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REPORT ON

SUBSIDENCE PREDICTION

FOR

DHANKASA U/G MINE

WESTERN COALFIELDS LIMITED

December 2009

CMPDI

(International Consultant)

Area Planning Officer
WCL, Pench Area

1.0 Introduction:

Project Report for Dhankasa U/G mine, Pench Area, WCL was prepared by CMPDI in March 1999 with a combination of Continuous Miner and SDL/LHD panels. This report envisaged a target production of 0.495 Mty with a total capital investment of Rs. 82.0834 crores.

This report was to be implemented in two phases since information regarding subsidence, angle of draw and cavability characteristics of strata was not available. WCL management shelved this report since the technology envisaged was far too advanced for Pench Area where SDL technology was still gaining ground. Later on WCL, vide letter no. WCL/CGM(P&P)/C.VI/1693 dated 04.05.2002 and subsequent letter no. WCL/ NGP/C.1(E)/ VI/2403 dated 04.07.2002 desired that another Project Report for Dhankasa UG mine be prepared with LHDs only.

Accordingly, CMPDI, RI-IV, Nagpur made an exercise with LHDs for two options with target production of 0.30 Mty (Option-I) and 0.36 Mty (Option-II). Both the above options were not economically viable and the I.R.R. at 85% of target production was negative. Hence these options were dropped.

Subsequently, WCL desired to recast the Project Report for Dhankasa UG mine prepared in March 1999 with a combination of Continuous Miner and LHD/SDL panels. Accordingly, a project report (recast) was prepared in December 2002 incorporating the capital and operating cost of continuous miner package as proposed in the agreement for deploying similar technology at Tandsi Project, experience gained in the mines where continuous miner technology had already been deployed and recommendations of the subsidence prediction study and cavability study carried out by CMPDI (HQ).

Dhankasa geological block is a virgin block located in the north-eastern part of Pench-Kanhan Valley Coalfield. It forms the south-western contiguous part of Sonpur block and north-eastern part of Naheriya Block, already explored by MECL. Naheriya, Thesgora & Mathani are the nearest operating U/G mines. Thesgora and Mathani mines are about 22 kms on the western side of Dhankasa Block. Naheriya U/G Mine is about 6 kms from proposed Dhankasa U/G Mine.

Dhankasa Block is located in the north-eastern part of Pench-Kanhan Valley Coalfield, District Chhindwara, Madhya Pradesh. It forms the south-western contiguous part of Sonpur Block and north-eastern part of Naheriya Block. The

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Jamunia Block forms the south-western boundary of the block. The area is covered in the Survey of India Toposheet No. 55 N/3 (RF 1:50,000) and is defined by:

Latitudes: N 22°17'39" and N 22°19'33"

Longitudes: E 78°59'04" and E 79°01'13"

Dhankasa geological block covers an area of 7.40 km^2. The block is divided into 17 sectors by faults of varying throw. Out of these 17 sectors only 9 sectors have been included in the mining area of the proposed Dhankasa U/G mine. The area covered by these 9 sectors (Sector-2, 3, 4, 5, 6, 7, 13, 14 and 15) is 5.20 km^2. The reasons for excluding the remaining 8 sectors have been explained in Chapter-5.

Sector-4 of Naheriya geological block enclosed between fault $F_{8(N)}$-$F_{8(N)}$ and $F_{9(N)}$-$F_{9(N)}$ was not included in Naheriya U/G mine due to 20 to 30m down throw fault $F_{8(N)}$-$F_{8(N)}$ and Gunor river flowing over this sector. Sector-4 of Naheriya geological block is in structural continuity with Sector-3 of Dhankasa block. Hence this sector, which covers a surface area of nearly 0.30 km^2, has been included in Dhankasa U/G mine. Therefore, area of the proposed Dhankasa U/G mine works out to 5.50 km^2.

Following features form the boundaries of the proposed Dhankasa U/G mine.

a) Northern boundary - Fault F_7-F_7, arbitrary line which corresponds to common block boundary between Dhankasa and Sonpur geological blocks, Faults F_8-F_8 and Fault F_4-F_4.

b) Eastern boundary - Sub- crop of Seam-IV (B)/(Combine)

c) Southern boundary - Gunor river and Fault $F_{8(N)}$-$F_{8(N)}$

d) Western boundary - An arbitrary line 200m west of boreholes PJP-1, PD-59, PU-87, PD-38, 64, 65 to be extended to grid line corresponding to N1338000, E 2998000 after further exploration.

The mine shall work two seams namely Seam-II (Packet) and Seam-IV (B)/(Combine). The average thickness of both these seam is 4.0m. The total extractable reserves of the mine are 17.714 Mt and the revenue life of the mine is 20 years at 100% capacity utilization.

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2.0 Topography, Drainage, climate and land use:

The entire area of Dhankasa geological block is covered by Deccan Trap basalt, which on differential erosion has given rise to rugged terrain comprising hills and valleys. The northern and eastern part of the area slopes towards Gunor river in the south- west. The area in the central part around boreholes PU-128, PD-52 and PD-46 and in the south central part around PD-19, is comparatively flat with gentle slope. The northern part around borehole PD-62 is occupied by hills with maximum altitude of 890m in the block, from which the ground slopes down to the level of 750m towards west near borehole PD-51. In the western part, the Junapani nalla flows southerly, with 776m elevation in the north to 722m in the south, which is the minimum altitude in the block. In the southern part of the block, slope is towards south which is controlled by Dhankasa nalla flowing westerly with elevation of 760m in the east to a minimum of 722m near Gunor river located in the south western peripheral part. The eastern part, near Bhumka Dhana village, is occupied by hills with altitude of 854m, 806m and 788m and the valleys in between them almost run north-south. In the proposed Dhankasa U/G mine, the ground elevation ranges between 722m to 854m.

The major drainage in the area is provided by southerly flowing perennial Gunor river located in the south-western part of the block. The southerly flowing Junapani nalla and Dhankasa nalla flowing westerly are the prominent tributaries to the Gunor river. The major part of the area is covered with forest.

The HFL along the course of Gunor river & Dhankasa nalla in the block has not been recorded anywhere and hence could not be incorporated in report. In the neighboring Naheriya Block, HFL value of 720m was considered. In proposed Dhankasa mine area the minimum level is 722m. The northern bank of Dhankasa nalla and Gunor river are marked by steep scraps and hence zones of flood levels are likely to be restricted to the banks on either side.

3.0 PRESENT LAND USE PATTERN

The land use pattern of this area is directly controlled by the topography. The plateau and valley portion are used as cultivated land round the year. The slopes are covered by forests of moderate to thick density.

Out of the total area of 550.65 ha involved for mining purpose, the forest covers an

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area of 367.46 ha while 168.15 ha area is tenancy land and 15.04 ha is Government land. In addition to this, 32.00 ha land is required for constructing infrastructure including service buildings, colony, approach road and rationalization of plots etc. Thus total land involved in this project is 582.65 ha.

The top soil is typical black cotton soil occurring mostly in the valleys. Thickness of soil varies from 0.50m to about 3.00m. Sub-soil is dull brown to grey in colour with dominance of boulders of basalt.

Major crops in this area are Maize, Jawar, Ground nut and Wheat. Major flora in this area are Teak, Sal, Mahua, Tendu together with thorny bushes. The Monkey, Peacock, Fox, etc. represent the major fauna of the area.

4.00 Geology:

The geological succession of the mining block as deduced from the borehole data has been given in the following table :-

Geological Succession in Dhankasa Block

Age	Formation	Lithology	Thickness Range (m)	
			Minimum	Maximum
Age	Formation	Lithology	Thickness Range (m)	
			Minimum	Maximum
Permian	Barakar	Sandstone with kaolinised feldspars interbanded with shale and coal-seams	4.50	83.65
Permian	Talchir	Fine grained argillaceous sand stones & green shale.	0.35	+ 7.99
----------UNCONFORMITY----------				
Pre-cambrian	Metamorphics	Not encountered in any boreholes.		
Sub- Recent to Recent	Soil (Residual & transported)	Sandy and Clayey soil	0.20	7.00
Upper Creta- ceous. To Eocene	Deccan trap with intertrappeans Dolorite dyke	Flows of Basalt with beds of clay/clayeystone of variegated colours	41.33	228.26
----------UNCONFORMITY----------				
Jurassic	Jabalpur	Gritty sandstone & clays with red jasper pebbles	1.34	32.38
----------UNCONFORMITY----------				
Permian	Motur	Clay/claystone of brick red, purple & grey colour with sandstone lenses/bands at places.	7.67	75.92

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4.1 **Sequence of Coal Seams and Partings**

Exploration in Dhankasa Block has confirmed the presence of all the five major coal seams (and their sections) of Pench-Kanhan Valley Coalfield, namely: I, II, III, IV and V in descending order. The youngest Seam-I is represented by three sections namely, IA, IB and IC. Seam-III and IV occur as coalesced as well as split sections designated as top and bottom. Seam- II and V occur as independent seams.

4.2 **Geological Structure of the Mining Block**

a) The geological structure of Dhankasa block has been deciphered entirely on the basis of sub-surface data obtained from the boreholes drilled in the block. While evolving the structure, due consideration has been given to core dip, omission of coal seams, reduction of seam thickness and or parting and the structural set-up evolved in the adjoining blocks.

b) The structure of Dhankasa block appears to be moderately disturbed in the southern half whereas the northern half is structurally complicated due to the presence of a number of faults. The east-west trending fault F_4-F_4 passing through central part of the block divides it into two halves. The south central part of the southern half which covers about 1/4th area of the block has comparatively flat topography and appears to be undisturbed. On the contrary the complicated structure evolved in the north & north–eastern part of the block is reflected on the surface in the form of rugged topography. In all 12 faults have been deciphered within the block.

c) The area of the block presents, Horsts and Graben structure. A major horst covering about 1/3rd part of the block is formed between fault F_2 & $F_{8(N)}$. Similarly an elongated horst is formed between fault F_3 & F_4. Like-wise two grabens are formed in the central part due to fault F_4 & F_5 and F_2 & F_3 respectively. One graben structure is formed in between fault $F_{6(N)}$ & $F_{8(N)}$ in the southern part of the block. The north and north-western part is traversed by eight easterly dipping step faults resulting in the repetition and dissection of the subcrop of the seam.

5.00 Details of the Project :

4.1	Company	-	Western Coalfields Limited
4.2	Area	-	Pench Area
4.3	Colliery	-	Dhankasa UG mine
4..4	Name of the seam proposed to be worked	-	2 Nos. of Seam – II(Packet) Seam – IV (Combined)

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4.5	Average Thickness of Seam	-	Seam – II (Packet) – 4.00m Seam –IV(Combined) -4.0m
4.6	Gradient of the seam-	-	1 in 10
4.7	Grade of Coal	-	D(ROM)
4.8	Estimated Reserve	-	48.141 Mty
4.9	Life of the mine	-	20 Yrs.(100% capacity)
5.0	Overall OMS (t)	-	5.509
5.1	Total Land to be acquired in Ha.	-	313.58 Govt.(10.88 Ha.) Tenancy (101.81 Ha.) Forest (200.89 Ha.)
5.2	Initial Capital Outlay	-	`. 27510.07
5.3	Proposed method of extraction	-	Semi-mechanized B&P with Caving using SDL/CM as loading machine.
5.4	Size of Panels	-	it is governed by incubation period, depth, and rate of extraction.
5.5	Parting between contiguous seams	-	to be maintained 3m & above
5.6	Net Geological Reserves	-	31.898 Mt.

6.0 Cavability Characteristics:

The strata between Seam-II(Packet) and the basalt traps comprises mainly sandstone, shale, clay and claystone. The thickness of the intervening strata varies between 10 to 108 m. The thickness of basalt traps varies from 41 to 208 m.

The cavability index of the intervening strata upto 20m above the roof of Seam-II(Packet) determined by Polish method using the data of borehole nos. PD-41 and PD-68 indicates that the roof is easily cavable.

At most places, the thickness of strata in between Seam-II (Packet) and the basalt traps is less than 10 times the combined thickness of extraction of the two workable seams. If the bulking factor is low, such as 1.1 or 1.2, the intervening strata may not be sufficient to fill the void after caving resulting in

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unfilled gaps below the basalt. This may give rise to large span of basalt hanging over unfilled areas in goaf. To avoid dynamic load due to sudden failure of basalt involving large spans, it may be advisable to restrict panel size and height of extraction in certain areas of the property till the caving characteristics of the basalt trap are established by trial in a panel in favorable part of the mine area.

The cavability characteristics of basalt traps in Dhankasa Block could not be determined due to absence of geo-engineering data and RQD and lengths of core pieces. This study has been carried out in Thesgora Block, which is about 15 km away. In Thesgora Block the thickness of basalt traps is much less as compared to Dhankasa Block and the test data on basalt obtained from cores of borehole No. TG-81 and TG-37 shows wide variations in strength and its density has also been reported to be abnormally high for some sections. such as 7.6 gm./cm^3. There are distinct sections in the basalt trap in Thesgora Block, which are likely to cave without any difficulty. There are also a few sections of basalt, which have difficult caving characteristics.

It is suggested to carry out fresh physico-mechanical tests for the entire thickness of basalt formation in Dhankasa Block. Piece length should also be obtained from the cores to ascertain the massive nature of the trap. If the basalt traps prove to be as dense as observed in Thesgora Block, difficulty in caving could be experienced in the panels where the thickness of strata between the basalt trap and Seam-II(Packet) is less than 10 times the combined thickness of extraction. In such a situation the thickness of extraction in Seam-II (Packet) would be restricted to 3.0 m.

Report on Cavability Study of Deccan Trap basalt formation in the adjacent Naheriya U/G Mine was received in December 2007 and this report has categorized the Deccan Trap basalt formation as difficult to cave. Therefore, caving of roof would be a difficult proposition over those panels where the thickness of strata between the basalt formation and first workable coal seam is less than 10 times the total thickness of extraction. Although the report on Cavability Study has restricted its conclusion to Naheriya U/G mine area only, it still serves as an indication for Dhankasa U/G Mine also.

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7.00 METHOD OF DEVELOPMENT

Dhankasa U/G mine is proposed to be developed on Bord & Pillar method. The main dips and the panels will generally consist of 5 headings as this is the standard and most productive width for a LHD or continuous miner district. In the panels, which are near the faults, or in odd shaped areas the number of headings may be increased or decreased in view of conservation of coal as against creating another panel.

The pillars and galleries in Seam-II (Packet) and Seam-IV (Combine) will be vertically superimposed since the parting of the seams is around 6m only in most of the mine area. The tensile strength of the parting is varying from 1.4 to 4.6 MPa, which is not very high, so stability of parting may have to be ensured by underpinning the floor of Seam-II (Packet) upto a depth of 3.5m.

The pillar sizes in the panels will vary as per depth in each sector for a gallery width of 4.8m. The pillars in panels will be square. The pillars in main dips in Sector-3 will be rectangular with the strike dimension being 36m and dip dimension being 28m. In all other sectors the pillars in main dips will be square of side 36m or 48m depending upon the depth at the floor of Seam-IV (Combine).

The height of development galleries will be restricted to 3.0m or the seam thickness whichever is less in case of development by blasting-off-the-solids using LHD for loading the coal. In the Continuous Miner district the height will be restricted to 4.6m or the seam thickness whichever is less. Since the maximum cutting height of continuous miner is 4.6m, the concept of continuous miner application demands that the galleries be supported only one time using good quality roof bolts so that no further heightening is involved and scope for secondary support is ruled out. It is good practice to develop and support in one phase. Removal of support particularly cement or resin grouted roof bolts is impossible without blasting. This then further weakens the roof and exposes the work force to unnecessary exposure to unsupported roof.

The standard layout for development using continuous miner is shown in Plate No. XI Figure-1. The reason for proposing a 5-heading layout is:

a) One drive for the continuous miner to be cutting i.e. Drive No.2 left (2L on the plan)
b) One drive being roof bolted (2R on the plan)
c) One drive being cleaned (1R on the plan)

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d) One drive having the ventilation and direction lines extended (Main on the plan)

e) One drive ready for cutting (IL on the plan)

This layout ensures that the continuous miner always gets a supported face to cut and there is no idling of equipment due to shortage of working face. No doubt, availability of supported face is subject to the support requirement and the capability of the bolting machine.

7.1 METHOD OF EXTRACTION

In Dhankasa U/G mine, extraction of developed pillars is proposed by caving at all places, which are outside the angle of draw of surface features.

7.2 LHD District

Since the seam thickness is more than 3.0 m in major portion of the mine area, in the LHD district, extraction is proposed by cable bolting method using 2.8 m long bolts in splits and slices and heightening of roof while retreating from the slices. The dimensions of splits, slices and ribs will vary with pillar size and the envisaged dimensions are shown in Plate No. XI Figure 12 to 15. Based on these dimensions the percentage extraction has been calculated. Splitting of pillars shall be restricted to a distance of one pillar from the pillar under extraction. The area of exposure shall be restricted to 80-85 m^2 at any place at a time. Extraction of pillars shall commence from the dip/in-bye side and proceed systematically to rise/out-bye side maintaining a diagonal line of faces and avoiding formation of 'V' in the line of extraction.

Before commencement of depillaring check surveys and leveling shall be done. Two safe outlets shall always be provided from the panel under extraction, the approach roadways to any pillar under extraction shall be cleared off all falls, the roof and sides there at be adequately supported. Adequate steps shall be taken to prevent accumulation of water on the surface above the panel. A sump of adequate capacity and adequate pumping arrangement shall be provided to deal with sudden influx of water, if any, at the time of strata movement. The surface area over the panel proposed for depillaring and 45 m on all sides from the side of the panel shall be

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temporarily fenced off. In case of any damage to the surface land, the cost of damage shall be indemnified to the owner.

All provisions of CMR 1957 and DGMS circular regarding

a) Fencing of surface area likely to subside
b) Formation of sub-panels keeping in mind the incubation period of the seam to be taken as specified by DGMS.
c) Standards of construction of isolation/preparatory stoppings to be provided around the panels.
d) Isolation of every panel immediately after it has been goaved out.
e) Inspection of depillaring district and around goaved out areas and maintenance of records thereof.
f) Maintenance of subsidence records, plans/sections, information regarding local falls, etc. and submission of copies thereof to the Directorate should be strictly adhered to.

7.3 Continuous Miner Panel

It is anticipated that permission to extract the pillars formed during development will be granted by DGMS prior to completion of development. Pillar extraction would then commence immediately upon reaching the panel boundary.

Full mining height will have been maintained during development and pillar extraction will commence without any advance support being required.

The infrastructure, conveyor, material transport system, power, water, pumping and ventilation are in place from the development phase. The same equipment is required for pillar extraction as for development.

Pillar extraction techniques may follow the traditional 'diagonal line' or the preferred 'straight line' method employed with continuous miners. The disadvantage of the 'diagonal line' system with fully mechanized equipment is the creation of excessive tramming distances, which effectively restricts production. The protection afforded by the 'diagonal line' was originally developed for a hand loading scenario due to the long time period the pillar had to stand whilst being extracted and the number of working places required by cyclic drill blast and hand-load method. The 'straight line' method reduces both tramming distances and cable lengths to a minimum whilst optimizing tramming routes.

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Pillar extraction will be by splitting and slicing of pillars. The pillars will be split into two/three parts dependent upon the pillar size, by driving level splits and the slices will be driven from the splits/original galleries at 60° as against 90° to the split direction. Splitting of pillar will be restricted to a distance of one pillar from the pillar under extraction. The proposed mining cycle for pillar extraction and the dimension of splits, slices and ribs for different pillar sizes are shown in Plate No. XI Figures 3 to 7. The sequence of operations is as under:

- cut 1 is driven a maximum 15 m. For purposes of this PR it has been assumed to be 12 m.
- The continuous miner is trammed to cut 2 and commences cutting whilst cut-1 is supported by the roof bolter.
- Once the continuous miner completes cut 2 and roof bolting is completed in cut-1, the miner commences cut 3.
- The roof bolter supports cut-2 whilst the continuous miner completes cut-3.
- This process is repeated for cut 4
- The pillar will be split right through as shown in the figures and closely spaced roof bolts installed at all the proposed goaf edges. These bolts serve the purpose of breaker line so the need of skin-to-skin chocks at goaf edges with corner props is obviated. In poor roof conditions, the split is not driven right through the pillar and a 2 m thick coal rib is left against the goaf edge as additional protection to the goaf edge. This reduces the in-panel extraction by 1%.
- Flanking cuts 5,6 and 7 are then taken from the cover of the supported pillar split (cuts 1 and 3). Further support is generally not necessary since the continuous miner operates within 15 m of the face and the continuous miner and shuttle car operators are always under the last row of support.
- Additional coal may be extracted from the 'snooks' (remnant portions of the coal pillars) as the continuous miner is retreated judiciously dependent upon the face conditions at the time of extraction.
- The remaining flanking cuts 8,9 and 10 are taken in a similar manner from the cover of the original fully supported development drive.

All activities required to be undertaken in the LHD district before commencement of depillaring will hold good for the continuous miner district also. All provisions of CMR 1957 and DGMS circulars regarding fencing of surface area, formation of sub-panels, standards of construction of isolation stopping, isolation of

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every panel immediately after it has been goaved out, inspection of depillaring district and around goaved out areas and maintenance of records thereof and maintenance of subsidence records, plan/sections, information regarding local falls etc. and submission for copies thereof to the DGMS, will hold good for the continuous miner district also.

Relevant extract of the permission granted by Director of Mines Safety, Nagpur Zone, Region-I for extraction of pillars by caving method with continuous miner and shuttle car combination in panel 7 X East A is reproduced below (Point No. 4.0 to 10.0):

7.4 Manner of Extraction :

Coal shall be won mechanically with the help of continuous miner and shuttle car combination. Only remote/umbilical chord control continuous miner shall be used, so that persons shall be deployed under supported roof only and no person shall be deployed in the slice under extraction. At no time, persons shall be employed under unsupported roof. In case, due to any reason or defect the remote/umbilical chord control system of the continuous miner is not working, the continuous miner shall not be deployed for extraction of pillars till the same is rectified fully.

The manner of extraction shall be as indicated in plans No. WCL/TNS/SURV/05-PER/17A dated 16.4.2005 and WCL/TNS/SURV/05-PER/19 dated 16.4.2005 enclosed by you in your application under reference.

(a) Each pillar shall be divided into two equal parts by driving one dip split not exceeding 4.8m in width and 3.5m in height.

(b) Each half of pillar so formed shall be extracted by driving slices at an angle of about 60° with respect to the center line of the split gallery. Such slices shall not exceed 3.3m in width and 3.5m in height leaving a coal rib of not less than 2m width between the slices, which may be judiciously, reduced while retreating.

(c) The maximum cut of distance in a split and slice shall not exceed 3.2m and 11 m respectively.

(d) The height of extraction shall not exceed 3.5m.

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(e) Sequence of extraction/cutting as shown in plan No. WCL/TNS/SUR/05-PER/17A dated 16.4.2005 and WCL/TNS/SUR/05-PER/19 dated 16.4.2005 enclosed with the application shall be strictly adhered to.

(f) The first slice in half pillar shall commence at least 5.0m away from the corner of the pillar, so however, that in case of any overhanging goaf the distance shall be increased to 7.0m.

(g) Extraction shall be restricted to minimum pillars at a time such that maximum of one pillars shall be under splitting and one more under slicing except at the commencement of extraction in an individual row of pillars when splitting shall be extended to maximum of two pillars.

(h) As proposed the line of extraction shall be straight and not diagonal.

(i) Extraction of pillars shall commence from the dip in bye side and proceed systematically to the rise out bye side maintaining a straight line of extraction. Sequence of extraction/cutting as shown in sketch No. WCL/TNS/SUR/05-PER/19 dated 16.4.2005 enclosed with the application shall be strictly adhered to. The operational sequence shall be reviewed in every 15 days.

(j) Sequence of extraction of pillars shall be always maintained against the ventilation current.

(k) All efforts shall be made to bring down any overhanging goaf and in case any overhanging goaf not normal to the strata is observed, extraction shall be stopped and this Directorate informed at the earliest.

Where there are prominent planes of weaknesses or other geological disturbances, the Manager shall judiciously plan extraction of pillar in advance and instructions in writing shall be given to shift supervisors and Assistant Managers. All geological weaknesses shall be plotted on a plan.

Once extraction of slice is commenced, the continuous miner shall be operated non-stop till the slice and reduction of the rib, as the case may be, is completed. In case the continuous miner is stopped during extraction of a slice or during reduction of a rib for more than two hours due to breakdown or any other reason, extraction shall not be commenced unless the stability of the slice and the rib is fully evaluated and in case of any doubt further extraction of the slice or rib, as the case may be, shall not be made.

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8.0 Subsidence :

Subsidence prediction study for Dhankasa U/G mine was carried out by CMPDI (HQ) in July 2006 based on the mining parameters and panel layout defined in the first Recast Project Report for Dhankasa U/G Mine (0.54 Mty) prepared in November 2005. As per this subsidence study, the angle of draw has been estimated as 35° positive near the three water bodies namely Gunor river, Dhankasa nalla and Junapani nalla.

The maximum subsidence at the fag end of mine life is expected to be around 2.935 m. In the present assessment, the mining parameters and liquidation plan have been changed. So a fresh subsidence study is warranted. In this report the angle of draw of 35° has been taken into account while estimating the extractable reserves. Angle of draw of 35° has been taken into account while estimating the extractable reserves. Further capital provision for acquisition of surface land affected due to subsidence and payment of crop compensation and compensatory afforestation has been made in this project report.

Caving is proposed as method of extraction in this report. The depth of the mine varies from around 105m to 280m. The surface topography is hilly in nature and major portion is covered with forest. Subsidence Prediction studies were carried out by CMPDIL (HQ) in July 2006 based on the Recast PR for Dhankasa UG Mine (0.54 Mty, November 2005). July 2009

As per this study, the maximum anticipated subsidence over the mining area at the end of the mine life is 2.935m. The maximum possible slope and tensile strain likely to occur over the mining area are 39.39mm/m and 20.96mm/m respectively over panel IX. The perennial Gunor River and the seasonal Junapani Nallah are unlikely to be affected by subsidence because sufficient barrier or solid coal pillar are proposed to be left vertically below and within 35° angle of draw from the river/nallah. The seasonal Dhankasa nallah is likely to be affected by a maximum of 0.084m subsidence and 0.80mm/m tensile strain near panel I in Seam – IV (Combine) which is well within the permissible limit. The other small seasonal streamlets over the mining area are likely to be affected by a maximum of 2.640m subsidence and 19.38mm/m tensile strain. Thus, due care has to be taken while extraction is done below them, such as avoiding extraction during monsoon and filling up the cracks

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developed in the streamlets bed, when dry, to avoid inrush of water below ground in the rainy season.

It is anticipated that the forest may not be considerably affected by subsidence. Only the tree falling on the edge of subsidence zones and surface cracks may get tilted or dislodged. After 20 yrs. of mining some stretches of forest roads running over the mining area are likely to be affected by a maximum of 1.412m subsidence and 6.90mm/m tensile strain. Bhumka Dhana village and the electric transmission line are not likely to be affected by subsidence. It is recommended that while carrying out extraction in the upper Seam-II(Packet), close subsidence monitoring should be done over the panels. The impact of subsidence and effectiveness of mitigative measure should be reviewed before starting depillaring in th lower Seam – IV(Combine). On the basis of observed data, necessary corrections in subsidence estimation may be done, if necessary.

While estimating the seam-wise extractable reserves, angle of draw of 350 has been considered. It is proposed to acquire the surface area affected due to subsidence and fence it to prevent unauthorized entry. Capital provision for compensatory afforestation and crop compensation has also been made in the PR. The subsidence cracks which reach the surface will be packed tightly with soil and mud and non-carbonaceous debris and regularly dozed so that topography does not change substantially and artificial water bodies are not created.

It is recommended that while carrying out extraction, close subsidence monitoring should be done, particularly in the area nearby the nallah/river, as a precautionary measure.

8.1 Subsidence prediction:

8.1.1 Methodology and parameters

Subsidence prediction model developed by Subsidence cell, CMPDI (HQ) based on stochastic influence function has been used for subsidence prediction of Dhankasa UG mine.

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All relevant data in respect of mining parameters, geology, surface features and sequence of operation have been collected from Project Report of Dhankasa UG Mine prepared by RI- IV, CMPDI in Dec. 2007. Details of mine layout plan, surface features, surface contours and other relevant date from plans were converted into digital form using Minex Package. Panel boundaries of working of plan were digitalized from scan folio plans of respective seams. Surface contours and surface features such as HT line, Gunor River, Dhankasa Nala and its tributaries were digitalized from topographical plan DRG No. NS-0 Forest Boundary, HFL and villages were digitalized from seam folio plan of seam.

The digital data have been used in input parameters for subsidence prediction model. Due to non-availability of subsidence data of Dhankasa UG Mine or its adjacent mine, the value of subsidence factor and likely subsidence influence area/angel of draw have been taken from the report on subsidence investigation carried by CMRI under S&T scheme at North Chandametta and Sukri Collieries, WCL which was carried by CMPDI.

The input parameters taken for subsidence prediction are as follows:

i) Subsidence factor - 0.46

ii) Angle of draw : a) for undisturbed overlying strata - 30^0

b) for disturbed overlying strata - 35^0

iii) Percentage of extraction - 80%

iv) Average thickness of the seam for each panel or for the part of the panel where thickness vary significantly within the panel.

v) Average depth of the seam for each panel or the part of the panel where depth vary significantly within the panel.

For subsidence prediction, underground extraction area has been divided into 20m X 20m grid blocks as an element of subsidence calculation. From the calculated subsidence at each grid point, subsidence contours, surface topography after subsidence at different stages of extraction and their 3D views have been drawn with the help of computer.

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Subsidence prediction result:

The subsidence prediction result and its impact on surface topography are shown in the plats. The plot have been generated using computers and HP Draft Master II Plotter. The scale of plates is 1:10.000. The maximum value of predicted subsidence observed over the entire mining area is 1.412m. after extraction of seam.

8.2 Subsidence contours and surface topography along with 3D views:

From the calculated subsidence at grid interval of 20mX 20m, subsidence contours have been generated at an interval of 20cm and 30cm at the end of 13yrs and at the end of 36 yrs. of mining respectively. Plate shows the subsidence contours at the end of 13yrs of mining i.e. after simultaneous extraction of seam II and III.

In 3D views of subsidence, view direction is South – West and Z- amplification in 1:40 so as to give better visual impact of the surface subsidence.

Surface topography before mining after 13 yrs. of mining and after 36 yrs. of mining are shown in plates. Change in surface topography due to subsidence can be seen in th plates. To give general idea about the ground behaviour after mining, 3D view of surface topography before mining, after 13 yrs. of mining and after 36 yrs. of mining are shown in plate. In 3D views of subsidence, view direction in South – West and Z-amplifications is 1:1.5.

From subsidence prediction it is found that Gunor river falls within subsidence influence zone. It is suggested that extraction should be further restricted so that influence of subsidence get restricted at the bank of river.

8.3 Cavability Study:

Cavability study of Deccan Trap Formation for Two Boreholes CMPNE -1 and CMPNE – 2.

Received vide letter No: CMPDI?HQ/UMD/1301 dt: 06/12/2007

Background :

Two boreholes namely, CMPNE - 1 and CMPNE – 2 were drilled in Naheriya Block to access cavability of Basalt Trap. The job was assigned to CMPDI (HQ) by RI- IV Nagpur.

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The cores of the above mentioned boreholes were tested for Physico-mechanical properties by NIT, Nagpur.

The present report is based on the physico-mechanical properties determined from these two Boreholes.

Procedure:

CMRI, Dhanbad has developed an empirical formula to determine an index by which cavability of roof rocks can ge quantify3d. the cavability Index, I is gven by :

$I = (S \times L^{n} \times t^{0.5}) / 5$

Where S= Compressive strength of Roof strata

L= Average length of core pieces

t= Thickness of individual bed

n = a constant, depends on RQD of a rock bed (1.1 to 1.3)

This empirical formula for cavability assessment of roof strata is meant for longwall method of mining.

Based on the above cavability index, each bed within the roof strata of a coal seam may be classified into five categories :

Cavability index	Category	Cavability Type
• Less than 2000	I	Easily cavable Roof
• 2000 to 5000	II	moderately cavable roof
• 5000 to 10000	III	Roof cavability with difficulty
• 10000 to 14000	IV	Cavable with substantial difficulty
• More than 14000	V	Cavable with extreme difficulty

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Results:

The cavability index of each bed as determined from the above empirical formula has been given in Table – 1 and 2. Ti can be seen from the tables that bed no. 16 (table – 1) within the basalt trap has a cavability index of 35742 which is "Cavable with extreme difficulty" i.e. of category V. similarly, bed No. 30 (Table -2) with the basalt trap has a cavability index of 80744 which too is " Cavable with extreme difficulty" i.e. of category V.

It can be observed from the cavability index table that strata in between coal seams and the basalt trap are easily cavable. No problem in caving is expected where the gap between the basalt trap and the upper coal seam is more than ten times of the combined working thickness. Several beds within the basalt trap are of extremely difficulty to cave category. Where such beds come within ten times of the combined working thickness from the upper working seam, difficulty in caving will be encountered.

8.4 Conclusion and effect of subsidence on surface features :

The above conclusion is based on the test results of the core from boreholes drilled in Nehariya Block. As the properties of rock change from place to place, the same may not hold good for Dhankasa Block.

The surface over the proposed mining area comprises of forest land and agricultural land. The generated elevation of the surface ranges from 700m to 782m i.e. the difference of elevation is 82m. for such elevation the maximum predicted subsidence of 1.412m will not extensively affect th drainage pattern in the area. However, drainage will be affected at several places due to formation of pools and cracks which needs to be filled up to achieve original drainage pattern.

Even after leaving 60m barrier from panel of Gunor river and Dhankasa Nalla, it is found that extent of subsidence influence is reaching inside the river at some places and therefore, extraction in some of the panels has been suggested to be limited so that subsidence does not affect the river.

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Non-metaled roads situated in the mining area will also get affected by subsidence, therefore considering the importance of road; either road should be diverted or regarded.

Note:

It is recommended that while carrying our extraction, close subsidence monitoring may be done and based on observations necessary corrections in prediction. if so required may be done.

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CAVABILITY INDEX BY CMRI METHOD
BOREHOLE NO. CMPNE – 01 (NEHARIYA BLOCK)

Bed No	Depth		Bed thickness (m)	RQD	Com. Strength (Kg/cm^2)	Average core length (cm)	Factor	Cav. Index	Category	Cavability	Rock type
	From (m)	To (m)	t	%	C	L	n	I			
31	12.00	17.00	5	76.8	190.8	14.7	1.3	2809	II	Moderately cavable	Basalt, grey, greenish grey with secondary fillings of quartz.
30	17.00	21.63	4.63	100	448.6	46.30	1.3	28245	V	Cavable with extreme difficulty	Basalt black, massive.
29	21.63	29.00	7.37	91.8	297.2	21.5	1.3	8709	III	Cavable with difficulty	Basalt black, vesicular with secondary fillings of quartz.
28	29.00	30.77	1.77	100	301.1	22.10	1.3	4482	II	Moderately cavable	Basalt black, massive.
27	30.77	31.28	0.51	29.4		9.60	1.1		-		Clay Greenish Grey
26	31.28	32.00	0.72	100	269.9	18.00	1.3		I	Easily cavable	Basalt black, vesicular
25	32.00	32.03	0.03	0		3.00	1.1	0			Clay green
24	32.03	32.46	0.43	100	244.2	43.00	1.3	4256	II	Moderately cavable	Basalt black, massive.
23	32.46	33.36	0.9	34.4		8.40	1.1	0			Clay greenish grey
22	33.36	34.71	1.35	90.4	237.8	14.90	1.3	1852	I	Easily cavable	Basalt black
21	34.71	34.78	0.07	0		0.00	1.1	0			Clay greenish
20	34.78	35.00	0.22	68.2	389	11.00	1.2	648	I	Easily cavable	Basalt black, massive.
19	35.00	41.00	6	91.8	407.7	28.40	1.3	15480	V	Cavable with extreme difficulty	Basalt black, vesicular with secondary fillings of quartz.

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CAVABILITY INDEX BY CMRI METHOD
BOREHOLE NO. CMPNE – 01 (NEHARIYA BLOCK)

Bed No	Depth		Bed thickness (m)	RQD	Com. Strength (Kg/cm^2)	Average core length (cm)	Factor	Cav. Index	Category	Cavability	Rock type
	From (m)	To (m)	t	%	C	L	n	I			
18	41.00	44.00	3	95.7	581.6	23.90	1.3	12478	IV	Cavable with substantial difficulty	Basalt black, massive
17	44.00	50.00	8	79.6	536.5	21.30	1.3	14014	V	Cavable with extreme difficulty	Basalt black massive with secondary fillings of quartz
16	50.00	63.16	13.16	95.8	599.7	29.70	1.3	35742	V	Cavable with extreme difficulty	Basalt black, massive
15	63.16	71.00	7.84	94.3	274.5	36.50	1.3	16509	V	Cavable with extreme difficulty	Clay stone
14	71.00	76.50	5.5	62.9	158.1	14.30	1.2	1805	I	Easily cavable	Conglomerate
13	76.50	78.70	2.2	9.5		6.40	1.1	0			White FGD SST
12	78.70	78.80	0.1	0		3.00	1.1	0			Grey Shale
11	79.80	81.30	1.5	0		3.00	1.1	0			Shaley Clayey
10	81.30	82.30	1.5	14.7	119	7.50	1.1	267	I	Easily cavable	FDG SST, Clayey
09	86.05	88.84	2.79	0		4.5	1.1	0			FGD SST
08	88.84	89.54	0.7	0		3.50	1.1	0			Grey Shale
07	90.42	91.25	0.83	0		0.00	1.1	0			Argillaceous SST
06	91.25	91.80	0.55	0		0.00	1.1	0			Shale, Grey, Clayey
05	91.80	93.55	1.75	5.7	118.7	4.4	1.1	160	I	Easily cavable	FGD SST with shaly strea
04	93.55	93.95	0.4	0		0.00	1.1	0			Sandy shale, grey
03	93.95	94.80	0.85	0	208.4	5.80	1.1	266	I	Easily cavable	FGD SST with shaly strea
02	94.80	95.80	1	33	188	5.80	1.1	260	I	Easily cavable	ICal
01	95.80	96.30	0.5	26		9.00	1.1	0			FGD SST with shaly strea

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CAVABILITY INDEX BY CMRI METHOD
BOREHOLE NO. CMPNE – 02 (NEHARIYA BLOCK)

Bed No	Depth		Bed thickness (m)	RQD	Com. Strength (Kg/cm^2)	Average core length (cm)	Factor	Cav. Index	Category	Cavability	Rock type
	From (m)	To (m)	t	%	C	L	n	I			
31	74.00	80.00	6.00	92.0	365.3	49.90	1.3	28859	V	Cavable with extreme difficulty	Basalt Amygdaloidal
30	80.00	87.67	7.67	82.8	1216.9	39.70	1.3	80744	V	Cavable with extreme difficulty	Basalt Amygdaloidal compact
29	87.67	88.56	0.89	100.0	107.7	29.70	1.3	1669	I	Easily Cavable	Green FGD SST Clay
28	88.56	89.20	0.64	28.1	0	7.10	1.1	0	-	-	Red sandy clay
27	89.20	92.00	2.8	81.8	106.1	22.60	1.3	2045	II	Moderately cavable	White SST friable
26	92.00	97.80	5.8	80.5	125.8	19.30	1.3	2842	II	Moderately cavable	White SST very CGD
25	97.80	98.94	1.14	89.5	218.9	19.00	1.3	2148	II	Moderately cavable	White SST red clay at bottom
24	98.94	99.14	0.2	60.0	0	10	1.2	0	-	Cavable with extreme difficulty	Red clay
23	99.14	99.94	0.8	92.5	228.5	11.40	1.3	966	I	Easily cavable	Grey Clay
22	99.14	100.80	0.86	89.5	176.7	14.30	1.3	1041	I	Easily cavable	Sandy clay whitish
21	100.80	106.60	5.8	76.7	78.2	13.70	1.3	1132	I	Easily cavable	Grey FGD SST
20	106.60	107.06	0.46	54.3	0	7.60	1.2	0	-	Cavable with extreme difficulty	Pink FGD SST
19	107.06	107.79	0.73	27.4	0	7.00	1.1	0	-	Cavable with difficulty	Carb Shale
18	108.62	108.72	0.10	100.0	0	10.00	1.3	0	-	-	Grey Shale
17	108.72	109.80	1.08	95.4	153.2	34.30	1.3	3154	II	Moderately cavable	Grey Shale sandy at bottom
16	109.80	111.35	1.55	14.8	0	5.10	1.1	0	-	Cavable with extreme difficulty	FGD SST with shale laminations

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CAVABILITY INDEX BY CMRI METHOD
BOREHOLE NO. CMPNE – 02 (NEHARIYA BLOCK)

Bed No	Depth		Bed thickness (m)	RQD	Com. Strength (Kg/cm^2)	Average core length (cm)	Factor	Cav. Index	Category	Cavability	Rock type
	From (m)	To (m)	t	%	C	L	n	I			
15	111.35	11.65	0.3	0.0	0	2.90	1.1	0	-	Cavable with extreme difficulty	Carb shale/shaley
14	111.65	112.8	1.15	19.1	0	5.60	1.1	0	-	Cavable with extreme difficulty	Grey shale
13	112.80	113.55	0.75	70.7	224.9	10.30	1.2	640	I	Easily cavable	Grey Shale with ICal at bottom
	113.55	115.0	1.5								COAL
12	116.45	117.1	0.7	50.0	275.8	8.50	1.2	602	I	Easily cavable	Grey Shale Sandy
11	118.45	118.80	0.35	37.1	87.9	8.80	1.1	114	I	Easily cavable	Grey FGD SST with shale laminations
10	118.80	121.80	3.0	77.3	48.6	18.70	1.3	758	I	Easily cavable	
09	121.80	121.90	0.1	0.0	0	3.30	1.1	0	-	Easily cavable	Ical
08	123.85	124.80	0.95	73.6	257.7	8.45	1.2	650	I	Easily cavable	Grey Sandy Shale
07	124.80	127.80	3.0	26.3	219.7	11.50	1.1	1117	I	Easily cavable	Grey FGD SST with shale Ical
06	127.80	130.80	3.0	88.0	97.0	13.18	1.3	960	I	Easily cavable	CGD SST with shale ICal
05	130.80	131.85	1.05	89.0	92.00	12.50	1.3	503	I	Easily cavable	CGD SST
04	134.55	136.80	2.25	86.0	0	0	1.3	0	-	-	Ical
03	136.80	137.05	0.25	62.0	0	0	1.2	0	-	-	FGD SST
02	137.45	137.80	0.35	40.0	0	0	1.1	0	-	-	FGD SST with Ical
01	137.80	138.30	0.5	48.0	0	0	1.1	0	-	-	Grey Shale

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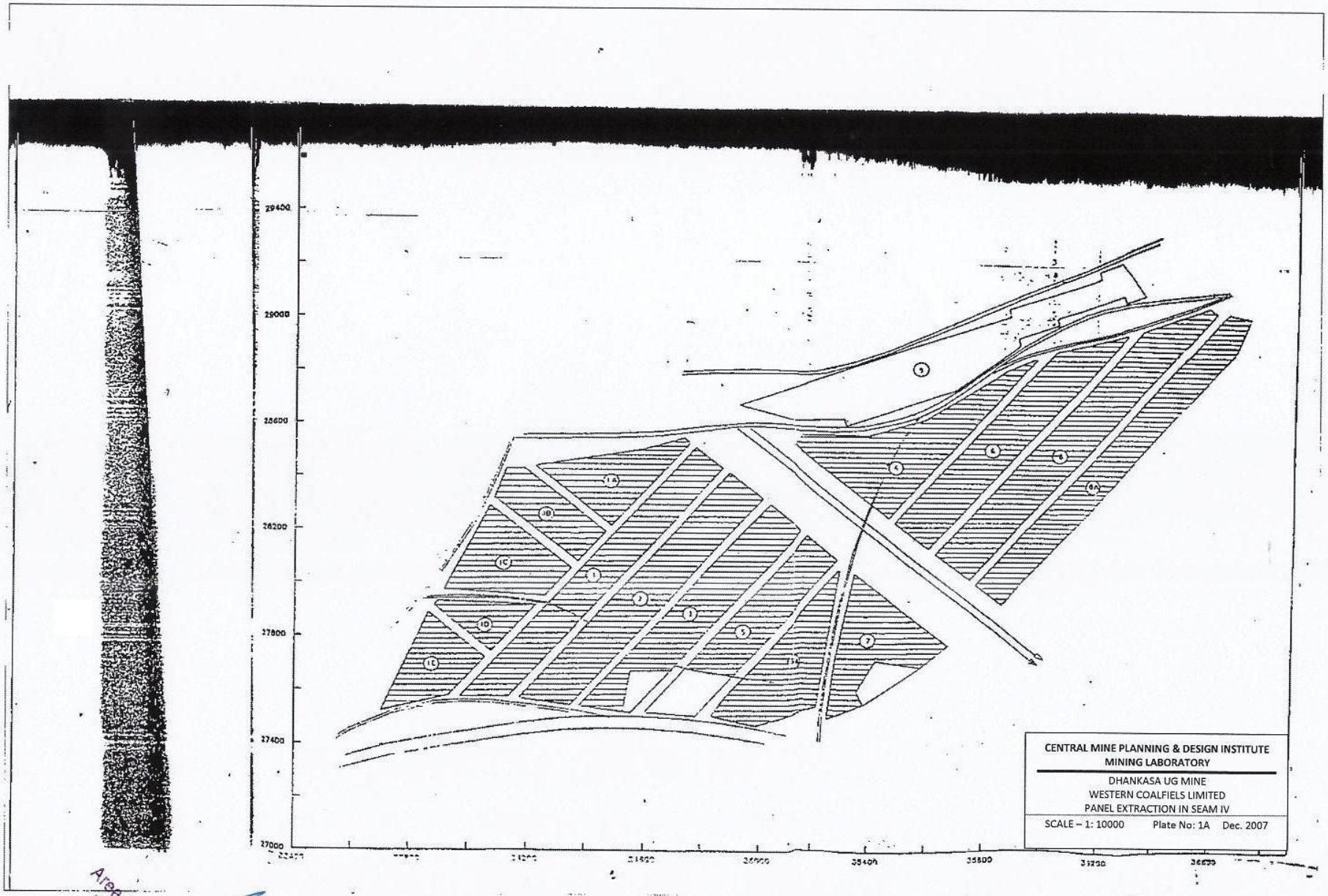

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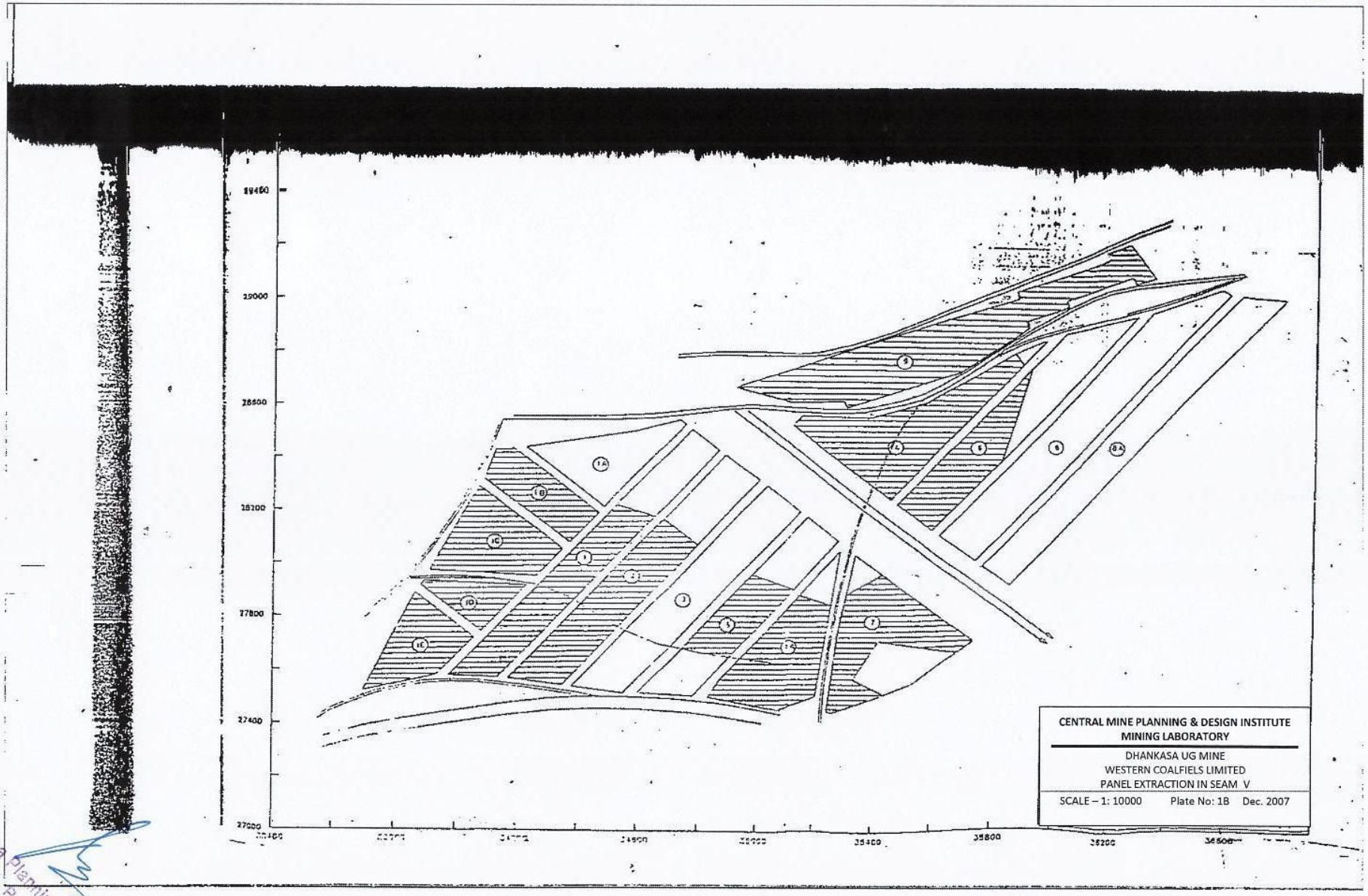

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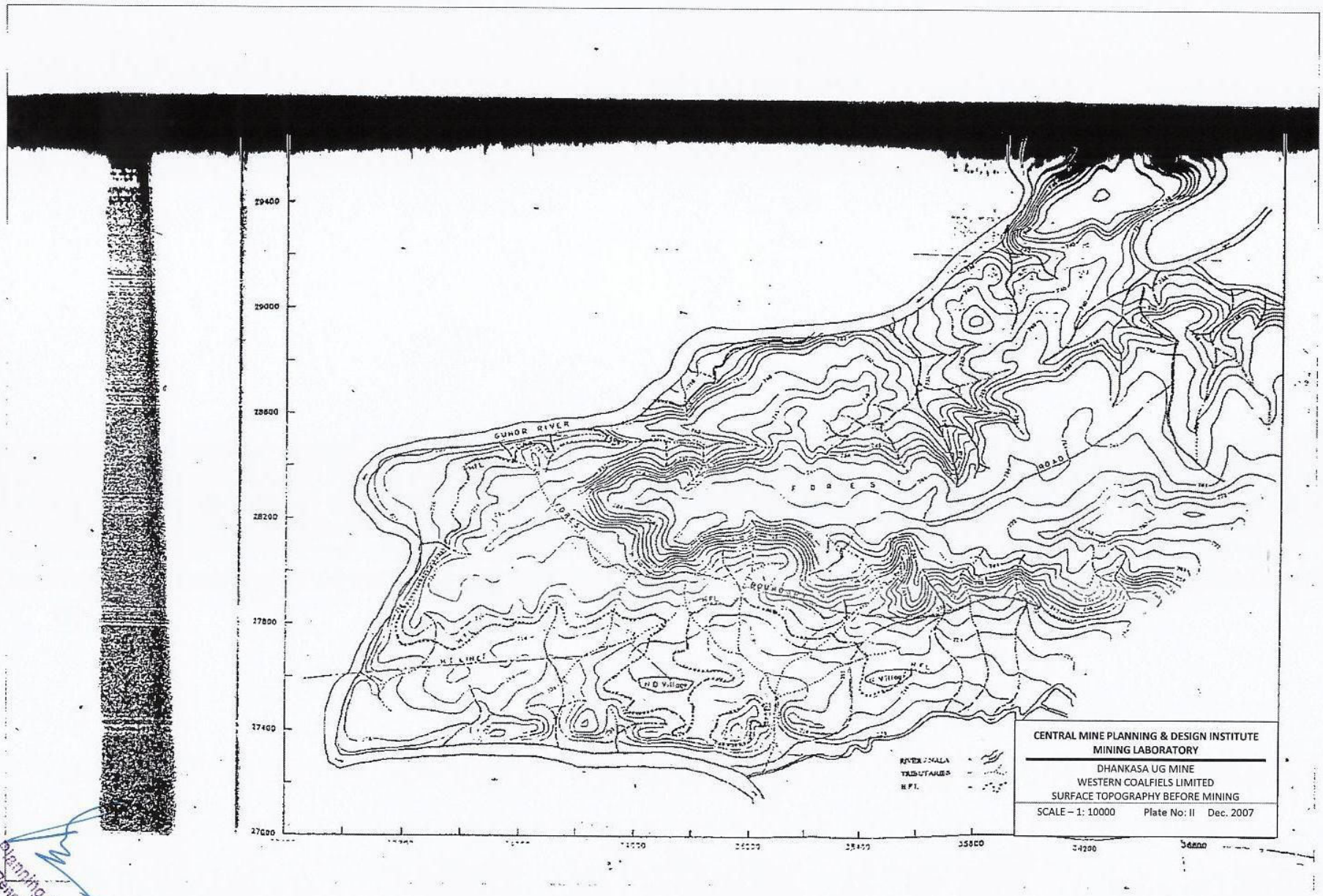

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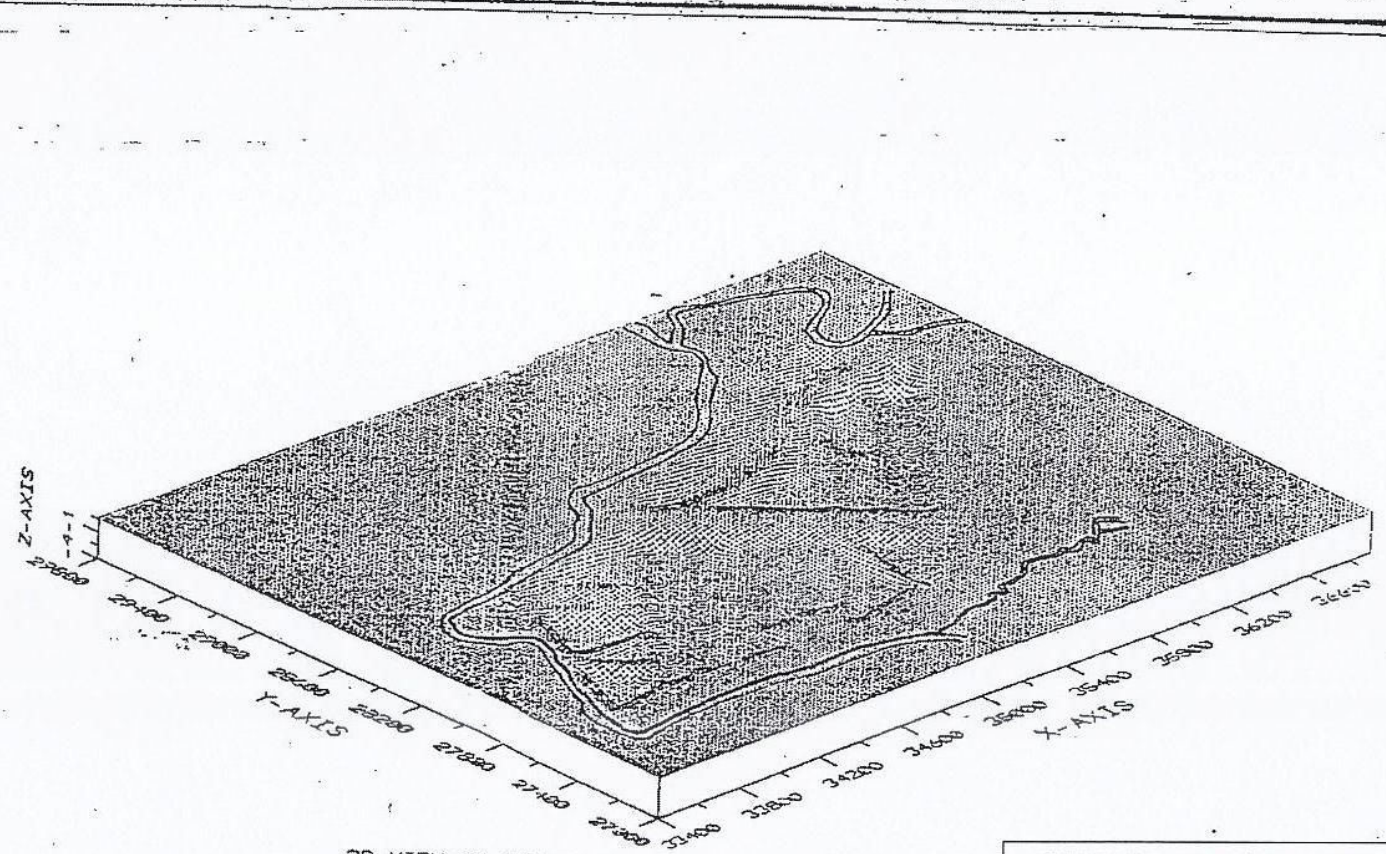

3D VIEW OF SUBSIDENCE AFTER 13 YEARS OF MINING

VIEW DIRECTION - S W

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WESTERN COALFIELS LIMITED
3d View of Subsidence after 13 yrs of mining

SCALE – 1: 10000 Plate No: III Dec. 2007

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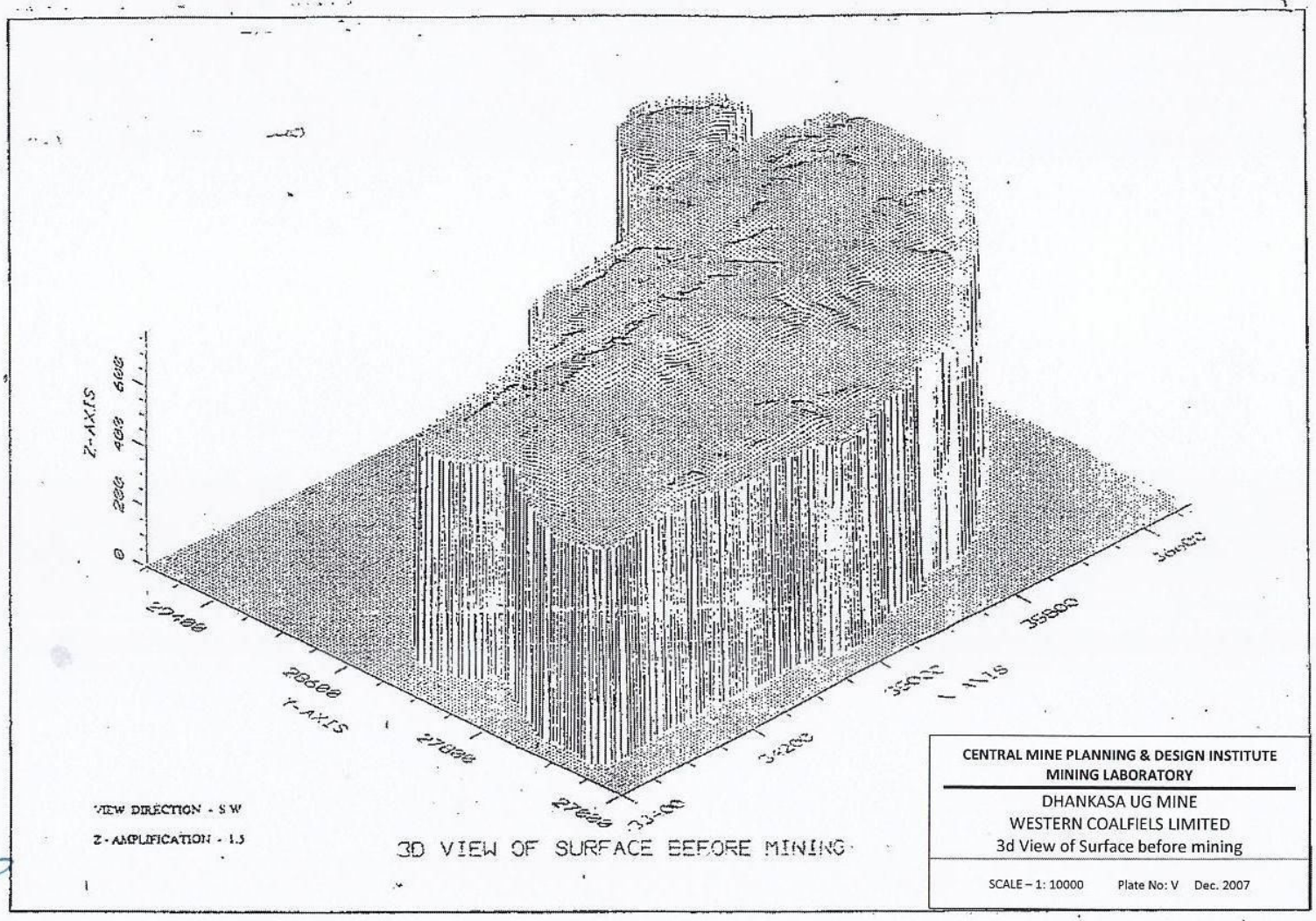

3D VIEW OF SURFACE BEFORE MINING

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3d View of Surface before mining

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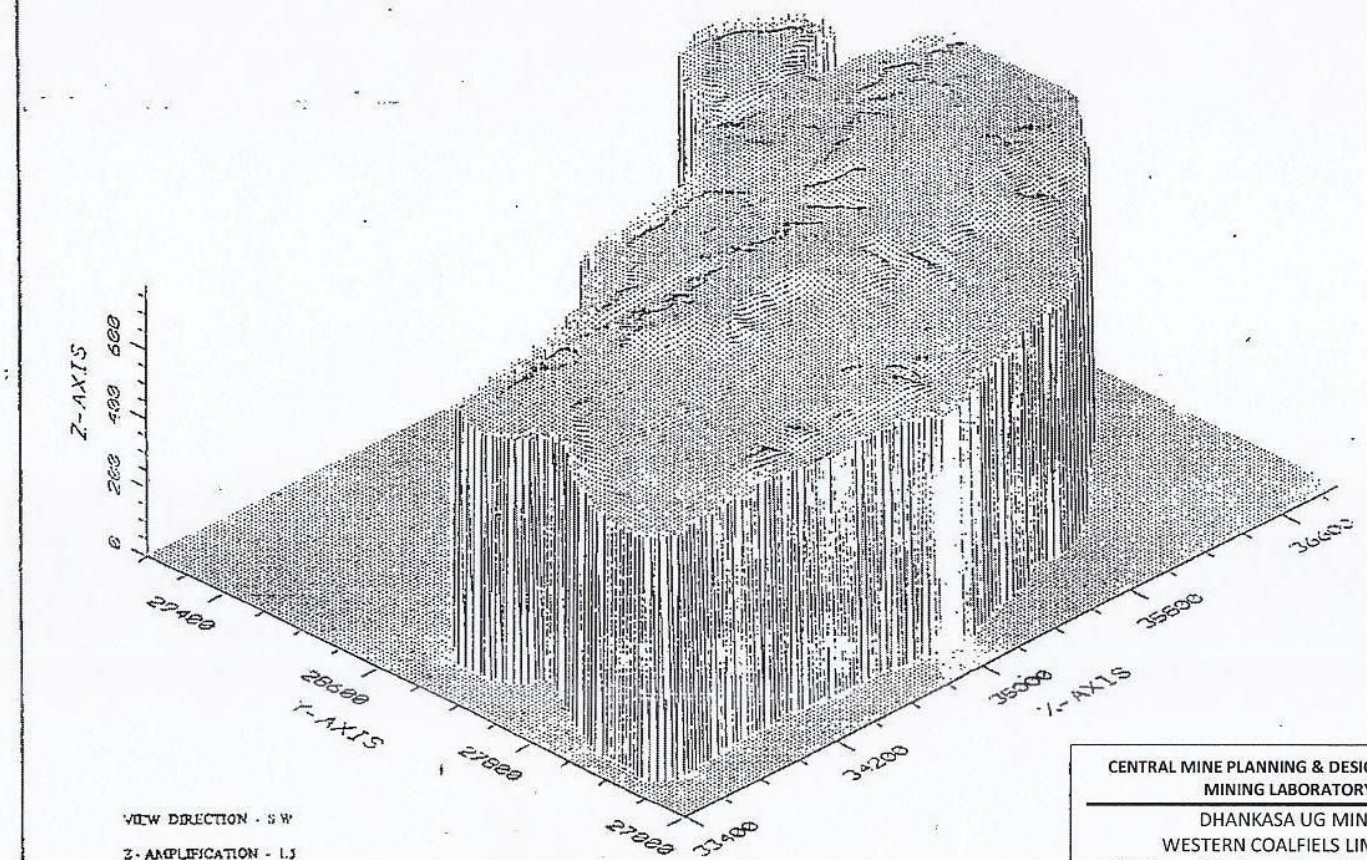

3D VIEW OF SURFACE AFTER 13 YEARS OF MINING

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3d View of Surface after 13 Yrs of mining

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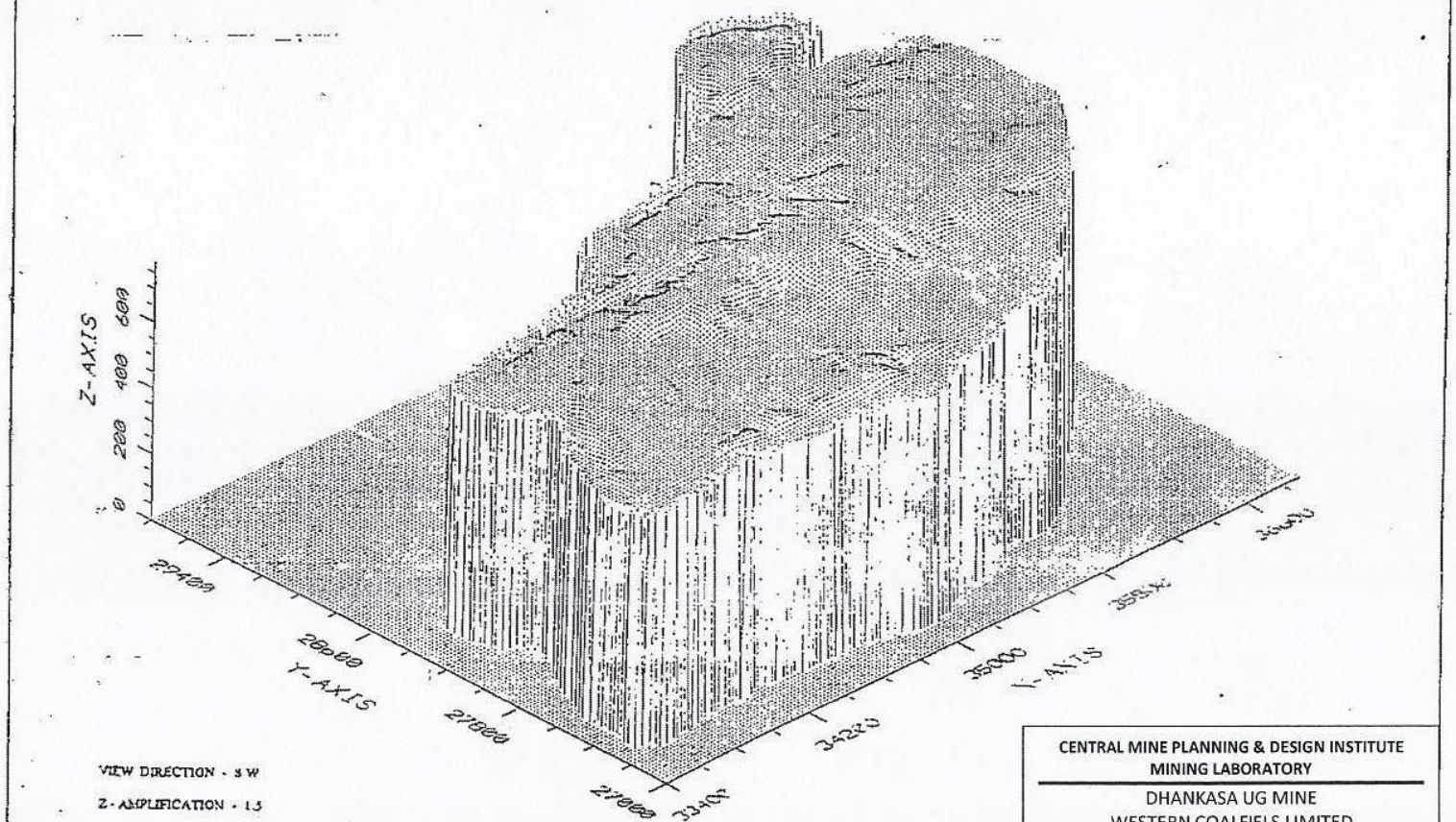

3D VIEW OF SURFACE AFTER 36 YEARS OF MINING

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3d View of Surface after 36 Yrs of mining

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Bench Area