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Mining design and short-term production scheduling by using 3D modeler in Coal mining at PT. Internasional Prima Coal, Palaran District, Samarinda City, East Kalimantan Province

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Abstract

PT. International Prima Coal is a subsidiary of a combination of two companies, namely PT. Bukit Asam (Persero) Tbk and PT. Mega Raya Kusuma which is engaged in coal mining in East Kalimantan, with an area of 3,238 hectares of Mining Business Permit in Bantuas and Handil Bakti Villages, Palaran District, Samarinda City which is planning to open a new block, namely North Eagle 3 block for the sustainability of coal production. This is the background for the author to research mining design and production schedule. This study aims to analyze resources and reserves, design mining, determine the combination of tools and monthly production scheduling. The research method used is qualitative and quantitative methods. the quantitative method will produce data such as the value of resources and reserves, slope geometry, SR (Stripping Ratio), and the amount of production per month. The qualitative method will produce data such as haul road designs, mining methods, mining sequences. Based on the results of modeling of coal deposits in the northern pit eagle 3 has 3 seams (Q050, Q070, Q080) with a total measured resource calculated by the polygon method is 726,898 tons. The design of the mining pit limit at an elevation of 0 masl is the contour of the Q070 seam structure with a total coal reserve of 66,516 tons and OB 651,952 bcm with SR 10. The haul road is made of 2 lanes with a straight road width of 9 m and a bend road width of 18 m. The form of drainage that is made is a channel with a trapezoid shape and a settling pond. The mining method used is open-pit with down-dip excavation. Mining sequences and production schedules are divided into 4 mining sequences to obtain a production target of ±16,000 tons/month.

1. Introduction

PT. Internasional Prima Coal is a subsidiary of a combination of two companies, namely PT. Bukit Asam (Persero) Tbk and PT. Mega Raya Kusuma, which is engaged in coal mining in East Kalimantan, with an area of 3,238 Ha Mining Business Permit in Bantuas Villages, Palaran District, Samarinda City, which plans to open a new block, namely North Eagle 3 block for the sustainability of coal production.

Basically, the mine planning stages are divided into three time periods, namely long-term planning, medium-term planning, and short-term planning[1]. Before carrying out coal mining activities, these activities must be planned with careful planning. Mining design is part of the planning which includes technical aspects. The design will be a guide to mining implementation issues, to reduce uncertainty in the mine because the extracted minerals are invisible to the eye and when sold the price of coal can fluctuate and can choose the best possibility to achieve the goal of efficient and effective use of reserves. productive. Mining design activity is to make a mine production plan for a mineral deposit. Some activities include the manufacture of mining excavation geometry, mining stages, mining sequences, and production scheduling. Before carrying out the design, it is necessary to try geological modeling, both topography and the structure of the composition of coal deposits. Geological modeling aims to obtain some information in carrying out a diagnosis of coal reserves after adding slope geometry aspects such as slope height, slope width, and slope, which meet the requirements for mining.

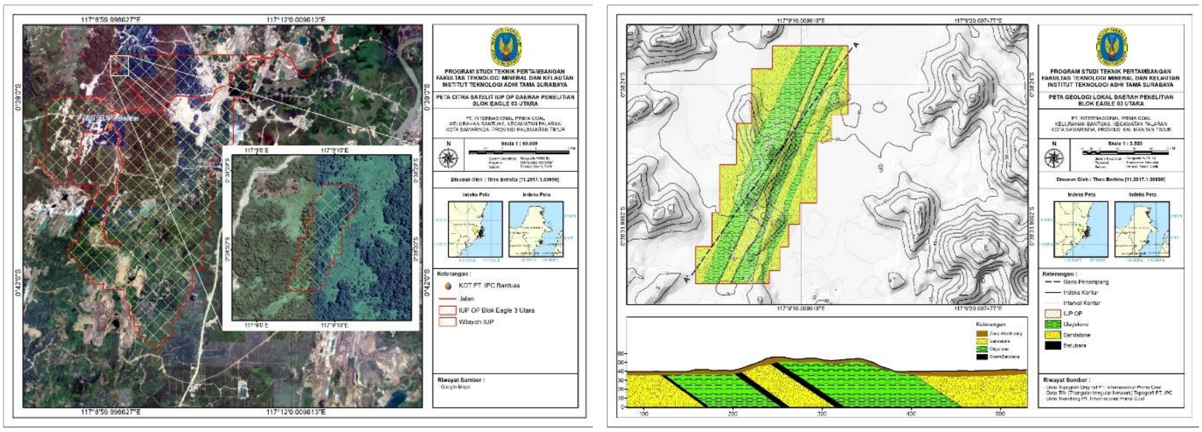

Figure 1. IUP OP Satellite Image Map (left), Local Geological Map (right)

After knowing the number of resources and reserves, it is necessary to determine the combination of tools that must be used because it will be related to the production schedule that will be applied. Production scheduling that will be made is monthly production scheduling so that the predetermined production schedule can be fulfilled, both schedules related to working time and those related to coal mining production targets. The production scheduling method that will be applied is short-term scheduling.

Therefore, based on the conditions stated above, it is necessary to design mining that is in accordance with the topography, geology, direction, and distribution of coal, tier geometry, and mechanical equipment used by PT. International Prima Coal to schedule production so that uncertainty in mining can be minimized. This study aims to analyze resources and reserves, design mining, determine the combination of tools and sequences as well as monthly production scheduling.

Coal resources are parts of coal in certain forms and quantities and have reasonable prospects that allow them to be mined economically. Location, quality, quantity, geological characteristics, and continuity of coal seams that have been known, estimated or interpreted from certain geological evidence. Coal resources are divided according to the level of geological confidence into inferred, indicated, and measurable categories[2].

Coal reserves are part of the indicated and/or measured coal resources that can be mined economically. In the process of estimating coal reserves, proper studies at the minimum level of pre-feasibility studies must have been carried out by considering all relevant modifying factors including mining technical, processing, facilities and infrastructure, economics, marketing, legal, environmental, social, and regulatory legislation. Based on the level of confidence, coal reserves are divided into probable reserves and proven reserves[2].

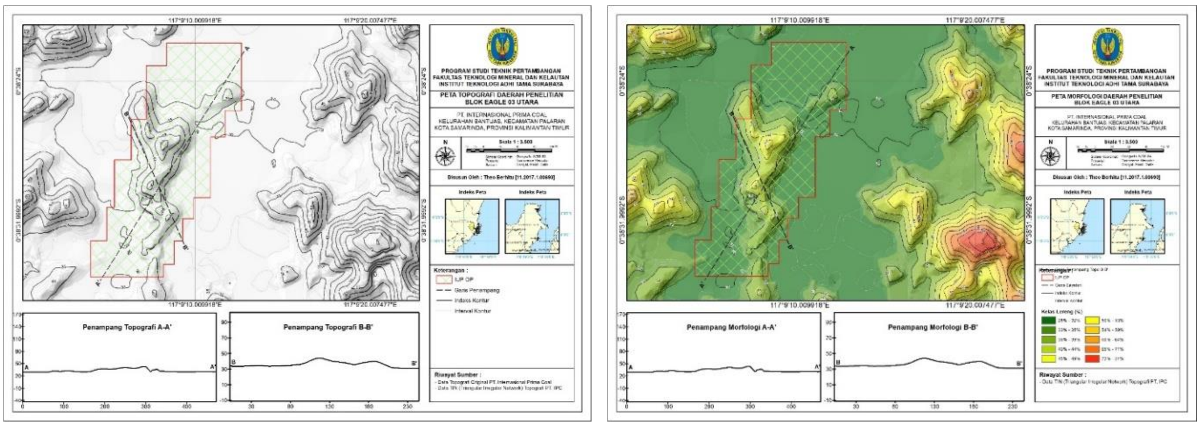

Figure 2. Local Topographic Map (left), Local Morphological Map (right)

Table 1. Trenching Point Coordinates

No	Trenching Id	X	Y	Z	Depth
1	TRCHIPE3_29	516924.968	9928958.783	29.995	3.987
2	TRCHIPE3_30	516929.259	9929007.833	31.63	7.851
3	TRCHIPE3_31	516914.827	9929047.627	31.24	7.465
4	TRCHIPE3_32	516885.33	9928984.313	23.976	9.397
5	TRCHIPE3_33	516995.428	9929156.215	29.321	3.601
6	TRCHIPE3_34	516985.199	9929173.228	32.559	7.465

Mine planning is an important stage in the mining operation plan. Modern mine planning requires modeling of the resources to be mined. The model is for tabular deposits such as coal. Two important aspects in mine design work are determining mining deadlines, and production scheduling[3].

Mining design is a form design of a mine that has dimensions, including the geometry of the ladder, the angle of the inter-ramp and the overall slope, the road, and the geometry of the road. To make mining action easier, it is necessary to design a pushback or mining sequence where all the volume contained in the overall pit is simplified in the form of smaller pit units. The theory used is block and strip, level. Mining units are separated into smaller parts, namely blocks and strips, and levels. In the block, each pit is broken down into transverse blocks, for example from west to east. The width of the block is usually 50m-100m. Block naming can be in the form of B1, B2, B3, and so on. The strip is the division of strips - small strips with a width of 50m-100m by cutting blocks from north to south. The naming of the strip is usually in the form of the code S1, S2, S3, and so on. After that make sure the area can be taken by looking at the intersection of the block and strip. Naming blocks and strips after that as B1S1, B2S2, B3S3, and so on[4].

One method that describes the geometrical efficiency in mining activities is the stripping ratio or stripping ratio. The stripping ratio (SR) displays the amount of overburden that must be removed to obtain the desired amount of coal[5].

This is the final mining limit which is influenced by the SR parameter, geotechnical (slope stability), and the geological condition of the coal (see figure 3). Ensuring the final limit of mining activity (ultimate pit limit) for a deposit means determining how much coal reserves to be mined (tonnage and quality) which will optimize the total net value of the deposit[6].

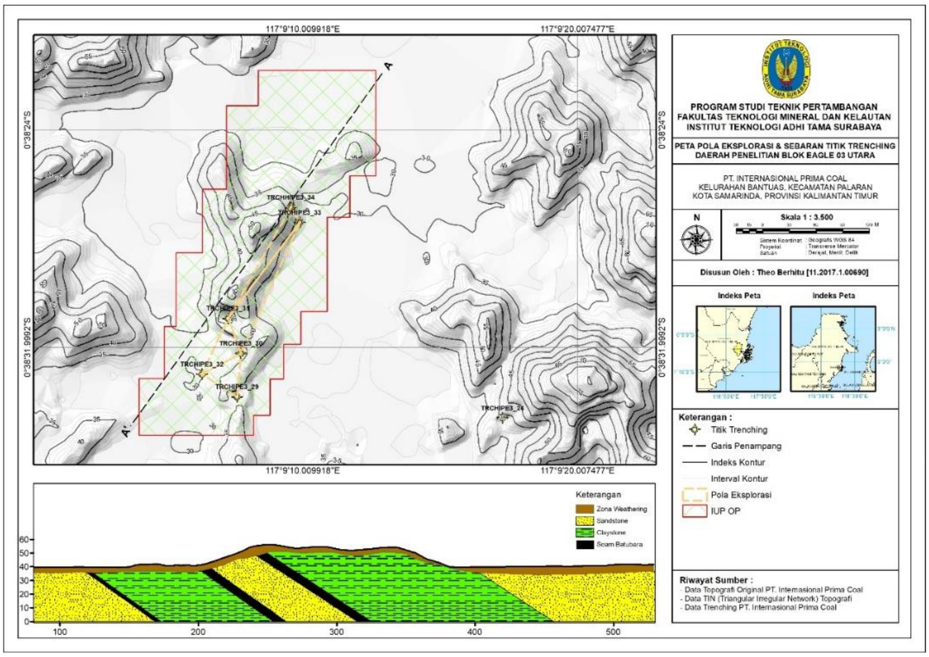

Figure 3. The geological section profile of the study area

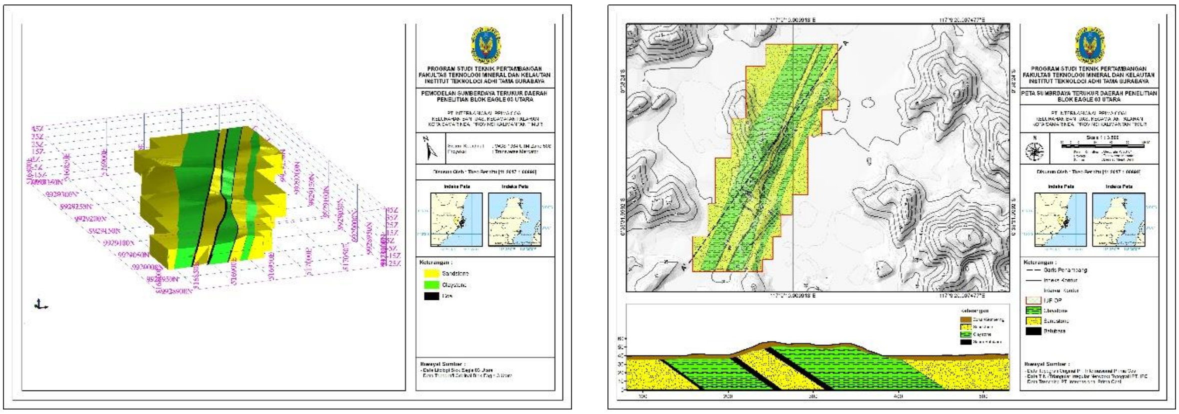

Figure 4. Measurable Resource Modeling Map (left), Measurable Resource Map (right)

Factors affecting slope geometry: Production, one of the objectives of determining the size of the slope is to be able to produce the desired product and have safety standards. So, the slopes that are made need to take into account the desired amount of production. In general, the amount of production determines the size of the slope be made[7].

The condition of the material, the condition of the material/rock available can ensure that the mechanical equipment that must be used to suit the production carried out can be determined. The more dominant rock conditions include rock strength, developmental aspects, rock size, and geological structure[7].

The mining system is one of the mine planning parameters because from the mining system we can know the mining process. To choose a mining system, there are several parameters used, including Types of minerals, Condition of minerals, the position of minerals, the economics of mining[8].

It is an attempt to thwart the entry of water to the mining area. This is usually done for the treatment of groundwater and water originating from surface water sources[9].

Some of the supporting aspects in the operation of mechanical conveyances are the condition of the size of the road which includes the width, length, magnitude of the bend or slope of the haul road, and the construction of the road made. The haul road design includes: road width, super elevation, road grade, cross slope[8].

In designing a production schedule, several things must be considered including production targets, working hours, number of tools, and work volume [10].

2. Methodology

Research Location

The research location is in the coal mining business permit (IUP OP) Block Eagle 03 Utara PT. International Prima Coal which is administratively located at coordinates 117^{o}8'59.998627” – 117^{o}9'14.006195” East Longitude and 0^{o}38'21.0012” – 0^{0}38'35.0016” South Latitude The research location is in Bantuas Village, Palaran District, Samarinda City, East Kalimantan Province with an area of 6.25 ha. The picture of the location of the IUP OP is shown in figure 1 left.

Table 2. Measured Resource Volume

Seam	Overburden (BCM)	Coal (Ton)	SR	Average caloric value (kcal/kg)
Q050	3,672,022	264,662	13.87	5,879
Q070	1,031,405	295,791	3.49	5,830
Q080	2,337,598	166,445	14.04	6,392
Total	7,041,025	726,898	9.69	18,100

Table 3. Estimated Reserve Volume

Seam	Overburden (BCM)	Coal (Ton)	SR	Average caloric value (kcal/kg)
Q050	278,220	26,039	11	5,856
Q070	175,816	32,322	5	5,835
Q080	197,916	8,155	24	6,395
Total	651,952	66,516	9.80	18,086

Research Data

The data used in the research on mining design and production scheduling related to the research area, which includes primary data, namely: data on the circulation time of digging-loading equipment and secondary data, namely: IUP boundary data, topographic data, trenching data, data geotechnical, rainfall data and coal production target data.

Data Processing

The stage of processing the data that has been taken in the field will be done with the help of software. To design a mining design and production scheduling in coal mining, in general, the data processing stages include: Determining the estimation of resources and reserves while there are several stages of data processing before calculating the resources and reserves, namely database creation, data verification, data correlation and resource, and reserve estimation. Define mining limits. Determining the mining design while there are several stages of data processing before determining the mining design which includes road geometry, level geometry, and drainage system. Determine the mining sequence and determine the production schedule.

Data Analysis

After processing the data, data analysis will be carried out. The data obtained were analyzed and then carried out a discussion based on the analysis. The data analysis activities are in the form of Analysis of the state and amount of coal resources and reserves, based on the estimated resource and reserve data, it will be possible to know the volume of resources and reserves as well as the distribution direction and quality per coal seam which can be used as a basis for determining pit limits, mining designs, targets. production and production scheduling. The analysis of the coal mining design that will be applied, based on the slope geometry data, the volume of resources and reserves as well as the distribution direction and quality of the coal seams, will be analyzed in the form of a coal mining design by the pit limit as well as the distribution direction and coal quality. Analysis of the combination of tools used, based on data on work volume, tool productivity, production targets, and working time, will be able to know the combination of tools used to take overburden and coal layers that are by predetermined production targets. Analysis of short-term production scheduling of coal mining, based on data on production targets, working time, number of tools, work volume, the analysis will be carried out in the form of short-term production scheduling with a period per month.

3. Results

Local Geology

A geological map is a map made to show geological appearances. Rock units and geological strata are indicated by colors or symbols to indicate their location on the surface[11]. The rocks in the study area are stratigraphically included in the Balang Island Rock Formation (Tmpb). Based on exploration reports and direct observations in the field and its surroundings, the area is composed of several rock units, namely: sandstone units, claystone units, and coal (see figure 1 right).

Local Topography

A topographic map is a map that depicts the earth's surface depicted by contour lines[12]. The location of the North Eagle 03 Block research area has a topography that is in a hilly area with the highest altitude of 80 meters above sea level and the lowest altitude of 29 meters above sea level where the topographic map presented uses a contour interval of 1 m and a contoured index of 5 m.

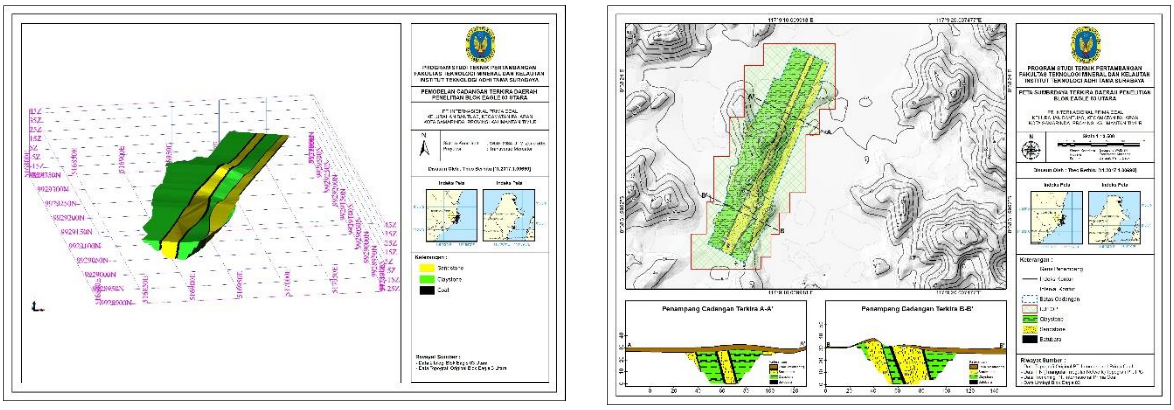

Figure 5. Estimated Reserve Modeling Map (left), Estimated Reserve Map (right)

Local Morphology

Based on studies from satellite imagery and direct observations in the field, it is known that the morphology of the Mining Business License area is hilly with steep slopes and the slope ranges from 20º - 55º leading from South to North. The Production Operation Mining Business License area has the lowest altitude of 29 meters above sea level in the North and South and the highest altitude of 52 meters above sea level in the middle of the IUP area, and a height difference of 23 meters (see figure 2).

Exploration Method

The exploration method was carried out by the exploration team at PT. International Prima Coal uses the trenching method, which is technically in the field making trenches by cutting from the coal strike direction. Part of the trenching is sampled for samples which are then sent to the Geoservice lab. Trenching has been carried out as many as 6 points with a distance between 20 meters - 200 meters and a maximum depth of 10 meters, this is to cover the entire area so that all seams can be found. The distance of the trenching point is made tight because the coal dip is up to 75º and the weathering zone is uncertain. The exploration pattern used is a triangular pattern, which can be seen from the line formed between the trenching points forming a triangular pattern, this pattern is used for undulating topography and homogeneous sediment conditions.

Coal State

The condition of the coal deposits located at the study site consists of 3 layers (seams) Q050, seam Q070, and seam Q080 with the thickness of each seam varying between 2.17 – 2.2 m for seam Q050, 2.18 – 2.36 m for seam Q070, and 0.8 – 1.14 m for the Q080 seam with a dip seam slope between 64º – 75º and strike direction between 25º-27º.

4. Discussion

Resource Estimation

Data from the results of topographic mapping activities and data from trenching are processed for data processing for resource estimation. Data processing carried out is processing the results of trenching to be used as a database (lithology data, survey data, and quality data), making geological model correlations (structure contours and crop lines) (see table 2). When estimating the number of resources, the parameters used in the calculation of resources are as follows: IUP OP boundary area of North Eagle 03 block 6.26 Ha, topographic data, trenching data (lithology, survey, quality) (see figure 4).

Table 4. Rock Physical and Mechanical Properties

No	Lithology	Original fill weight (kN/m^3)	Cohesion (kPa)	Inner shear angle (°)
1	Soil	18.75	20.10	45.78
2	Sandstone	11.15	55.20	4.99
3	Claystone	19.211	280.00	5.40
4	Coal	19.68	96.57	9.74

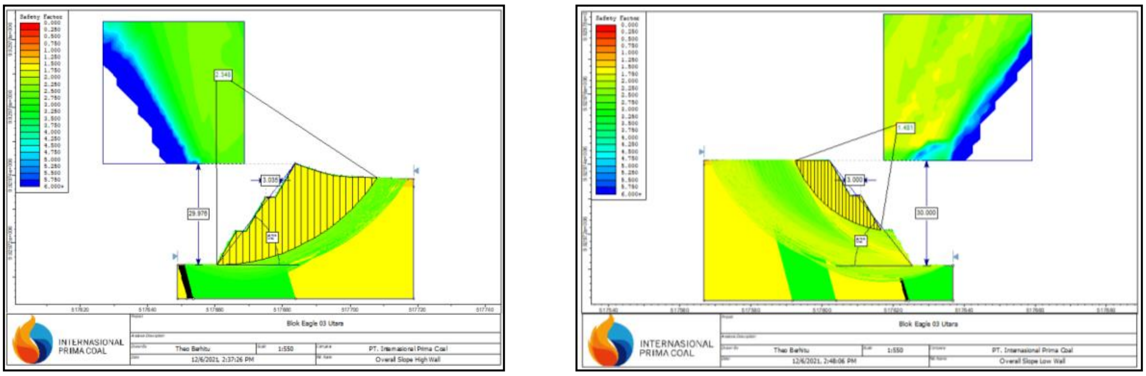

Figure 6. High Wall Overall Slope (left), Low Wall Overall Slope (right)

Reserve Estimation

For reserve estimates (see figure 5), the steps taken are the same as for resource estimates. The method used to estimate reserves is the polygon method. However, MineScape 5.7 software is used to simplify calculations when estimating the number of reserves (see table 3). The following parameters are used to calculate reserves: The area of the pit boundary or mine opening limit is 3.33 Ha, topographic data, excavation data (lithology, survey, quality), slope geometry with a height between slopes of 10 m, the overall height of 30 m, width between slopes 3 m, inter-slope slope 70^o and overall slope 52^o, ramp width 12 m, pit boundary or mining end limit is at an elevation of 0 masl.

Geotechnical Recommendations

In determining the dimensions or size of slope geometry (see table 1), a careful study must be carried out. In carrying out mining activities the geometry of a slope such as height and the slope is needed to produce a bench that matches the required slope[13].

From the results of the analysis of the recommendation modeling for the overall high wall slope in Figure 6 (left) above, the height between the slopes is 10 m, the width between the slopes is 3 m, the angle between the slopes is 70^o and the overall slope is 52^o and the overall slope height is 30 m with a safety factor value. of 2.34 in this condition, the slope is still in a safe condition. Meanwhile, from the analysis of the recommendation modeling for the overall low wall slope in Figure 6 (right) above, it is found that the height between the slopes is 10 m, the width between the slopes is 3 m, the angle between the slopes is 70^o and the overall slope is 52^o and the overall slope height is 30 m with a factor value safety of 1.48 in this condition the slope is still in a safe state (see table 4).

Drainage System

The drainage system made is a mine drainage system by making trenches around the pit openings and disposal. The ditch made to accommodate the runoff water discharge is 1,340.15 m^3/hour, while the dimensions of the designed ditch are 2,791.17 m^3/hour. The runoff water that enters the ditch will then be channeled to the settling pond to precipitate the mud material carried by the water, the dimensions of the settling pond are designed with a storage capacity of 3,788.86 m^3 (see figure 7 left).

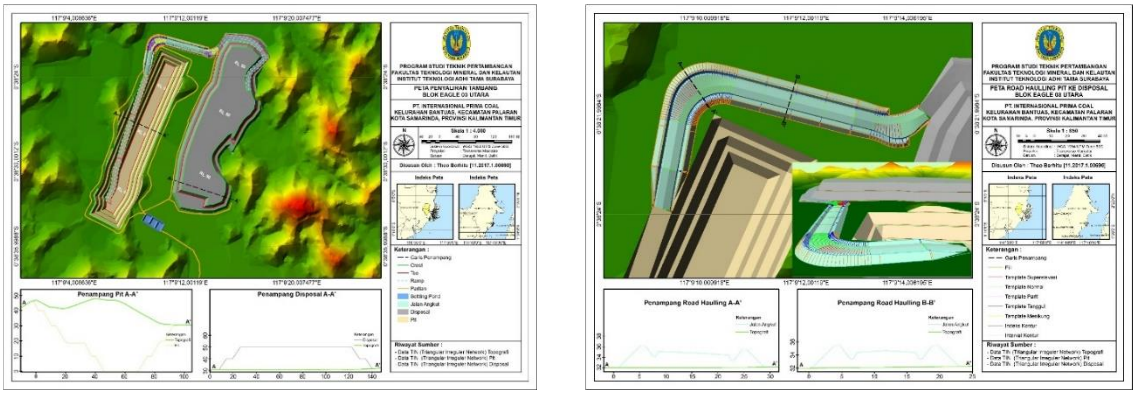

Figure 7. Mine Drain Map (left), Haul Road Map (right)

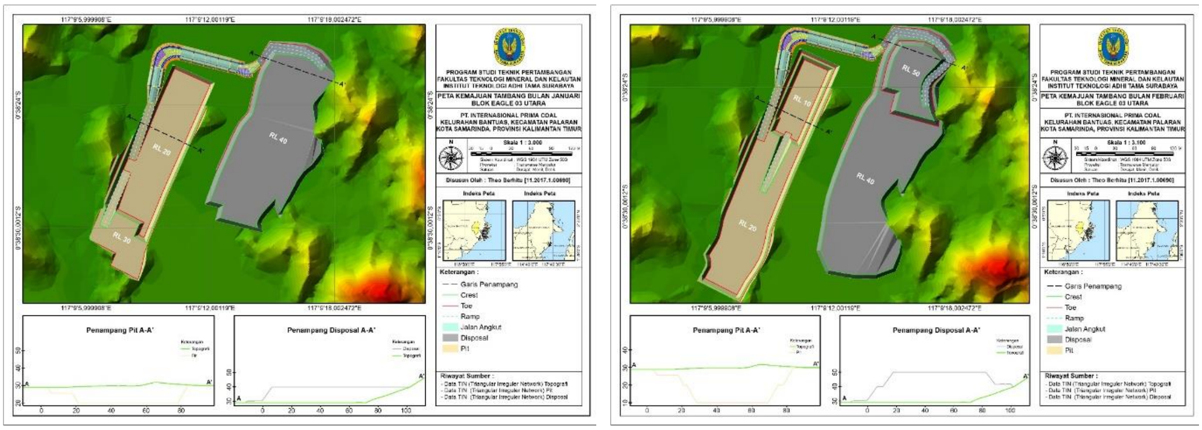

Figure 8. January Mining Sequence Map (left), February Mining Sequence Map (right)

Haul Road

There are basically two geometric designs haul roads to be made for transportation facilities material in the mining area, namely the geometric design straight road and bend road geometry design[14]. The haul road is made and planned to connect the pit area and the disposal area. The width of the road made based on the width of the largest conveyance used by the company in this study was calculated using the width of the Hino 500 FM 260 JD dump truck with a tool width of 2.5 m, the width of the haul road with two lanes on a straight road is 9 m, and the width of the road is 9 m. at the bend is 18 m, and the maximum grade of the road is 8%. Construction of haul roads with a super elevation value of 0.03 m/m and a cross slope value of 4%. The distance from the pit to the disposal is ± 220 meters (see figure 7 right).

Mining Method

The open-pit mining method using down dip excavation is used by considering the conditions and characteristics of coal deposits and the composition of the cover material (overburden and inter burden). These two aspects are used because coal deposits in the research area are exposed with a strike direction of 25°-27° to the northeast and a coal seam slope (dip) 64°-75° to the northwest and a thickness between 0.8-2.36 m, as well as for overburden and inter burden layers in the form of clay and limestone. Therefore, it can be stated that the excavation and stripping process can be carried out by harrowing. The mining process will be carried out from north to south following the direction of coal distribution starting from an elevation of 50 masl until it reaches the pit limit at 0 masl.

Mining Sequence and Production Scheduling

Sequences often called push back, expansions, phase, working pit, slice, or stage, are the initial stages of mine planning where pits are divided into smaller units to simplify mining arrangements[15]. A mine production schedule states the tons of minerals, grades, and total material removals that will be produced by the mine in a period (years or months)[16].

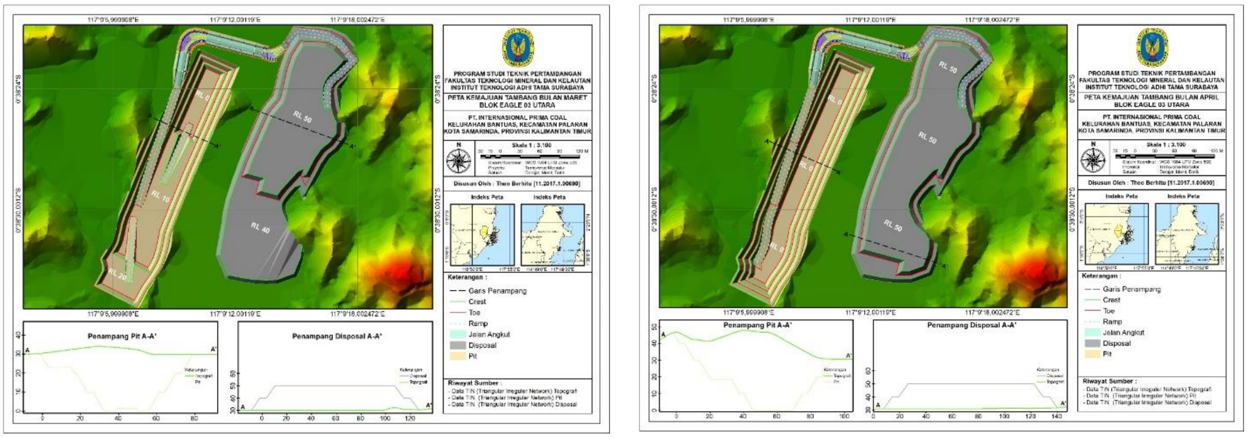

Figure 9. March Mining Sequence Map (left), April Mining Sequence Map (right)

January Mining Sequence
In January the mining direction is carried out from north to south. Starting from the elevation of RL 50 – RL 20 in the north, while the elevation is RL 30 in the south. The area of the mine opening in January was 2.58 Ha. In January, overburden stripping and coal extraction were carried out, with a planned volume of overburden to be removed in January of 268,389 bcm. To peel the overburden using a Doosan 520 excavator as many as 1 unit with the productivity of 429.66 bcm/hour and 5 units of a Hino 500 FM 260 JD dump truck with the productivity of 280,203.71 bcm/month, while for coal mining the planned volume to be mined is 16,767 tons of which This coal mining is carried out using a combination of Hitachi 470 excavator loading equipment totalling 1 unit with productivity of 358.85 tons/hour with 3 units of Hino 500 FM 260 JD dump truck with productivity of 21,047.55 tons/month (see figure 8 left).

February Mining Sequence
In February the mining direction continued from January by being carried out from the north with an elevation of RL 10 to the south with an elevation of RL 20. The mine opening area in February was 3.33 Ha. In February, overburden stripping and coal extraction were carried out, with a planned volume of overburden to be removed in February of 169,482 bcm. To remove the overburden, a combination of a Doosan 520 excavator digging tool is used as much as 1 unit with the productivity of 419.66 bcm/hour and 3 units of Hino 500 FM 260 JD dump truck with the productivity of 138.298.56 bcm/month, while for mining the planned volume of coal mined is 17,767 tons, of which coal mining is carried out using a combination of digging and loading equipment, a Hitachi 470 excavator, totalling 1 unit with the productivity of 358.85 tons/hour with 3 units of transport equipment Hino 500 FM 260 JD dump truck with the productivity of 19,883.83 tons/month (see figure 8 right).

March Mining Sequence
In March the mining direction continued from the previous month by being carried out from the north with a target elevation of RL 0 to the south with a target elevation of RL 10 and RL 20. The mine opening area in March was 3.33 Ha. In March, overburden stripping and coal extraction were carried out, with a planned volume of overburden to be removed in February of 120,820 bcm. To remove the overburden, a combination of a Doosan 520 excavator digging tool is used as much as 1 unit with the productivity of 419.66 bcm/hour and 3 units of Hino 500 FM 260 JD dump truck with the productivity of 138.298.56 bcm/month, while for mining the planned volume of coal mined is 17,653 tons, of which coal mining is carried out using a combination of digging and loading equipment, a Hitachi 470 excavator, totalling 1 unit with productivity of 358.85 tons/hour with 3 units of transport equipment Hino 500 FM 260 JD dump truck with productivity of 19,883.83 tons/month (see figure 9 left).

April Mining Sequence
In April the direction of mining continued from March to be carried out from north to south with a target elevation of RL 0. The mine opening area in February was 3.33 Ha. In April, overburden stripping and coal extraction were carried out, with a planned volume of overburden to be removed in April of 92,268 bcm. To remove the overburden using a combination of a Doosan 520 excavator digging tool as much as 1 unit with the productivity of 419.66 bcm/hour and 3 units of Hino 500 FM 260 JD dump truck with the productivity of 130,727.53 bcm/month, while for mining the planned volume of coal mined is 16,268 tons, of which coal mining is carried out using a combination of digging and loading equipment, a Hitachi 470 excavator, totalling 1 unit with the productivity of 358.85 tons/hour with 3 units of transport equipment Hino 500 FM 260 JD dump truck with the productivity of 19,162.86 tons/month (see figure 9 right).

5. Conclusion
The total volume of resources is 7,041,025 bcm overburden and 726,898 tons of coal, the average calorie is 6,034 kcal/kg, SR 9.69 while the calculation results of the reserve volume are 651,952 overburden and 66,516 tons of coal, the average calorie is 6,029kcal/kg. SR 9.80. The mining design in the northern eagle 3 block has an opening area of 3.33 ha with the highest initial topography height in the study area being 50 masl. Based on the location and distribution of coal, a pit modeling was built with an optimal depth of 0 masl following the depth of the structural contour of the Q070 seam. The pit design is built taking into account the slope safety aspects.

The combination of tools used to carry out mining on the North Eagle 03 block consists of an excavator digging tool and a dump truck. For overburden and coal stripping, Doosan 520 and Hitachi 470 excavators are used, while for overburden and coal transportation, Hino 500 FM 260 JD dump trucks are used. Production scheduling and mining sequences are divided into 4 months. In January, the scheduled production of OB is 265,389 bcm and coal is 16,767 tons. In February, the scheduled production of OB is 169,482 bcm and coal is 17,767 tons. In March the scheduled OB volume was 120,820 bcm and 17,653 tons of coal, while in April the scheduled OB volume was 92,268 bcm and 16,268 tons of coal.

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