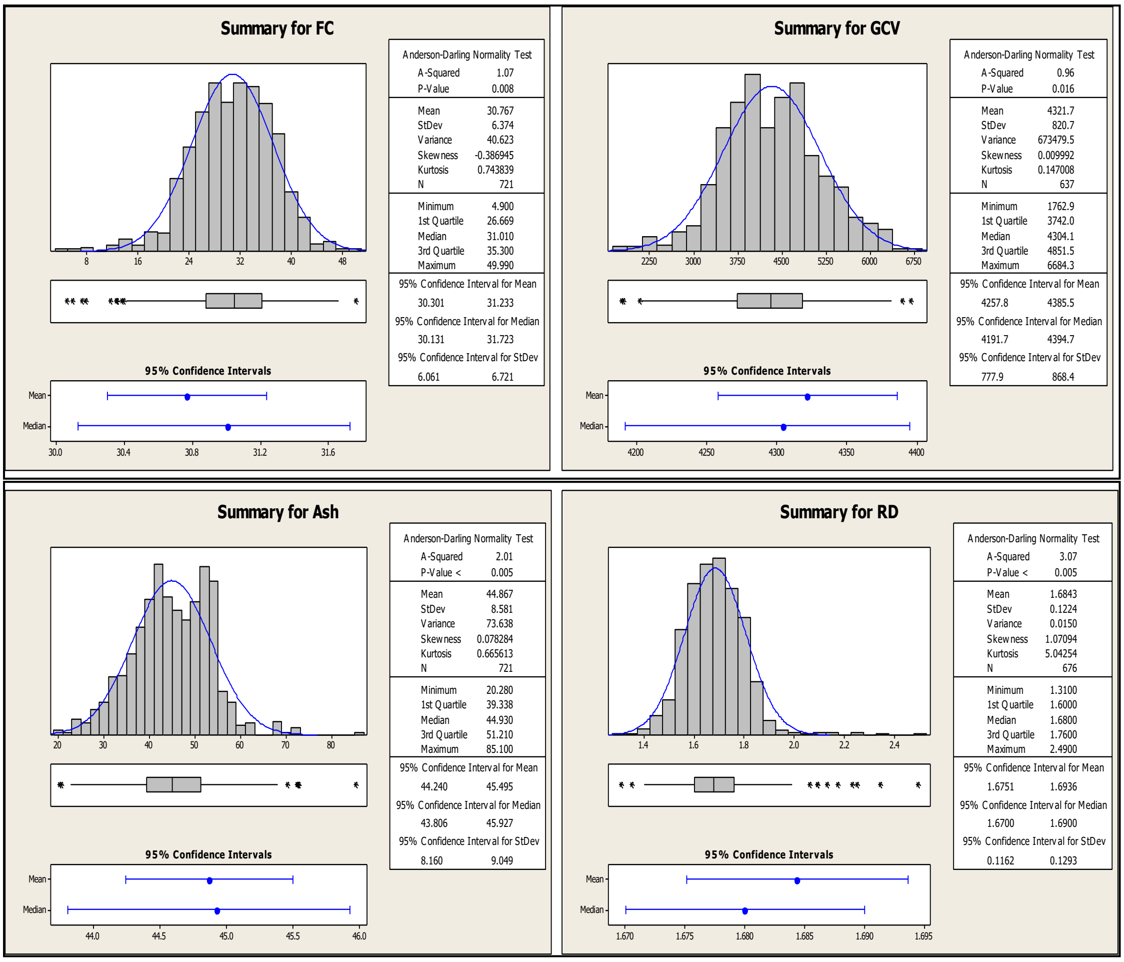


Fig. 6-14: Histogram Showing Coal Assay Population

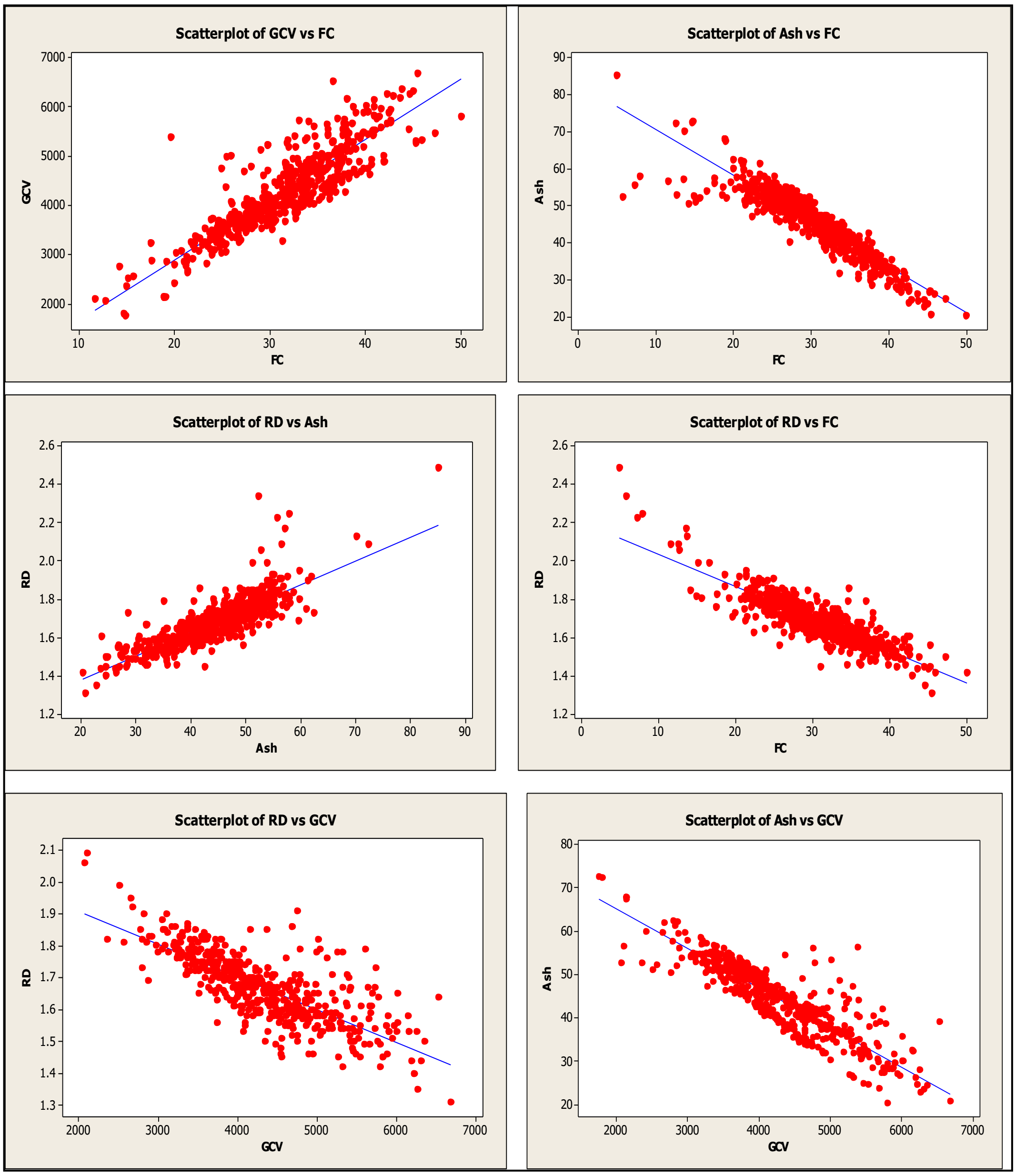


Fig. 6-15: Scatter Plot of Coal Assay

Salient inferences drawn are as follows:

- All the graphical plots demonstrate consistency that there is reasonable grade continuity in coal quality along strike and dip.
- There is a good correlation between RD and Ash% i.e. ash content increases in coal with increase in RD. GCV values decrease with increase in ash% and RD.
- VM% increases with decrease in ash% and RD; Similarly, FC% increases with decrease in ash%.

Implication: Histograms, scatter plots and mean deviation indicate that there is a variation in coal assay but confined to particular means, which is a characteristic feature of high ash coals. This is likely to constrain in the form of high content of near gravity material with a connotation of “difficult to separate”.

6.8 COKING COAL TESTS QUALITY & CHARACTERIZATION

The Midwest has adopted the following comprehensive procedure to characterize coking coal.

- A total of 6500 coal core samples covering the entire 5086C property have been subjected to basic coking property (FSI/CSN) determination along with the proximate analysis. In case of RC open holes, rock chip cuttings are washed to get a float of 1.45 density and subjected to FSI/CSN tests.
- From core bore samples, a float at 1.55 RD which matches to ash content of < 10% have been subjected to the following coking coal tests: Grey-King, Roga Index, Dilatometer, Gieseler Fluidity, Vitrinite Reflectance (MMR), Vitrinoid profile, Reactive/Inerts, VM, Alkalies & small-scale coking tests, CRI/CSR and calculated CSR and Drum Indices.
- It may be mentioned that coking coal characterization presented in this report is indicative and data augmentation is a continuing process during the life of the project.

6.8.1 FSI/CSN:

It is a measure of the extent of swelling of a coal and its tendency to agglutinate when heated rapidly. It is an index of coking propensity. The test consists of carbonizing coal under specified temperature. The coke button produced is compared with standard profiles classified by numbers from 1 to 9 with 0.5 unit increments. Coal seams in the Midwest deposit shows varying degrees of coking propensity ranging from 1.5 to 8. Seam-wise coking coal propensity of raw coal is given in Table 6.13.

Table 6.13: Seam-wise FSI Values on Raw Coal at sub seam level

BH.ID	SOUSO PINTO			CHIPANGA			GRANDE FALESIA			UC
	L	M	U	L	M	U	L	M	U	
CA01	3.0		3.0	6.5		4.0	2.5	3.5	5.0	
CA03	-		4.5	4.0		2.5	3.0	3.5	3.5	2.5
CB02	1.0		1.5	1.0		6	2.5	1.5		
MDC01	3	3	2	1.5		2.5	2.5	1.5	3.5	
MDC02	2	4	2.5	2.5		3	2	3	3.5	
CC07	5.0		4.0	1.5		4.0	2.0	4.5	4.0	
CC05	2.5		2.0	2.0		1.5	1.5	3.5	3.0	
MDC06	1.0		4.5	3.5	3.4	2.0	1.5	2.5	2.0	1.5

On washing, the same coals display FSI/CSN**of 8 to 9** on 1.55 float confirming the product to be metallurgical grade.

6.8.2 Roga Index & G Caking Index:

In Roga Caking power test, a gram of coal sample is mixed with five grams of anthracite (with defined characteristics). The mixture is compressed using a weight and is placed in a furnace at 850^0 C for 15 minutes. Once cooled, the fused sample is removed from the crucible weighed and placed in a small tumble drum where it is rotated for 250 revolutions, screened at +1mm and reweighed. Roga Index determined seam wise is given in table 6.14.

Table 6.14: Seam wise Roga Index values

	KBH029 (Chipanga)	**KBH45 (Grande Falesia)**	**CE-14 (Baneneiras)**	**CE-14(Intermedia)**	**LD01(Souso pinto to Chipanga)**	**LD02 (Chipanga)**
Roga Index	82	88	87	86	80	92

The Roga index is used in Europe to indicate caking capacity. It was also given as an alternative to the crucible swelling number for defining the group number in the international classification of Hard Coal by Type system.

G Caking index was developed in China as an alternative to Roga Index. Both have similar methods of testing with minor variation but the same purpose to test Caking strength G_{RI} amounts to +50.

6.8.3 LTC Coke Type (Grey-King) and Assay:

The low temperature carbonization coke types are determined by Grey King assay method, by heating 20 grams of coal at 600^0 C for 1 1/4 hour and comparing the profile of carbonized residue with those formed from a series of standard coals producing coke types A to G, G1, G2, G3, G4 etc. Coke type was also determined for individual coal bands as well as composite samples of raw coal at washed product for 15% ash. The coke type for raw coal is D to G and for 15% targeted ash, it is **G1**whereasfor targeted ash of 10%, and it is **G8 & G9**. Grey King is an important parameter in market specification of metallurgical coal.

6.9 COAL PETROGRAPHY

6.9.1 Macerals:

Macerals are microscopically recognizable individual organic constituents of coal. There are three major maceral groups viz Vitrinite, Exinite and Inertinite.

6.9.2 Vitrinite:

The coal in 5086C is banded coal of bituminous type. It is characterized by vitrain laminae of up to 3cm thickness. It dominates over all other coal macerals. A special attention is given during core logging to estimate the vitrain content by visual examination has indicated to be in the range of 60 to 85%. Petrography studies have revealed 70 to 80% of vitrinite in the Midwest coal.

6.9.3 Mean Maximum Reflectance (MMR):

Petrographic study on reflectance was conducted on Vitrinite maceral. Fine coal is set into a small block of epoxy type material and one face is polished. Oil immersion of macerals of this polished face allows the measurement of reflectance using incident light. The Mean Maximum Reflectance is determined by the mean of number of measurements of vitrinite macerals (usually a minimum of 50), where the stage is rotated to give maximum readings. Vitrinite reflectance increases with coal rank and is a very significant parameter for assaying coals for coke making potential.

Summary of MMR is determined for composite samples are shown below. There is a good deal of consistency in MMR values from different laboratories as shown below (Table 6.15).

Table 6.15: Summary of MMR

Borehole No	LD01 (Souso pinto)	LDO2 (Chipanga)	MDC02 (Chipanga)	KBH45 (Baneneiras)	CE14 (Intermedia)	Trail pit
ACT LAB, SOUTH AFRICA	0.98	0.98	---	0.94	0.97	-
CIMFR, NAGPUR, INDIA	---	---	0.98	---	---	-
SAIL,INDIA	-	-	-	-	-	0.80
CMPDI,INDIA	-	-	-	-	-	0.96

6.9.4 Vitrinoid Type:

These are individual reflectance measurement groupings covering a 0.1% range, e.g. vitrinoid type, V6, includes all individual reflectance measurements from 0.60% - 0.69%, V7 - 0.70%-0.79%, V8 - 0.80%-0.89%, V9 – 0.9-0.99, V12 - 1.20-1.29% etc. A Vitrinite reflectance histogram (also called a reflectogram) can be drawn by plotting the number of individual measurements in each vitrinoid type versus reflectance. In Midwest coking coal V9 is dominant vitrinoid type. The +V9 vitrinoids amount to 69-80%, mean being 75%, which determines the market value of metallurgical coal in some countries like India.. There is broad symmetrical distribution of vitrinoids on both sides of maxima (see Fig. 6-16).

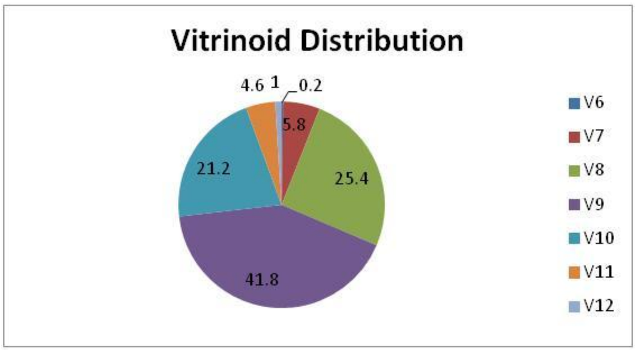


Fig. 6-16: Vitrinoid Distribution in Midwest Coal

6.9.5 Reactives and Inerts:

Reactives refers to those macerals which burn readily during combustion and become plastic during carbonization in the coke oven. The reactives include vitrinite and exinite maceral groups and a portion of the semi fusinite from the inertinite group. The inertinite macerals are not reactive group is generally not reactive which include macrinite, fusinite, sclerotinite and inertodetrinite. The reactives in 5086C coking coal amount up to 84%; the total inerts is 16%, calculated mineral matter being 5.5% and the determined optimum inerts amount to 17-22%.

6.9.6 Dilatometer:

The dilatometer test measures the expanding and contraction characters of coal. Finely crushed coal is compressed into a pencil form and heated slowly. As the coal passes through its plastic range, initially it gets shorter (contracts) and then gets longer (expands). Measurements taken are the maximum contraction and maximum dilation, both expressed as percentage of initial pencil length. Summary of Dilation values available are shown in Table 6.16.

Table 6.16: DilatationValues for Midwest Coal

Dilatation		**KBH029 Lot # V & VI**	**KBH45 Lot # VI**	**CE-14 Comp-1**	**CE-14 Comp-2**	**LD01**	**LD02**
Softening temp	^{0}C	371	372	358	365	378	354
Temp. Of Max. contraction	^{0}C	419	412	405	402	424	397
Temp. Of Max. dilation	^{0}C	474	465	445	442	450	510
Max. contraction	%	22	27	26	25	28	26
Max. dilation	%	95	111	120	102	37	246

Maximum dilation is a key parameter in market specification of metallurgical coal. There is a relation between volatile content and dilation range whose generalized dilation ranges are

High volatile coals: +50 to >300%; Medium volatile +100 to 250%: Low volatile <0 to 200%.

6.9.7 Gieseler Plastometer:

The G. Plastometer test measures the fluidity characteristics of coal. Fine coal is heated slowly; as it melts and passes through its plastic range its fluidity is measured. Results are expressed as maximum fluidity in dial divisions per minute (ddpm). Characteristic temperatures recorded are initial softening temperatures, maximum fluidity temperature and resolidification temperature. Summary of fluidity values are given in Table 6.17.

Table 6.17: Gieseler Fluidity Values Midwest Coal

Gieseler Fluidity		KBH029 Lot # V & VI	KBH45 Lot # VI	CE-14 Comp-1	CE-14 Comp-2	LD01	LD02	Trail Pit
Seam Name		Grande Falesia	Intermedia	Bananeiras		Souso Pinto	Chipanga	Chipanga
Initial softening temp	0C	398	398	408	406	406	380	-
Fusion temp	0C	409	407	-	-	-	-	-
Max. fluid temp	0C	442	433	446	446	436	433	-
Solidification temp	0C	477	469	478	477	466	475	-
Plastic Range	0C	79	71	-	-	-	-	-
Max. fluidity	ddpm	2528	1844	390	1180	1120	2271	2654(CMPDI) 13157(SAIL)
Log Max. fluidity		3.4	3.27	-	-	-	-	-

Mean Maximum fluidity reported at this stage is1455 ppm and Log Max fluidity is 3.3. Which broadly corresponds to medium volatile coal hen viewed on a scale: - High Vol-5000 to 30000ddpm; medium volatiles <200 to 20,000 ddpm and 20 to 1000ddpm.

6.9.8 Volatile Matter:

Volatile matter and fluidity play an important role in coke making. The VM should be neither too high nor too low. The desirable levels of VM on daf basis is 24% to 34% to quality as a coking coal. The coking coal in Midwest Concession has VM (daf) in the range of 27% to 31%. The analytical report of washed coal samples at 10% ash show 31% VM. The highest VM value of 31% for Midwest Coal was considered for reporting. .

Market classification of coking coal is based on the quantum of Volatile Matter present in the washed coal and the categories are as follows:

a) Premium Low Vol HCC= 21 to 25% VM;

b) Mid vol + 26 to 28% VM;

c) High Vol 29-34% VM;

6.9.9 Metallurgical Coke Making Test (HTC):

Coking coal recovered from Large-dia boreholes was tested for HTC in small scale oven at ACT Bureau veritas Laboratory in South Africa. Coke is made by wetting -3mm coking coal product to 7-7.5% moisture and the sample is stamp charged to get a density of around one. The coal is then heated from room temperature over a period of 5 hours to 1100^0 C in an oxygen deficient coke oven. Temperature inside the reaction is recorded at two different portions namely the side bottom and center middle.

Table 6.18: Table showing HTC coking proflie of 5086C coal property

Request Number	1213-139	Time	Oven Setting	Temp. ˚C Side, Bottom	Temp. ˚C Centre, Middle	Mass loss g
DATE	2/21/2012	0	200	28.6	28.7	0
SAMPLE	Midwest	10	200	28.9	29.6	0
SAMPLE	CE 14 Comp. 1	20	200	33.6	34.5	0
SAMPLE DATE	2/7/2012	30	300	41.7	41.3	0
START TIME	12:20	40	300	53.4	51.2	0
END TIME	17:30	50	300	87.7	63.4	2
MASS BEFORE	2002.8	60	400	95.6	80.8	6
MASS AFTER	1302.2	70	400	95.6	98.6	30
CALC. MASS LOSS	680	80	400	96.7	104.1	57
% MASS LOSS	33	90	500	101.2	122.4	75
MASS LOSS/20min.	2.12	100	500	111.1	147.1	95
ACTUAL MASS LOSS	700.6	110	500	131.9	175.3	113
Height	8	120	600	158.1	200.6	125
Volume	2151.3	130	600	180	224.2	130
Density	0.93	140	600	210.8	241.8	138
Moisture	6-8%	150	700	244.3	250	152
Temp setting:	Cotrolled ramp rate	160	700	276.8	261.8	170
Atmosphere	None	170	700	286.9	283.6	200
		180	800	322.7	297.6	242
		190	800	358.1	310.3	276
		200	800	414.1	328.1	314
		210	900	488.8	348.8	355
		220	900	561.3	370	402
		230	900	654.3	400.8	449
		240	1000	739.5	441.5	492
		250	1000	793.7	490.4	545
		260	1000	871.6	538.2	597
		270	1100	925.6	748.8	638
		280	1100	962.6	934.9	668
		290	1100	999.2	963.5	677
		300	1100	1036.6	1000.7	680
		310	1100	1024.8	1010.5	680
		320	off	998.5	1002.3	680
		330	off	970.2	999.5	680

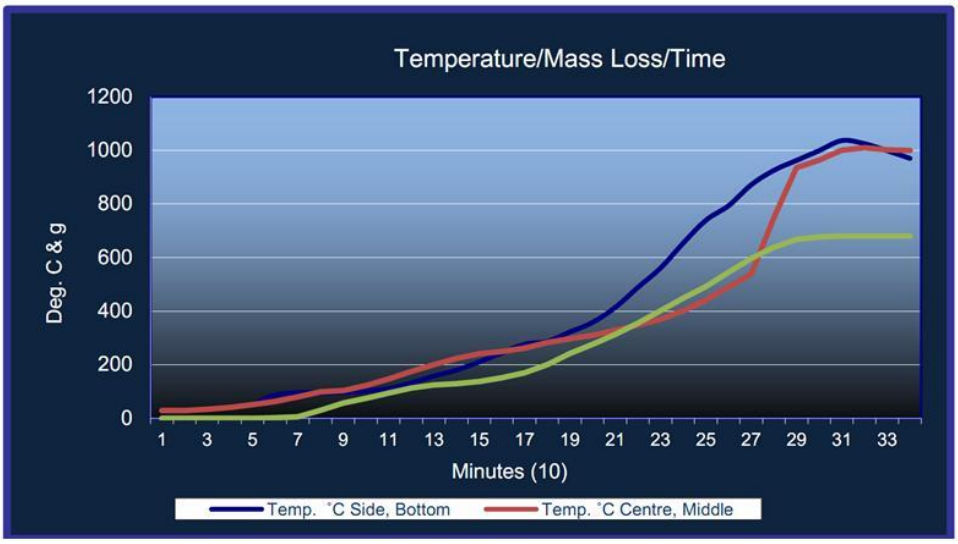


Fig.6-17: HTC Coking Profile

The coke made from this study shows moisture 6-8%, mass loss of 35% with a potential to yield 67% of coke product at a density of 0.9.

Following table shows the expected behavior of Midwest coking coal in coke oven battery. Graphical representation of temperature, mass loss and time are also shown below (Fig 6-17). Coke reactivity index is 33% and coke strength after reaction is primarily determined as 39% on one sample only, which is inadequate for reporting and bench marking.

The CP recommends that the CSR/CRI should be tested on a minimum 5 samples from each sub-seam. Meanwhile, the calculated CSR is indicative of coke strength whose values derived from commonly accepted standard procedures are broadly accepted and showed in Table 6.17.

6.9.10 Reactivity Testing:

CSR testing is recommended from pilot scale coke making test at Ipswich laboratory, Australia during feasibility stage of the project.

Meanwhile, CSR was calculated following standard procedures adopted in coking coal industry.

The CSR prediction methods are given below

- Nippon Steel Corporation Method.
- BHP Australian Method.
- KOBE Steel Method.

6.9.11 Nippon Steel Corporation Method:

NSC published a model for CSR based on Vitrinite reflectance and optimum inertinite content. CSR prediction of Midwest coal is shown in Fig 6-18.

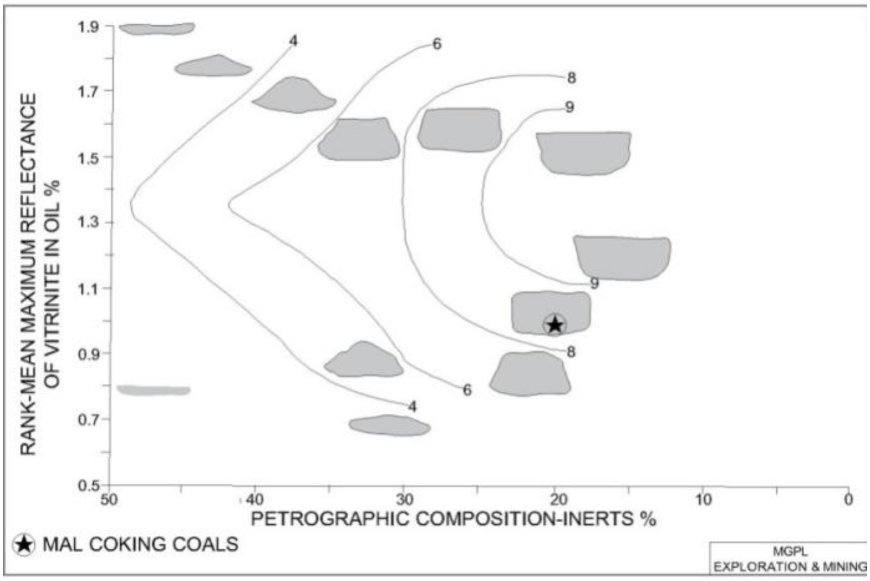


Fig. 6-18: Rank Prediction Based On Nippon Steel Company Method

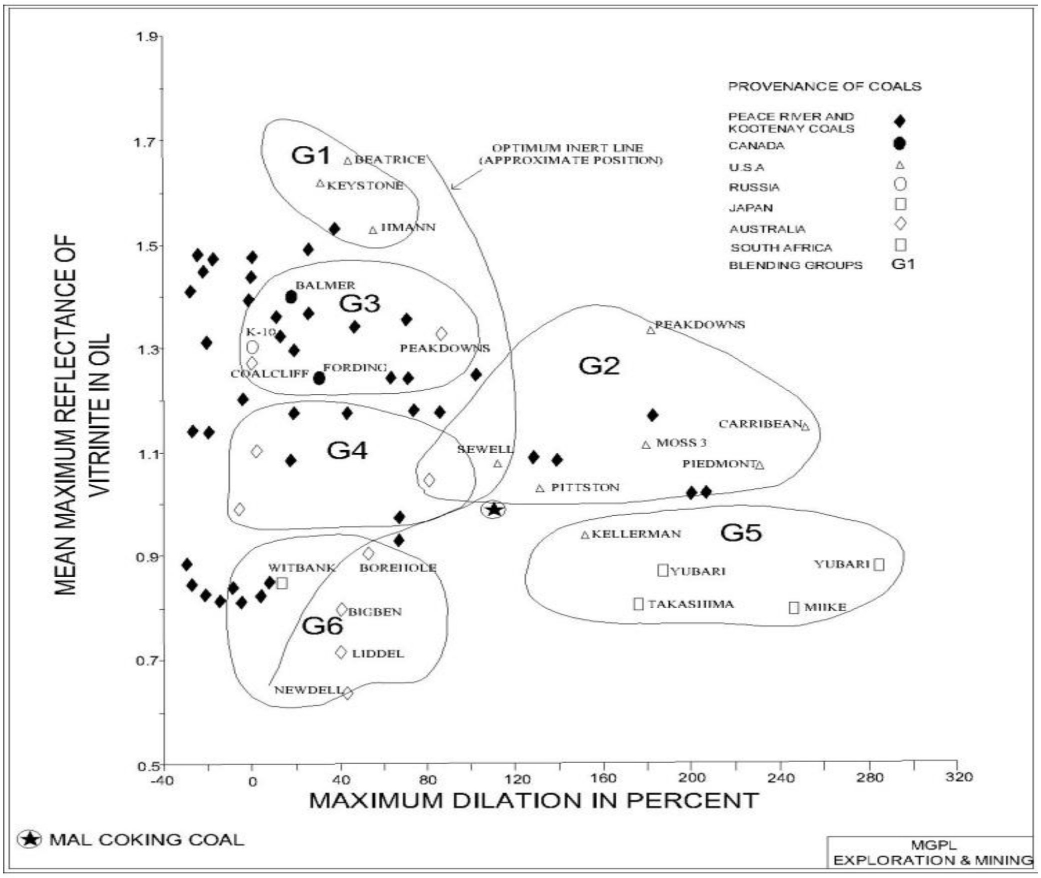


Fig. 6-19: Rank Prediction Based On Nippon Steel Company Method

6.9.12 BHP Australian Method:

Australian Research at BHP produced regression equation better suited to Queensland and New South Wales coals. This equation of predicted CSR vs. Measured CSR on 52 coals and cokes have a correlation coefficient of 0.92.

CSR=133.8-15.56 X BAR-3.1 X VM + 8.5 X log (fluidity) - 0.22 X Inerts

Where, **BAR** = (Fe_2O_3+CaO+MgO+K_2O+Na2O)/ (SiO_2+Al_2O_3+TiO_2)

Fluidity = maximum fluidity in drum dial divisions per minute (ddpm)

Inerts = Total inert material in sample

6.9.13 KOBE Steel Method:

Kobe steel method regression equation for RSI determination is

CSR =70.9 X Rmax% + 7.8 X Log (fluidity) – 89 X BAR-32

The RSI values obtained for Midwest coal is 74. RSI means Reactive strength index.

Here RSI is CSR +10. (See Pearson research on Canadian coking coals)

Although there are no universally accepted prediction techniques, a comparison of several methods provides a fair prediction of CSR of Midwest coal Comparative statement of predicted CSR values is given below (Table 6.19).

6.9.14 Price et.al:

CSR=52.7+0.0882 X (C+D)-6.73 X $(\text{MBI})^2$+14.6 X Rmax

(33 Western Canadian coals & 22 Appalachian coals (Price et al., 1988)

Where, **C+D** = Total Dilation

MBI = Modified basicity index = $\dfrac{100\text{xashx } (Na_2o+K_2o+Cao+Mgo+Fe_2o_3)}{(100\text{-VM}) \text{ X } (SIO_2+Al_2o_3)}$

Table 6.19: CSR Values (From CSR Perdition Model)

CSR VALUES (From CSR Perdition Model)		
CSR		
PRICE ETAL	BHP AUSTRALIA	KOBE STEEL
55.0	60.4	56.3
54.1	54.3	47.5
52.4	52.4	51.7

From the above data the CSR values of Midwest coal are in the range of 48 – 60 (ASTM Coke strength). These compare well with High Volatile- A/USA and marginally less than 64 HCC of Australian coking coals. Coals of similar nature with ASTM stability of 50 to 60 contains <25% of optimum Inerts.

CP’s view point is that the MAL coal may be characterized as Medium MMR and Medium CSR category in the market.

6.9.15 Coke Drum Indices:

Drum testing is a common analysis used to understand the cold strength of coke sample and the influence of mechanical action on coke. Drum Indices - Micum and Irsid, as worked out on calculation basis in ACT Lab, Johannesburg, South Africa are mentioned below (Table6.20). These drum indices broadly correspond to some of good metallurgical coal trade in global market.

Table 6.20: Drum Indices MAL coal (calculated)

Predicted Drum Indices	KBH-45 Lot # 6	CE-14 Comp-1	CE-14 Comp-2	LD01	LD02
Micum 10 Index	8	<6.0	8.2	6.6	6.4
Micum 40 Index	69	-	-	65	63
Irsid 10 Index	21.1	<17.8	21.5	18.8	18.5
Irsid 20 Index	76.1	>79.5	75.8	78.5	78.8
Irsid 20 Index(COR)	-	>79.5	75.8	-	-

6.9.16 Sulfur, Phosphorous and Chlorine:

Sulfur is an undesirable element responsible for corrosion. Chlorine has negative effect in coke oven refractories, slagging and corrosion. Phosphorous has a tendency to enter the molten metal easily and degrades the product. **The permissible range is S=0.61to1.00; P=0.03 to 0.06 and Cl=0.03 to 0.09**. Midwest coal contains sulfur 1 +/- 0.2 in which organic sulfur averaging 0.8% remaining is sulphide and sulphate. Phosphorous content is <0.03 and Cl is 0.05 to 0.06, which comply with the coking coal specifications.

6.10 COKING COAL CHARACTERIZATION

Pearson (1980), ALS (2011) and Thomas (2013) plots are widely used for characterization of coking coal from global and geographic perspective and attendant comparisons. The following diagrams depict that the Midwest coking coal fits well with the global brands like Australian, Canadian and US coking coals as per Pearson petrographic plots and ALS(Australia) characterization graphs (Figs.6-20 to 6-23).

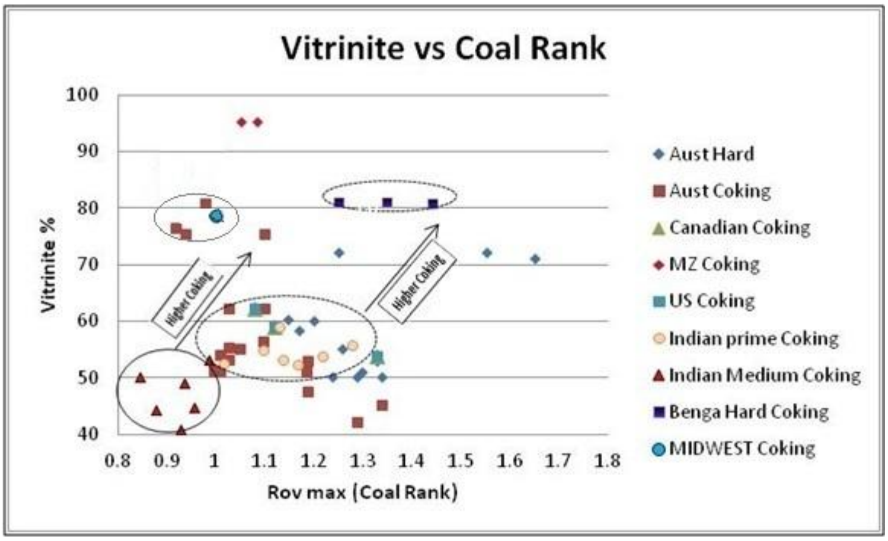


Fig. 6-20: Midwest Coking Coal Vitrinite Vs Coal Rank

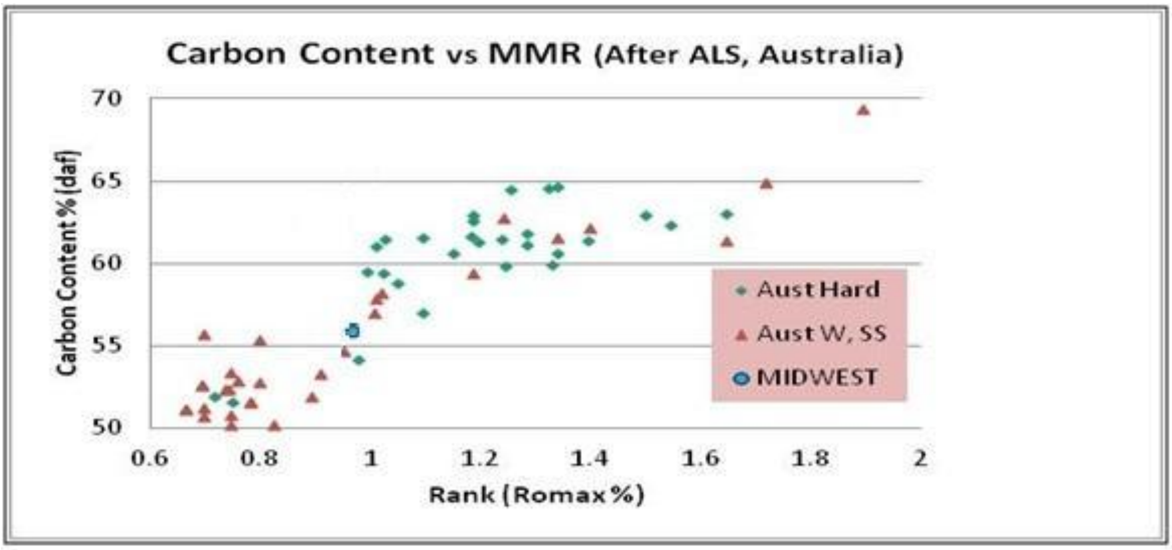


Fig. 6-21: Midwest Coking Coal Fc Vs Rank

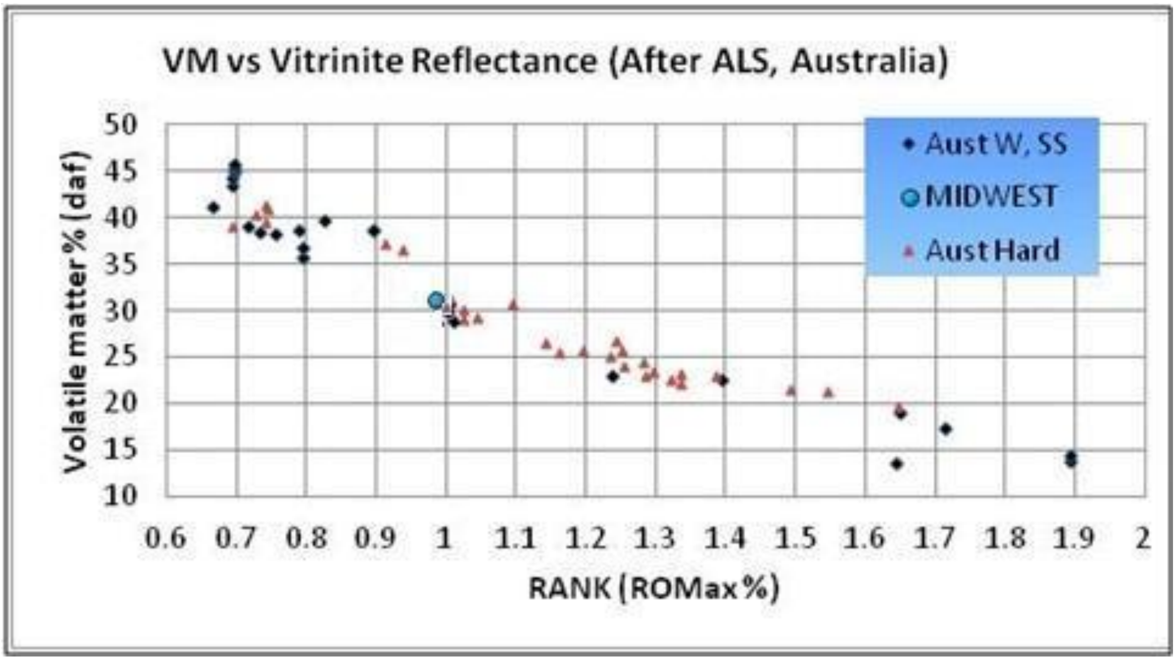


Fig. 6-22: Midwest Coking Coal VM VS Rank

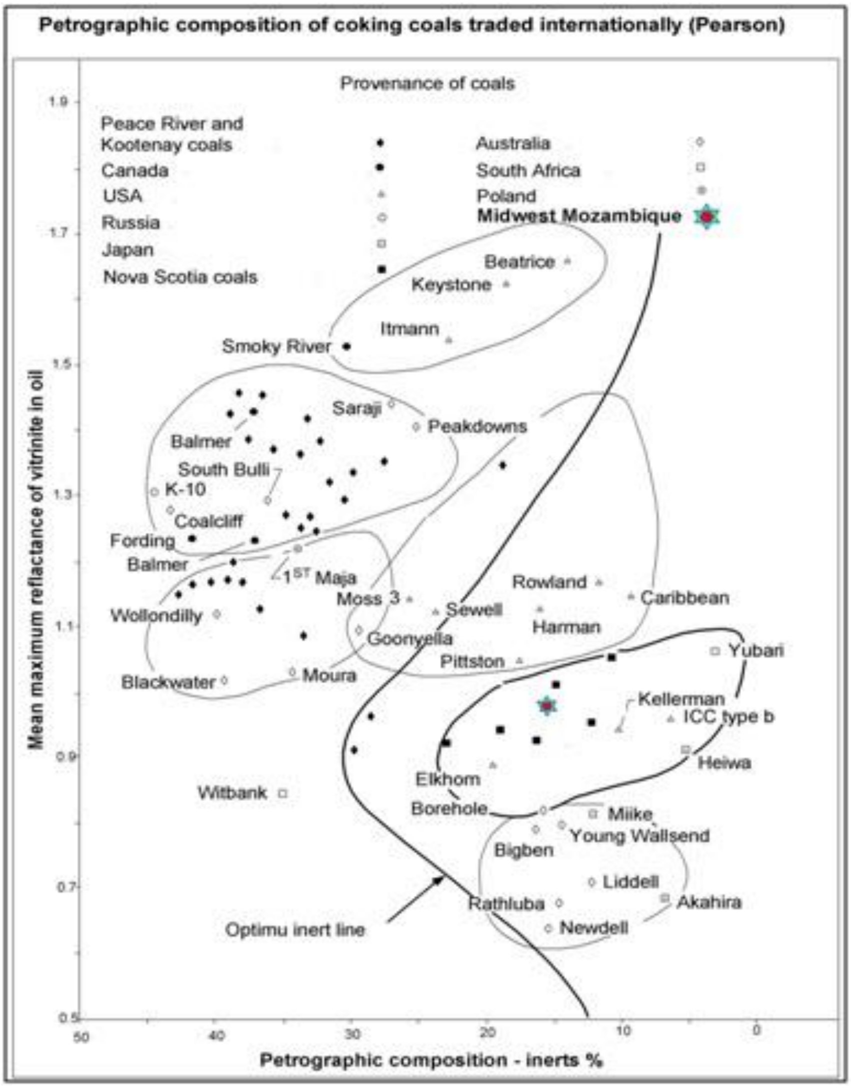


Fig. 6-23: Midwest Coking Coal Inerts Vs MMR

6.10.1 ISO Classification of 5086C metallurgical coal:

International Standards Organization (ISO) has prepared a common terminology for classification of coal. As per ISO 11760 the Midwest coal may be defined as

- Rank: Medium Rank Bituminous ‘B’ Coal.
- Vitrinite: Moderately high Vitrinite.
- CSN: Hard Coking Coal.
- VM: Mid to High vol.

6.10.2 By Australian standards:

- By MMR- The measured value of vitrinite reflectance in oil as per ISO procedure is 0.98. Y Australian hard coking coal coding system (Australian standard 2096-1987), the Midwest coking coal code **is 5442**.The first digit denotes VM (27 to 31%), second is CSN (8-9); third is GK type(G6-G8) and fourth is ash (10%).

6.10.3 By Chinese classification (Table 6.21)

The Chinese coal classification is defined in National Standard No. GB/T5751-1986. In addition to Volatile Matter, it takes into consideration of caking properties such as G_{RI} Caking Index –a modified form of RI (Roga Index), Ymm maximum thickness of plastic layer.

Table 6.21: Classification of Chinese Coals

Classification of Chinese Coals (GB/T5751-1986)							
Class	**Group**	**V.daf (%)**	**$G_{R.I}$**	**Y(mm)**	**b (%)**	**Pm (%)**	**Qgr, maf (MJ/Kg)**
Anthracites	Wy-01	≤3.5					
	WY-02	3.5-6.5					
	WY-03	6.5 to 10					
Bituminous	PM	10 to 20	≤5				
	PS	10 to 20	5 to 20				
	SM	10 to 28	20 to 65				
	JM	10 TO 28	50 TO 65	≤25	<150		
	1/3 JM	28 to 37	>65	≤25	<220		
	FM	10 to 37	>85	≤25	<150		
	QF	>37	>85	≤25	<220		
	QM	28 to 37	35 to 65	≤25	<220		
	1/2ZN	20 to 37	30 to 50				
	RN	20 to 37	5 to 30				
	BN	20 to 37	≤5				
	CY	>37	≤5			>50	
Lignite	HM1	>37				≤30	
	HM2	>37				30 to 50	≤23.9

The Midwest coking coal by rank (Ad VM <31% and dmmf VM 31-33%; and > 32MJ/kg.) Byrank mid to high vol-A by ASTM (D-388) and 1/3 JM (GB/15751-1986)

RI (Roga) 85 corresponding to GRI>50 by Chen Peng (195) correlation coefficient indicting similarity to JM type.

Y</~ 25mm on (Ting Lu and Gerard Laman graph) indicating 1/3JM type

b (max dilation) <150 similar to JM type.

MAL, Mozambique, metallurgical coal may broadly be categorized as JM to i/3 JM category.

FSI- 8-9 =strong caking

6.10.4 By Hampton road index:

Coking coal data presented so far in this report is adequate enough to compare the Midwest coking coal with other indexed coals for commercial purposes. As there is no coking coal consumption in Mozambique, most of the coal produced from its coalfields has to be exported to overseas markets. Technical and commercial aspects of Midwest coking coal indexing is presented in chapter on Economic analysis.

Boyle Trading Consultants has created coking coal indices for the major hubs of Queensland, Australia (CCQ) and Hampton Road in the US (CCH-Low and CCH-High). These indices are credible and Tradable Proxies for the physical market (Table 6.22).

Table 6.22: Coking Coal Index

Coal component	CCQ	CCH-Low	CCH-High	Midwest Mozambique
Variable component				
Total moisture %(ad)	10	8.0	8.0	1.6
Ash % (ad)	9.7	5.5	7.0	9.9
Sulfur % (ad)	0.6	0.6	0.9	~1
CSR	70(normal) 67min	30+	-	41 – 59%
Core component				
CSN	>7	7-9	7-9	8-9
Fluidity(ddpm)	100+	-	>28,000	2500
VM % (ad)	<27	16-19	32-35	31
MMR %	1.15-1.52	1.4-1.7	1.01-1.15	0.98
Arnu %	-	-	240	

It is suggested to undertake market index for Midwest coking coal during the feasibility study.

6.11 THERMAL COAL QUALITY

Calorific value and ash percentage are two parameters used for thermal coal pricing. Specifications of the Midwest coal are

At 44% ash = 4525 Kcal/kg

At 28% ash = 5800 Kcal /kg

At 25% ash = 6000 Kcal /kg

At 10% ash = 7200 Kcal/kg

6.11.1 MAL's export thermal coal specifications:

Coal preparation studies and coal quality tests have revealed that the coal ~tor > 25% ash is suitable for burning in boilers. Thermal coal specifications include Moist: 2%, Ash: 25%, VM: 28%, FC: 44% and GCV: ~ 6000 Kcal/kg.; NCV: 5980 Kcal/kg; at 28% ash level, the GCV amounts to ~5800 Kcal on adb. A comparative statement showing comparison between 5086C thermal coal and Richard bay Bench mark coals is shown in Table 6.23.

Table 6.23: Comparative statement of Richard bay bench mark coals and MAL coal specifications

Specifications	RB1	RB3	MAL
Calorific Value Basis (kcal/kg NCV)	6,000	5,500	6,000
Calorific Value Min (kcal/kg NCV)	5,850	5,300	5,980
Total Moisture (ARB)	12% max	14.0% max	2.0%(ADB)
Volatile Matter (ARB)	22% Min	20.0% min	28.0%(ADB)
Ash (ARB)	15.0% Max	23.0% max	23-25(ADB)
Sulfur (ARB)	1.0% Max	1.0% max	1.0%(ADB)
Hardgrove Grindability Index (HGI)	45-70	45 – 70	54-68%
Nominal Topsize	50mm	50 mm	50mm
IDT	Min 1,250 °C in reducing atmosphere	Min 1,150 °C in reducing atmosphere	1500°C In reducing atmosphere
Calcium Oxide in Ash (DB)	12.0% max		0.9-1.2%

MAL= Midwest Africa Limitada, Mozambique, RB= Richard Bay

6.12 ASH FUSION TEMPERATURE (AFT)

Ash fusion temperatures provide an indication of softening and melting behavior of ash on coal burning in a boiler. Information on AFT is used in boiler designs as it gives an indication of slagging behavior of burnt coal in boiler and also an insight into high temperature behavior of fuel inorganic material. AFT is measured at four deforming points under both reducing and oxidizing condition (Table 6.24). It is suggested that some more coal samples be tested for AFT.

Table 6.24: AFT Values

KBH02	**REDUCING(^oC)**				**OXIDISING (^oC)**			
Sample No	**Deformation**	**Spherical**	**Hemisphere**	**Flow 0° C**	**Deforma**	**Spherica**	**Hemisph °**	**Flow 0° C**
KBH02/C12	>1550	>1550	>1550	>1550	>1550	>1550	>1550	>1550
KBH02/C21	>1550	>1550	>1550	>1550	>1550	>1550	>1550	>1550
KBH02/C28	>1158	>1168	>1194	>1258	>1290	>1298	>1328	>1394
KBH02/C36	>1550	>1550	>1550	>1550	>1550	>1550	>1550	>1550
KBH02/C43	>1550	>1550	>1550	>1550	>1550	>1550	>1550	>1550

6.13 HARDGROVE GRINDABILITY INDEX (HGI)

Grindability of coal denotes physical quantity of coal in regard to resistance of coal against grinding. Hardgrove Grindability Index (HGI) is determining factor of energy consumption during grindability. It is significant for the design of grinding circuits. Power plants burns ground coal usually requires HGI>60, coal while HGI<50 is considered heavily grindable. The following is the Australian categorization of coal based on HGI, <40 = very hard; 60-80 = medium hard; 80-100=soft, 100-120 = very soft. (ACARP report on 5, 1998). HGI values for Midwest coal is shown in Table 6.25.

Table 6.25: HGI Values

	Borehole No: KBH02				**Borehole No: KBH03**					
Sample. No	C9	C27	C30	C39	C6	C18	C30	C36	C54	C63
HGI	58	54	54	54	71	62	68	63	62	59

6.14 ASH ANALYSIS

Concentration of oxide compounds such as silica, sesquioxides, alkalies present in coal influence the performance of boilers and Blast furnace. Ash composition of the Midwest coal is presented in Table 6.26.

Table 6.26: Ash Analysis

BH.ID	SAMPLE ID	SiO2	Fe2O3	Al2O3	Cao	Mgo	Na2o	K2o	Mn3O4	SO3	P2O5	Sr	Ba	ZnO	TiO2	Cr2O3	MnO	V2O5	ZrO2
MDC5	C2	49.3	5.3	16.55	0.92	2.37	0.91	2.16	0.07	0.16	0.43	0.04	0.11	0.02	0.48				
	C3	68.12	7.22	16.98	0.14	1.51	1.06	2.41	0.07	0.2	0.36	0.05	0.12	0.03	0.78				
	C5	61.92	52.4	17	0.16	2.28	1.15	2.18	0.11	0.36	0.39	0.04	0.12	0.04	0.83				
	C6		3.54	7.75	0.64	0.42	1.16	2.07	0.06		0.31	0.03	0.18	0.06	0.94				
	C9	69.32	4.57	18.4	0.36	1.5	1.23	1.97	0.06	0.18	0.3	0.02	0.08	0.03	0.76				
	C12	71.14	3.08	16.42	0.64	1.94	1.33	2.92	0.05	0.1	0.31	0.02	0.04	0.02	0.62				
	C17	68.35	5.63	17.88	0.36	1.74	0.78	2.02	0.12	0.23	0.47	0.08	0.22	0.04	0.83				
	C24	66.47	3.41	19.21	0.57	2.19	0.84	2.22	0.07	0.46	0.65	0.06	0.15	0.03	1.33				
	C46	68.79	3.93	19.58	0.65	0.96	0.87	2.37	0.06	0.38	0.38	0.05	0.15	0.03	1.41				
	C54	73.25	4.05	15.72	2.11	0.89	1.02	2.36	0.04	0.16	0.25	0.04	0.12	0.03	0.92				
MDC6	C3	67.16	3.41	19.04	0.17	2.93	1.44	2.05	0.21	0.25	0.39	0.06	0.28	0.03	1.11				
	C24	57.47	32.63	17.92	0.14	3.5	0.69	1.52	0.01	0.68	0.5	0.79	0.35	0.07	1.04				
	C36	64.5	6.29	22	0.91	0.46	0.34	2.24	0.06	0.35	0.41	0.05	0.52	0.04	1.4				
	C50	59.94	7.11	20.6	1.13	3.58	0.34	1.56	0.04	0.98	1.83	0.07	0.11	0.03	0.99				
	C56	51.54	35.14	25.78	0.21	0.77	0.85	2.5		0.27	0.3	0.04	0.07	0.07	1.7				
KBH45	Lot V & VI	60.77	4.64	24.03	1.01	0.67	0.09	2.63		0.38	0.64	0.1	0.12		3.7	0.06	0.02	0.19	0.14
KBH29	Lot - VI	63.92	2.45	24.81	0.85	0.61	0.15	2.94		0.09	0.67	0.06	0.22		1.71	0.04	0.01	0.07	0.07
CG14	Comp I	66.06	6.44	13.66	0.73	0.42	0	2		0.22	0.34	0.06	0.15		0.34	0.04	0.08	0.28	0.35
	CompII	72.2	4.35	16.11	0.45	0.69	no	2.3		0.12	0.4	0.09	0.16		2.25	0.06	0.04	0.09	0.13

Ash composition is used to derive productive indices that indicate ash depositional behavior. These indices may not be universally applicable to all the coals. A caution should be exercised to make use of the following indices.

6.15 SLAGGING INDEX

Based on oxide concentration, an attempt is made to understand ash deposition behavior in boilers and furnaces in the form of slagging and fouling indices (after Mineskill, 2010) as given below (Table 6.27).

Table 6.27: Boiler Performance Indices

Sample no	**Attig & Duzy Slagging Factor**	**Silica Ratio**	**Base-Acid Ratio**	**Silica /Alumina Ratio**	**Iron/Calcium Ratio**	**Sodium content**	**Attig &Duzy Fouling Factor**
MDC05/C2	0.08	88.96	0.13	4.17	5.76	0.91	0.12
MDC05/C3	0.11	88.48	0.14	4.01	51.57	1.06	0.15
MDC05/C5	0.19	80.56	0.23	3.64	34.44	1.15	0.26
MDC05/C6	0.34	0	0.9	0	5.53	1.16	1.05
MDC05/C9	0.08	91.15	0.11	3.77	13.53	1.23	0.14
MDC05/C12	0.04	92.76	0.11	4.29	5.37	1.33	0.15
MDC05/C17	0.03	89.5	0.12	3.82	8.66	0.78	0.1
MDC05/C24	0.05	89.37	0.13	3.46	1.48	0.84	0.11
MDC05/C46	0.07	93.15	0.09	3.51	23.12	0.87	0.08
MDC05/C54	0.06	93.51	0.09	4.66	28.93	1.02	0.1
MDC06/C3	0.05	90.26	0.12	3.53	3.75	1.44	0.18
MDC06/C24	0.17	76.9	0.26	3.21	11.18	0.69	0.18
MDC06/C36	0.06	89.76	0.11	2.93	29.95	0.34	0.04
MDC06/C50	0.21	82.73	0.18	2.91	3.91	0.34	0.06
MDC06/C56	0.14	76.16	0.25	2	65.83	0.85	0.21
KBH45/Lot#V &VI	0.13	90.58	0.1	2.53	4.59	0.09	0.01
KBH029/Lot#VI	0.08	94.24	0.08	2.58	2.88	0.15	0.01
CE14 /Comp-I	0.003	89.21	0.11	4.84	8.82	0.09	0.01
CE14 /Comp-II	0.002	92.22	0.09	4.48	11	0	0

6.16 TRACE ELEMENTS

Trace element analysis of Midwest coal is presented in Table 6-28. During combustion along with solid ash several inorganic elements or elemental oxides such as So_2, No_2, Br, Cl, F, B, Se and I are released into the atmosphere. Elements with relatively less volatility in that order include As, Cd, Ga, Ge, Pb, Sb, Sn, Te, Ti, Zn, Ba, Be, Bi, Co, Cr, Cs, Cu, Mo, Ni, Sr, Ta, U, V, W, Eu, Hf, La, Mn, Rb, Sc,Sn, Th and Zr.

Some of the elements like Mercury (Hg) and Cadmium (Cd) are of great concern, because of their deleterious effects on environment. Mercury content in the Midwest coal is 150ppb to 200ppb similar to US coals(180ppb) lesser than Canadian coals (100 to 400ppb) and marginally higher than Australian (~100ppb). Mercury concentration as in other coals is linked to sulfur content in coals. Cadmium (Cd) content in the Midwest coal ranges from 0.1 to 0.3ppm more or less similar to Australian and Canadian coal but significantly less than US coals. Arsenic content in Midwest coal is in range of 8 to 10ppm which is marginally higher than Canadian coals.

Table 6.28: Ash Trace element composition

Sl. No	Test parameters	MDC 05				MDC 06					
		C3 (3546/1)	C6 (3546/2)	C10 (3546/3)	C11 (3546/4)	C36 (3546/5)	C40 (3546/6)	C41 (3546/7)	C42 (3546/8)	C49 (3546/9)	C56 (3546/10)
1	Arsenic as As, ppm	9.3	10.98	8.52	9.5	9.26	9.5	9.3	8.08	8.16	19.72
2	Boron as B, ppm	180	150	183	95	110	90	65	43	16.42	25.5
3	Cadmium as Cd, ppm	0.31	0.25	0.13	0.13	0.21	0.12	0.13	0.11	0.22	0.13
4	Lead as Pb, ppm	87.5	69.45	8.83	25.56	28.97	14.3	24.91	28.25	34.88	36.14
5	Mercury as Hg, ppb	350	260	180	150	150	160	210	130	150	200
6	Molybdenum as Mo, ppm	20.4	5.43	1.21	3.98	3.99	1.3	4.08	6.35	17.77	11.98
7	Selenium as Se, ppm	1.41	1.11	0.67	1.8	2.08	1.39	2.21	2.44	3.75	4.41
8	Chromium as Cr, ppm	9.5	10.6	10.2	13.44	8.27	9.8	6.79	7.17	32.82	38.86
9	Copper as Cu, ppm	7.1	8.5	5.01	18.23	31.22	5.64	17.32	23.58	38.58	35.1
10	Fluorine as F, ppm	42	38	46	55	44	39	40	56	47	62
11	Nickel as Ni, ppm	8.5	14.2	4.54	36.47	52.85	2.93	13.96	17.79	26.69	35.4
12	Vanadium as V, ppm	74.7	65.8	52.86	74.62	60.26	46.63	46.22	52.38	83.88	124.1
13	Zinc as Zn, ppm	133	100	119	236	219	110.5	110.45	168	169	172
14	Antimony as Sb, ppm	0.33	0.45	0.2	1.36	0.94	0.28	1.23	1.5	1.04	1.01
15	Barium as Ba, ppm	286	477	171	386	277	680	163	161	336	220
16	Bromine as Br, ppm	<0.1	<0.1	<0.1	<0.1	< 0.1	<0.1	<0.1	<0.1	<0.1	<0.1
17	Chlorine as Cl, ppm	50	50	150	150	75	75	25	25	100	25
18	Cobalt as Co, ppm	4.83	11.42	2.84	13.3	7.02	8.22	6.11	6.04	8.05	13.06
19	Lithium as Li, ppm	50.7	108.9	54.2	49.67	31.16	58.64	38.07	34.34	47.37	33.44
20	Manganese as Mn, ppm	94	42	34	122	20.94	14.36	217	76.25	64.7	18.32
21	Strontium as Sr, ppm	29	27.65	6.02	5.98	34.06	18.42	12.17	17.31	15.13	16.02
22	Gold as Au, ppb	64.6	98.1	64.4	74	60.5	82.9	<0.2	7.22	55.9	49.1
23	Silver as Ag, ppb	65	80	60	70	65	85	2.5	60	50	40
24	Platinum as Pt, ppb	3.8	20.3	3.55	10.3	1.09	1.5	<0.3	0.67	2.14	1.41
25	Palladium as Pd, ppb	0.4	0.93	0.63	1.1	<0.2	<0.2	<0.2	0.24	0.3	<0.2
26	Gallium as Ga, ppm	26.7	31.9	20.76	23.43	37.01	39.37	33.11	18.57	23.54	20.52
27	Titanium as Ti, ppm	280	302	234	1013	904	254	751	820	2134	1095
28	Iron as Fe, %	0.82	0.49	0.12	1.2	0.58	0.13	3.3	3	1.13	2.94
29	Aluminum as Al, %	1.94	2.03	1.13	7.26	5.91	1.37	4.76	5.77	10.98	7.9
30	Magnesium as Mg, %	0.19	0.11	0.08	0.43	0.23	0.01	0.11	0.14	0.53	0.21
31	Total Ash content, %	48.07	42.33	46.63	52.99	36.51	31.45	31.33	35.93	54.36	36.75

7 GEOTECHNICAL STUDIES

MAL had undertaken the study of Geotechnical properties by the following methods.

- Study of Sonic logs in Mb-A & Mb-B
- Study of core bores for RQD Mb-A & Mb-B
- Laboratory tests for determination of UCS, TCS and SS etc.

M/S RR Geophysical logging consultants have conducted study of sonic logs to determine geotechnical properties. RQD was determined during core drilling by the MAL exploration team. Laboratory tests for determination compressive and shear properties were done Bureau Veritas Laboratory, Tete. Results of these studies have been applied in designing pit slopes and benches, rippability of rocks in Mine plan.

7.1 GEOPHYSICALSONIC LOGGING (ANNEXURE-IX)

Sonic logs of representative boreholes of Rb-A (CC 05, CC07&CE05) and Rb-B (CF10&CG14) are used for deciphering the physico-mechanical attributes viz. Modulus of elasticity and Poisson's ratio of roof and floor rock units.

Elastic properties: Elastic properties, characterizing the relationship between stresses and recoverable strains will help in mine planning. Mining practice and theory utilize all the physical properties relating to their mechanics, thermodynamics etc. The amount of energy spent on breaking a rock is directly dependent on its elastic constants. The distribution of acoustic and shock waves in rocks depend on their elastic properties. Therefore, the modulus of elasticity E and the Poisson's ratio σ are the most important physical properties of rocks. The effectiveness of mechanical techniques for breaking up rock depends upon the mechanical characteristics of rock and its strength. The elastic properties of rocks are used in calculations concerning their breaking by mechanical means, for example by excavations, explosives etc.

The formulae utilized to compute these values are

Formulae:

Young's Modulus (E) = $Vp^2 \rho (1-2\sigma)(1+\sigma)/(1-\sigma)$

Shear modulus (μ) = $E/2(1+\sigma)$

Bulk modulus (K) = $E/3(1-2\sigma)$

Compressibility (β) = $1/K$

Compressive strength (Sc) = $Vp^2 \rho (1-2\sigma)^2/140g(1-\sigma)^2$ $g = 9.806 m/s^2$

Tensile strength (St) = Sc/k K= 10, Farmer, 1968

Shear strength (Ss) = k' Sc k'=0.15, farmer, 1968

Geophysical logging is found to be more useful for accurate coal boundary delineation in non-core boreholes and is quick method of sampling physical properties of certain formation without taking any core or sample to the laboratory. The geophysical logging in this area has brought the following:

1. Accurate delineation of coal zones
2. Identification of coal partings within shalycoal and carbonaceous shale based on N.Gamma. The increase of shale content in coal increases the N.Gamma intensity.
3. The following physical properties of different formations in the area are derived from these operations:

Table 7.1: Basic Geophysical Attributes and Physical Properties of Rock Units.

Formation	Physical Property				Remarks
	Nat. Gamma API Units	Density gms/cc	Resistivity Ohm m.	P-Velocity m/sec	
Coal	50-100	1.4 - 1.8	500-2000	2000-2400	
Shaly coal	100-150	1.8 – 2.0	300-500	2200-2400	
Carb.shale	100-125	1.85-2.15	300-600	2300=2400	
Shale	200-400	2.15-2.4	> 200	3000-3500	
Sandstone	150-200	2.3 – 2.7	>200	3500-4000	

4. In addition to above, the elastic properties are also derived for different velocity ranges representing different formations at roof and floor level, which facilitates in mine planning are shown in the following table:

Table 7.2: Sonic velocities and rock strength

Velocity Range m/sec	ρ gms/cc	E $X10^4$ Newton's/m^2	μ $X10^4$ Newtons/m^2	K $X10^4$ Newtons/m^2	B $X10^{-4}$ M^2/Newtons
2500-3000	2.09 – 2.43	1.22 – 1.66	0.468- 0.638	0.162 - 0.217	2.15 – 2.84
3000-3500	2.43 – 2.62	1.66 – 2,38	0.638 -0.921	0.217 – 0.319	2.84 – 3.79
3500-4100	2.62 – 2.81	2.38 – 3.5	0.921- 1.34	0.319 – 0.466	3.79 – 6.16

Thus the geotechnical properties of rocks are derived from geophysical logs. The seismic rippability of rocks based on velocities is shown in Fig 7-1.

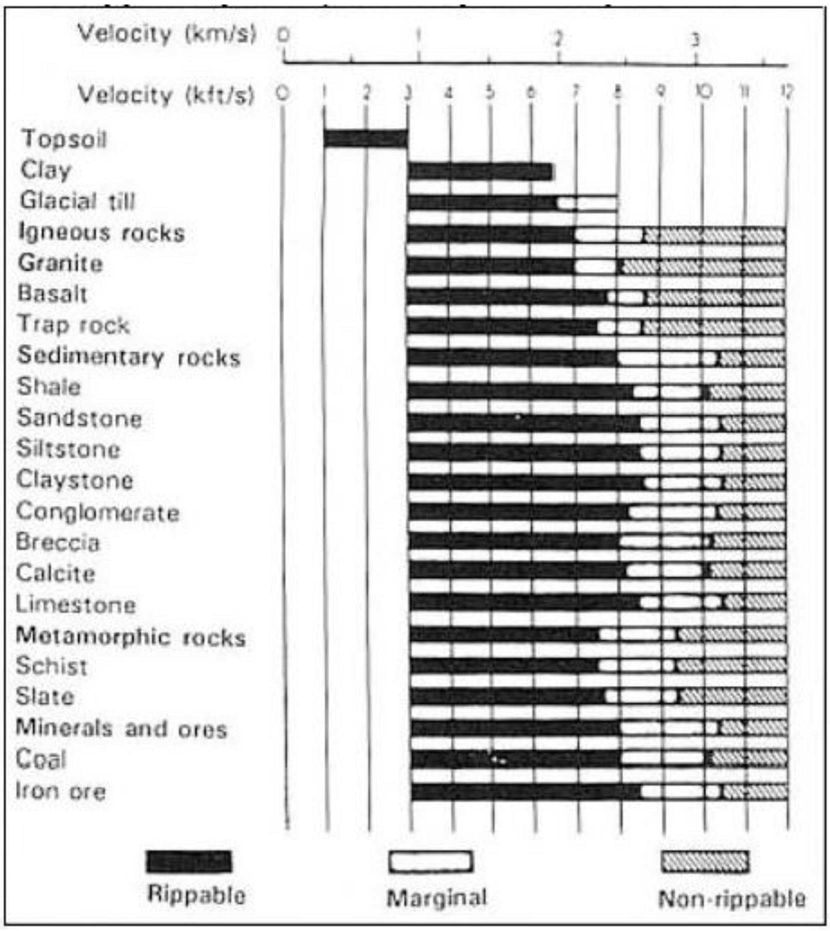


Fig. 7-1: Standard Seismic Rippability Chart vs Sonic velocity ranges of Caliper inc

From the above chart it is clear that the formations with less than 2500 m/sec is easily rippable and up to 3200 m/sec is marginal and above 3200 m/sec is non-rippable,this probable need bulldozer with high capacity.

7.1.1 Study of Sonic logs in Mb-A:

Sonic logging completed in two boreholes in Mb-A, elastic properties from sonic logs for these two boreholes are given below in Tables 7.3 & 7.4. They indicate roof and floor roc properties in Mb-A.

Table 7.3: Elastic properties of roof & floor formations of bh CC07

Elastic properties of roof & floor formations Bh-CC07												
S.No.	Level	Depth	Vp	ρ	E	μ	K	β	Sc	Sc	St	Ss
		m	m/s	gms/cc	X10 Newtons/m^2	X10 Newtons/m^2	X10 Newtons/m^2	X10 Newtons/m^2	Kgs/cm^2	MPA	Kgs/cm^2	Kgs/cm^2
1	Roof	41	3000	2.34	1.56	0.602	0.209	4.79	5009	491.215	501	751
	Floor	51.5	3500	2.62	2.38	0.917	0.318	3.15	7634	748.64	763	1145
2	Roof	55	3500	2.63	2.39	0.921	0.319	3.13	7663	751.484	766	1149
	Floor	72.5	3000	2.34	1.56	0.602	0.209	4.79	5009	491.215	501	751
3	Roof	80	2800	2.19	1.28	0.491	0.17	5.88	4084	400.504	408	613
	Floor	86	3600	2.6	2.5	0.963	0.334	3	8015	786.003	801	1202

Table 7.4: Elastic properties of roof & floor of bh CC06

Elastic properties of roof & floor formations Bh-CC05												
S.No.	Level	Depth	Vp	ρ	E	μ	K	β	S_c	Sc	S_t	S_s
		m	m/s	gms/cc	X10 Newtons/m^2	X10 Newton/m^2	X10 Newton/m^2	10^{-4} m^2/Newto	Kgs/cm^2	MPA	Kgs/cm^2	Kgs/cm^2
1	Roof	42	2800	2.21	1.29	0.49	0.17	5.8	4121	404.132	412	618
	Floor	72	3100	2.55	1.82	0.7	0.24	4.12	5829	571.63	583	874
2	Roof	75	3300	2.64	2.14	0.82	0.28	3.51	6838	670.579	684	1026
	Floor	87	3700	2.74	2.79	1.07	0.37	2.69	8922	874.949	892	1338
3	Roof	95	3600	2.66	2.56	0.985	0.34	2.93	8200	804.145	820	1230
	Floor	100.5	3300	2.52	2.04	0.78	0.27	3.68	6527	640.08	653	979

7.1.2 Study of Sonic logs in Mb-B

Sonic logging in Mb-B is available for three boreholes CE05, CF10 &CG14; elastic properties from sonic logs for these two boreholes are given below in Tables 7.5-7.7.

Table 7.5: Elastic Properties of Roof & Floor Rocks of Borehole CE05

Elastic Properties of roof & floor levels of formations Bh-CE05												
S.No	Level	Depth	Vp	ρ	E	μ	K	β	Sc	Sc	St	Ss
		m	m/s	gms/cc	X10 Newtons/m^2	X10 Newtons/m^2	X10 Newtons/m^2	X10 Newtons/m^2	Kgs/cm^2	MPA	Kgs/cm^2	Kgs/cm^2
1	Roof	160	3800	2.7	2.29	1.11	0.386	2.59	9273	909.371	927	1391
	Floor	161.5	3700	2.62	2.66	1.02	0.355	2.81	8531	836.605	853	1280
2	Roof	191.8	3000	2.43	1.62	0.625	0.217	4.62	5202	510.142	520	780
	Floor	193.5	4000	2.71	3.22	1.24	0.429	2.33	10313	1011.36	1031	1547
3	Roof	240	4000	2.81	3.34	1.28	0.445	2.25	10694	1048.72	1069	1604
	Floor	346	2800	2.09	1.22	0.468	0.162	6.16	3897	382.165	390	585
4	Roof	374	3800	2.68	2.87	1.11	0.383	2.61	9205	902.702	920	1381
	Floor	408	3300	2.43	1.97	0.756	0.262	3.82	6294	617.231	629	944
5	Roof	444	3500	2.51	2.28	0.879	0.305	3.28	7313	717.16	731	1097
	Floor	461	3800	2.62	2.81	1.08	0.375	2.67	8999	882.5	900	1350
6	Roof	507	3000	2.2	1.47	0.566	0.196	5.1	4709	461.795	471	706
	Floor	525.5	3200	2.6	1.98	0.761	0.264	3.79	6333	621.055	633	950
7	Roof	542	4000	2.71	3.22	1.24	0.429	2.33	10313	1011.36	1031	1547
	Floor	573.5	3000	2.18	1.46	0.561	0.194	5.15	4667	457.676	467	700
8	Roof	576	3200	2.3	1.75	0.673	0.233	4.29	5602	549.369	560	840
	Floor	6111	4100	2.8	3.5	1.34	0.466	2.15	11195	1097.85	1120	1679
9	Roof	628	4000	2.76	3.28	1.26	0.437	2.29	10503	1029.99	1050	1576
	Floor	648	3400	2.54	2.18	0.839	0.291	3.44	6984	684.896	698	1048

Table 7.6: Elastic Properties of Roof & Floor Rocks of bh CF10

Elastic Properties of roof & floor formations Bh-CF10												
S.No	Level	Depth	Vp	ρ	E	μ	K	β	Sc	Sc	St	Ss
		m	m/s	gm/cc	X10 Newtons/m^2	X10 Newtons/m^2	X10 Newtons/m^2	X10^{-4} m^2/Newtons	Kgs/cm^2	MPA	Kgs/cm^2	Kgs/cm^2
1	Roof	54.2	3000	2.48	1.66	0.638	0.21	4.52	5309	520.635	531	796
	Floor	174	3100	2.5	1.78	0.686	0.238	4.2	5714	560.352	571	857
2	Roof	216	3200	2.38	1.81	0.696	0.241	4.14	5797	568.492	580	870
	Floor	221	3800	2.62	2.81	1.08	0.375	2.67	8999	882.5	900	1350
3	Roof	232	3800	2.66	2.85	1.1	0.38	2.63	9136	895.936	914	1370
	Floor	238	3400	2.57	2.21	0.849	0.294	3.4	7066	692.938	707	1060
4	Roof	292.5	4100	2.8	3.5	1.34	0.466	2.15	11195	1097.85	1120	1679
	Floor	306	4000	2.75	3.27	1.26	0.436	2.29	10465	1026.27	1047	1570
5	Roof	339	3500	2.6	2.37	0.91	0.315	3.17	7576	742.952	758	1136
	Floor	390	3600	2.6	2.5	0.963	0.334	3	8015	786.003	801	1202

Table 7.7: Elastic Properties of Roof & Floor Rocks of bh CG14

Elastic properties of roof & floor formations Bh-CG14												
S.No	Level	Depth	Vp	ρ	E	μ	K	β	Sc	Sc	St	Ss
		m	m/s	gms/cc	X10 Newtons/m^2	X10 Newtons/m^2	X10 Newtons/m^2	X10 Newtons/m^2	Kgs/cm^2	MPA	Kgs/cm^2	Kgs/cm^2
1	Roof	53	2800	2.43	1.42	0.544	0.189	5.3	4531	444.339	453	680
	Floor	62	3100	2.6	1.86	0.714	0.247	4.04	5943	582.809	594	891
2	Roof	110.5	3200	2.63	2	0.769	0.267	3.75	6406	628.214	641	961
	Floor	142	3600	2.66	2.56	0.985	0.341	2.93	8200	804.145	820	1230
3	Roof	180	3000	2.43	1.62	0.625	0.217	4.62	5202	510.142	520	780
	Floor	186	2900	2.33	1.46	0.56	0.194	5.15	4661	457.088	466	699
4	Roof	207.5	2900	2.28	1.42	0.548	0.19	5.27	4561	447.281	456	684
	Floor	214	3400	2.59	2.22	0.855	0.297	3.37	7121	698.332	712	1068
5	Roof	251.5	3100	2.47	1.76	0.678	0.235	4.25	5646	553.684	565	847
	Floor	268.5	3700	2.72	2.77	1.06	0.369	2.71	8857	868.575	886	1329
6	Roof	287	2900	2.27	1.42	0.545	0.189	5.29	4541	445.32	454	681
	Floor	327	2800	2.27	1.32	0.508	0.176	5.67	4233	415.116	423	635
7	Roof	332	3700	2.67	2.72	1.04	0.362	2.76	8694	852.59	869	1304
	Floor	340	2900	2.26	1.41	0.543	0.188	5.31	4521	443.359	452	678
8	Roof	346	3700	2.6	2.64	1.02	0.353	2.84	8466	830.231	847	1270
	Floor	360	3000	2.26	1.51	0.581	0.201	4.96	4838	474.446	484	726

ρ	:Density	**E**	:Young'smodulus	**μ**	:Shear modulus
K	:Bulk modulus	**β**	:Compressibility	**Vp**	:P-Velocity
Sc	:Compressive strength	**St**	:Tensile strength	**Ss**	:Shear strength

7.2 ROCK QUALITY DESIGNATION (RQD)

The geotechnical studies play a key role in mine planning. The quality of rock is invariably affected by grain size, compactness, cementing material and bedding planes and secondary structures such as fractures, shear zones, faults, joints, faults etc., Breakages are a common phenomenon during drilling. These kinds of breakages are collected in the field as well as during drilling operation. These breakages are measured in the form of Rock Quality Designation (RQD).

RQD studies are made of a zone of about 25m strata above the seam for the roof rocks and about 6m below the seam for the floor rocks. These studies have been carried out in all the exploratory boreholes. The basic information is gathered from the drill core (HQ: 64mm size) in the drill site and also from the digital core photography of the boreholes. The digital core photographs have been taken for all the drill core samples with a 12 mega pixel digital camera. Extreme care has been taken, in taking the core photographs to religiously record all geological structures, photograph for each core box invariably displaying a scale, labeled with all relevant details such as borehole number, box number, depth etc. These photographs are used extensively for derivation of geotechnical studies.

The RQD values provide a basis for making preliminary design decisions involving estimation of required depths of excavation for foundations of structures. The RQD values also can serve to identify potential problems in respect of bearing capacity, settlement, erosion or sliding in rock foundation.

The RQD alone is not adequate to provide a sufficient description of rock mass quality. The RQD does not account for joint orientation, tightness, continuity, and gauge material. Therefore, the RQD must be judiciously used in combination with other geological and geotechnical input. From RQD index the rock mass can be classified as per ASTM as follows: Excellent (90-100%), Good (75-90%), Average (50-75%), Poor (25-50%), and Very poor (25%).

7.2.1 RQD study in mining Rb-A

In Mb-A three longitudinal cross sections covering 11 boreholes for which RQD data are available have been prepared. They are as follows (from south-north) (see Fig. 7.2)

- Southern longitudinal cross section (southern section) covering boreholes CA01 & CA03.
- South Central longitudinal cross-section covering boreholes, namely CC07, CC05, MDC06, MDC02, CB02 and MDC01.
- Northern longitudinal cross-section (North-central section) covering three boreholes such as MDC06, MDC04 and CC01A.

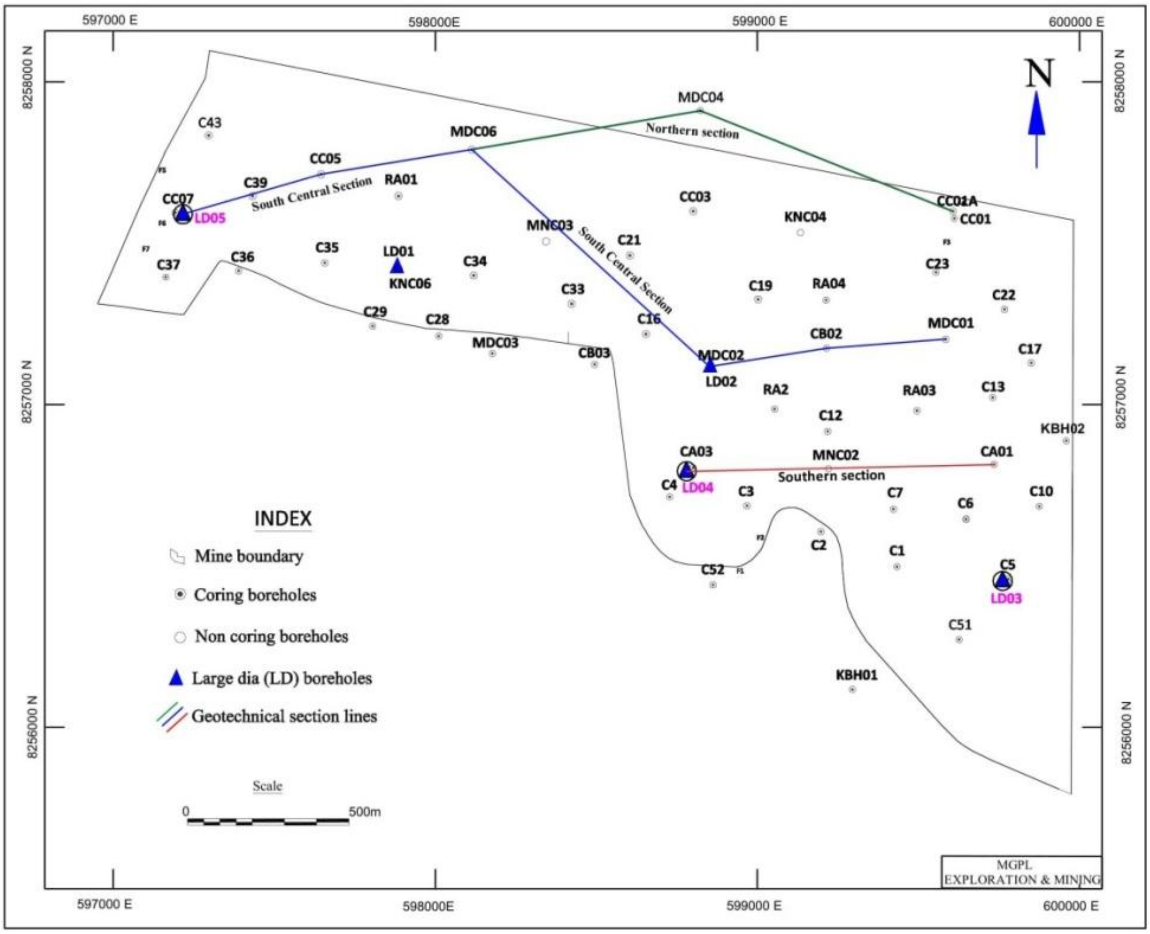


Fig. 7-2: Map Showing Geotechnical Section Lines In Rb-A, 5086C

Southern Section: This section covers a strike distance of about 940m in E-W direction covering two boreholes CA01 and CA03. In the borehole CA01 the RQD is good in all coal zones 3, 2 and 1. Seam wise the RQD is good in roof of the 3 seam while floor is marked by average, for seam 2 RQD is average in roof and good in floor with 75% RQD and for seam 1 both roof & floor depicting RQD as good & excellent. In the borehole CA03, RQD is good in all seams, the weathered zone is (8.31m (?)) forms the roof of 3rd seam, while the floor of seam 3 represents as good with 74% RQD (6m), roof & floor of seam 2 showing RQD good with average 80%, roof of seam 1 representing RQD good with 80% while floor is showing RQD as average with 62% average.

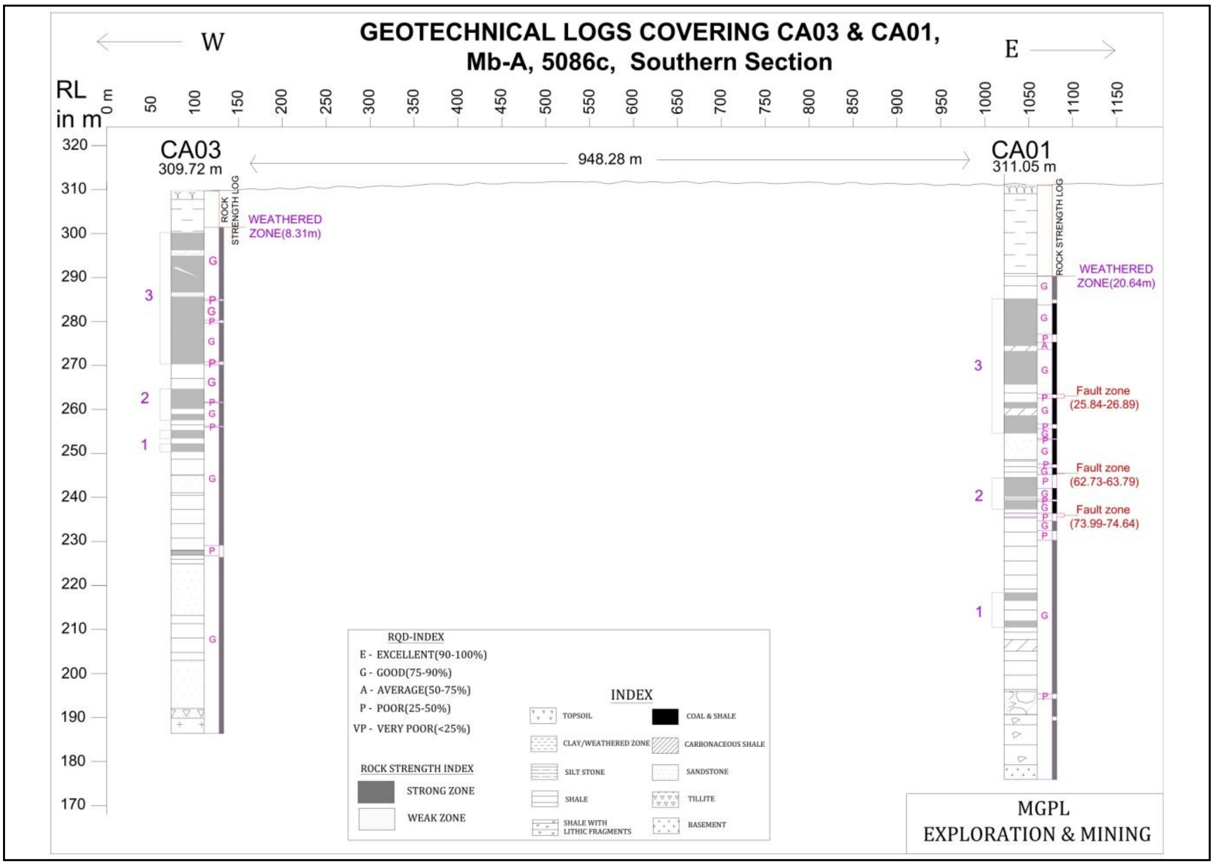


Fig. 7-3: Geotechnical Section Covering Boreholes CA01 & CA03 Boreholes

South Central Section: This section covers a strike distance of about 2.40km in WNW-ESE direction, encompassing six boreholes, namely MDC01, CB02, MDC02, MDC06, CC05 and CC07. In the borehole MDC01 good RQD is registered for the coal seam 1, 2 & 3. Almost all the roof rocks of the above coal seams have given good RQD index. The floor rock of the coal seam 1 has given poor RQD index (1m).

The borehole CB02 registered good RQD for coal zones 1, 2 & 3 while average RQD index for floor of 3rd seam is registered as poor presumably because of a fault zone. Average to good index is registered for the roof rocks of 2nd& 1st coal seams while the floor rocks are marked as good to average with average 75-80% RQD.

In the boreholeMDC02, coal zones 2 & 3 have registered good RQD index except the coal zone 1, while average RQD index is registered in respect of the coal zone 1. Average RQD index is recorded for the roof rocks of the coal zone 1. The roof rocks in respect of other coal zones 2 &3 have recorded good RQD index. Good RQD index is registered for the floor rocks of the coal zone 1 over a width of about 10m.

In the borehole MDC06, good to excellent RQD index is registered for all coal zones 1, 2, 3 & 4. The rocks between 283.03 and 273.15mRL forming part of floor rocks for the coal seam4 are shattered, presumably because of some structural discontinuity. Good and excellent RQD index is registered in respect of roof rocks for the coal seam 2, while the roof rocks for the coal zone 1 have recorded poor RQD index. About 20m of floor rocks for the coal zone 1 have recorded good RQD index.

In the borehole CC05, weathered zone continues up to 285.52m RL (322.70m), where the water zone falls with the weathered zone at 285.641m. The coal zone 3, 2 and 1 have registered good RQD index, while the bottom of coal seam 3 have recorded a mixture of average, good and poor RQD index. In all probability the roof rock for the coal zone 3 is poor, because the weathered zone continues almost up to the entire part of the roof of the coal seam 3. The roof rocks for the coal zone 3 and 1 have registered average RQD index.

In the borehole CC07, Good RQD index is recorded in respect of 3rd and 2nd seams while poor RQD is present in 1st seam. The roof rock for the coal seam 3 may be poor, because the weathered zone continues almost up to the entire part of the roof of the coal seam 3, as seen in the case of the borehole CC05. Floor of 2nd seam recorded as good, roof of 1st seam is indicating good while floor of all seems to be represent from poor to average.

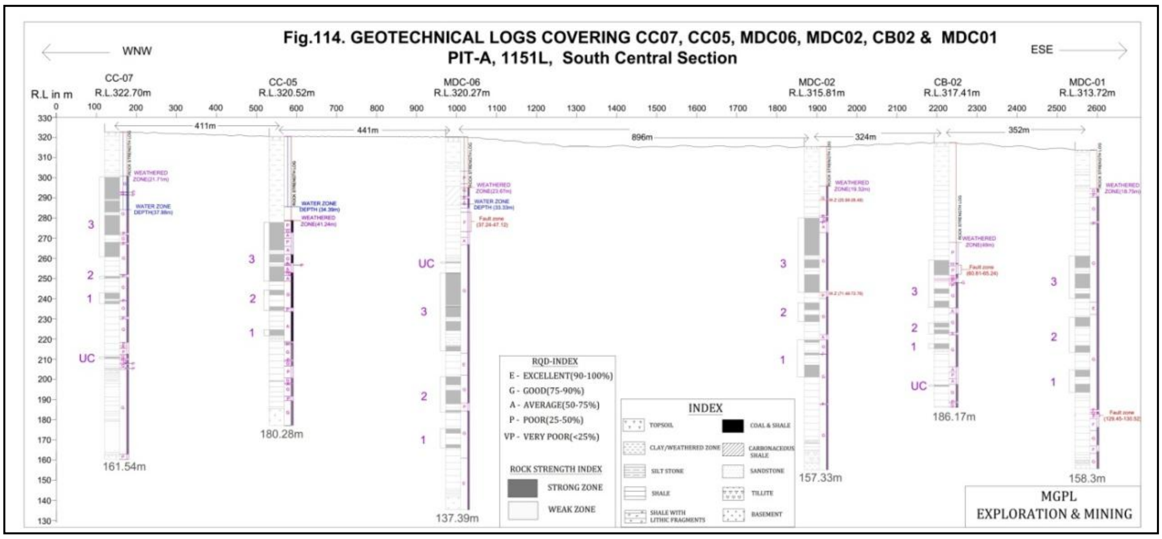


Fig. 7-4: Geotechnical Section Covering Boreholes MDC01, CB02, MDC02, MDC06, CC05 and CC07

North central section: The north central section extends over distance of about 1.50km in strike direction covering three boreholes CC01A, MDC 04 and MDC06 (projected) in WNW-ESE direction. In the borehole CC01A, weathered zone exists up to 295.08mRL and water zone has been intersected at 288.22m RL. Fair RQD index is registered in respect of 5, 4 and UC, while the coal zone 2 has recorded average RQD index. Between 217.10 and 213.79m RL and between 210.44 and 209.89m RL, the rocks appear to be shattered, presumably because of some structural discontinuities and hence these portions of rocks have recorded poor RQD index. Similarly, between 146.98 and 140.01m RL, structural discontinuity is visualized, because the rocks are found to be shattered and this portion of rock has recorded fair RQD value. The floor rocks of UC have recorded poor and good RQD index, while the floor rocks for I have registered poor and average RQD values alternatively. The roof rocks for the coal seam 5 and 4 registered fair, poor and good RQD index.

In the borehole MDC 04, weathered zone exists up to 281.19m RL. The coal seams UC, 8, 7 and 6 have recorded good RQD index, while 9 seam showing poor RQD. The roof rocks of the coal seam 8, 7 and UC showing good to average RQD while other seams 9, 6 & UC's are showing poor to average RQD. Floors of 9th, UC and 6th seams are recorded poor because of structurally disturbed areas. At three places structural discontinuities are visualized, because of the presence of broken rocks. They are as follows:

- Between 48.44 and 43.24m RL
- Between 38.19 and 32.09m RL and
- Between 17.61 and -32.55m RL

In the borehole MDC06 weathered zone exists up to 295.14m RL, all the coal seams 4, 3, 2 & 1 have recorded good to excellent RQD, roofs of all seams have represented good RQD, except 1st seam having poor up to 2m, floor of all seams represent good to excellent RQD. At 273.15m RL to 283.03m RL structural discontinuous are present because of broken rocks.

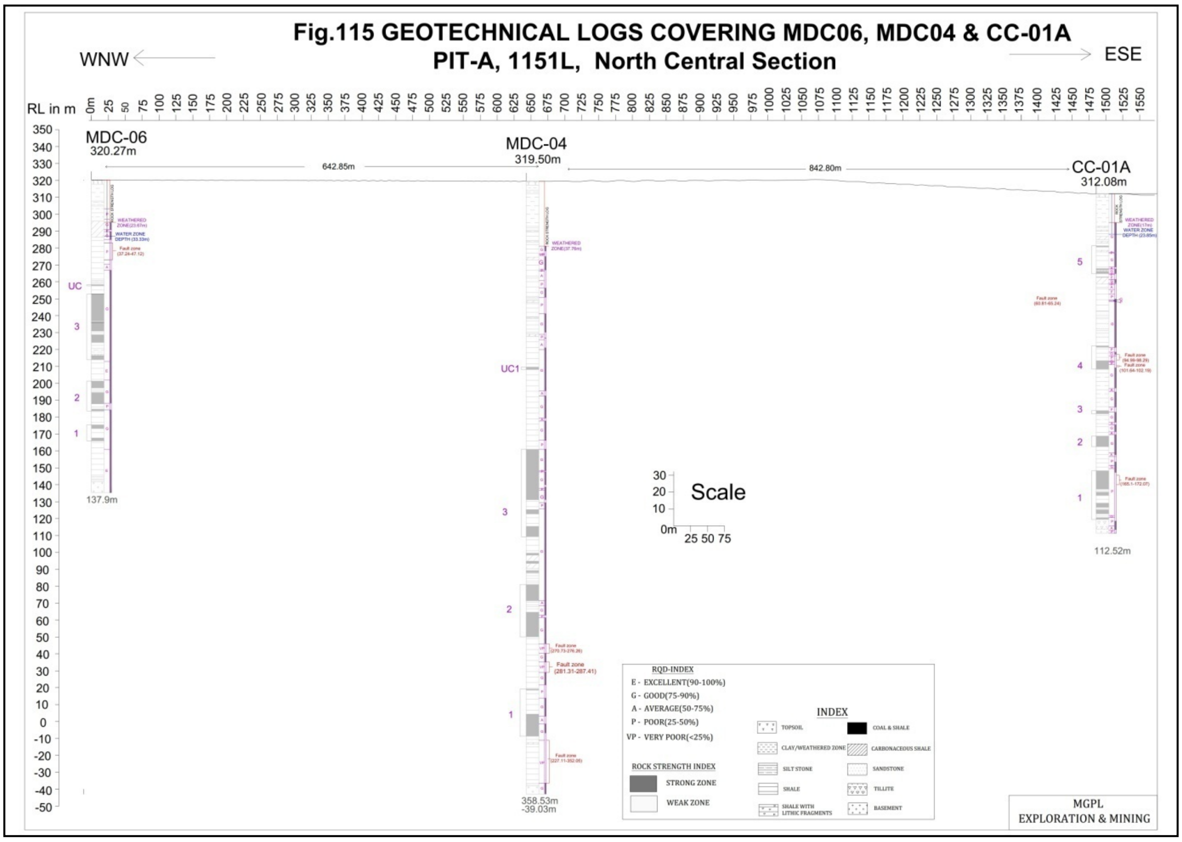


Fig. 7-5: Geotechnical Section Covering Boreholes CC01A, MDC 04 and MDC06

7.2.2 RQD study in mining Mb-B

In Mb-B, two longitudinal cross sections covering nine boreholes for which RQD data are available have been prepared. They are as follows (from south to north)

- Southern section covering four boreholes, namely CH21A, CG16, CG19, CE13, and CE14.
- Northern section covering three boreholes, viz. CF12, CE10, and CD08 have shown in (fig 7.6) i.e., outline map of Mb-B with section lines.

Southern Section: This section extends over a strike distance of about 2.90km in WNW-ESE direction covering four boreholes namely CH21A, CG16, CG19, CE13, and CE14.

In the borehole CE14, the weathered zone exists up to 297.76m RL (?). Within all coal seams 1, 2, 3, 4, 5, 6, 7 & 8 RQD has recorded as good to excellent, roof of 6th, 7th& 8th seams have indicating poor RQD because of broken material. Invariably all other floor rocks for coal seams1,2, 3, 4, 5, 6, &8 have recorded RQD as good while 7th seam floor has representing poor RQD.

In the borehole CE13, the weathered zone exists up to 303.29m RL. The coal seams 7, 6, 5 lower half of 2nd, the bulk barring 2m at top of 1st have recorded good RQD. The roof rocks for the coal zone 6, 5 4 have recorded as excellent RQD index, while roof of coal seams 7, 3, 2 &1 have recorded as good RQD index. While the floor rocks of 7, 6, 5 & 4 seams have representing excellent RQD, other seams are showing good RQD.

In the borehole CG19, the weathered zone exists up to 287.88mRL (?), five fault zones- a) Between 280.28 - 273.28mRL, b) 265.48 – 264.15m RL, c) 195.24 – 190.36m RL, d) 171.24 – 168.05m RL and e) 132.24 – 126.24m RL, have been deciphered based on the fractured and shattered rocks encountered. These fault zones have registered average and poor RQD index. The coal seams 8, 7, 5, 4 & 3 have recorded good RQD index. The roof rocks for the coal zones 7, 5 and 3 have registered good RQD index, while the immediate roof rocks for coal zone 8 have recorded average and poor RQD, followed by good RQD for the rest of the roof rocks. The roof rock for the coal seam 3 has recorded average and good RQD index ultimately. The floor rock of the coal seam 5 has recorded poor RQD due to fracture zone; while invariably all other floors are recorded as Good RQD.

In the borehole CH21A, the weathered zone exists up to 283.60m RL (?). A fault zone between 140.53 and 137.53m RL is visualized based on the fractured rocks encountered in the borehole. The coal zones 8, 4, 3 and 2 have registered good RQD index, while the coal zone 1 has recorded poor RQD index because of fault zone.

In the borehole CG16, the weathered zone continues up to 289.71m RL (?). Two fault zones- a) between 121.71 and 118.71mRL and b) between 67.71 and 64.71mRL - are Inferred. The coal seams 6 & 5 have exhibited good RQD index, while the other seams 7, 4, 3, 2 and 1 have represented poor to average RQD. Good to excellent RQD index is recorded in respect of the roof rocks

The coal zones VU, VL, IV and III have recorded good RQD index. The coal zones II, IU, IM, and IL have exhibited poor and average RQD index. Good to excellent RQD index is recorded in respect of the roof rocks for the coal zones VL, IV, III, IU and IL. The roof rocks for the coal zones II and IM have exhibited poor and good RQD index.

The roof rocks for the coal zone V and II have returned good RQD values. The roof rocks for the coal zones IV have exhibited average and poor RQD index, while the roof rocks for the coal zone III have recorded poor and good RQD index. The floor rocks for the bottom most coal zone I have returned average, poor and good RQD index.

Northern section: This section extends over a strike distance of about 3.95km, covering three boreholes namely CD08, CE10 and CF12.

In the boreholes CD08, the weathered zone continues up to a depth of 285.63mRL (?). Six fault zones- a) between 283.43 – 281.93mRL, b) between 146.38 -145.33mRL, c) between 59.13 -58.63mRL d) between -23.37 and –29.37mRL, e) between -37.25and - 39.37mRL, f) between -50.37 and -51.24mRL- are visualized, based on the fractured and shattered rocks encountered. The coal zones 8, 7, 6, 5 and 4 have recorded good RQD index, while the coal seam 3 and upper portion of coal seam 8 have registered poor and average RQD. Since the weathered zone continues up to a depth of 285.68mRL (?), the roof rocks for the coal seam 8thhave recorded average RQD. The roof rocks for the coal zone such as 7th, 6th, 5th and 4th have invariably registered good RQD index. The nature of the floor rock for the 3rd coal seam is not known, as the borehole was closed prematurely in the 3rd coal seam itself due to some technical snag. The roof rocks for the 3rd coal seam have recorded poor, very poor RQD index with occasional good RQD index.

In the borehole CE10, the weathered zone continues up to 289.89mRL (?). Four fault zones- a) between 225.65 and 220.65mRL, b) between 190.33 and 186.65m RL, c) between -2.35 and -8.35mRL and d) between- 80.35 and -83.35mRL- are inferred based on the fractured and shattered rocks encountered. The coal seams 8th, 7th, 4th and lower part of 5th have recorded good RQD index, while the coal seams 6th, 3rd, 2nd, 1st and upper part of 5thhave recorded mostly poor and average RQD index with a little bit of good RQD index. The RQD index in respect of the roof rocks for the coal seams 8, 7, 6, 5, and 4 invariably ranges from average to good, while the other seams are having poor to average RQD index. The floor rocks for all seams have recorded average to good RQD index.

In the borehole CF12, the weathered zone is recorded up to a depth of 291.44mRL (?). A fault zone between 261.74 and 258.44mRL is deciphered in this borehole based on the presence of fractured rock for which poor RQD index is recorded. All the coal seams 8, 7, 6, 5, 4, 3, 2 and 1 have registered mostly good RQD index. The roof rocks for the coal zones 3 & 4 and the floor rock for the coal zone 1st seam have recorded excellent RQD index, while the roof rocks for the coal seams 2 & 3 have registered mostly good RQD index. The roof rocks for the coal seams 1, 2, 5 and 8 have registered good RQD index. RQD of some of the boreholes in Rb-B is given below.

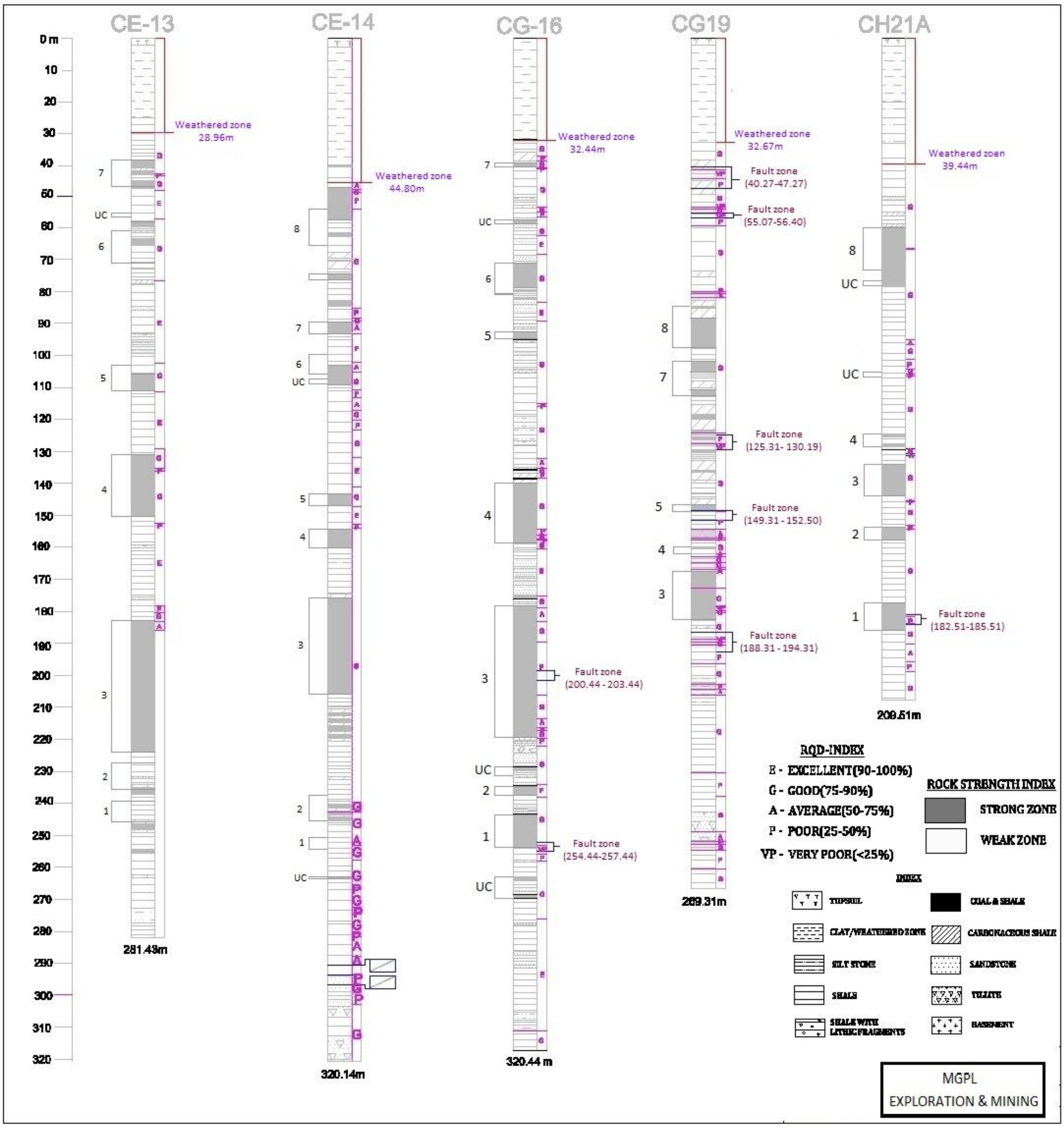


Fig. 7-6: Geotechnical Cross Section Covering Boreholes CE13, CE14, CG16, CG19 and CH21A

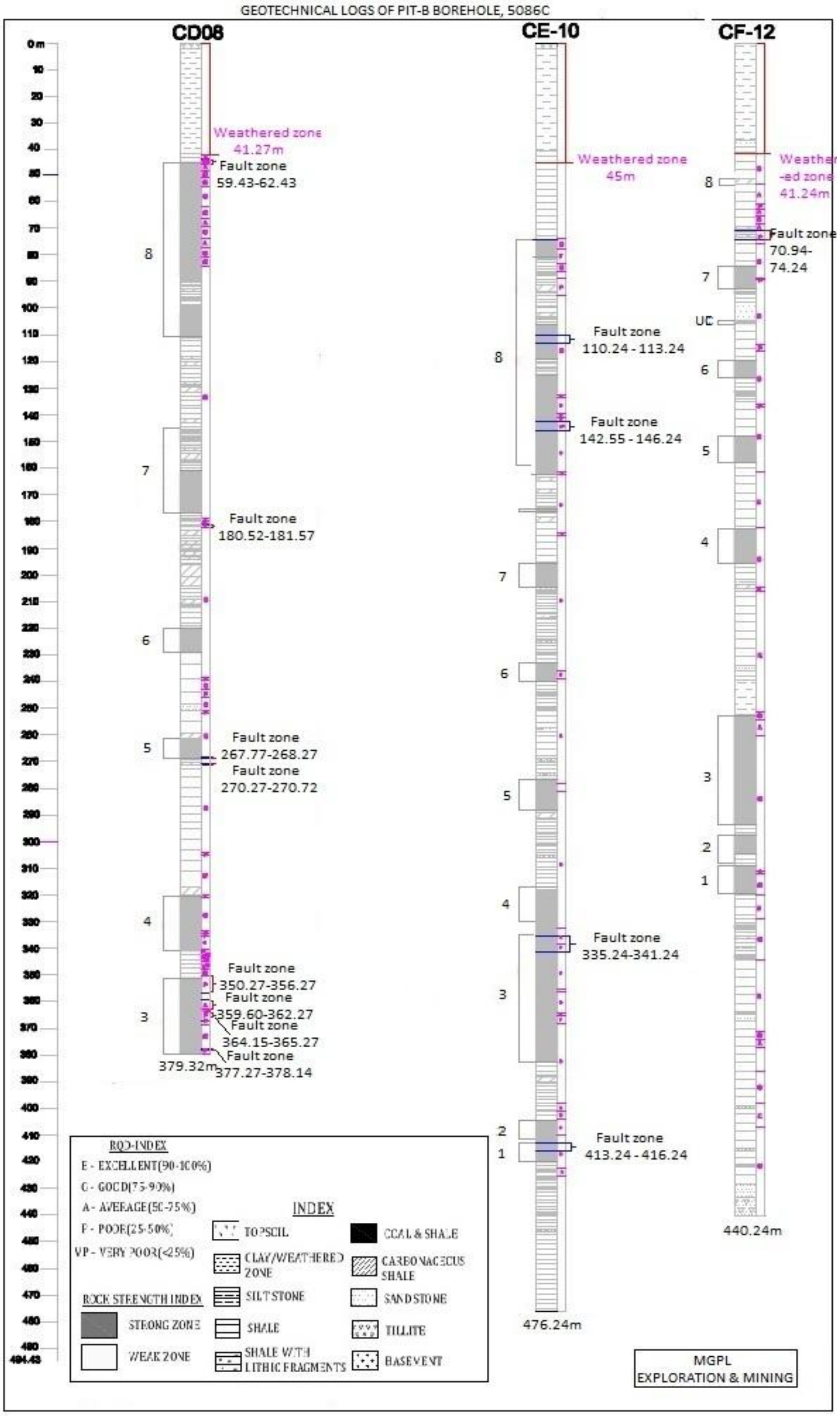


Fig. 7-7: Geotechnical Cross Section Covering Boreholes CD08, CE10 and CF12

7.3 LABORATORY DETERMINATION OF GEOTECHNICAL PROPERTIES

The following samples are submitted to geotechnical Laboratory for determination of UCS (Uniaxial Compressive Strength) and Triaxial Compressive Strength (TCS) and SS – Shear Strength of representative boreholes, results are awaited.

Table 7.8: Log of Samples Sent To Laboratory for Determination of UCS, TCS &SS

SI.No	Borehole	Lithology	Depth		Core length** (l) (mm)	Core Dia (d) (mm)	Core Wt.** (Kg.)	Density of Core sample	Load(KN)	Compressive strength (N/Sq.mm)	Corrected Compressive strength (N/Sq mm)
			From	To							
1	CA01	Shale	19.44	20.14	88	58	0.648	2786	38.2	14.5	15.6
2	CA01	Sandstone	25.44	25.84	87	58	0.597	2596	21.80	8.2	8.9
3	CA01	Shale	70.33	71.14	80	58	0.560	2648	46.9	17.7	18.9
4	CA01	Rhythamite	74.78	75.2	77	58	0.592	2909	32.5	12.3	13
5	CA01	Gritty Sandstone	91.34	91.7	73	58	0.536	2778	101.6	38.4	40.3
6	CA01	Shale	94.45	96.59	85	58	0.641	2853	78	29.5	31.7

Laboratory determination of geotechnical properties on representative roof and floor rock units have been made in accredited laboratories (Table 7.8), these values broadly conform the sonic log value determination present in table 7.3-7.7.(See Annex –IX)

PART-II

8 MINE PLAN

(Note; The terms used in this document such as open pit mining / open cast mining /surface mining are synonyms)

8.1 MINE LAY OUT FOR PIT-I

Detailed fault modelling has been done before delineating mining blocks. Major faults have been considered in fixing the boundaries between the blocks. Mine layout of open pit coal mining area is shown in Fig 8-1. Areal extent of PIT-I is 14.42 sq.km. Datum controlled Coordinates are given in Table 8.1. Mine elongation is about 8km and progression width is 2.2km, mine lay out area is oriented in NW-SE along formation strike.

This mine layout area contains an extractable coal reserves of 714MMT and has been designated as PIT-I. For planning purpose, the mine lay out area has been sub-divided into five mining modules namely Mb-A, Mb-B1, Mb-B2, Mb-B3 and Mb-B4. (Fig.8-1).

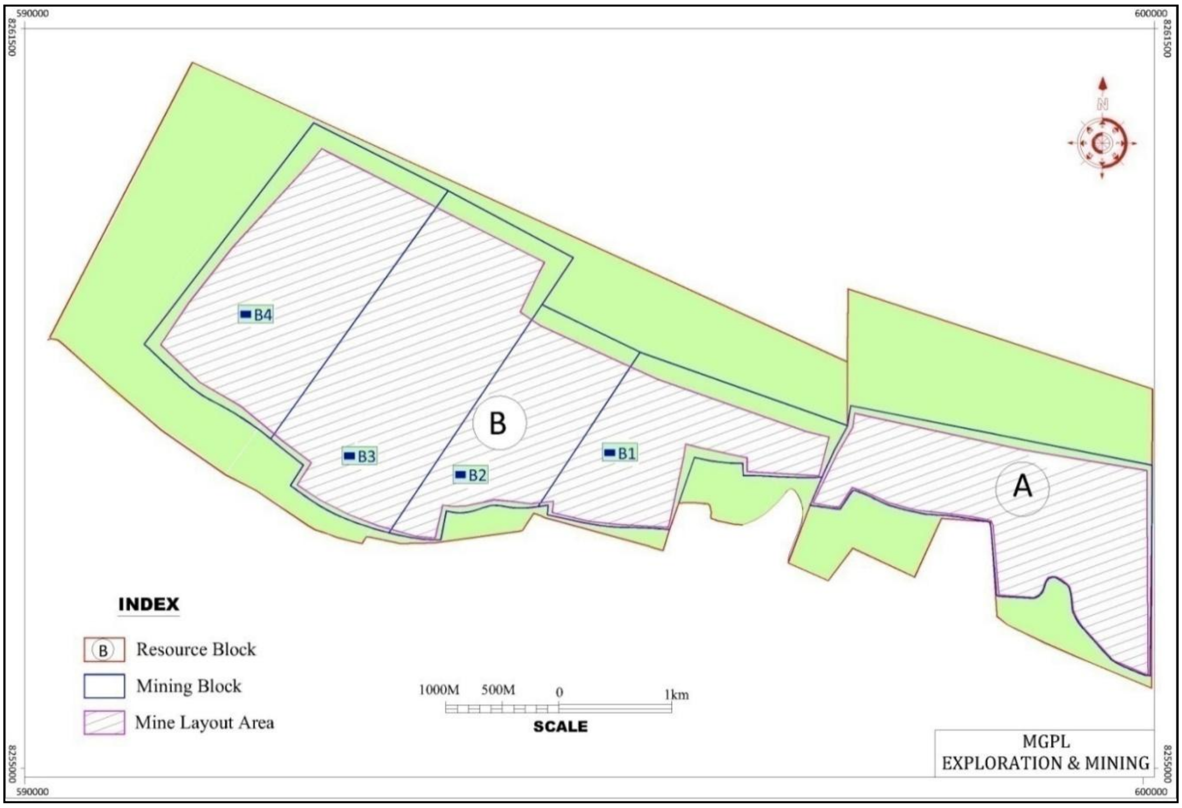


Fig. 8-1: Mine Lay Out Area Of PIT-I

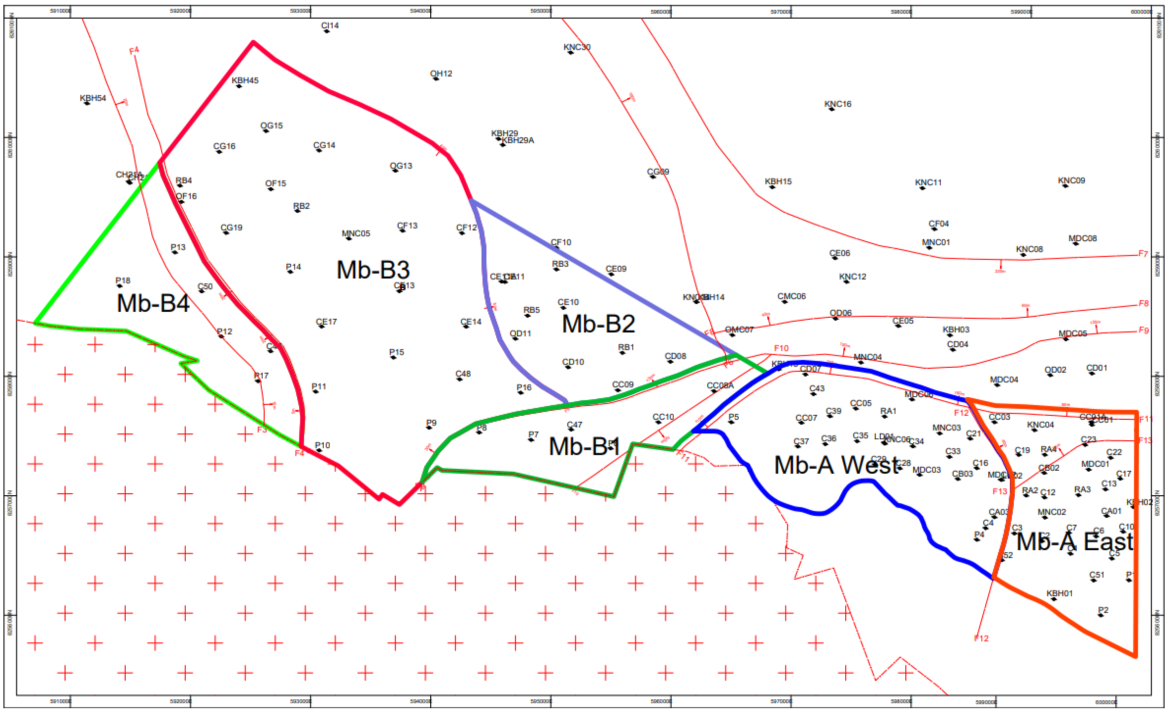


Fig. 8-2: New Mine Lay Out Area Of PIT-I

Further, based on the present geological model, mining blocks are divided based on the faults and divided in to 5 mining blocks i.e. Mb-A, Mb-B1, Mb-B2, Mb-B3 & Mb-B4. The Mining Block Mb-A is comparatively shallower blocks and is bound by the major fault F11 which has a down throw of 100 to 250 m towards north and West (Fig.8-2). The Mining Block Mb-B1 is delineated from Mb-A and Mb-B2 7 Mb-B3 by Major Fault F11 & F10 in the East and F9 in the west and North. The fault F9 is the boundary in the north and west with the blocks Mb-B2 & Mb-B3. The Fault F9 is having throw of 30 to 130 m towards north. The Mining Block Mb-B2 is bound by Fault F5 in the west and F9 in the east and the northern boundary is assumed as 450 m depth of Chipanga seam. The Fault F5 is having down throw towards east i.e. Mb- B2 with a throw of 50 m and the fault F9 is having down throw towards the block with a throw of 100 to 130 m.

The Mining Block Mb-B3 was delineated based on the faults F9 in the east and F4 in the west. The southern boundary is the metamorphic high and northern boundary is 450 m depth of Chipanga seam. The Fault F4 is having down throw towards with a throw of 5 to 30 m towards west. The Mining Block Mb-B4 was delineated based on the fault F4 in the west and north and metamorphic high in the south.

Further the Mining Block Mb-A was divided in to west and East blocks as the Fault F11 which is North south fault with a throw of 0 to 40 m towards east. The Fault F13 is east west fault with a throw of 25 m towards North.

Mining modules are planned in such a way that each module is expected to yield ROM production as per the production schedule at Table 9.9. The capacity utilization is considered at 85% during the first full year of operation, reaching full capacity in the subsequent year for each mining block. All these blocks will be developed in quick succession to ramp-up the production to the peak level, as early as possible.

The mine plan parameters presented in this document are flexible and taken into consideration effective combination of shovel -dumper for removal of OB and Inter Burden and Surface Miner is envisaged for mining out of coal and intra seam parting. The facilities such as waste dump, coal processing plant, electrical sub-station and water storage are planned in a modular fashion with a view to integrate the same into an expanded future operation. In the current level of study, a conceptual mine plan has been developed for mining module MB-A. Similar plan shall be extended into the remaining modules MB-B, MB-C, MB-D, MB-E subsequently.

8.2 MINE PLAN FOR MODULE (MB-A)

8.2.1 Mine outlay for Mb-A

Areal extent of Mb-A is 4.50 km^2 say 450 ha (Figs.8-3& 8-4). Length of lay out area is 3700 m in E-W and width is 1250 m in N-S.

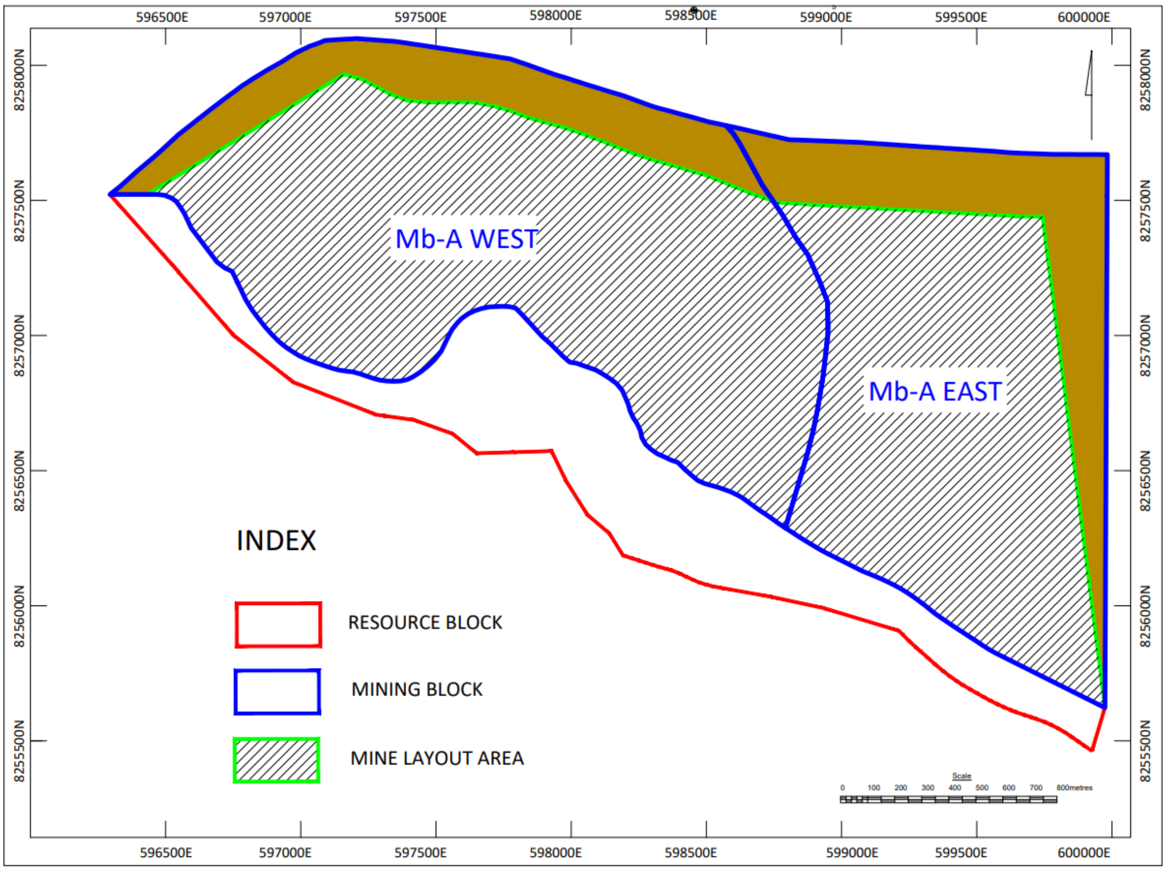


Fig. 8-3: Mine Outlay For Mb-A

Boundary coordinates are presented in Table 8.1and contour map is given in Fig. 8-4.

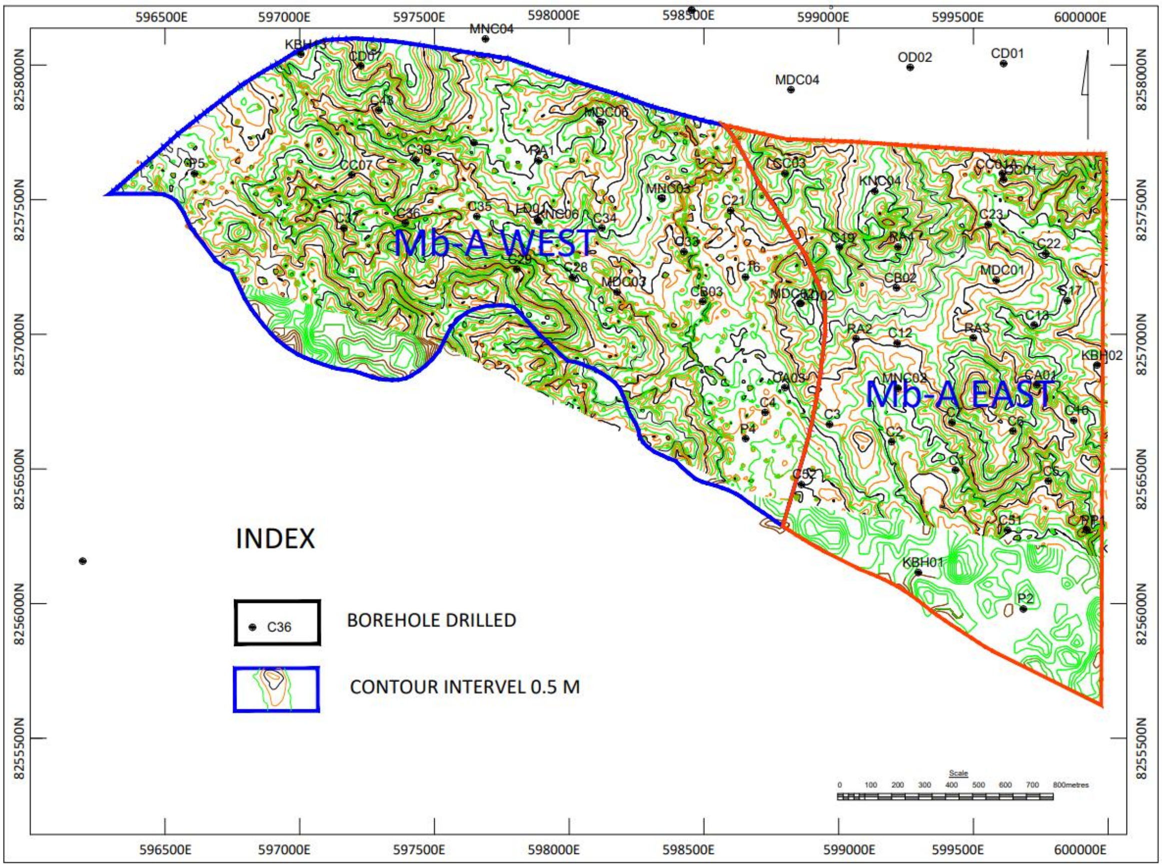


Fig. 8-4: Topographic Contour Map Of Mining Module Mb-A

Table 8.1: Coordinates Of Mining Block Mb-A

Sl.No.	ZONE	LATITUDE	LONGITUDE
1	36 L	596293.875	8257524.000
2	36 L	596565.094	8257759.500
3	36 L	596781.375	8257925.500
4	36 L	596895.188	8257995.750
5	36 L	597002.625	8258058.500
6	36 L	597088.938	8258094.000
7	36 L	597209.926	8258101.036
8	36 L	597348.594	8258090.250
9	36 L	597779.438	8258024.000

10	36 L	598243.875	8257870.500
11	36 L	598315.266	8257845.078
12	36 L	598512.027	8257792.326
13	36 L	598806.750	8257726.500
14	36 L	599168.875	8257709.500
15	36 L	599532.063	8257686.000
16	36 L	599713.058	8257675.599
17	36 L	599982.687	8257671.500
18	36 L	599973.812	8255624.530
19	36 L	599556.375	8255834.000
20	36 L	599349.198	8255970.274
21	36 L	599251.844	8256044.170
22	36 L	599155.477	8256097.789
23	36 L	599088.818	8256125.269
24	36 L	599002.203	8256167.713
25	36 L	598913.185	8256212.413
26	36 L	598812.461	8256275.500
27	36 L	598660.977	8256379.246
28	36 L	598601.807	8256418.386
29	36 L	598507.272	8256449.056
30	36 L	598468.875	8256465.000
31	36 L	598392.287	8256532.924
32	36 L	598317.740	8256564.795
33	36 L	598275.250	8256599.000
34	36 L	598260.875	8256624.000

35	36 L	598217.062	8256724.000
36	36 L	598190.973	8256794.919
37	36 L	598154.391	8256834.095
38	36 L	598085.014	8256877.480
39	36 L	597996.759	8256902.900
40	36 L	597892.966	8256996.044
41	36 L	597793.875	8257104.000
42	36 L	597699.962	8257107.720
43	36 L	597621.237	8257084.684
44	36 L	597558.813	8257024.000
45	36 L	597519.714	8256945.249
46	36 L	597434.216	8256859.744
47	36 L	597370.933	8256833.053
48	36 L	597298.681	8256836.195
49	36 L	8256836.195	8256865.205
50	36 L	597126.726	8256877.968
51	36 L	596980.143	8256934.918
52	36 L	596918.875	8256979.500
53	36 L	596833.671	8257077.545
54	36 L	596689.562	8257274.000
55	36 L	596593.875	8257400.500
56	36 L	596523.325	8257509.061
57	36 L	596493.875	8257521.500
58	36 L	596293.875	8257524.000

The mining limits (Table 8.1) of Block-Aare governed on the East side by Coal India boundary, west and north by extension of Karoo sediments whereas in south it is entry point to mine. Therefore, west and north of the present limits are open, as such there is a scope to extend the mine lay out, if necessary in both these directions due to the fact that the coal seam continuity has been established beyond the mine lay out limits.

8.3 MINING METHOD

Mining method proposed is Open Cast type as the roof of top coal seam occurs at depths varying from 9m in shallowest part and 45m in down dip part. Deepest part of the proposed mine (pit floor) coincides with the floor of the Chipanga seam at 180 m in north. Dip of coal seams is almost sub-horizontal to 8^{o} towards north. Schematic sections showing disposition of overburden, coal seams, interseam parting and intra seam parting are shown (Figs. 8-5 and8-6)

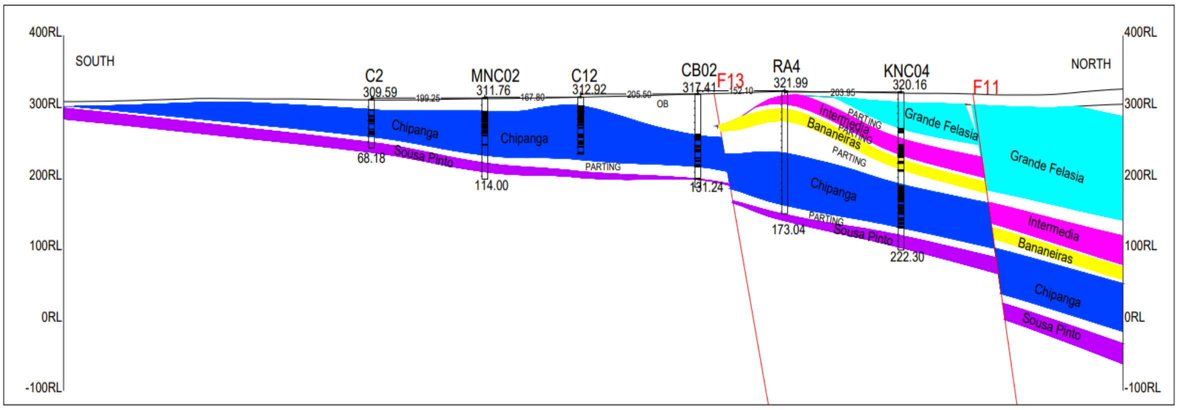


Fig. 8-5: Transverse Cross Section Covering Boreholes C2, MNC02 & C12, CB 02,RA 4, KNC 04

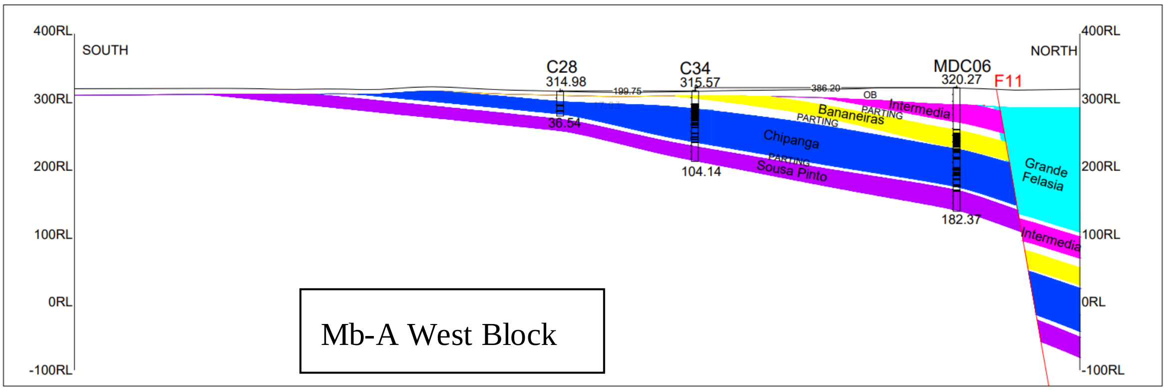


Fig. 8-6: Transverse Cross-Section Covering Boreholes C 28, C 34&MDC 06

8.3.1 OB rock attributes:

The overburden removal is proposed by shovel and dumper combination. Rock types in OB and their geotechnical properties are as follows.

a) Top soil: Silty soil and weathered rock; compressive strength 4 MPa, RQD: very poor. Loose or partly lithified.

b) Bed rock shale; RQD- poor UCS – 14-18 N/sq.mm, lithified and easily rippable due to splintery nature.

c) Bed rock sandstone; lithified rock, medium hard; RQD-good to fair; UCS 9-40 N/sq.mm.

d) Bed rock rhythmite; lithified rock, medium to hard; RQD good to fair, UCS 9- 13 N/sq.mm.

e) Material density and swell factors are given in Table 8.2.

Table 8.2: Material Density and Swell Factors

Material	Density ($t/Bm^{3)}$	Swell Factor
Topsoil	1.44	1.56
Coal, Bituminous	1.35	1.67
Shale	2.64	1.5
Sandstone	2.42	1.61
Siltstone	2.42	1.61

Since the OB volumes are not large during the initial phase, medium size machinery such as3M^3 Capacity shovels, 35 Tonnes dump trucks will be deployed to remove the overburden which consists of top soil, weathered rock as well as soft sandstone. Blasting may be used sparingly, if needed, to fragment the sandstone bands.

8.3.2 Coal seam mining

Once the overburden is removed up to the roof of the topmost coal seam, coal seam mining shall be initiated by deploying surface miner instead of conventional dumper-shovel combination. Mineralization is complex type, to overcome the constraints induced by thick inter-bedded type of seams selective coal mining by Surface Miner has been proposed (please see sections on mineralization). Selective coal mining by surface miner is prevalent in the Gondwana coal mines of India, of late VALE in Mozambique has also switched over to selective mining by WIRTGEN/L&T make Surface miner.

Prime objective of selective coal mining is to improve clean coal recovery and reduce contamination and control mine dilution of coal as well as to improve the recovery of coal from the ground, as the coal is contained in thick and thin bands alternated with the shale beds (parting) (Fig 8-7).It is envisaged a reduction of ash by 10% in ROM coal by this method and limit the ash to 47-48%.

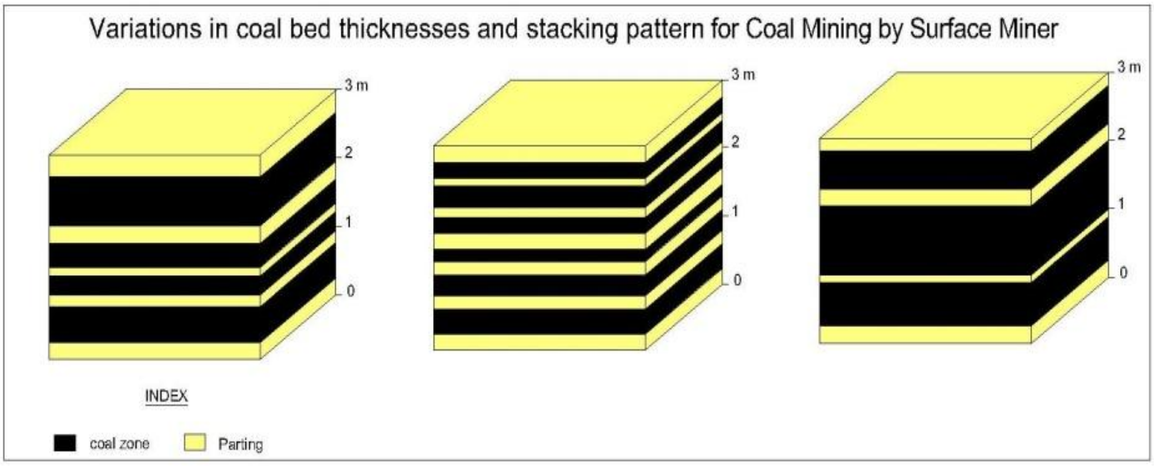


Fig. 8-7: Diagram Depicting Stacking Pattern Of Coal Beds And Partings

Considerable coal is contained in thin bands which will be lost in case of mining by shovel and dumper combination by taking minimum mining height of 50 cm. whereas surface miner can work effectively up to a minimum mining height of 10 cm to a maximum mining height of 30cm in every run. Multiple runs shall be undertaken in thick coal sections. Field photograph showing coal mining operation by surface miner is shown in Fig.8-8 (White machine).

Fig. 8-8: Model Operation by Surface Miner (White Machine). Supporting Machines are Seen in Background

Geotechnical properties of planned rocks to be cut by surface miner indicate their amenability for cuttability and rippability (Fig.7-8).Surface miner cuts coal by picks fitted to drum in its lower part. These drums can cut coal as well dirt bands in the form of furrows which will be separated by using ancillary machinery documented in text. Partings shall be transported to

OB dump where as the coal is carted to coal stock yard. Size of coal fraction is -100mm/-150mm. The coal thus transported may be subjected to direct separation of -50 mm size material as the surface miner operated coal contains considerable coal of that size and the remaining coal may be sent to rotary breaker controlled primary crusher to prepare to the size of -50mm as required.

8.3.3 Why coal extraction by Surface Miner

- The dilution of coal can be kept at a very low level due to the fact that the coal and waste are separated before carted away.
- Drilling and blasting can be avoided, which will enhance the mine productivity.
- Fragmentation of coal is very uniform and loading efficiency is better and also improves RoM coal quality.
- Primary crushing is minimized to save the cost of crushing (Surface Miner worked out RoM coal size is -100/-150mm).
- Surface Miner Operation results in smoother floor, making operation easy for loading and travelling of the equipment within the mining area. Tyre/Under carriage life of equipment such as trucks, front end loaders and other equipment will increase.
- Surface Miner can cut and prepare the base for smoother ramps and haulage roads or bench to bench ramps.
- Surface Miner reduces the manpower requirement. Only one supervisor is required apart from the operator.
- Very high productivity L&T's SK403 / SM 220 / 3800 Writgen with drum width of 4200mm can produce up to 4.5 MTPA, though lower numbers have been considered in the plan.
- Compared to HEMM (Heavy Earth Moving & Mining Equipment), the operations are simple and cost effective.
- Slope of high wall is very smooth, leaving no loose boulders leaving the working near the high wall benches much safer.
- Surface Miner is a continuously operating mobile open cast mining machine. In few Indian mines, 6000 operational hours/annum was recorded resulting in very high productivity.

8.3.4 Pit design:

Pit design is guided by coal seam geometry, disposition of faults and maneoravility of machines and slope stability factors.

Coal Seam Geometry: Coal extraction in mining module Mb-A shall focus on Chipanga seam which holds over 90% of extractable coal and the remaining will be mined out from Bananeiras, Intermedia and Grande Felasia seams. Geological cross section showing seam 2-D geometrical disposition is shown in Fig.8-9.

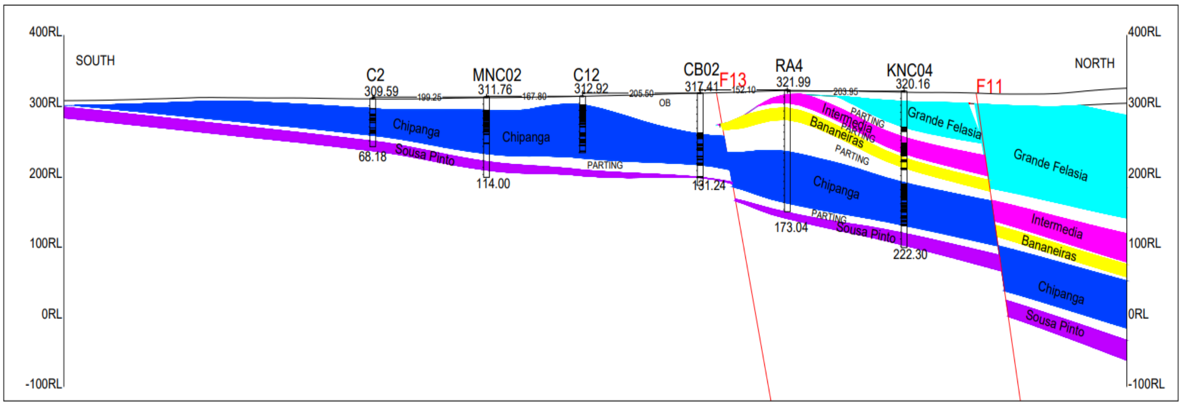


Fig. 8-9: Geological Section Showing 2-D Geometrical Disposition Of Coal Seams, Sousa Pinto, Chipanga, Bananeiras,Intermedia and Grande Felasia

Faults: Detailed Fault modeling has been done and expected in crop positions are shown in Fig.7-10. One vertical fault (dip raise) F_{12}-F_{12} is running in the middle of Block A and separating the block as East & West blocks. The down throw of the fault is towards east block with a throw of 0 (towards incrop in the south) to 40m (in the North). The other fault F_{13}-F_{13} is encountered in the Northern part of the East Block with a throw of about 25 m towards north. Impact of these faults on seam/sub-seam wise roof and floor contour plans shown in (Figs.8-10 to 8-26)

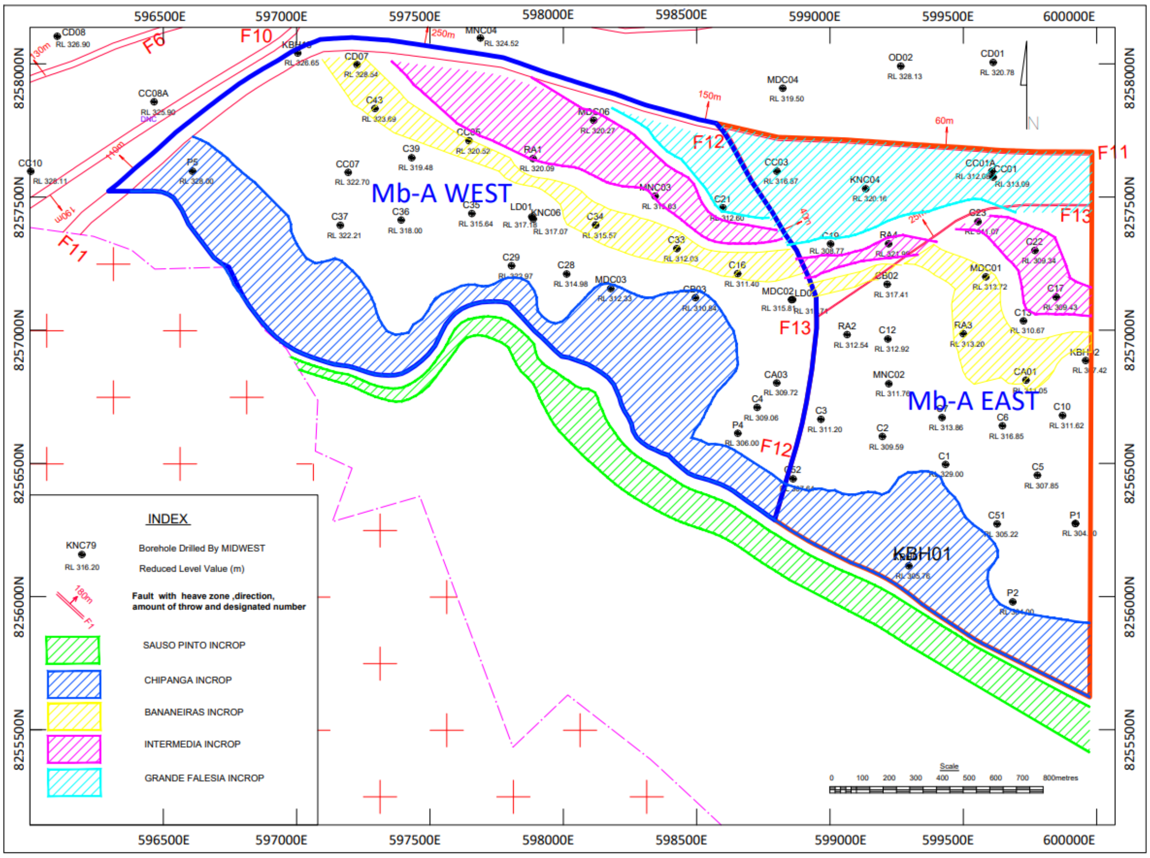


Fig. 8-10: Model and Disposition Pattern of Seam Incrops. In Mb-A

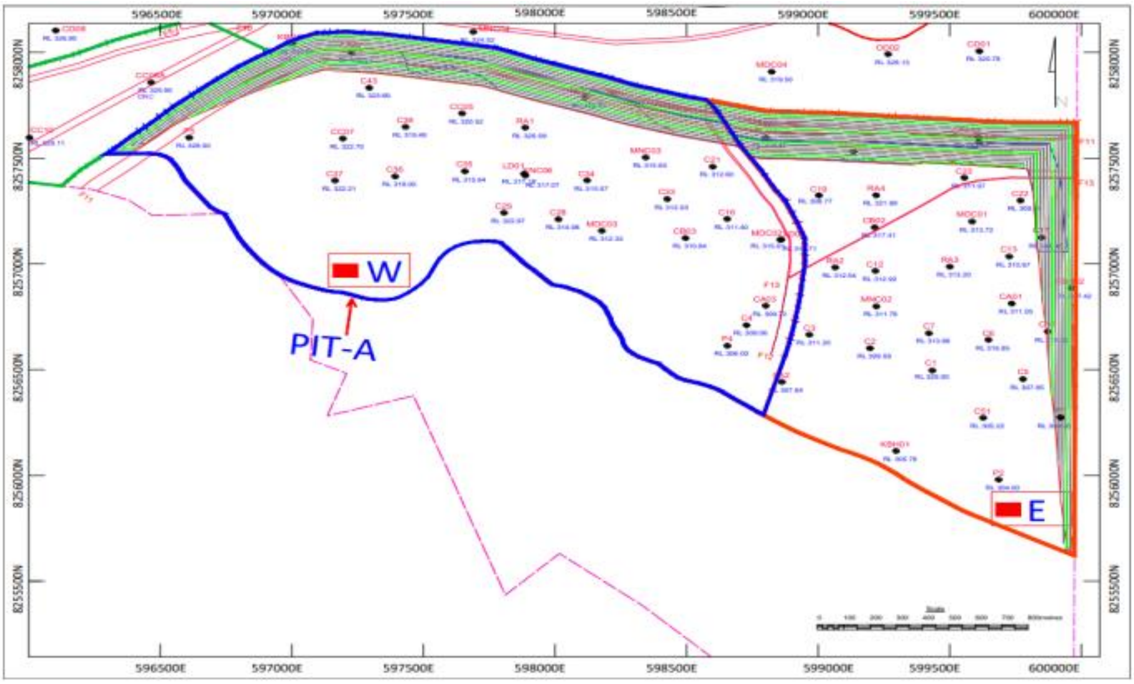


Fig. 8-11: Ultimate Pit Floor Plan

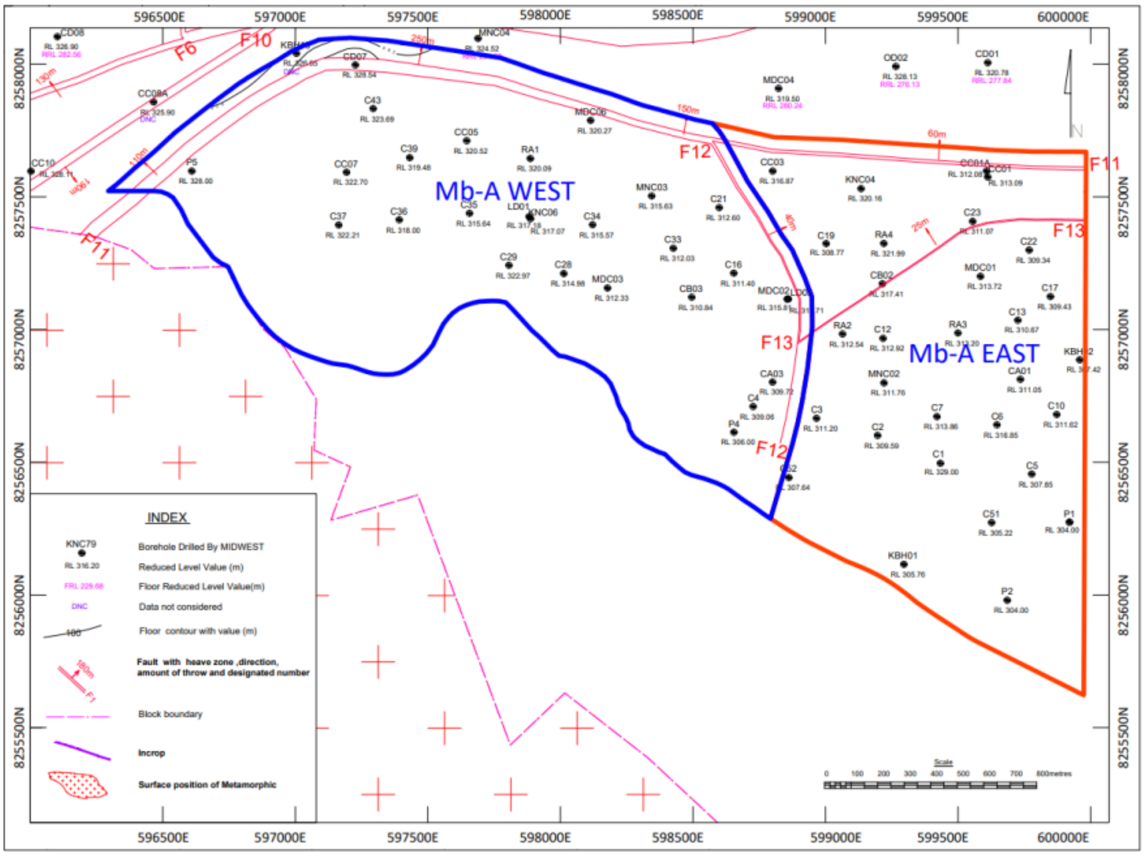


Fig. 8-12: Roof Contours Of Grande Falesia Seam

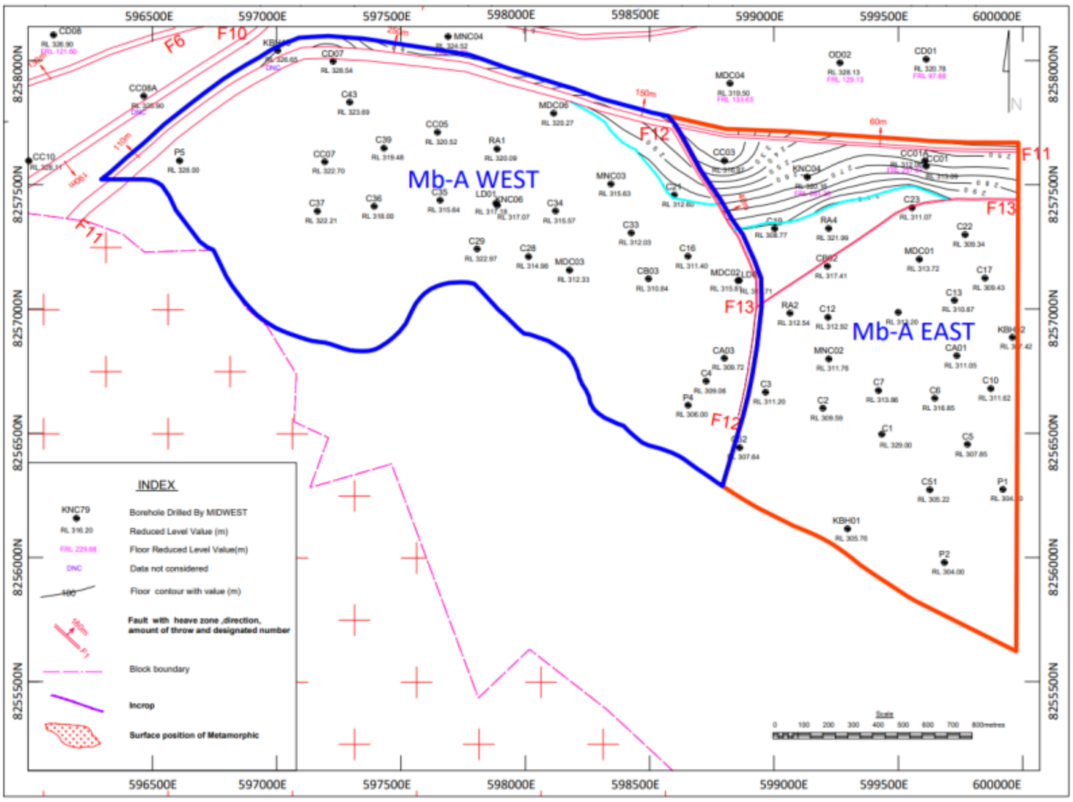


Fig. 8-13: Floor Contours Of Grande Falesia Seam

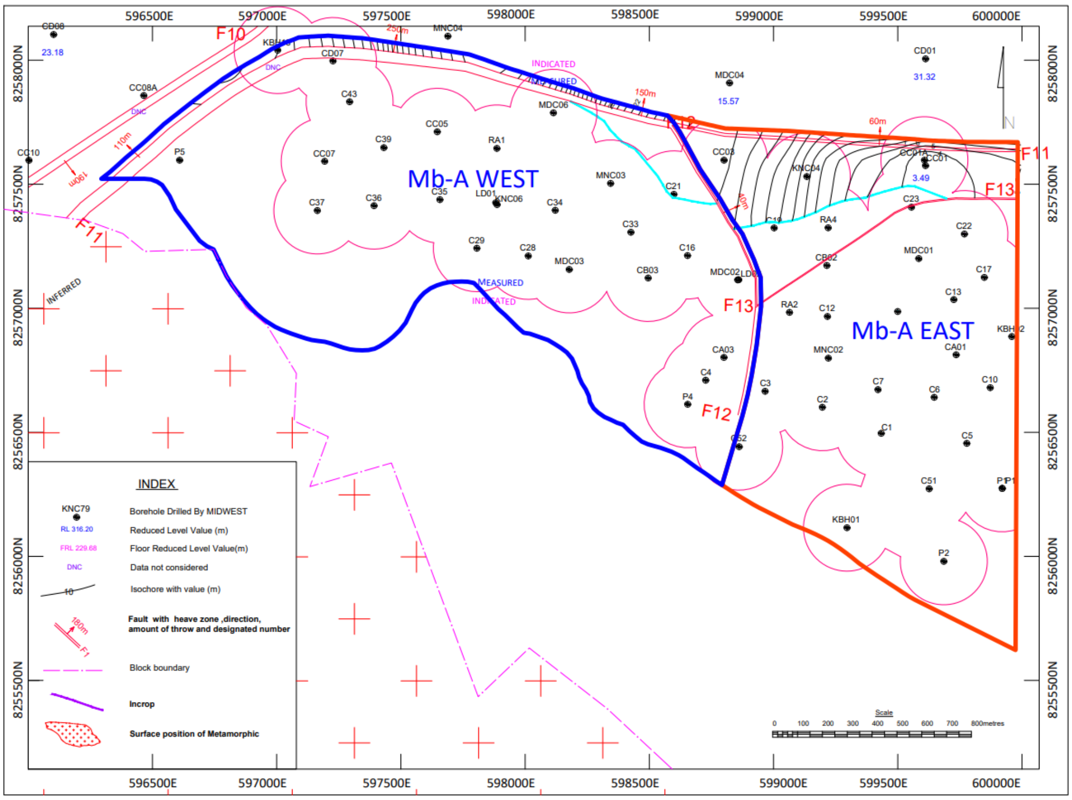


Fig. 8-14: Isopach Contours Of Grande Falesia Seam

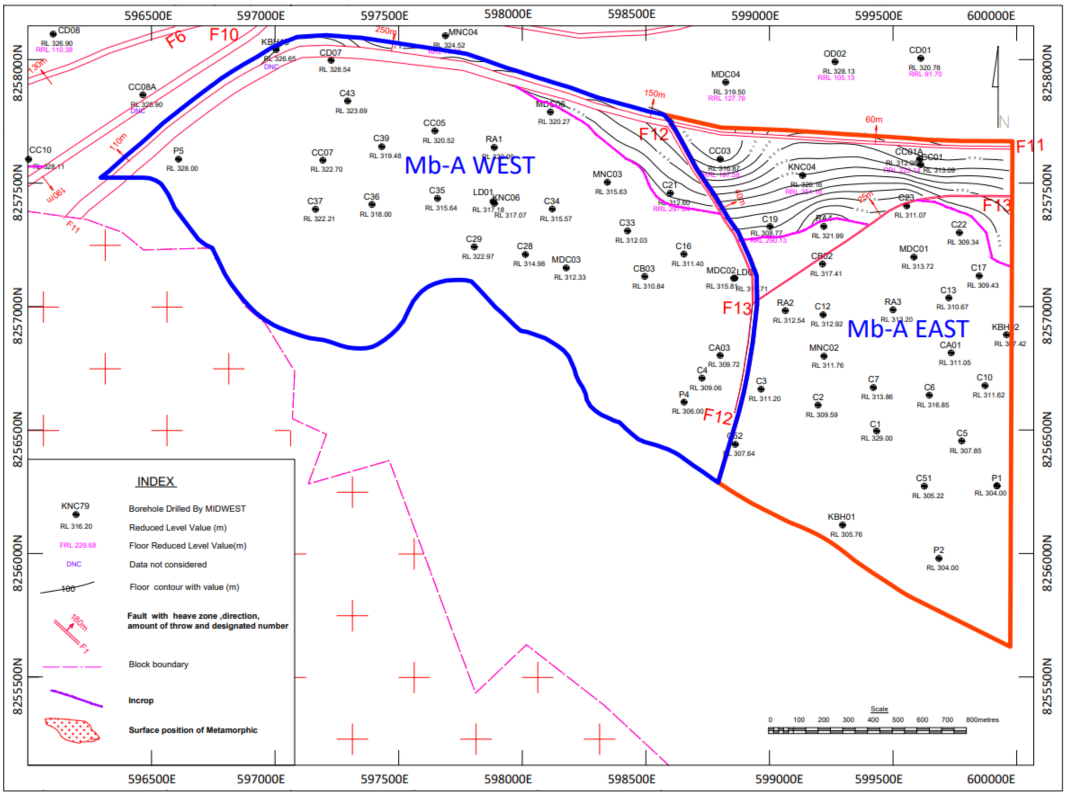


Fig. 8-15: Roof Contours Of Intermedia Seam

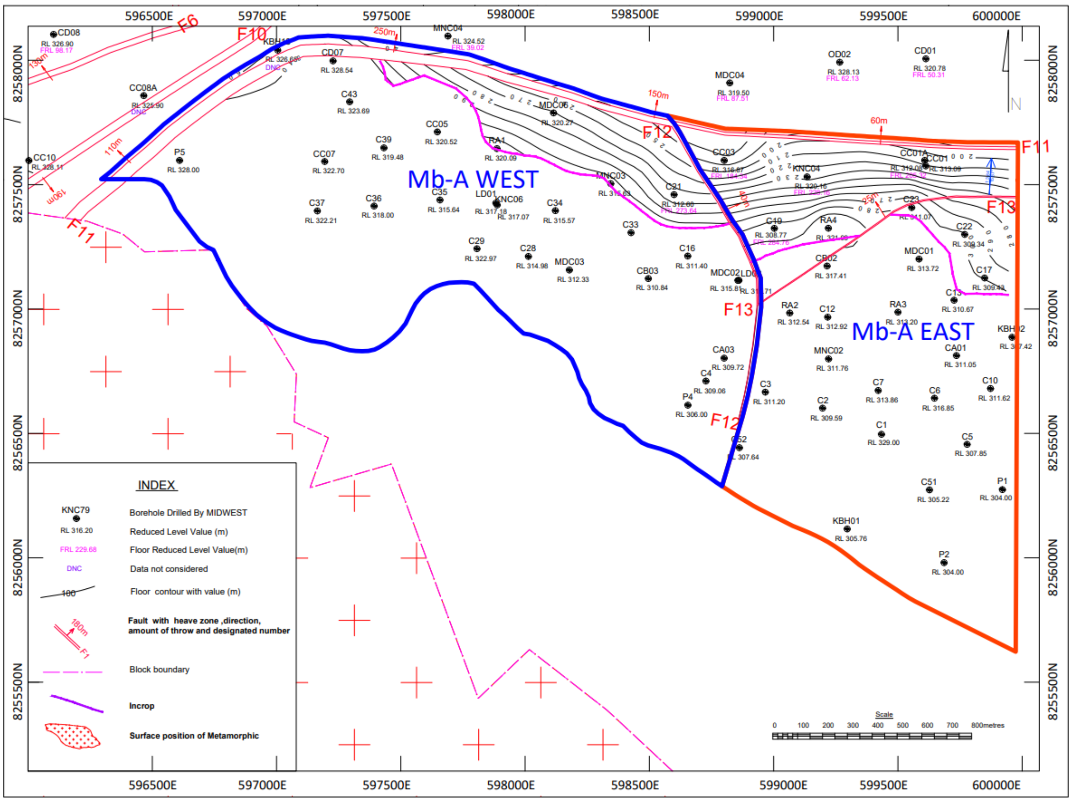


Fig. 8-16: Floor Contours of Intermedia Seam

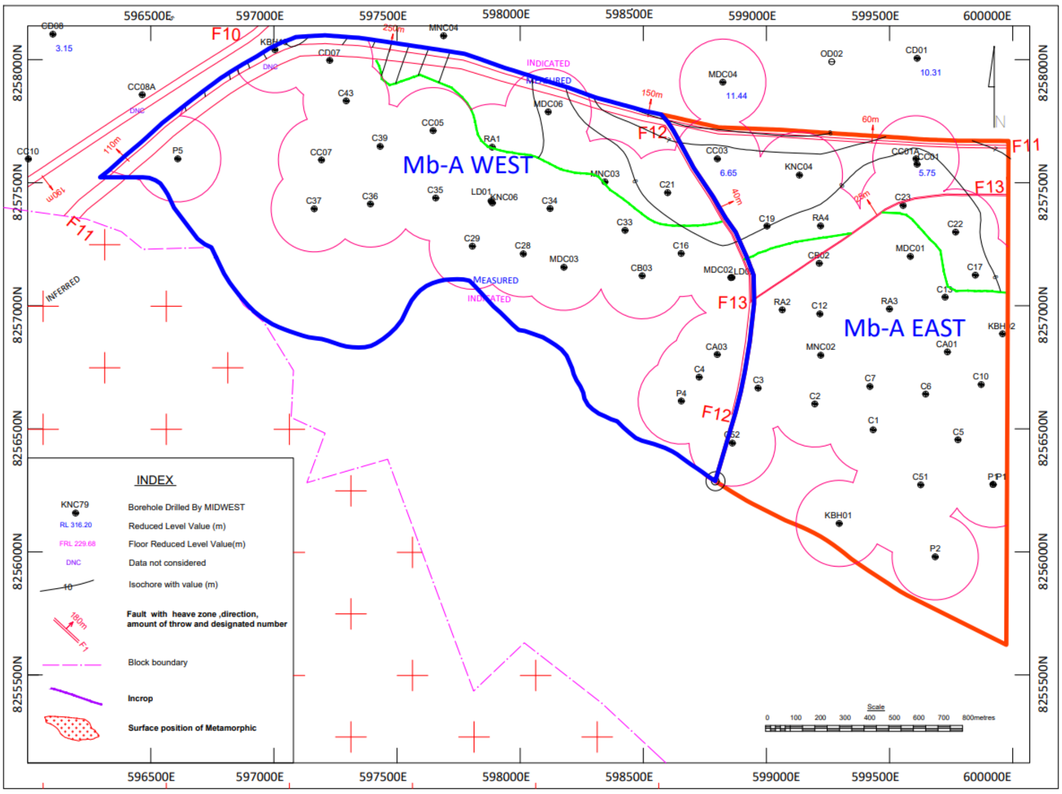


Fig. 8-17: Isopach Contours Of Intermedia Seam

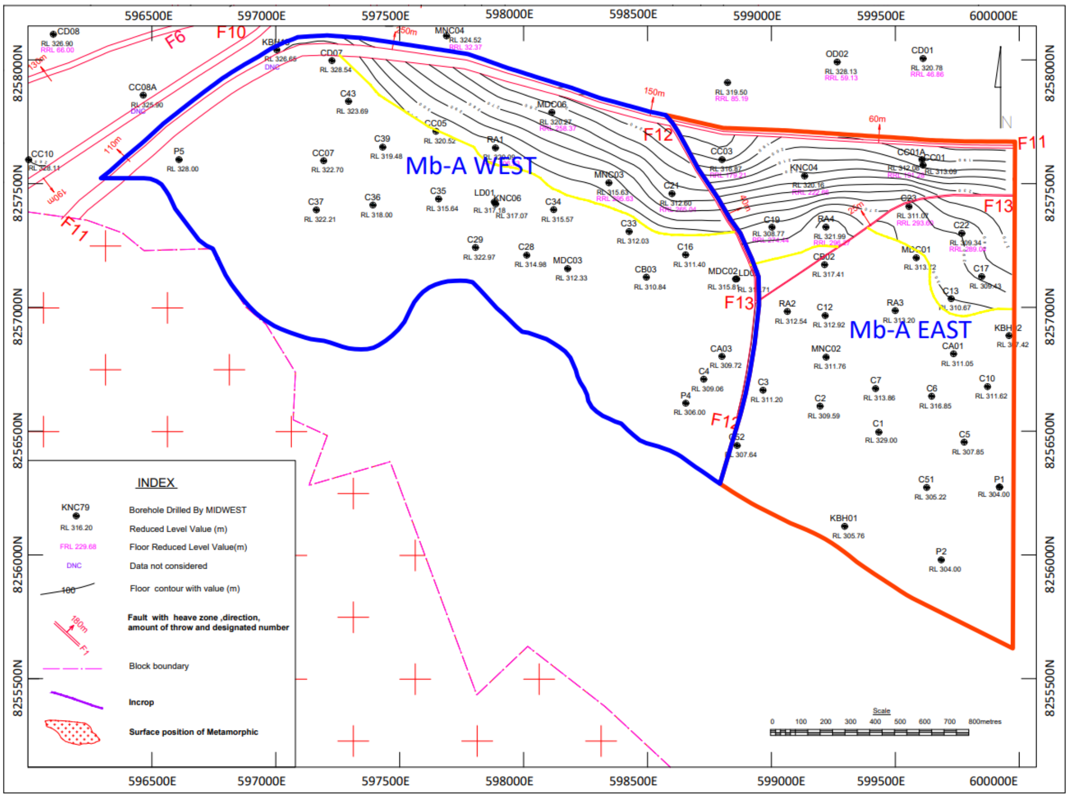


Fig.8-18:Roof Contours of Bananeiras Seam

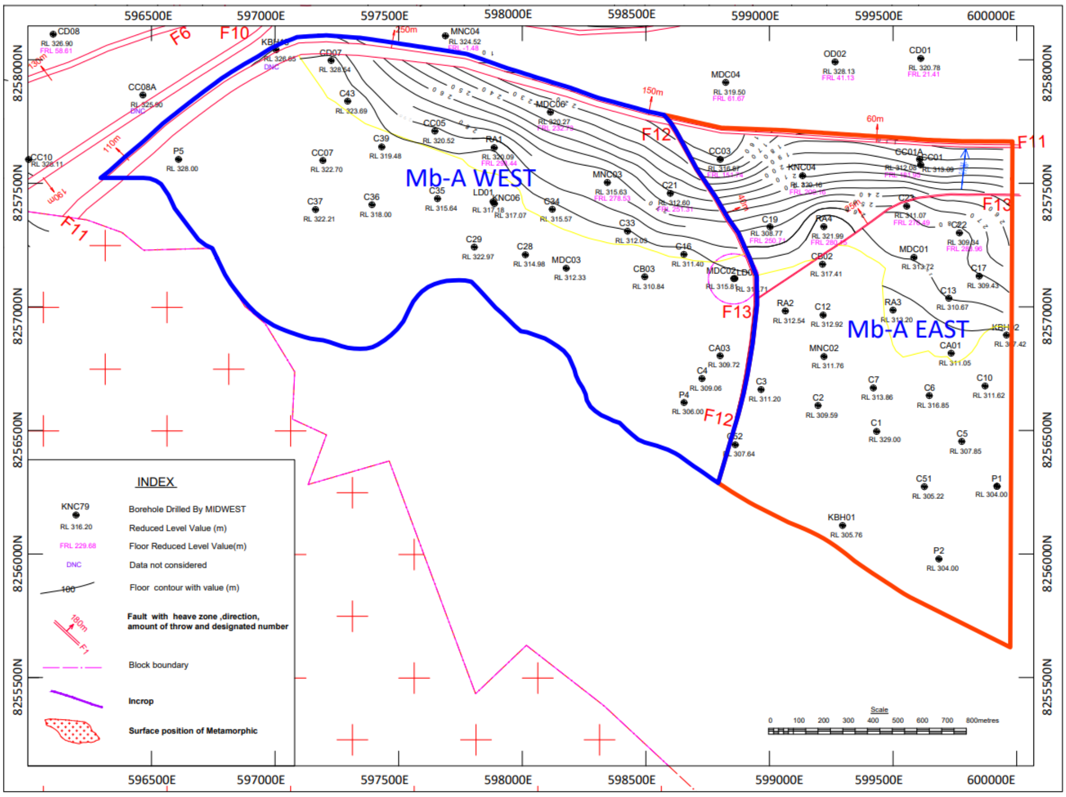


Fig.8-19: Floor Contours of Bananeiras Seam

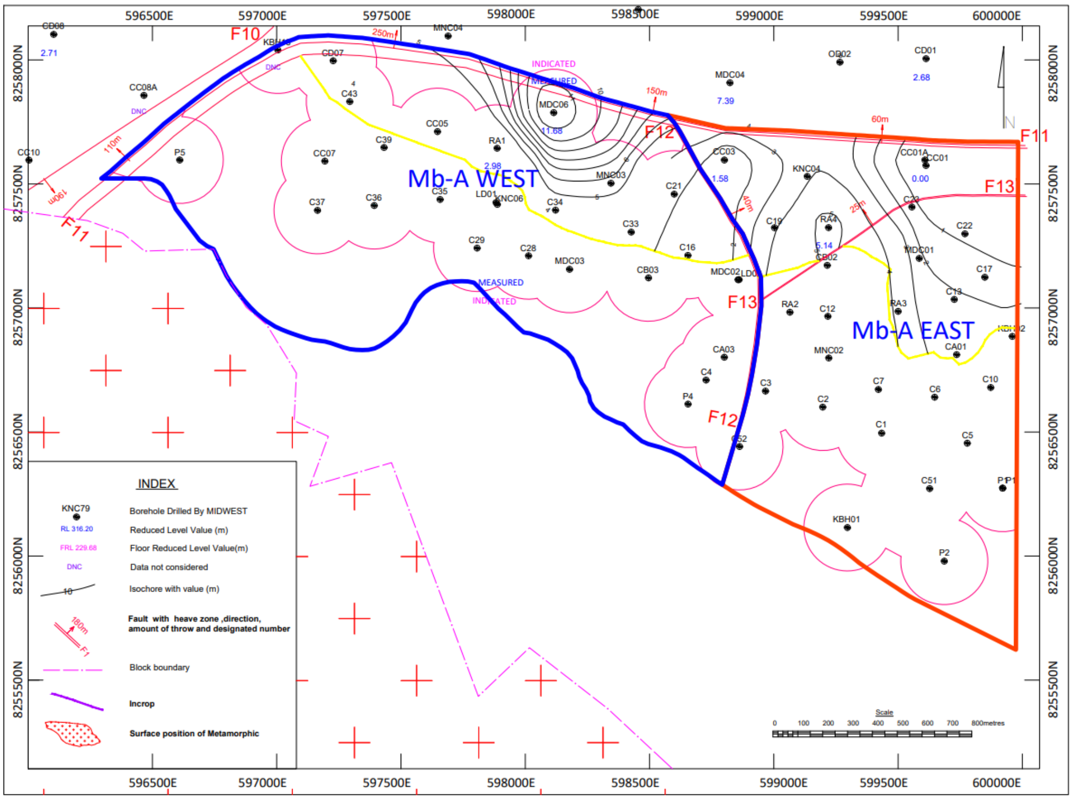


Fig. 8-20: Isopach Contours Of Bananeiras Seam

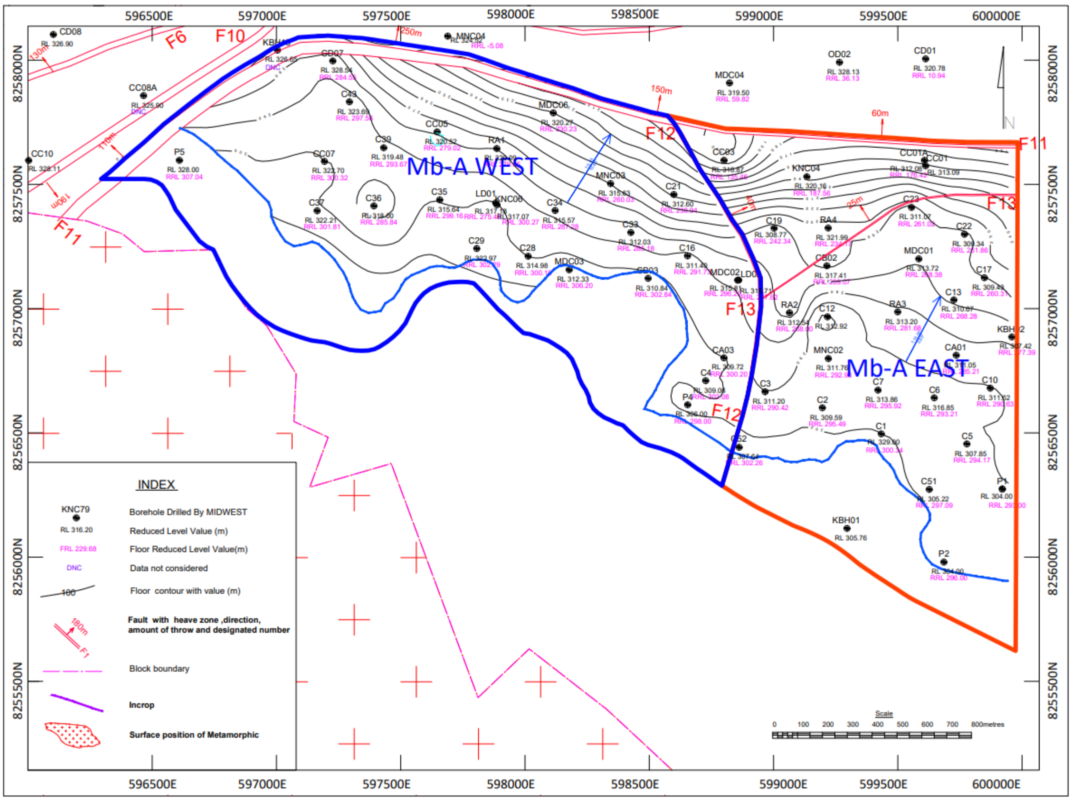


Fig. 8-21: Roof Contours of Chpanga Seam

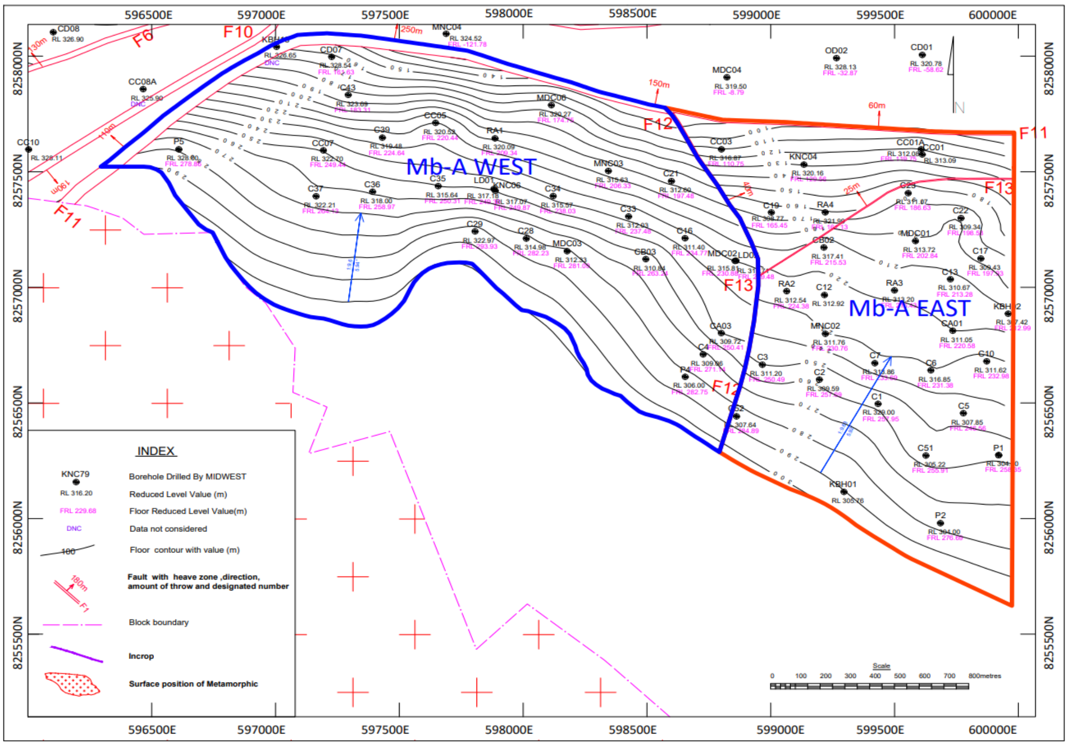


Fig. 8-22: Floor Contours of Chipanga Seam

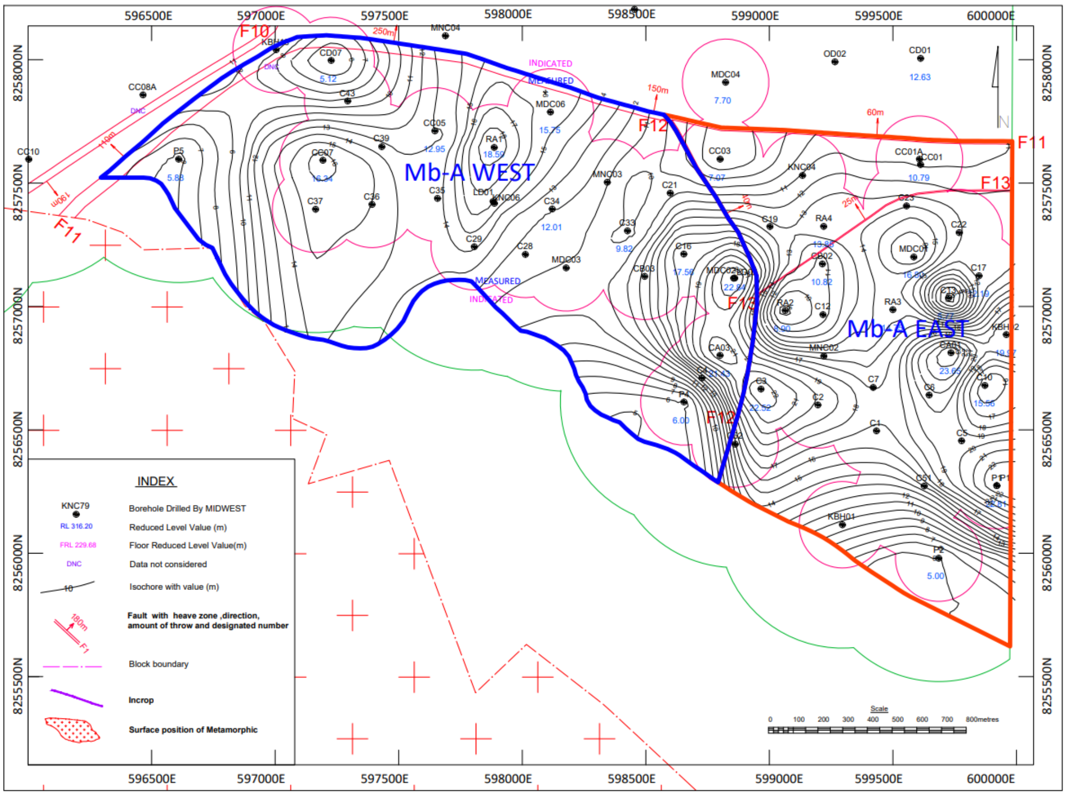


Fig. 8-23: Isopach Contours of Chpanga Seam

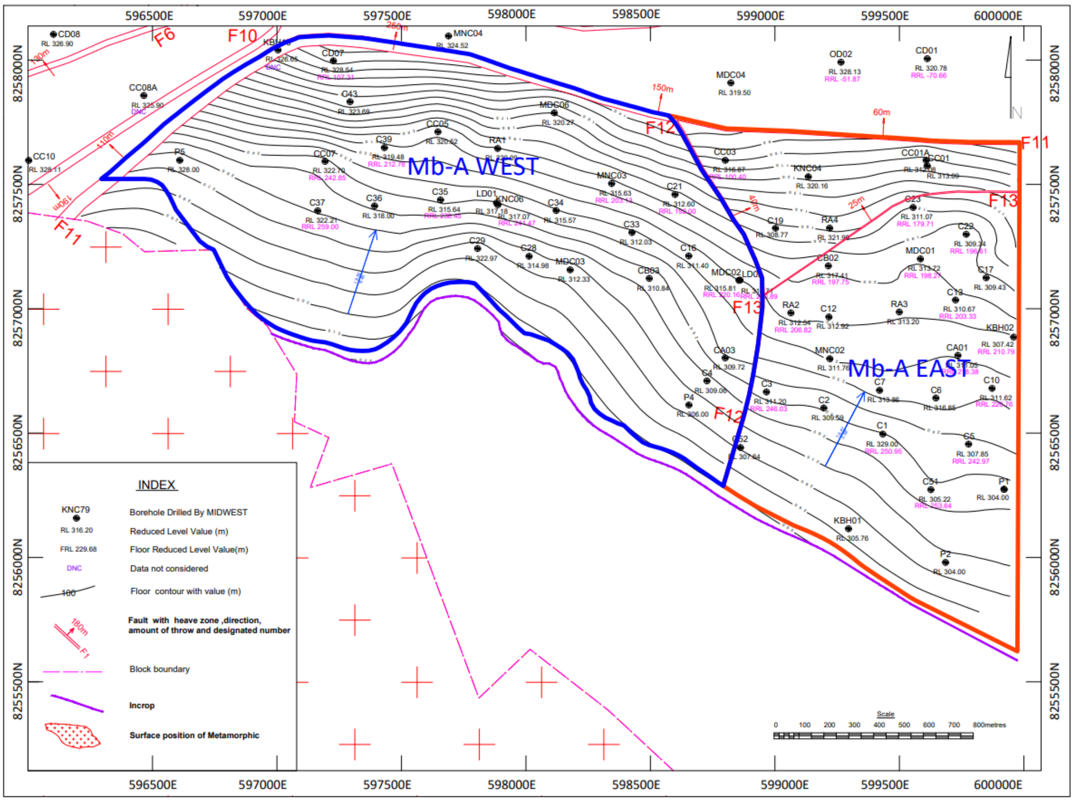


Fig. 8-24: Roof Contours of SausoPinto Seam

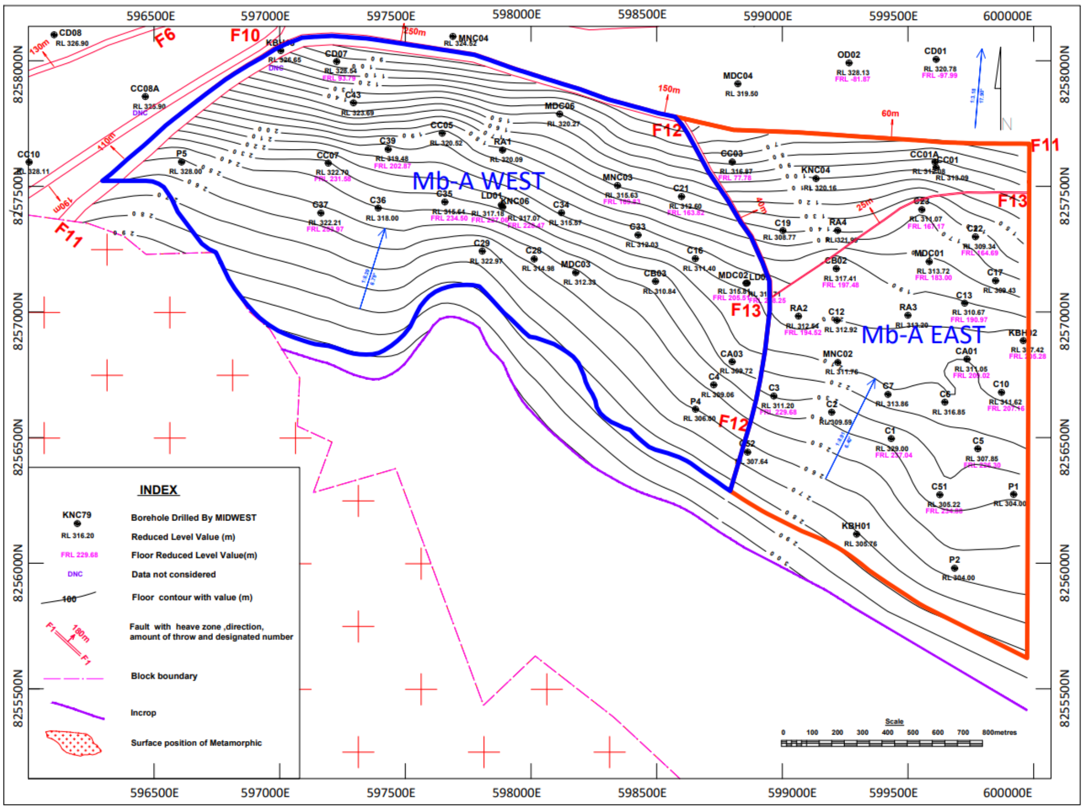


Fig. 8-25: Floor Contours of SausoPinto Seam

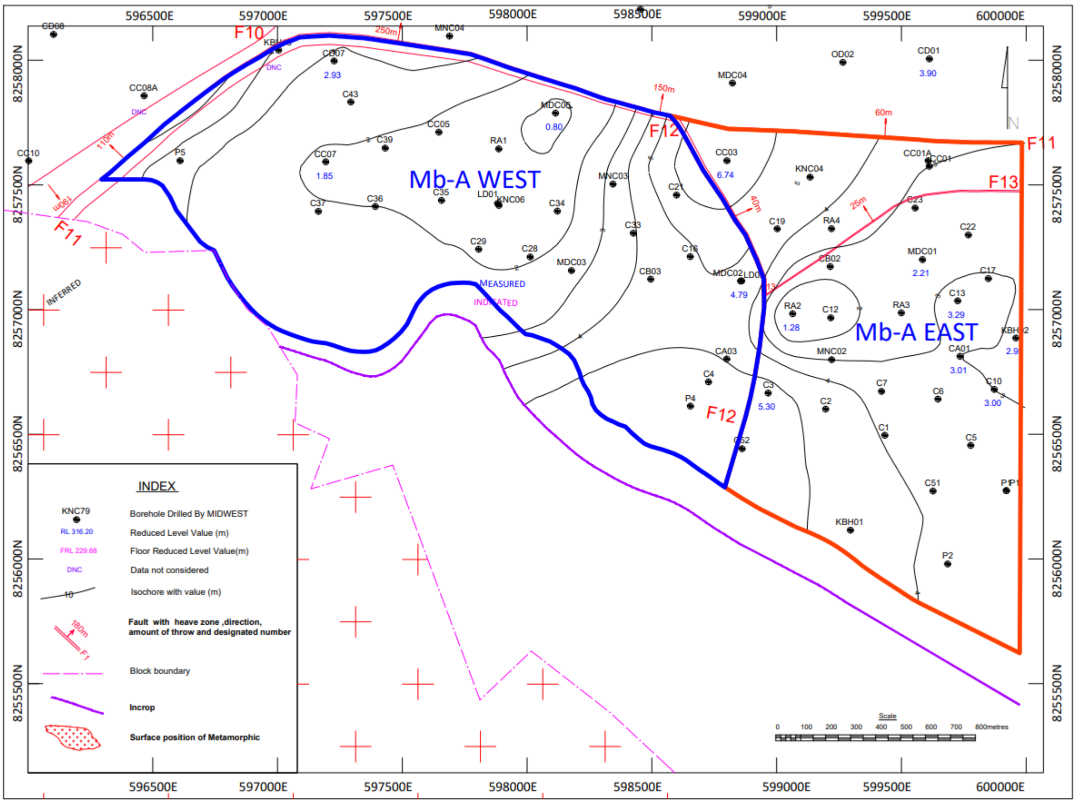


Fig. 8-26: Isopach Contours of SausoPinto Seam

8.4 MINING STRATEGY

8.4.1 Mining sub-blocks:

Taking F_{12}-F_{12} as a marker line the mining module Mb-A is sub-divided into two sub blocks namely the East and West. The mining will be carried out up to the floor of the Chipanga seam covering Chipanga, Bananeiras, Intermedia and Grande Falesia from bottom to top. East block covers an area of 197 ha extending 1.5 km to 1.7km in dip raise direction and 1 to 1.3km in strike direction. Coal targeted for extraction in the east sub block is 42.62 MMT up to the floor of the Chipanga Seam.

West block is covering an area of 253 ha.with mineable resource of 47.81 million tonnes extending 870 m to 1.4km in dip raise direction and 2.0 to 2.3km in strike direction.

Each mining sub-block is divided into mining strips in E-W direction and each strip has been further sub-divided into mining cells (Fig.8-27). Length and width of each cell is (220 to 250 mX100m) which supports theoretical operational maneorability of surface miner in theory, if needed cell dimension may be extended or excavation can be made in several cells together as per practical operational convenience.

Initially, the mining is planned in East Block in Southern most part of the mine in strip 1.

In the following chapters we have elaborated the mining method using surface miner and details of mine planning, mine design and workings in Mining block-A to meet the envisaged targets.

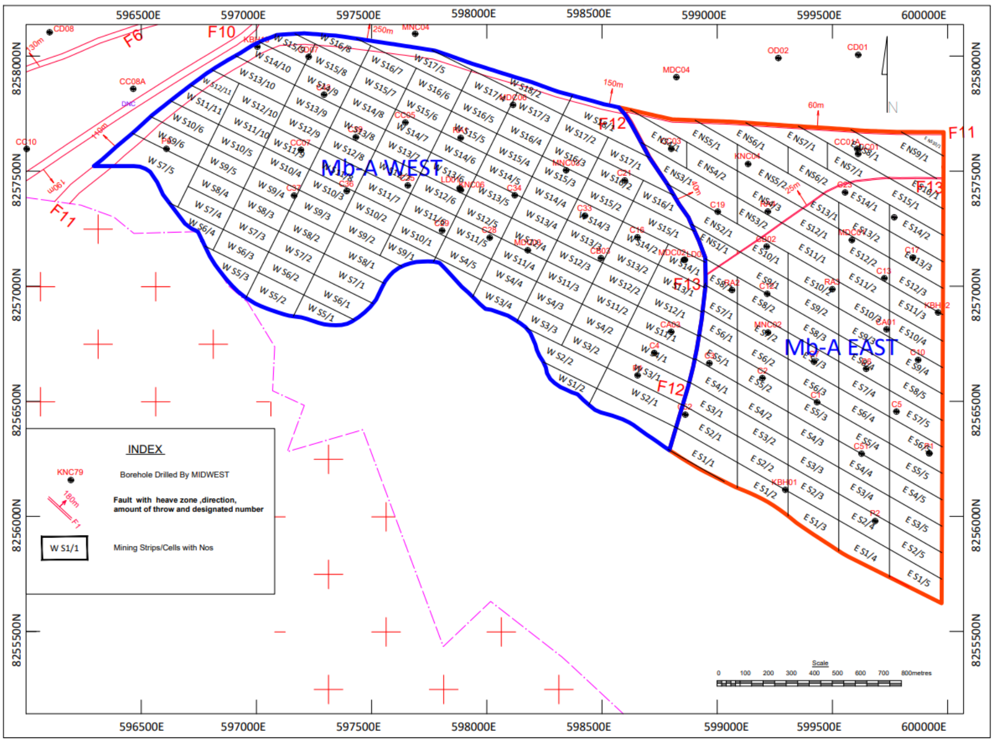


Fig. 8-27: Mining Strips and Sub Blocks Mb-A

8.4.2 Mine Life:

Mining Block-A (Mb-A) contains 90.43 MMT of extractable coal up to the floor of Chipanga seam. Life of Mining Block-A is considered as10.8 years as per the production schedule at Tables8.3, 8.4 & 8.5.

8.4.3 Volumetric estimates for Scheduling:

The quantities of over burden including top soil + weathered rock + Hard rock + intra burden + inter burden, coal resource seam wise, details were given in Tables 8.3, 8.4 & 8.5.

The total volume of waste to be removed is 290 million m^3.

There are five mineable seams in this blocki.e. SausoPinto, Chipanga, Bananeiras, Intermedia and Grande Falesia and however in the mining pit four seams up to floor of the chipanga seam are considered.i.e.Chipanga, Bananeiras, Intermedia and Grande Falesia.

Table 8.3: Total coal resource tonnages and waste volumes in Mb-A.

Mb-A MINING BLOCK RESERVE										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB						1,09,15,689				
Grande Falesia WASTE										
GRANDE FALESIA		10.64	2,52,215	26,84,303	47,24,374		2.31	2.31	1.76	50.90
Intermedia WASTE	41.15					2,37,78,438				
INTERMEDIA		5.78	5,77,853	33,41,462	59,47,802		4.00	3.25	1.78	52.15
Bananeiras WASTE	49.46					2,64,60,327				
BANANEIRAS		3.78	5,35,024	20,22,863	34,79,324		7.61	4.32	1.72	48.05
Chipanga WASTE	68.83					22,93,99,403				
CHIPANGA		13.31	33,32,715	4,43,49,833	7,62,81,713		3.01	3.21	1.72	47.22
TOTAL					**9,04,33,213**	**29,05,53,857**		3.21		

The coal resources, waste and coal seam quantities of East & West block are given respectively in Table 8.4 &8.5.

Table 8.4: Total coal tonnages and waste volumes in East sub-block

Mb-A EAST MINING BLOCK RESERVE										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB						96,54,694				
Grande Falesia WASTE										
GRANDE FALESIA		8.89	1,99,874	17,76,010	31,25,778		3.09	3.09	1.76	50.41
Intermedia WASTE	44.24					1,45,21,790				
INTERMEDIA		5.97	3,28,247	19,58,284	34,85,745		4.17	3.66	1.78	52.26
Bananeiras WASTE	48.51					1,38,21,904				
BANANEIRAS		2.42	2,84,952	6,90,332	11,87,371		11.64	4.87	1.72	46.76
Chipanga WASTE	68.64					9,66,83,225				
CHIPANGA		14.29	14,08,577	2,01,28,797	3,48,22,819		2.78	3.16	1.73	48.53
TOTAL					**4,26,21,713**	**13,46,81,613**		3.16		

Table 8.5: Total coal tonnages and waste volumes in West block

Mb-A WEST MINING BLOCK RESERVE										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB						12,60,995				
Grande Falesia WASTE										
GRANDE FALESIA		17.16	52,341	8,98,088	15,98,596		0.79	0.79	1.78	51.95
Intermedia WASTE	37.09					92,56,648				
INTERMEDIA		5.54	2,49,606	13,83,178	24,62,057		3.76	2.59	1.78	52.32
Bananeiras WASTE	50.54					1,26,38,423				
BANANEIRAS		5.33	2,50,072	13,32,531	22,91,953		5.51	3.65	1.72	48.70
Chipanga WASTE	68.97					13,27,16,178				
CHIPANGA		12.67	19,24,138	2,43,87,585	4,14,58,894		3.20	3.26	1.7	46.03
TOTAL					**4,78,11,500**	**15,58,72,244**		3.26		

East block contains extractable coal resource of 42.62 MMT of coal with stripping ratio of 1:3.16 and west block 47.81 MMT of coal with stripping ratio of 1:3.26.

The East and West blocks are sub-divided into 100m strips. East sub block will have 14 strips (ES1 to ES14) and west sub block is made into 11 strips (WS1 to WS11) (Figs.8-28& 8-29). Strip-wise the coal resource and waste quantities are computed in Table 8.6(east block) and Table 8.7 (west block).

Each strip has been sub-divided into the cells. Each cell is a basic mining unit and has dimension of approximately 220 to 250 X100m to facilitate the maneuverability of Surface Miner. In case of any inconvenience for vehicle movement and for operational maneuvers, due to smaller space, such cell will be worked with along the adjacent cell. The planned mining cell network will support the coal winning by two surface miners simultaneously to keep up the pace of production depending on the coal target.

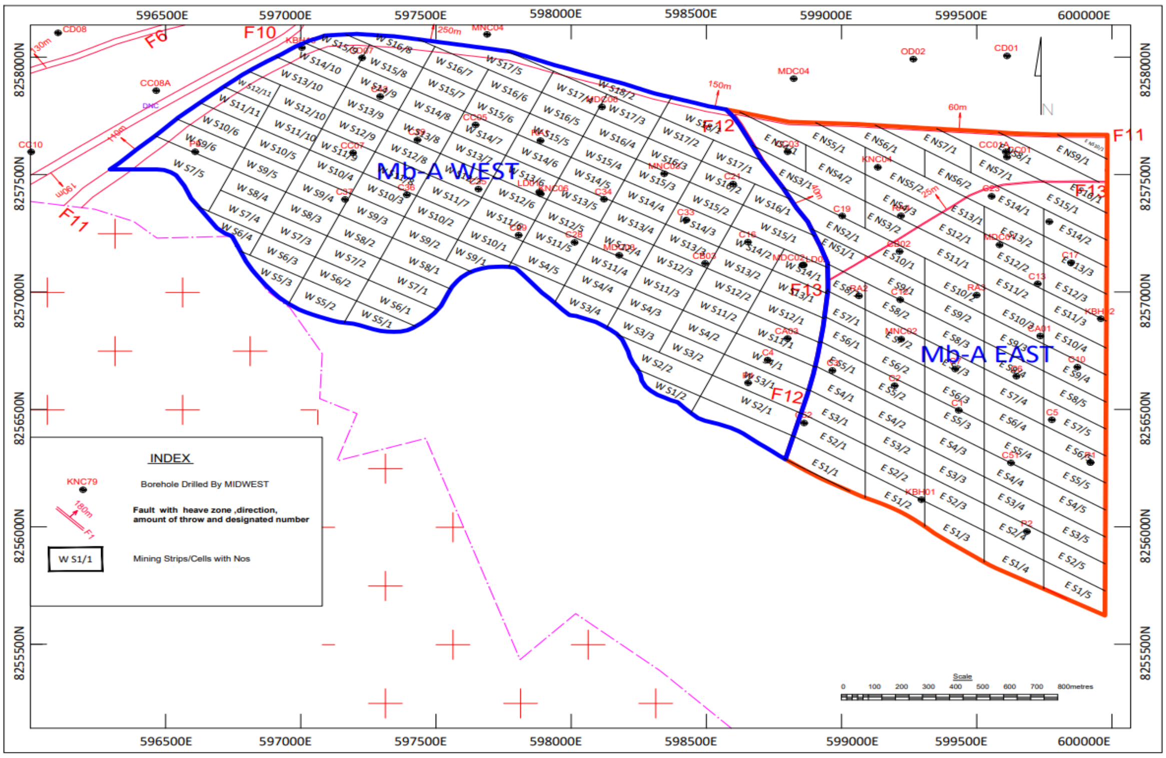


Fig. 8-28: A Layout Plan Of Mining Strips And Cells In Mb-A

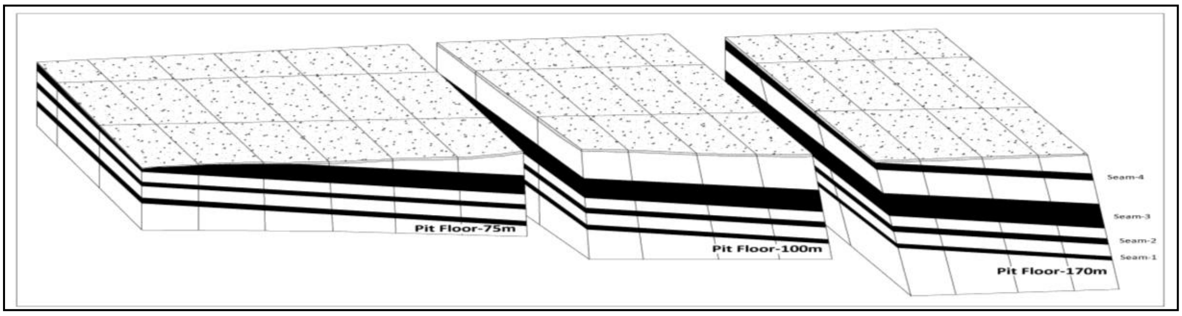


Fig. 8-29: A Schematic Block Diagram Shows Sectional View Of Mining Strips and Cells

Strip-wise coal tonnages and waste volume estimates are shown in east and west sub-blocks in Tables 8.6 and 8.7 respectively.

Table 8.6: Strip-Wise coal tonnage and waste volumes in East sub-block

BLOCK ES1 / 1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	4.05					91,138				
CHIPANGA		11.10	22,487	2,49,522	4,29,178		0.21	0.21	1.72	47.15
TOTAL					**4,29,178**	**91,138**		0.21		
BLOCK ES1 / 2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	6.86					1,01,453				
CHIPANGA		10.08	14,788	1,49,031	2,56,333		0.40	0.40	1.72	48.52
TOTAL					2,56,333	1,01,453		0.40		
BLOCK ES1 / 3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	13.38					2,40,812				
CHIPANGA		5.79	18,000	1,04,254	1,83,487		1.31	1.31	1.76	50.20
TOTAL					1,83,487	2,40,812		1.31		
BLOCK ES1 / 4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	17.23					2,49,507				
CHIPANGA		4.70	14,478	68,099	1,21,216		2.06	2.06	1.78	51.01
TOTAL					**1,21,216**	**2,49,507**		2.06		

BLOCK ES1 / 5

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	29.96					37,150				
CHIPANGA		5.02	1,240	6,228	11,086		3.35	3.35	1.78	51.19
TOTAL					**11,086**	**37,150**		3.35		

BLOCK ES2 / 1

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	10.39					2,44,535				
CHIPANGA		16.15	23,543	3,80,138	6,53,838		0.37	0.37	1.72	46.52
TOTAL					**6,53,838**	**2,44,535**		0.37		

BLOCK ES2 / 2

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	12.98					2,82,973				
CHIPANGA		12.65	21,802	2,75,836	4,74,438		0.60	0.60	1.72	48.00
TOTAL					**4,74,438**	**2,82,973**		0.60		

BLOCK ES2 / 3

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	16.49					3,84,844				
CHIPANGA		8.63	23,337	2,01,458	3,50,537		1.10	1.10	1.74	49.72
TOTAL					**3,50,537**	**3,84,844**		1.10		

BLOCK ES2 / 4

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	19.83					5,02,499				
CHIPANGA		5.25	25,338	1,33,045	2,36,820		2.12	2.12	1.78	50.98
TOTAL					**2,36,820**	**5,02,499**		2.12		

BLOCK ES2 / 5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	19.91					3,72,153				
CHIPANGA		5.42	18,695	1,01,244	1,80,215		2.07	2.07	1.78	51.22
TOTAL					**1,80,215**	**3,72,153**		2.07		

BLOCK ES3 / 1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	22.43					4,65,730				
CHIPANGA		18.66	20,764	3,87,469	6,66,447		0.70	0.70	1.72	45.89
TOTAL					**6,66,447**	**4,65,730**		0.70		

BLOCK ES3 / 2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	23.46					5,07,479				
CHIPANGA		15.08	21,630	3,26,163	5,61,001		0.90	0.90	1.72	47.47
TOTAL					**5,61,001**	**5,07,479**		0.90		

BLOCK ES3 / 3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	23.19					5,38,561				
CHIPANGA		11.31	23,226	2,62,612	4,51,693		1.19	1.19	1.72	49.22
TOTAL					**4,51,693**	**5,38,561**		1.19		

BLOCK ES3 / 4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	26.60					6,73,906				
CHIPANGA		8.22	25,337	2,08,356	3,70,873		1.82	1.82	1.78	50.76
TOTAL					**3,70,873**	**6,73,906**		1.82		

BLOCK ES3 / 5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	26.06					6,16,760				
CHIPANGA		7.30	23,671	1,72,730	3,07,459		2.01	2.01	1.78	51.21
TOTAL					**3,07,459**	**6,16,760**		2.01		

BLOCK ES4 / 1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	37.89					6,89,994				
CHIPANGA		21.22	18,212	3,86,464	6,60,853		1.04	1.04	1.71	45.28
TOTAL					**6,60,853**	**6,89,994**		1.04		

BLOCK ES4 / 2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	39.82					7,13,713				
CHIPANGA		17.81	17,922	3,19,166	5,48,964		1.30	1.30	1.72	46.89
TOTAL					**5,48,964**	**7,13,713**		1.30		

BLOCK ES4 / 3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	29.44					6,85,375				
CHIPANGA		14.24	23,283	3,31,580	5,70,317		1.20	1.20	1.72	48.77
TOTAL					**5,70,317**	**6,85,375**		1.20		

BLOCK ES4 / 4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	31.87					8,07,436				
CHIPANGA		12.61	25,338	3,19,535	5,64,074		1.43	1.43	1.77	50.39
TOTAL					**5,64,074**	**8,07,436**		1.43		

BLOCK ES4 / 5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	55.99					7,89,808				
CHIPANGA		12.14	14,106	1,71,218	3,04,767		2.59	2.59	1.78	51.14
TOTAL					**3,04,767**	**7,89,808**		2.59		

BLOCK ES5 / 1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	43.86					7,93,714				
CHIPANGA		21.48	18,098	3,88,782	6,63,546		1.20	1.20	1.71	45.30
TOTAL					**6,63,546**	**7,93,714**		1.20		

BLOCK ES5 / 2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	33.11					8,38,941				
CHIPANGA		19.26	25,338	4,87,948	8,39,270		1.00	1.00	1.72	46.43
TOTAL					**8,39,270**	**8,38,941**		1.00		

BLOCK ES5 / 3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	33.37					8,45,632				
CHIPANGA		16.40	25,338	4,15,426	7,14,533		1.18	1.18	1.72	48.38
TOTAL					**7,14,533**	**8,45,632**		1.18		

BLOCK ES5 / 4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	37.93					9,61,061				
CHIPANGA		16.94	25,338	4,29,201	7,48,866		1.28	1.28	1.74	49.87
TOTAL					**7,48,866**	**9,61,061**		1.28		

BLOCK ES5 / 5

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	29.71					7,26,783				
CHIPANGA		18.73	24,463	4,58,257	8,15,698		0.89	0.89	1.78	50.99
TOTAL					**8,15,698**	**7,26,783**		0.89		

BLOCK ES6 / 1

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	59.82					9,93,775				
CHIPANGA		17.96	16,614	2,98,351	5,13,163		1.94	1.94	1.72	46.31
TOTAL					**5,13,163**	**9,93,775**		1.94		

BLOCK ES6 / 2

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	47.25					11,97,161				
CHIPANGA		18.89	25,338	4,78,672	8,23,315		1.45	1.45	1.72	46.44
TOTAL					**8,23,315**	**11,97,161**		1.45		

BLOCK ES6 / 3

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	46.16					11,69,601				
CHIPANGA		17.40	25,338	4,40,956	7,58,445		1.54	1.54	1.72	48.13
TOTAL					**7,58,445**	**11,69,601**		1.54		

BLOCK ES6 / 4

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	45.44					11,51,319				
CHIPANGA		18.54	25,338	4,69,884	8,08,903		1.42	1.42	1.72	49.43
TOTAL					**8,08,903**	**11,51,319**		1.42		

BLOCK ES6 / 5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	33.56					8,86,098				
CHIPANGA		21.32	26,402	5,62,768	9,96,047		0.89	0.89	1.77	50.56
TOTAL					**9,96,047**	**8,86,098**		0.89		

BLOCK ES7 /1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	74.37					11,16,808				
CHIPANGA		12.70	15,017	1,90,671	3,27,954		3.41	3.41	1.72	46.69
TOTAL					**3,27,954**	**11,16,808**		3.41		

BLOCK ES7 /2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	64.62					16,37,226				
CHIPANGA		15.18	25,338	3,84,529	6,61,390		2.48	2.48	1.72	46.81
TOTAL					**6,61,390**	**16,37,226**		2.48		

BLOCK ES7 /3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	63.31					16,04,087				
CHIPANGA		17.05	25,338	4,32,071	7,43,162		2.16	2.16	1.72	47.98
TOTAL					**7,43,162**	**16,04,087**		2.16		

BLOCK ES7 /4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	56.72					14,37,075				
CHIPANGA		19.16	25,338	4,85,549	8,35,144		1.72	1.72	1.72	49.35
TOTAL					**8,35,144**	**14,37,075**		1.72		

BLOCK ES7 /5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	45.20					11,95,948				
CHIPANGA		20.31	26,459	5,37,420	9,33,659		1.28	1.28	1.74	49.53
TOTAL					**9,33,659**	**11,95,948**		1.28		

BLOCK ES8 /1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	85.41					10,72,548				
CHIPANGA		10.87	12,558	1,36,497	2,34,775		4.57	4.57	1.72	47.17
TOTAL					**2,34,775**	**10,72,548**		4.57		

BLOCK ES8 /2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	75.54					19,14,066				
CHIPANGA		11.65	25,338	2,95,235	5,07,804		3.77	3.77	1.72	47.16
TOTAL					**5,07,804**	**19,14,066**		3.77		

BLOCK ES8 /3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	74.09					18,77,200				
CHIPANGA		15.85	25,338	4,01,642	6,90,824		2.72	2.72	1.72	47.95
TOTAL					**6,90,824**	**18,77,200**		2.72		

BLOCK ES8 /4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	67.13					17,01,036				
CHIPANGA		20.03	25,338	5,07,529	8,79,871		1.93	1.93	1.73	49.58
TOTAL					**8,79,871**	**17,01,036**		1.93		

BLOCK ES8 /5

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	56.75					15,04,964				
CHIPANGA		18.15	26,517	4,81,397	8,28,003		1.82	1.82	1.72	48.06
TOTAL					**8,28,003**	**15,04,964**		1.82		

BLOCK ES 9/1

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	84.68					24,89,253				
CHIPANGA		10.99	29,397	3,23,182	5,56,773		4.47	4.47	1.72	48.57
TOTAL					**5,56,773**	**24,89,253**		4.47		

BLOCK ES 9/2

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	79.54					20,15,305				
CHIPANGA		14.48	25,338	3,66,816	6,30,924		3.19	3.19	1.72	48.07
TOTAL					**6,30,924**	**20,15,305**		3.19		

BLOCK ES 9/3

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	71.29					18,06,421				
CHIPANGA		20.75	25,338	5,25,692	9,20,638		1.96	1.96	1.75	49.89
TOTAL					**9,20,638**	**18,06,421**		1.96		

BLOCK ES 9/4

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	63.10					16,76,884				
CHIPANGA		17.34	26,574	4,60,729	7,94,369		2.11	2.11	1.72	47.30
TOTAL					**7,94,369**	**16,76,884**		2.11		

BLOCK ES 10/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	90.17					16,94,512				
CHIPANGA		11.32	18,792	2,12,717	3,76,053		4.51	4.51	1.77	50.67
TOTAL					**3,76,053**	**16,94,512**		4.51		

BLOCK ES 10/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	84.83					21,49,448				
CHIPANGA		13.86	25,338	3,51,215	6,04,739		3.55	3.55	1.72	48.64
TOTAL					**6,04,739**	**21,49,448**		3.55		

BLOCK ES 10/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	77.09					19,53,407				
CHIPANGA		17.60	25,338	4,46,033	7,81,668		2.50	2.50	1.75	49.84
TOTAL					**7,81,668**	**19,53,407**		2.50		

BLOCK ES 10/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	69.47					18,50,048				
CHIPANGA		18.83	26,631	5,01,433	8,72,955		2.12	2.12	1.74	48.64
TOTAL					**8,72,955**	**18,50,048**		2.12		

BLOCK ES 11/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	94.78					31,25,910				
CHIPANGA		13.46	32,982	4,44,043	7,70,344		4.06	4.06	1.74	49.69
TOTAL					**7,70,344**	**31,25,910**		4.06		

BLOCK ES 11/2

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	85.43					21,64,590				
CHIPANGA		12.00	25,338	3,04,061	5,32,702		4.06	4.06	1.76	50.29
TOTAL					**5,32,702**	**21,64,590**		4.06		

BLOCK ES 11/3

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	77.25					20,61,708				
CHIPANGA		17.10	26,689	4,56,340	8,05,946		2.56	2.56	1.77	50.37
TOTAL					**8,05,946**	**20,61,708**		2.56		

BLOCK ES 12/1

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE						20,979				
INTERMEDIA										
Bananeiras WASTE						16,061				
BANANEIRAS										
Chipanga WASTE	101.73					22,24,024				
CHIPANGA		14.77	21,862	3,22,871	5,55,339		4.00	4.07	1.72	48.94
TOTAL					**5,55,339**	**22,61,064**		4.07		

BLOCK ES 12/2

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE						3,403				
INTERMEDIA										
Bananeiras WASTE						9,239				
BANANEIRAS										
Chipanga WASTE	92.94					23,54,848				
CHIPANGA		12.46	25,338	3,15,586	5,50,212		4.28	4.30	1.75	50.30
TOTAL					**5,50,212**	**23,67,490**		4.30		

BLOCK ES 12/3

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	5.41					10,595				
INTERMEDIA		5.40	1,957	10,559	18,794		0.56	0.56	1.78	51.84
Bananeiras WASTE	37.35					73,090				
BANANEIRAS		1.83	1,957	3,573	6,145		11.89	3.36	1.72	46.95
Chipanga WASTE	85.28					22,80,879				
CHIPANGA		13.21	26,746	3,53,320	6,22,142		3.67	3.65	1.76	50.20
TOTAL					**6,47,081**	**23,64,564**		3.65		

BLOCK ES 13/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	108.58					72,531				
INTERMEDIA		5.46	668	3,649	6,495		11.17	11.17	1.78	51.82
Bananeiras WASTE	#DIV/0!					49,435				
BANANEIRAS								18.78		
Chipanga WASTE	101.69					12,22,047				
CHIPANGA		14.51	12,017	1,74,371	2,99,918		4.07	4.39	1.72	48.88
TOTAL					**3,06,413**	**13,44,013**		4.39		

BLOCK ES 13/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	11.47					34,579				
INTERMEDIA		5.52	3,016	16,644	29,627		1.17	1.17	1.78	51.73
Bananeiras WASTE	45.84					1,10,611				
BANANEIRAS		1.30	2,413	3,142	5,404			4.14	1.72	46.99
Chipanga WASTE	94.73					24,00,215				
CHIPANGA		14.98	25,338	3,79,670	6,53,633		3.67	3.70	1.72	49.63
TOTAL					**6,88,664**	**25,45,405**		3.70		

BLOCK ES 13/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	5.23					1,12,813				
INTERMEDIA		5.76	21,574	1,24,244	2,21,154		0.51	0.51	1.78	51.86
Bananeiras WASTE	18.30					3,94,865				
BANANEIRAS		1.50	21,574	32,388	55,707		7.09	1.83	1.72	47.14
Chipanga WASTE	75.24					20,16,681				
CHIPANGA		12.70	26,804	3,40,340	5,85,584		3.44	2.93	1.72	48.39
TOTAL					**8,62,445**	**25,24,359**		2.93		

BLOCK ES 14/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	9.47					1,87,347				
INTERMEDIA		5.51	19,786	1,08,936	1,93,905		0.97	0.97	1.78	51.67
Bananeiras WASTE	25.01					4,94,817				
BANANEIRAS		1.02	19,786	20,269	34,863		14.19	2.98	1.72	47.39
Chipanga WASTE	76.85					19,48,246				
CHIPANGA		14.21	25,351	3,60,315	6,19,742		3.14	3.10	1.72	49.61
TOTAL					**8,48,510**	**26,30,410**		3.10		

BLOCK ES 14/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	10.99					2,95,271				
INTERMEDIA		5.93	26,861	1,59,409	2,83,747		1.04	1.04	1.78	51.83
Bananeiras WASTE	17.05					4,57,998				
BANANEIRAS		0.94	26,861	25,261	43,449		10.54	2.30	1.72	47.28
Chipanga WASTE	72.95					19,59,517				
CHIPANGA		12.64	26,861	3,39,507	5,83,952		3.36	2.98	1.72	48.12
TOTAL					**9,11,148**	**27,12,786**		2.98		

BLOCK ES 15/1

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	24.76					7,50,950				
INTERMEDIA		5.87	30,325	1,77,987	3,16,817		2.37	2.37	1.78	51.73
Bananeiras WASTE	20.87					6,32,840				
BANANEIRAS		0.48	30,325	14,544	25,016		25.30	4.05	1.72	47.76
Chipanga WASTE	85.55					25,94,413				
CHIPANGA		12.67	30,325	3,84,343	6,61,318		3.92	3.97	1.72	48.90
TOTAL					**10,03,151**	**39,78,203**		3.97		

BLOCK ES 16/1

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE						1,54,942				
GRANDE FALESIA			2,264	9,994	17,190		9.01	9.01	1.72	47.07
Intermedia WASTE	59.84					4,40,280				
INTERMEDIA		6.27	7,358	46,147	82,141		5.36	4.43	1.78	51.76
Bananeiras WASTE	35.74					2,62,967				
BANANEIRAS		0.19	7,358	1,407	2,421		108.62	6.91	1.72	48.34
Chipanga WASTE	151.93					11,17,923				
CHIPANGA		12.25	7,358	90,165	1,55,084		7.21	7.09	1.72	48.83
TOTAL					**2,56,836**	**19,76,112**		7.69		

BLOCK ENS 1/1

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE						10,244				
INTERMEDIA										
Bananeiras WASTE						15,332				
BANANEIRAS										
Chipanga WASTE	107.90					11,84,336				
CHIPANGA		15.43	10,976	1,69,321	2,91,232		4.07	4.15	1.73	49.40
TOTAL					**2,91,232**	**12,09,912**		4.15		

BLOCK ENS 2/1

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	15.54					57,891				
GRANDE FALESIA		13.40	3,725	49,908	88,836		0.65	0.65	1.78	51.06
Intermedia WASTE	23.48					3,93,643				
INTERMEDIA		6.01	16,764	1,00,765	1,79,361		2.19	1.68	1.78	52.73
Bananeiras WASTE	33.65					5,64,117				
BANANEIRAS		3.41	16,764	57,198	98,381		5.73	2.77	1.72	47.23
Chipanga WASTE	86.33					25,72,979				
CHIPANGA		13.87	29,803	4,13,369	7,14,537		3.60	3.32	1.73	49.39
TOTAL					**10,81,115**	**35,88,630**		3.32		

BLOCK ENS 3/1

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	39.64					11,24,863				
GRANDE FALESIA		13.37	28,376	3,79,491	6,74,730		1.67	1.67	1.77	51.03
Intermedia WASTE	19.08					7,06,344				
INTERMEDIA		6.23	37,013	2,30,519	4,10,324		1.72	1.69	1.78	52.76
Bananeiras WASTE	28.60					10,58,496				
BANANEIRAS		2.82	37,013	1,04,324	1,79,437		5.90	2.29	1.72	48.16
Chipanga WASTE	60.86					22,52,695				
CHIPANGA		11.40	37,013	4,21,783	7,25,466		3.11	2.58	1.72	48.93
TOTAL					**19,89,957**	**51,42,398**		2.58		

BLOCK ENS 3/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	#DIV/0!					7,970				
GRANDE FALESIA		#DIV/0!					#DIV/0!	#DIV/0!		
Intermedia WASTE	27.87					2,58,861				
INTERMEDIA		5.85	9,289	54,332	96,711		2.68	2.76	1.78	52.38
Bananeiras WASTE	29.41					2,92,714				
BANANEIRAS		4.87	9,952	48,433	83,305		3.51	3.11	1.72	46.56
Chipanga WASTE	96.84					15,42,155				
CHIPANGA		12.80	15,924	2,03,841	3,52,612		4.37	3.95	1.73	48.37
TOTAL					**5,32,628**	**21,01,700**		3.95		

BLOCK ENS 4/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	97.38					20,38,464				
GRANDE FALESIA		15.32	20,934	3,20,622	5,70,706		3.57	3.57	1.78	52.04
Intermedia WASTE	20.51					4,29,435				
INTERMEDIA		6.90	20,934	1,44,439	2,57,100		1.67	2.98	1.78	52.74
Bananeiras WASTE	30.19					6,31,925				
BANANEIRAS		2.21	20,934	46,222	80,042		7.89	3.41	1.73	49.46
Chipanga WASTE	40.22					8,41,879				
CHIPANGA		7.81	20,934	1,63,578	2,83,992		2.96	3.31	1.73	49.79
TOTAL					**11,91,840**	**39,41,703**		3.31		

BLOCK ENS 4/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	49.47					12,53,549				
GRANDE FALESIA		12.20	25,338	3,09,150	5,48,171		2.29	2.29	1.77	50.66
Intermedia WASTE	20.99					5,31,786				
INTERMEDIA		6.38	25,338	1,61,564	2,87,585		1.85	2.14	1.78	52.67
Bananeiras WASTE	24.91					6,31,091				
BANANEIRAS		2.77	25,338	70,165	1,20,684		5.23	2.53	1.72	48.38
Chipanga WASTE	60.08					15,22,354				
CHIPANGA		9.92	25,338	2,51,378	4,32,370		3.52	2.84	1.72	49.07
TOTAL					**13,88,810**	**39,38,780**		2.84		

BLOCK ENS 4/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	27.08					2,03,998				
GRANDE FALESIA		9.02	7,534	67,934	1,16,847		1.75	1.75	1.72	49.06
Intermedia WASTE	22.06					5,54,012				
INTERMEDIA		5.90	25,112	1,48,276	2,63,931		2.10	1.99	1.78	52.24
Bananeiras WASTE	19.87					4,98,941				
BANANEIRAS		4.74	25,112	1,18,947	2,04,589		2.44	2.15	1.72	46.90
Chipanga WASTE	93.32					23,43,340				
CHIPANGA		13.21	25,112	3,31,622	5,70,391		4.11	3.12	1.72	46.93
TOTAL					**11,55,758**	**36,00,291**		3.12		

BLOCK ENS 5/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	96.58					23,13,068				
GRANDE FALESIA		13.15	23,950	3,14,897	5,59,863		4.13	4.13	1.78	51.25
Intermedia WASTE	28.09					6,72,674				
INTERMEDIA		6.97	23,950	1,66,829	2,96,956		2.27	3.48	1.78	52.54
Bananeiras WASTE	26.69					6,39,333				
BANANEIRAS		2.83	23,950	67,744	1,17,009		5.46	3.72	1.73	49.45
Chipanga WASTE	64.34					15,40,945				
CHIPANGA		8.50	23,950	2,03,490	3,52,092		4.38	3.90	1.73	49.64
TOTAL					**13,25,920**	**51,66,020**		3.90		

BLOCK ENS 5/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	39.65					8,60,702				
GRANDE FALESIA		8.08	21,709	1,75,306	3,01,629		2.85	2.85	1.72	48.61
Intermedia WASTE	36.61					11,56,137				
INTERMEDIA		6.11	31,577	1,93,026	3,43,586		3.36	3.13	1.78	52.12
Bananeiras WASTE	22.32					7,04,900				
BANANEIRAS		4.12	31,577	1,29,987	2,23,577		3.15	3.13	1.72	47.61
Chipanga WASTE	96.54					30,48,573				
CHIPANGA		12.38	31,577	3,90,947	6,72,429		4.53	3.74	1.72	47.68
TOTAL					**15,41,221**	**57,70,312**		3.74		

BLOCK ENS 6/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	84.51					19,82,876				
GRANDE FALESIA		9.25	23,464	2,17,042	3,77,563		5.25	5.25	1.74	49.47
Intermedia WASTE	44.71					10,49,042				
INTERMEDIA		7.03	23,464	1,64,932	2,93,579		3.57	4.52	1.78	52.17
Bananeiras WASTE	22.79					5,34,709				
BANANEIRAS		3.76	23,464	88,165	1,51,916		3.52	4.33	1.73	49.21
Chipanga WASTE	87.20					20,46,169				
CHIPANGA		10.50	23,464	2,46,445	4,23,885		4.83	4.50	1.72	48.81
TOTAL					**12,46,943**	**56,12,796**		4.50		

BLOCK ENS 6/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	32.53					3,30,504				
GRANDE FALESIA		5.44	10,160	55,279	95,080		3.48	3.48	1.72	47.47
Intermedia WASTE	50.03					8,89,513				
INTERMEDIA		5.77	17,780	1,02,649	1,82,715		4.87	4.39	1.78	51.79
Bananeiras WASTE	28.02					4,98,193				
BANANEIRAS		2.53	17,780	45,039	77,466		6.43	4.84	1.72	47.98
Chipanga WASTE	93.95					16,70,350				
CHIPANGA		12.34	17,780	2,19,353	3,77,286		4.43	4.63	1.72	48.83
TOTAL					**7,32,547**	**33,88,560**		4.63		

BLOCK ENS 7/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	84.88					13,57,951				
GRANDE FALESIA		6.40	15,999	1,02,426	1,76,172		7.71	7.71	1.72	48.27
Intermedia WASTE	53.32					8,53,040				
INTERMEDIA		6.54	15,999	1,04,710	1,86,383		4.58	6.10	1.78	51.89
Bananeiras WASTE	27.44					4,39,062				
BANANEIRAS		2.34	15,999	37,461	64,434		6.81	6.21	1.73	49.44
Chipanga WASTE	91.95					14,71,040				
CHIPANGA		10.86	15,999	1,73,767	2,98,879		4.92	5.68	1.72	49.19
TOTAL					**7,25,868**	**41,21,093**		5.68		

BLOCK ENS 7/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	27.81					4,41,977				
GRANDE FALESIA		3.97	15,895	63,140	1,08,601		4.07	4.07	1.72	46.98
Intermedia WASTE	44.77					8,48,519				
INTERMEDIA		5.65	18,952	1,07,007	1,90,472		4.45	4.31	1.78	51.60
Bananeiras WASTE	24.44					4,63,261				
BANANEIRAS		0.71	18,952	13,528	23,268		19.91	5.44	1.72	48.79
Chipanga WASTE	64.88					12,29,686				
CHIPANGA		11.70	18,952	2,21,818	3,89,359		3.16	4.19	1.76	50.05
TOTAL					**7,11,700**	**29,83,443**		4.19		

BLOCK ENS 8/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	57.45					19,97,154				
GRANDE FALESIA		4.20	34,764	1,46,181	2,51,432		7.94	7.94	1.72	47.07
Intermedia WASTE	51.29					17,83,204				
INTERMEDIA		6.02	34,764	2,09,334	3,72,614		4.79	6.06	1.78	51.61
Bananeiras WASTE	25.06					8,71,054				
BANANEIRAS		0.26	34,764	8,946	15,550		56.02	7.27	1.74	49.71
Chipanga WASTE	66.89					23,25,399				
CHIPANGA		11.10	34,764	3,85,897	6,81,822		3.41	5.28	1.77	50.24
TOTAL					**13,21,418**	**69,76,811**		5.28		

BLOCK ENS 9/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	65.30					14,60,353				
GRANDE FALESIA		4.55	22,365	1,01,764	1,75,034		8.34	8.34	1.72	47.13
Intermedia WASTE	47.65					10,65,778				
INTERMEDIA		6.48	22,365	1,44,883	2,57,892		4.13	5.84	1.78	51.68
Bananeiras WASTE	22.56					5,04,663				
BANANEIRAS		0.09	22,365	2,062	3,645		138.45	6.94	1.77	50.47
Chipanga WASTE	72.61					16,23,811				
CHIPANGA		11.12	22,365	2,48,758	4,37,941		3.71	5.32	1.76	50.17
TOTAL					**8,74,512**	**46,54,605**		5.32		

BLOCK ENS 10/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	94.60					3,30,912				
GRANDE FALESIA		5.33	3,498	18,649	32,077		10.32	10.32	1.72	47.35
Intermedia WASTE	47.31					1,65,480				
INTERMEDIA		6.91	3,498	24,174	43,029		3.85	6.61	1.78	51.74
Bananeiras WASTE	19.47					68,121				
BANANEIRAS		0.14	3,498	480	854		79.77	7.43	1.78	51.42
Chipanga WASTE	75.24					2,63,205				
CHIPANGA		10.98	3,498	38,415	68,306		3.85	5.74	1.78	50.30
TOTAL					**1,44,266**	**8,27,718**		5.74		

Table 8.7: Strip –wise coal tonnages and waste volumes in west sub-block block

BLOCK WS 1/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	13.03					1,88,390				
CHIPANGA		6.33	14,456	91,508	1,57,395		1.20	1.20	1.72	48.64
TOTAL					**1,57,395**	**1,88,390**		1.20		

BLOCK WS 1/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	9.51					94,155				
CHIPANGA		5.21	9,900	51,609	88,768		1.06	1.06	1.72	48.74
TOTAL					**88,768**	**94,155**		1.06		

BLOCK WS 2/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	13.39					4,68,770				
CHIPANGA		6.92	35,005	2,42,366	4,16,869		1.12	1.12	1.72	48.52
TOTAL					**4,16,869**	**4,68,770**		1.12		

BLOCK WS 2/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	17.53					4,68,770				
CHIPANGA		6.46	26,736	1,72,596	2,96,864		1.58	1.58	1.72	48.44
TOTAL					**2,96,864**	**4,68,770**		1.58		

BLOCK WS 3/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	21.65					7,33,305				
CHIPANGA		9.08	33,868	3,07,420	5,28,763		1.39	1.39	1.72	48.18
TOTAL					**5,28,763**	**7,33,305**		1.39		

BLOCK WS 3/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	20.93					3,79,216				
CHIPANGA		8.08	18,118	1,46,347	2,51,717		1.51	1.51	1.72	48.36
TOTAL					**2,51,717**	**3,79,216**		1.51		

BLOCK WS 3/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	7.86					1,66,319				
CHIPANGA		8.85	21,164	1,87,336	3,22,218		0.52	0.52	1.72	48.09
TOTAL					**3,22,218**	**1,66,319**		0.52		

BLOCK WS 3/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	7.12					1,19,189				
CHIPANGA		10.03	16,750	1,68,077	2,89,092		0.41	0.41	1.72	47.84
TOTAL					**2,89,092**	**1,19,189**		0.41		

BLOCK WS 3/5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	22.54					1,06,035				
CHIPANGA		10.95	4,705	51,537	88,643		1.20	1.20	1.72	47.21
TOTAL					**88,643**	**1,06,035**		1.20		

BLOCK WS 4/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	27.87					8,87,691				
CHIPANGA		14.75	31,850	4,69,840	8,08,125		1.10	1.10	1.72	47.77
TOTAL					**8,08,125**	**8,87,691**		1.10		

BLOCK WS 4/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	24.28					4,71,395				
CHIPANGA		10.86	19,412	2,10,852	3,62,665		1.30	1.30	1.72	48.01
TOTAL					**3,62,665**	**4,71,395**		1.30		

BLOCK WS 4/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	17.84					3,59,788				
CHIPANGA		10.03	20,167	2,02,291	3,47,941		1.03	1.03	1.72	47.90
TOTAL					**3,47,941**	**3,59,788**		1.03		

BLOCK WS 4/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	22.20					3,39,214				
CHIPANGA		10.48	15,278	1,60,085	2,75,347		1.23	1.23	1.72	47.86
TOTAL					**2,75,347**	**3,39,214**		1.23		

BLOCK WS 4/5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	16.38					3,07,281				
CHIPANGA		11.98	18,765	2,24,744	3,86,560		0.79	0.79	1.72	47.15
TOTAL					**3,86,560**	**3,07,281**		0.79		

BLOCK WS 5/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	18.21					51,686				
CHIPANGA		14.16	2,838	40,188	69,124		0.75	0.75	1.72	45.45
TOTAL					**69,124**	**51,686**		0.75		

BLOCK WS 5/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	9.41					1,84,974				
CHIPANGA		13.40	19,660	2,63,422	4,37,715		0.42	0.42	1.67	44.49
TOTAL					**4,37,715**	**1,84,974**		0.42		

BLOCK WS 5/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	13.10					1,96,788				
CHIPANGA		10.69	15,026	1,60,590	2,64,974		0.74	0.74	1.65	42.56
TOTAL					**2,64,974**	**1,96,788**		0.74		

BLOCK WS 6/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	13.72					2,67,635				
CHIPANGA		13.80	19,513	2,69,363	4,63,304		0.58	0.58	1.72	45.39
TOTAL					**4,63,304**	**2,67,635**		0.58		

BLOCK WS 6/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	17.34					3,81,573				
CHIPANGA		14.16	22,000	3,11,532	5,18,311		0.74	0.74	1.66	44.60
TOTAL					**5,18,311**	**3,81,573**		0.74		

BLOCK WS 6/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	19.24					4,23,241				
CHIPANGA		11.18	22,000	2,45,934	4,05,792		1.04	1.04	1.65	42.59
TOTAL					**4,05,792**	**4,23,241**		1.04		

BLOCK WS 6/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	26.40					2,60,554				
CHIPANGA		8.07	9,869	79,601	1,31,271		1.98	1.98	1.64	40.62
TOTAL					**1,31,271**	**2,60,554**		1.98		

BLOCK WS 7/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	17.17					4,75,113				
CHIPANGA		13.70	27,678	3,79,181	6,50,796		0.73	0.73	1.72	45.26
TOTAL					**6,50,796**	**4,75,113**		0.73		

BLOCK WS 7/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	24.63					5,41,827				
CHIPANGA		14.64	22,000	3,22,050	5,31,557		1.02	1.02	1.65	44.64
TOTAL					**5,31,557**	**5,41,827**		1.02		

BLOCK WS 7/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	30.31					6,47,707				
CHIPANGA		12.25	21,371	2,61,853	4,32,058		1.50	1.50	1.65	42.87
TOTAL					**4,32,058**	**6,47,707**		1.50		

BLOCK WS 7/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	29.31					6,44,822				
CHIPANGA		8.26	22,000	1,81,703	2,97,855		2.16	2.16	1.64	40.56
TOTAL					**2,97,855**	**6,44,822**		2.16		

BLOCK WS 7/5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	41.35					13,85,363				
CHIPANGA		6.33	33,506	2,12,160	3,37,334		4.11	4.11	1.59	39.07
TOTAL					**3,37,334**	**13,85,363**		4.11		

BLOCK WS 8/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	21.25					6,02,682				
CHIPANGA		13.79	28,356	3,91,040	6,65,438		0.91	0.91	1.70	45.14
TOTAL					**6,65,438**	**6,02,682**		0.91		

BLOCK WS 8/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	50.71					7,67,047				
CHIPANGA		14.92	15,125	2,25,696	3,72,399		2.06	2.06	1.65	44.58
TOTAL					**3,72,399**	**7,67,047**		2.06		

BLOCK WS 8/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	55.97					8,89,199				
CHIPANGA		13.33	15,888	2,11,866	3,49,578		2.54	2.54	1.65	43.12
TOTAL					**3,49,578**	**8,89,199**		2.54		

BLOCK WS 8/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	43.89					8,58,244				
CHIPANGA		9.41	19,556	1,84,026	3,02,946		2.83	2.83	1.64	40.73
TOTAL					**3,02,946**	**8,58,244**		2.83		

BLOCK WS 9/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	23.95					2,61,243				
CHIPANGA		13.22	10,907	1,44,198	2,48,021		1.05	1.05	1.72	45.45
TOTAL					**2,48,021**	**2,61,243**		1.05		

BLOCK WS 9/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	42.27					7,04,572				
CHIPANGA		13.98	16,667	2,33,039	3,92,008		1.80	1.80	1.67	44.95
TOTAL					**3,92,008**	**7,04,572**		1.80		

BLOCK WS 9/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	42.91					8,60,761				
CHIPANGA		15.16	20,059	3,04,187	5,01,909		1.71	1.71	1.65	44.52
TOTAL					**5,01,909**	**8,60,761**		1.71		

BLOCK WS 9/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	54.72					10,03,115				
CHIPANGA		14.58	18,333	2,67,380	4,41,177		2.27	2.27	1.65	43.37
TOTAL					**4,41,177**	**10,03,115**		2.27		

BLOCK WS 9/5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	52.46					10,25,861				
CHIPANGA		10.73	19,556	2,09,803	3,46,097		2.96	2.96	1.65	41.15
TOTAL					**3,46,097**	**10,25,861**		2.96		

BLOCK WS 9/6										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	50.44					11,51,688				
CHIPANGA		6.84	22,833	1,56,289	2,48,571		4.63	4.63	1.59	39.20
TOTAL					**2,48,571**	**11,51,688**		4.63		

BLOCK WS 10/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	21.19					4,11,277				
CHIPANGA		13.59	19,412	2,63,818	4,53,767		0.91	0.91	1.72	45.61
TOTAL					**4,53,767**	**4,11,277**		0.91		

BLOCK WS 10/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	45.37					9,98,096				
CHIPANGA		15.34	22,000	3,37,454	5,56,799		1.79	1.79	1.65	44.44
TOTAL					**5,56,799**	**9,98,096**		1.79		

BLOCK WS 10/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	45.37					9,98,096				
CHIPANGA		15.34	22,000	3,37,454	5,56,799		1.79	1.79	1.65	44.44
TOTAL					**5,56,799**	**9,98,096**		1.79		

BLOCK WS 10/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	56.72					11,05,152				
CHIPANGA		15.38	19,485	2,99,683	4,94,477		2.23	2.23	1.65	43.54
TOTAL					**4,94,477**	**11,05,152**		2.23		

BLOCK WS 10/5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	50.23					11,05,152				
CHIPANGA		11.38	22,000	2,50,322	4,13,032		2.68	2.68	1.65	42.01
TOTAL					**4,13,032**	**11,05,152**		2.68		

BLOCK WS 10/6										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	109.52					13,25,503				
CHIPANGA		7.95	12,103	96,264	1,56,838		8.45	8.45	1.64	40.49
TOTAL					**1,56,838**	**13,25,503**		8.45		

BLOCK WS 11/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	42.11					11,04,207				
CHIPANGA		19.95	26,225	5,23,077	8,99,693		1.23	1.23	1.72	47.86
TOTAL					**8,99,693**	**11,04,207**		1.23		

BLOCK WS 11/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	36.30					6,34,166				
CHIPANGA		13.87	17,470	2,42,316	4,16,784		1.52	1.52	1.72	47.47
TOTAL					**4,16,784**	**6,34,166**		1.52		

BLOCK WS 11/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	41.79					5,61,805				
CHIPANGA		10.99	13,445	1,47,793	2,54,204		2.21	2.21	1.72	47.70
TOTAL					**2,54,204**	**5,61,805**		2.21		

BLOCK WS 11/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	19.06					4,19,247				
CHIPANGA		10.83	22,000	2,38,366	4,09,989		1.02	1.02	1.72	47.87
TOTAL					**4,09,989**	**4,19,247**		1.02		

BLOCK WS 11/5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	20.98					4,61,579				
CHIPANGA		12.26	22,000	2,69,713	4,63,906		0.99	0.99	1.72	47.20
TOTAL					**4,63,906**	**4,61,579**		0.99		

BLOCK WS 11/6										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	28.14					6,19,180				
CHIPANGA		14.37	22,000	3,16,036	5,43,582		1.14	1.14	1.72	45.56
TOTAL					**5,43,582**	**6,19,180**		1.14		

BLOCK WS 11/7										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	47.50					10,44,912				
CHIPANGA		13.85	22,000	3,04,649	5,05,158		2.07	2.07	1.66	44.87
TOTAL					**5,05,158**	**10,44,912**		2.07		

BLOCK WS 11/8										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	56.58					12,44,815				
CHIPANGA		15.36	22,000	3,38,000	5,57,700		2.23	2.23	1.65	44.43
TOTAL					**5,57,700**	**12,44,815**		2.23		

BLOCK WS 11/9										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	61.90					13,61,836				
CHIPANGA		15.59	22,000	3,42,907	5,65,951		2.41	2.41	1.65	44.06
TOTAL					**5,65,951**	**13,61,836**		2.41		

BLOCK WS 11/10										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	94.92					17,98,231				
CHIPANGA		11.26	18,944	2,13,356	3,52,037		5.11	5.11	1.65	43.61
TOTAL					**3,52,037**	**17,98,231**		5.11		

BLOCK WS 11/11										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	87.48					12,60,866				
CHIPANGA		9.03	14,414	1,30,195	2,14,821		5.87	5.87	1.65	42.50
TOTAL					**2,14,821**	**12,60,866**		5.87		

BLOCK WS 12/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	61.03					13,70,774				
CHIPANGA		20.09	22,459	4,51,268	7,76,182		1.77	1.77	1.72	47.98
TOTAL					**7,76,182**	**13,70,774**		1.77		

BLOCK WS 12/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	44.48					8,15,370				
CHIPANGA		15.60	18,333	2,85,946	4,91,827		1.66	1.66	1.72	46.67
TOTAL					**4,91,827**	**8,15,370**		1.66		

BLOCK WS 12/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	31.55					6,94,054				
CHIPANGA		11.41	22,000	2,51,011	4,31,739		1.61	1.61	1.72	47.57
TOTAL					**4,31,739**	**6,94,054**		1.61		

BLOCK WS 12/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	32.17					7,07,634				
CHIPANGA		11.08	22,000	2,43,727	4,19,211		1.69	1.69	1.72	47.88
TOTAL					**4,19,211**	**7,07,634**		1.69		

BLOCK WS 12/5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	22.76					5,00,699				
CHIPANGA		12.54	22,000	2,75,844	4,74,451		1.06	1.06	1.72	47.25
TOTAL					**4,74,451**	**5,00,699**		1.06		

BLOCK WS 12/6										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	44.45					9,77,807				
CHIPANGA		15.40	22,000	3,38,903	5,82,913		1.68	1.68	1.72	45.61
TOTAL					**5,82,913**	**9,77,807**		1.68		

BLOCK WS 12/7										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	59.91					13,17,975				
CHIPANGA		13.66	22,000	3,00,454	4,98,604		2.64	2.64	1.66	44.88
TOTAL					**4,98,604**	**13,17,975**		2.64		

BLOCK WS 12/8										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	72.52					15,95,439				
CHIPANGA		14.45	22,000	3,17,877	5,29,932		3.01	3.01	1.67	44.86
TOTAL					**5,29,932**	**15,95,439**		3.01		

BLOCK WS 12/9										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	90.05					18,64,554				
CHIPANGA		14.06	20,706	2,91,191	4,94,695		3.77	3.77	1.70	45.48
TOTAL					**4,94,695**	**18,64,554**		3.77		

BLOCK WS 12/10										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	120.45					22,81,832				
CHIPANGA		10.36	18,944	1,96,245	3,34,750		6.82	6.82	1.71	45.69
TOTAL					**3,34,750**	**22,81,832**		6.82		

BLOCK WS 12/11										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	111.16					9,23,432				
CHIPANGA		9.47	8,307	78,661	1,31,957		7.00	7.00	1.68	44.88
TOTAL					**1,31,957**	**9,23,432**		7.00		

BLOCK WS 13/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	64.79					13,54,257				
CHIPANGA		20.10	20,903	4,20,142	7,22,644		1.87	1.87	1.72	48.26
TOTAL					**7,22,644**	**13,54,257**		1.87		

BLOCK WS 13/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	51.00					10,28,562				
CHIPANGA		16.63	20,167	3,35,416	5,75,826		1.79	1.79	1.72	45.88
TOTAL					**5,75,826**	**10,28,562**		1.79		

BLOCK WS 13/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	47.14					10,37,051				
CHIPANGA		11.38	22,000	2,50,436	4,30,750		2.41	2.41	1.72	47.49
TOTAL					**4,30,750**	**10,37,051**		2.41		

BLOCK WS 13/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	52.98					11,65,623				
CHIPANGA		11.07	22,000	2,43,539	4,18,888		2.78	2.78	1.72	47.90
TOTAL					**4,18,888**	**11,65,623**		2.78		

BLOCK WS 13/5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	57.85					12,72,677				
CHIPANGA		13.03	22,000	2,86,642	4,93,023		2.58	2.58	1.72	47.25
TOTAL					**4,93,023**	**12,72,677**		2.58		

BLOCK WS 13/6										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	63.34					13,93,449				
CHIPANGA		16.51	22,000	3,63,202	6,24,708		2.23	2.23	1.72	45.59
TOTAL					**6,24,708**	**13,93,449**		2.23		

BLOCK WS 13/7										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	73.29					16,12,486				
CHIPANGA		13.59	22,000	2,99,062	4,96,814		3.25	3.25	1.66	44.88
TOTAL					**4,96,814**	**16,12,486**		3.25		

BLOCK WS 13/8										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	91.20					20,06,417				
CHIPANGA		12.66	22,000	2,78,486	4,78,293		4.19	4.19	1.72	45.78
TOTAL					**4,78,293**	**20,06,417**		4.19		

BLOCK WS 13/9										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	115.53					24,66,837				
CHIPANGA		10.93	21,353	2,33,328	4,01,323		6.15	6.15	1.72	47.59
TOTAL					**4,01,323**	**24,66,837**		6.15		

BLOCK WS 13/10										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	192.50					30,49,080				
CHIPANGA		8.81	15,839	1,39,502	2,39,944		12.71	12.71	1.72	47.91
TOTAL					**2,39,944**	**30,49,080**		12.71		

BLOCK WS 14/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	63.51					12,93,437				
CHIPANGA		21.13	20,365	4,30,380	7,40,253		1.75	1.75	1.72	49.14
TOTAL					**7,40,253**	**12,93,437**		1.75		

BLOCK WS 14/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	60.58					13,32,731				
CHIPANGA		17.53	22,000	3,85,745	6,52,784		2.04	2.04	1.69	45.51
TOTAL					**6,52,784**	**13,32,731**		2.04		

BLOCK WS 14/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	65.13					14,32,958				
CHIPANGA		11.21	22,000	2,46,690	4,24,306		3.38	3.38	1.72	47.54
TOTAL					**4,24,306**	**14,32,958**		3.38		

BLOCK WS 14/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	72.14					15,87,014				
CHIPANGA		11.20	22,000	2,46,508	4,23,993		3.74	3.74	1.72	47.98
TOTAL					**4,23,993**	**15,87,014**		3.74		

BLOCK WS 14/5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	76.87					16,91,217				
CHIPANGA		13.76	22,000	3,02,767	5,20,759		3.25	3.25	1.72	47.17
TOTAL					**5,20,759**	**16,91,217**		3.25		

BLOCK WS 14/6										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	81.80					17,99,578				
CHIPANGA		17.44	22,000	3,83,658	6,59,892		2.73	2.73	1.72	45.56
TOTAL					**6,59,892**	**17,99,578**		2.73		

BLOCK WS 14/7										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	85.91					18,90,086				
CHIPANGA		13.82	22,000	3,04,114	5,09,842		3.71	3.71	1.67	44.94
TOTAL					**5,09,842**	**18,90,086**		3.71		

BLOCK WS 14/8										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	132.15					25,84,401				
CHIPANGA		11.38	19,556	2,22,637	3,82,936		6.75	6.75	1.72	46.82
TOTAL					**3,82,936**	**25,84,401**		6.75		

BLOCK WS 14/9										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE										
INTERMEDIA										
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	139.25					30,63,484				
CHIPANGA		8.21	22,000	1,80,577	3,15,054		9.72	9.72	1.75	49.85
TOTAL					**3,15,054**	**30,63,484**		9.72		

BLOCK WS 14/10										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE						31,774				
GRANDE FALESIA										
Intermedia WASTE						1,90,815				
INTERMEDIA		10.54	602	6,348	10,918					
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	133.15					24,85,688				
CHIPANGA		6.97	18,668	1,30,122	2,28,931		10.86	11.16	1.76	50.39
TOTAL					**2,39,849**	**27,08,277**		11.29		

BLOCK WS 15/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	35.33					43,842				
INTERMEDIA		6.05	1,241	7,504	13,357		3.28	3.28	1.78	52.86
Bananeiras WASTE	53.28					66,119				
BANANEIRAS		1.64	1,241	2,030	3,491		18.94	6.53	1.72	48.29
Chipanga WASTE	74.49					24,96,063				
CHIPANGA		17.42	33,507	5,83,806	10,03,407		2.49	2.55	1.72	47.38
TOTAL					**10,20,255**	**26,06,024**		2.55		

BLOCK WS 15/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	15.56					1,32,470				
INTERMEDIA		5.97	8,516	50,846	90,506		1.46	1.46	1.78	52.78
Bananeiras WASTE	33.55					2,85,724				
BANANEIRAS		2.50	8,516	21,282	36,605		7.81	3.29	1.72	48.70
Chipanga WASTE	62.17					13,67,770				
CHIPANGA		10.92	22,000	2,40,209	4,13,159		3.31	3.31	1.72	47.80
TOTAL					**5,40,270**	**17,85,964**		3.31		

BLOCK WS 15/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	35.03					42,812				
INTERMEDIA		5.81	1,222	7,098	12,634		3.39	3.39	1.78	52.59
Bananeiras WASTE	82.26					1,00,525				
BANANEIRAS		4.59	1,222	5,615	9,658		10.41	6.43	1.72	48.97
Chipanga WASTE	82.84					18,22,520				
CHIPANGA		11.20	22,000	2,46,334	4,23,695		4.30	4.41	1.72	48.10
TOTAL					**4,45,987**	**19,65,857**		4.41		

BLOCK WS 15/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	20.71					1,13,904				
INTERMEDIA		5.11	5,500	28,080	49,982		2.28	2.28	1.78	52.03
Bananeiras WASTE	39.62					2,17,902				
BANANEIRAS		7.44	5,500	40,941	70,418		3.09	2.76	1.72	49.07
Chipanga WASTE	77.26					16,99,708				
CHIPANGA		14.13	22,000	3,10,955	5,34,842		3.18	3.10	1.72	47.17
TOTAL					**6,55,242**	**20,31,514**		3.10		

BLOCK WS 15/5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	12.65					1,63,647				
INTERMEDIA		4.30	12,941	55,706	99,157		1.65	1.65	1.78	51.04
Bananeiras WASTE	24.85					3,53,796				
BANANEIRAS		4.43	14,235	63,074	1,08,487		3.26	2.49	1.72	48.58
Chipanga WASTE	73.23					16,11,042				
CHIPANGA		17.66	22,000	3,88,606	6,68,403		2.41	2.43	1.72	45.73
TOTAL					**8,76,047**	**21,28,485**		2.43		

BLOCK WS 15/6										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	47.90					29,265				
INTERMEDIA		4.04	611	2,469	4,394		6.66	6.66	1.78	50.80
Bananeiras WASTE	47.21					8,07,864				
BANANEIRAS		3.72	17,111	63,686	1,09,540		7.38	7.35	1.72	48.39
Chipanga WASTE	70.49					15,50,816				
CHIPANGA		14.35	22,000	3,15,744	5,41,228		2.87	3.64	1.71	45.32
TOTAL					**6,55,162**	**23,87,945**		3.64		

BLOCK WS 15/7										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	42.41					51,829				
INTERMEDIA		7.51	1,222	9,182	15,793		3.28	3.28	1.72	49.33
Bananeiras WASTE	82.72					6,57,179				
BANANEIRAS		4.02	7,945	31,908	54,881		11.97	10.03	1.72	48.13
Chipanga WASTE	154.79					24,59,334				
CHIPANGA		11.10	15,888	1,76,312	3,03,257		8.11	8.47	1.72	47.46
TOTAL					**3,73,931**	**31,68,342**		8.47		

BLOCK WS 15/8										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	170.04					2,13,737				
INTERMEDIA		9.92	1,257	12,470	21,448		9.97	9.97	1.72	49.01
Bananeiras WASTE	#DIV/0!					50,877				
BANANEIRAS										
Chipanga WASTE	165.64					33,31,625				
CHIPANGA		6.68	20,114	1,34,440	2,38,333		13.98	13.84	1.77	51.34
TOTAL					**2,59,781**	**35,96,239**		13.84		

BLOCK WS 15/9										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	93.90					3,86,496				
INTERMEDIA		10.50	4,116	43,212	74,324		5.20	5.20	1.72	47.85
Bananeiras WASTE										
BANANEIRAS										
Chipanga WASTE	373.54					33,31,625				
CHIPANGA		5.79	8,919	51,634	91,909		36.25	22.37	1.78	52.15
TOTAL					**1,66,233**	**37,18,121**		22.37		

BLOCK WS 16/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE						44,709				
GRANDE FALESIA										
Intermedia WASTE	20.75					2,77,773				
INTERMEDIA		6.18	13,384	82,657	1,47,130		1.89	1.89	1.78	52.89
Bananeiras WASTE	29.68					3,97,189				
BANANEIRAS		1.58	13,384	21,085	36,266		10.95	3.68	1.72	48.59
Chipanga WASTE	60.81					11,80,217				
CHIPANGA		13.86	19,407	2,68,911	4,62,526		2.55	2.87	1.72	47.68
TOTAL					**6,45,922**	**18,99,888**		2.94		

BLOCK WS 16/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	7.85					25,397				
GRANDE FALESIA		9.90	3,235	32,024	57,003		0.45	0.45	1.78	52.01
Intermedia WASTE	24.17					5,31,752				
INTERMEDIA		6.09	22,000	1,34,028	2,38,570		2.23	1.88	1.78	52.78
Bananeiras WASTE	21.06					4,63,428				
BANANEIRAS		2.68	22,000	58,981	1,01,447		4.57	2.57	1.72	48.81
Chipanga WASTE	48.19					10,60,261				
CHIPANGA		10.55	22,000	2,32,161	3,99,317		2.66	2.61	1.72	48.19
TOTAL					**7,96,337**	**20,80,838**		2.61		

BLOCK WS 16/3										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	18.35					3,81,187				
INTERMEDIA		5.75	20,778	1,19,382	2,12,499		1.79	1.79	1.78	52.54
Bananeiras WASTE	22.33					4,64,023				
BANANEIRAS		6.14	20,778	1,27,522	2,19,338		2.12	1.96	1.72	49.28
Chipanga WASTE	60.21					13,24,594				
CHIPANGA		11.23	22,000	2,47,022	4,24,878		3.12	2.53	1.72	48.28
TOTAL					**8,56,715**	**21,69,804**		2.53		

BLOCK WS 16/4										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	24.31					5,34,822				
INTERMEDIA		5.22	22,000	1,14,835	2,04,406		2.62	2.62	1.78	51.87
Bananeiras WASTE	23.47					5,16,372				
BANANEIRAS		9.31	22,000	2,04,864	3,52,366		1.47	1.89	1.72	49.66
Chipanga WASTE	52.46					11,54,225				
CHIPANGA		14.23	22,000	3,13,120	5,38,567		2.14	2.01	1.72	47.32
TOTAL					**10,95,339**	**22,05,419**		2.01		

BLOCK WS 16/5										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	31.06					6,23,123				
INTERMEDIA		4.47	20,059	89,598	1,59,483		3.91	3.91	1.78	51.00
Bananeiras WASTE	26.91					5,39,875				
BANANEIRAS		7.43	20,059	1,49,057	2,56,380		2.11	2.80	1.72	49.15
Chipanga WASTE	68.08					13,65,629				
CHIPANGA		16.73	20,059	3,35,494	5,77,050		2.37	2.55	1.72	46.28
TOTAL					**9,92,913**	**25,28,627**		2.55		

BLOCK WS 16/6										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	52.56					5,13,959				
INTERMEDIA		4.19	9,778	40,936	72,866		7.05	7.05	1.78	50.64
Bananeiras WASTE	56.34					8,60,749				
BANANEIRAS		4.69	15,278	71,582	1,23,121		6.99	7.01	1.72	48.57
Chipanga WASTE	114.59					17,50,754				
CHIPANGA		14.77	15,278	2,25,582	3,88,001		4.51	5.35	1.72	45.96
TOTAL					**5,83,988**	**31,25,462**		5.35		

BLOCK WS 16/7										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE										
GRANDE FALESIA										
Intermedia WASTE	55.77					7,52,408				
INTERMEDIA		6.58	13,491	88,765	1,53,351		4.91	4.91	1.73	49.72
Bananeiras WASTE	37.99					7,22,188				
BANANEIRAS		4.32	19,010	82,155	1,41,306		5.11	5.00	1.72	48.22
Chipanga WASTE	101.06					19,21,156				
CHIPANGA		11.32	19,010	2,15,119	3,70,175		5.19	5.11	1.72	47.78
TOTAL					**6,64,832**	**33,95,752**		5.11		

BLOCK WS 16/8										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE						39,799				
GRANDE FALESIA										
Intermedia WASTE	123.77					5,18,365				
INTERMEDIA		8.81	4,188	36,910	63,486		8.17	8.79	1.72	48.85
Bananeiras WASTE	44.68					1,24,754				
BANANEIRAS		4.47	2,792	12,488	21,480		5.81	8.04	1.72	47.91
Chipanga WASTE	124.86					6,97,207				
CHIPANGA		7.62	5,584	42,569	75,494		9.24	8.60	1.78	51.04
TOTAL					**1,60,460**	**13,80,125**		8.60		

BLOCK WS 17/1										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	12.86					2,77,899				
GRANDE FALESIA		15.46	21,610	3,34,175	5,94,832		0.47	0.47	1.78	52.02
Intermedia WASTE	27.71					6,86,907				
INTERMEDIA		6.31	24,788	1,56,443	2,78,470		2.47	1.10	1.78	52.81
Bananeiras WASTE	24.75					6,13,616				
BANANEIRAS		2.44	24,788	60,458	1,03,988		5.90	1.62	1.72	48.96
Chipanga WASTE	51.57					12,78,407				
CHIPANGA		10.16	24,788	2,51,846	4,33,175		2.95	2.03	1.72	48.67
TOTAL					**14,10,465**	**28,56,829**		2.03		

BLOCK WS 17/2										
SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	20.45					87,475				
GRANDE FALESIA		19.09	4,278	81,662	1,45,359		0.60	0.60	1.78	51.81
Intermedia WASTE	56.12					7,88,743				
INTERMEDIA		6.11	14,055	85,849	1,52,810		5.16	2.94	1.78	52.38
Bananeiras WASTE	39.19					5,50,840				
BANANEIRAS		6.71	14,055	94,244	1,63,564		3.37	3.09	1.73	49.62
Chipanga WASTE	93.40					13,12,772				
CHIPANGA		11.43	14,055	1,60,617	2,76,261		4.75	3.71	1.72	48.39
TOTAL					**7,37,994**	**27,39,830**		3.71		

BLOCK WS 17/3

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE						3,433				
GRANDE FALESIA										
Intermedia WASTE	51.30					9,71,757				
INTERMEDIA		5.62	18,944	1,06,548	1,89,656		5.12	5.14	1.78	51.64
Bananeiras WASTE	31.06					5,88,478				
BANANEIRAS		10.78	18,944	2,04,235	3,59,265		1.64	2.85	1.76	50.02
Chipanga WASTE	57.89					10,96,714				
CHIPANGA		14.67	18,944	2,77,923	4,78,026		2.29	2.59	1.72	47.43
TOTAL					**10,26,947**	**26,60,382**		2.59		

BLOCK WS 17/4

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE						33,176				
GRANDE FALESIA										
Intermedia WASTE	65.96					11,90,770				
INTERMEDIA		4.78	18,053	86,326	1,53,659		7.75	7.97	1.78	50.95
Bananeiras WASTE	32.13					5,80,000				
BANANEIRAS		10.08	18,053	1,81,943	3,13,165		1.85	3.86	1.72	49.62
Chipanga WASTE	67.09					12,11,121				
CHIPANGA		15.99	18,053	2,88,618	4,96,423		2.44	3.13	1.72	46.80
TOTAL					**9,63,247**	**30,15,067**		3.13		

BLOCK WS 17/5

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE						33,224				
GRANDE FALESIA										
Intermedia WASTE	70.21					11,89,625				
INTERMEDIA		4.44	16,944	75,294	1,33,924		8.88	9.13	1.78	50.53
Bananeiras WASTE	21.41					3,62,690				
BANANEIRAS		5.42	16,944	91,847	1,57,977		2.30	5.43	1.72	48.76
Chipanga WASTE	69.31					11,74,419				
CHIPANGA		14.66	16,944	2,48,402	4,27,251		2.75	3.84	1.72	46.65
TOTAL					**7,19,152**	**27,59,958**		3.84		

BLOCK WS 18/1

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	31.81					8,33,729				
GRANDE FALESIA		19.24	26,210	5,04,315	8,97,680		0.93	0.93	1.78	51.97
Intermedia WASTE	27.60					7,23,305				
INTERMEDIA		6.89	26,210	1,80,526	3,21,337		2.25	1.28	1.78	52.27
Bananeiras WASTE	23.93					6,27,285				
BANANEIRAS		6.13	26,210	1,60,792	2,82,833		2.22	1.45	1.75	49.86
Chipanga WASTE	57.51					15,07,438				
CHIPANGA		11.07	26,210	2,90,203	4,99,150		3.02	1.84	1.72	48.81
TOTAL					**20,01,000**	**36,91,757**		1.84		

BLOCK WS 18/2

SEAM NAME	WASTE (Interburden + Intraburden) (m)	Net Coal (m)	COAL AREA (sq.m.)	COAL VOLUME (cu.m)	INSITU TONNES (Tonnes)	WASTE VOLUME (cu.m)	INCREMENTAL	ACCUMULATED	RD	ASH %
OB										
Grande Falesia WASTE	199.17					4,63,470				
GRANDE FALESIA		27.08	2,327	63,012	1,12,162		4.13	4.13	1.78	51.08
Intermedia WASTE	35.12					3,47,242				
INTERMEDIA		6.08	9,887	60,153	1,07,073		3.24	3.70	1.78	51.36
Bananeiras WASTE	20.50					2,02,657				
BANANEIRAS		10.60	9,887	1,04,809	1,85,586		1.09	2.50	1.77	50.10
Chipanga WASTE	46.35					4,58,296				
CHIPANGA		14.79	9,887	1,46,183	2,51,435		1.82	2.24	1.72	47.46
TOTAL					**6,56,256**	**14,71,665**		2.24		

The mining cells which will be mined during the first ten years of the Mine life are given below (Table 8.8).

Table 8.8: Year wise operation schedule

S.No.	Year	Cells to be mined
1	First Year	E S1/1, E S1/2, E S1/3, E S1/4, E S1/5, E S2/1, E S2/2 E S2/3, E S2/4 & E S2/5
2	Second Year	E S3/1, E S3/2, E S3/3, E S3/4 & E S3/5 E S4/1, E S4/2
3	Third Year	E S4/3, E S4/4, E S4/5,ES5/1, ES5/2, ES5/3, ES5/4, ES5/5
4	Forth Year	WS1/1, WS1/2, WS2/2, WS3/3, WS3/4, WS4/4, WS4/5, WS5/1, WS5/2, WS5/3, WS6/1, WS6/2, WS6/3, WS6/4
5	Fifth Year	WS2/1, WS3/1, WS3/2, WS7/2, WS7/3, WS7/4, WS7/5, WS8/1, WS8/2, WS9/2, WS10/1, WS11/3, WS11/4, WS11/5
6	Sixth Year	WS4/1,WS8/3,WS8/4,WS9/3, WS9/4, WS9/5, WS9/6,WS10/2,WS11/2,WS12/3,WS12/4,WS12/5
7	Seventh Year	ES5/5,ES6/1, ES6/2, ES6/3, ES6/4, ES6/5, WS10/3,WS10/4,WS10/5,WS10/6,WS11/1,WS11/8,WS11/9,WS12/2,WS12/6, WS13/2,WS13/3,WS13/4,WS13/5
8	Eight Year	ES7/1, ES7/2, ES7/3, ES7/4, ES7/5, ES8/5, WS11/10,WS12/1,WS13/1,WS13/6,WS13/7,WS14/1, WS14/2, WS14/3, WS14/4
9	Ninth Year	ES8/1, ES8/2, ES8/3, ES8/4,ES9/1, ES9/2, ES9/3, ES9/4, WS11/11,WS12/8,WS12/9,WS12/10,WS13/8, WS14/5,WS14/6,WS14/7,WS15/1,WS15/2,WS15/3
10	Tenth Year	ES10/1, ES10/2, ES10/3, ES10/4,ES11/1,ES11/2,ES11/3, ES12/1,ES12/2,ES12/3,ES13/2,ENS1/1,ENS2/1,WS12/1,WS13/9, WS13/10,WS14/8,WS14/9,WS15/4,WS15/5,WS15/6,WS15/7,WS16/1, WS16/2, WS16/3, WS16/4

8.4.4 Grade control:

Grade control is mainly on the basis ash, GCV and CSNs. In the present report ash% and GCV variations are shown in Figs 5-4 and 5-5 respectively. At the current level of study Ash% information, GCV, CSN and Volatile Matter have been determined. Coking coal profile is available for a whole seam level. Proposed grade control envisages testing of coal core samples collected during production support drilling at an interval of 50 m. samples may be tested at mine site laboratory established for the purpose. Grade profiles shall be developed from time to time at mining strip level as well as mining cell level. Desired level of ROM coal grade control shall be ensured by mining and combing the extracted coal from different mining cells.

8.4.5 Excavatability and slope stability:

The MAL has conducted relevant geotechnical studies needed at this level of mine planning process. They are mainly physical characteristics of coal and waste rock units derived from engineering logs and sonic logs. Engineering logs of boreholes showing rock type, strength, degree of weathering, and discontinuities by RQD, and also ground water levels have been elaborated in section. Sonic logs showing seismic attributes of various rock units are provided in chapter-8 on Geotechnical study.

Slope stability, slope failure, excavatability, rippability and cuttability of rock units are dependent on rock textural properties physical factors viz. texture, degree of rock lithification, vertical stacking pattern of various rock units of different physical attributes; faults and joints**.** Geotechnical data derived from RQD of core boreholes. The MAL has taken into consideration of comprehensive geotechnical studies while making mining machinery and equipment selection for rock excavation. Vertical and lateral variation of physical characteristics of stacked rock units have formed basis for relevant assumptions on slope stability and slope failures and slope angles in open pit coal mines of Mb-A and Mb-B. Accordingly pit slope angle derived is 60^{o}.

In the area covered by Block-A, one east - west and one north - south fault exist. As the downward working is limited to shallow depths of <81 to ~180m (pit floor) no fatal issues are anticipated due to these faults. However, the vertical fault running in North/south direction needs to be taken care by adopting of appropriate mine operation/safety measures. The severity of cleavages and the risk of wedge failures on the pit slopes would be evaluated once the ground cut is made. This work will be undertaken on priority. Ground water hydrology needs to be better defined as the presence of ground water can act to lubricate fault zones, cleavage planes, fracture planes, and boarding planes. This will have an impact on pit slopes. The hydrological studies will be fast tracked and required remedial measures to be incorporated. However, basic study of hydrology has not revealed any complication so far.

Whereas no significant sum of coal is lost in the targeted area, below the northern and western wall slopes, about 3 million tonnes of coal will be sterilized in eastern high wall slope.

8.5 MINECONSTRUCTION

Mine construction involves site preparation, mine drainage control, removal of vegetation and construction of haul roads, development of mine site infrastructure facilities.

8.5.1 Mine drainage control plan:

Mine drainage control is an important aspect that precedes the mine construction. A garland canal around Mb-A has been planned (see Fig.8-2 in chapter 8 and sub section). Most of the tenement has gently rolling topography and topographic gradient slopes from north to south. No perennial streams are present in the tenement area. However, a small dam is envisaged to divert water from it during rainy season into the garland canal. During rainy season collected rain water flows from north to south through naturally formed gullies / streams will be stored in a water harvesting tank designed for this purpose. The contaminated water which is pumped out of the pit are to be stored in designated tanks for in-mine usage, excess over flow to be treated before leaving it out into the main drainage channels.

Ground water quality: Ground water table levels encountered from boreholes are ranges from 35-50m; it fluctuates partially according to season.

The ground water samples in core area, as well as surrounding villages from hand pumps or open well are collected and analyzed for determinations of following constituents to determine the quality of water:

- Chlorides
- Sulphates
- Sodium
- Total dissolved solids

8.5.2 In pit water quality:

In pit water quality depends on the seasonal fluctuations of surface water run-off. During monsoon season, total dissolved solids as well as PH value will be within the tolerance limit for inland surface water. Suspended solids will be high in surface run-off outside the mine as well as within the mine. Thus, the drainage water shall be routed through earthen basins outside the mine, before release to the streams in order to enable settling of suspended particles.

In dry season, the effect of weathering of pyrite will determine the in-pit water quality with high value of dissolved solids, especially the sulphates, iron and PH value will show extreme values.

A monitoring scheme for in-pit water quality and quantity will be established during operation through-out the year. These values will indicate the extent of purification required for in-pit water.

8.5.3 Pump Design parameters:

Rainfall data available are restricted to monthly rainfall for 10 years period (see Table 8.9) and some additional data such as max. Rainfall in a day or 24 hours and average heavy rainfall within 24 hours is required. The same will be procured and applied for refinement of plan.

Table 8.9: Rain Fall Data

Rain fall	Jan	Feb	Ma	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total rain falls in the year
1999	292	139	62.8	6.1	0.5	4.2	6	0.2	0	0	71.4	50.4	632.6
2000	70	203	143	8.2	5.1	2.9	9.3	0.8	0	4.1	106	70	623
2001	166	676	114	1	8.6	0.9	23.3	2.9	0.3	0	85.5	188	1265.4
2002	49.6	40.7	63.1	10.5	1.1	0.1	0	4.5	77.3	7.7	51.8	30.9	337.3
2003	200	130	127	2.6	1.4	2.2	2.4	0	2.7	0	12.2	150	630.4
2004	217	189	81.6	7	5.4	5.6	2.5	0	0.3	0.3	72.5	257	838.2
2005	272	7.3	3.8	3	0	10.8	3.9	0	17.8	0.3	288	184	791.5
2006	192	85.1	107	1.6	3.9	1.1	0	0	0	0	89.5	27.3	506.9
2007	193	115	97.6	14.2	0	1.7	0.9	0.6	0	2.2	40.9	198	663.6
2008	212	53.8	68.4	0	1	0	4.3	4.3	5.8	1.5	2.1	235	587.8
2009	266	2.2	58.3	0	0	0	0	0	0	0	0	0	326.9
Avg	194	149	84.2	4.93	2.45	2.68	4.78	1.21	9.47	1.46	74.5	126	654.8

- Average annual total 654 mm/year
- Maximum monthly rainfall in peak rainy season 292 mm/ month
- Maximum daily rainfall (assumed) 250 mm/day (assumed)
- Average annual maximum rain /day 150 mm/d (assumed)

We further assume that during monsoon, 80% of total rainfall will contribute to run-off from mining benches and slopes finally accumulating at the mine bottom. Thus, a run of coefficient will be 0.8.

In order to keep the size and investment costs of the sump and pumping system within reasonable limits, the pumping time to discharge the total run-off water resulting maximum daily rainfall (here 250 mm/day) should be allowed to last over 10 days.

The sump pumps installed at the bottom of the mine shall operate at a constant pumping rate.

QP = 0.8 x 250/10 = 20 mm/d

Considering that 1mm rainfall is equivalent to 1 liter / M^2 or 1000 M3/km^2 (meter volume per catchment area)

QD = 20000 M3 /KM2/d = 840 M3 /KM2/d = 14 M3 /KM2/minute

8.5.4 Sump Capacity (Figs. 8-30 & 8-31):

The required storage capacity to match 20mm/d will be 100,000 M^3, allowing space for siltation of solids during the monsoon. A sump with a volume of at least 120,000 M^3/KM^2 is needed.

In the event of catastrophic / abnormal rainfall (250mm/d) an additional flood storage capacity of 120,000 M^3 is needed, bringing up the total flood pump sump storage volume to 240,000M^3.

The total storm water run of at a maximum monthly rainfall of 292 mm/m which was peak level ever measured in that region can be cleared in 14 to 15 days.

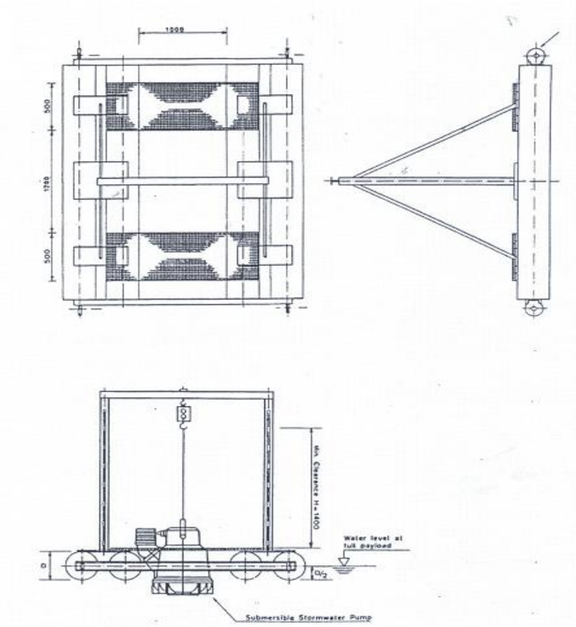


Fig. 8-30: Floating Platform For Submersible Water Sump

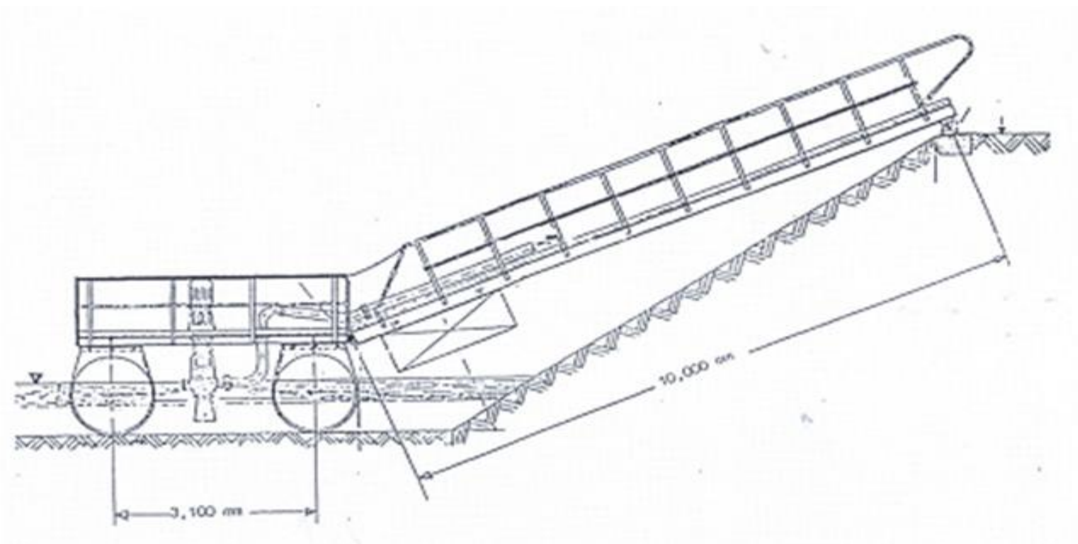


Fig. 8-31: Floating Platform With Vertical Pump

8.5.5 Basic design of inpit drainage:

Open pit mine will be drained by means of centralized pump sump system consisting of:

Travelling Sumps feature small size storm water pumps (pumps of 40 to 90 KW motor rating) installed on small floating platforms (pantoons) for the early years after opening of the mine. The pumps lift water straight across the mine rim to garland drains or to the settling reservoirs from there to nalas.

Semi-permanent, intermediate sumps are required to re-handle the water from lower benches or from the mine bottom semi-permanent sumps are located at eastern high wall of the mine in East Block and are successively relocated with the mine extending north wards. Semi-permanent sump-pumps of medium size storm water (250 to 220 KW motor rating) are installed on floating platforms. The pumps lift the water straight across mine rim.

Mine Bottom Sumps have to drain all storm water run-offs from the mine bottom as well as water eventually over flowing from pump sumps at higher level mining benches. These sumps have to be relocated every year. Small or medium size pumps (90 to 250 KW) will be installed on floating platforms.

8.6 SITE PREPARATION

Clearing of vegetation, site preparation, approach roads and other facilities like construction personal office, accommodation, provisions for drinking water etc. are completed before starting mining operations. (Water pipe lines, electric sub-stations installation of transformers, workshops and ware house facilities are out lined in chapter on infrastructure).

8.6.1 Development of haul roads:

Haulage access roads are of 3 basic categories:

- Main Haul Roads with a width of approximately 25 to 30M with a gravel surface.
- Main roads outside pit limit with a width of 8 to 10m with a bituminous surface.
- Secondary access roads with a width of 7Mto 10m with gravel surface.

Common design feature of all these roads should be to enable uninterrupted moment of heavy equipment. Road should be strengthened with sufficient compact and road bed to withstand the vehicular traffic.

Generally, at least three 25 cm layers of well compacted gravel forms the top of the road, over a 10cm compacted bituminous layer should be made if required.

The top of the road should slope at 3°from the middle on either side. Should the ground still be soft or wet even after the removal of top soil layer a geo-textile filter to be installed on the base.

In general, drainages are proposed by open ditches along both sides of the road.

The ditches should be designed with suitable erosion protection flow retarders, dissipation boxes, etc. to withstand the monsoon season without damage. Where the roads pass through open drains, a design with an embankment for the road and steel pipes or concrete pipes for the drain water are proposed.

To limit the landslides and siltation of the drainage ditches, all slopes, cuts as well as embankments are proposed to be planted with grass and bushes.

Access roads of the different categories are mainly planned as follows:

- Along the excavated OB and Coal benches.
- Out of the Mine at the Main exit ramp
- Up the dump ramp and on to the dump

The preparation and maintenance of all mine haul roads are the responsibility of the operational department and considered part of the mining operation.

Cost of this haul roads are not considered separately.

8.6.2 Main haul roads outside the mine:

- About 25m gravel top road designed for operating fully loaded 100T mine trucks to provide access from mine ramp to coal beneficiation plant.
- 25m wide road with 20cm bituminous cover will be designed for hauling of empty 100T Mine Trucks for return.

Phase II: Mining operations will start initially with two PC450/Volvo480 Excavators and six 35T tippers for removing of top soil and weathered rock. The work is started in ES1/1 blocks, as the top soil and weathered rock quantities are not much. It takes about 15 days to 1 month for excavating one block. Blasting may not be required as the geotechnical properties of shale and siltstone with thin sandstone bands can be excavated/ripped.

First surface miner will be commissioned in ES1/1 block in the 2^{nd} month of starting the mining operation. Another surface miner will be commissioned in the fourth year when the mine progresses to 6 MTPA capacity.

Overall stripping ratio to 1:3.2, initially stripping ratios will work out to 1:0.75. The surface miner will be mining coal bands, intra seam partings (waste bands), inter seam partitions everything till coal in Chipanga seam is exhausted. The inter seam partings of <1m shall be attempted by surface miner or excavators/Ripper dozers whichever are suitable.

8.6.3 Dump plan:

To reduce the impact of land use from open cast mining, it is essential to minimize the temporary and permanent use of land. This could be achieved by

Avoidance of large external dumps

Filling the mined-out area by dumping of waste in the process of reclaiming the mined-out area

Separate storage of top soil and spreading the same on reclaimed surface

8.6.4 Top Soil Dump:

The total top soil to be removed from the mining area is 4.5MBCM (generally the upper most 1m of the original ground is stripped for stocking).

These soils stay fertile only for certain period when stock piled. Therefore, whenever slopes and surface on the dumps reach their final shape, they should be covered with top soil immediately. This will allow for early reclamation of land for controlling of erosion in the wet season and dust control during dry season.

The top soil dump will be used mainly in the beginning of the mining operation when the slopes and surface of the dumps have not yet reached their final shape. After certain time, balance will be reached between the land used for mining and return of reclaimed land. At this point of time most of the top soil can be directly used for reclaiming without prior stock piling.

Hence stockpile area required will be 1/3 of total quantity i.e. 1 MBCM. Area required for stocking of top soil to a height of 10 is 500 x 100 x 10 (5 hectares) on east side and another 500 x 100 x 10m on west side will be a totally 10 hectares.

8.6.5 External waste dump:

Total waste	=	290.55 MBCM
Refuse generated in the beneficiation process	=	57.87 MBCM
Total waste generated	=	348.42

Due to the swelling factor, it is not possible to fill the entire waste mined out to dump in the excavated Block-A. Maximum of88% of generated waste may be possible to be dumped back in worked out area and about 34 MCBM has to be dumped outside the pit requiring about 160Ha of land. This dump area is planned very close to the pit in such a way that by the time the pit dumping starts, it will become an extension of the pit. Dump high will be 25m above the original ground level due to swelling factor. The pit dump when it attains final height will be systematically covered with top soil and reclaimed by using biological reclamation techniques on dumped soil through the application of bio-fertilizers, humic acid, organic matter and cultivation of leguminous crops.

The overburden, inter-burden and other wastes are dumped on the south eastern corner of the east Block and south west corner of the west block will cover a total area of 160ha (80ha on east block and 80ha on west block). This dump will have final height of 25 to 30m which will be formed in two stages. The angle of repose of the over burden dump will be kept at 28° to prevent sliding of material.

8.7 PRODUCTION SCHEDULES& MANPOWER PLANNING

8.7.1 Production schedule:

Planned production schedule is presented in Table 8.10.Commencement of the year of production shall be decided in due course. Production schedule shall be linked to the construction of CHHP. Hence, the production schedules mentioned here reflect year-wise from the start of mining operations (Fig. 8.32). Details of man power deployment are given in Table 8.11 to 8.13.

Table 8.10: Year Wise Production Schedule, Mb-A

Mine Production Schedule - Mb - A											
	Total	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Waste (MCBM)	228.80	2.25	4.90	6.30	5.70	10.50	14.40	31.90	38.50	42.35	72.00
ROM Coal (MT)	77.00	3.00	3.50	3.50	6.00	6.00	6.00	11.00	11.00	11.00	16.00
Stripping Raio	2.97	0.75	1.40	1.80	0.95	1.75	2.40	2.90	3.50	3.85	4.50
Coking Coal Product Product @ 18% Yield (MT)	13.86	0.54	0.63	0.63	1.08	1.08	1.08	1.98	1.98	1.98	2.88
Export Thermal Product Product @ 18% Yield (MT)	13.86	0.54	0.63	0.63	1.08	1.08	1.08	1.98	1.98	1.98	2.88
Total Salaeble Product (MT)	27.72	1.08	1.26	1.26	2.16	2.16	2.16	3.96	3.96	3.96	5.76

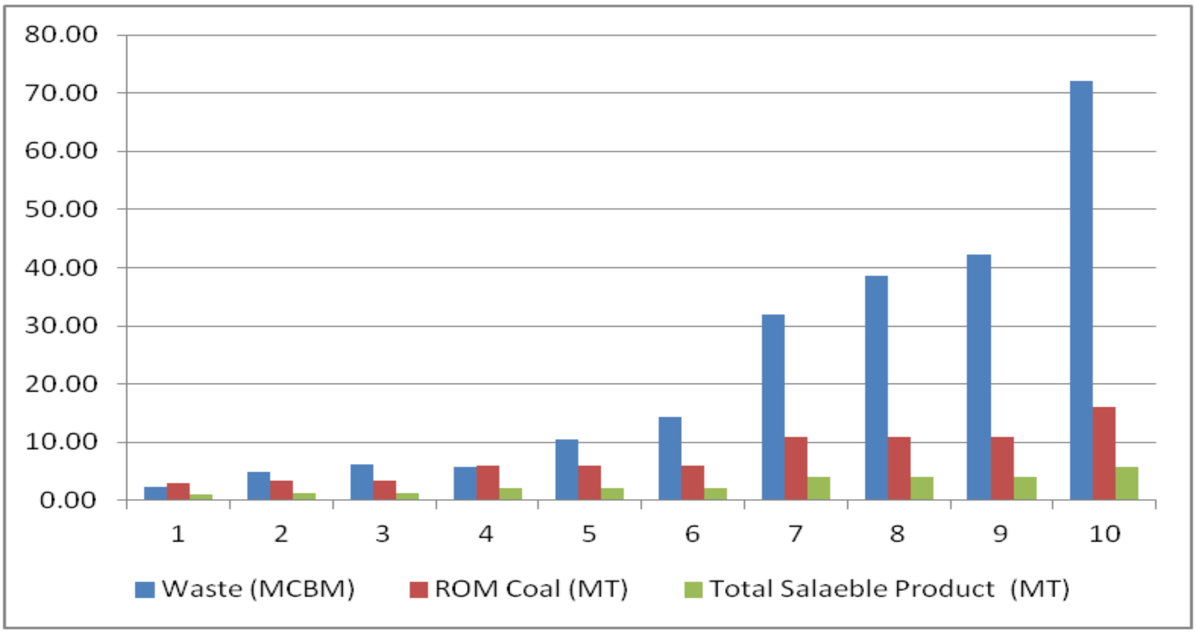


Fig. 8-32: Bar graph showing year-wise production

8.7.2 Time scheduling and Man Power planning:

Table 8.11: Time Scheduling: Annual Working Hours

Total days in year	**364**		**Average Rainfall**
Sundays	51		Dec – 126 – 5
	313		Jan – 194 – 6
Public Holidays in Mozambique	10		Feb – 149 – 5
Provision for unforeseen disruptions	4		March – 84.2 – 1
Actual working day	299		Nov – 74.2 -1
Work loss due to rains	18		
	281 days		
Working Hours available	281x8x3	6744 hours	
	Ist	IInd	IIIrd
Shift Hours	8.0	8.0	8.0
Less: Shift change	0.5	0.5	0.5
Less: Tea Break	0.3	0.3	0.5
Less: Lunch/dinner time	0.6	0.6	0.3
Less: 10% inefficiency in night shifts			0.72
Hour available	6.6	6.6	6.48
Average = 6.56			
Machinery available	90% = 5.904		
Effective available time per hour	5.904x60 8	= 44.28	= 0.73%
Effective Hours	6744 x 0.73	= 4923	Say = 4800

8.7.3 Manpower Requirement for 3 Mtpa Production:

Table 8.12: Mine Machine Operators and Helpers

Manpower Requirement			
Machine	Make	For 3MMT Nos	Operators/ Drivers
For OB removal			
Hydraulic Excavators	Volvo 480	6	18
Dumpers Volvo 460	Volvo 460	36	108
Dozers cum Rippers- D275 (400HP)	Komatsu	3	9
Dozer-D85	Komatsu	2	6
Motor Graders GD-755 (4.2 Mtr blade width)	Komatsu	3	9
For Coal excavation			0
Surface Miners	Writgen	1	3
Coal Loading dumpers with high body	Volvo	20	60
Wheel loader WA600/500 with Coal bucket	Komatsu WA600/500	3	9
Dozer-D85	Komatsu	2	6
General equipment			0
Diesel Bowsers 15KL	SINO	3	9
Water sprinklers-15KL	SINO	3	9
Water sprinklers 10 KL		2	6
Service van(Mobile service)	SINO	2	6
Tyre Handlers WA 470	Komatsu WA470	2	4
Open body 10T trucks	SINO	2	6
Escorts crane 12T	Escorts	2	2
Hose crimping machine		1	1
Welding plants mobile		3	3
Welding plants static		3	3
Dewatering pumps 100HP	Kirloskar	8	16
4 wheel drive pickups	Isuzu	6	18
Air compressors for tyre		2	4
100mm dia drills	PRD	3	18
Explosive van		3	3
Fork lifter 5T	CAT/Komatsu	2	2
Work shop support			10
Note: Abscentiesm relief to be added to the critical categories @10%			

Table 8.13: .Administrative and Support Staff

	Administrative and Support Staff	**# of Staff**
1	Project CEO	1
2	Mine Manager	1
3	Shift Manager	3
4	Foreman	6
5	Engineers	4
6	Geologists	2
7	Supervisors	6
8	Technicians	6
9	Mechanics / Electricians / Fitters	20
10	Accountants	1
11	Clerks	2
12	Personnel Dept	2
13	Secretaries	2
14	Surveyors	2
15	Draftsman	1
16	Storekeepers	2
17	Security	4
	Total	65

8.8 MACHINERY PLANNING

8.8.1 Machinery for Top Soil & OB:

Top soil and OB are removed by digging with excavator. Top soil is more or less 1.5m thick, weathered shale and weather coal is varying from 5 to 6m, sometimes 1 to 2m clay may be encountered. All these constituents can be mined by back hoe/excavator without blasting.

The total volume of top soil is 4.5 MBCM in entire Mb-A including east & west blocks and weathered shale is 10.68MBCM. Taking life of mine 10.8 years, 1.01MBCM has to be mined per year.

Machinery for Waste:

Volvo 480(Excavator)
Hourly production = 465 BCM
Yearly production = 2.23 MBCM (4800 x 465)
No’s required = 6
Volvo 460 (Dump truck)
Hourly production = 77BCM
Yearly production = 0.369 MBCM
No’s required = 36 dumpers

8.8.2 Machinery for Coal & Partings:

In each strip, block-wise, top soil, OB, coal tonnage, intra seam waste, and inter seam waste are estimated and quantified. Once top soil and OB is excavated, this block will be ready for surface miner to work. Production capacity of each surface miner is 1000T/Hour. Partings may be removed by Surface miner or excavator or Ripper dozer depending on their thickness Surface miner manufacturers suggested same rate of production in intra & inter bed partings is similar to that of coal owing to the low uniaxial compressive strengths, i.e.

In coal	= 1000/1.7	= 588 BCM
OB & Inter Seam partitions	= 1000/2.4	= 417 BCM
Intra banded waste	= 1000/2.2	= 454 BCM

Average production recorded in India = 550 m^3/Hour.

Surface Miner KSM 403 – The Principal Production Machine

- Capacity in coal, OB, intra, Inter burden = 1000T/Hour
- Coal = 1000/1.7 = 588 m^3/Hour
- OB + Inter burden = 1000/2.4 = 416 m^3/Hour
- Intra Burden = 1000/2/2 = 454 m^3/Hour
- Average capacity for the purpose of = 500 m^3 calculation

WA600 Front End Loader

- Bucket capacity = 6 m^3
- Loose density = 1.7
- Waste BCM density = 2.3
- Back fill factor = 0.80 = 6 x 0.80 = 4.8 m^3
- Loading capacity in tonnes = 4.8 x 1.7 = 8.76
- Cycle Time = 45Sec
- Number of passes = 80 passes
- Job efficiency = 64 passes
- Per hour production = 580
- Per Surface Miner = 1000/580 = 1.88
- (2 loaders to serve 2 surface miners)
- Surface miner production = 1000T
- Number of dumpers = 1000/352 = 2.8 = say 3 dumpers

Table 8.14: Machinery for coal winning

Machine	**Make**	**For 3MMT**	**For 6MMT**
		Nos	**Nos**
For OB removal			
Hydraulic Excavators	Volvo 480	6	12
Dumpers Volvo 460	Volvo 460	36	72
Dozers cum Rippers- D275 (400HP)	Komatsu	3	5
Dozer-D85	Komatsu	2	2
Motor Graders GD-755 (4.2 Mtr blade width)	Komatsu	3	3
For Coal excavation			
Surface Miners	Writgen	1	2
Coal Loading dumpers with high body	Volvo	20	35
Wheel loader WA600/500 with Coal bucket	Komatsu WA600/500	3	3

Dozer-D85	Komatsu	2	2
General equipment			
Diesel Bowsers 15KL	SINO	3	4
Water sprinklers-15KL	SINO	3	4
Water sprinklers 10 KL		2	2
Service van(Mobile service)	SINO	2	3
Tyre Handlers WA 470	Komatsu WA470	2	2
Open body 10T trucks	SINO	2	2
Escorts crane 12T	Escorts	2	3
Hose crimping machine		1	2
Welding plants mobile		3	4
Welding plants static		3	4
Dewatering pumps 100HP	Kirloskar	8	8
4 wheel drive pickups	Isuzu	6	8
Air compressors for tyre		2	3
100mm dia drills	PRD	3	5
Explosive van		3	4
Fork lifter 5T	CAT/Komatsu	2	2
Work shop support		1	1

8.9 MINE SAFETY

The Manpower will be trained locally, regionally, as well as globally. The company will maintain and upgrade a core team to execute the key functions and ensure controls while some of the operations will be executed by the competent contractors under the strict guidance, vigilance and supervision of the core team. The company plans to establish a Vocational Training Center close to the mine site, install simulators for training of operators on various machines. The local human resource base will be expanded and upgraded using training facilities in the Vocational Training Center before deputing them for on job training. The regular operators will also be imparted advanced training on a regular basis. The company will closely work with mining machinery manufacturers of surface miners, back hoe and large dumpers for training of operators, mechanical engineers and maintenance personnel to ensure enhanced availability and utilization of machine time. The operation will have 30% expatriate work force to start with. This will be gradually reduced to 10% with Mozambican work force taking over the jobs.

Health and Safety are two other essential components in any mining project. Unsafe practices that lead to accidents in OPENCAST MINING along with preventive measures are discussed below:

8.9.1 Accident on Account of Machinery Operation:

- Failure of breaks
- While reversing the dumper or other trucks
- Fire due to over-heated oils
- Not providing guards for moving parts when people are working near them.

Preventive measures

- Prevention of unauthorized persons operating or riding on the vehicles.
- Regular monitoring of the equipment and timely maintenance
- Posting and display of notices in workplace, and machine operating cabins, precautions to be taken while working.
- Provide safety gadgets like reversal lights, alarms and cameras, vicinity sensors, AFDDs etc.

8.9.2 Haulage Roads:

Haulage Roads will be well constructed, so that vehicle movement is smoother and unobstructed.

The prescribed guidelines are:

- Whenever possible, one way traffic will be maintained and wherever it is not possible haul road shall be widened to three times wider than the widest vehicle plying.
- Corner bends shall have clear view for over 30m.

- Gradient should be 1 in 16 or flatter, except at smaller stretches where it should not be more than 1 in 10.
- When the road is above the level of surrounding ground, a parapet wall of at least 1m height will be provided.
- Haul road will be provided with drains on both the sides.

8.9.3 Bench Failures:

OB Benches:

Where Shovel / dumpers are employed in a mine usually bench width is 3 to 4 times more than bench height. Here low bench heights are maintained and wider bench width up to 40-50m which can take care of sliding of boulders and rock mass. Bench failures are common when working near faults and bench heights are kept as low as possible near such workings, and proper precautions will be taken while negotiating a fault.

A bad blast also can create cracks ahead of the working area which may cause the failure of the bench.

The following can ensure safe benches:

- Low height of the benches and more width of the benches.
- Good suitable blasting patterns with blast holes having an angle of 10° to 30° from the vertical giving the bench an intended slope.
- Careful mining near fault.

Coal benches:

- As Surface Miner is being used for mining of coal no blasting is required thereby less bench problems.
- Surface miner leaves smooth slopes on benches sliding boulders and loose mass is avoided.
- Careful mining near a fault.

8.9.4 Dump failures:

Both inside and outside dumps can slide and cause accidents. The following precautions shall be taken to prevent dump failures:

- Dumps should not be very high
- Dumps should be well graded so that there is no depression or pockets where water can get collected. Dumps should be well drained.
- Dump should have proper benching system
- Soil or clay should not form the base of the dump.
- For inside dump the quarry floor should be made rough by ripping.
- Re-vegetation (trees and grass on slope) should be done as early as possible. On slope, coir mat with grass seed is helpful.

- Regular visits of the dumps will enable to notice developing cracks and widening of the same to corrective actions against possible dump side.

8.9.5 Blasting:

The present mining method does not envisage any large scale continuous blasting operations. In case it is taken up, the accidents are mainly due to fly rock

- Fly rock generated during blasting can cause accidents.
- The best action against generation of fly rock is proper design of drill holes and explosive charge i.e. proper burden, spacing and explosive charge with respect to dia of hole.
- The under charge results in blown out blast hole and over charge creates excess energy than needed on both the cases fly rock is created.
- Proper blast-hole pattern and charge also reduces secondary blasting which will again interrupt the mining operation. Lesser secondary blasting results in better safety.
- Better fragmentation will increase the efficiency of loading operation and safety. It also reduces the burden on crushing.
- Defective design in blasting parameters may result in misfires, which may create dangerous situation.
- Proper safety procedures will be evolved for handling, charging and blasting of explosives and implementation of the same.
- Blasting will be carried, according to the established procedures.
- Storing and transport of explosives will be strictly adhering according to the standard procedure.

Fires: Most of the fires in open cast are due to spontaneous heating. Fire may be generated due to

- Long exposure of thick coal benches to the atmosphere
- Fire in thick banded seam because of cracks developed due to heavy blasting. Air may enter through the cracks and create suitable conditions for spontaneous heating.
- Fire in carbonaceous shale in waste dumps.

Preventive Measures

- When coal benches are formed approx. 0.3 m inert Overburden is left, so that coal is not exposed to directly to the atmosphere. Sealants can be mechanically spread on the exposed coal to prevent air coming in contact with the coal.
- In present case, Surface Miner is being used, no blasting is required, thereby no backward cracks and reduced risk of fire.
- Carbonaceous shale is almost 70 to 90% ash which may not be conducive for spontaneous heating.

8.9.6 Accident due to poor visibility:

- Good lighting not only increases safety but also productivity and lighting should be in such way, it creates good visibility but not glare.
- Lighting standard norms are already in practice in the open cast mines at various places, such as haulage road ways, working places on OB and coal benches, dumping area, etc. such standard should be followed.
- Another reason for poor visibility is, dust raised in air by moving vehicles such as dumpers.
- Sprinkling of water on haul road by water sprinklers or by installing water sprinklers can control dust to great extent at regular interval.
- Sprinkling of water to suppress dust is required not only on mine roads but also waste dump loads.
- Dust generated during drilling will be controlled by vaccum suction. This arrangement is part and parcel of the drills available in the market.

8.9.7 Provision for health:

First aid

In every mine zone first aid facility will be provided and maintained so as readily accessible during all working hours. First aid boxes or cup boards equipped with same are to be provided.

One or more suitable first aid room attended by trained male nurse during all working hour will be ensured.

One or more Ambulances to be available at the mine at all point of times with driver.

Hospital

- A fully fledged hospital for not only treating the accident cases but also for treating employees and their families for general complaints is planned.
- All the workers will be subjected to periodical medical check-up.

Safety equipment to be provided

- Providing Safety shoes, helmets, hand gloves for all works.
- Respirators for dust as well as gas masks to all workers wherever necessary.
- Safety belts for those working in Hazardous area like steep slopes, while doing maintenance work or electrical work.
- Welding goggles.
- Spectacle type goggles for dozer operators & machinists.
- Rubber boots and Rain coats in the Rainy season.
- Ear plugs for all operators of earth moving machines.

Drinking water: In every mining zone, effective arrangements will be made to provide and maintain at suitable points conveniently situated, a sufficient supply of cool and hygienic drinking water for all employees.

Convergence: There shall be provision for male and females. Sufficient number of lavatories and urinals will be provided separately, conveniently situated and accessible to persons employed.

All the standard safe practices will be diligently adopted and improved to suit the exact operating conditions.

8.10 MINE CLOSURE PLAN

Mine reclamation and closure are an ongoing process to restore the physical, chemical, and biological qualities disturbed by the mining operation to a level acceptable to all concerned. Its goal will be to leave the area in such a condition that rehabilitation does not become a burden on the society after mining is completed. It must also create a self-sustaining ecosystem.

The Mining Block A will be a large open pit with a life of about 10.8 years. The pit will be approximately 1250 meters in length and 3700 meters in width and 180M meters deep. The goal will be to backfill the mine to the extent possible with mine waste and refuse from the coal preparation plant.

The mine will be developed in three phases beginning at the sub-crops of the coal zones and progress down dip from the southwest to the northeast in both east and west blocks. Before stripping begins in any of the mining phases the top soil will be removed and stockpiled to be used in the mine reclamation. After the top soil is removed and stockpiled the overburden will be hauled and loaded by trucks to designated waste disposal areas.

Initially some of the waste will have to be disposed in areas on the surface near the Pit but the objective will be to place as much of the waste material as possible in mined out areas of the pit to facilitate reclamation of the mine. It is also planned to deposit coarse refuse from the Coal preparation plant. Stockpiling waste and refuse on the surface is not the most economical method of disposing of the waste. There is also a cost advantage in backfilling the pit because it provides the shortest waste hauls for the waste trucks, and a back haul for the coal trucks from the preparation plant. There is approximately 290 million BCM of waste in total and 58 million BCM of refuse generated by the preparation plant for a total of 348 million BCM of material to be reclaimed. However, considering that there will be a swell factor on the waste and refuse in the range of 25% to 30% the actual total volume of waste will exceed the total pit volume.

In development of Phase I of Block A, it will be necessary to dispose a portion of the mine waste (12%) and process reject material in stockpiles on the surface near Block-A. The plan is to open East Block and West Block in Phase I on the southeast boundary where the bottom of the pit is near to the surface. This will facilitate the commencement of backfill at the earliest possible stage in the mine development. As the pit floor is exposed, the initial waste disposal areas adjacent to Block-A will be designed to expand into the backfill area. The backfill will form a hill above the surface of the previously mined out areas. As the pit expands through Phases II & III, initial out of pit wasted and reject disposal area will form a hill that grades down to the pit bottom in final area of mining. The slopes around this area will be graded to and reclaimed.

As areas are back filled to final elevation and re-graded, top soil will be placed over the backfill and it will be seeded for final reclamation. When mining is completed, a large portion of the Pit will have been reclaimed and seeded leaving a depression, which will eventually form an impoundment, or lake, for water storage and recreational purposes. The stockpiles of waste and refuse that remain on the surface will also be covered with topsoil in the reclamation process. It is also planned to disassemble and remove the mining equipment, preparation plant, offices, shops, warehouses, and other mine related facilities.

8.10.1 Periodical Review:

Review of implementation of Mining Plan / Scheme of Mining includes five-year progressive closure plan up to final closure of mine.

A Register is maintained as explained in Mine dumps reclamation of mined out area showing area used for mining and areas reclaimed and rehabilitated.

It also includes:

- Top soil Management
- Waste Management
- Tailing Dam Management
- Infrastructure
- Disposal of discarded Mining Machinery
- Disaster Management
- Care and Maintenance during temporary discontinuance
- Air and water quality management is taken care of in EMP
- Economic repercussions of closure of mine and man power retrenchments.
- Cost under Mine Closure Plan are given below (Indian Standards are considered)

8.10.2 Mine closure cost:

- Mining Area: 450 ha
- Mining support area (roads, wash plant etc.) 300 ha
- Mine closure Cost for per Ha 11, 86, 000 usd
- Total cost (2000 Hectare) 4,000,000 usd
- Mine life 10.8 years
- Average annual cost 79,000 usd
- Mark up for Mozambique 80,000 usd
- Average mine closure cost per tonne 0.13 usd per ton

8.11 MINE OPERATION MODEL & COST ESTIMATES

The License holder is having long experience and high level of expertise in open cast mining and is capable of taking up the mining operations by itself which will result in substantial savings. However, for the purpose of all financial computations, operations by contractor and the resultant costs have been used.

The MAL has proposed contractor model of operation. The role of contractor is removal of soil cover, OB and to mine coal and its delivery at CHPP. A provisional negotiated price is 5$ per ton.

Nevertheless, MGPL made its own independent cost estimates on mining.

Optimization of cost estimates is an essential element for successful project and program management. Midwest cost estimates based on four characteristics as established by industry best practices - credibility, reliability, accuracy and adequacy.

The cost estimate is based on estimates received from Suppliers, Consultants, and Machinery manufacturers. The cost estimate is considered reasonable accurate to within +/- 15-20% at the summary level and is expressed in US dollars.

Capital Cost of machinery:

The capital cost is estimated on price quotation provided by the suppliers and manufacturers for landing cost of the machinery. Other auxiliary equipment costs are based on secondary research and consultant information.

Operating Cost of mining (Tables 8-15 & 8-16):

The operating cost is the cost of running the mine; items which are included in the model are based on contract pricing.

- Salaries & Allowances: Manpower needs are assessed based on planned HEMM, P&M and Support services.
- Cost of expats also included in salaries.
- The performance parameter and overall output of machinery is estimated based on Midwest own experience and information available in current coal mining operations in India which employ surface miners.
- The cost estimates based on Indian conditions are escalated by 15-20% based on Mozambique conditions.
- The cost of raw material and other inputs are estimated based on Mozambique current prices.
- The operating costs include maintenance of machinery

Table 8.15: Indicative Mine Equipment –Capital & Operating Costs

				For 3MMT	For 6MMT	For 3MMT	For 6MMT
Sl.NO	Machine	Make	Unit cost excl GST (Rs.)	Nos	Nos	Total cost excl GST	Total cost excl GST
	For OB removal						
1	Hydraulic Excavators	Volvo 480	1,95,00,000	6	12	11,70,00,000	23,40,00,000
2	Dumpers Volvo 460	Volvo 460	1,33,25,700	36	72	47,97,25,200	95,94,50,400
3	Dozers cum Rippers- D275 (400HP)	Komatsu	4,16,47,875	3	5	12,49,43,625	20,82,39,375
4	Dozer-D85	Komatsu	1,60,00,000	2	2	3,20,00,000	3,20,00,000
5	Motor Graders GD-755 (4.2 Mtr blade width)	Komatsu	2,81,73,563	3	3	8,45,20,688	8,45,20,688
	For Coal excavation					-	-
7	Coal Loading dumpers with high body	Volvo	1,34,75,200	20	35	26,95,04,000	47,16,32,000
8	Wheel loader WA600/500 with Coal bucket	Komatsu WA600/500	4,89,97,500	3	3	14,69,92,500	14,69,92,500
9	Dozer-D85	Komatsu	1,60,00,000	2	2	3,20,00,000	3,20,00,000
	General equipment					-	-
9	Diesel Bowsers 15KL	SINO	48,00,000	3	4	1,44,00,000	1,92,00,000
10	Water sprinklers-15KL	SINO	45,00,000	3	4	1,35,00,000	1,80,00,000
11	Water sprinklers 10 KL		30,00,000	2	2	60,00,000	60,00,000
12	Service van(Mobile service)	SINO	66,60,000	2	3	1,33,20,000	1,99,80,000
13	Tyre Handlers WA 470	Komatsu WA470	1,95,99,000	2	2	3,91,98,000	3,91,98,000
14	Open body 10T trucks	SINO	34,75,000	2	2	69,50,000	69,50,000
15	Escorts crane 12T	Escorts	20,00,000	2	3	40,00,000	60,00,000
16	Hose crimping machine		6,00,000	1	2	6,00,000	12,00,000
17	Welding plants mobile		80,000	3	4	2,40,000	3,20,000
18	Welding plants static		1,60,000	3	4	4,80,000	6,40,000
19	Dewatering pumps 100HP	Kirloskar	3,60,000	8	8	28,80,000	28,80,000
20	4 wheel drive pickups	Isuzu	26,00,000	6	8	1,56,00,000	2,08,00,000
21	Air compressors for tyre		3,25,000	2	3	6,50,000	9,75,000
22	100mm dia drills	PRD	32,00,000	3	5	96,00,000	1,60,00,000
23	Explosive van		30,00,000	3	4	90,00,000	1,20,00,000
24	Fork lifer 5T	CAT/Komatsu	12,00,000	2	2	24,00,000	24,00,000
25	Work shop support		10,00,000	1	1	10,00,000	10,00,000
26	Surface Miners	Writgen	10,00,00,000	1	2	10,00,00,000	20,00,00,000
	Sub Total cost in Rs.					**1,52,65,04,013**	**2,54,23,77,963**
	10% for transport and contingency					**15,26,50,401**	**25,42,37,796**
	Total Cost in Rs					**1,67,91,54,414**	**2,79,66,15,759**

Table 8.16 Opex for coal mining

ROM cost at Mine	US$/ROM ton	Remarks
Mining Costs	13.2	Strip Ratio of 1:1.5 @5 $/cbm
Management & Support Expenses	0.5	
Average mine closure cost per tone	0.5	
Environment Related Costs	0.4	
CSR	0.2	
A) Cost per ton of ROM	**14.8**	
B) Washing cost per ton of ROM	4.0	
C) Mining + Washing cost per ton of ROM (A+B)	**18.8**	
Product cost at Mine	US$/Product t	
Cost per ton of Saleable Coal Product (Coking & Thermal Coal) @ 38% max yield after washing.	49.5	
Royalty	4.3	
Total Cost per ton of product	**53.8**	
Transport Costs	US$/Product t	
Road Transport to Rail sliding	4.2	
Rail transport to Port cost	35.0	
Port Charges including loading ship	9.5	
Export product transport cost	**48.7**	
Total	US$/Product t	
Total Operating cost at FOB	**102.5**	

Note: CAPEX and OPEX estimate presented in this report is indicative only which needs to be updated before actual start of the project.

9 COAL PREPARATION & PROCESSING PLANT

9.1 COAL CHARACTERIZATION AND LIBERATION

Coal consists of three maceral types known as Vitrinite, liptinite and inertinite. Coal in Moatize coalfield is vitrine rich sub-bituminous.Vitrinite occurs as mm scale stringers and cm scale bands that constitutes over 60% of coalified components. Vitrine is fragile and breaks easily into mm scale lustrous dust particles (Fig.9-1). Liptinite occurs as a minor component. Inertinite is a dull coal and represent more than 30% of the coalified components in furnace and contributes more to reactivity of coal and it soils the finger easily, Besides these three, there are non-carbonaceous matter in coal namely moisture and mineral matter which will not burn in furnace . Mineral matter is indicated as 1.1 x ash%. Mozambique coal is rich in inherent mineral matter. Besides, non-inherent mineral matter is contributed with coaly matter in the mining process. Coal bands alone contain 20 % ash only, but due to mining of associated dirt bands, the ash content in ROM coal goes up to 50 -55% ash. Removal of ash (including mineral matter) is a tedious process due to intermixing nature of coal and clay particles. The main objective of coal preparation is to reduce the non-carbonaceous matter as low as possible so that the prepared coal becomes more economic. Of all the methods of coal preparation, deshaling of coal and the float-sink analysis are the basic laboratory procedures method to work out the liberation and separation based on density to work the various combinations of coal preparation techniques and to prepare flow sheet for coal preparation in connection with the design and erection of coal preparation plant

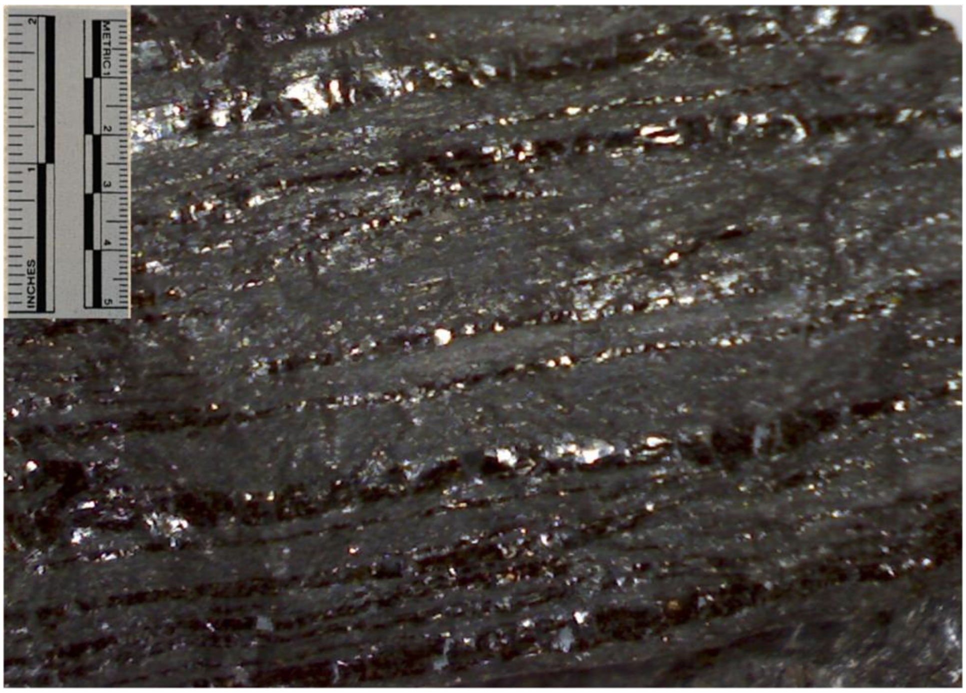


Fig. 9-1: Natute of Midwest coal: Bright Bands are vitrinite and liptinite & Dull bands are inertinite + invisible& mineral matter

Midwest seam structure Vis-à-vis RoM coal- Need for grade control.

Coal seam structure is interbanded. Coal and band (shale) are centimeter scale. There is a compositional grading between these two as

Coal------> Shaly coal ------>Carb shale ------>Shale

Based on carbon content of first three types of bands potential workable sections are determined. See Figs9-2 &9-3.Coal from PWS Would go into Coal preparation Plant. Likely coal content of the ROM coal is shown as ‘I’ & ‘E’.This would help in great control during the mining stage.

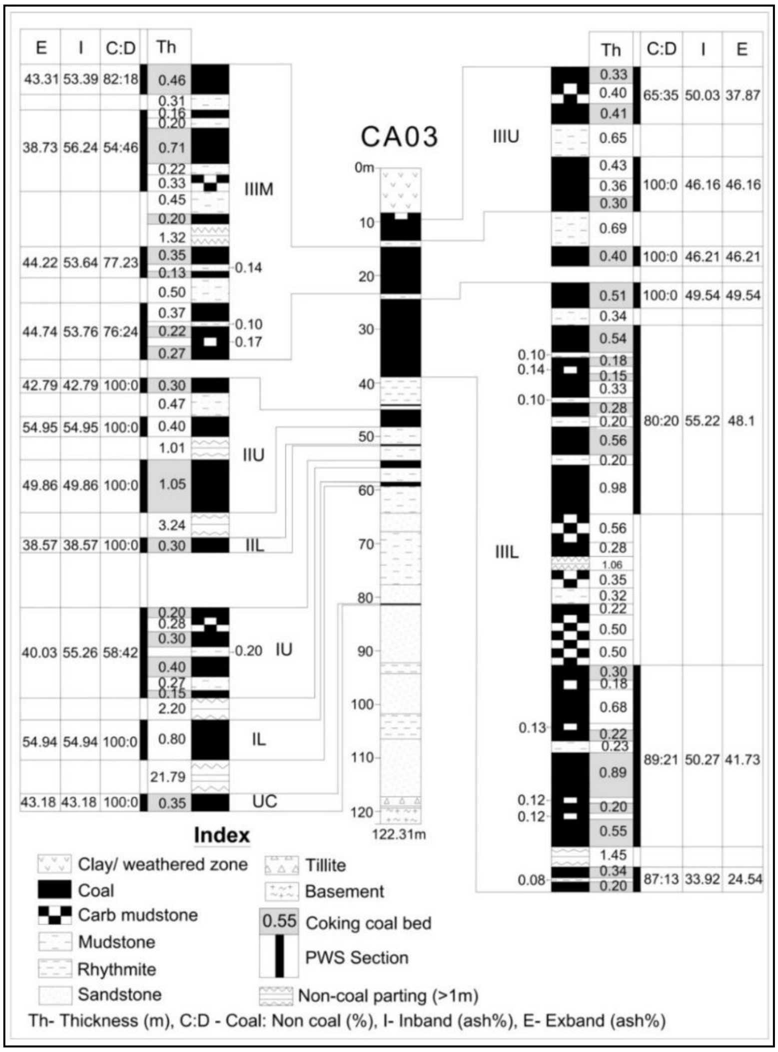
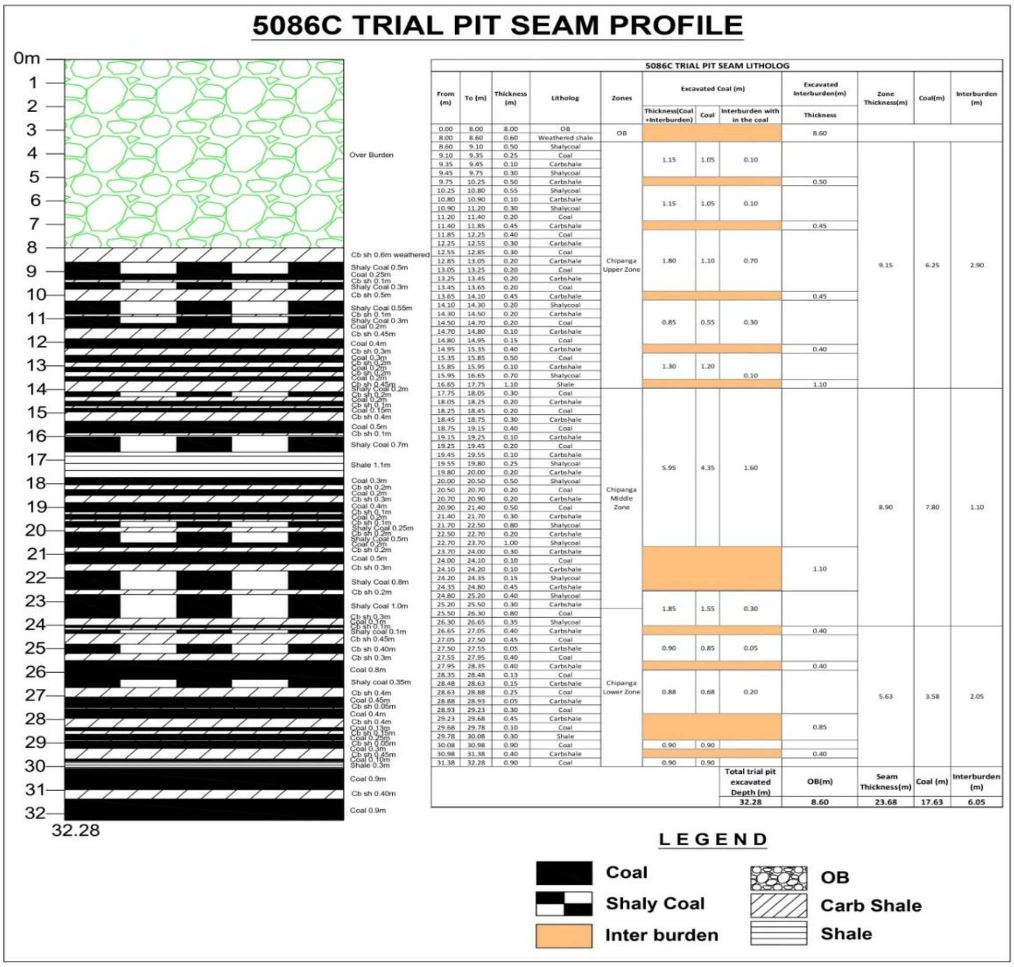


Fig. 9-2: Barcode morphology of coal seams. I&II: Sousa Pinto seam, III: Chipanga seam, L M U, lower, middle and upper sub-seams. Figs in boxes: bed thickness. Thick vertical lines: potentially workable sections—PWS.



5086C TRIAL PIT SEAM LITHOLOG

From (m)	To (m)	Thickness (m)	Litholog	Zones	Excavated Coal (m): Thickness(Coal +Interburden)	Excavated Coal (m): Coal	Excavated Coal (m): Interburden with in the coal	Excavated Interburden(m): Thickness	Zone Thickness(m)	Coal(m)	Interburden (m)
0.00	8.00	8.00	OB	OB				8.60			
8.00	8.60	0.60	Weathered shale								
8.60	9.10	0.50	Shalycoal	Chipanga Upper Zone	1.15	1.05	0.10		9.15	6.25	2.90
9.10	9.35	0.25	Coal								
9.35	9.45	0.10	Carbshale								
9.45	9.75	0.30	Shalycoal								
9.75	10.25	0.50	Carbshale					0.50			
10.25	10.80	0.55	Shalycoal		1.15	1.05	0.10				
10.80	10.90	0.10	Carbshale								
10.90	11.20	0.30	Shalycoal								
11.20	11.40	0.20	Coal								
11.40	11.85	0.45	Carbshale					0.45			
11.85	12.25	0.40	Coal		1.80	1.10	0.70				
12.25	12.55	0.30	Carbshale								
12.55	12.85	0.30	Coal								
12.85	13.05	0.20	Carbshale								
13.05	13.25	0.20	Coal								
13.25	13.45	0.20	Carbshale								
13.45	13.65	0.20	Coal								
13.65	14.10	0.45	Carbshale					0.45			
14.10	14.30	0.20	Shalycoal		0.85	0.55	0.30				
14.30	14.50	0.20	Carbshale								
14.50	14.70	0.20	Coal								
14.70	14.80	0.10	Carbshale								
14.80	14.95	0.15	Coal								
14.95	15.35	0.40	Carbshale					0.40			
15.35	15.85	0.50	Coal		1.30	1.20					
15.85	15.95	0.10	Carbshale								
15.95	16.65	0.70	Shalycoal				0.10				
16.65	17.75	1.10	Shale					1.10			
17.75	18.05	0.30	Coal	Chipanga Middle Zone	5.95	4.35	1.60		8.90	7.80	1.10
18.05	18.25	0.20	Carbshale								
18.25	18.45	0.20	Coal								
18.45	18.75	0.30	Carbshale								
18.75	19.15	0.40	Coal								
19.15	19.25	0.10	Carbshale								
19.25	19.45	0.20	Coal								
19.45	19.55	0.10	Carbshale								
19.55	19.80	0.25	Shalycoal								
19.80	20.00	0.20	Carbshale								
20.00	20.50	0.50	Shalycoal								
20.50	20.70	0.20	Coal								
20.70	20.90	0.20	Carbshale								
20.90	21.40	0.50	Coal								
21.40	21.70	0.30	Carbshale								
21.70	22.50	0.80	Shalycoal								
22.50	22.70	0.20	Carbshale								
22.70	23.70	1.00	Shalycoal								
23.70	24.00	0.30	Carbshale					1.10			
24.00	24.10	0.10	Coal								
24.10	24.20	0.10	Carbshale								
24.20	24.35	0.15	Shalycoal								
24.35	24.80	0.45	Carbshale								
24.80	25.20	0.40	Shalycoal								
25.20	25.50	0.30	Carbshale		1.85	1.55	0.30				
25.50	26.30	0.80	Coal	Chipanga Lower Zone							
26.30	26.65	0.35	Shalycoal								
26.65	27.05	0.40	Carbshale					0.40	5.63	3.58	2.05
27.05	27.50	0.45	Coal		0.90	0.85	0.05				
27.50	27.55	0.05	Carbshale								
27.55	27.95	0.40	Coal								
27.95	28.35	0.40	Carbshale					0.40			
28.35	28.48	0.13	Coal		0.88	0.68	0.20				
28.48	28.63	0.15	Carbshale								
28.63	28.88	0.25	Coal								
28.88	28.93	0.05	Carbshale								
28.93	29.23	0.30	Coal								
29.23	29.68	0.45	Carbshale					0.85			
29.68	29.78	0.10	Coal								
29.78	30.08	0.30	Shale								
30.08	30.98	0.90	Coal		0.90	0.90					
30.98	31.38	0.40	Carbshale					0.40			
31.38	32.28	0.90	Coal		0.90	0.90					
							Total trial pit excavated Depth (m)	OB(m)	Seam Thickness(m)	Coal (m)	Interburden (m)
							32.28	8.60	23.68	17.63	6.05

Fig. 9-3: Coal Seam Structures as revel in Trial Pit (Pilot mining pit)

9.1.1 Run-of-Mine Coal Characterization

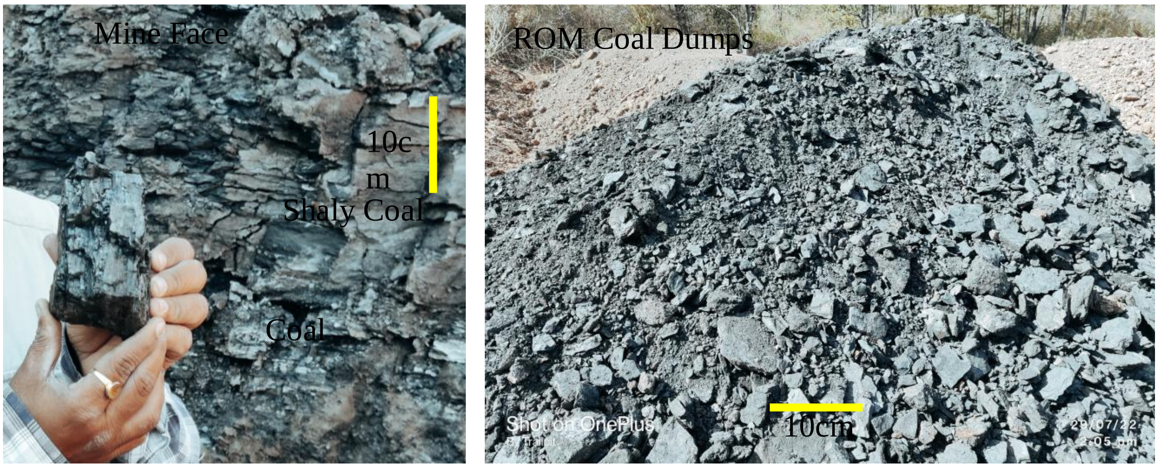


Fig.9-4: Run-of-Mine Coal Characterization

Visual examinations of coking coal dump broken pieces are shown in Fig9-4 and there proportion is given in table below. Coarse of the fraction dirt is more which goes up to 80%.Medium size fragments contain sub-equal amount of coal and dirt. Most of the coal in <1 cm class is vitrain and clarain.Dull coal in the mm scale is Inertinite. Size of the coal and clay particles is an indication that there is a likely to be more near gravity material.

Table 9.1: Size of the coal and clay particles relation

Size Class	**%**	**Coal : Shale**
>50 cm	<5	20:80
50 to 10 cm	20	20:80
10 to 5cm	25	30:70
5 to 1 cm	30	50:50
<1 cm	20	60:40

Deshaling of coal: In any given mining height coal bands constitute up to a maximum of 60 % of coal and 40% of shale. In the deshaling process dirt bands have to be separated out before crushing the coal. A circuit for deshaling process shall be furnished in the following pages. Meanwhile the float sink analysis is detailed in (Table 9.1).

The ROM Coal is sent to coal processing plant. The processing plant principles are coal crushing for liberation and effective separation for coal liberation. The laboratory scale yard-stick for this process is float sink analysis.

The Midwest has conducted float sink analysis collected for samples from exploratory core bores, large dia boreholes and bulk sample from Trail pit. Laboratory level float-Sink analysis have formed base for coal preparation and processing plant flow sheet preparation.

9.2 FLOAT-SINK ANALYSIS

The following salient aspects have been kept in mind while preparing samples for undertaking float-sink tests.

- Ash content in coal beds range from 25 to 50% with a mean ash of 44%. Coal beds are invariably interbedded with carbonaceous mudstone beds that contain ash 55 to 70% with a mean ash of 65%.
- Relative Density (RD) of coal is <1.7 and mean RD of carbonaceous mudstone is 1.9.
- Thickness of coal beds range from 10cm to about 150cm with a mean thickness of ~ 50cm. Similarly, carbonaceous mudstone beds also display sub equal thickness.
- Although the coal beds are targets of exploitation, it is inevitable that some amount of carbonaceous mudstone beds should be mined out along with coal beds during mining.

As a result, some non-coal partings invariably will be added to the coal during mining. Details of the above-mentioned aspects are elaborated in seam structures and coal zone data sheets. For ready reference, Net coal of plant feed ash is considered as 42 - 44% for surface mining method. Whatsoever may be the selective mining method, some amount of dilution is unavoidable. The reported dilution and contamination in selective mining by a surface miner is 7% and the extractable/RoM coal shall contain ~48% ash, say 50%.

9.2.1 Sampling for float-sink testing:

The Midwest sampling pattern has been band-by-band which allows flexibility in the form of ex-band and in-band. Broadly, the float-sink analysis of in-band samples includes the dirt and low carbon bands along with coal in bulk sample which is broadly similar to the RoM coal mined out by traditional bulk mining using dumper and shovel. On the other hand, the float–sink test carried out on ex-band samples broadly correspond to that of RoM coal mined out by selective method using surface miner.

Midwest has so far undertaken float-sink analysis of 101 composite bulk samples from 24 boreholes (Table 9.2).

The number of samples subjected to float-sink tests excluding in-seam partings (ex-band), are 16, while those including in-seam partings (in-band) are 85 samples. Average ash content of ex-band coal is <45%, whereas the in-band coal average ash content for in- band coal ranges from 50% to 55%.

List of boreholes and the number of composite bulk samples subjected to float-sink analysis by Midwest are given below.

Table 9.2: Details of samples for float –sink analysis

S.No	BH no.	# of Composite Samples	Sample Type	Year of Test	Incl - 0.5 mm	Laboratory
1	KBH02	4	Ex-band	2010	No	ACT Tete
2	MDC01	1	Ex-band	2010	No	CIMFR
3	MDC02	2	Ex-band	2010	No	CIMFR
4	MDC04	5	In-band	2010	No	ACT Tete
5	MDC05	1	Ex-band	2010	No	CIMFR
6	MDC06	1	Ex-band	2010	No	CIMFR
7	KBH14	10	In-band	2010	No	ACT Tete
8	KBH45**	1	Ex-band	2010	No	ACT Tete
9	KBH29**	2	Ex-band	2010	No	ACT Tete
10	MDC08	6	In-band	2010	No	ACT Tete
11	CA01	1	In-band	2011	Yes	ACT Tete
12	CA03	1	In-band	2011	Yes	ACT Tete
13	C10	6	In-band	2013	Yes	ACT Tete
14	C16	4	In-band	2013	Yes	ACT Tete
15	C17	6	In-band	2013	Yes	ACT Tete
16	C33	6	In-band	2013	Yes	ACT Tete
17	C34	7	In-band	2013	Yes	ACT Tete
18	C49	13	In-band	2013	Yes	ACT Tete
19	CE14	3	Ex-band	2011	Yes	ACT Tete
20	CC05	1	Ex-band	2012	Yes	ACT Tete
21	CF13	5	In-band	2012	Yes	CIMFR
22	LD01	2	In-band	2012	Yes	ACT SA
23	LD02	3	In-band	2012	Yes	ACT SA
24	Seam Composite	10	In-band	2013	yes	Intertek
	Total	101				

**Limited to floats at an Ash of 10% and 20% only.

The number of ex-band subjected to float-sink tests are 16 samples.

Numbers of in-band samples subjected to float sink tests are 85 samples.

Average ash content of ex-band coal is <45%, whereas the in-band coal average ash content for in- band coal is ~50 to 55%. Standard procedure adopted in coal preparation for float-sink analysis in brief is as follows:

Seam compositing for bulk sample is done from coal plies on proportionate basis in the laboratory and the screen-size analysis has been performed. As far as possible a minimum of 10kg bulk sample was maintained for testing purposes.

- The float-sink analysis is carried out using heavy liquids for the screen size fractions of 13 - 6mm; 6 – 3mm; 3 – 0.5mm separately. Wherever, the facility is available cumulative floats for -0.5mm fraction samples are also determined. Sieve sizes vary from laboratory to laboratory and the comparative sizes are given below (Table 9.3). Float-sink tests for large dia boreholes were done on size fraction of 50-0 mm for in-band coal only at ACT lab, South Africa. .

Table 9.3: size fraction facilities available at different labs

CIMFR NAGPUR	ACT- TETE	ACT- SA(LD)	Intertek
-13 to 6mm	-12.5/11.2 to +6.3mm	-50 + 8 mm	-25 to +8mm
-6 to +3mm	-6.3 to +4.75mm	-8 + 2 mm	-8 + 2 mm
-3 to +0.5mm	-4.75 to +0.5mm	-2 + 0.6 mm	-2 + 0.5 mm
-0.5mm	-0.5mm	-0.6 + 0.25 mm	-0.5 mm
		-025 mm	

- -0.5 mm size wash analysis was not carried out in some of the boreholes (indicated in table) due to unavailability of facilities in Lab.
- Float-sink analysis carried out for fractions of relative densities 1.4, 1.5, 1.6, 1.7, 1.8 and 1.9 and also on 0.5 scale i.e. 1.30, 1.35, 1.4, 1.45 etc. for few samples on 0.25 scale i.e. 1.3, 1.325, 1.35, 1.375, 1.4, 1.425, 1.45 etc.

9.2.2 Size Fractions

Size fraction analysis based on large dia samples.

The Wet Tumble for LD01 and LD02 in-band samples is as follows.

Top Size 50mm

Size Fraction	Weight%
-50 + 8 mm	68.9%
-8 + 2 mm	14.1%
-2 + 0.6 mm	9.9%
-0.6 + 0.25 mm	2.9%
-0.25 + 0.075 mm	2.1%
-0.075 mm	2.2%
Loss	0.7%
TOTAL	100.0%

In case, the selective mining method is followed by surface miner, the top size of RoM coal is less than 100mm. This ROM coal when crushed to <12mm top size, the expected proportion of resultant size fraction is as follows.

Top Size 12 mm

SIZE mm	Weight%
12-6	53.7
6-3	18.7
3-0.5	20.0
-0.5	7.6
TOTAL	100.0

Other top size fraction analysis

Top Size 6 mm

SIZE mm	Weight%
6-3	50.26
3-0.5	35.60
-0.5	14.13
TOTAL	100.0

Top Size 3 mm

S. N0.	Size mm	Weight%
1	3-0.5	74.6
4	-0.5	25.4
5	TOTAL	100.0

9.2.3 Size Fractions Yields

The samples are categorized (grouped) based on the top size, yields and Head ash% are plotted in the graphs shown below (Fig.9-5).

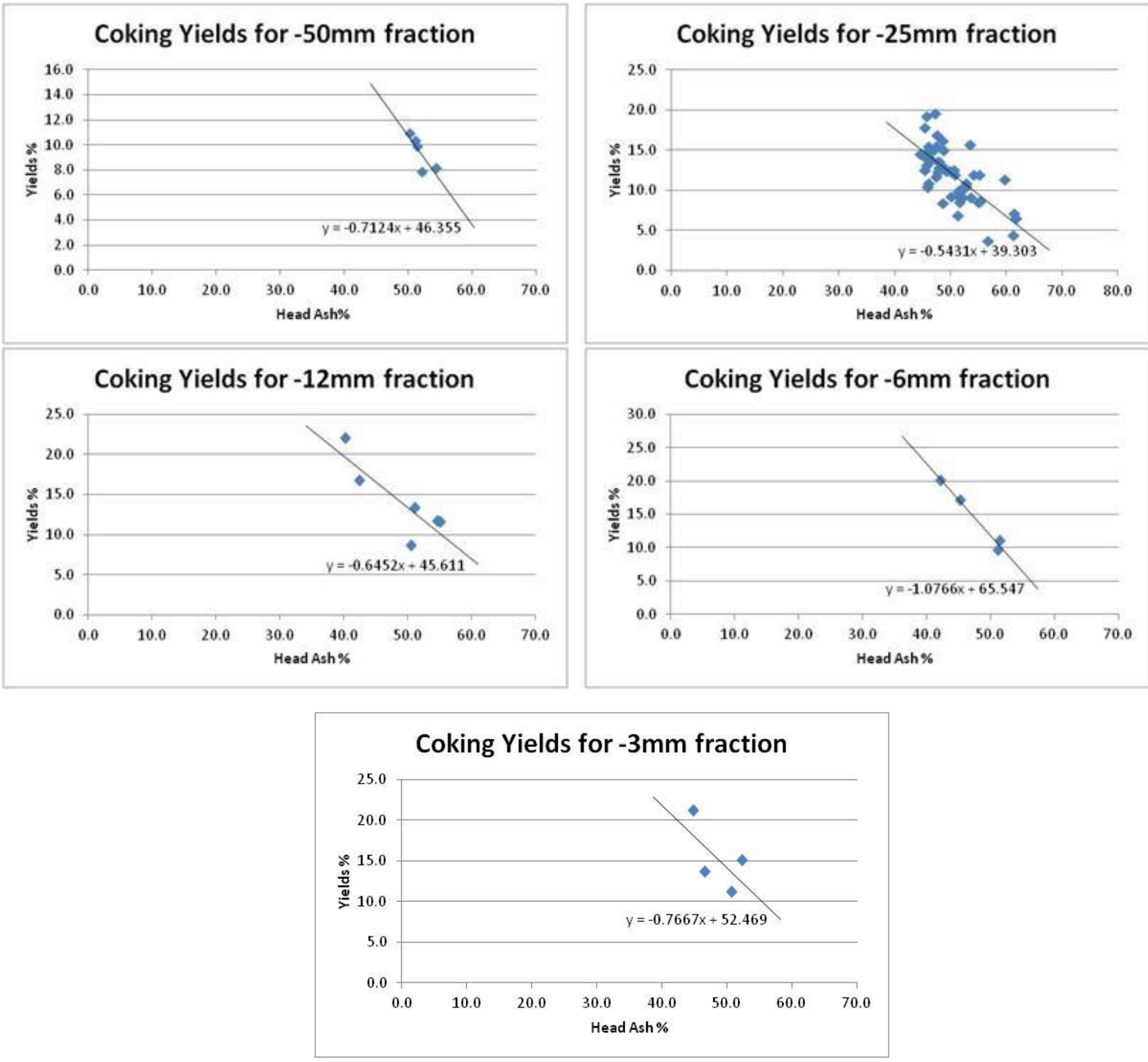


Fig. 9-5: Regression plots of cumulative yields for various top size fractions

Each sample is having different Head Ash% which is a prime factor for variation in yields. It is also noted that each size fraction has shown different yields. The each category of size fraction is plotted on graph and drawn a trend line to derive at yields at specific Head Ash%. Summary datasheet is shown in Table 9.4.

Table 9.4: Cumulative yields at various size fractions & Ash contents

Head Ash % (input)	Size Fractions	Estimated Coking Coal Yield %	Estimated Export Thermal Yield %	Estimated Domestic Thermal Yield %
35	-50mm	21.4	7.9	44.7
	-25mm	20.3	11.3	57.7
	-12mm	23.0	12.0	52.6
	-6mm	27.9	5.9	74.4
	-3mm	25.6	6.6	57.9
40	-50mm	17.9	8.6	39.8
	-25mm	17.6	9.3	50.9
	-12mm	19.8	10.6	45.5
	-6mm	22.5	6.2	61.2
	-3mm	21.8	6.7	48.6
45	-50mm	14.3	9.2	35.0
	-25mm	14.9	7.3	44.2
	-12mm	16.6	9.2	38.3
	-6mm	17.1	6.5	47.9
	-3mm	18.0	6.9	39.4
50	-50mm	10.7	9.9	30.1
	-25mm	12.1	5.3	37.4
	-12mm	13.4	7.9	31.2
	-6mm	11.7	6.8	34.7
	-3mm	14.1	7.0	30.1
55	-50mm	7.2	10.6	25.3
	-25mm	9.4	3.3	30.7
	-12mm	10.1	6.5	24.0
	-6mm	6.3	7.1	21.4
	-3mm	10.3	7.2	20.8

9.3 CUMULATIVE WASHABILITY OF ALL SAMPLES WITH DIFFERENT TOP SIZE FRACTIONS

Following are the washability results of all samples where -0.5 size analysis was included are plotted against head ash% (Figs. 9-6 & 9-7).

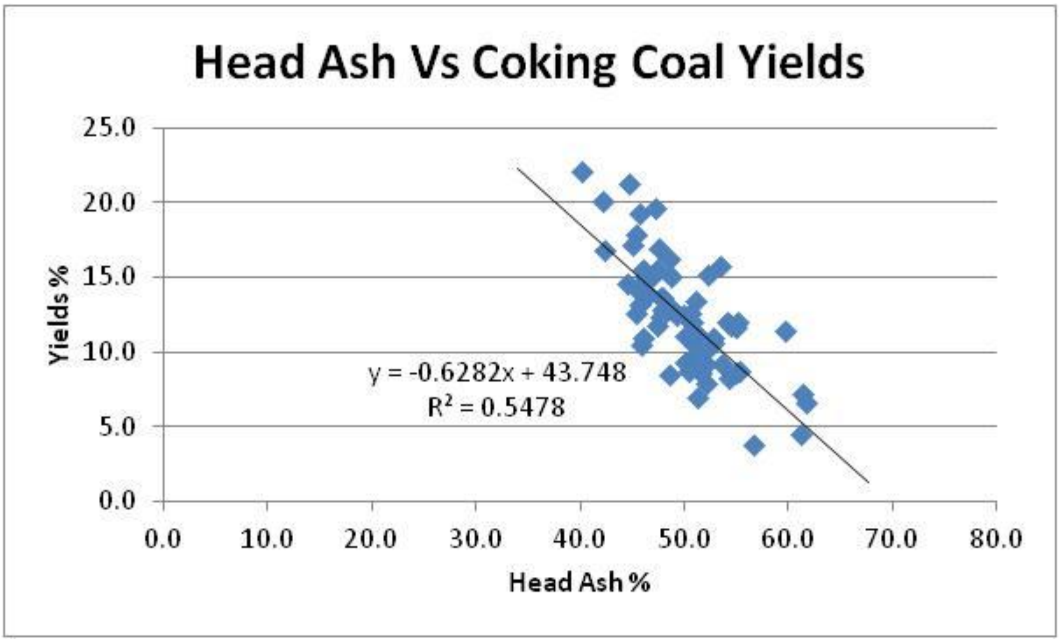


Fig. 9-6: Head Ash vs coking coal yields regression

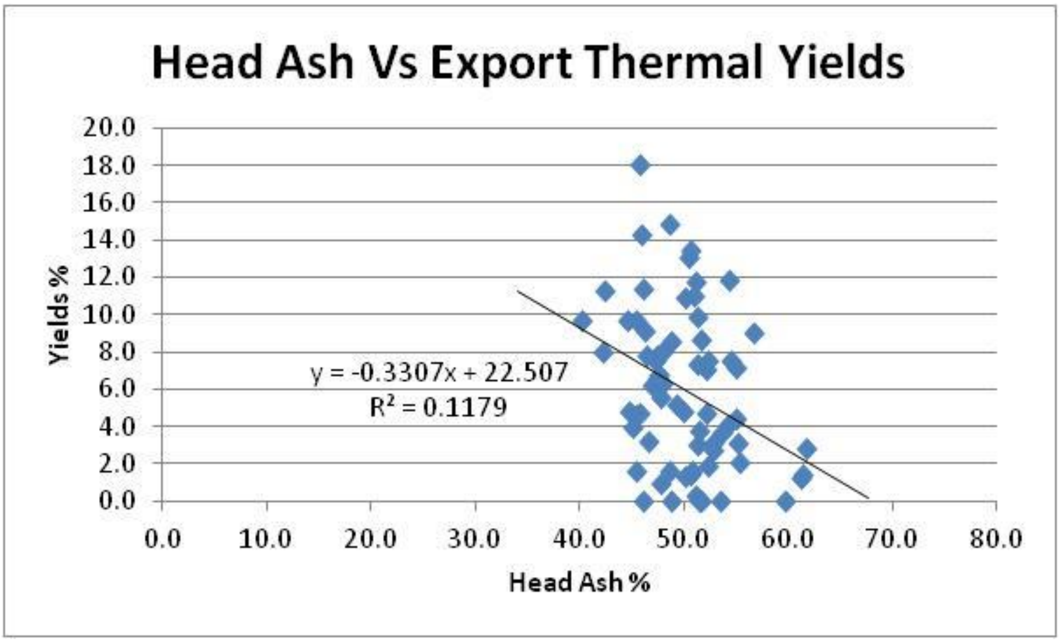


Fig. 9-7: Head Ash vs Export Thermal Coal Yields linear regression

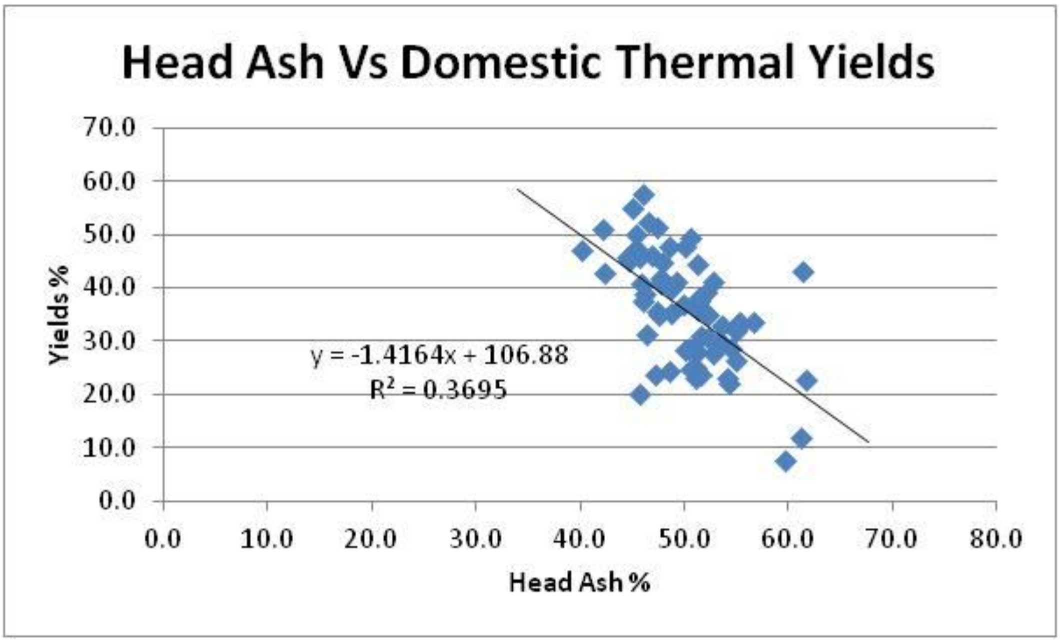


Figure 9-8: Head Ash vs Domestic Thermal Coal Yields linear regression

The above regression plots show wide dispersal and nominal coefficient values indicating inconsistency in coal product yields. This is attributed to the fact that the Midwest had undertaken float-sink tests at different size ranges in different laboratories over a long span of three years. Besides, another reason could be coal seams at different locations of the deposit have responded differently to liberation process. This point needs to be addressed in course of mining.

Based on the linear regression graphs shown in Figs. 9-6 to 9-8, the following provisional yields are derived at different feed ash levels (Table 9.5).

Table 9.5: Summary of theoretical yields for Midwest coal

Head Ash % (input)	**Estimated Coking Coal Yield %@10%ash**	**Estimated Export Thermal Yield %@25% ash**	**Estimated Domestic Thermal Yield %@45% ash**
35	20-22	11-12	50-57
40	19-21	10-11	41-48
45	17-20	9-10	35-43
50	10-12	6-9	30-36
55	7-10	4-7	25- 29.

The following inferences are drawn from the summary of the above observations

- On selective mining, the maximum yields of coking coal is proportionately considered to be 18% to 20%, Export Thermal Coal is 7 to 10% and domestic thermal 39.4%.
- On Bulk mining the maximum yields of Coking coal is 10.3%, Export Thermal Coal is 7 to 12% and domestic thermal 20.8%.

The float-sink test data collected by the Midwest, so far, are of indicative nature only. However, the following areas need adequate attention during feasibility study.

Gaps in float–sink tests are addressed in feasibility study

- Seam-wise characterization of cumulative float yields.
- Until now, there are instances where the sample volume falls short of minimum sample weight required for float sink analysis. This should be avoided in the next level of work.
- All the large dia core samples during feasibility stage are subjected to detailed float-sink studies, so that the seam-level yield characterisation is made. Data collected for size fraction of 0.05 intervals would provide right information for increasing the precision of wash plant flow sheet.
- Cumulative float yields modelling should be undertaken on Minex for creating baseline information for achieving grade control during mining.
- The CP has opined the computer aided simulation studies and flow chart preparation would fulfil the minimum requirement in the Engineering study stage of the project.

9.3.1 Large Dia Borehole:

The float sink analysis data of **LD-01-**1 have been reviewed byqualified subject expert**:**

1. **Size Analysis (Table 9.6)**

Table 9.6: Size analysis

Size, mm	**wt%**	**Ash%**
50 - 8	76.2	56.4
8 - 2	13.3	49.7
2 - 0.6	6.0	36.3
0.6 - 0.25	2.6	33.4
0.25 - 0.075	1.2	34.5
-0.075	0.7	43.7
	100	53.4

50 - 8	76.2	56.4
8 - 0.25	21.9	44.1
-0.25	1.9	38.0

The feed ash content is as high as **53.4%.** From the size analysis data it may be observed that the fraction 50 – 8mm yield is very high (76.2%) and the ash content of 56.4% is on the higher side. The ash content is reducing with decrease in the size, however it may be observed that the fraction -0.075mm ash content is high, which may be due to very fine clay content of the sample.

2. **Size wise Float and sink data (Table 9.7)**

Table 9.7: Size wise float and sink data

Size, mm	**50 - 8**		**8 - 2**		**2 - 0.6**		**0.6 - 0.25**	
	Wt%	Ash%	Wt%	Ash%	Wt%	Ash%	Wt%	Ash%
Sp. Gr.	76.2	55.7	13.3	51.1	6.0	35.8	2.6	32.1
<1.40	0.1	6.5	5.7	2.0	23.6	1.8	28.4	1.8
1.40-1.50	3.4	15.8	6.8	13.9	9.9	7.9	13.1	8.9
1.50-1.60	7.4	25.1	8.6	24.1	9.5	18.4	7.8	19.3
1.60-1.70	9.5	34.8	8.7	33.6	5.2	29.9	5.3	29.5
1.70-1.80	10.7	42.8	8.2	41.7	6.5	38.7	4.5	37.8
1.80-1.90	11.9	49.3	7.2	48.5	7.0	47.1	4.5	44.6
1.90-2.00	20.2	57.6	17.8	56.1	11.5	55.2	8.4	53.8
>2.00	36.8	75.8	37.0	76.1	26.8	71.5	28.0	68.4
	100.0	55.7	100.0	51.1	100.0	35.8	100.0	32.1

The size wise float and sink data reveals that in the case of the size 50 – 8mm, more than 50% of the material is reported above 1.9 specific gravity having very high ash content, the washability characteristics are also poor.

3. Washability data of the fraction 50 – 0.25 mm (Table 9.8)

Table 9.8: Washability data of the fraction 50 – 0.25 mm

Sp.Gr	Wt%	Ash%	Cum. Float		Cum. Sink		Ch. Wt%	Mayer's pt.value
			Wt.%	Ash%	Wt.%	Ash%		
<1.40	3.0	2.0	3.0	2.0	97.0	54.8	1.5	0.1
1.40-1.50	4.5	13.8	7.6	9.0	92.4	56.8	5.3	0.7
1.50-1.60	7.7	24.3	15.3	16.7	84.7	59.8	11.4	2.6
1.60-1.70	9.0	34.4	24.3	23.3	75.7	62.8	19.8	5.7
1.70-1.80	9.9	42.5	34.2	28.9	65.8	65.9	29.3	9.9
1.80-1.90	10.8	49.1	45.0	33.7	55.0	69.2	39.6	15.2
1.90-2.00	19.0	57.3	64.0	40.7	36.0	75.5	54.5	26.1
>2.00	36.0	75.5	100.0	53.2			82.0	53.2
	100.0							

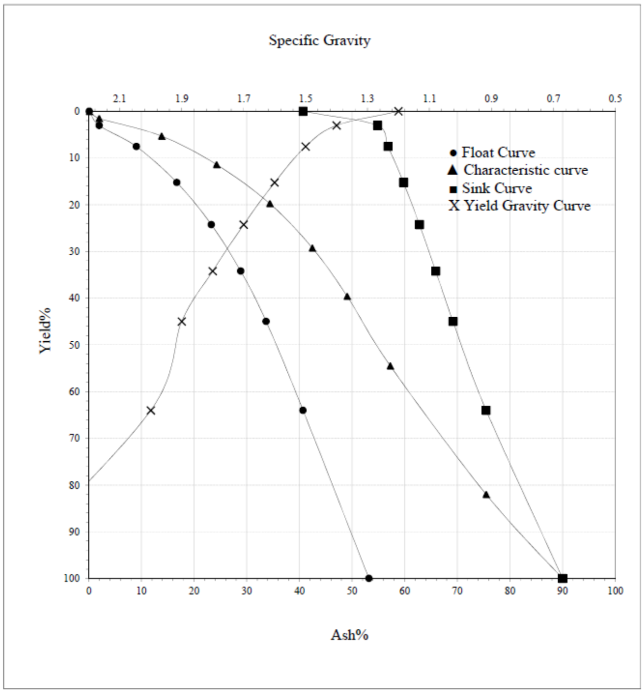


Fig.9-9: Washability Curves of corebore samples

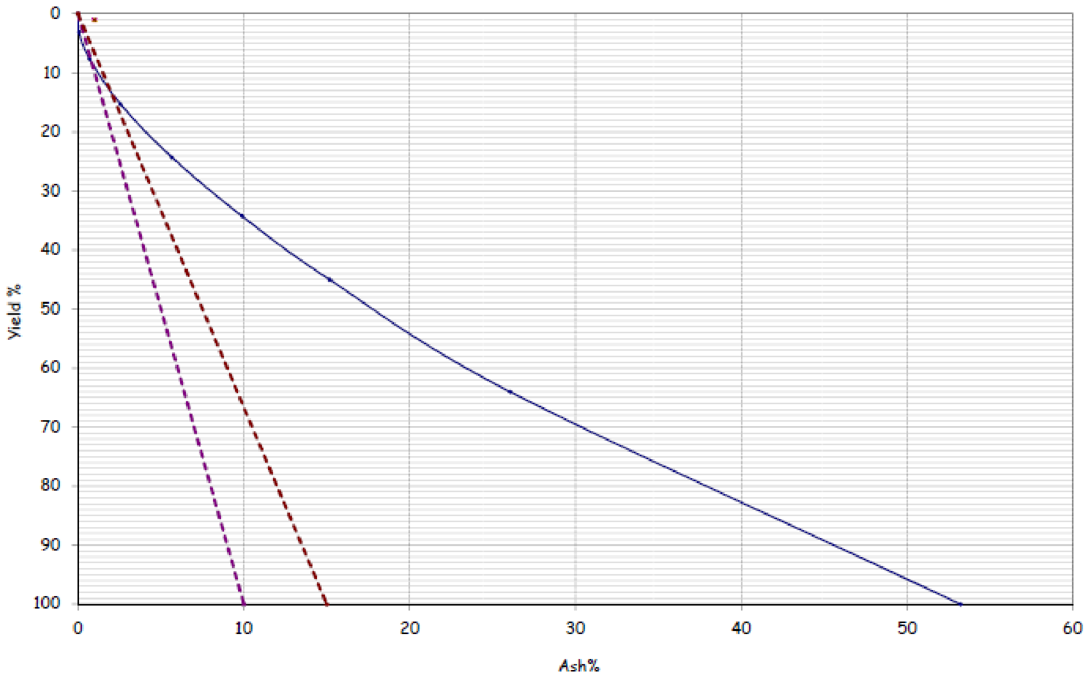


Fig.9-10: Mayer Curve of corebore samples

Clean coal recoveries: size – 50 + 0.25mm

No	cut gravity	Cl Yld%	Ash%	Rj Yld	Rj Ash%
1	1.510	8.1	9.8	91.8	57.1
2	1.550	11.0	13.0	88.9	58.3
3	1.575	13.1	14.9	86.8	59.1
4	1.605	15.6	17.2	84.3	60.0
5	1.645	19.1	19.9	80.8	61.2
6	1.680	22.3	22.1	77.6	62.2
7	1.730	27.2	25.1	72.7	63.8
8	1.825	36.4	30.1	63.5	66.6
9	1.920	48.1	35.0	51.8	70.3
10	1.990	61.9	40.0	38.0	74.8

Views:

From the washability data of the fraction 50 – 8 mm it was observed that it is difficult to achieve appreciable coking coal recoveries at ash content of 10 to 13 percent. Even at 25 percent ash content the recoveries are low. The fraction may be used for power generation after beneficiation.

The fraction – 8 + 0.25 mm may be used for coking coal beneficiation

9.4 FLOAT SINK ANALYSIS OF TRIAL PIT SAMPLES

9.4.1 Sampling for float-sink testing:

The entire cross section of the seam was sampled on mine cut face. A total of about 100 tons was collected. This was mixed thoroughly and about 10 tons was sampled and collected for detailed study. The Midwest sampling pattern has been with the total coal as bulk sample which is broadly similar to the RoM coal mined out by traditional bulk mining using dumper and shovel.

9.4.2 Analytical procedure:

Standard procedure adopted in coal preparation for float-sink analysis in brief is as follows:

- The float-sink analysis is carried out using heavy liquids for the screen size fractions of -50 to + 25 mm; -25-+ 12.5 mm; 12.5 – 6mm; 6 – 3mm and 3 – 0.5mm separately. The -0.5mm fraction samples was subjected to sieve analysis and laboratory flotation tests (Table 8.9).
- Float-sink analysis carried out for fractions of relative densities 1.4, 1.5, 1.6, 1.7, 1.8, 1.9 and 2.0.

9.4.3 Size fractions & proportions:

It is well known that the size of a coal generally influences its washability characteristics. It is, therefore, expected that the various parameters used to define the washability characteristics of any coal should vary with the size of screening and size of crushing the coal. Size fractions derived by crushing the raw coal at 50 mm are as follows.

Table 9.9: Size analysis of ROM coal crushed at 50 mm

Size in mm	Wt%
-50+25	30.1
-25+12.5	21.5
12.5+6	15.2
-6+3	7.9
-3+0.5	16.6
-0.5	8.6
	100.0
-50+12.5	51.7
-12.5 + 0.5	39.7
-0.5	8.6

9.4.4 Coal Washabilitytests and Curves

Based on Float-sink test data, the following curves have been derived for estimating theoretical coal yields. Washability and Mayers curves developed for the samples collected from the trial pit and are presented in Figs.9-9 to 9-10 for corebore samples. Washability curves for trail pit samples is given in Figs. 9-11 to 9-15.

1. The Cumulative Floats Curve

The Cumulative floats curve shows the relationship between the yield of cleaned coal and the ash of that coal. Consequently, if the ash is known then the yield (the cumulative mass % floats) can be found from the graph. Conversely, if the yield is known then the corresponding ash value can be found from the graph.

2. The Cumulative Sinks Curve

The cumulative sinks curve gives the relationship between the yield or percentage of sinks and the ash content of the sinks. If the yield of sinks is known, (Usually from 100% minus percentage of floats) then the ash of the sinks can be found from the graph. Conversely, if the ash of the sinks is known then the yield of sinks (the cumulative mass % sinks) can be found from the graph. The cumulative sinks curve is mainly used in conjunction with the cumulative floats curve.

3. The Relative Density Curve

The relative density curve shows the relationship between the relative density of the separation and the theoretical yield of clean (floats) coal. The relative density curve is used in conjunction with the previous curves in that, given any relative density of separation, then the yields of floats ad sinks can be read from the graph, together with the corresponding ash. Conversely, given the ash of a float coal, then the relative density required for separation may be determined.

4. The instantaneous Ash Curve.

The instantaneous ash curve gives the relationship between the yield of floats and the ash percentage of a particle that just floats or just sinks at that yield. It gives the ash of the particle which has the highest ash in the floats product and/or the lowest ash of any particle contained in the sinks product. Again, the instantaneous ash curve can be used with the previous curves, the relative density curve, the cumulative floats curve and the cumulative sinks curve.

5. Mayers Curve

The Mayer curve, known as the m-curve, is a method of plotting float-and-sink analysis to predict the results of cleaning properties of coal in a three-component system. The method was first described by F.W.Mayer in 1950 and applications of the method were discussed by him in 1956 and 1957. It is a useful tool to predict cleaning properties of a three-product separation wherein clean coal and middling can be predicted for the required ash percentages of clean coal and refuse. It can also be used in predicting cleaning properties of a product mixture resulting from blending a cleaned coal with un-cleaned coal, or blending two different plant clean coal products.

9.4.5 Combined Curves Graph

All the curves described above are related and termed Washability Curves. The washability curves show the cumulative floats curve, the cumulative sinks curve, the relative density curve, the instantaneous ash curve and the $\pm$ relative density curve, note, that the cumulative mass % floats scale on the left-hand side applies to all the curves except the sinks Curve, which has the cumulative mass % sinks on the right-hand scale. The horizontal ash % scale applies to all curves except the relative density curves which have a separate horizontal scale.

The advantages of the combined curves graph are that if one fact is known from among the following

Yield of floats (Cumulative mass % floats),
Yield of sinks (Cumulative mass % Sinks),
Ash of the floats or,
Ash of the sinks.

Size wise Washability and Mayer curves for sample collected for Trail Pit:

The size wise fraction was subjected to float and sin test and the washability and Mayers curves are drawn and depicted in Figs 9-11 to 9-15.

● Float Curve
▲ Characteristic curve
■ Sink Curve
X Yield Gravity Curve

Fig.9-11: Washability and Mayers Curve for the fraction 50-25mm

● Float Curve
▲ Characteristic curve
■ Sink Curve
X Yield Gravity Curve

Fig. 9-12: Washability and Mayers Curve for the fraction 25 – 12.5 mm

● Float Curve
▲ Characteristic curve
■ Sink Curve
X Yield Gravity Curve

Fig. 9-13: Washability and Mayers Curve for the fraction 12.5 – 6 mm

● Float Curve
▲ Characteristic curve
■ Sink Curve
X Yield Gravity Curve

Fig. 9-14: Washability and Mayers Curve for the fraction 6 – 3 mm

● Float Curve
▲ Characteristic curve
■ Sink Curve
X Yield Gravity Curve

Fig. 9-15: Washability and Mayers Curve for the fraction 3- 0.5 mm

9.5 COAL FINES:

The coal fines (-0.5mm) were subjected to sieve analysis and standard laboratory flotation tests. The coal fines were tested at sizes 0.212 mm, 0.075mm and 0.045 mm (Table 9.10). The individual size fractions were further analyzed for moisture and ash content.

Table 9.10: Sieve Analysis of coal fines

Size in mm	Wt%
-0.5+0.212	40.5
-0.212+0.075	26.0
-0.075+0.045	8.2
-0.045	25.4
	100.0

The coal fines are subjected to laboratory flotation test and batch flotation studies were carried out in Denver D12 sub aeration flotation machine, with a cell capacity of 2.5 L. The studies were carried out keeping the normal collector and frother dosage. The rpm was kept constant at 1500 for each test. The required quantity of sample was taken and conditioned with required amount of collector at 40% solids concentration for 2 minutes. Then the slurry was adjusted to 10% solids concentration by adding fresh water and then frother was added and further conditioned for one more minute. The aeration was started by opening the air valve and the froth floated as concentrate was collected at different time intervals, dewatered, dried and weighed. The air dried concentrate/clean were sub sampled and ash content of each sample was determined.

It may be observed from the Fig. 8-16 that the response to flotation is poor indicating the poor floatability characteristics of the coal fines. The ash content is very high at C1 which indicates that the slimes in the form of clay is reported to the C1 increasing the ash content. It is next to impossible to achieve clean coal ash content of less than 13% by using mechanical flotation cells.The CP has noted variations in fine coal analysis of large dia boreholes given in Annexure-VIII and opined that it could due to procedure variations.Because the floation procudre to be standerised as most of the fine coking coal consists of vitrain.The fine coal fraction is effectively won by the other processing plants operating the area like Valey,Coal India and JSPL whose yields are reported at 25 to 28% of coal recovery.

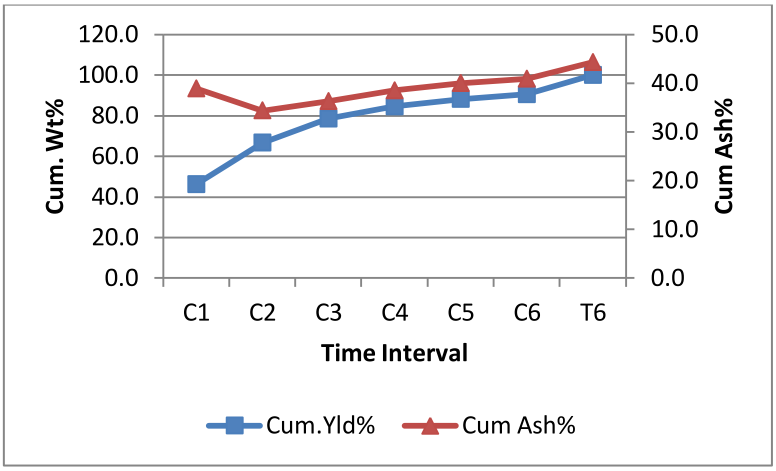


Fig. 9-16: Laboratory flotation of coal fines

9.6 THEORETICAL COAL PRODUCT YIELDS (Table 9.11)

Based on the washability of individual size fractions the theoretical yields at the specified ash content was estimated. Each sample is having a different head Ash% which is a prime factor for variation in yields. It is also noted that each size fraction has shown different yields.

Table 9.11: Theoretical Yield% of Various Size Fractions and Ash Contents

Head Ash % (input)	Size Fractions	Estimated Coking Coal Yield % (13% ash)	Estimated Export Thermal Yield % at 30% Ash
47	-50mm + 25mm	0.0	21.6
	-25 + 12.5mm	7.7	38.3
	-12.5 + 6mm	15.4	40.5
	-6 + 3mm	25.6	35.0
	-3 + 0.5mm	48.7	6.2

Size ranges of the export coking coal at Nacala and Baira Ports and likely yield of Midwest coking coal fractions is given in the following Table 9.12.

Table 9.12: Size Ranges of Vale Export Coal Vs Midwest

Size Fraction (mm)	Vale (%) @ Beira FOB	Midwest (approx %)
+50	1	~1
50-32	4	~4
32-25	1.3	~2
25-4	33.7	~13
4-1	34.5	~40
1-0.5	18.1	
0.5-0.25	5.6	~40
-0.25	1.8	

The following inferences are drawn from the summary of the above observations

- The yield% of coking coal increased with decrease in the particle size and for the size fraction -50 + 25mm there is practically no coking coal yield at 13% ash content.
- The yield% of thermal coal at 30% ash content is on the higher side up to the size fraction of 3mm. The fraction below 3 mm the yield% is less.
- The coal fines did not respond to flotation as the floatability characteristics are poor. The usability of these coal fines is to deslime in a two product classifying cyclone the overflow fraction may be sent to thickener for recovery of water while the underflow may be treated in high speed screens or spirals for additional recovery of power grade coal. Another option is to classify the fines at 0.212 mm and the fraction -0.5 + 0.212 mm may be subjected to reflux classifier for additional recovery of coking/power coal. The – 0.212 mm may be sent to the thickener for recovery of water.
- Based on the washability studies of the individual size fraction and the theoretical yield% of coking and thermal coal it was opined to go for a hybrid coal washing circuit wherein the coarser fraction viz., 50-20/12.5mm may be deshaled at 19 specific gravity and the deshaled clean coal may be subjected for beneficiation to recover thermal coal. While the smaller fraction viz., 20/12.5 – 0.5mm may be deshaled at 1.9 specific gravity and the deshaled clean coal be subjected to beneficiation to recover coking coal cleans. The crushing and deshaling may be at the mine end so that bulk of the rejects may be disposed at the mine head, which will not only reduce the quantum of rejects in the beneficiation circuit but also reduce the logistics problem.

The float-sink test data is of indicative nature only based on the feed ash%, if the feed ash percent is improved the corresponding clean coking coal and thermal coal yields will increase. However, the data profile is adequate enough to prepare conceptual plant flow sheet.

9.7 DESHALING(Table 9.13)

The size fraction 50-12.5mm, that more than 60% of the material is reporting to the >1.90 specific gravity with ash content of above 75%. Similarly,the size fraction 12.5 – 0.5mm that more than 50% of the material is reporting to the >1.90 specific gravity with high ash content. This material may be discarded at the mine site itself by deshaling it in a suitable Jig equipment. Table 8.13 shows the deshaling of both the sized coals at 1.9 specific gravity.

Table 9.13: Deshaling of sized coal

	Sp.gravity	**Cleans**		**Rejects**	
Size, mm		Wt%	Ash%	Wt%	Ash%
50-12.5	1.9	32.3	36.8	67.7	77.6
12.5-0.5	1.9	44.9	26.4	55.1	75.9

9.8 COAL BENEFICIATION

After initial deshaling of the coal fractions viz., 50-12.5mm and 12.5-0.5mm, it is now mandatory to further beneficiate it to achieve the clean coking coal and thermal coal at requisite ash content. Both the deshaled clean coal of size -50 + 12.5 mm and 12.5 – 0.5mm was further subjected to float and sink test and the washability and Mayers curve are depicted in Fig. 9-17 & 9-18.

Based on the washability and Mayers curve as depicted in Fig. 9-17 for the size fraction 50 – 12.5mm, the theoretical recoveries for the thermal grade coals was estimated (Table 9.14 & 9.15).

Similarly based on the washability and Mayers curve as depicted in Fig. 9-18, the theoretical recoveries for the coking coal grade coals was estimated and the same is shown in (Table 9.14 & 9.15).

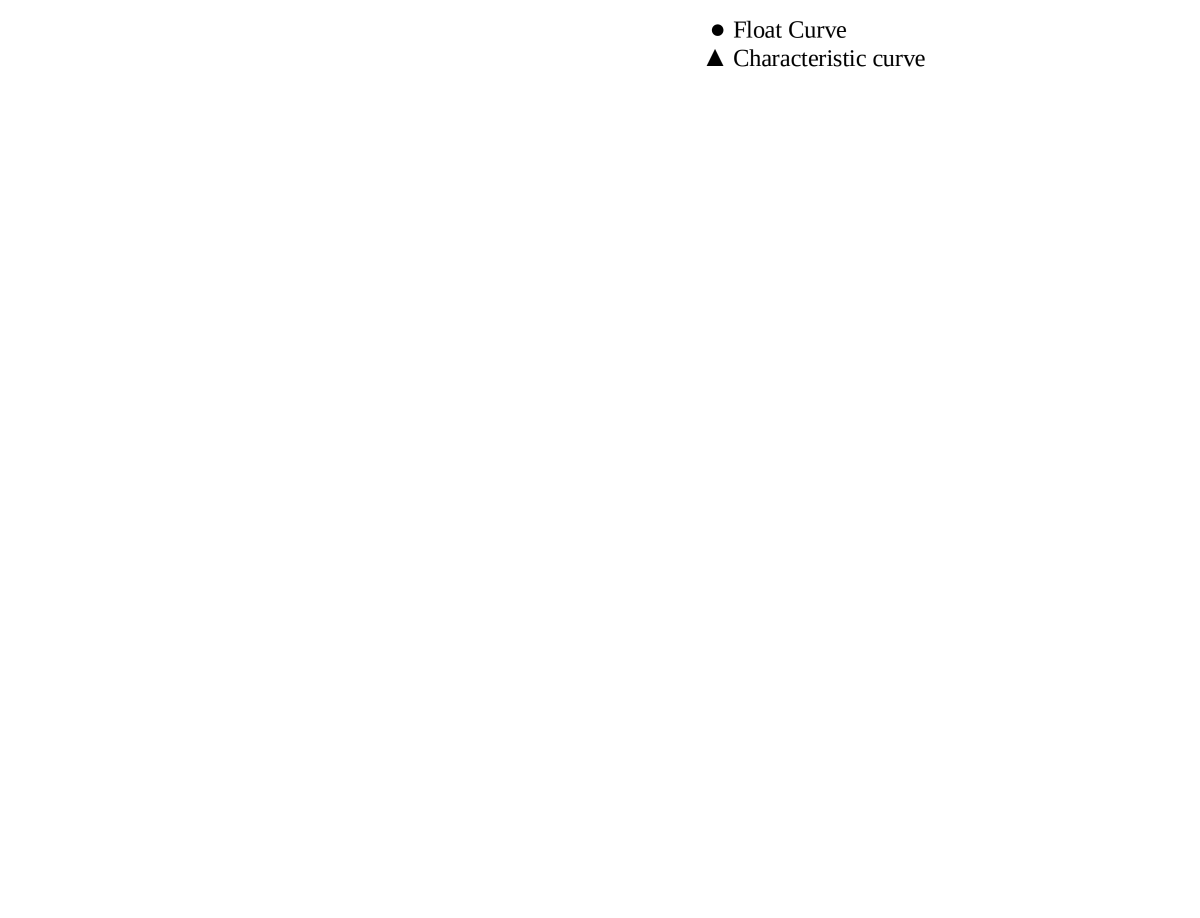


Fig. 9-17: Washability and Mayers curve for deshaled cleans (-50+12.5mm)

● Float Curve
▲ Characteristic curve
■ Sink Curve
X Yield Gravity Curve

Figure 9-18: Washability and Mayers curve for deshaled cleans (-12.5 + 0.5 mm)

Table 9.14: Theoretical recoveries for power grade coal (-50+12.5mm)

Specific Gravity of Cut	Cleans		Rejects	
	Wt%	Ash%	Wt%	Ash%
1.56	30.7	23.0	69.3	45.8
1.59	37.8	25.0	62.2	47.2
1.70	60.6	30.0	39.4	52.3

Table 9.15: Theoretical recoveries for coking grade coal (-12.5 + 0.5mm)

Specific Gravity of Cut	Cleans		Rejects	
	Wt%	Ash%	Wt%	Ash%
1.47	44.2	10.0	55.8	42.0
1.53	54.9	11.5	45.1	47.7
1.58	61.2	13.0	38.8	51.2

9.9 GENERATION OF CLEAN COKING COAL FOR CHARACTERIZATION

Based on the detailed washability studies, the fraction -12.5+0.5mm was subjected to separation based on the specific gravity of cut and the clean coal was subjected to different characterization tests. The characterization test results are shown in Table 9.16 & 9.17.

Table 9.16: Characterization of coking coal cleans w.r.t proximate, petrography, V type distribution

Sample Details		Cleans
1	Proximate Analysis	
	Moisture %	1.4
	Volatile Matter, %	34.1
	Ash %	9.4
	Fixed Carbon, %	55.1
2	Petrograghy	
	Vitrinite	87.6
	Exinte	0.7
	Reactive Semifusinite	1.0
	Inert semifusinite	4.0
	Fusinite + Secretinite	1.2
	Micrinite	0.0
	Minerals	5.5
	Ro	0.91
3	Vitrinite Classes	
	V7	4
	V8	39
	V9	48
	V10	9

Table 9.17: Characterization of coking coal cleans w.r.t Carbonization, Gieseler Plastometer, Dilatometer

Sample Details		Cleans
1	Carbonization	
	CSN	9
	Roga Index	86
	LTGK	G11
2	Gieseler Plastometer	
	Initial Soft. Deg, C	390
	Fusion, Deg, C	398
	Max. Fluidity, Deg, C	438.0
	Max. Fluidity dd/m	7079.0
	Max. Fluidity, log	3850
	Solid. Deg, C	478.0
	Plastic Range, Deg, C	88
3	Dilatometer	
	Initial Soft. Deg, C	352
	Max. Cont. Deg, C	389
	Max. Dil. Deg, C	466
	Max. Cont. %	18
	Max. Dil. %	236

9.10 GENERATION OF THERMAL COAL FOR CHARACTERIZATION

Based on the detailed washability studies, the fraction -50 + 12.5 mm was subjected to separation at RB4 (30% clean coal ash content) based on the specific gravity of cut and the clean coal was subjected to different characterization tests. The characterization test results are shown in Table 9.18.

Table 9.18: Characterization of power coal cleans w.r.t proximate, AFT and others

Sample Details		Thermal
1	Proximate Analysis (ad basis)	
	Moisture %	1.1
	Volatile Matter, %	26.7
	Ash %	30.4
	Fixed Carbon, %	41.8
2	Other	
	GCV, kcal/kg	5221
	HGI	51
	Abrasion Index	205.0
3	AFT (oxidizing) degree cent.	
	Deformation	1470
	Spherical	1490.0
	Hemisphere	>1500
	Flow	>1500
4	AFT (reducing) degree cent.	
	Deformation	1400
	Spherical	1450
	Hemisphere	1480
	Flow	>1500

9.11 FLOW SHEET DEVELOPMENT

Coal Washing or preparation covers all aspects of preparing run of mine (ROM) coal for the end user and can be broadly defined as the deliberate modification of the properties of the run of mine coal when it passes along the chain from mine to end user, in order to meet end use quality specification and constraints of the transportation and handling systems.

Preparation includes treatment step of size reduction, blending, sizing, physical beneficiation and dewatering. Main aim of washing is to generate product of consistent quality as per specification with consistent recovery. The degree of processing will depend on the coal quality and cost of processing will rise rapidly with the complexity of processing approach.

Coal preparation and processing are based on principles of gravity separation. Current level of Float-sink tests data has provided basic information on cumulative yields at different size fractions at various ash levels. The process proposed is two stage separation one is crushing and deshaling of the coal at the mine head and the other is beneficiation of the deshaled clean coal for achieving desired saleable products in market for Coking coal ~ 13% ash and Export Thermal coal ~ 30% ash to feed into boilers.

Recovery percentages of saleable coal products are dependent on plant feed /throughput ash levels size ranges as well as plant efficiency. Selective mining method as envisaged in provides ROM coal top size of ~ 200mm and ROM coal ash of 47 %. Summation of laboratory level technical studies on size-wise analysis and fractional -yields have revealed that coal of size 50-12.5mm may be beneficiated to achieve thermal coal. The fraction 12.5-05mm data may be used for coking coal beneficiation.

9.11.1 Size fraction requirements:

The projected range of fine coal of less than 0.5 mm size may not exceed 10-15% which indicates that there is no need to make extra provision of treatment of ultrafine material. Treatment of ultrafine coal by flotation is an expensive process. This translates to higher capital and operation cost as ultra-fine particles are more expensive to process. The studies on the coal fines indicated that it may be classified at 0.25mm and the fraction -0.5+0.25mm may be either washed in spiral or reflux classifier to get additional clean coal.

9.12 PROCESS SELECTION AND FLOW SHEET

The targeted RoM production is 5 million per annum for crushing and deshaling and 2.5 million per annum which warrants erection of a regular washery at pit head. This plant is expected to deliver washed coking coal product and second exportable coal for thermal use and waste.

9.13 CHPP FLOW SHEET BY ABHIK MUKHOPADHYAYA (2013-14)

Coal preparation and processing are based on principles of gravity separation. Current level of Float-sink tests data has provided basic information on cumulative yields at different size fractions at various ash levels. The process proposed is two stage separation.

MAL has hired Ms.A.Mukhopadhyaya & Associates, a CHPP consulting firm based in Kolkata to prepare a process-flow sheet for cleaning the raw coal to produce the maximum possible recovery of coking coal meant for sea borne trade. The coal is considered to be a refractory feed requiring multiple intensive processing steps to achieve maximum possible recovery of saleable coal products from the ROM coal throughput into the preparation plant.

Desired saleable products in market are Coking coal ~ 10% ash and Export Thermal coal ~ 21% ash to feed into boilers.

Recovery percentages of saleable coal products are dependent on plant feed /throughput ash levels size ranges as well as plant efficiency. Selective mining method as envisaged in chapter 9 provides ROM coal top size of ~ 100mm and ROM coal ash of 47 %(see chapter 7. Summation of laboratory level technical studies on sieve-size analysis and fractional -yields have revealed coal liberation potential is high in <50 mm top size and optimum in case the coal is prepared to 25 / 12 mm top size. Current data shows that the coking coal recoveries hover around 15% once the feed ash content goes above 50%. Scatter plot of wash yields show random distribution of scatter points indicating lateral variation in coal liberation which will be taken care by quality control and RoM quality optimization during mining stage. Recent advancements in coal liberation and separation should be taken into consideration while preparing CHPP flow sheet.

9.13.1 Size fraction requirements:

The projected range of fine coal of less than 1mm size may not exceed 15-25% which indicates that there is no need to make extra provision of treatment of ultrafine material. Treatment of ultrafine coal by flotation is an expensive process. This translates to higher capital and operation cost as ultra-fine particles are more expensive to process. As there is a limitation on number of data sets available on sieve fractions of -0.5mm, Decision on top size crushing will be taken up after preparation of Cumulative size distribution plots and also log-log plot. It is suggested that the Midwest should undertake more sieve size distribution study during feasibility study stage and trial pit stage but before finalization of the CHPP process flow chart for wash plant.

Table 9.19: Size Ranges of VALE Export Coal Vs Midwest

<table>
<tr><th>Size Fraction(mm)</th><th>VALE(%)at Beira FOB</th><th>Midwest (approx. %)</th></tr>
<tr><td>+50</td><td>1</td><td>-1</td></tr>
<tr><td>50-32</td><td>4</td><td>-4</td></tr>
<tr><td>32-25</td><td>1.3</td><td>-2</td></tr>
<tr><td>25-4</td><td>33.7</td><td>-13</td></tr>
<tr><td>4-1</td><td>34.5</td><td rowspan="2">-40</td></tr>
<tr><td>1-0.5</td><td>18.1</td></tr>
</table>

0.5-0.25	5.6	-40
-0.25	1.8	

9.13.2 Ash-specific gravity regression:

As a quality control check, Ash-Specific Gravity Regression of the ash contents of the individual size/specific gravity fractions are plotted against the midpoint values of the sink/float data. The spread in data points at each specific gravity midpoint is common, given that each specific gravity midpoint represents a span of 0.10 specific gravity units. There is no indication of solvent absorption in the data and in the opinion of CP; the sink/float analysis was properly performed.

The following regression equation can be used to estimate the density of material of various ash contents for mine modeling.

Specific Gravity = 1.2502 + 0.0061 x Ash% + 0.00008 x Ash%^{2}

- Process selection and flow sheet

The targeted RoM production is 6 MMT per annum which warrants erection of a regular washery at pit head. This plant is expected to deliver prime coking coal product and second exportable medium ash coal apart from middling's and waste.

9.13.3 CHPPFLOW SHEET (Fig.9-19)

A preliminary process-flow diagram for plant design for 1000tph is shown in Figs.9-19& 9-20. All of the crushed RoM coal is fed to Baum jigs in order to remove the high-density rock from the plant feed. The jig product is mechanically dewatered and can either be directed to the thermal coal stockpile or, more typically, can be further processed to produce wet coal. Fines from the dewatering screen and centrifugal dryer report to the fines coal circuit.

When producing wet coal, the Baum jig product is cleaned in the primary dense medium cyclones (DMC). Primary DMC product is mechanically dewatered and sent to the met coal stockpile. Middling product from the DMCs is hammer-milled and re-washed in the secondary dense medium cyclones. Secondary DMC product is mechanically dewatered and sent to the met coal stockpile. Secondary DMC reject is mechanically dewatered and reports to the reject belt. Fines from the DMC circuits report to the fine coal cleaning circuit.

Fine coal from the jig and DMC circuits is cleaned in a two-stage circuit consisting of water-only cyclones (WOC) and coal spirals. Fine coal slurry is pumped to the WOC for primary cleaning and the WOC reject is re-cleaned in the coal spirals. Product from the WOC and spirals is combined and is mechanically dewatered using screen bowl centrifuges.

Coal fines of <0.25m are pumped to froth flotation cells. The froth product is combined with woc/spiral product and is dewatered using screen bowl centrifuges. Tailings from the woc/spiral and flotation circuits report to the thickener. Decision on flotation cell may be taken up once the trial pit sample is studied for pilot scale testing of coal washability.

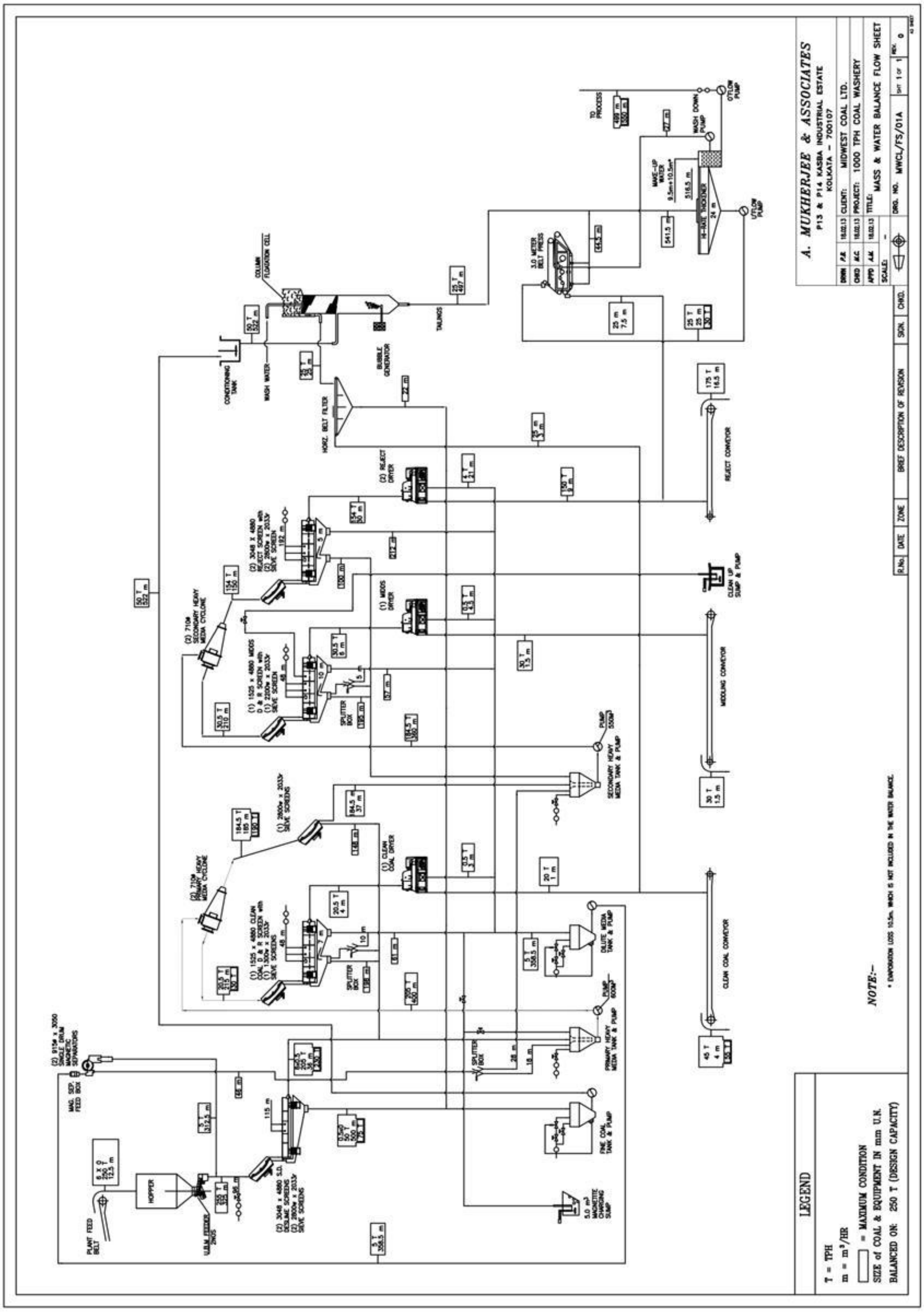


Fig. 9-19: Indicative Mass & Water Balance Flow Sheet for Coal Washery

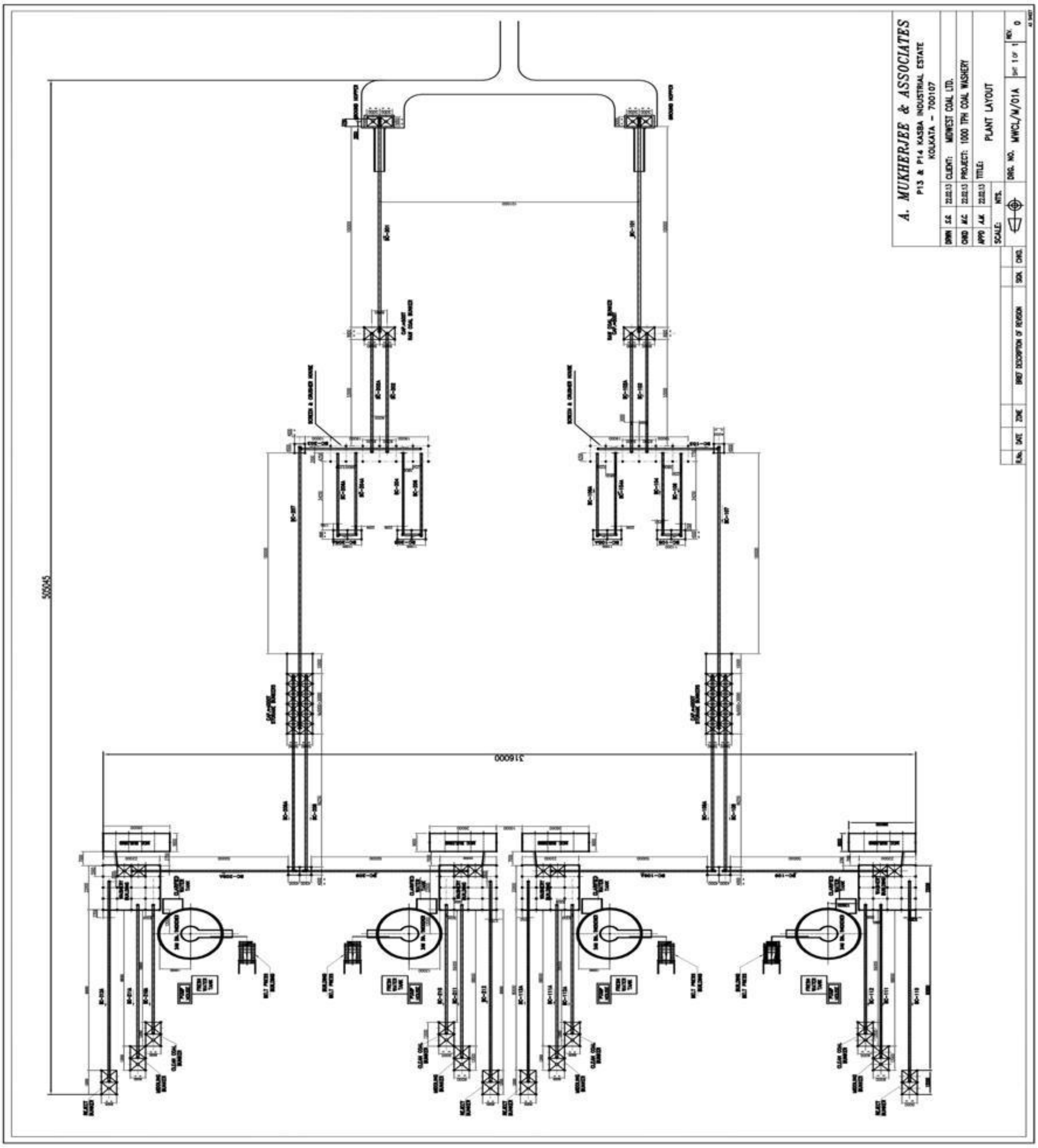


Fig. 9-20: Indicative plant Layout for Coal Washery

9.13.4 MATERIAL HANDLING SYSTEM DESIGN (Fig.9-20):

A preliminary general arrangement for the proposed material handling system is shown in Fig. 9-21 wherein RoM coal is delivered to truck dumps to be conveyed to a two-stage crushing system. 50mm x 0 crushed RoM coal is transferred to two raw coal stacking tubes and stockpiles. Coal reclaimed from the raw coal stockpiles is transported through the raw coal reclaim tunnel and is conveyed to the coal preparation plant. Clean coal from the preparation plant is conveyed to a product stockpile and plant reject is conveyed to a reject bin. Coal from the product stockpiles is conveyed to a truck/unit train batch-weigh system.

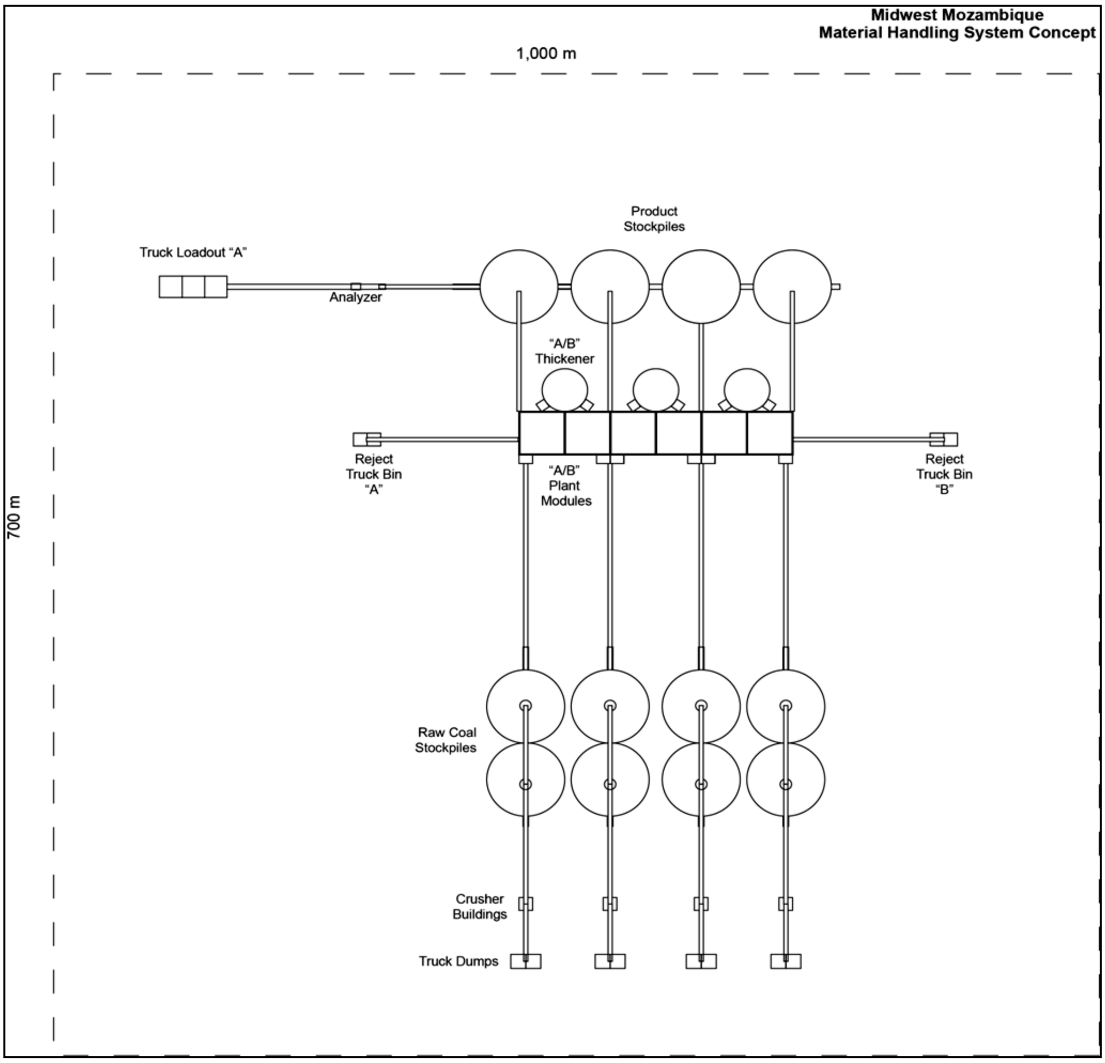


Fig. 9-21: Conceptual Material Handling System

9.13.5 COAL WASHERY EQUIPMENT

The processing or washing is basically a process of gravity separation of dirt and shaly matter from the clean coal. The plant will use the following main equipment.

- Drying Equipment
- Crushing and screening
- Gravity separation jigs
- Dense medium cyclones-two stage separation
- Shaking separators /spiral separators
- Flotation circuits
- Coal product dewatering centrifuges, slurry screens, dewatering cyclones and filtration equipment

- Dewatering of rejects- vibration screens and coal thickeners
- In plant handling feeders and conveyers
- Metallurgical supervision

9.13.6 COST ESTIMATES FOR CHPP (A Mukhopadhyay)

Table 9.20: Cost Estimation for CHPP

Sl. No.	Items	TOTAL
		USD
A	Survey, Soil testing & Design Engineering Cost	416,667
B	Civil & Structural Works	14,166,667
C	Plant & Machinery	
C1	Supply of Plant & Machinery	
	1.0 Mechanical Equipment- Indigenous	13,389,855
	2.0 Electrical Equipment- Indigenous	2,898,551
	3.0 PLC based Plant Sequence Control, Automation & Instrumentation - Indigenous	173,913
	4.0 Communication System- Indigenous	36,232
	5.0 Illumination System- Indigenous	217,391
	6.0 Auxiliary- Indigenous	
	7.0 Imported Equipment	
	Total P&M C1 (1.0 to 7.0)	16,715,942
C2	Erection, Installation & Commissioning of Plant & Machinery	
	1.0 Mechanical Equipment	1,250,000

	2.0 Electrical Equipment	333,333
	3.0 PLC based Plant Sequence Control, Automation & Instrumentation	25,000
	4.0 Communication System	8,333
	5.0 Illumination System	25,000
	6.0 Auxiliary	
	7.0 Service of Foreign Experts, if any	
	Total P&M C2 (1.0 to 7.0)	1,641,667
	TOTAL PLANT & MACHINERY (C1 + C2)	18,357,609
C3	Furniture & Fittings	83333
Sub Total (C1+C2+C3)		18,440,942
GRAND TOTAL (A+B+C)		33,024,275
Total Wash plant estimate to step up in Mozambique*		39,629,130

Note: The cost estimate is provided by Midwest consultant in the field of coal beneficiation based on Indian prices; however, a 20% addition cost is estimated for setting up in Mozambique for 5086C Mine. It includes freight charges and price difference with Mozambique standards.

9.14 CHPP FLOW SHEET (Gouri Charan):

9.14.1 CHPPFLOW SHEET

It has been proposed to crush Run of Mine coal (maximum size range of 100- 200mm) preferably by a sizer or suitable crushing equipment to crush ROM coal down to size 50mm (close circuit is preferred) with minimum quantity of fines. Since, it is proposed to use surface miner, care should be taken not to increase the quantity of coal fines. Coal of size – 50 mm will then be classified into three sizes viz., 50-20/12.5mm, 20/12.5-0.5mm and -0.5mm.

All of the crushed RoM coal is fed to Batac jigs in order to remove the high-density rock from the plant feed. Jigging is the process of separating the particles of different specific gravity, size and shape by introducing them on a perforated surface (or screen) through which a fluid is made to pulsate alternately. Hydraulic jigs use water as the fluid medium whereas pneumatic jigs use air. The device used for this process is called Jig.

The Batac Jig was developed in Germany in response to a need for jigs of greater capacity. The Batac Jig consists of two compartments and six cells of equal dimensions and is pneumatically operated. In this jig, water pulsations are produced by valve controlled compressed air acting on the water from air chambers arranged underneath the jig bed. This allows the air to be uniformly distributed across the width of the jig. This design promotes more even stratification and gives both improved efficiency and greater processing capacity.

The jig product is mechanically dewatered and stored in stockpile for further beneficiation to produce thermal and coking coal. Fines from the dewatering screen and centrifugal dryer report to the fines coal circuit. The media used for separation is water, which is recirculated.

The heavy medium cyclone also called as DSM cyclone was developed by the Dutch State Mines with an included cone angle of approximately 20o, and is used to treat coal in varied size ranges. The principle of operation is very similar to that of the conventional hydro cyclone. Instead of water alone, a suspension of heavy particles in water is used in heavy medium cyclone. This suspension, called heavy medium, is a mixture of -325 mesh particles of magnetite and water in case of beneficiation of coal. The quantity of magnetite added to the water depends on the specific gravity of separation. The fraction of magnetite to be added can be determined by the following formula

$$C_w = \frac{\rho_p\,(\rho_{hm} - 1)}{\rho_{hm}(\rho_p - 1)} \qquad \ldots 1$$

WHERE C_W = FRACTION OF MAGNETITE BY WEIGHT
ρ_P = DENSITY OF MAGNETITE, GM/CM^3
ρ_{HM} = DENSITY OF HEAVY MEDIUM, GM/CM^3

After preparing the heavy medium accordingly, a de-slimed raw coal is added to this heavy medium which forms the feed to DM cyclone. A medium-to-coal ratio of about 5:1 is recommended for coal washing. This feed is forced tangentially into the DM cyclone through feed inlet orifice, a vortex with a hollow air core extending from the overflow to the underflow orifice forms in the cyclone. Under the influence of the centrifugal force, high specific gravity coal particles move through the medium to the wall of the cyclone and descend in a spiral flow pattern to the underflow orifice. Those coal particles in the feed stream having the lower specific gravity than the heavy medium follow the major portion of the flow to the center of the core where they are caught in the high velocity upward central current and are carried out through the overflow orifice. Some particles arriving in the core leave again under the influence of the centrifugal acceleration imparted to them and move to the apex discharge opening along the wall. At the point, near the apex opening, the non-tangential current is direct upward into the core, the particles can again be selected for discharge through either the apex or the overflow opening.

Particles much below the specific gravity of separation will immediately, after entering the cyclone, move rapidly toward the centre and issue through the overflow opening without being recirculated. Heavy particles, on the other hand, will immediately after getting into cyclone move towards the wall and issue through the apex opening.

The clean deshaled coal fraction, the jig product -50+12.5 mm is cleaned in dense medium cyclone (DMC). Primary DMC product is mechanically dewatered and sent to the thermal coal stockpile. DMC reject is mechanically dewatered and reports to the reject belt. The clean deshaled coal fraction, the jig product -12.5 + 0.5 mm is cleaned in another DMC. The clean product is mechanically dewatered and sent to coking coal stockpile and the rejects are mechanically dewaters and reports to the reject belt.

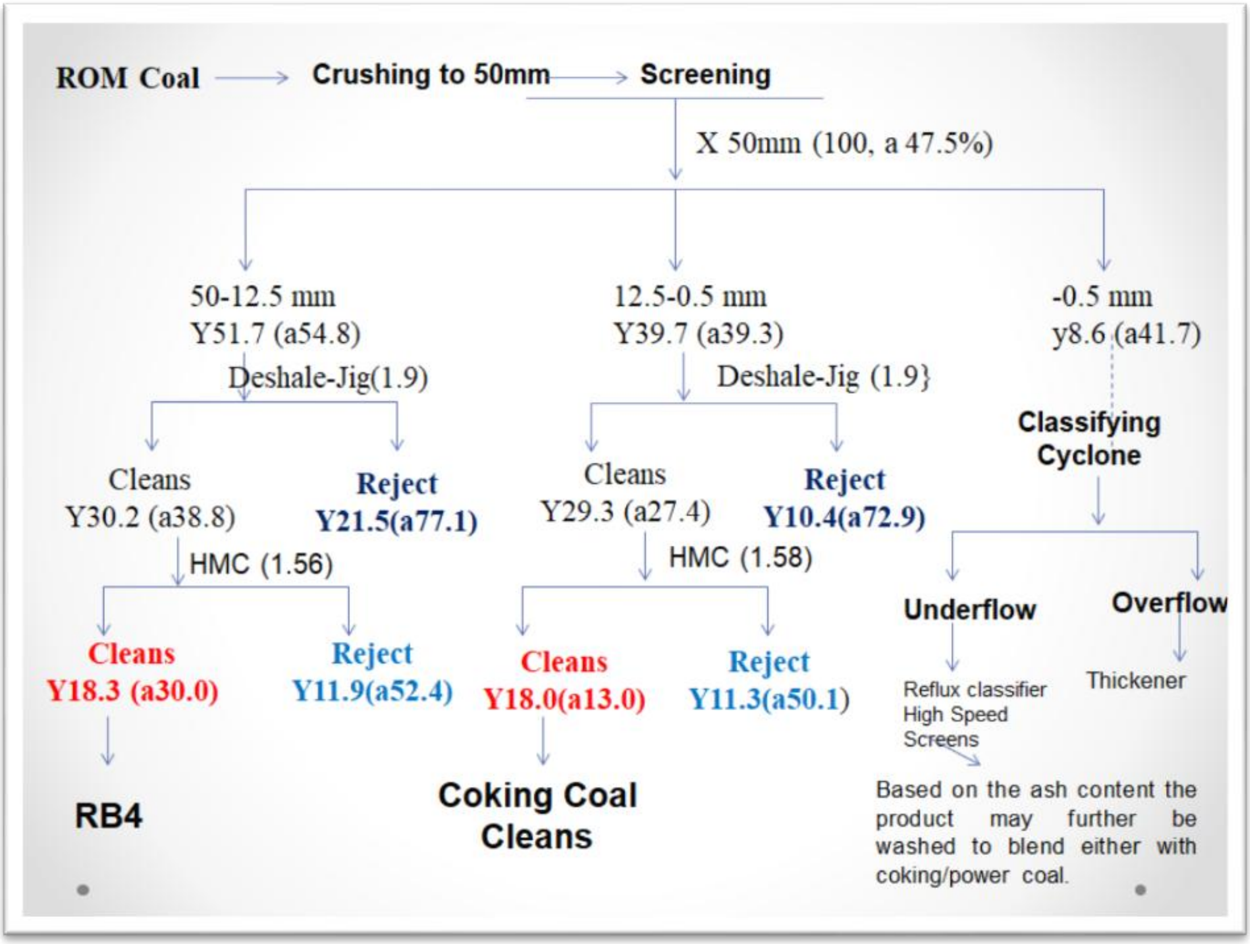


Fig. 9-22: Sequential. Process Tree diagram of proposed Coal processing plant

Depulping and rinsing of both the products will be done in screens for recovery of magnetite. The complete magnetite feeding and recovery system will be automatic. Dense medium Cyclone will be equipped with Medium regeneration circuit complete with appropriate density control, size composition of Magnetite for washery, recovery of water from dilute media and its use in the circuit.

Fine coal from circuits is cleaned in a two-stage circuit consisting of classifying cyclones and coal spirals/reflux classifier. Fine coal slurry is pumped to the classifying cyclone and the overflow will be settled in a thickener and water will be reused while the underflow will be subjected to either high speed screens or reflux classifier or spirals for recovery of addition coal Product from the reflux classifier/ spirals is mechanically dewatered using screen bowl centrifuges.

Scope for flotation circuit is to be provided for future installation (if required) Water will be recycled to the maximum extent possible, Rejects from the process steps will be taken to reject dump area or in future may be subjected to dry beneficiation for additional recovery of power grade coal.

9.14.2 COAL WASHERY EQUIPMENT

The processing or washing is basically a process of gravity separation of dirt and shaly matter from the clean coal. The plant will use the following main equipment.

- Crushing and screening
- Gravity separation jigs
- Dense medium cyclones-two stage separation
- Classifying Cyclones/High speed Screens /reflux classifier
- Media recovery and reuse systems
- Coal product dewatering centrifuges, slurry screens, dewatering cyclones and filtration equipment
- Dewatering of rejects- vibration screens and coal thickeners
- In plant handling feeders and conveyers
- Automatic samplers
- Online analyzers and weight meters
- Other Ancillary equipment.

10 INFRASTRUCTURE

The MGPL has reviewed existing infrastructure facilities at MAL property and conducted assessment of additional facilities required for the proposed mining activities. Expenditure for various mine site infrastructure facilities is given in Table 10.2. Details are as follows

10.1 MINE SITE INFRASTRUCTURE

10.1.1 Land use plan and Land preparation:

Land preparation for seed project site has been accomplished by deploying bulldozer, grader and shovel. The MAL has developed moderate infrastructure facilities at its project site which includes construction of office building, accommodation for 40 personnel. Expansion of these facilities have been planned to accommodate over a hundred skilled, semi-skilled and unskilled workers, CHPP office, Mining office and warehouse facilities etc. An outlay of land use pattern for mine site infrastructure is shown in (Fig.10-1).

The project site will be extended to accommodate the enhanced requirements. Land preparation for CHPP (over an area of 30 ha.) at the designated site shall be taken up almost a year ahead of the commencement of mining operation. Mine site preparation for Mb-A module covers 303ha. Land preparation includes removal of vegetation; leveling of land, removal of soil covers where necessary, fencing and garland canal and rainwater storage tanks at or around mining site (see Fig.10-2).

10.1.2 Fencing garland canal and water storage tank:

Mb-A module area spreads in 303 ha (Fig.10-2). Fencing is planned for 9666.5-linemeters as appropriate. Total length of barbed wire requirement is 22000 m. Pillars are five feet height. Wiring in three rows and cross wires shall be made wherever required. A garland canal encircling mining pit shall be made to manage surface water runoff during rainy season. The canal is 2m wide and 1.5m deep. Total length of canal is 574.2m.

10.1.3 A Water harvesting tank:

A second order stream flowing towards in the central part of the pit shall be dammed and water is diverted through the garland canal along which water flows into a storage tank (Fig.10-2). Storage capacity of this tank is about half a million-gallon water. This water harvesting tank is supported by another water tank of similar capacity wherein water pumped from NCondezi River shall be stored. Both tanks are shaped by contour gradient.

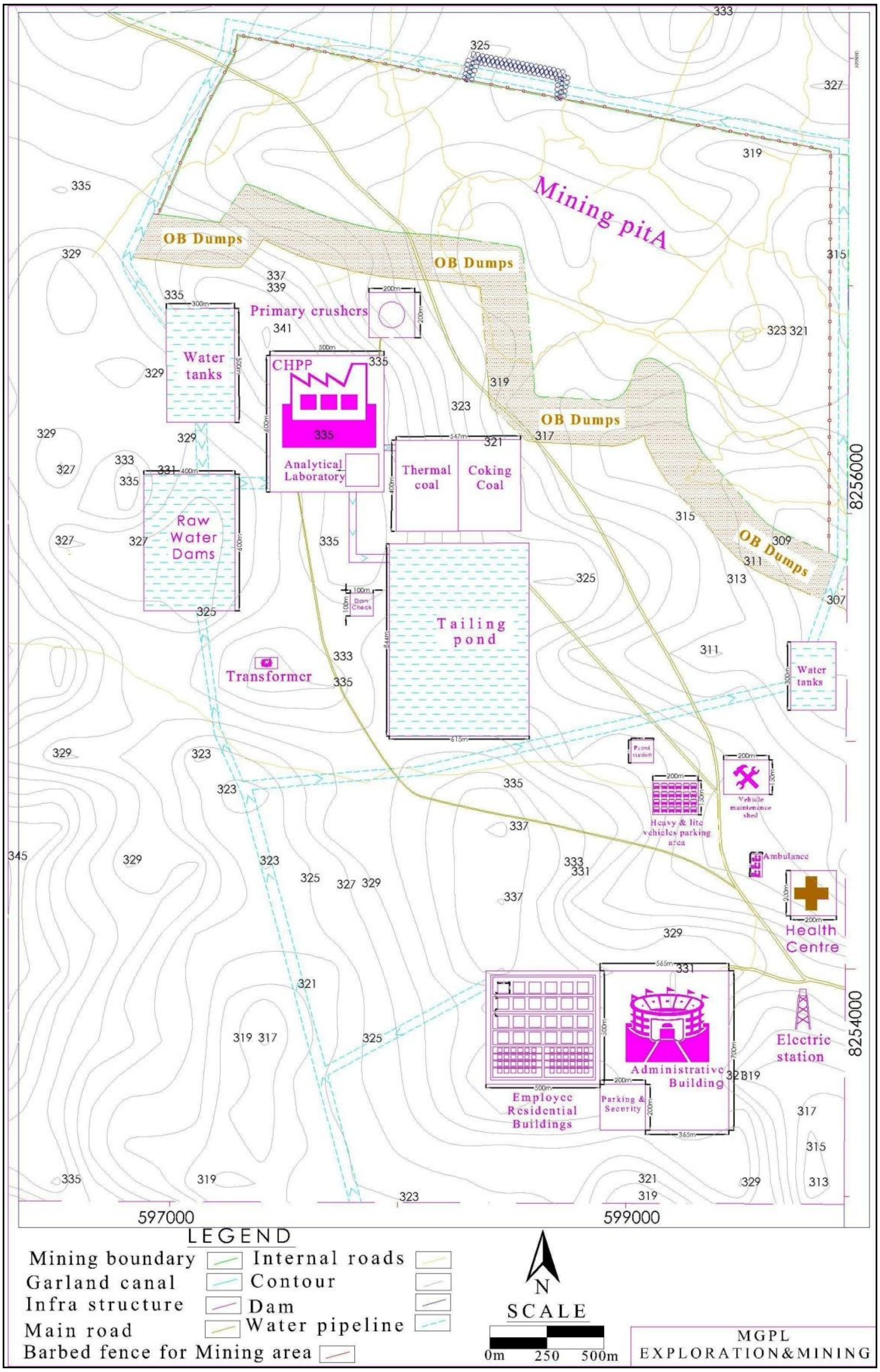


Fig. 10-1: Outlay Of Comprehensive Project at 5086C

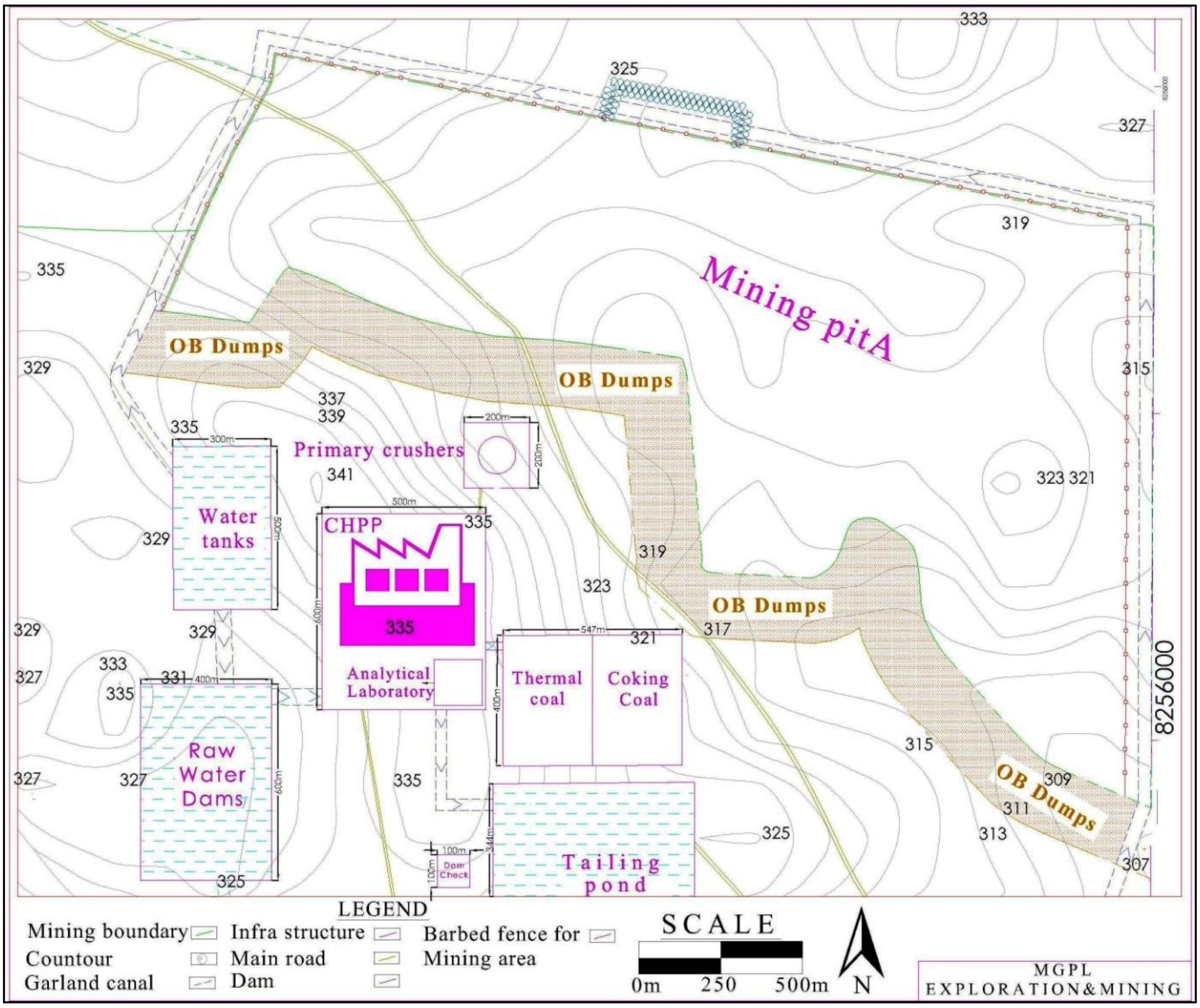


Fig. 10-2: Mine Fencing Area, Garland Canal To Control Mine Drainage for Mb-A.

10.1.4 Soil dump and OB dumps:

Both soil and OB dumps are planned along the southern margin of the mine. Width of OB dumps is ~100m and maximum dump height proposed is 20m. After extraction of coal from Sauso Pinto and Chipanga seams, pit void shall be progressively back filled (Fig.10-2).

10.1.5 Haul road at mine site:

MAL team has already constructed a 4km long main haul road passing through the northern limits of mining blocks A and B. This road can be further strengthened to enable dump truck movement. Off roads from main haul rods may be developed during mine construction stage.

10.1.6 Workshops and ware houses:

Site for two workshops, one each for light and heavy vehicles has been earmarked within inter connected distance of 500m to CHPP as well as mine site. Ware house is planned adjacent to workshops (Fig.10-1). It will house the consumables like tools, spares and stores including

- Parts and components for mining machinery.

- Lube oil
- Hose pipes
- Conveyor belts
- Nuts and Bolts
- Idlers
- Welding rods
- Bearings
- Drill rods
- Tacks and shackles
- Wire rope
- Tires and Tubes
- Under Carriage Components
- Hydraulic Oil
- Line Oil (Drilling)
- Grease
- Gaskets & Seals
- Oil Seals & Rings
- Back Hoe Tooth Point
- Surface Miner Picks

Procurement of spares, tools and consumables will be planned and adequately stocked. The recurring procurement will be based on evolved study and historic data of usage. However, due to the remote location, care and caution will be taken to stock sufficient quantities of consumable stores and spares to meet any exigencies though it may result in higher holding cost. Good SCM Software solutions will be adopted to help plan the supply chain efficiently. Midwest is currently implementing well known ERP solution SAP and the same will be used in the mining operation for perfect control of MIS.

10.1.7 Site for CHPP:

An area of 30 ha has been earmarked for CHPP. Distance between mine site and CHPP is contained within a kilometer. Road distance between CHPP and mine site is planned at a distance of <1km.

10.1.8 Fuel Tank & Consumables:

The main fuel requirement for mining operation is High Speed Diesel. Storage tanks with a total capacity of 1000000 liters along with dispensers, as well as small tanks mounted on tractor trolleys with dispensers are planned for the purpose of providing required fuel for the operation. The closest source of supply of diesel is Moatize and Tete. However, as large-scale mining operations are picking up in the region, mining industry is likely to draw their supplies collectively directly from Beira port through Import of diesel with resultant cost saving. The regular train service between Moatize and Beira will help cut down the cost of transport. The daily consumption of diesel is estimated at 75 kilo liters forming the single largest component of operational cost. Acetylene gas for welding and machinery maintenance etc. can be drawn from Tete. Several mine utility vendors are opening shop in Moatize area to service the coal mining operations for supply of spares and to meet the mining related supplies.

10.1.9 Water Availability:

Water is required primarily in the coal processing plant. It is also required in mining operation for dust suppression in the mine pit as well as on the haul roads and mine ramps. Water is required to meet the domestic consumption of the employees and for raising and maintaining the plantation in the vicinity of mining zone. Water is also required for stabilizing the dumps and for dust suppression at the waste dump. Most of the water used in the processing plant will be re-circulated requiring only top up water on day to day basis. The total fresh water requirement on a daily basis will be 3000 BCM for this phase of operation which can be easily met.

ARA Zambezi is water regulating authority for both surface as well as underground water use for mining purposes. Water usage permit was obtained in 2013, valid up to 2018 and due for renewal at the end of 2018 for the period up to 2023.

Water requirement for 5086C coal project has advantage of both underground and surface water. The former is limited to project office purposes only; two bore wells in operation and two more are proposed to meet the project office complex needs.

Water for CHPP and mining operations shall be drawn by pumping from NCondezi River (Fig.10-3) through pipeline. Total length of pipe line is ~6.8km from the river. Two transit storage tanks and three booster pumps shall be constructed at CHPP site, one for water inflow from river and another for water recycling and disposal.

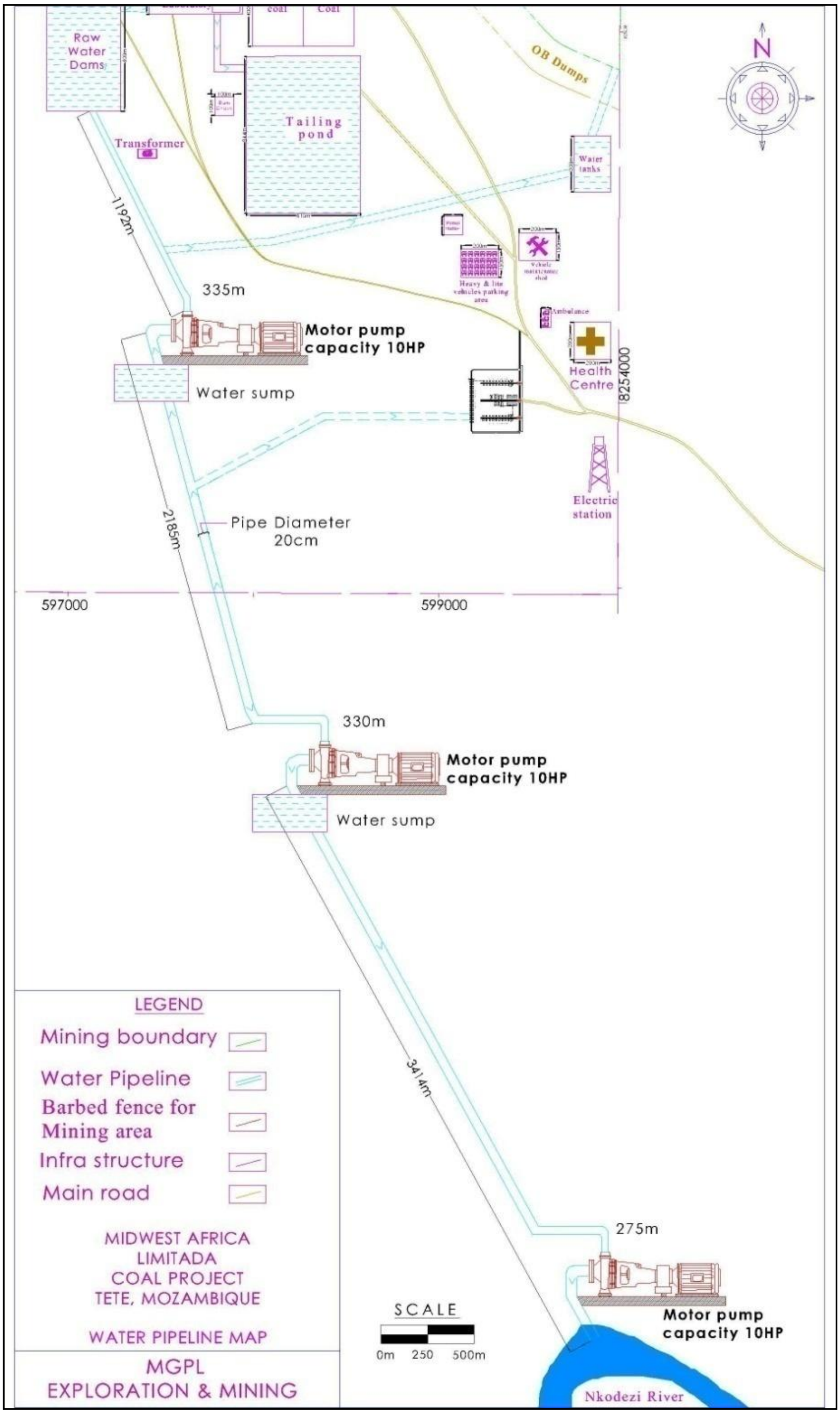


Fig. 10-3: Water Pipe Line Alignment From Nkondezi River to 5086C.

10.1.10Power line:

Power is required for operation of some of the mining equipment, all of the coal processing equipment, material handling, water supply and lighting as well as to meet the domestic needs of the employees. The total power requirement for the first module of operation (3 MTPA) is estimated at 2.5 MW. The power will be drawn from the regional distribution system through a step-down transformer, 33 KVA transmission line connecting the sub-station to be established at the mining site.

At MAL project site, the power needs are met from 5 and 50 KV diesel generators. Coharo bassa regular one more 100 KV diesel generators shall be procured as a standby till that time a regular power line comes into operation.

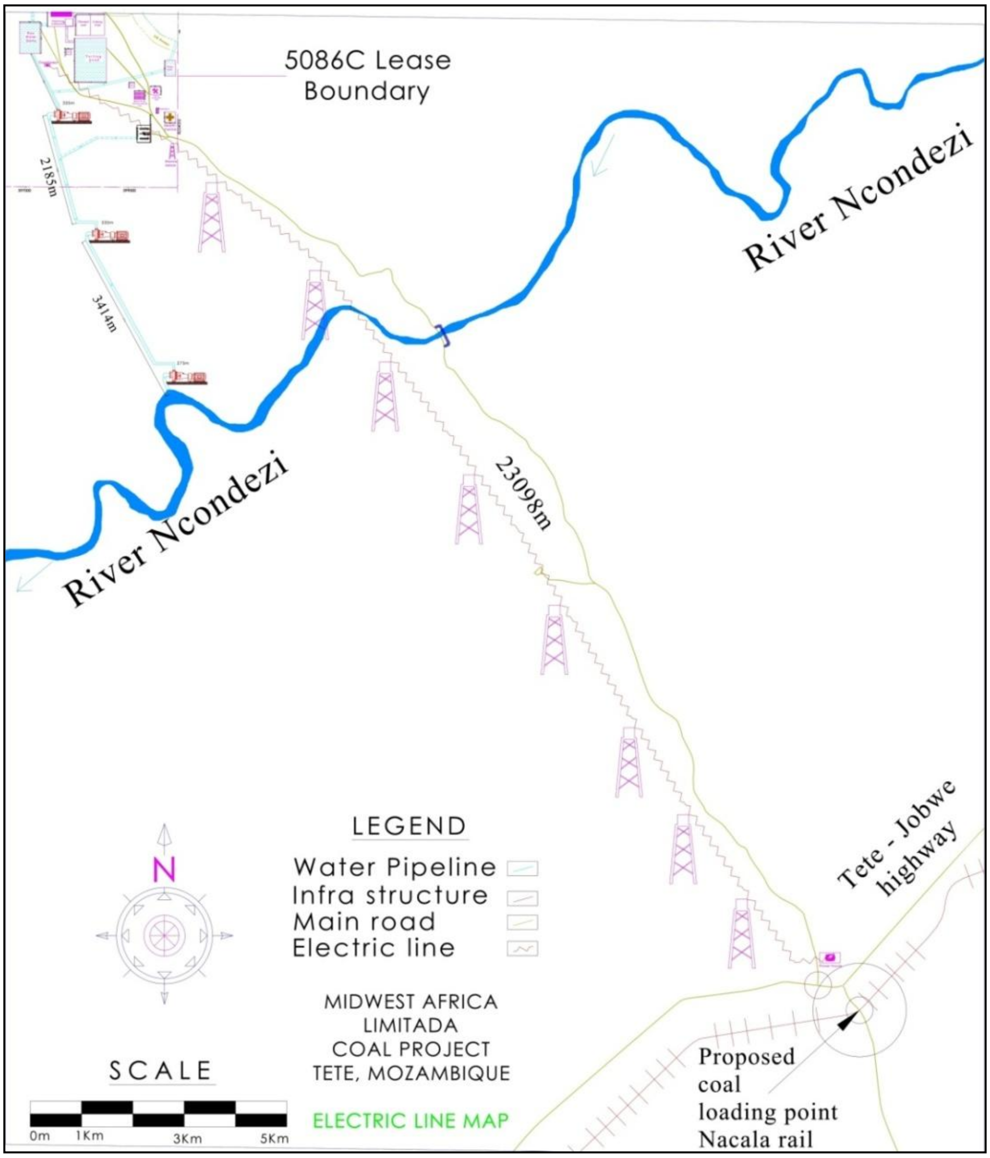


Fig.10-4: Power Line Alignment Between Mpassi and 5086C.

Tete area is covered by regular power from Cohora bassa hydroelectric power grid which has adequate capacity to supply power to all mining and industrial needs in the province. A 33 KV line is available between Moatize and Muthrara which passes through Mpassi. Plans are afoot to erect a feeder line from Mpassi to 5086C project sites over a distance of 21km as shown in Fig.10-4. Discussions were held with the EDM, Mozambique and an application were filed to that effect, electric regulatory approval is awaited. A provisional cost estimate is prepared in consultation with the electrical engineers of EDM department at Tete.

10.1.11Housing accommodation and other basic amenities:

The existing infrastructure at camp site is shown in Fig.9-6. To expand, the project office and dwelling units, a total of another 7000 M^2 accommodation will be provisioned whose details are as follows and a sketch plan is shown in (Fig.9-5). The revised house accommodation plan will be drawn by the service provider in consultation with the Midwest. Most of the units are modular in nature to serve for LOM period of 15years.

Table 10.1: Table Showing Space Allotted to Different Infrastructures in 5086C coal project

Type of Infrastructure	Area in Sq.m
Project Manager Office	20X8 = 160 M^2
General Admin. Office	20X8 = 160 M^2
Technical office	20X8 = 160 M^2
CHPP office	15X6 = 90 M^2
Guest House	20X8 =160 M^2
Dining:	20X8 = 160 M^2
Recreation room/Gym	15X10 = 150 M^2
Total Grade I ACC plants	1120 M^2
Total Grade II ACC plants	840M^2
Staff Quarters	960M^2
Parking area	1000M^2
Workshop I	30000M^2
Workshop II	5000M^2
Ware house	5000M^2

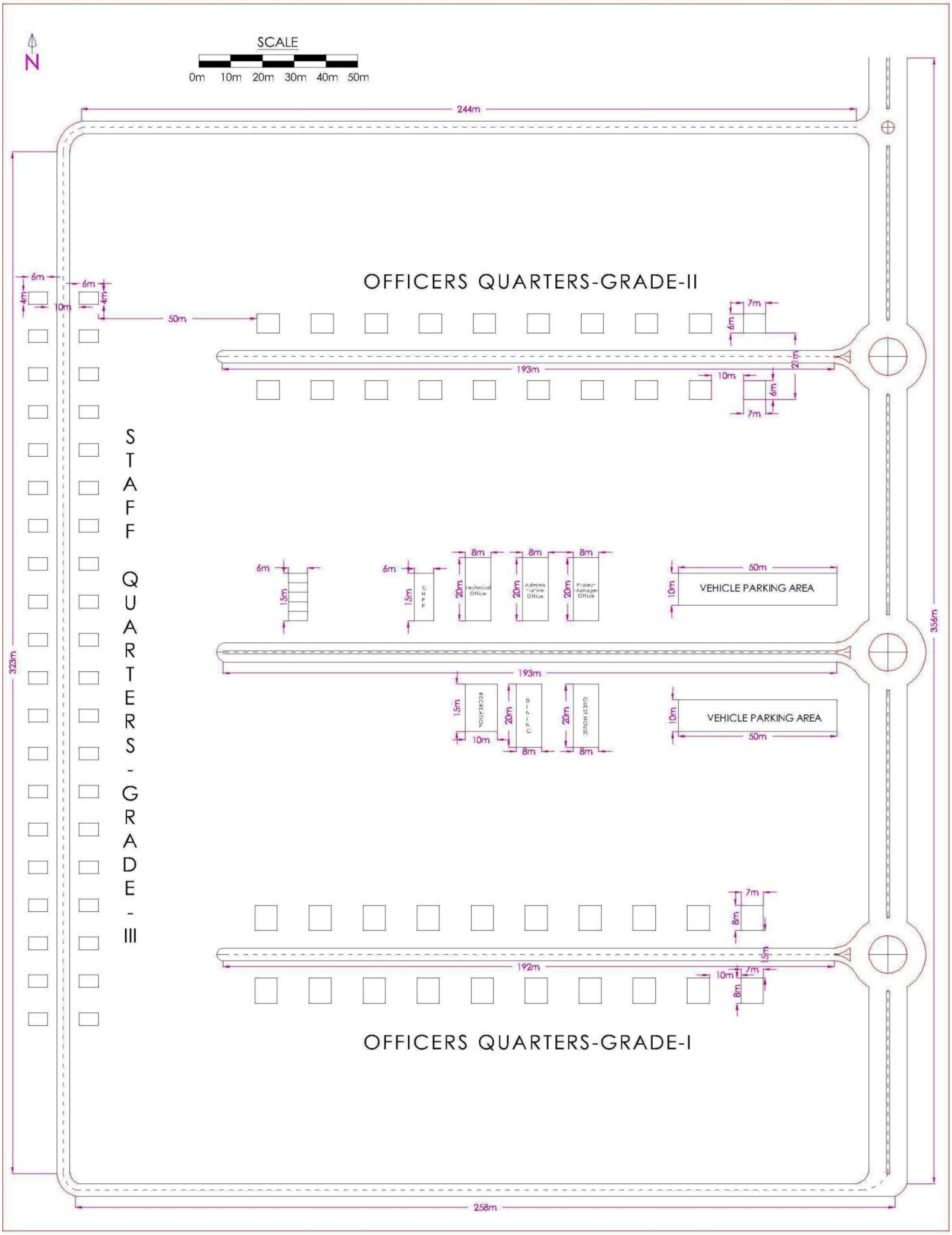


Fig. 10-5: Lay Out For Office and Accommodation Units.

Fig. 10-6: Part Of Existing Office and Accommodation Units.

A total of 65 units will be built to start with; more units can be added as and when needed. These core units shall house site engineers, operators, technicians and senior administrative staff. Whereas the locally drawn staff from the neighboring villages will be provided transport facilities to & fro from the work place. A club house with a theatre, indoor /outdoor games facility and gym are planned. In addition, the base camp with a guest house and store will be maintained at Tete / Moatize for facilitating transit accommodation, supplies, etc. Similar facility of guest house / transit place will be maintained at Maputo.

10.1.12Communication Facilities:

Moatize Mining area is serviced by fairly good coverage of cellular and landline access. However, the low speed network available may not support large scale data transmission to and fro the mine site on a real time basis. Hence, a V-Sat terminal with ground communication system is planned to maintain real time connectivity between the mine site, base camp and central / control office. The communication within the mining area will be radio / walkie talkie to ensure ease, safety and efficiency of the operational communication. The radio equipment will have operational radius of 30kms and will have sufficient number of Receivers / Walkie Talkies (say 100 Nos.).

10.1.13Catering and Recreational Facilities:

A club house near the mine site with a library, theatre, Gym, Swimming Pool along with Indoor and Outdoor sports facilities is planned for health, relaxation and entertainment of the employees. An industrial catering unit along with dining hall will be in place for serving food for the employees. A satellite food service / dining facility will be in place at mine pit and processing plant for convenience of service and time saving.

10.2 COAL TRANSPORT ROUTE

Transport route from 5086C to Nacala line crossing is shown in (Fig.10-7). It runs for23.5km. The existing road can support 40 ton long trucks during dry season only. That part of the road between the Nkondezi River and 5086C stretching over 5km was developed by MAL, whereas the road between the River and Mpassi was developed by Nkondezi Power Company.

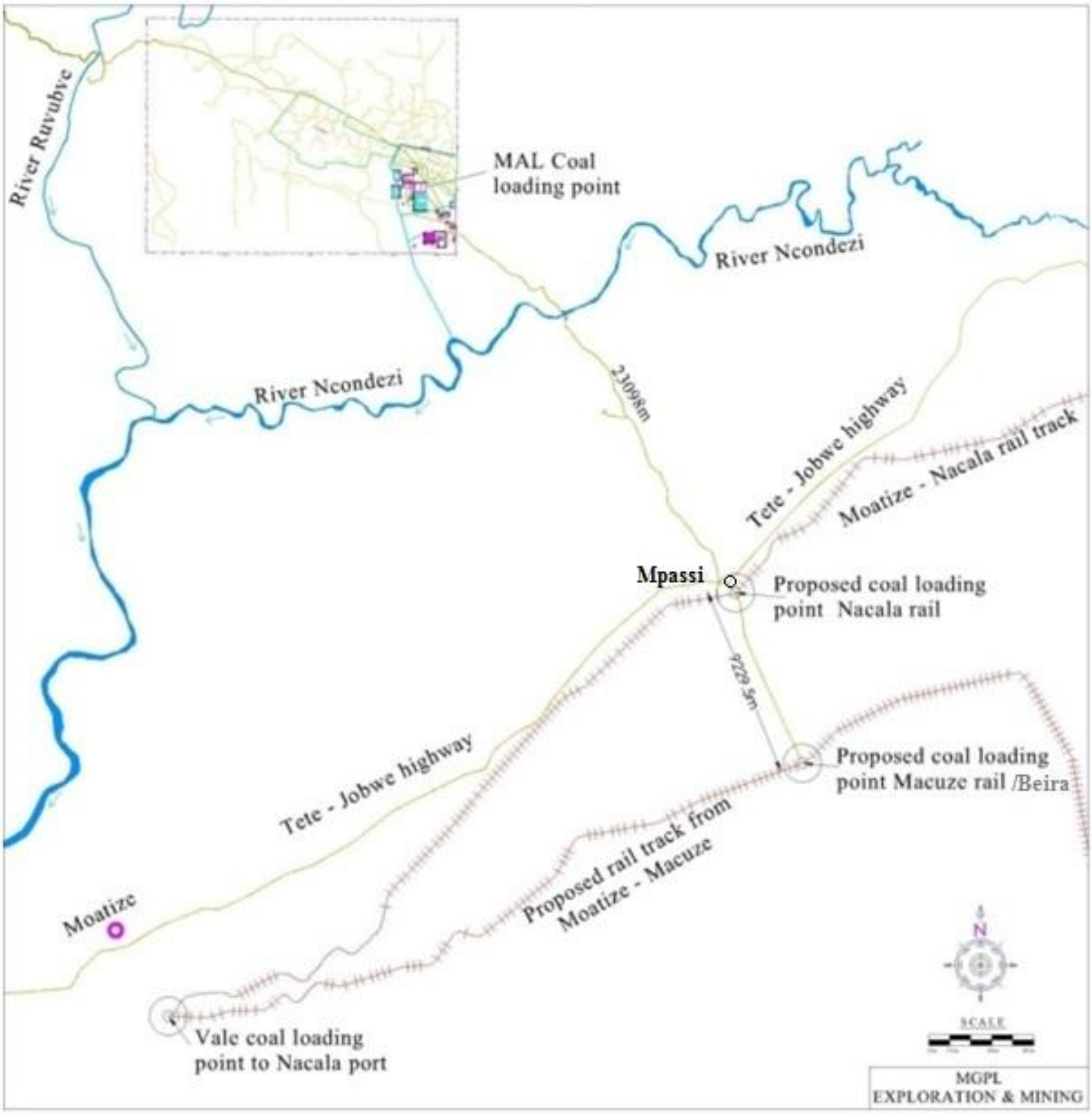


Fig. 10-7: Coal Haul Route and Indicative Rail Loading Point.

Nonetheless, this main haul road needs to be strengthened to facilitate uninterrupted truck movement. Indeed, this transport route is common for neighboring companies as well, thus it is appropriate to invite them for a dialogue on road construction costs and also bridge construction costs. The road has to pass through the NKondezi River over which a cause way bridge has to be built. It may be noted that the river is negotiable for transport trucks in dry season only, in wet season, water flow levels are too high to support transport truck movement, as such construction of bridge is inevitable.

10.2.1 Bridge across Nkondezi River:

MAL has conducted preliminary studies on seasonal water flow levels and foundation testing across Nkondezi river channel. Channel width at low water level is 20 m; at high water level it is 45 m and attains a maximum depth of 2.5 m. At low water level water velocity is negligible where as it reaches up to 0.9 m/sec. As a result, during December to March, it is very difficult to cross the river (Fig.10-8). Therefore, construction of bridge over the Kondezi River is inevitable. MAL has conducted foundation tests and obtained quotations from bridge construction companies. It may be negotiated further to bring costs down to 1.2million USD for bridge as well as two minor culverts construction by the same company.

Fig. 10-8: Nkondezi River at High Water Level and Foundation Testing

10.3 COAL HAULING & RAIL LOADING

In initial stages, coal will be hauled by transport trucks up to the railway loading point at Mpassi. Two export products namely Metallurgical and Thermal coal will be separately stacked at the loading point where it is filled into wagons using high speed loading system at rail loading point, there is a single track, as such a rail siding and loop should be built over a length of one kilometer.

The haulage distance from the mining point to rail loading point is 23km. In the 2^{nd} / 3^{rd} year of operation, a branch rail line may be built to connect CHPP loading point to Mpassi loading point (see Fig.10-7).

10.4 RAIL TRANSPORT FROM MPASSI TO PORT

Coal transport facility by rail has improved considerably during last five years. As a result, Coal from 5086C has an advantage of connectivity to multiple rail transport lines i.e. currently operating Nacala and Sena lines as well as the proposed Macuse line. By road, distance between the coal mine and the nearest point on Nacala rail line is ~23km, whereas it is 34km at Cambuletsi in case of Sena rail line (see Fig.10-7).

10.4.1 Port Handling and Loading:

The CP has visited port handling facilities at Beira. The MAL coal has no difficulty to get slot at coal loading berth and quay for coal handling as VALE has withdrawn from Beira and coal from ICVL looms on a great deal of uncertainty.

The MAL coal mining property has an advantage of reasonable connectivity to multiple rail transport lines i.e. currently operating Nacala and Sena lines as well as the proposed Macuse line. Road distance between the coal mine and the nearest point on Nacala rail line is ~22km, whereas it is 34km at Cambuletsi in case of Sena rail line.

10.4.2 Sena rail line-Beira port:

The Sena railway line connects the coal mining town of Moatize with the port of Beira at a distance of 570km. The railway line was refurbished for transporting coal from Moatize to Beira Port in 2010. The southwest railway terminal is Moatize located at a distance of about 45km, whereas Cambuletsitsi is the nearest major station at about 34km distance southeast from the MAL project area (see Fig.10-9).

Fig. 10-9: Beira Rail Line Coal Transport

Sena railway line is meant to transport coal from Moatize coalfields to Beira port for onward shipping to overseas destinations. Rated haulage capacity is in the range of 6 to 10 mtpa. VALE had started coal export on this line in 2011 and Rio Tinto in 2012.As per records, actual coal transported by three coal producing companies viz VALE, Rio Tinto (now ICVL) and Beacon Hill resources on this line amounted to ~ 3mtpa since 2012. Coal mining companies have their own railway rolling stocks. All the coal mining companies except VALE have discontinued coal mining and transportation during 2015 to 2017 due to nose diving of coal prices in international markets. At the time of writing this report, coal transportation through Sena rail line has been temporarily discontinued for various reasons. However, Beira Port is a Shallow Port and the channel needs continuous dredging. This port can currently handle a Super Handy Max Vessels (45000 Tonne) and is being expanded to accommodate Panamax Vessels (65000 Tonne). Cape size vessels can be loaded by using a transhipper. The current handling capacity of the port is 7-8 MTPA which is likely to be increased to 20 MTPA with higher loading rate envisaged to reach loading rate of 3000 TPH.

10.4.3 Moatize-Nacala rail line:

In spite of down trend in coal markets**,** VALE continued coal mining and transportation but switched over to its own Nacala line in 2016 on cheaper transport costs. In its 2017 annual statement, VALE announced significant reduction in transport costs and port handling by using Nacala line. At the beginning of 2018, coal transport and port handling charges together are indicated to be 40$/ton.

MGPL examined rail transport options and recommended MAL to start engagement with the VALE consortium to utilize the Nacala coal transport facility. Another advantage is road transport distance from mine to rail line will be reduced by another 12km thereby providing some relief to road transport cost. Coal transport from MAL mine to Nacala rail line may be viewed as a short-term option, but a 22km long loop line would be a viable choice for optimization of coal transport costs.

10.4.4 Moatize-Macuse rail line:

In order to meet the increasing demand for inland material transport, another port at Macuse with a connecting link to Moatize are under construction by a consortium led by Thai operator. Project is expected to commission by 2021. The Mozambique Government is committed to provide cheap transport for Moatize basin coal and expects it to be ~ 30 $/ton towards transport cost. As things stand today, the Macuse facility should be available by 2021, coinciding with the commencement of coal production in MAL mine, which would give a fillip to optimization of transport costs. A clear picture will emerge soon on alignment of this rail line, so that the MAL should decide upon rail loading point and siding.

10.4.5 Labor Availability &Government Regulations:

The MAL exploration project had employed 80 no’s of laborers comprising 62nos local un skilled workers, 8 no’s local semi-skilled workers (drivers and mechanics and accountants) and 8 expats skilled and 2 no’s of native skilled workers (geologists and engineers). Most of the unskilled workers are residing with a radius of 10km from project site. Skilled and semi-skilled workers were drawn from Moatize and Tete.

As MAL previous experience and current trends any indication, labour is available to meet the mining project requirements. Good number of mining technicians/engineers and mining geologists are graduated every year from Moatize college of Mining; commerce, economics and engineering graduates pass out from University of Tete, Although the medium of learning is Portuguese, English is also common spoken language for educated people. Educations standards are good, people are receptive to new skills. Some induction training courses and vocational training would make them ready to use in mining industry.

Employment relationship in Mozambique is governed by The Labour Law No. 23/2007.

Hiring of foreign non-resident employees is guided by specific legislation including

The General Hiring of Expats Regulation vide Decree No. 55/2008
The Regulation on Hiring of Expats in Petroleum and Mining Sector vide Decree No. 63/2011 and decree No. 37/2016 of 31/8/2016
The Immigration Law regulation vide Decree No. 108/2004

Mozambique is a signatory to International Labour Conventions and Treaties and thus has well defined employment regulations. Mozambique employment law No. 23/2007 sets forth principle of equality between foreign and national employees as well as general prohibition of discrimination against employees.

10.5 CONSUMABLES TOOLS, SPARES AND STORES

The guidelines which have formed bases for CHPP flow sheet preparation includes.

- The larger the average size for processing, the lower the overall plant operating cost
- The larger the average size the lower the surface area and the total moisture held
- The more complicated the process Flow sheet the more opportunities for inefficiencies and losses,
- Fines are a technical and financial burden for processing and devalue the product by adding moisture; avoid fines generation wherever possible,
- The cost of processing is inversely proportional to size, the finer the size the costlier the unit process,
- Ever selection of a process and equipment must be “questioned” in terms of possible effects on the rest of the plant,
- Optimum plant yield for a given product ash is achieved when all density-based processes separate at the same incremental ash level,
- The plant operates most effectively and efficiently on a steady flow of well homogenized feed,
- Higher unit capacity usually means some reduction in efficiency,
- For water-based process, better results are obtained when treating narrower size fractions.

Table 10.2: Mine Site Infrastructure & Development Cost

Mine site Infrastructure & Development					
Sr.No.	**Main Heading**	**Description**	**Units**	**Unit cost**	**Total cost($)**
1	**Land-One time cost**				
i)	Clearing	Land covering, Block A of pit1 and supporting area covering 3 sq km	3 sq.km		$ 1,00,000.00
ii)	Fencing of certain areas	Mining, Wash plant, Residentials and other areas to be fenced 10km	10km	30	$ 3,00,000.00
iii)	Levelling/Development	Wash plant and civil structure areas to be levelled and developed			
iv)	Garland canal preparation	Garland canal of 2m wide and 2m depth	3.6km	20	$ 72,000.00
v)	Survey and preparation of detailed maps				$ 10,000.00
vi)	Study of flora and fauna for conservation/ land use plans/enclosures for conservation	Comprehensive plan for land use			$ 10,000.00
2	**Site Infrastructure-Per 6 MTPA Module**				
i)	Approach roads/Improvement	Internal roads 15km	15km	13330	$ 2,00,000.00
ii)	Water pipeline	Pipeline construction from Ncondrezi river to Mine site	7km	14300	$ 1,00,000.00
iii)	Borehole/Pumping		4	29000	$ 1,16,000.00
iv)	Pipelines				$ 1,00,000.00
3	**Power for 6MTPA**				
i)	Transmission Lines	11KV line of 40km from Mphassi substation	23 km	22000	$ 5,06,000.00
ii)	Substation/transformers at mine site	33/11KV & Wiring in Camp			$ 3,00,000.00
iii)	Distribution-internal	10km			$ 1,00,000.00
iv)	Back up generation	As per			$ 10,000.00
v)	Lightening arresters/ earthing/cabling				$ 10,000.00
vi)	Electrical equipment, fixtures installations				$ 25,000.00
4	**Roads and Bridges one time cost**				
i)	Haul road improvement connecting highway	5km with in the concession	5	35000	$ 1,75,000.00
ii)		28km outside the concession@50000/km (50% cost)	28	40000	$ 11,20,000.00
iii)	Culverts				$ 2,00,000.00
iv)	Internael roads connecting various facilities	Mining pit to processing plant & dump yard 3km			$ 20,000.00
v)	Bridge across river				$ 20,00,000.00
5	**Buildings- For 6MTPA Module**				
i)	Site office, Dining & Guest house	830 sqm	830	300	$ 2,49,000.00
ii)	Housing/Dormitory	80 houses-2920 sqm	2920	100	$ 2,92,000.00
iii)	Dispensary	200 sqm	200	500	$ 1,00,000.00
iv)	Store	500 sqm	500	300	$ 1,50,000.00
v)	Work shop	High roof with internal crane-1000sqm	1000	1000	$ 10,00,000.00
vi)	Fuel tanks	400 KL-Capacity-2 modules			$ 50,000.00
vii)	Water storage tank	300 KL open			$ 50,000.00
viii)	Rest rooms and public baths	5 Nos	3	3300	$ 9,900.00
6	Fire fighting systems				$ 10,000.00
7	Slurry dam				$ 50,000.00
8	Communication equipments	V-Sat, Radio/walkie talkie			$ 28,000.00
9	Licenses registrations/surface rights				$ 50,000.00
10	Cost of environmental License				$ 1,00,000.00
11	Rail track preparation for coal loading				$ 21,87,100.00
12	Miscellaneous Capex				$ 2,00,000.00
	Total				**$ 1,00,00,000.00**

11 ENVIRONMENTAL STUDIES, EPDA, EIA &COMMUNITY CONSULTATIONS

Extracted from EIA draft note under preparation from GMSC Lda. The GMSC Lda is service provider for EIA studies.

11.1 COAL MINING AND ENVIRONMENTAL IMPACTS

‘Mining involves extraction of minerals and rocks from the earth’s surface to recover one or more useful components. By doing so, environmental equilibrium established over millions of years gets disturbed; effluents and gases are released into water and air, thereby causing ill effects to communities living in the area. Therefore, surface mining is intertwined with land, air, water, noise *interalia* inhabitants and organic life in the surroundings. A general flow chart showing major components of coal mining and coal preparation is given in Fig. 11-1.

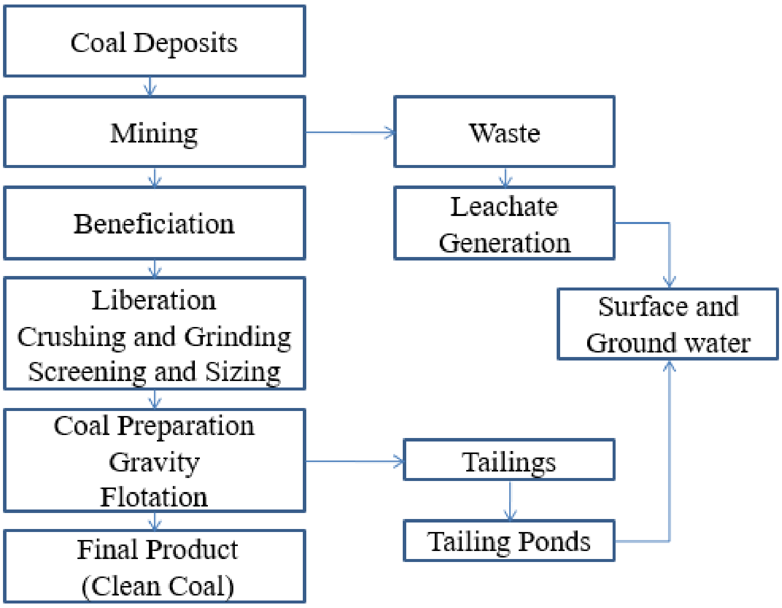


Fig. 11-1: General Flow Chart of Coal Mining Activities in Relation to Environment.

After mining, the coal is sent to a beneficiation plant where the coal quality is improved by reducing ash content there by making it as industry usable coal product.

There are two types of mine wastes: Waste rock including soil and overburden i.e. grain size >1mm and tailings of grain size (<1mm). The waste rock that is not backfilled is deposited in a waste rock pile (waste dump). Revegetation of dumps can be carried out to restore the environment. The disposal of tailings is carried out in a tailing pond. The waste rock and the tailings are the main source of acid mine drainage (AMD).

Water resources are the main target of mining pollution. Pollutants from mining activities have the potential of destroying the environment, presenting a risk to public health. Communities located around mining areas are at great risk if appropriate measures to avoid pollution are not undertaken.

Climate change is another factor which exacerbates the negative impact of mining. It is of vital importance to have well- functioning environment management system to mitigate ill effects which can be achieved by an integrated involvement of mining industries, the regulators and the stakeholders working on the project.

11.2 GOVERNMENT LEGISLATION ON ENVIRONMENT

The notified Mozambique Government regulations on environment management of coal mining are as follows**.**

- The Land Law and the Regulations of land Law (Decree n^{o}66/98).
- The Environmental Law and the Environmental Regulations for Mining Activities (Decree n^{o}26/2004.)
- The Regulations on Technical Safety and Health for Geological and Mining Activities (Mine safety regulations) Decree n^{o}61/2006.
- The Regulation on the Commercialization of Mineral products (Decree n^{o}20/2011).
- The Policy of Corporate Social Responsibility for the extractive industry of Mineral Resources (Resolution no. 21/2014).

11.3 STATUS OF EIA AND EMP

MAL has commissioned GMSC Lda, a consulting company recognized by Government of Mozambique to prepare Environmental Impact Assessment Report and Environmental management plan. The work is enumerated in the following phases (Fig.10-2).

- Step I - Instruction Process, which is the registration of the project with MICOA for their respective categorization (already completed).
- Step II- Pre-feasibility study and definition of Scope (EPDA), including the terms of reference (TdR) for the EIA (completed).
- Step III-Completion of the environmental impact assessment (EIA) based on the terms of reference for the EIA approved by MICOA (in progress)
- Step IV - Submission of the EIA report to MICOA (last phase) for obtaining the environmental license.

To partially fulfill the environmental licensing mandates, the GMSC Lda. has conducted EPDA (Pre-environmental feasibility and definition of scope) study along with community consultation and a detailed report was submitted to MICOA (Ministry for the coordination of environmental action) for approval.

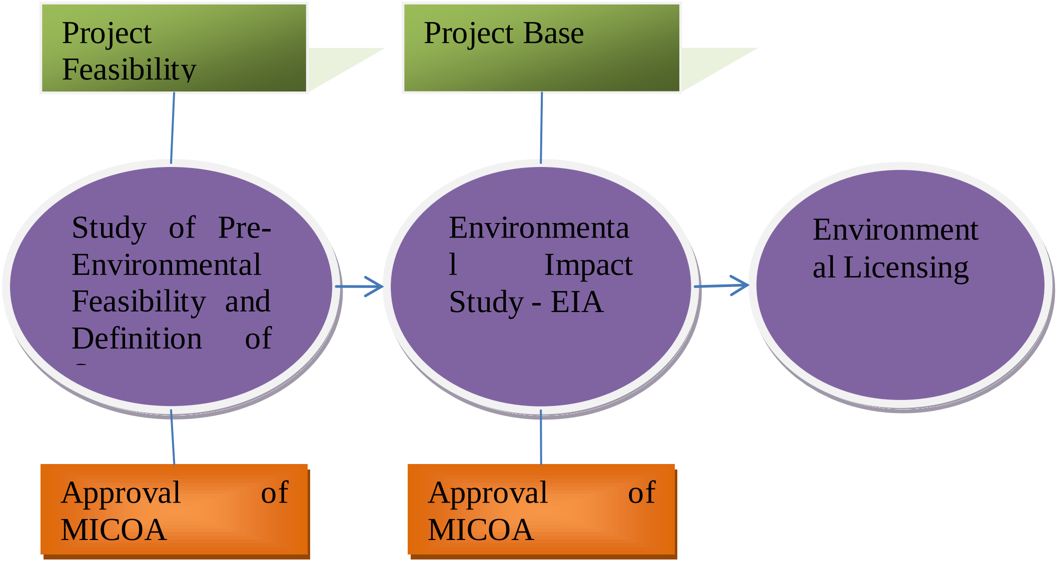


Fig. 11-2.Environmental Licening Stages

11.3.1 EPDA:

The EPDA report has reviewed the proposed coal mining operations and CHPP activities. Environmental standards for the mining industry are contained in the, the law of the environment, the Environmental Regulation for Mining Activities (Decree 26/2004 of 20 August) and other regulations and directives as outlined in the report. Among other things delimitation of (AID) Area of Direct Influence; (AII) Area of Indirect Influence; AIR (Area of Regional influence) have been made (Fig.11-3).

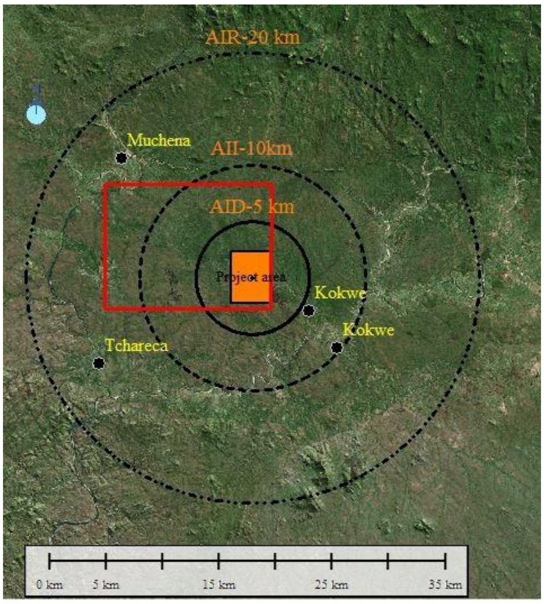


Fig.11-3: Area of Regional Influence

A Review of Bio-physical environment and socio-economic environment components has been illustrated. Community consultations including local administration along with local people were held and written approval from all stake holders has been obtained.

The EPDA report has been approved by MICOA, who advised the consultants to proceed for stage-2 i.e. EIA study. Agreement between the MAL and GMSC Lda is in force to complete the EIA study.

11.3.2 EIA:

Procedures and practices envisaged for Environmental Impact Study (EIA) have been defined. The ultimate objective is to being reduce negative impacts of mining on Health, Safety and Environment of people. The report shall be submitted in due course and permit shall be obtained before the commencement of mining operations.

There is no human habitation in mining project area or within five-kilometer radius. However, there are few habitations within ten-kilometer radius. People living in those hamlets have been appraised about the proposed coal mining activities.

11.3.3 EIA Format and Progress:

The proposed Environmental Management Plan will focus on the following major aspects

- Collection of base line information on relevant environmental aspects of assessment of prevailing environmental status.
- Assessment of the area of environmental impact due to various mining operations

There are no ecological sensitive areas such as the biosphere reserves or national parks or wild life sanctuaries or other protected areas within the tenement area or within distance of 15km from the border of the tenement.

11.3.4 Surface Features:

Coal mine project area is gently undulating plain country with low density of first and second order streams in dendritic pattern which remain dry most part of the year. Maximum elevation is 326.71mand minimum elevation is 305.76m. Topographic gradient is towards south (Fig.11-4).

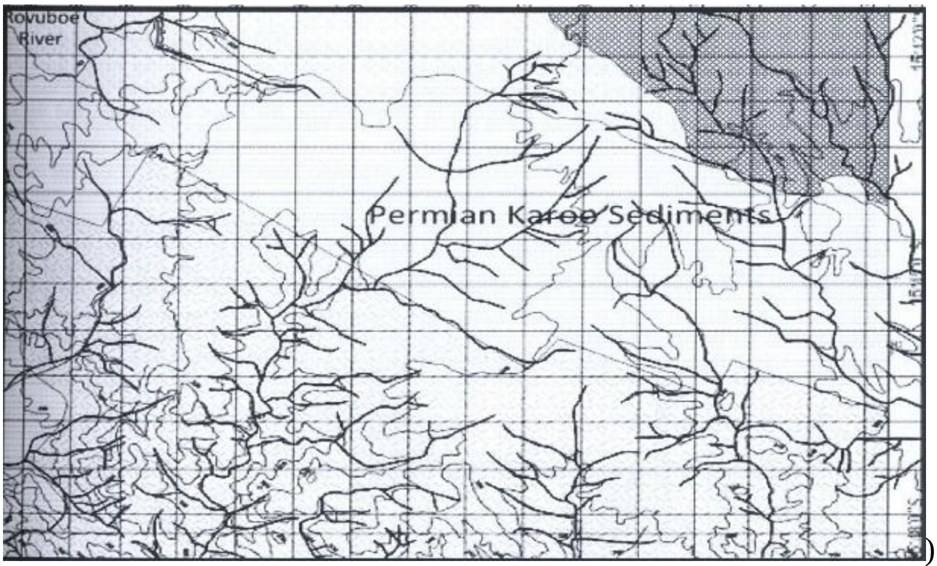


Fig. 11-4: Topography and Drainage Pattern in the Project Area

The GMSC has examined MAL mine plan and found that the impacts on geomorphological features is minimal and limited to diversion of rain water in proposed mining area.

There are two perennial rivers in & outside of the tenement area. The Rovubwe River is located in NW quadrant (Fig.11-4) of the tenement, whereas the Nkondezi River is 6km southeast of mine site. It should be ensured that these two major rivers are not polluted by mine waters. Remedial measures have already been outlined in mine plan chapter.

11.3.5 Flora and Fauna:

Statistical account of tree types and their executed loss due to mining operation is under preparation. Flora in the area is typical of savannah grass lands marked by sporadically distributed wide trunked tall trees which supports lumbering for export and making of char coal. The under growth is 1 to 1.5m tall African grass. The density of vegetation increases markedly near the river banks.

The forest in the area is classified as “deciduous savannah”. Plant types include African grass, gigantic Baobab trees, hardwood trees, thorny bushes, and mango and jujube trees. The other common plant species belong to cordyla and Acacia families.

There is a low degree of fauna diversity. Nile crocodiles are present in Nkondezi River. The area contains various types of snakes and scorpions. Common snakes found in this area are African Rock Python and the Mozambique spitting cobra.

The common birds sighted in the area are white stork, the Africa skimmer, the rock Prantincole and the dwarf bittern, a small heron. Elephants from Chiriza dense forests cross over Rovubwe streams and enter in mine area. Appropriate safety measures should be taken to avoid any untoward incident.

11.3.6 Human Settlements:

- No densely populated built-up areas exist within 10km radius of the project.
- No National and State Highways.
- No Highways or Railway lines are located.
- No Villages/Houses are to be shifted
- No rehabilitation of villages is involved on account of this operation. The nearest village is 5km from the west boundary of Mining Lease Area.

There are three villages in the east i.e. Mozambezi and Gunda which are 5Km from Eastern boundary and Mushi is 13km in N/E direction. These villages are located in adjacent Coal India tenement area (3450 & 3451). There are two villages viz. Nyamitalala (4.5km) and Katabwe (11.5km) in the southern side of the tenement area and these two villages lie in the Nkondezi Tenements.

11.3.7 Regional Meteorological Conditions:

Climate change leads to a rise in temperature, the frequency and the magnitude of extreme weather events changing, the precipitation levels and the seasonal patterns. Such changes have a strong impact on the mining industry.

The changes and variability in climate can aggravate adverse impacts due to coal mining in the area. Both the precipitation and the temperature in Moatize, play an important role in the quality and quantity of the mine water coming from coal mine. Temperature and the precipitation in Moatize during the period of 1953 and 2015 are given in Fig.11-5.

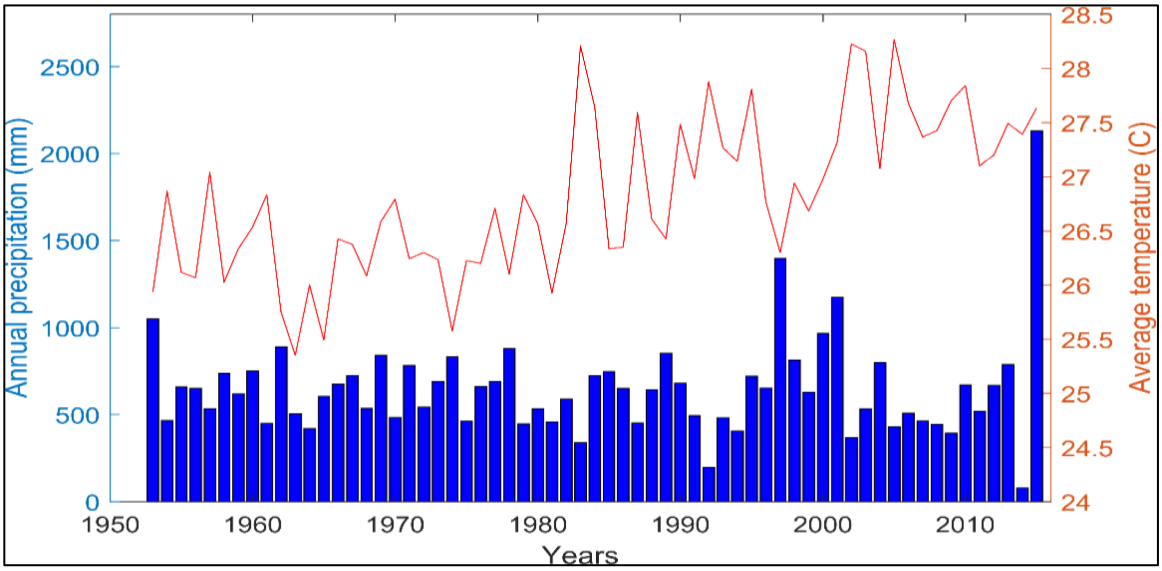


Fig. 11-5: Temperature and Precipitation in Moatize during the Period of 1953 to 2015

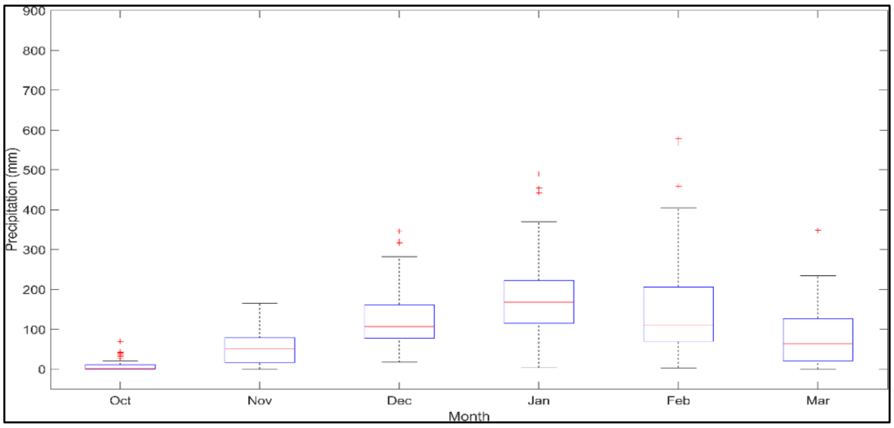


Fig. 11-6: A box plot of the monthly precipitation during each month of the rainy season in Moatize during the period of 1953 to 2015

The monthly mean temperatures in Moatize for the period of 1953to 2015 are presented (Figs 10-6& 10-7). Looking at the rainy season (October to March), one can note that the mean temperature then is high. This is conducive to development of *ithiobacillus ferrooxidans* bacteria, which enhance the oxidation of Fe^{2+} to Fe^{3+}.

The optimum growth temperature for these bacteria is between 25 to 35°C, which is the case during the rainy season. The presence of the sebacteria can enhance oxidation and production of Acid mine drainage (AMD).

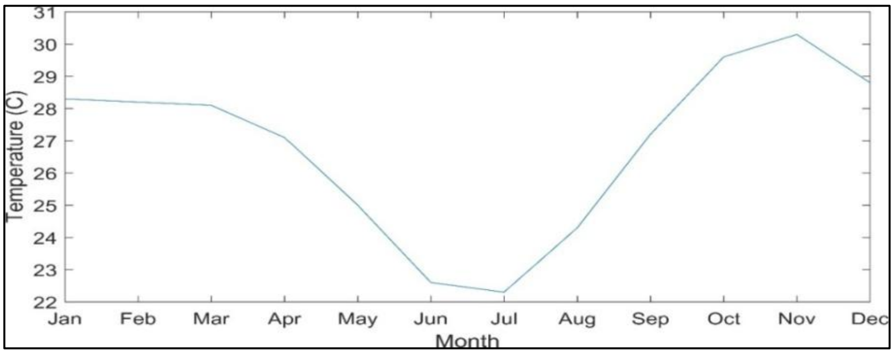


Fig. 11-7: Average monthly temperatures during the period of 1953 to 2015 in Moatize area

11.3.8 Site Meteorological data:

Preliminary studies on site specific meteorological studies have revealed similarities in temperature, rainfall and wind pattern within the broad regional spectrum. However, site specific details are under compilation for incorporation into next level of EMP report which is under preparation. In order to monitor site specifications meteorological aspects two weather stations are planned in the core area to monitor diurnal variations for 90 days. Weather station height proposed is 10msuch that there will be free flow of wind. Similar stations will be located in nearby villages to monitor changes in air quality.

- Mashambaz
- Katabue
- Monga
- Nyamitalala
- Mozambezi
- Gunda
- Muchena

The critical weather elements that influence the pollution are wind speed, wind direction, temperature which together determines atmosphere stability. Hence, it is an indispensable part of any air pollution studies and requires interpretation of baseline information. The details of the temperature, relative humidity and rainfall observed during study period will be tabulated as under Table 11.1.

Table 11.1: Observed Meteorological data

Period	**Temperature**		**R. Humidity**		**Rainfall (Cm)**	**Predominant Wind Direction**
	Max	**Min**	**Max**	**Min**		
April						
May						
June						

Wind speeds will also be recorded and tabulated.

- The prime object of the baseline air quality is to assess the existing air quality of the area. The ambient air quality will be monitored as per prescribed guidelines.
- Ambient air quality monitoring (AAQM) stations will be set up at 9 locations as shown in the above Table 11-1
- The parameters to be monitored are particulate matter (PM10), particulate matter (PM2.5), Sulfur dioxide (SO_2), Oxides of nitrogen (NO_2) and carbon-monoxide.

11.4 MINE WATER MANAGEMENT AND GUIDELINES

- The standard guideline for wastewater discharge in the coal mines of Mozambique is presented in Table 11.2. This guideline is very weak since it does not include pollutants of relevance that can damage the environment. The concentration of mercury presented in the guideline is very high in comparison with other international guidelines. The coal mining companies in Moatize use this guideline and other mining companies follows South African guidelines due to the weakness of it.

Table 11.2: The guideline used for coal mine water in Mozambique

Parameter	Value
pH	06-09
TSS	35 –50
Oil & fat	10
Mercury	3.5

- The unit for each of the parameters is mg/L, except for the pH values (Assembleia da República, 2004).
- Drinking water guidelines from different countries and mine water guidelines from international institutions were combined in order to propose a strong guideline for the coal mine wastewater in Mozambique. The guideline presented in (Table 11.3&11.4) is for mine water and surface run-off. Mine water is considered to be the water coming from underground locations, its quality and quantity depending upon the local rock mass and location of the water table, respectively.

Table 11.3: A guideline for coal mine water and for surface run-off in Mozambique as expressed in mg/L

Pollutants	Maximum permissible value
pH	06-Sep
TDS	300
TSS	70
COD	150
BOD5	50
Oil and grease	10
2-	250
SO4	
As	0.1
Cd	0.05
Cr	0.1
Cu	0.3

CN	1
Fe (total)	2
Pb	0.2
Hg	0.02
Ni	0.5
Zn	0.5
Mn	2
Al	0.2

Guideline to process wastewater from coal preparation plant in Mozambique has been proposed. The GMSC shall take cognizance of AMD management measures.

Table 11.4: Guideline to Process Wastewater from Coal Preparation Plant in Mozambique

Pollutants	Maximum permissible value
pH	06-Sep
BOD5	30
COD	150 (40 cooling water)
NH4-asnitrogen	5
Total nitrogen	10
Total phosphorus	2
Sulfide	1
SO42-	250
Oil and grease	10
TDS	300
TSS	35
Total metals	10

Cd	0.1
Cr(total)	0.5
Cr(hexavalent)	0.1
Cu	0.5
Co	0.5
Zn	1
Pb	0.5
Fe	3
Ni	1
Hg	0.02
V	1
Mn	2
Phenol	0.5
CN	0.5 0

11.5 SOIL MANAGEMENT

Soil is a top most layer of earth's surface and supports vegetation for survived of local communities. It is vulnerable to liquid and solid pollutions coming from coal mining project (Table 11.5).

Table 11.5: Soil Sampling Locations

S. No	Code	Name of the Station	W.R.T. Site	
			Direction	Distance (Km)
1	Si			
2	S2			
3	S3			
4	S4			
5	S5			
6	S6			
7	S7			
8	S8			
9	S9			
10	S10			

The analytical results of the soil samples collected during the study period shall be summarized as given below.

The pH of the soil is an important property; plants cannot grow in low and high pH value soils. The normal range of the soils in 6.0 to 8.5 is called as normal to saline soils. Most of the essential nutrients like N, P, K and Cl are available for plant at the neutral pH except for Zn and Mn which are available at low pH range. The soils having pH below 7 are considered to be acidic from the practical standpoint, those with pH less than 5.5 and which respond to liming may be considered to qualify to be designated as acid soils. On the basis of pH measurements, the degree of soil acidity shall be charted. The other important parameters for characterization of soil for irrigation are Nitrogen, Phosphorus and Potassium (NPK) which are known as primary nutrients, Calcium, Magnesium and Sulfur as secondary nutrients. Nitrogen encourages the vegetative development of plants by imparting a healthy green color to the leaves

Phosphorus influences the vigor of plants and improves the quality of crops. It encourages the formation of new cells, promotes root growth (particularly the development of fibrous roots), and hastens leaf development.

11.6 SOCIO-ECONOMIC ENVIRONMENT

People living in project area of influence are dependent on primitive agriculture; as such their standard of living is very poor. They live in thatched huts with mud floors and are not privileged to avail basic amenities such as protected drinking water, First Aid & Emergency medical facilities, motor transport etc. With a view to contributing its share to committed betterment of social life, the MAL has initiated CSR activities in the form of bore wells for protected drinking water. The Moatize administration has appreciated MAL activities in remote areas.

11.6.1 CSR activities:

The MAL has undertaken CSR activities in the form of drinking bore wells and road improvements (Fig.10-8). As it is ongoing process, it is proposed to set up wellness center and primary education facilities at Kokwe which benefit the people living in nearby villages as well.

Fig. 11-8: MAL officials providing drinking water borewells and pipe line at Kokwe village as part of CSR activities.

11.6.2 Community Consultations:

The GMSC along with the Maputo administration conducted public consultation and public hearing with the nearby local communities (Fig.11-9). Local people have been apprised about the upcoming coal mining project in the area including its benefits for betterment of their social status and impacts of coal mining. All the participants have unanimously approved the project and signed the relevant documents required for social licensing by the stake holders (people and officials).

Fig. 11-9 Community Consultation Meeting at 5086C Project Site

The Midwest had advised GMSC to focus on EMP with emphasis on sustainable environment combined with viable coal mining so that it will benefit the local communities and all the stake holders and mitigate adverse impacts of coal mining in the area. It may be mentioned that there are no local communities living in core zone of the mining project, few hamlets are present in the zone of influence of stipulated radius.

11.7 EMP OUT LINE DURING MINING OPERATIONS

The following standard provisions are envisioned by MAL during mining to comply with Government regulations on the subject.

11.7.1 Air environment:

Mining activity generate large quantities of dust during drilling, blasting, loading and transportation operations. It will be managed by

Effective water spraying arrangements in all working places as well as at coal loading bunkers at pithead on surface.

Effective water spraying at all coal transfer points.

Enclosures on coal transfer points.

Water spraying arrangement along the haulage roads within mine premises.

Clearing off coal dust heaps on surface.

Use of Hygroscopic salt to draw moisture from the atmosphere to form aqueous solution. A surface treated with this sort of solution can be kept damp for longer period of time.

Plantation within the mine premises and also along coal transport route.

Proper periodic maintenance of vehicles.

11.7.2 Noise Environment:

The major noise-generating sources from the proposed activity are Pit-head coal handling arrangements and plying of vehicles. The following control measures are to be undertaken to bring down the noise levels.

Height of fall is to be minimized at all coal transfer points. Internal lining of bins and chutes will be ensured.

In high noise intensity working areas / zones ear muffs or earplugs or any other suitable personal protective equipment would be provided to the workmen.

Regular noise level monitoring will be undertaken periodically for taking corrective action, wherever required.

Isolating / enclosing the noisy machines / using resilient mountings, balanced and properly aligned conditioning machines to reduce vibration.

Good preventive maintenance of machinery to eliminate the noise as far as possible.

11.7.3 Water Environment:

Mining activities may cause adverse impact due to discharge of mine drainage, siltation due to rain water, and contaminated water from workshops and domestic waste water. Some of the control measures adopted for controlling water pollution are as follows:

The mine discharge water, which may contain coal fines, needs sedimentation, before discharge into the natural water course/ open land. The treatment facilities such as sedimentation, filtration and chlorination have been provided for mine discharge, so as to conform to the prescribed effluent standards. The overflow treated mine discharge water from mine filter beds if flowing through the seasonal ephemeral nala to the outside agricultural fields for cultivation and there is no effect on seasonal stream flow due to mining activities.

The domestic effluents from the townships are being treated in septic tanks followed by soak pits. The treated effluents from the septic tank/ soak pit will be let out into the adjacent agricultural land. The quality of the treated effluent from the septic tank/soak pit will be regularly monitored. It is also recommended that the mine water, which is being discharged, can also be used for agricultural purposes as its quality will conform for this use.

11.7.4 Land Management & Land Reclamation:

The total mining block consists of 303Ha. It is a forest land. ~80 to 85% land will be reclaimed by backfilling. Top soil which will be collected before mining operation and preserved is spread in reclaim areas. Re-plantation programme will be initiated as appropriate.

Along the road sides both in project and mine complex and in the vacant lands of the residential area plantation shall be taken up.

11.8 STATEMENT OF ENVIRONMENT RELATED COSTS (DIRECT COST)

Environment related costs estimated are around 2.9 million USD over a span of first year.

Table-11.6 Environmental Cost Estimates

Item	Cost(USD) in million
Baseline Data Generation, Environmental Impact Assessment & Environment Management Plan	0.1
Public Hearing	0.1
CFE Charges & TC Meeting	0.1
Air Pollution Abatement facilities	0.2
Effluent treatment Plant	0.1
Pollution Monitoring facilities	0.1
Water treatment Facilities	0.2
Settling Pond	0.1
Greenbelt Development	0.5
Scientific Studies	0.1
Rain water harvesting structures / recharging ponds	0.1
CSR	1.2
Total	2.9

12 ECONOMIC ANALYSIS

12.1 MARKET STUDY:

Global coal consumption climbed to a new all-time high in 2022 and will stay near that record level this year as strong growth in Asia for both power generation and industrial applications outpaces declines in the United States and Europe, according to the IEA's latest market update.

Coal consumption in 2022 rose by 3.3% to 8.3 billion tonnes, setting a new record, according to the IEA's mid-year Coal Market Update, which was published today. In 2023 and 2024, small declines in coal-fired power generation are likely to be offset by rises in industrial use of coal, the report predicts, although there are wide variations between geographic regions.

China, India and Southeast Asian countries together are expected to account for 3 out of every 4 tonnes of coal consumed worldwide in 2023. In the European Union, growth in coal demand was minimal in 2022 as a temporary spike in coal-fired power generation was almost offset by lower use in industry. European coal use is expected to fall sharply this year as renewables expand, and as nuclear and hydropower partially recover from their recent slumps. In the United States, the move away from coal is also being accentuated by lower natural gas prices.

After three turbulent years marked by the Covid-19 shock in 2020, the strong post-pandemic rebound in 2021 and the turmoil caused by Russia's invasion of Ukraine in 2022, coal markets have so far returned to more predictable and stable patterns in 2023. Global coal demand is estimated to have grown by about 1.5% in the first half of 2023 to a total of about 4.7 billion tonnes, lifted by an increase of 1% in power generation and 2% in non-power industrial uses.

By region, coal demand fell faster than previously expected in the first half of this year in the United States and the European Union – by 24% and 16%, respectively. However, demand from the two largest consumers, China and India, grew by over 5% during the first half, more than offsetting declines elsewhere.

"Coal is the largest single source of carbon emissions from the energy sector, and in Europe and the United States, the growth of clean energy has put coal use into structural decline," said IEA Director of Energy Markets and Security Keisuke Sadamori. "But demand remains stubbornly high in Asia, even as many of those economies have significantly ramped up renewable energy sources. We need greater policy efforts and investments – backed by stronger international cooperation – to drive a massive surge in clean energy and energy efficiency to reduce coal demand in economies where energy needs are growing fast."

The shift of coal demand to Asia continues. In 2021, China and India already accounted for two-thirds of global consumption, meaning together they used twice as much coal as the rest of the world combined. In 2023, their share will be close to 70%. By contrast, the United

States and the European Union – which together accounted for 40% three decades ago and over 35% at the beginning of this century – represent less than 10% today.

The same split is observed on the production side. The three largest coal producers – China, India and Indonesia – all produced record amounts in 2022. In March 2023, both China and India set new monthly records, with China surpassing 400 million tonnes for the second time ever and India surpassing 100 million tonnes for the first time. Also in March, Indonesia exported almost 50 million tonnes, a volume never shipped by any country before. By contrast, the United States, once the world's largest coal producer, has more than halved production since its peak in 2008.

After the extreme volatility and high prices of last year, coal prices fell in the first half of 2023 to the same levels as those seen in summer 2021, driven by ample supply and lower natural gas prices. Thermal coal returned to being priced below coking coal, and the big premium for Australian coal narrowed following the easing of disruptive La Niña weather that had hampered production. Russian coal has found new outlets after being barred in Europe, but often at considerable discounts.

Cheaper coal has made imports more attractive for some price-sensitive buyers. Chinese imports have almost doubled in the first half of this year, and global coal trade in 2023 is set to grow by more than 7%, outpacing overall demand growth, to approach the record levels seen in 2019. Seaborne coal trade in 2023 may well surpass the record of 1.3 billion tonnes set in 2019.

Mozambique Market

Mozambique produced around eight million metric tons of coal in 2020. Of these, 4.7 million metric tons were from coking coal, while steam coal amounted to 3.4 million metric tons. Both items registered a decrease in production compared to the previous year. During the period observed, coal production in Mozambique peaked at over 15 million metric tons in 2018.

12.1.1 Saleable coal product specifications:

Saleable Coal products from 5086C property are two types

1) Coking coaland2) Thermal coal

12.1.2 Metallurgical coal:

Metallurgical Coal produced from Moatize coal basin has been a part of sea borne trade since 2011. It has been indexed as Chipanga and Moatize brands, the source for both being the coal from Chipanga seam.

Nearest coal mines working on Chipanga seam belong to VALE&ICVL, both are located at about 40km west of 5086C in the same coal basin. There is no information available on trading of Chipanga coal from ICVL. Whereas, coal qualities of VALE product, trading volume, and price realization are available in public domain. Hence they have been considered as bench mark to evaluate marketing aspects of metallurgical coal form Midwest project which is well set for extraction of coal from the Chipanga seam.

There is a similarity in Value-in-use (VIU) components such as CSN (Crucible swelling number), Moisture%, Ash%, vitrinite% but variation in VIU which is likely to invite penalty for VM%, CSR%, & MMR and command a premium for low phosphorous and fluidity.

12.1.3 Metallurgical Coal Market and Pricing:

The main markets for metallurgical Coal are India, China, Brazil, South Africa, Europe, Japan & Korea. West Africa is likely to emerge as a new market for coking coal as good quality Iron Ore is available in abundance and iron ore mining is gaining in volume and steel plants are proposed to be established. , West Africa is expected to be the next destination for metallurgical coal from Mozambique. Steel production capacity in India is scaling new heights though in small increments. Metallurgical coal from Mozambique enjoys close proximity to the large market which depends mostly on imports to meet its requirement. Therefore, the market scenario for Mozambique coal is encouraging and has been supported by encouraging prices.

Metallurgical coal imports in India are broadly guided by specifications followed by SAIL (Steel Authority of India) (see Table 12.1). Metallurgical coal prices in India are derived from Australian and US Bench mark coals.

Table 12.1: Technical Specifications of SAIL Vis-À-Vis MIDWEST (5086C) Metallurgical Coal

Technical Specifications of Hard Coking Coal, Soft coking coal of SAIL, India compare to MAL coking coal Size (0-50mm)					
S. No	**Parameter**	**Unit**	**Absolute Max./Absolute Min. Tolerance Limit for hard coking coal ##**	**Absolute Max./Absolute Min. Tolerance Limit for soft coking coal ##**	**Midwest Coking coal**
1	Total Moisture (On "As received Basis)	% Max	12	11	2
2	Proximate Analysis (On "Air Dried Basis") (BS 1016-1973 Part 3)				
	a) Volatile Matter	%	20 Min. 32 Max.	20 Min. 34 Max.	31
	b) Ash	% Max	10	10	10
3	Sulphur (BS 1016-	% Max	1	0.85	1

	1973)				
4	CSN (ISO/501-1974)	Min.	5	3	9
5	MMR(ISO/7404)	%	1.15 Min. 1.40 Max.	0.85 Min. 1.35 Max.	0.98
6	Vitrinite % (ISO/7404)	% Min.	50	45	80
7	Vitrinite Distribution (V9-V14) (ISO/7404)	% Min.	75		69
8	Max. Fluidity (ASTM D 2639)	Min.ddpm	300	150	1455
9	Micro Fines (Size Fractions <0.5mm)	% Max	30	30	30

(Technical committee appointed by SAIL shall decide premia /penalty to nearest specifications)

12.1.4 Price Realization:

Australian coking coal prices averaged USD 301 per metric ton in September, up 18.6% from August's 2023 price and 13.0% higher year on year.

12.1.5 Midwest Realizable Prices for Metallurgical Coal:

Table 12.2Price realization of metallurgical coal

Particulars	Price/Discount	Remarks
Current Price	301 $ per ton	HCC-64, US High Vol-A. reference
Quality adjustment and market	30 $ per ton	Index reference price due to different product characteristics as well as value in use adjustments which may have a negative affect (15%)
Other adjustments like sales, penalties	5 $ per ton	3%
FOB Realized price	266$ per ton	

CP has envisioned a price realization for Midwest metallurgical coal on f.o.b basis to be in the range of 250-280 $ at the time of reporting.

However, economic assessment has been computed at 266 $ realized metallurgical coal price providing a further discount to the market price as well as cyclic price fluctuations.

12.1.6 Thermal coal specifications:

Thermal coal specifications and pricing in Southern Africa are governed by Richards Bay index. Penalties are imposed for high ash and low thermal heat value.

A comparative statement of MAL Thermal coal with RB1 and RB3 bench mark coals is shown in Table 12.3.

Table 12.3: Comparative statement of Richard bay bench mark coals and MAL coal specifications

Specifications	RB1	RB3	MAL
Calorific Value Basis (kcal/kg NCV)	6,000	5,500	6,000
Calorific Value Min (kcal/kg NCV)	5,850	5,300	5,980
Total Moisture (ARB)	12% max	14.0% max	2.0%(adb)
Volatile Matter (ARB)	22% Min	20.0% min	28.0%(adb)
Ash (ARB)	15.0% Max	23.0% max	23-25(adb)
Sulphur (ARB)	1.0% Max	1.0% max	1.0%(ADB)
Hardgrove Grindability Index (HGI)	45-70	45 – 70	54-68%
Nominal Top size	50mm	50 mm	50mm
IDT	Min 1,250 °C in reducing atmosphere	Min 1,150 °C in reducing atmosphere	1500°C In reducing atmosphere
Calcium Oxide in Ash (DB)	12.0% max		0.9-1.2%

MAL= Midwest Africa Limitada, Mozambique, RB= Richard Bay

12.1.7 Thermal coal price realization on f.o.b basis:

VALE, Mozambique has been engaged in export trade of thermal coal since the time of commencement of its mining operations in the year 2011. Thermal coal prices are linked to calorific value and ash content. Though Mozambique thermal coal has favorable heat value but high in ash content and hence poses a concern to the consumers and attracts a significant amount of discount. Vis-à-vis Richard Bay indexed price. In fact, against the price realization

@ 110$ / MT for RB3 type in last quarter of 2023. Price realization for Midwest thermal coal will also attract the same discount and thus is considered@96$/ton.

12.1.8 Midwest Realizable Prices for Thermal Coal:

Table 12.4: Price realization of Thermal coal

Particulars	Price/Discount	Remarks
Current Price	110 $ per ton	Thermal coal
Quality adjustment	12 $ per ton	Index reference price due to different product characteristics as well as value in use adjustments associated with ash content, which has a negatively affect (15%)
Other adjustments l	2 $ per ton	3%
Realizable price FOB	96 $ per ton	

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12.2 MARKETING STRATEGY

MGPL foresees a marginal upsurge in the price of both metallurgical and thermal coal in the coming years. Midwest shall adopt a mixed strategy of sale of coal through long term supply contract as well as partly through spot sales. Midwest will strive for least cost delivery of products to ensure continued viability / profitability of the project. However, MAL has been advised to engage marketing agency in the light of large in-situ coal product tonnages identified in 5086C license. A review of global coal outlook, Mozambique scenario and constraints are documented in the report.

12.3 SUMMARY OF COST ESTIMATES

Capital expenditure is the money spent on project development; mine site infrastructure development, coal processing plant (washery) and contractor advance for mining. Coal processing plant shell be developed in modular basis there will be 5 modules, each with a capacity of 6 mtpa.

12.3.1 Capital Cost (CAPEX):

The capital cost for 3 Mtpa for First year and ramp up to 30 Mtpa ROM coal production which is segmented into different modules (Mines) developed in a sequential manner to achieve the desired targets and objectives. Capital and operational cost estimates are presented in Tables 12.5&12.6.

Table 12.5: Capital Estimates

Capital Costs (in USD Million)		**Initial Capital for 3 MTPA (2024)**	**Total Capital cost over life of Mine (30 MTPA)**
	Mine Equipment - Advance	5.0	5.0
	Washery equipment	33.9	335.6
	Mine Infrastructure & Development	6.3	31.3
	Contingency (5%)	2.3	18.6
	Working capital margin	0.7	0.7
	Total Capital Cost	48.1	391.3

12.3.2 Operating Cost (OPEX):

The operating cost is the cost of running the mine; items included in the model are.

Coal Mining price to contactor $13.2 per ton of ROM

Washing/Processing (USD/t RoM) $4 per ton of ROM

Coal Transport& port handling charges $48.7 per ton of FOB product

Management & Support Expenses $0.5 per ton of ROM

Mine closure $0.5 per ton of ROM

Environment Related Costs $0.4 per ton of ROM

CSR 1% of capital expenditure

Table 12.6: product cost estimate per ton of saleable coal Product

Operating costs	**US$/ROM ton**
Mining Costs (Strip ratio of 1:2.5)	13.2
Management & Support Expenses	0.5
Average mine closure cost per tone	0.5
Environment Related Costs	0.4
CSR	0.1
Cost per ton of ROM	14.7
Washing cost per ton of ROM	4.0
Mining + Washing cost per ton of ROM	18.7
	US$/Product t
Cost per ton of Saleable Coal Product	49.3
Royalty (3% Ex mine revenue)	4.1
Total Cost per ton of product	53.4
Transport Costs	US$/Product t
Road Transport to Rail sliding	4.2
Rail transport to Port cost	35.0
Port Charges	9.5
Export product transport cost	48.7
	US$/Product t
Total Operating cost at FOB	102.1

Assumptions and basis for cost estimates are described in the present report.

12.3.3 Financial Model:

Midwest has prepared a financial model, incorporating technical and cost input parameters which have been derived from current level of technical studies.

The following are deemed to be appropriate for the current level of economic assessment.

- Discount Rate: 10%
- The operating cost input parameters driving the revenue stream include
- Mining unit costs for waste and coal.
- A wash plant unit cost, including Run-of-Mine and coal product handling.
- Discard and slime disposal unit costs.
- Rail and port unit costs.
- The general and administration annual fixed cost.
- Royalty to be paid to the Government on sale value.
- A mine closure cost at the end of the mine life. The continued monitoring costs required at the end of the mine life have not been considered at this level of study.
- Project economics for 30mtpa has been worked out and presented in Excel spread sheets incorporated in the report.

12.3.4 Internal Rate of Return (IRR):

The internal rate of return (IRR) is a method of calculating rate of return. Rate of return is a profit on an investment over a period of time, expressed as a proportion of the original investment.

NPV	US$m	1795
IRR	%	115.1%

Cost Sensitivity and market sensitivity on overall project financial analysis presented in the report indicate that the project can sustain up to 10% negative trend on production operating costs and 20% negative in revenues. Therefore, the project financial robustness and sensitivity are rated to be moderately strong.

12.4 FINANCIAL MODEL

The model is prepared for 21 years including ramp up period of nine years to achieve 30 Mtpa scale of full production. In this process we can mine out only 327 MMT of ROM coal. Coal production which is expected to yield saleable coal product of 65.4 MMT of metallurgical coal and 58.9 MMT of thermal coal in 21 years. It translates into saleable coal of 6mtpa metallurgical type and 5.4 mtpa thermal coal per year at peak production. Price realization at FOB is 266$ for metallurgical coal and 96$ for thermal coal taking into consideration of coal cyclical and present market value (details are provided in section on market analysis.

Midwest has prepared a financial model (the “Financial Model”), incorporating technical and cost input parameters and coal sale revenues to derive project economics.

The Financial Model has been prepared on Microsoft Excel.

Periodicity is presented in the model on annual basis.

Financial Model is presented on US Dollars.

The corporate income tax rate assumed is 32%. Midwest is aware that various tax related benefits may exist and/or to be negotiated. However, in the absence of better defined terms, these benefits (corporate income tax rate and the depreciation allowances etc.) are not incorporated in the model.

Discount Rate of 10% is considered for NPV calculation.

Input Parameters

The technical input parameters and commodity prices driving the revenue stream primarily consist of the following:

The coal products are saleable in the current overseas market.

The operating cost input parameters impacting the revenue stream include:-

Mining costs of ROM coal.

Washing cost of coal.

Transport and port handling charges.

Administration and miscellaneous cost.

Mine closer cost.

12.5 FINACIAL MODEL

Financial projections for 10 years

Midwest Africa Limitada												
Flags												
Model Year			1	2	3	4	5	6	7	8	9	10
Year			2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Operations												
Physicals												
Total ROM Production	Mt	327.0		3.0	3.5	3.5	6.0	6.0	6.0	11.0	11.0	11.0
Export Coking Coal	Mt	65.4		0.6	0.7	0.7	1.2	1.2	1.2	2.2	2.2	2.2
Export Thermal Coal	Mt	58.9		0.5	0.6	0.6	1.1	1.1	1.1	2.0	2.0	2.0
Saleable Product(FOB)	Mt	124.3		1.1	1.3	1.3	2.3	2.3	2.3	4.2	4.2	4.2

Revenue											
Coking Coal FOB price	US$/t		266.0	266.0	266.0	266.0	266.0	266.0	266.0	266.0	266.0
Thermal Coal FOB Price	US$/t		96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0
Coking Coal Revenue	US$ m	17,396.4	159.6	186.2	186.2	319.2	319.2	319.2	585.2	585.2	585.2
Thermal Coal Revenue		5,650.6	51.8	60.5	60.5	103.7	103.7	103.7	190.1	190.1	190.1
Total Revenue		23,047.0	211.4	246.7	246.7	422.9	422.9	422.9	775.3	775.3	775.3
Ex Mine Revenue		16,995.5	155.9	181.9	181.9	311.8	311.8	311.8	571.7	571.7	571.7
Costs											
Operating Costs											
Mining	US$ m	4,316.4	39.6	46.2	46.2	79.2	79.2	79.2	145.2	145.2	145.2

Washing	US$ m	1,308.0		12.0	14.0	14.0	24.0	24.0	24.0	44.0	44.0	44.0
Production Tax (Royalty)	US$ m	509.9		4.7	5.5	5.5	9.4	9.4	9.4	17.2	17.2	17.2
Management, Administration & Support Expenses	US$ m	163.5		1.5	1.8	1.8	3.0	3.0	3.0	5.5	5.5	5.5
Mine Closure	US$ m	163.5		1.5	1.8	1.8	3.0	3.0	3.0	5.5	5.5	5.5
Environment Related Costs	US$ m	130.8		1.2	1.4	1.4	2.4	2.4	2.4	4.4	4.4	4.4
CSR	US$ m	43.2		0.4	0.6	0.6	0.9	0.9	0.9	1.5	1.5	1.5
Transport to Port	US$ m	4,871.0		44.7	52.1	52.1	89.4	89.4	89.4	163.9	163.9	163.9
Port charges	US$ m	1,180.5		10.8	12.6	12.6	21.7	21.7	21.7	39.7	39.7	39.7
Total	US$ m	12,686.7		116.4	135.9	135.9	232.9	232.9	232.9	426.8	426.8	426.8

Capital Costs

Mine Equipment - Advance	US$ m	5.0	5.0									
Washery	US$ m	335.6	33.9	18.8		28.2			50.0			50.0
Mine Infrastructure & Development	US$ m	31.3	6.3						6.3			6.3
Contingency (5%)	US$ m	18.6	2.3	0.9	0.0	1.4	0.0	0.0	2.8	0.0	0.0	2.8
Working capital margin	US$ m	0.7	0.7									
Total Capital Cost	US$ m	391.3	48.1	19.8	0.0	29.6	0.0	0.0	59.1	0.0	0.0	59.1
Repairs and Maintenance	US$ m	431.9		4.2	6.2	6.2	9.2	9.2	9.2	15.1	15.1	15.1
Total Capital Cost + Maintenance	US$ m	823.2	48.1	24.0	6.2	35.9	9.2	9.2	68.3	15.1	15.1	74.2
Profit and Loss (for Tax Calculation), dividend from Coke plant not added												
EBITDA	US$	10,360.2	0.0	95.0	110.	110.	190.	190.	190.	348.	348.	348.

	m				7	7	0	0	0	5	5	5
Interest cost	US$ m	-97.2	0.0	-4.1	-5.7	-4.7	-4.4	-3.4	-2.4	-2.7	-2.7	-2.7
Depreciation	US$ m	-603.6		-6.6	-7.3	-10.8	-11.8	-12.7	-19.5	-21.0	-22.5	-29.9
EBT	US$ m	9,659.4	0.0	84.3	97.8	95.2	173.8	173.9	168.0	324.8	323.3	315.8
Corporate Tax	US$ m	-3,091.0	0.0	-27.0	-31.3	-30.4	-55.6	-55.6	-53.8	-103.9	-103.4	-101.1
EAT (Earnings After tax)	US$ m	6,568.4	0.0	57.3	66.5	64.7	118.2	118.2	114.3	220.8	219.8	214.8
Free Cash Flow												
Revenue	US$ m	23,047.0	0.0	211.4	246.7	246.7	422.9	422.9	422.9	775.3	775.3	775.3
Operating Costs	US$ m	-12,686.7	0.0	-116.4	-135.9	-135.9	-232.9	-232.9	-232.9	-426.8	-426.8	-426.8
Interest cost			0.0	-4.1	-5.7	-4.7	-4.4	-3.4	-2.4	-2.7	-2.7	-2.7

Tax	US$m	-3,091.0		0.0	-27.0	-31.3	-30.4	-55.6	-55.6	-53.8	-103.9	-103.4	-101.1
Capital Expenditure	US$m	-823.2	0.0	-48.1	-24.0	-6.2	-35.9	-9.2	-9.2	-68.3	-15.1	-15.1	-74.2
Free Cash Flow	US$m	6,348.8	-1E-06	-48.1	40.0	67.5	39.7	120.8	121.7	65.5	226.8	227.3	170.6

NPV	US$m	1795
IRR	%	115.1%

12.6 INTERNAL RATE OF RETURN (IRR)

The internal rate of return (IRR) is a method of calculating rate of return. Rate of return is a profit on an investment over a period of time, expressed as a proportion of the original investment.

IRR is designed to account for the time preference of money and investments. A given return on investment received at a given time is worth more than the same return received at a later time, so the latter would yield a lower IRR than the former, if all other factors are equal.

The formula for *IRR* is:

0 = P0 + P1/(1+IRR) + P2/(1+IRR)2 + P3/(1+IRR)3 + . . . +Pn/(1+IRR)n

Where P0, P1 . . . Pn equals the cash flows in periods 1, 2 . . . n, respectively;

Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in capital budgeting to analyze the profitability of a projected investment or project.

The following is the formula for calculating NPV:

In this equation:

- Ct = net cash inflow during the period t
- Co = total initial investment costs
- r = discount rate, and
- t = number of time periods

NPV	US$m	1795
IRR	%	115.1%

12.7 SENSITIVE ANALYSIS (NPV)

The forecasted cash flows depend on the expected revenue and costs. The net present value of the project was determined by analyzing the after-tax cash flows arrived at by combining forecasts of various variables. The reliability of NPV of the project will depend on the reliability of the variables underlying the estimates of net cash flows. To determine the project's NPV, we worked out how much difference it makes if any of these forecasts deviates from assumptions. We changed each of the forecasts, over time, to at least three options: pessimistic, expected and optimistic. The NPV of the project is recalculated under these different assumptions. This method of recalculating the NPV, by changing each forecast is called sensitivity analysis. Sensitivity analysis is a way of analyzing change in the project's NPV for a given change in one of the variables. It indicates how sensitive a project's NPV is to changes in particular variables.

Cost Sensitivity and market sensitivity on overall project financial analysis presented in the report indicate that the project can sustain up to 10% negative trend on production operating costs and revenues. Therefore, the project financial robustness and sensitivity are rated to be moderately strong.

Table 12.7 NPV (million USD)

		Operating cost		
Revenue /Sales	% of Change	10% increase	No Change	10% decrease
	20% increase	2784	3160	3536
	10% increase	2102	2478	2853
	No Change	1419	1795	2171
	10% decrease	736	1112	1488
	20 % decrease	54	430	805

13 ENVIRONMENTAL STUDIES & COMMUNITY CONSULTATIONS

MAL has commissioned GMSC Lda, a consulting company recognized by Government of Mozambique to prepare an Environmental Impact Assessment Report and Environmental Management Plan. The work involves two phases of study 1) EPDA 2) EIA.

In partial fulfillment of environmental licensing mandate, the GMSC Lda has conducted EPDA (Pre-environmental feasibility and definition of scope) study along with community consultation and a detailed report was submitted to MICOA (Ministry for the co-ordination of environmental action) for approval.

13.1.1 EPDA:

The EPDA report has been prepared for the proposed coal mining operation and CHPP activity. Environmental standards for the mining industry are contained in the, the law of the environment, the Environmental Regulation for Mining Activities (Decree 26/2004 of 20 August) and other regulations and directives as outlined in the report. Among other things, delimitation of (AID) Area of Direct Influence; (AII) Area of Indirect Influence; AIR (Area of Regional influence) has been accomplished. Review of bio-physical environment and socio-economic environment has been accomplished. Community consultations including local administration and local residents were held and written approval from all stake holders has been obtained.

The report thus prepared and submitted has been approved by MICOA, who has approved the report to proceed for stage-2 i.e. EIA study. Agreement between MAL and GMSC Lda is in force to complete the EIA study.

13.1.2 EIA:

Procedures and practices envisaged in next level of EIA have been defined. The ultimate objective is to reduce negative impacts of mining on environment as well as Health and Safety of the people in the area of influence. The report will be submitted in due course and permit will be obtained before the commencement of the mining operations.

13.1.3 CSR Activities:

The MAL has undertaken CSR activities in the form of sinking and energizing bore wells to provide drinking water to the local residents as well as road improvements. It is proposed to set up a wellness center and provide primary education facilities at Kokwe. Safety, health and education benefits will be accrued to people living in area of influence apart from enhanced demand for goods and services in the area of influence along with economic expansion on account of huge expenditure and cash infusion on account of the proposed operation.

13.1.4 Social acceptance:

There is no human habitation in the vicinity of the proposed mining project or within (AID) five-kilometer radius. However, there are few habitations within ten-kilometer radius (AII). People living in those hamlets have been appraised about the proposed coal mining activities. Consultations were held from time to time along with the officials from Moatize district administration. The CP has participated in community consultation meetings and found that the social acceptance of the mining project is very positive.

RISK ANALYSIS

Overall, Risk rating of the Project is **Low to Medium**. Item-wise risk assessment is as follows.

13.1.5 Geology:

Geology of the project area is simple. The MAL exploration has indicated excellent coal Formation continuity and has been rated as very good, thus no risk factor is visualized in this regard. It was a flat terrain

13.1.6 Mineralization:

Mineralization potential is very good. Coal seams are rich in coal. The thick interbedded type coal seam measuring >200m thickness which is one of the thickest in the world has been reported from 5086C and suitable for eventual exploitation in selected domains However, the coal distribution in seam is complex cyclic at close vertical intervals which may pose some problem in mining. Though there is no threat of seam missing due to faulting, yet up throw / down throw components along the fault planes may impose some constraints during mining. Risk related to mineralization is rated to be low to medium.

13.1.7 Mining:

Coal mining of thick inter bedded seams is a challenging task to overcome the constraints induced by seam morphology. The proposed selective mining method is a positive proposition to reduce mine dilution and mine recoveries. ROM grade control needs constant efforts to enhance optimization of feed ash content at CHPP**.** No fatalities are identified in proposed mining method. Hence mining related risks at this level of technical study is same as other risks related to other similar coal mining projects in Mozambique or elsewhere, thus classified as low to medium category.

13.1.8 Coal Preparation:

Coal preparation studies up to this level have been based on HX core bores and a couple of large dia holes, near gravity material estimates and theoretical recovery estimates for marketable metallurgical and thermal coal. These yields of 20% met coal and 18% thermal coal broadly confirms to the reported yields from nearby mining operations on Chipanga seam. Furthera 15 ton dedicated sample may be subjected to pilot scale washing which may through more relevant information on preparation aspects to enable the development of efficient CHPP flow sheet and plant construction. At this level of study the risk is rated at medium level. These suggestions may be incorporated in the next level of engineering studies,

13.1.9 Man power:

Mozambique is an under developed country with lower educational level of people. The MGPL past experience indicates availability of un-skilled man power. There is a shortage of Semi-skilled and skilled man power. Up gradations of skills are possible. Some conflict is visualized to ensure semblance between requirements and Government policies. Risk is rated as low to medium.

13.1.10Transport Risk:

Coal transport scenario by rail and through ports has improved manifold since 2011. Multiple rail and port network options are now available. Risk and reward are centered on choosing the right option on rail line and negotiations with the concerned parties.

13.1.11Market risk:

Price realization in the market involves a great deal of acumen and demands a great deal of strategic planning of sales. Suitable marketing agency may be appointed to conduct global market requirements, pricing pattern and shipment direction so that the risk relating to markets can be minimized.

13.1.12Administration Risk:

Past experience of MAL with the local and central administration has remained very good on account of excellent cooperation and timely response received. Licenses and permits have been obtained from local administration as per schedule. Law and order situation is good. There are no fatal risks encountered or envisaged in this regard.

13.1.13Social License:

Community consultation and community involvement efforts put up by MAL have yielded positive results. Proposed environmental measures are up to desired level of satisfaction. Thus, risk related to social license is very low.

13.1.14Sovereign Risk:

sovereign risk rating by Moody’s is placed Mozambique in Caa3 negative category which implies subdued growth in economy, elevated debt and poor governance**,** a common feature in under developed countries of Africa. However, the large Hydrocarbon and coal resources of Mozambique is attracting considerable investment and likely to improve revenues of the Government and general economy.

INTERPRETATIONS & CONCLUSIONS

Based on the outcome of the present Economic Feasibility Study, the MGPL has arrived at the following interpretations and conclusions

- The coking coal mining project 5086 C is economically viable. For,
- Exploration procedures and practices comply with the state-of-art industry practices.
- Coal quality characterization presented in the report meets the minimum requirements of economic feasibility study.
- Nature of mineralization has been elucidated.
- Geological model incorporates, grade continuity, geological continuity and Geometrical configuration of coal seams and fault modeling.
- Cut-off parameters have been defined. Resource estimates for various categories of resources conducted on Minex have been presented.
- Mining method proposed is opencast mining with selective mining of coal using Surface Miner. Conceptual mine plan has been outlined. Reserve estimate has been made in a sequence, which amounts to 714 MMT of proved coal reserve.
- Based on coal washability data, an indicative wash plant flow sheet has been developed. Theoretical wash yields are inconformity with the practical coal yields currently realized by the other coal mines in the area i.e. VALE, JSPL and ICVL in the Moatize coal basin.
- Infrastructure study to meet the project requirements has been outlined.
- Progress of environmental studies has been reviewed. Study on EIA & EMP is in progress to meet the timely environmental permitting for the project.
- Item-wise CAPEX and OPEX estimates have been developed based on reasonable assumptions and also in consultation with service providers
- Community consultations and CSR activities have indicated that the social acceptance of the project is very positive.
- Economic analysis of the project has been conducted as per industry norms and coal bench marks.
- Financial model is very positive .There are no fatal flaws identified in technical studies up to economic feasibility level. .

- Outcome of the present study is positive to justify investment for the next level of study and project development i.e. engineering drawing study in preparation for the start of mining operations.

RECOMMENDATIONS

The following recommendations have been made for next level of technical study

- The MAL may proceed to obtain public /private funding to move further on Engineering drawings and start mining operation.
- Working mine plan is immediate need of the hour.
- Coal processing and CHPP flow sheet may be developed by reputed consulting company like Minopex etc. Construction activity for CHPP may be started
- Infrastructure up gradation and bridge construction need immediate attention.

13.1.15Coal transport and handling:

- Negotiations with the coal transport authorities like VALE and CFM of Mozambique as well may be continued for securing the capacity and to determine coal transport and handling costs. Well known

13.1.16Marketing Strategy:

- A suitable agency may be engaged to work out effective marketing strategies including the identification of potential customers, market linkages for better price realization.

13.1.17Permits, Licenses and CSR activities:

- The MAL should ensure renewal of existing permits on hiring of Manpower, water, Land use, power utilities etc.
- GMSC should speed up approval of Environment Management plan (EMP) from MICOA and obtain license to operate.
- Health, Safety Environment and social license shall be maintained.
- CSR activities may be planned as per the latest guidelines issued by the Government of Mozambique.

References

ALS Presentation, (12-03-2009) Coal petrography.

AusImm (2003), Australian Guidelines for Estimating and Reporting of Inventory Coal. Coal Resources and Coal Reserves.

AusIMM (The JORC Code 2012): Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves 44p.

David E. Pearson, British Columbia Ministry of Energy, Mines and Petroleum resources Victoria, British Columbia, The Quality of Western Canadian coking coal, coal mining and technology.

Energy Publishing 2012, Methodology and Specifications for coking coal Queensland index (CCQ) and coking coal Hampton road index (CCH) 12p.

Framer, I.W., 1968- Engineering Properties of rocks, E and F.N.Spon limited, London.

Lakshminaraya, G. (2015) Geology of Barcode type coking coal seams, Mecondezi sub-basin, Moatize Coalfield, Mozambique. International Journal of Coal Geology 146 (1-13)

Larry Thomas, Coal Geology second edition.

Mine skill Australia 2010, Understanding Coal Quality, 5th edition, 295 p.

Pre-Feasibility Report (2018), Technical Report On Pre-Feasibility Study Of Coal Reserves In 5086c Tenement, Moatize Coal Basin, Mozambique by MGPL Exploration & Mining, Road No. 12, Banjara Hills, Hyderabad-34, India.

PRICE et.al 1988, The predicted coke strength after reaction values of British Colombia coals, with comparison to international coals, geological field work 1992, paper 1993-1.

Report-I, MIDWEST AFRICA LDA. April 2010, A Report on Phase-I COAL EXPLORATION in Concession No.5086C, N.Kondezi Area, Moatize coal fields, Tete, Mozambique.

Report-II, MIDWEST AFRICA LDA. June 2011, JORC Compliant coal resource report, Coal exploration in 5086C, Nkondezi area, Moatize coalfield, Tete, Mozambique.

Report-III, MIDWEST AFRICA LDA.May2012, JORC Compliant coal resource report, Coal Exploration in 5086C, Moatize coalfield, Tete, Mozambique.

Report-IV, BEHRE DOLBEAR (USA),INC., September 2011, JORC Report of Coal Resources Midwest Mozambique Coal Project Nkondezi Coal Fields, Tete Province, Mozambique, Africa, Mineral tenement 5086C – Mozambique.

Report-V, BEHRE DOLBEAR (USA), INC., December 2011, Scoping Study for Development of Coal Mine Mb-A on Mineral Tenement 5086C – Mozambique.

Report-VI, BEHRE DOLBEAR (USA), INC., March 2012, Mining Plan study for Development of Coal Mine Mb-A on Mineral Tenement 5086C – Mozambique.

Report-VII, GEOS MINING MINERALS CONSULTANTS, 06 December 2012, Independent JORC Audit and Estimation Tenement 5086C Mozambique Midwest Africa Limitada.

SANS: 10320:2004; South African guide to the systematic evaluation of coal resources and coal reserves.

Swede Coal (1981) Coal Investigation in the province of Tete, The People's Republic of Mozambique, Phase-III, Five based opportunity study.

List of abbreviations

adb	-	Air dried basis
AID	-	Area in Direct Influence
AIR	-	Area of Regional Influence
AII	-	Area of Indirect Influence
AMSL	-	Above mean sea level
Ash	-	Measure of the non-combustible material in coal expressed as a percentage
BCM	-	Bank Cubic Meter
CHPP	-	Coal Handling and Preparation Plant
CPR	-	Competent Persons Report (defined in SAMREC and JORC)
CSN	-	Crucible swell number
CSR	-	Coke strength after reaction
CSR	-	Corporate Social Responsibilities
CSV	-	Comma Separated Value File Format
CV	-	Calorific Value is a measure of contained heat measured in MJ/kg
DAF	-	Dry ash free
Db	-	Dry basis
DGPS	-	Differential Global Positioning System
DMMF	-	Dry Mineral Matter Free
EBITDA	-	Earning Before Interest, Tax, Depreciation and Amortization
EBT	-	Earning Before Tax
FC	-	Fix Carbon Content
FSI	-	Free swelling index
FoB		Free on Board
GTIS	-	Gross Tonnes in Situ
HEMM	-	Heavy Earth Moving Machines

HTC	-	High Temperature Carbonates
IM	-	Inherent moisture content in coal expressed as a percentage
IRR	-	Internal Rate of Return
JORC	-	Australasian Code for Reporting of Mineral Resources and Mineral Reserves
LAS	-	Log ASCii Standards
LD	-	Large Dia Borehole
LIDAR	-	Light Detection and Ranging
LoM	-	Life-of-Mine
Mb	-	Mining Block
MGPL	-	Midwest Granite Private Limited
MTIS	-	Mineable tonnes in-situ
MTPA	-	Million tonnes per annum
NPV	-	Net Percent Value
RAW	-	Quality of the whole coal that has not been beneficiated
Rb	-	Resource Block
RD	-	Relative density measured in g/cm^3
RL	-	Reducing Levels
SANS	-	South African National Standards
RoM	-	Run-of-Mine
TS	-	Total Sulphur Content
TTIS	-	Total tonnes in-situ
VM	-	Volatile matter
V-TYPE	-	Vitrinite Type
Vols	-	Volatile or (combustible gasses in coal) expressed as a percentage
Yield	-	The amount of coal of a certain quality expressed as a percentage of whole coal after beneficiation

LIST OF UNITS

DDPM	-	Dial Divisions Per Minute
Ha	-	Hectare
%	-	percentage
k	-	one thousand units
kg	-	a kilogram
km	-	kilometer
kt	-	thousand metric tonnes
ktpm	-	thousand metric tonnes per month
m	-	metre
m^2	-	square metre – measure of area
m^3	-	cubic metre
Mj/kg	-	Mega Joule per kilogram
Mt	-	Million tonnes
MMT	-	a million metric tonnes
MPTA	-	Million Tonnes Per Annum
mm	-	a millimetre
Mt	-	a million metric tonnes
Mtpa	-	a million metric tonnes per annum
MW	-	a million watts
º	-	degrees
ºC	-	degrees centigrade
pa	-	per annum
t	-	a metric tonne
tpa	-	Metric tonne per annum