Report on Subsidence Prediction & Management at Piparwar Mangardaha Underground Mine

1.0 Introduction:

Piparwar Mangardaha UGP is situated in Piparwar Area of CCL and falls in North Karanpura Coalfield in the district of Ranchi, Jharkhand. The UG mines covers part area of Piparwar Block and part area of Mangardaha Block. It is a new mine and considers only Lower Bachra seam. At present Piparwar OC is being worked in the Piparwar mining block in the overlying seams (i.e., upto Lower Dakra seam).

2.0 Location & Communication:

Location

Piparwar Mangardaha UGP is located in Piparwar and Mangardaha Blocks of North Karanpura Coalfield. It is 75 km from Ranchi and 60 km from Hazaribagh. It is well connected from Khalari railway station and Ray railway station, which are at 10 km and 5 km respectively from the project.

Communication

The Piparwar Mangardaha underground mine is connected by a black topped road from Khalari to Ranchi (S.H.-47) via Bijupara (about 26 km from Khalari) on Ranchi-Daltonganj Road (S.H.-48). The Piparwar Mangardaha UGP is well connected from Hazaribagh and Ranchi districts of Jharkhand.

3.0 Objective / Purpose of the Report:

The objective of the report is to predict and manage the impact of subsidence on surface topography and other surface features over the mining area due to depillaring of Lowe Bachra seam in Piparwar Mangardaha UGP.

This report is intended to constitute a part of the Environment Management Plan Report, which may be used for getting release of the forest land of Piparwar Mangardaha UG mine and EMP approval for the project.

4.0 Brief Description of the Mine:

The brief description of the Piparwar Mangardaha UG mine is as under:

Table-1.0

Sl. No.	Particulars	Details
1	Name of the Mine	Piparwar Mangardaha UG mine
2	Area in which it belongs	Piparwar Area
3	Company	Central Coal Fields Limited
4	Total Leasehold Area	662.90 Ha
5	Land falling below Piparwar OCP	485.50 Ha (already acquired)
6	Land falling outside Piparwar OCP	177.40 Ha (to be acquired)
7	Break-up of Land to be acquired	Forest: 134.32 Ha Non Forest : 43.08 Ha
8	Status of Land Acquisition in the existing mining area	Additional land of 177.40 Ha is to be acquired.
9	Proposed Production	1.38 MTY
10	Mode of coal Transport	By road, through Truck.
11	Proposed Method of Work	Bord & Pillar with Low height LHD & Room & Pillar with Continuous Miner
12	Any subsidence record in the mine.	No subsidence record available in the mine or area.
13	Gradient of Seam	1 in 10 to 1 in 40
14	Gassiness of Seam	Degree-I (assumed)
15	Name of seam to be worked	Lower Bachra (Bottom Section) Seam
16	Avg. thickness of the seams considered for subsidence prediction in the present mining area.	3.0 m
17	Weighted average Grade of Coal	Grade ‘B’
18	Coal Linkage	Linked customer.
19	Size of the Pillar	As per CMR 1957 guidelines
20	RMR of the present workings	Not determined.
21	Surface features to be protected	Water Filled Pilot Quarry, Major connecting Road, Saphi River, Damodar River and Overhead High Tension Line etc.
22	No. of families to be rehabilitated	Nil (Since no Depillaring is proposed below village)

4.1 Roof and Floor of the seam :

The details of the roof and floor of the individual seams considered for subsidence prediction are as under:

Sl. No.	Seam	Roof of Seam	Floor of the seam
1	Lower Bachra Seam (in Piparwar block)	The roof of the seam consists of carbonaceous shale, shale, sandstone & alternate band of shale and sandstone.	The floor of the seam consists of carbonaceous shale, shale, sandstone, alternate band of shale and sandstone.
	Lower Bachra Seam (in Mangardaha block)	The roof of the seam consists of carbonaceous shale, shale, sandy shale.	The floor of the seam consists of carbonaceous shale, shale, sandy shale, coarse-grained & medium-grained sandstone, alternate band of shale and sandstone..

4.2 Topography

Major mining area lies below Piparwar OC. The decoaled area is partly filled by internal dump. The existing topography of the area lying in Piparwar OC is undulating. A part of the dump area is planted. The remaining area where quarry operation is yet to be done is gently dipping and represented by paddy lands. The highest and lowest elevation of the area (as per GR) is +464m and 409m respectively.

The topography of the area lying in the Mangardaha block is also undulating. It is flat along east-west and central portion and gently sloping on either side. The area is fair admixture of farm land and forest. The drainage of the area is mainly controlled by Damodar River and its tributaries.

5.0 Area Considered for subsidence Prediction:

Selection of Mining Area: The selected mining area for Piparwar-Mangardaha underground project covers Sector-A, Sector-B, part of Sector-C and part of Sector-D of Piparwar Block and south of fault F28 in the Mangardaha Block. The area considered is around 5.19 sq.km from Piparwar Block and 1.05 sq.km from Mangardaha Block. Total area of the selected mining area is about 6.24 sq.km. In the approved Project Report, the mine

has been proposed to work through two separate units, namely: Piparwar Unit and Mangardaha Unit.

However, the entire working area of Piparwar Mangardaha underground mine has been considered as single section for the purpose of subsidence prediction. All the 36 panels for the proposed underground mine have been considered for the subsidence prediction. The panel names are as follows:

PL1, PL2, PL3, PL4, PL5, PL6, PL7, PL8, PL9, PL10, PL11, PL12, TP1, TP2, PC1, PC2, PC3, PC4, PC5, PC6, PC7, MC1, MC2, MC3, MC4, MC5, MC6, MC7, MC8, MC9, TM1, TM2 & TM3

6.0 Brief Geology:

Both the blocks, Piparwar & Mangardaha are situated in the North Karanpura Coalfield of CCL. The Piparwar opencast is in operation for exploitation of coal up to Lower Dakra seam in the block. The Piparwar block is geologically explored. But majority of boreholes have been drilled up to Lower Dakra seam only. The Mangardaha Block is adjacent to Piparwar Block located to its East. It forms an integral part of northern limb of N.K basin (recognized as Karkata-Piparwar anticline). Fault F28 divides the block approximately in two halves.

The borehole density for the Lower Bachra Seam in Piparwar Block is around 5.0, whereas in Mangardaha block it is around 7.5, both on the lower side. The distribution of boreholes throughout the block is not uniform. The concentration of boreholes towards Damodar River and north of fault F25 is more in comparison to rest of the area. Only few boreholes have been analyzed for ascertaining the structure of Bachra seam in the Piparwar and Mangardaha block.

6.1 Dip & Strike

The geological structure of Piparwar block is that of homocline with super imposed rolling dips. The general strike of beds is NNW-SSE which swings to almost North-South in Sector-D around borehole NNKP-42 and 73.Generally the westerly Dip varies from 1 in 10 to 1 in 40. However, in large part of the area, the gradient is around 1 in 27 to 1 in 35. The gradient varies locally with decrease and increase in the parting thickness of coal seam.

The Mangardaha block is characterized by wide variation in gradient. In the synclinal portion between faults F40 and F30, the gradient in the east is about 1 in 10 which steepens to 1 in 8. Between faults F28 and F30, the gradient are influenced by drag effect and vary from 1 in 8. Between faults F28 and the Damodar River, flat gradient to the extent of 1 in 30 has been observed.

6.2 Coal Seams

The detailed exploration of Piparwar & Mangardaha Block has proved the presence of 8 coal seams. However, only Lower Bachra seam has been considered for the underground mines. All the upper seams in Piparwar Block have already been considered for Piparwar OCP. The overlying seams doesn't exist in the mining area considered in Mangardaha Block.

6.3 Sequence of Seams in the Block

The sequence of coal seams and partings in the Piparwar Block are as under:

Sl. No.	Coal Seam	Drilled thickness of coal seam		parting with overlying seam / surface (m)		Remarks
		Min.	Max.	Min.	Max.	
Barakar Formations						
Strata above Karkata seam – 110m approx. with minor coal bands.						
1.	Karkata	4.90	5.42	7.92	14.07	Encountered in only two bhs.
2.	Bisrampur	2.40	5.27	7.80	13.21	Encountered in six bhs.
3.	Bukbuka Top	2.25	4.32	6.16	23.05	Also encountered in two splits
4.	Bukbuka	9.24	14.41	0.75	23.21	
5.	Upper Dakra	3.10	8.82	1.11	13.48	Seam splits up in North - eastern part.*
6.	Lower Dakra	18.65	29.16	89.12	106.34	Wherever Up. Bachra seam is not developed parting between Lr. Dakra seam & Lr. Bachra seam ranges between 95.68m (NNKP-41) & 110.73 (NNKP-6).
Karharbari Formation:						
7.	Upper Bachra	Nil	2.37	1.53	12.61	Except in 3 boreholes.*

Sl. No.	Coal Seam	Drilled thickness of coal seam		parting with overlying seam / surface (m)		Remarks
		Min.	Max.	Min.	Max.	
8.	Lower Bachra	0.74	8.42	90.35		Also considered in splits in Bh. NNKP-14, 41 & 30.
	Talchir	More than 37.70 base not drilled.				

Succession of coal seams & partings, Mangardaha block

Seam	Thickness Range (m)		Parting range (m)	
	Min.	Max.	Min.	Max.
Upper Dakra	3.51	4.89	1.27	9.67
Middle Dakra	7.63	12.94	1.43	14.47
Lower Dakra	7.30	14.40	74.94	100.81
Upper Bachra	0.56	2.61	0.73	12.11
Lower Bachra	1.73	6.10		
Lower Bachra Bottom Section (Ususally low ash)	1.18	4.51		

7.0 Methods of Mining:

Proposed Method of Mining: It is proposed for application of the following method of mining for extraction of coal from Piparwar & Mangardaha units of the project. (as per the approved PR of Piparwar Mangardaha UG)

- ❖ Bord and Pillar method with low height LHDs
- ❖ Room and Pillar with Continuous Miner technology

Depillaring of the seam is proposed by caving.

8.0 Subsidence Prediction:

8.1 Subsidence Prediction Procedure:

The subsidence prediction procedure consists of the following steps:

(a) Collection of Data and Plans

The data related to mine like leasehold area, mining area, and seams worked, seams proposed to work, and history of subsidence in the mine / area, etc and other related data required for the subsidence prediction model is collected from the colliery. Layout plan of Lower Bachra seam showing the panel projections, surface plan of the mine, land use plan of the mine is taken

from the plans of approved PR. The subsidence prediction is to be done for the bottom section of lower Bachra seam.

(b) Discussion & finalization of panel projection plans

The panel projections have been taken from the approved Project Report of Piparwar Mangardaha UG. A mining schedule for the panels to be worked in future, at intervals of 5 years, is also taken from the approved PR. The plan and schedule provided will be discussed and finalized in consultation with colliery management. Then plan will be scanned for digitization.

(c) Generation of panel parameters

A list of panels parameters, like - average depth, average working/extraction thickness, percentage of extraction in a panel, etc. is generated for all the panels to be worked. The panel parameters are generated with the help of bore data, floor contour of the seam, surface contour plan, isocore plan of the individual seams, etc.

(d) Generation of Electronic data (Scanning & digitization) of mine plans

Before scanning of the prepared mine plan, the co-ordinates of the mining area are fixed which covers the extent of workings of all the seams proposed for subsidence prediction. After ensuring that the extent of workings of all the seams proposed for subsidence prediction is falling within the fixed co-ordinates of the mining area. The working and projection plans of panels to be worked is scanned and digitized to generate the coordinates values of

- Panel extents,
- Surface contours,
- Surface features, like Road River, nalla, village, forest area, etc.

(e) Processing of electronic data

Based on the panel parameters data and the electronically generated data, subsidence prediction model is used for estimation of maximum subsidence, maximum strain, and maximum slope for the individual seams and combined all seams. The impact of subsidence on surface is estimated with the use of above estimated subsidence parameters in subsidence prediction model.

(f) Use of Subsidence Prediction Model

The subsidence prediction model is based on “Influence Function Method”, developed by CMPDI, has been used for estimation of likely subsidence over the mining area. This type of method calculates subsidence at surface points based on the theory that there is an area of influence around a point due to extraction of a small element within the sphere of influence of that surface point. The area of influence is generally assumed to be circular. The panel parameters like angle of draw, edge factor, estimated subsidence factor along with assumptions and other considerations for the mine are used as input data for the subsidence prediction model.

i) Estimation of subsidence factor: For calculation of subsidence factor, the formula of “Profile function method of CMRI” has been used. The relationship developed by CMRI between S_{max} and other extraction parameters is as under-

$S_{max} = 0.5 (1+M) (e' a' n' m')$

Where,

S_{max} = Maximum possible subsidence (m)

M = Rock mass factor,

0.5 - for predominantly sandstone, to

1.0 - for weak & totally disturb strata above coal seam.

e’ = extraction percentage factor

0.95 - for long wall,

0.1 to 0.80 - for Bord & Pillar.

a’ = goaf treatment factor

0.95 - for caving,

0.07 to 0.10 - for hydraulic sand stowing

h’ = depth factor,

1.0 - for depths up to 250m,

1.1 - for depth ranges from 250-400m, and

1.15 - for depth beyond 400m.

m’ = extraction thickness in (m)

$$\text{Subsidence factor} = \frac{S_{max}}{\text{Thickness of extraction (m')}}$$

ii) The angle of draw, subsidence factor and edge factors are either taken from the actual available data for the mine or from the standard value for that particular coalfield.

iii) Calibration & Griding: Before subsidence prediction, the prediction model is calibrated according to the above mentioned subsidence parameters. For subsidence calculation, underground extraction area was divided into 10m x 10m grid block as individual elements. The numerical procedures followed for prediction involves estimation of subsidence at the grid points of each element and subsequent integration to arrive at resultant values and the final area influenced by ground movement.

g) Estimation & Prediction of Subsidence: The generated panel & other coordinates along with panel parameters are used in the model / software developed by CMPDI is used to estimate and predict the subsidence on surface for individual seams, and combining all seams.

h) Assumptions, considerations & Limitations

The various assumptions, considerations used for subsidence prediction & limitations of the report are briefly stated below:

Assumptions:

(i) It has been assumed that the layout plan of lower bachra seam showing the proposed working and the other surface features marked on the surface plan are correct and it has been used as input data for this subsidence prediction.

(ii) The surface topography of the mining area below existing Piparwar OCP may change after completion of quarry operation and backfilling of the area. Presently, the original topography as per the available GR of Piparwar & Mangardaha Block is used as input data of surface topography for prediction of subsidence & impact analysis.

(iii) The proposed method of mining will be Bord & Pillar with caving. Proposed mechanization is with Continuous Miner & Low Height LHD.

(iv) The schedule of mining is as per the mining schedule of the approved Project Report of Piparwar Mangardaha UGP.

(v) The overlying seams of Lower Bachra seam is extracted by opencast and filled up with overburden through internal or external dumps. The parting between floor of Dakra seam to roof of lower Bachra seam is around 100m, which is around 30 times the proposed thickness of extraction. Hence, the strata overlying to Lower Bachra seam has been assumed as intact rock mass strata. Since the area is back filled with loose and fractured material it may create dead load over the parting. Hence, rock mass factor has been assumed considering the dead load over parting for estimation of amount of maximum subsidence and subsidence factor for the proposed underground project.

(vi) The size of the panel is assumed to be super critical.

(vii) The extent of mining and mining schedule is considered as per the approved PR of the project. No further extension of working of the seam has been assumed.

(viii) Although the same seam is worked in the adjacent Bachra underground mine. Due to non availability of subsidence record, the standard values of subsidence factor and angle of draw of those particular coalfields have been assumed as input data for subsidence prediction. The details are as under:

Sl. No.	Particulars	Description / Values
1	Subsidence factor	0.60
2	Angle of draw	35^{o}
3	Edge Factor	0.15
4	Anticipated percentage of extraction within the panel	80%
5	Depth from surface	Av. Depth for each panel
6	Non-effective width of the panel	0.4h (h-depth of panel)
7	Thickness of extraction	Average thickness for the panel(Panel wise thickness is shown in table below)

Considerations:

i) The plan and data as per the approved Project Report of Piparwar Mangardaha UGP has been considered base data for prediction of subsidence for the mine.

ii) The depth of the panel for the individual seams is as per the approved Project Report of Piparwar Mangardaha UGP, however the depth of the panels for the seam has been cross checked and considered on the basis of the borehole falling within the panel, the influence of the surrounding boreholes, (as shown in GR of Piparwar & Mangardaha Block) and the value of surface contour over the panel. The depth of the panel considered for subsidence prediction is the average depth of the panel from surface.

iii) The seam thickness and parting with overlying seams have been taken on the basis of the borehole falling within the panel, the influence of the surrounding boreholes, actual thickness observed while development and the general trend of parting between the seams and seam thickness and cross checked by Isochore plan of individual seams. The seam thickness of the panel represents the average seam thickness of the panel.

The panel wise depth, seam thickness & thickness of extraction considered are as under:

S.N.	Seam Name	Panel Name	Depth of Panel	Avg. Seam Thickness
1	Lower Bachra	PL1	172	2.50
2		PL2	181	2.80
3		PL3	174	3.00
4		PL4	172	2.00
5		PL5	173	2.00
6		PL6	172	2.50
7		PL7	167	2.00
8		PL8	181	2.50
9		PL9	182	1.80
10		PL10	191	2.50
11		PL11	192	2.00
12		PL12	191	2.50
13		PC1	167	3.50
14		PC2	168	3.50
15		PC3	148	3.00
16		PC4	132	2.50
17		PC5	137	2.50
18		PC6	126	3.00
19		PC7	125	3.00
20		TP1(A)	161	2.50
21		TP1(B)	168	2.50
22		TP2	184	2.50
23		MC1	138	2.50

S.N.	Seam Name	Panel Name	Depth of Panel	Avg. Seam Thickness
24		MC2	87	2.50
25		MC3	82	2.50
26		MC4	133	4.00
27		MC5	147	2.50
28		MC6	128	3.50
29		MC7	155	2.50
30		MC8	152	2.50
31		MC9	160	2.50
32		TM1(A)	152	2.50
33		TM1(B)	150	3.00
34		TM1(C)	152	3.00
35		TM2	131	3.00
36		TM3	89	3.50

iv) The thickness of extraction of the panel has been considered as its bottom clean coal section where, the seam thickness is more. In low thickness area, full seam thickness has been considered.

The list of panels considered for subsidence prediction is as under:

Sl. No.	**Seams**	**No of Panels**	**Panels considered for prediction**
1	Lower Bachra seam	36	PL1 to PL12, PC1 to PC7, TP1(A), TP1(B), TP2, MC1 to MC9, TM1(A), TM1(B), TM1(C), TM2 & TM3

vii) Surface features marked on the surface plan and land use plan have been considered as the base data and impact of subsidence on those marked surface features only have been assessed.

viii) Kisto village is falling over MC2 panel in the proposed mining area, where no depillaring is proposed below that area. Impact assessment over Kisto Village is being done.

Limitations

1. In Piparwar Block, overlying seams are partly quarried out and backfilled by debris hence, there will be change in the surface topography of the area considered for subsidence prediction. But the assessment of damages on the surface due to subsidence is done on the original topography.

2. The proposed thickness of extraction for the panel is bottom clean coal section and subsidence prediction is also conducted for the bottom section only. Mining of complete section of the seam I,e full seam thickness in higher thickness area may create more damage on to surface and may create more damage to surface features.

8.2 SUBSIDENCE PREDICTION RESULTS:

After successful processing of all the data, we may get the following results:

8.2.1 Seam wise, Panel wise data of maximum subsidence, maximum stain, maximum slope and their impacts on surface.

8.2.2 Surface contour plan before and after subsidence (considering individual & final extraction of all considered seams).

8.2.3 Subsidence contour plan for extraction of individual and combined all seams. Here only one seam is considered(I,e Lower Bachra Seam)

8.2.4 3-D view of surface profile before and after subsidence.

8.2.5 Horizontal X-section (A-A') and Vertical X-section (B-B') showing the amount of subsidence at the end of mine life.

8.2.1 Seam wise, Panel wise Maximum Subsidence, Strain, Slope and their impacts on Surface:

The maximum subsidence, slope & strain are obtained from the processing of seam data in the program of subsidence model for Lower Bachra seam. The impact of subsidence has been assessed considering Bottom section of lower bachra seam in subsidence prediction model. The panel wise maximum subsidence, slope, tensile strain & impact of subsidence on surface are given in Table- 2.0 & 3.0 the report.

8.2.2 Surface Contour Plan Before & After Subsidence:

Surface contour plan before and after subsidence is shown in Plate no III and Plate no IV respectively.

8.2.3 Subsidence Contour Plan:

Lower Bachra Seam subsidence contour plan is shown in plate number Plate no V.

8.2.4 3-D view of surface profile before and after subsidence:

3-D view of surface profile before and after subsidence is shown in Plate no VI and Plate no VII respectively.

8.2.5 Longitudinal X-section (A-A') and Transverse X-section (B-B'):

Longitudinal and Transverse cross section showing the surface profile before & after the subsidence and subsidence profile at the end of mine life is shown in plate numbers VIII to XI.

9.0 Impact of Subsidence and its Management

9.1 Effect of subsidence on topography, Surface features & others:

i) Effect on surface topography

The existing original topography will change due to opencast mining in the upper seams in part of the considered mining area. The assessment of impact due to depillaring of Bottom section of Lower Bachra seam at surface has been done considering original existing topography as per GR of the Piparwar & Mangardaha Block. Due to depillaring of the seam, depression on surface may be observed at the centre of the most of the panels considered for study. It may change the existing natural drainage pattern of the mining area. There may be accumulation of water in the low lying area created due to subsidence, which may endanger the safe underground working. Surface cracks developed due to depillaring of the seam may provide passage to air and water, which may be potential source for spontaneous heating and inundation.

Suggested Management

a) Depression and cracks generated due to caving should be filled with noncombustible material. Filling of the area should be done in such a way that there should be outward drainage from the mining area. The slope of topography should make natural drainage pattern.

b) The topography of the backfilled area should facilitate the outward slope from the mining area to avoid accumulation of rain water.

c) Regular and constant observation of the depillaring area by the competent person for record of subsidence.

d) Subsidence trough generated due to caving should be completely filled up immediately with non combustible material.

Panel wise amount of subsidence and its impacts are given in Table 2.0 & 3.0.

ii) Effect on surface features

The following surface features may get affected due to caving of the lower bachra seam (bottom section):

a) PWD Road and other Roads (Like approach road to village and other existing colliery establishments of existing opencast mine.)
b) Dump Hopper of existing CHP,
c) Kisto Village falling over panel MC2,
d) Pilot Quarry of Piparwar OCP filled with water,
e) Other surface features
f) Forest Land

The details of impacts and nature of damages are shown in Table 2.0 of the report.

a) PWD Road & other roads

These roads are mostly passing over PC6, PC7, MC2, MC3, MC4, TM2 and TM3. Impact assessment shows that cracks over these panels may be observed up to 300mm width. In some of the area, minor repair may be required or in some of the area major repair may be required (shown in Table 2.0). Other roads like haul roads are also over the proposed mining area but that has been assumed as temporary roadway and it may not be utilized after completion of quarry operation.

Suggested Measures and its Management

i) Depression and cracks generated due to depillaring of the seam may be filled completely with non combustible material or soil and compressed.

ii) After filling with non combustible material, it should be reinforced with concrete and cement.

iii) Regular monitoring of the subsidence area and compliance of suggested measures for filling.

b) Dump Hopper of Existing CHP

Dump Hopper is mainly falling over the panel TM1 (A), and MC1.The impact analysis shows that the tensile strain generated due to depillaring of the seam is more than 3mm/m but less than 5mm/m. There may be the generation of fine cracks over the panel. This may damage the water pipeline used for dust suppression and structure of the hopper. If there will be brick construction, minor repair works may be required.

Suggested Measures and its Management

i) The fine cracks generated in the wall should be reinforced with cement and concrete as and when required.

ii) Regular maintenance of the water pipeline used for dust suppression.

iv) Depillaring of these panels are to be done after completion of opencast mining.

c) KISTO Village

Part of the Kisto Village may fall over the considered mining area of the Piparwar –Mangardaha UGP. The impact assessment shows that the crack generated due to caving may be up to 200mm and tensile strain may be around 17.47 mm/m. It may create severer impact on the single storied buildings and multistoried buildings.

Suggested Measures and its Management

i) No depillaring is proposed below these area where villages are present.

d) Pilot Quarry of Piparwar OCP filled with water

The pilot quarry is falling over the panel MC6 and PC7.This old quarry is completely filled with water. Presently, this filled up water cater the industrial as well as the domestic need of the Piparwar area. The impact assessment shows that the crack generated due to depillaring of the seam may be up to 200mm and tensile strain generated may be up to 15.47 mm/m. Depillaring below this pilot quarry may cause inundation of the underground working due to surface inrush of water.

Suggested Measures and its Management

i) No depillaring is proposed below these area where pilot quarry is present. It is proposed to leave protective pillars along the boundary of pilot quarry, so that the depillaring of the adjoining panels may not develop crack up to the bed of pilot quarry and may cause inundation.

ii) Regular monitoring of water level and any abrupt change in water level should be recorded and analysed and precautions should be taken accordingly.

e) Other Surface Features

Other surface features are like Damodar river, Saphi River, Benti nala, Mangardaha nala. Mangardaha nala is in the outside of the considered mining area, where as the Benti nala is passing over the panel PL9 & PL11.The impact assessment shows that the tensile strain generated due to caving may be up to 6.0mm/m and may create crack width up to 50mm. Mining below this nala may cause inundation due to surface inrush of water. Damodar and Saphi river makes its natural eastern & southern mining boundary of the proposed mining area.

Suggested Measures and its Management

i) No depillaring is proposed below Benti nala.It is proposed to leave protective barrier of 60m along the bank of nala, so that the depillaring of the adjoining area may not develop crack up to the bed of nala and may cause inundation.

ii) No depillaring is proposed within 60m of the bank of river. Strengthening of embankment along the bank of Damodar and construction of embankment along the bank if Saphi river is proposed in the approved PR.

iii) Strict compliance of the statute and related circulars for safe underground working.

f) Impact of Subsidence on Forest Land:

The depillaring of panels falling within the leasehold area of the existing Piparwar opencast may also affect the forest land but this forest land is already damaged by the existing opencast. Compensation against the

damage of the forest land within the existing leasehold of Piparwar opencast is already made and it is acquired.

Table 2.0 shows the impact assessment for the forest land falling in the Mangardaha Block. The Impact assessment shows that the tensile strain generated due to caving may be up to 23.93mm/m and width of the crack may be more than 300mm.This may cause minor tilting, major tilting and high tilting of the trees in the forest area.

Suggested Measures and its Management

i) NPV for the forest land should be paid against the forest damages.

ii) In addition to NPV payment the area where minor tilting of the trees taken due to cracks generated due to depillaring, the cracks should be filled up and trees may be protected as many as possible.

iii) The cracks should be effectively filled up and fresh new plantation of trees over the depillared area should be made after detailed study by the environmentalists.

10.0 General Subsidence Management:

Considering the impact of subsidence on surface topography and surface features, as explained above, the suggested measures should be effectively complied for the effective subsidence management. In addition to above suggested measures against each impact analysis, the following general subsidence management should be done:

i) It is suggested that a team is formed by the mine management which will be responsible for the proper and regular filling of surface cracks, pot holes developed due to subsidence. The team will also maintain records of the development and filling of surface cracks. Adequate supply of filling materials should be arranged by mine management at the site.

ii) Provision has to be made for compensatory afforestation and strengthening of forest cover to take care of losses, if any. Subsidence may result in depressions on the surface with accumulation of water during the rains. Such accumulation of water may be beneficial for vegetation in the forest.

iii) Surface drains should be made outside of the subsidence influence area to prevent the surface water of adjoining area from coming into active subsidence area.

iv) Quarried out area over the depillaring panels need to be filled up with solid where required, and dried up before commencement of depillaring operation in the panels underlying these areas.

v) Coal pillars are to be left un-extracted vertically below and within subsidence influence area from the surface features like nala, river, road etc which are required to be protected from subsidence damages.

The impact of subsidence on different surface features along with the degree of damage is given in Annexure–I for reference, i.e. the "Subsidence Impact Matrix". The Subsidence Impact Matrix (SIM) shown therein was developed under a Ministry of Coal funded S&T project.

11.0 CONCLUSIONS:

The impact of subsidence on topography and surface features, as also the suggested measures to minimise their adverse impact are summarised below:

i) In this study all the proposed panels are considered to be depillared with caving method and accordingly subsidence calculation has been carried out. The subsidence generated due to depillaring of seams in the considered mining area may affect the topography, natural drainage and surface features with cracks more than 300mm width and strain up to 23.93mm/m.

ii) As per recommendation of MOEF, the forest area having tensile strain more than 10mm/m would be considered as subsidence affected area due to underground mining and accordingly NPV is to be paid.

iii) Due to extraction of the seam considered for mining the estimated maximum possible subsidence likely to occur over the panel MC4 and its surrounding. The amount of maximum subsidence is around 2.43m over the panels MC-4 in Mnagardaha Block.

iv) The maximum possible slope and tensile strain likely to occur are 47.87 mm/m and 23.93 mm/m respectively over the TM3 panel.

v) Benti Nala flowing over the PL9 & PL11 panel in the mining area. The depillaring below nala may cause inundation of underground workings. Therefore, to make it safe, coal should be left un-extracted vertically below and within 35^0 angle of draw from the nala in the proposed panels along the bank of the nala.

vii) All perceptible cracks developed due to subsidence should be filled up with clay, stone chips and non combustible material to achieve the original drainage pattern in the mining area.

viii) Surface drains should be made outside of the subsidence influence area to prevent the surface water of adjoining area from coming into active subsidence area.

ix) Subsidence prediction has been done on the basis of various assumed data and data supplied by the mine management. Hence, there may be variation with actual subsidence while mining. So, it is recommended that while carrying out extraction, close subsidence monitoring is required to be done over some initial panels. On the basis of observed data, necessary correction in subsidence estimation may be done, if required.

ANNEXURE – 1

SUBSIDENCE IMPACTS

The Subsidence Impact Matrix given below shows the degrees of damage for various surface features, including forest land, vis-à-vis subsidence, slope and strain values was developed as part of a Ministry of Coal funded S&T project and is extracted from the S&T Report titled “Subsidence in Mining Areas” by CMRI.

SN	Impact	Subsidence (mm)	Slope (mm/m)	Strain (mm/m)
1	2	3	4	5
SURFACE TOPOGRAPHY				
1.	Practically no impact.	<500	<3	<3
2.	Some fine cracks or one or two 50mm wide cracks with visible depression.	<500 500-1000	3-5 5-10	3-5 3-5
3.	A large number of fine cracks or a few 100mm wide cracks with marked depression	500-2000	10-20	5-10
4.	A large number of 50-100mm wide cracks or a few 200mm wide cracks with stepping. Marked distortion in surface topography.	500-2000	>20	10-20
5	500mm wide cracks with stepping and prominent distortion in surface topography.	>1000	>50	20-50
6.	Many 500mm wide cracks some upto 1000mm width, large stepping. Severe distortion in surface topography.	>2000	>100	50-100
7.	Very severe distortion in surface topography. Stepped subsidence with very wide cracks.	>2000	>100	>100
SURFACE WATER BODIES (Ponds, Rivers, Nala, Jores, HFL)				
1	Practically no impact. No loss of water.	<500	<3	<3
2	Marginal impact in some cases only. Some loss of water and water logging.	<1000	<5	<5
3	Severe impacts. Major loss of water. Severe water logging.	>1000	>5	>5
SUB-SURFACE WATER TABLE				
1.	Marginal depletion in water retaining capacity	<500	<3	<3
2.	Severe depletion in water retaining capacity	-	-	>5
AQUIFERS				

SN	Impact	Subsidence (mm)	Slope (mm/m)	Strain (mm/m)
1	**2**	**3**	**4**	**5**
1.	Depletion in water retaining capacity	-	-	>3
WATERLOGGING ON SURFACE				
1	Very little water-logging	<500	-	-
2	Some (300-500mm deep depending on surface topography)	500-1000	-	-
3	Marked waterlogging	>1000	-	-
ROADS				
1	Practically no impact	<500	<5	-
2	Depressions with gentle slope	-	5-10	-
3	Steeper slopes (speed restriction may be necessary)	-	20-50	-
4	Marginal repairs necessary	-	20-50	>10
5	Major repairs necessary	-	>50	>10
RAILWAY LINES-JOINTED CONSTRUCTION				
1	Practically no impact	-	<10	<3
2	Minor to severe impacts, repairs necessary due to bending twisting and breaking of rails and steeper gradients	-	>10	>3
RAILWAY LINES –WELDED CONSTRUCTION				
1	No subsidence permitted .Even very small strain can cause twisting and breaking of rails.			
RAILWAY SIDINGS (Jointed Constructed)				
1	Practically no impacts	-	<10	<3
2	Minor to severe impacts, repairs necessary	-	>10	>3
SINGLE STORIED HUTMENTS (KUCHCHA)				
1	Practically no impacts. A few fine cracks in plastered walls	-	<5	<3
2	Minor repairable impacts. Fine cracks. A few 10mm wide cracks.	-	<10	3 - 5
3	Major / severe impacts. Wide cracks, stepping, tilting.	-	>10	>5
SINGLE STORIED BUILDINGS				
1	Very little impacts. A few fine cracks or one / two 5 -10 mm wide cracks in plaster.	-	<5	<3
2	Minor impacts, repairable.5 -10mm wide cracks, door and window getting slight jamming, slight tilting.	-	5-10	3-5
3	Severe impacts, major repairs necessary. Wider cracks, stepping, crushing and marked tilting.	-	>10	>5

SN	Impact	Subsidence (mm)	Slope (mm/m)	Strain (mm/m)
1	**2**	**3**	**4**	**5**
UNDERGROUND PIPE LINES				
1	Practically no impact	-	-	<1.5
2	Severe impacts, major repairs necessary			>1.5
DOUBLE STORY BUILDINGS				
1	Very little impact. A few fine cracks or one/two 5-10mm wide cracks	-	<5	<3
2	Little repairable impact, 5-10mm wide cracks, slight displacement of walls against roof, doors and windows getting slightly jammed.	-	5-10	3-5
3	Severe impacts, major repair necessary. Wider cracks, stepping, crushing and tilting. Gaps between walls and roof.	-	>10	>5
MULTI-STORY BUILDINGS				
1	Little impacts, repairable 5-10mm wide cracks, doors and windows getting slight jamming, displacement of walls against roof.	-	<5	<3
2	Severe impacts. Winder cracks, crushing tilting, and stepping	-	>5	>3
LARGE BUILDINGS, MOVEMENTS, HISTORICAL BUILDINGS ETC.				
1	Very little impact. A few fine cracks or one/two 5-10mm wide cracks	-	<3	<1.5
2	Little impact, 5-10mm wide cracks, damage to decorations, slight displacement, doors and windows getting jammed.	-	3-5	1.5-3
3	Severe impacts. Wider cracks, tilting, crushing etc. Major repairs necessary.	-	>5	>3
AERIAL ROPEWAYS				
1	Practically no impact	-	<5	<3
2	Little repairable impacts	-	5-10	3-5
3	Severe impacts. Ropes may leave pullies due to change in alignment. Tilting of pylons. Buckling of structure.	-	>10	>5
HIGH TENSION PYLONS				
1	Practically no impact	-	<5	<3
2	Severe impacts. Tilting, buckling and may be collapse of pylons.	-	>5	>3
UNDERGROUND CABLES				
1	Practically no impact	-	-	<1.5
2	Severe impacts. Breaking of piles.	-	-	>1.5

SN	Impact	Subsidence (mm)	Slope (mm/m)	Strain (mm/m)
1	2	3	4	5
OVERLYING VIRGIN SEAMS				
1	Practically no impact. No visible signs of subsidence when the seams are developed.	-	<5	<3
2	A little impact. A little crushing of coal, roof and floor rock. Fire risk when development is done in upper seam.	-	5-10	3-5
3	Severe impacts. Crushing of coal, roof and floor rock. Stepping in tensile strain zone. Fire risk. Heaving, supports necessary during development.	-	10-20	5-10
4	Very severe impacts. Severe crushing, large stepping, entry into subsided area rather difficult. High fire risk. Arching necessary.	-	>20	>10
OVERLYING WORKINGS (Standing on developed pillars)				
1	Practically no impact on galleries and pillars. Some spalling.	-	<5	<3
2	Visible floor lifting, side spalling and roof falls. Supports required. Fire risk.	-	-	3-5
3	Marked floor lifting, side spalling and roof falls. High fire risks. Workings unsafe.	-	-	5-10
4	Severe floor lifting, large roof falls, wide spread side spalling, stepping, very high fire risk, workings unsafe.	-	-	>10
OVERLYING WORKINGS (Standing on reduced pillars)				
1	Practically no impact.	-	<3	<1.5
2	Marginal impact on stability of stooks. The stooks with marginal factor of safety may collapse, increasing loading on adjoining stooks.-	-	<5	<5
3	Failure of a few stooks may lead to chain of failures causing partial or total collapse of area. Thus causing additional subsidence on overlying horizons.	-	>5	>3
OVERLYING WORKINGS (Packed or stowed)				
1	Practically no impact on stowed workings. Some loss of water.	-	-	<5
2	Complete loss of water from stowed areas and also from adjoining rise	-	-	>5

SN	Impact	Subsidence (mm)	Slope (mm/m)	Strain (mm/m)
1	2	3	4	5
	side areas.			
WATERLOGGED OVERLYING WORKINGS (Standing on developed pillars)				
1	Practically no impact on pillars, galleries and water retaining capacity of the workings.	-	-	<3
2	Marginal loss of water through fine cracks in strata around. Dewatered areas may have risk of fires, roof falls, side spalling, floor lifting.	-	-	<5
3	Major loss of water. High fire risk in dewatered areas with roof falls, side spalling, floor lifting etc.	-	-	5-10
4	Total loss of water. Very high fire risk with severe floor lifting, roof falls and spalling.	-	-	>10
WATERLOGGED OVERLYING WORKINGS (Standing on reduced pillars / stooks)				
1	Stooks may collapse causing additional subsidence on surface	-	-	<3
2	Partial loss of water. Collapse of stooks. Additional surface subsidence. Fire risk.	-	-	3-5
3	Total loss of water. Collapse of workings. Additional surface subsidence; fire risk.	-	-	>5
IN CURRENT WORKINGS FROM SUBSIDENCE AT THE LEVEL OF SURFACE				
1	Practically no impact.	-	-	<5
2	Leakage of air. Fire in goaves at shallow depth	-	-	>5
IN CURRENT WORKINGS FROM SUBSIDENCE AT THE LEVEL OF OVERLYING WATER BODIES				
1	Practically no impact	-	-	<3
2	Marginal increase in make of water	-	-	3-5
3	Appreciable increase in make of water	-	-	5-10
4	Heavy increase in make of water, which may lead to inundation	-	-	>10
SURFACE ATMOSPHERE				
1	Practically no impact	-	-	<5
2	Some air from underground workings at shallow depth may leak to surface	-	-	5-10
3	Air leakage from shallow depth workings. If the workings have fire, surface atmosphere is likely to be polluted by gases coming from the fire/	-	-	>10

SN	Impact	Subsidence (mm)	Slope (mm/m)	Strain (mm/m)
1	**2**	**3**	**4**	**5**
SUB-SOIL				
1	Practically no impact.	-	-	<3
2	Very little impact in the form of reduction of water retaining capacity.	-	-	3-5
3	Temporary loss in water retaining capacity. Cracks filling may improve water retaining capacity.	-	-	5-10
4	Long term loss of water retaining capacity. Suitable protective measures necessary.	-	-	>10
AGRICULTURE				
1	Practically no impact	-	-	<5
2	Marginal impact i.e. reduction in yield due to loss in water retaining capacity of sub-soil.	-	-	5-10
3	Major impact i.e. sizeable reduction in yield.	-	-	>10
FOREST AND PLANTATION				
1	Practically no impact.	-	<10	<5
2	Temporary loss in water retaining capacity of top-soil may affect under growth slightly. Slight tilting of plants/ trees.	-	10-20	5-10
3	Short term impact on trees in zones having cracks. The cracks may get filled in due course. Tilting of trees.	-	20-50	10-20
4	Wide cracks may severely affect undergrowth but may not have much impact on large trees except those in the tensile strain zone where wide cracks develop; high tilting may cause some trees to fall in the high slope zone.	-	>50	>20