MP BIRLA GROUP

RCCPL Private Limited
(formerly Reliance Cement Company Private Limited)
Registered Office:
Industry House, 2nd Floor,
159, Churchgate Reclamation
Mumbai - 400 020, India
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Ref No: RCCPL/ Bigodi_MP/MoEF&CC/02
Date: 29th July, 2019

To,

The Member Secretary,
Expert Appraisal Committee (Non-Coal Mining)
Ministry of Environment, Forest & Climate Change
3rd Floor, Vayu Wing, Indira Paryavaran Bhavan
Jorbagh Road, Aliganj, New Delhi-110003

Dear Sir,

Sub: Bigodi limestone mine of RCCPL Private Ltd. with proposed production capacity of 0.85 Million Tonnes Per Annum (MTPA) Limestone/ 3.03 Million Tonnes Per Annum (MTPA) Total Excavation, over an ML area of 184.149 Ha. located at Dithora, Sannehi Singti and Karaundi villages, Tehsil Amarpatan, District: Satna, Madhya Pradesh

Sir,

With reference to the captioned subject and reference, additional details have been sought vide Minutes for 4th EAC Meeting held during April 23-24, 2019. In this regard, we are herewith submitting / uploading point wise response / clarifications with corresponding enclosures for ADS.

Sr.No	ADS Sought	Reply
3(I)	The total mine lease area is 184.149 ha out of which 14.409 ha is Government land and 169.740 ha is private agriculture land. Hence, the committee is of the view that PP needs to submit the regional crop patterns including area getting affected by the project.	The regional crop patterns including area getting affected by the project is enclosed as Annexure-1.
3(II)	A village road is passing through the Lease area, therefore, PP need to show protection measurement and/or alternative road for diversion from existing village road passing through the mining Lease area.	The protection measures for the village road has been addressed and described in Annexure-2. Alternative road for the existing village road has been shown in the Conceptual Plan.

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3 (III)	A High tension power line is passing through the mining lease area, and information on proposed necessary measures in this regard to be submitted.	Necessary measures for protection from HT line are given in Annexure - 3.
3 (IV)	Hydro geological study to assessment the impact on ground water and its percolation effects on adjacent area.	Hydrogeological study is attached as Annexure – 4.
3 (V)	PP needs to submit R&R plan for Project Affected Areas.	Rehabilitation and Resettlement study is on process. Brief write up is given in Annexure – 5
3 (VI)	A proper conceptual plan for proposed mining with reclamation plan and also measures for protection the river, Nallah in the vicinity of the mine lease area.	Conceptual plan is attached as Annexure – 6. A note on protection measures for river/ nalla in the vicinity of the mine lease area is given in Annexure – 7.
3 (VII)	Top soil management plan	Top soil management plan is referred as Annexure – 8.

We request your good self to kindly consider the documents / information asked by you with regard to ADS. Kindly consider our proposal for grant of Terms of Reference (TOR).

Thanking you,

Yours sincerely,
For RCCPL Private Limited

Dr. Ashok Kumar Singh
Authorised Signatory

Annexure – 1

REGIONAL CROP PATTERN INCLUDING AREA GETTING AFFECTED BY BIGODI LIMESTONE MINE

Cropping pattern data for the year 2018 – 19 pertaining to Bigodi ML area, Amarpatan Tehsil and Satna District were obtained through Village Revenue Officer from the Madhya Pradesh Govt web site named : http://164.100.196.130/girdavari_live/web/

Cropping data of ML area, Amarpatan Tehsil and Satna district are given as Table – 1, Table – 2 and Table – 3. The same are summarised as under:

Area	**Cropping Area (Ha.)**	
	Rabi	**Kharif**
Inside Mine Lease	**151**	**134**
Amarpatan Tehsil	**36,772**	**31,218**
Satna District	**3,30,102**	**2,98,261**

From the above table, it is evident that total area under Rabi and Kharif crops within ML is only 0.42% of total crop area of Amarpatan Tehsil and 0.045% of total crop area of Satna District.

Thus, diversion of agriculture land in Bigodi ML will not have any significant impact on cropping area on regional scale.

ML Area Breakup

Sr.No.	Land Use	Area (Ha)
1	Govt. Land	14.409
2	Private Land	169.740
a	Double crop land	134.111
b	Single crop land	16.428
Total ML Area (Sr.no 1+ Sr.no. 2)		184.149
Remaining lands are non-cultivated / non-agricultural.		

Table – 1: Cropping Data within ML Area (184.149 Ha)

Crop Pattern		Name of villages			Total area Crop wise (in ha)
		Sannehi Singti	Karaundi	Dithora	
Rabi	Wheat	25.418	18.573	95.983	139.974
	Jao	0.000	0.012	0.023	0.035
	Chana	1.972	1.183	4.918	8.073
	Masur	0.319	0.326	0.407	1.052
	Aalu	0.000	0.037	0.079	0.116
	Tomato	0.000	0.010	0.017	0.027
	Sarso	0.000	0.013	0.000	0.013
	Onion	0.000	0.000	1.024	1.024
	Masala	0.225	0.000	0.000	0.225
	Sub Total	**27.934**	**20.154**	**102.451**	**150.539**
Kharif	Urad	0.000	2.494	5.903	8.397
	Mung	0.000	0.265	0.996	1.261
	Toor	0.000	0.283	0.000	0.283
	Dhan	25.595	13.732	84.701	124.028
	Soyabean	0.000	0.097	0.000	0.097
	Tilli	0.000	0.045	0.000	0.045
	Sub Total	**25.595**	**16.916**	**91.600**	**134.111**

Table – 2: Cropping Data of Amarpatan Tehsil

Rabi Crops	
Type of Crop	**Area (In Ha)**
Wheat	26949.006
Jao	228.034
Makka	0.952
Jwar	0.164
Chana	6361.502
Masoor	1514.989
Tuwar	691.025
Matar	66.320
Batra	40.245
Urad	7.924
Other pulses	3.594
Barbati	2.746
Vegetables	442.262
Sugarcane	224.312
Other Oil bearing seeds	183.449
Spices	42.419
Medicinal	9.393
Flowers	2.957
Commercial	1.000
Total (ha)	**36,772.293**

Kharif Crops	
Type of Crop	**Area (In Ha)**
Dhan	22963.290
Kodo/Kutki	21.917
Makka	14.192
Jwar	10.117
Urad	4837.696
Tuwar	1484.709
Moong	422.010
Barbati	11.157
Soyabean	774.007
Tilli	250.897
Other Oil bearing seeds	1.333
Sugarcane	209.074
Vegetables	125.529
Fruits	69.441
Spices	13.260
Medicinal	8.873
Flowers	0.681
Total	**31,218.183**

Table – 3: Cropping Data of Satna District

Rabi Crops	
Type of Crop	**Area (In Ha)**
Wheat	244838.615
Jao	2615.315
Other crops	29.254
Chana	55851.622
Masoor	12310.140
Matar	902.911
Batra	543.942
Rae	6093.526
Alsi	446.043
Tili	17.645
Vegetables	5855.319
Fruits	352.935
Spices	180.451
Flowers	53.106
Paan	10.781
Total Area (ha)	**3,30,101.605**

Kharif Crops	
Type of Crop	**Area (In Ha)**
Dhan	174905.071
Jwar	1701.128
Makka	414.002
Other crops	86.860
Kodo/Kutki	57.244
Bajra	16.975
Urad	79323.846
Tuwar	11715.810
Moong	5254.531
Barbati	40.265
Soyabean	14906.325
Tilli	7728.960
Other oil bearing seeds	22.362
Vegetables	1481.082
Fruits	275.430
Sugarcane	232.882
Spices	66.772
Flowers	31.319
Total Area (ha)	**2,98,260.864**

Annexure - 2

Protection Measures of Village Roads

- A portion of road from Sannehi Bara Tola Village to Sannehi Singti village is proposed to be diverted. About 400 m road length is proposed to be diverted to the adjacent non-mining area. Length of diverted road will be 512 m.
- Other portion of road from Sannehi Singti to Dithoura village is proposed to be diverted. About 623 m of road length is proposed to be diverted in the back filled area after mining. Length of diverted road will be 753 m.
- Diverted road will be constructed after maintaining proper gradient and providing tar on the surface.
- Thick plantation is proposed on the both sides of road to act as a barrier, which would cover around 6.816 ha and around 17040 no of trees would be planted in the road barrier.
- Existing and proposed diverted roads are shown in Conceptual Plan enclosed as **Annexure – 6.**
- In the mining operation, wet drilling system, water sprinkling on haul roads, dust collector and water spraying arrangements at crusher plant, regular maintenance of mining machinery etc. will be practised to minimize air pollution.
- Regular maintenance of mining machinery and controlled blasting technique will be practised to minimize noise and vibration pollution.

Annexure - 3

Protection Measures of High Tension Electric Line

- A 400 KVA HT line passes through the lease area in E-W direction.
- Length of the HT line inside lease area is 1930 m. Width of towers is 12 m.
- Mining will be carried out after leaving safety barrier of 50 m on both the sides of power line.
- Thick plantation will be done in the safety barrier @ 2500 trees per ha. Total number of trees will be around 47,100.

1.0 INTRODUCTION

1.1. Background

RCCPL Private Limited manufactures and sells cement. RCCPL Pvt. Ltd., was formerly known as Reliance Cement Company Private Limited and changed its name to RCCPL Pvt. Ltd. in August, 2018. The company was founded in 2007 and is based in Mumbai, India. As of August 22, 2016, RCCPL Pvt. Ltd. operates as a subsidiary of Birla Corporation Limited.

RCCPL has an operating cement plant of 5 Million Tonne Per Annum (MTPA) (3.6 MTPA Clinker) capacity at villages Bharauli and Itehara, Maihar tehsil, Satna district, Madhya Pradesh (MP). Annual limestone requirement for 3.6 MTPA clinker plant is to the tune of 5.4 million tonne. Limestone requirement for 50 years of economic plant of life is 270 million ton, whereas limestone resources in existing mine leases are to the tune of 160 million tons which is grossly inadequate to operate cement plant till its economic life.

1.2 Project

To meet limestone requirement of cement plant, RCCPL Pvt. Ltd. has applied for mining leases in various parts of Satna district of MP. The RCCPL Pvt. Ltd. obtained Letter of Intent (LoI) for ML area in villages Sannehi Singti, Dithoura and Karaundi (184.149 ha) of Amarpatan tehsil, Satna district from Department of Mineral Resources, Government of Madhya Pradesh vide letter no: F 3-1/2018/12/1 dated 23.03.2018. Limestone which will be mined from this area will be used as captive source for cement plant of RCCPL Pvt. Ltd. in Maihar. It is proposed to produce 0.85 MTPA of limestone by opencast mechanized method of mining and the life of mine will be 41 years up to a maximum working depth of 65.0 m to 70.0 m.

M/s Vimta Labs Limited, Hyderabad has assigned Mr. J Rajendra Prasad, Empanelled Expert, Hyderabad carrying out geological and hydrogeological studies in 10 km radius area of ML area indicating the impact of the project on the water regime along with rain water harvesting and artificial recharge strategies.

1.3 Location, Extent and Communication

The ML area is situated in Dithora, Sannehi Singti and Karaundi villages, Amarpatan tehsil, Satna district of Madhya Pradesh spread over an area of 184.149 ha. Of the total ML area, 14.409 ha is government land which is waste and grazing land and 169.740 ha is private agriculture land.

The ML area lies between latitudes 24°23'59.59"N to 24°24'46.30"N and longitudes 81°10'34.46"E to 81°12'06.24"E. The area is covered by Survey of India toposheet no G44V3 (64H/3) on the scale 1:50000.

Geographically, the 10 km study area lies between 24°17'46.98"N to 24°30'16.05"N latitudes and 81°03'46.94"E to 81°18'01.17"E longitudes and is covered by Survey of India toposheet nos G44V2 (64H/2), G44V3 (64H/3) and G44V7 (64H/7) on the scale 1:50000. The study area encompasses the geographical area of parts of Amarpatan block of Satna district and Huzur block of Rewa district of Madhya Pradesh.

Nearest town of the ML area is Rewa and distance from Dithora village to Rewa is 30 km (by road). Amarpatan is the tehsil headquarter and the distance from the ML area is 35 km. Satna, district headquarter is 52 km away. The ML area is approachable by NJ-39 and Katra road from Rewa and NH-39/SH-13 from Satna. The nearest railway station and airport are Rewa and Khajuraho at a distance of 30 km and 174 km respectively.

Location map of the study area is shown in **Figure-1** and the study area is presented in **Figure-2**.

1.4 Water Source and Requirement

Water requirement of the project is 183 KLD (183 m^3/day – 54,900 m^3/300 working days in a year – 0.055 MCM/300 working days in a year) for dust suppression, washing of mining machinery, plantation and domestic purposes, initially up to 5^{th} year from ground water. Of the total water requirement, domestic water requirement at the mine site for mine office, mine workers etc., is 5 KLD (5 m^3/day) which will be met from bore well till the end of mining period. Break-up of water consumption is given in **Table-1**.

Table-1. Bigodi Mining Project Water Requirement

Purpose	Water requirement KLD	Source
Dust suppression at mine	128	Initially from groundwater and subsequently from mine pit water
Dust suppression at crusher	10	
Green belt	30	
Domestic	5	
Workshop	10	
Total	**183**	

	
24°24'14.62"N, 81°10'50.14"E	24°24'36.58"N, 81°11'54.96"E

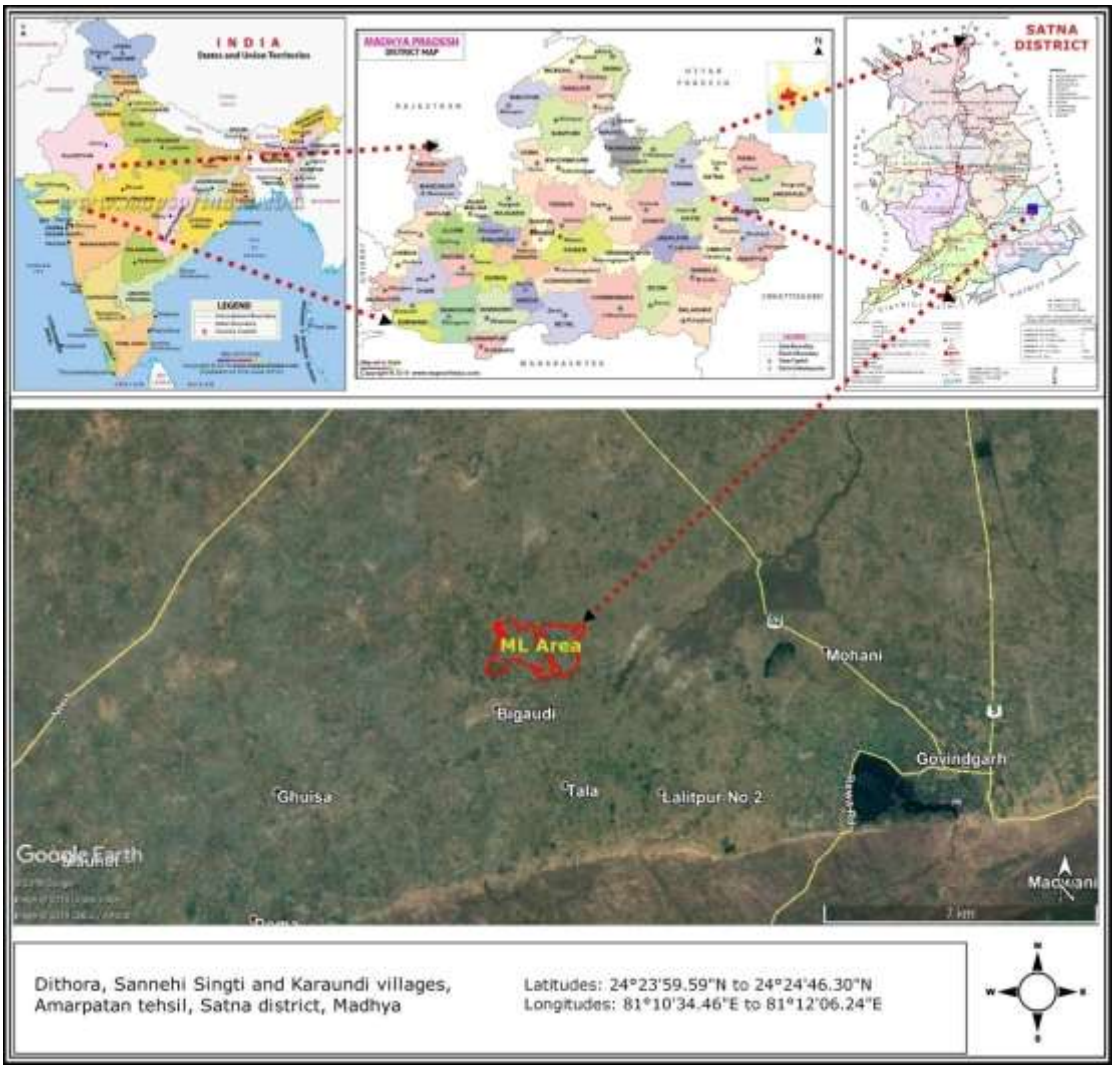


Figure-1. Location Map of Bigodi ML Area

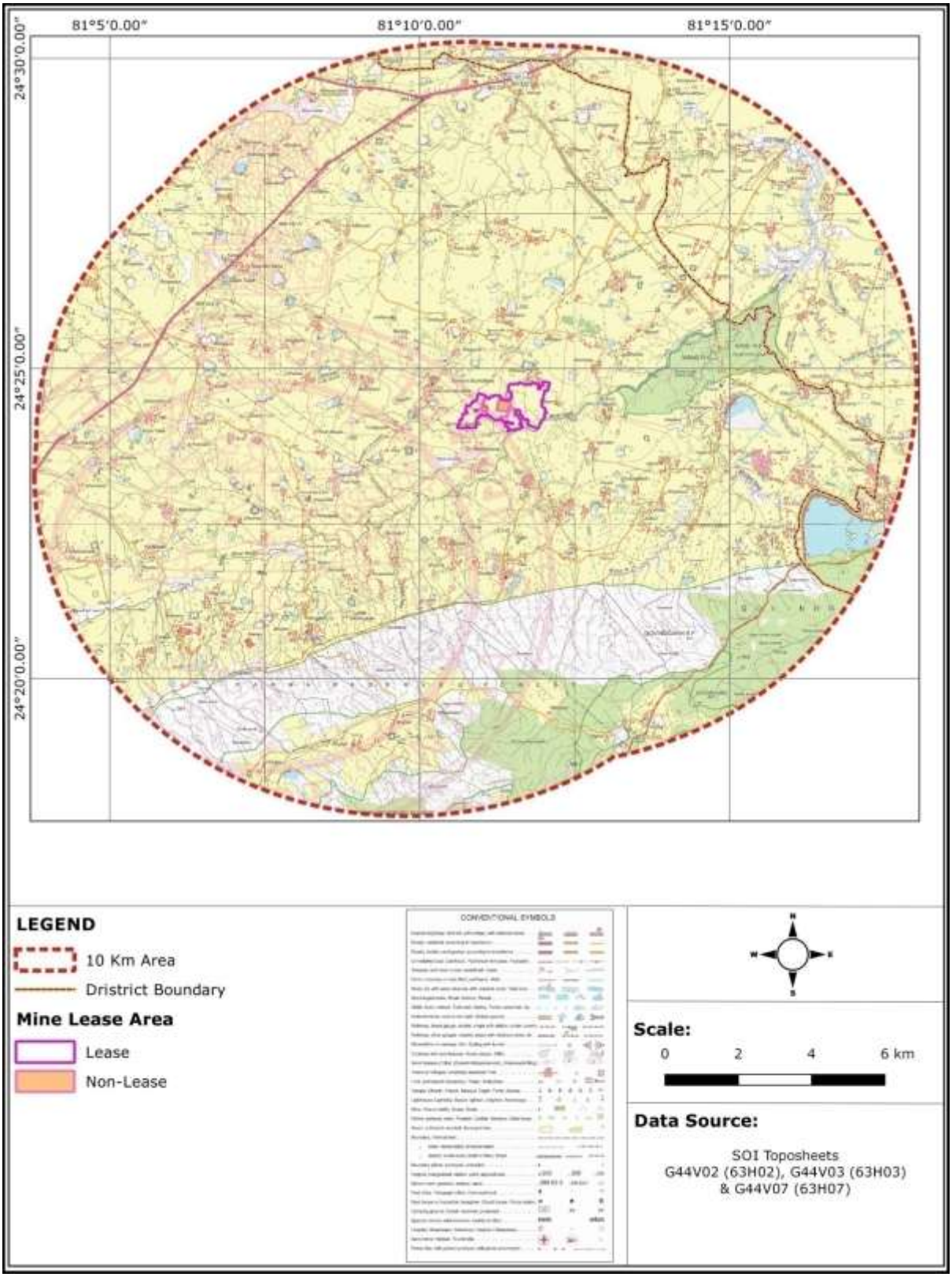


Figure-2. Study Area – 10 km Radius Area of the Project

2.0 HYDROLOGY

2.1 Climate

The study area falls in Vindhyan Scarpland and Beghelkhand Plateau, which is hot dry sub-humid Ecological Sub Region (I6Cd5) with deep loamy to clayey mixed red and black soils, medium to high Available Water Capacity (AWC) and Length of Growing Period (LGP) 150-180 days.

The climate of the region is characterized by a hot summer with general dryness, except during the S-W monsoon season. The year may be divided into four seasons. The cold season from December to February is followed by the hot season from March to about middle of June. The period from the middle of June to September is the S-W monsoon season. October and November form the post monsoon or transition period. Meteorological data of IMD, Satna at a distance of 52 km from project site is presented in **Table-2** and graphical presentation is made in **Figure-3**.

The normal maximum temperature is 41.7°C observed during May and the normal minimum temperature is 9.1°C observed during January. The annual mean temperature is 25.7°C. Minimum and maximum extreme temperatures recorded were 0.4°C on 27.12.1961 and 47.8°C on 02.06.1954 respectively.

The average annual rainfall based on 30 year IMD data (1971-2000) of Satna is 1142.0 mm received on an average of 54.5 rainy days. About 88.87% of the rainfall is received during S-W monsoon (June-September). The highest total monthly rainfall, 351.5 mm occurs in August contributing 30.78% of the total rainfall. The heaviest rainfall in 24 hours was 299.7 mm recorded on 09.08.1919.

A review of rainfall pattern during last 5 years (2013-2017) based on IMD, Satna data reveals that the rainfall in the area is highly erratic. The annual rainfall ranges from 743.2 mm during 2017 to 1351.2 mm during 2013. About 87.62% of the rainfall is contributed by SW monsoon where as the NE monsoon between October and December contributes 6.14% of the annual rainfall. Rainfall pattern during last 5 years for Satna district from IMD is presented in **Table-3** and **Figure-4**.

During the SW monsoon season, the relative humidity generally reaches 86% (August month). The rest of the year is drier. The driest part of the year is the summer season, when relative humidity is less than 20%. April is the driest month of the year.

The maximum atmospheric pressure observed is 981.5 mb at 08.30 hours during December and minimum pressure is 960.9 mb at 17.30 hours during June. It can be seen from the data that not much variations are observed in the average atmospheric pressure levels and fairly consistent over the region.

Table-2. Meteorological Data, IMD, Satna (1971-2000)

Month	Atmospheric Pressure (mb)		Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	08:30	17:30	Mean Max.	Mean Min.	08:30	17:30		
January	980.6	977.6	24.0	9.1	73	46	22.5	1.8
February	978.8	975.5	26.8	11.6	65	37	23.6	1.8
March	976.3	972.4	32.9	16.4	47	25	11.1	1.1
April	972.2	968.0	38.8	22.2	32	17	6.6	0.9
May	968.4	964.3	41.7	26.6	34	20	12.8	1.2
June	964.5	960.9	39.1	27.7	56	44	135.6	6.6
July	964.5	961.6	32.7	25.5	80	72	329.7	14
August	965.8	963.1	31.2	24.9				14.6
September	970.2	967.1	31.7	24.1	81	71	198.1	9
October	975.8	972.5	32.4	20.1	69	50	32.3	2.2
November	979.5	976.3	29.2	14.0	64	44	9.8	0.6
December			25.4	9.4	72	47	8.4	0.7
Range/ Total	960.9-981.5		9.1-41.7		17-86		1142.0	54.5

Figure-3. Climate Graph – Satna

Table-3. Rainfall Pattern During Last 5 Years, IMD, Satna (2013-2017)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Total	Departure
2013	0.0	45.9	11.5	4.2	0.0	284.2	338.6	451.6	71.5	143.7	0.0	0.0	**1351.2**	23.72
2014	22.7	35.7	6.8	1.6	0.5	37.6	248.4	125.9	201.6	109.9	0.0	14.7	**805.4**	-26.25
2015	89.3	4.5	6.8	13.5	22.5	115.9	301.6	286.0	120.1	48.7	4.9	0.0	**1013.8**	-7.17
2016	37.4	0.0	16.3	0.0	20.8	31.0	811.5	681.3	86.1	19.2	0.0	0.0	**1703.6**	55.99
2017	2.4	3.2	3.2	0.0	1.5	102.8	422.6	132.6	71.0	3.9	0.0	0.0	**743.2**	-31.95
Average	**30.36**	**17.86**	**8.92**	**3.86**	**9.06**	**114.3**	**424.54**	**335.48**	**110.06**	**65.08**	**0.98**	**2.94**	**1123.44**	**2.87**

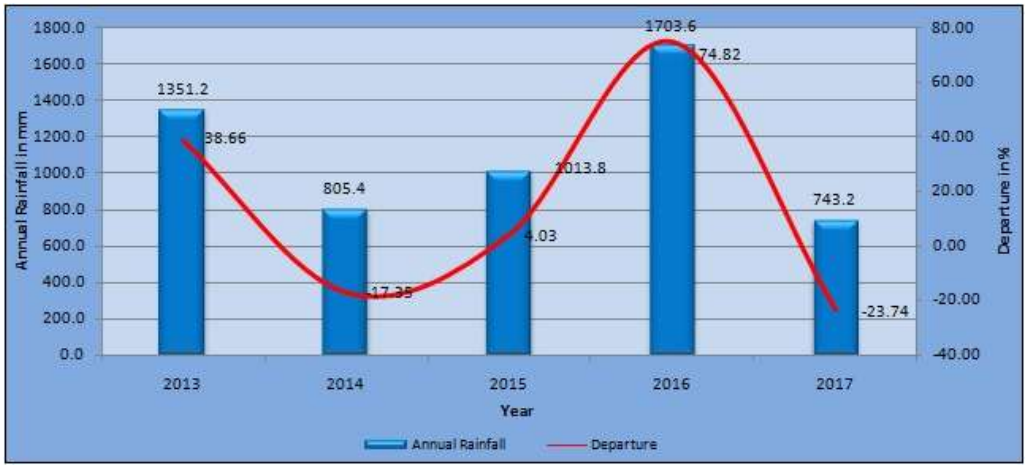


Figure-4. Rainfall Pattern – IMD, Satna (2013-2017)

2.2 Physiography and Drainage

Almost entire Satna district lies on the Vindhyan plateau, which extends from the Kaimur hill range in the south to the edge of the Ganga valley in the north. Fringes of Kaimur hill range run NE-SW in the southern part of the study area with elevations ranging from 340 m above mean sea level (amsl) in the foot hills to 660 m amsl in Papra RF in the south. Elevations in the rest of the study area range from 300 m amsl in the northeast along Bihar Nadi to 360 m amsl in the west. The general slope in the study area is towards NE following Bihar Nadi.

Papra RF and Govindgarh RF running NE-SW on Kaimur hill range in the southern part and Mand RF in the east-central part of the study area are major forest covers in the study area.

According to River Basin Atlas of India, Ministry of Water Resources, the study area forms part of C2ATON06 to 09 watersheds in Tons Sub-basin of Ganga River Basin. The Tons/Tamasa River is a tributary of the Ganga River flowing through Madhya Pradesh and Uttar Pradesh. The Tons rises in a tank at Tamakund in the Kaimur Range at an elevation of 610 m. It flows through the fertile districts of Satna and Rewa. At the edge of the Purwa plateau, the Tons and its tributaries form a number of waterfalls. Satna River, Simrawal Nala, Bihar Nadi, Mahanadi River, Bichia Nadi, Naina Nadi and Adh Nadi are its tributaries.

Major part of the study area is drained by the drainage network of Bihar Nadi drainage flowing out from NE of the study area. The drainage network in the west to north of the study area is controlled by Nar Nadi joining Tons River before Tons Reservoir (20 km NNW of

study area), Karari Nadi joining Tons River after Tons Reservoir and Bihar Nadi respectively. The drainage network presents an ideal dendritic pattern having a drainage density of 1.78 km/sq km. There are a number of small to medium water bodies spread over the entire study area. Mukundpur Tank and Govindgarh Tank located in the east-central and ESE respectively are major water bodies in the study area.

A main and secondary canal network from Bansagar Reservoir runs in the eastern part of the study area. Physiography and drainage network of the study area is presented in **Figure-5**.

As per ML area surface plan, elevation in the ML area ranges from 312 m amsl in the south to 320 m amsl in the north. The general slope in the ML area is towards south. As per the Survey of India toposheet, there are two first order nallahs – one running from the east-central part to southeast and the other running across from north to SSE and one second order stream running across the ML area from NW to SE in the western part in the ML area. These nallahs are not well developed stream courses, discontinuous due to agricultural activity, seasonal and carrying mainly sheet flow from the agricultural fields downstream joining Bihar Nadi.

Nallah South of ML Area
24°23'57.02"N, 81°10'59.84"E

Govindgarh Tank
24°22'41.01"N, 81°16'57.94"E

Canal near Govindgarh
24°24'22.23"N, 81°15'59.19"E

Water Body near Semara
24°25'33.65"N, 81°11'13.13"E

Bihar Nadi
24°23'21.05"N, 81°11'12.23"E

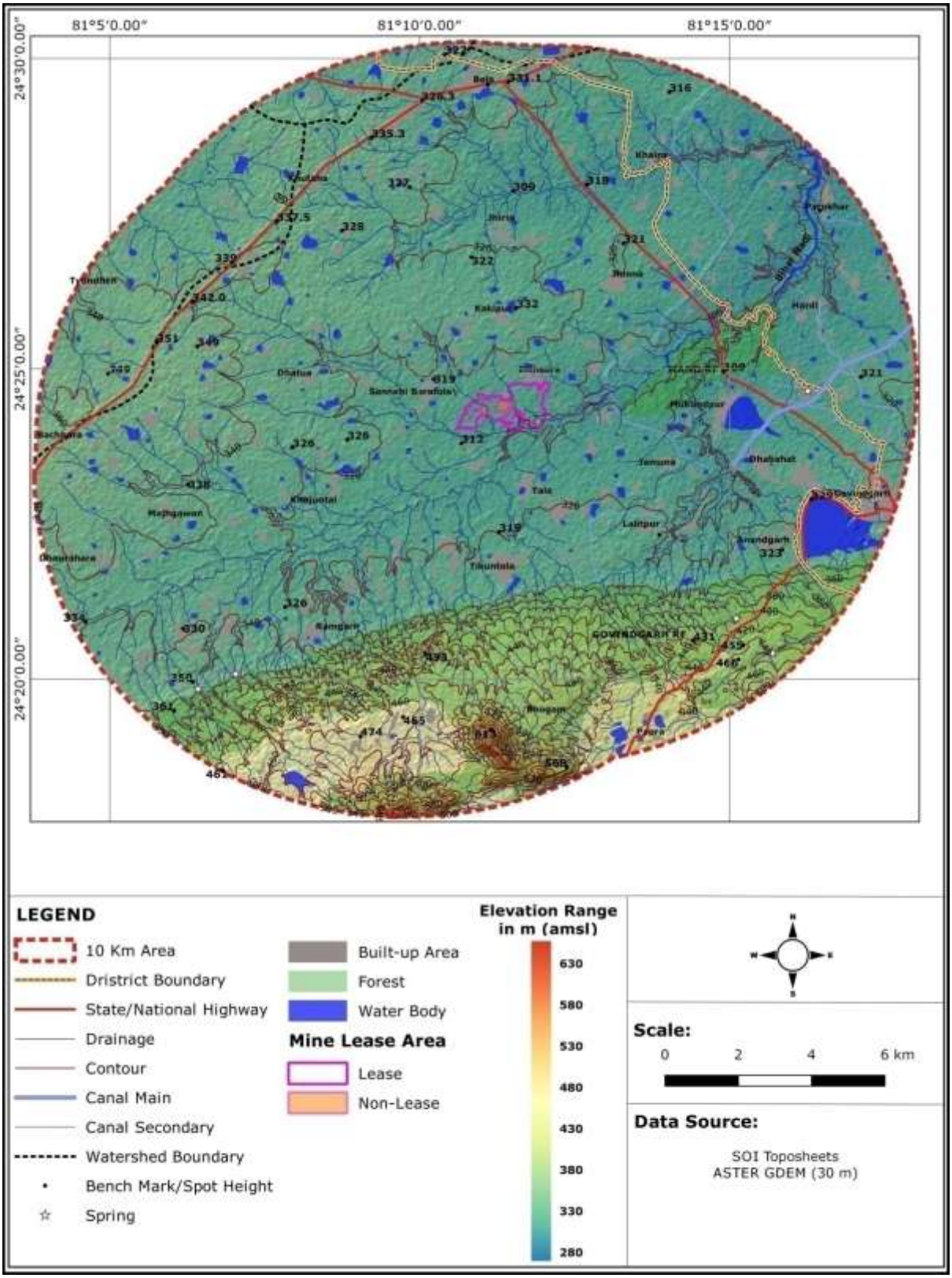


Figure-5. Physiography and Drainage Map of the Study Area

3.0 GEOLOGY

3.1 Geomorphology

Geomorphological features on earth surface craft by various geomorphic processes such as erosional, depositional, tectonic etc. Geomorphological characteristics of the region facilitate important hydrologic processes like surface run-off and infiltration. Geomorphology map of the study area has been prepared based on Geomorphology Theme (2005-06), Bhuvan, National Remote Sensing Center (NRSC) with landforms classified at Level-2 and is presented in **Figure-6**.

Geomorphologically, the study area can be divided into:

- Denudational origin
  - Pediment-Pediplain complex
- Structural origin
  - Moderately dissected hills and valleys

Pediment occurs as gently sloping rocky surface covered intermittently with weathered debris, residual gravel, wind-blown and sheet wash sand/silt deposits of variable thickness (Twidale, 1978). Pediplain is an extensive plain formed by the coalescence of pediments. Fringes of Kaimur hill range run NE-SW in the southern part of the study area with elevations ranging from 340 m above mean sea level (amsl) in the foot hills to 660 m amsl in Papra RF in the south. Rest of the study area covering major part is identified as Pediment-Pediplain complex.

3.2 Regional Geology

The rocks in the region range in age from Archaean to Cainozoic. The Archaean rock comprises of granites and gneisses and is exposed only in the northern part of the district. The rocks of Vindhyan Supergroup comprises of Semri, Kaimur, Rewa and Bhander Groups. The Semri Group of rocks are represented by an alternating sequence of sandstone and shale along with pocellanite and limestone. The Semri Group of rocks are mainly exposed in the southern and northern part of the district. The Rohtas limestone is light to dark grey in colour, fine grained compact and well bedded. The Kaimur Group comprising mainly sandstone which is fine grained, massive and thickly bedded is exposed in the northern and southern parts. The Rewa Group of rocks comprises mainly of sandstone, shale and conglomerate. The Bhander Group of rocks exposed as broad band and comprises mainly shale, Nagod limestone and Upper Bhander sandstone. The Nagod limestone is fine grained, hard, compact, thinly bedded to massive with some stomatolitic bands. The Upper Bhander sandstone forms the cliff of the Bhander plateau and is composed of purple to reddish brown, fine to medium grained, flaggy to massive and well sorted sandstone inter-bedded with splintery shale and siltstone. Lameta Formation comprising sandstone and shale range in thickness from 15-80 m and occurs as clusters on the hillocks of Upper Rewa sandstone. Laterite occurs as capping on the Bhander Group of rocks and on the Upper Rewa sandstone. It has a maximum thickness of 60 m.

The district has a large potential of limestone, bauxite, cohre and building and construction material. Limestone bands occur in Rohtas and Nagod limestone. The Nagod limestone is extensively quarried for the manufacture of lime and cement and also for use as flux in the steel industry. A preliminary assessment indicates a possible reserve of 1865 million tonnes of cement and flux grade limestone.

The regional stratigraphic succession based on Geological Survey of India (GSI) publication, 1997 is given in **Table-4**.

3.3 Geology of the Study Area

Of the total study area of 438.06 sq km, Sirbu shale, Nagod limestone and Simrawal/Gunargarh shale belonging to Bhander Group are the major geological formations occupying 345.15 sq km (170.61 sq km, 79.62 sq km and 94 92 sq km respectively). Rest of the area in the southern part is with Upper Rewa sandstone and Jhiri shale with conglomerate of Rewa Group covering 92.90 sq km (91.87 sq km and 1.03 sq km respectivley). The lighological boundaries in the study area trends NW-SW. Geology of the study area based on Geological Survey of India (GSI) publication, 2002 is presented in **Figure-7**.

The study area does not show any major tectonic evidences except few geomorphic lineaments parallel to drainage courses mainly in the Bhander Group formations covered by pediplain. Joints and fractures of structural origin are noticed in the Kaimur hill rangetrending NE-SW in the southern part. Lineaments mapped based on Geomorphology and Lineament Theme, Bhuvan, National Remote Sensing Center (NRSC) are shown in **Figure-7**.

3.4 Geology of the ML Area

The rocks exposed in the area under consideration apparently belong to the Nagod limestone of Bhander Group. In Bigodi ML area, the rocks include a conformable package of limestone, siliceous and high magnesian limestone as waste and shale. The rocks in the area trend NE-SW to ENE-WSW with significant plunging of strike towards SW direction. These sedimentary beds have sb-horizontal to very low dip ranging from 5° to 7° due NW. The full sequence of litho-stratigraphic succession is not exposed anywhere within the mining lease area but could be delineated in the bore hole sections. On the basis of drill hole data and the geological knowledge acquired through repeated regional traverses, the following tentative litho-stratigraphic succession has been worked out for the entire area:

Age	Group	Formation	Member
Recent to Sub-Recent			Lateritic soil
Proterozoic	Upper Vindhyan	Bhander Group	Sirbu shale
			Nagod limestone
			Ganurgarh limestone
		Rewa Group	Upper Rewa sandstone

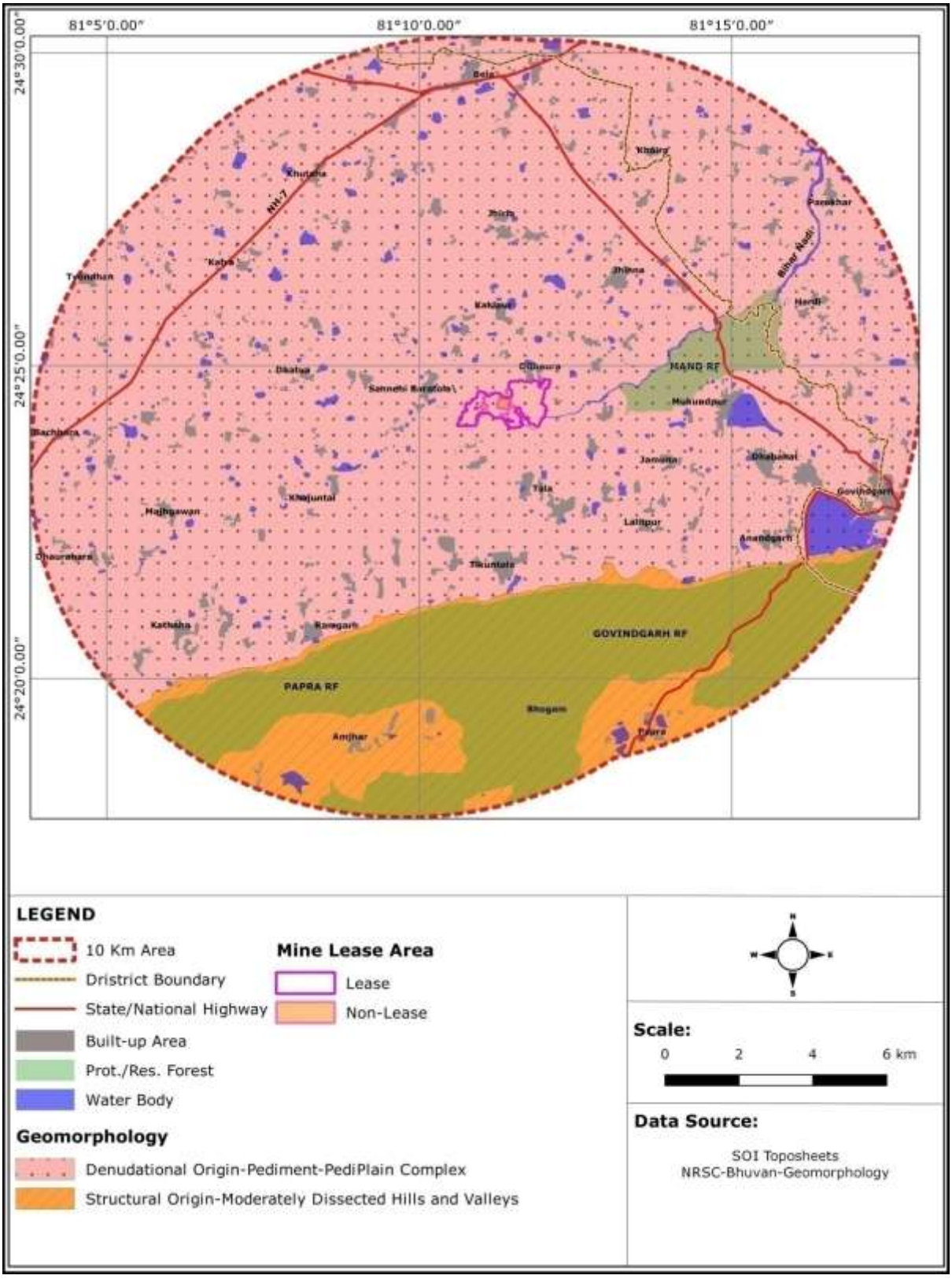


Figure-6. Geomorphology of the Study Area

Table-4. Regional Stratigraphic Succession

Lithology	Stratigraphic Status		Age	Nature and Characteristics
Laterite			Cainozoic	Reddish brown, hard and massive rock
Sandstone, shale with pockets of clay	Lameta Group		Cretaceous	Soft to medium, hard sedimentary rock
Upper Bhander sandstone with inerbeds of shale and siltstone	Bhander Group	Vindhyan Super Group	Neo-Proterozoic (Late)	Purple to reddish brown, fine to medium grained and flaggy to massive sandstone
Sibu shale/limestone within shale				Purple and olive green, thinly laminated silty shale with interbeds of bluish grey limes
Nagod limestone/shale				Fine grained, hard and compact, thinly bedded to massive with few stromatolite bands of calcite, gypsum and with interbeds of purrplish grey limestone
Simrawal/Ganurgarh shale/limestone				Soft, purple and reddish brown, thinly laminated to flaggy, calcareous with thin bands of cacite, gypsum and with interbeds of purplish grey limestone
Upper Rewa sandstone with conglomerate at top	Rewa Group		Neo-Proterozoic (Early)	Reddish brown, hard and massive, coarse grained, thick bedded sandstone with conglomerate at top
Jhiri shale with congolomerate at base				Soft, reddish, splintery with interbeds of siltstone and thin bands of conglomerate at base
Lower Rewa sandstone with conglomerate at top				Moderately hard rock with interbeds of shale, siltstone and limestone
Panna shale				Soft, calcareous, splintery shale with interbeds of siltstone and sandstone
Sandstone	Kaimur Group		Meso Proterozoic	Fine grainged, massive, hard and thickly bedded
Bhagwar shale				Soft, bleached, yellowish, carbonaceous, micaceous and pyritiferous
Rohtas limestone	Semri Group			Light to dark grey, fine grained, compact and well bedded limestone, with sandy and shaly interbeds
Rampur sandstone and shale				Light green, fine grained, thinly bedded, compact sandstone with tiny grains of bluish green glauconite and grey to khaki grey splintery shale
Limestone, sandstone and siltstone				Dark greyish, blue, thickly to thinly bedded limestone. Sandstone is ferruginous, purple, flaggy, fine to medium grained and compact
Olive shale				Olive green, fined grained, hard and compact thinly laminated
Porcellanite and shale				Light grey, greenish yellow, compact and jointed porcellanite with grey to khaki grey splintery shale
Chert				White to earthy white, very fine grained, hard rock
Bansakar sandstone				Yellowish white, fine to medium grained sandstone
Tirhowan limestone				Dirty grey to greyish blue, fine grained, massive and thinly bedded
Arangi/Kanwari shale				Grey coloured fine grained, laminated shale
Deoland sandstone				Yellowish white, fine to medium to coarse grained, matured arenaceous sandstone
Granite and gneisses	Bundelkhand Granite		Archaean	Light pink in colour, medium to coarse grained, porphyritic, massive, foliated and banded

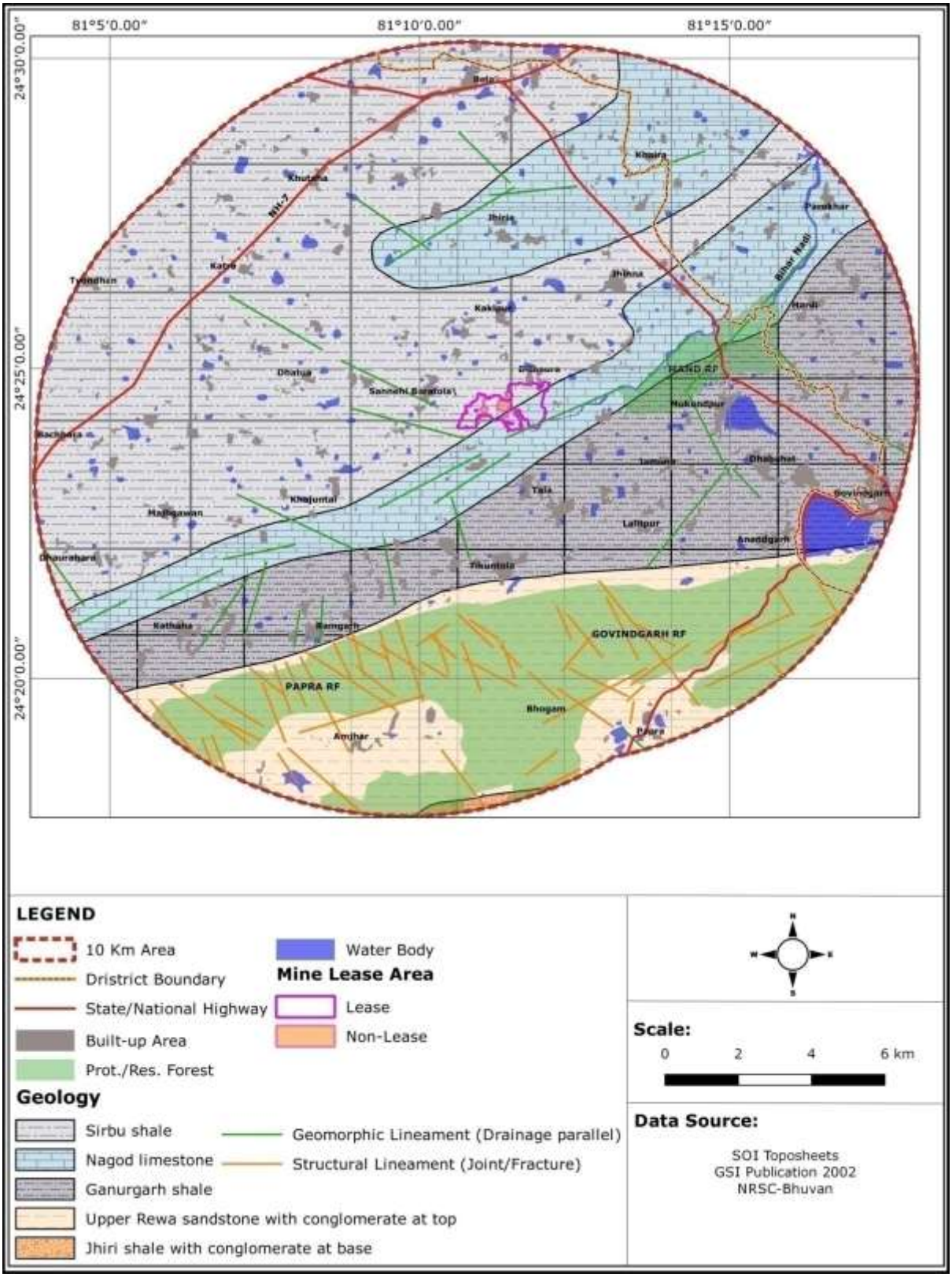


Figure-7. Geology of the Study Area

Except southern part of Dithora village, no outcrops/exposures were seen in the area. The most common variety of limestone below the capping in the ML area is grey coloured and fine grained. The area has two limestone bands as the lithologs of the bore holes exhibit and as per interpretation made on Geological Plan and Section, these two bands occur as upper and lower band of limestone. The upper band of limestone is overlain by lateritic soil cover for average 4.0 – 6.0 followed by shale band and at places siliceous or high magnesian limestone occurring which is considered as waste for 8.0 – 40.0 m while lower band limestone is overlain by OB as shale for average 28.0 m. The rock formations trend NW-SE with sub-horizontal to low dip 5° to 7° due northwest. The rocks are un-deformed and un-metamorphosed.

The surface geological map of the ML area and geological cross sections prepared on a scale of 1:2000 are presented in **Figure-8** and **Figure-9a** and **9b** respectively.

3.4.1 Limestone

The limestone is well exposed in the drilled bore holes and as per logs, two bands of limestone have been considered for average 12.0 m thickness each and these two bands have been overlain by OB capping of average 8.0 – 40.0 m. The thickness of soil is almost uniform in the entire ML area except the southern part where limestone exposures are peeping through the surface or has meagre soil capping. The disposition and behaviour of limestone occurrences is well depicted in cross sections as shown in **Figure-9a** and **9b**.

3.4.2 Shale along with High Magnesia Limestone

In general, shale and at some places, high magnesia limestone is below the soil cover resting over the upper band limestone again followed by shale and lower band limestone for average 8.0 – 40.0 m. The disposition and behaviour of shale occurrence is well depicted in cross sections as shown as shown in **Figure-9**.

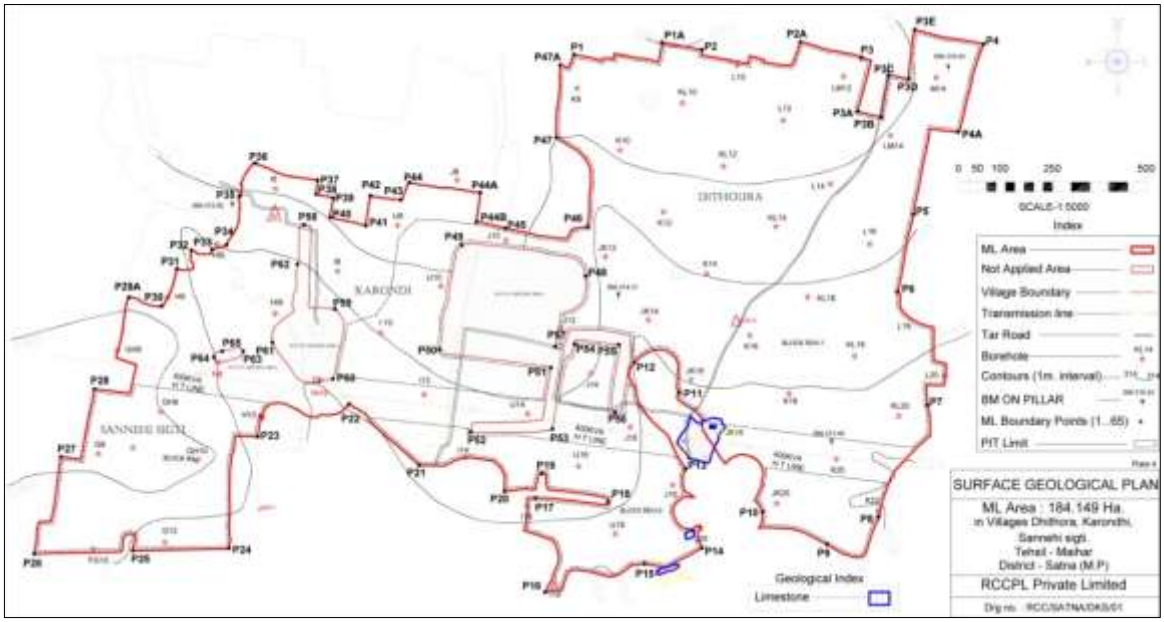


Figure-8. Surface Geological Plan of the ML Area

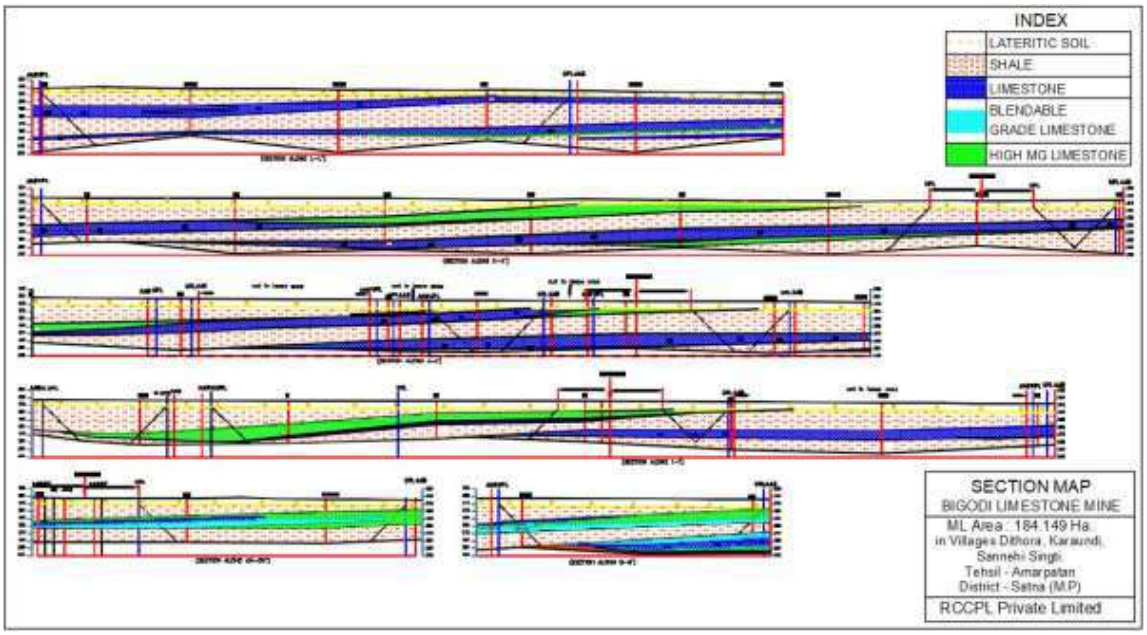


Figure-9. Geological Cross Sections of the ML Area

4.0 HYDROGEOLOGY

Hydrogeology is the area of geology that deals with the distribution and movement of ground water in the soil and rocks of earth's crust commonly in aquifers. The hydrogeological studies have been carried out in the study area to understand the local geology, geomorphological features, drainage network, aquifer characteristics and yield of water. Accordingly various components controlling the hydrogeological regime of the study area have been studied. Hydrogeological investigations were carried out in the study area between 28.12.2018 and 30.12.2018. Hydrogeology of the study area is presented in **Figure-10**.

4.1 Nature of Occurrence of Ground Water

Ground water systems are a result of the complex combination of different lithological and structural types within an area that together constitute an aquifer within which ground water accumulates and moves. Rather than describing individual lithologies and their tendencies to form aquifers or otherwise, it is useful to describe the ground water as **one continuous across** various lithological types (Kulkarni and Deolankar, 1995).

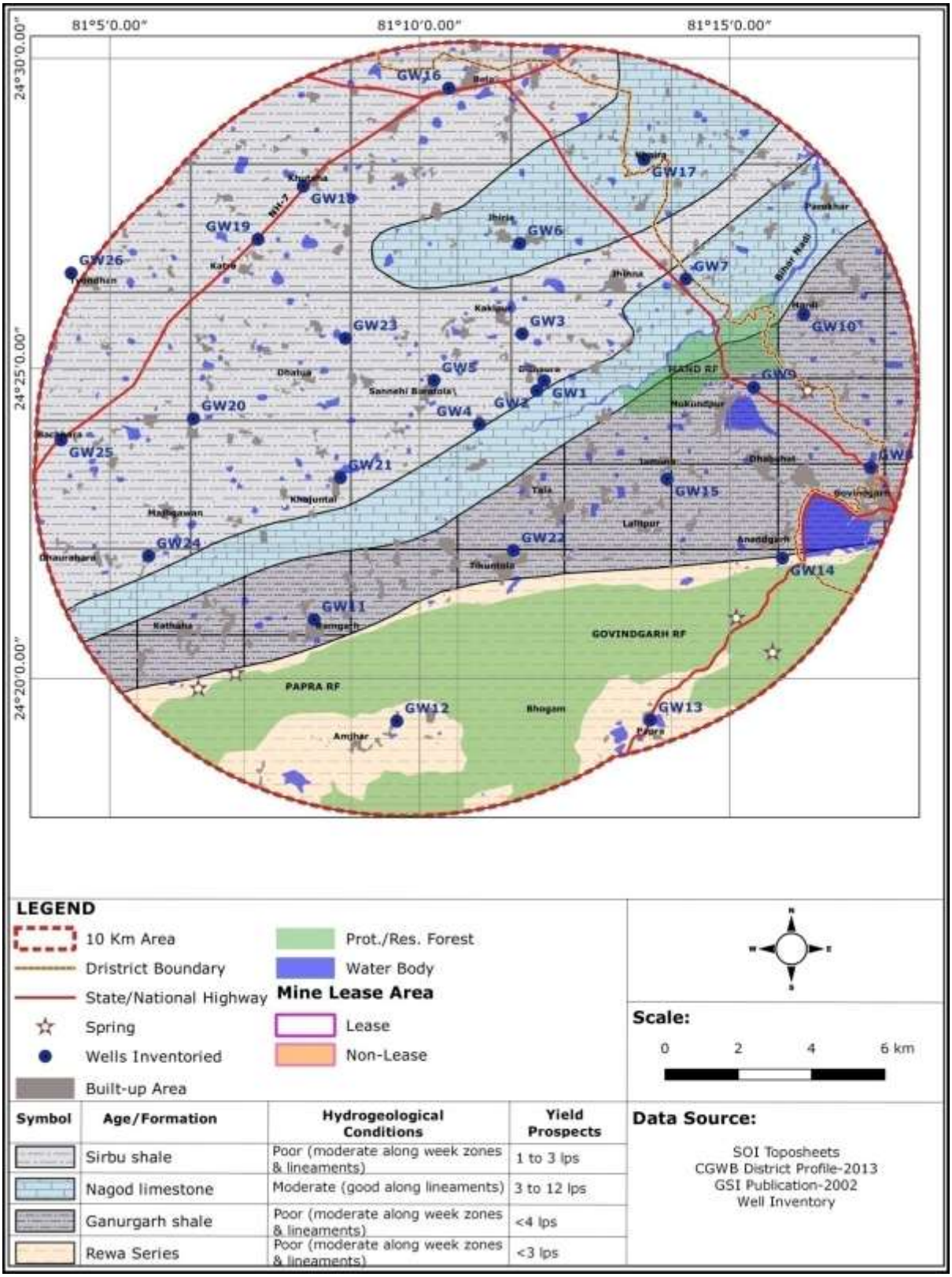
Of the total study area of 438.06 sq km, Sirbu shale, Nagod limestone and Simrawal shale belonging to Bhander Group are the major geological formations occupying 345.15 sq km (170.61 sq km, 79.62 sq km and 94 92 sq km respectively). Rest of the area in the southern part is with Upper Rewa sandstone and Jhiri shale with conglomerate of Rewa Group covering 92.90 sq km (91.87 sq km and 1.03 sq km).

4.1.1 Kaimur and Rewa Series Formations (Upper Vindhyan)

Kaimur and Rewa Series formations of Upper Vindhyan are together forming hilly and forested area, consisting of two limbs of synclinal basin. Main rock units are hard and compact siliceous (Quartzitic) sandstone and shales. Northern limb is quite broad while southern limb is rather narrow, representing "Kaimur Hill Range". In Kaimur hill range excepting establishment of Maihar Cement Plant, entire area is barren. Ground water generally occurs in jointed, fractured and weathered horizons. Weathering of shales occurring in between sandstones has created valley like structures in northern limb area of Kaimur and Rewa series formations. Inhabitation is mostly confined in valley areas of northern limb where some ground water is available for domestic and agriculture needs. Otherwise, this is scarcity area from the ground water availability point of view.

4.1.2 Ganurgarh Shale (Bhander Series, Upper Vindhyan)

Although shales are normally poorly permeable, but Ganurgarh shale due to its soft nature as compared to other compact formations, it has undergone deep weathering (6-8 m). Resultant weathering mantle support development of dug wells for limited ground water exploitation. The presence of several joints and fissures has facilitated deeper percolation of ground water. Occurrences of solution cavities have been developed along the contact of gypsum and limestone. At deeper level, gypsum bands are found in Ganurgarh shale.



Symbol	Age/Formation	Hydrogeological Conditions	Yield Prospects
	Sirbu shale	Poor (moderate along week zones & lineaments)	1 to 3 lps
	Nagod limestone	Moderate (good along lineaments)	3 to 12 lps
	Ganurgarh shale	Poor (moderate along week zones & lineaments)	<4 lps
	Rewa Series	Poor (moderate along week zones & lineaments)	<3 lps

Figure-10. Hydrogeology of the Study Area

Gypsum content is supporting development of artesian conditions in it, but quality of ground water is reported to be unsuitable, having excessive suphate content. Ganurgarh shale is forming two limbs of syncline structure in the district. Width of northern limb is wide, whereas southern limb is narrow and pinches south-westwards. Part of Ganurgarh shale horizon is covered with alluvium received from Kaimur/Rewa sandstone and deposited over this shale making good phreatic aquifer, especially in southern limb area where its surface exposures are not seen due to overlain alluvial cover and providing good yield to dug wells located along foot hills of Kaimur hill range.

4.1.3 Bhander Limestone

The unit is hard and compact but jointed and fractured. Along the joints and planes of stratification “Grikes” and “Solution Cavities” get developed through the process of dissolution of country rock by circulating ground water. Often cavities are filled with yellow coloured plastic clay known as “Terra-Rosa”. Cavernous limestone hold good quantity of ground water, but quality may be slightly hard.

4.1.4 Sirbu Shale

Sirbu shale is younger unit of Upper Vindhyan having very thick horizon along syncline axis. In low lying topographic areas and in the weathered mantle, occurrence of ground water is in limited quantity yet enough to sustain dug wells for domestic/drinking purposes. The brownish red variety is more productive than the greyish shales. Due to its impervious nature, lot of small ponds are constructed in Sirbu shales, which holds water even during summer season in Maihar and Amarpatan blocks. These ponds are also used for production of water-nuts in abundance.

4.2 Wells, Water Levels and Yields

Mostly the ground water in the study area is developed by way of 1) dug wells or dug-cum-bore wells for domestic and agriculture purposes with bucket lift and electric engines/submersible pumps and 2) bore wells for domestic, agriculture and industrial purposes with hand pumps, electric submersible pumps. Well inventory of 26 wells was conducted in the study area during field investigation period.

Depth of dug wells inventoried range from 4.00 to 19.00 m and one dug well has bore well drilled up to 30.00 m from bottom of the well. Depth of bore wells in the study area range from 45.00 m to 120.00 m bgl. Domestic dug wells at places are seen with 0.5 HP centrifugal pumps and dug wells for agriculture purpose are with 3.0 HP to 5.0 HP centrifugal pumps. Hand pumps are installed on community bore wells drilled for domestic purpose and 0.5 HP to 1.0 HP submersible pumps are installed domestic individual bore wells. Agricultural bore wells are mainly with 3.0 HP to 5.0 HP submersible pumps.

Water levels during the field visit (last week of December, 2018) were recorded measuring depth to standing water and post monsoon water levels were recorded up to the moisture indication in the dug wells. Pre monsoon water levels were recorded through interaction with well owner or local person available at the site. The depth to water level during field

visit ranges from 2.00 m below ground level (bgl) near Katra to 12.62 m bgl near Bachra. Dug wells near Sannehi Sigti, Kharia and Dithora of depth between 6.57 m and 8.20 m were dry during the field visit. The depth to water level during pre and post monsoon ranges from 5.40 m to 18.00 m bgl and 1.00 m to 7.88 m bgl respectively. Almost 54% of the dug wells were reported to go dry during pre monsoon period. The average water level fluctuation in the study area is 6.53 m. Well inventory data is furnished in **Table-5**.

Yield potential of Kaimur and Rewa Series formations is less than 3 litres per second (lps). Yield potential of Ganurgarh shale is less than 4 lps, but exploratory well drilled at village Jura has yielded 14 lps discharging during pumping test for 24.00 m drawdown, tapping Ganurgarh shale aquifer at depth having sulphate content 700 mg/l making water unsuitable for human consumption. General yield potential of Bhander (Nagod) limestone is 3 to 12 lps. Exploratory wells drilled at Kirpalpur (Satna-Anicut), Maihar Stadium and Jhinna-Nala tapping limestone aquifers have given good yields. General yield potential of Sirbu shale is 1 to 3 lps.

There are three dug wells in Mauhari Katra, Mukundpur and Kemar under CGWB water level monitoring network in the study area. Of these, Mauhari Katra has been monitored from 1996 and other two well have been monitored from 2014. Water levels at these wells have been monitored four times in a year – monsoon, post monsoon rabi, post monsoon kharif and pre monsoon. Water level monitoring data of these three wells is presented in **Table-6** and the well hydrograph of Mauhari Katra with rainfall is presented in **Figure-11**. A review of this monitoring data indicate that the average monsoon, post monsoon rabi, post monsoon kharif and pre monsoon water levels at these locations are 2.45 m, 5.18 m, 3.49 m and 7.48 m bgl respectively with an average fluctuation of 5.03 m. The long term monsoon and pre monsoon water levels between 1996 and 2018 at Mauhari Katra (7.5 km NW from the ML area) showan increasing trend of 0.8 m and 2.4 m respectively.

<table>
<tr><td> 
Agri./Dom. Bore Well with Submersible Pump
24°24'06.35"N, 81°11'00.09"E</td><td> 
Bore Well with Hand Pump-Public Domestic
24°24'08.41"N, 81°11'01.02"E</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td colspan="2">Dug Well-Private Domestic : 24°24'48.50"N, 81°10'13.81"E</td></tr>
<tr><td> 
Dom. Bore Well with Submersible Pump
24°24'06.34"N, 81°10'58.14"E</td><td> 
Dug Well-Private Agriculture
24°24'48.20"N, 81°12'00.62"E</td></tr>
</table>

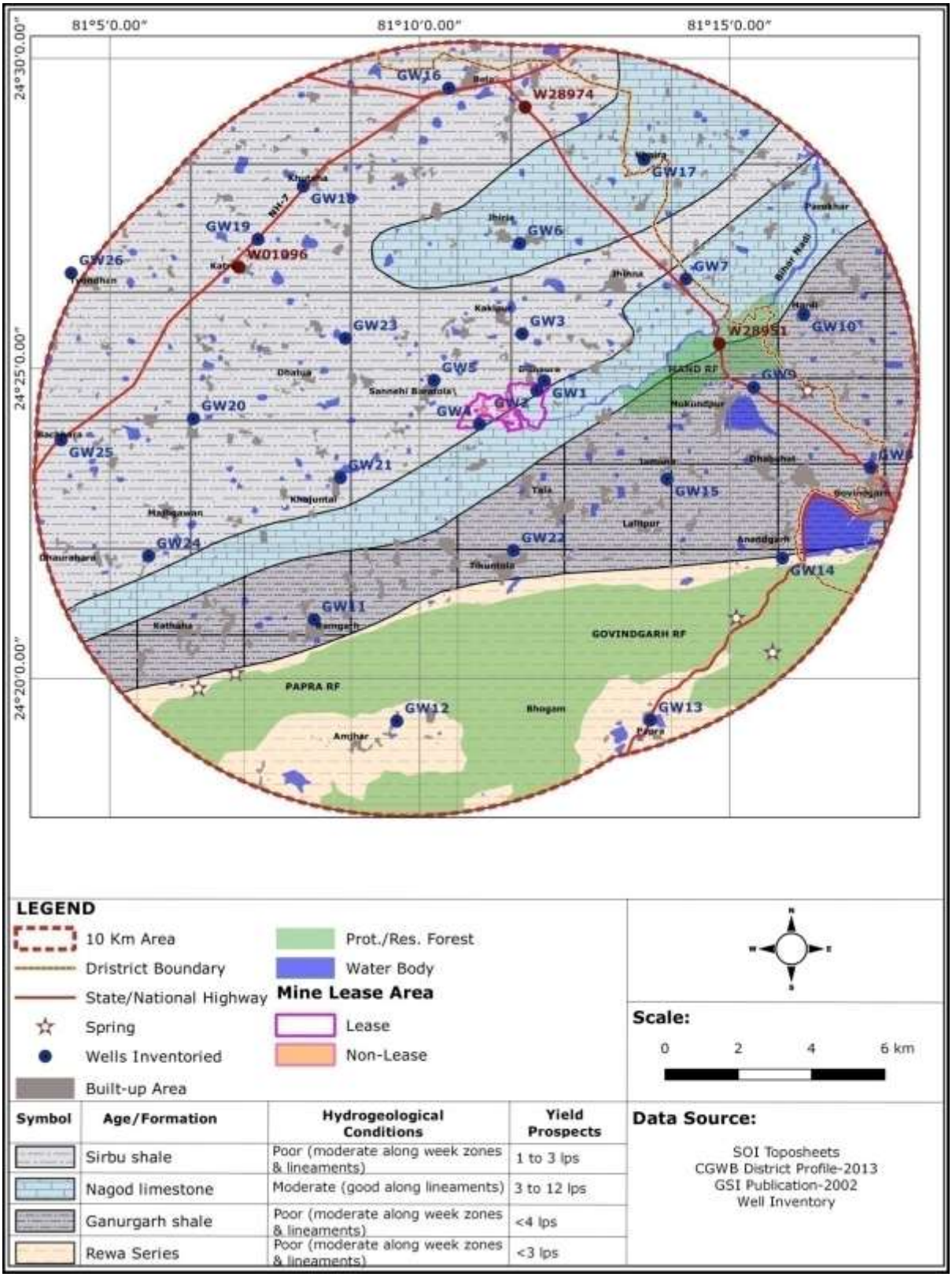


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Figure-11. Hydrogeology of the Study Area

Table-5. Details of Well Inventory in Study Area

Sr.No.	Well No	Village	Lat	Long	Well Type	Purpose	Total Depth (m)	Dia (m)	Lining (Dug Well) (m)	Static Water Level (m)			Fluctuation (m)	Aquifer
										Dec-18	Pre Monsoon (May)	Post-Monsoon		
1	GW1	Dithoura	24°24'48.20"	81°12'00.62"	Dug	Agriculture	11.00	7.70	8.20	Dry	Dry	7.30	-	Sirbu shale
2	GW2	Dithoura	24°24'38.61"	81°11'53.40"	Dug-cum-Bore	Agriculture	14.00	7.00	7.50	11.20	13.30	5.70	7.60	Sirbu shale
3	GW3	Dithoura-Piaseatola	24°25'33.65"	81°11'39.17"	Dug	Domestic	10.00	3.40	8.00	4.85	8.60	3.05	5.55	Sirbu shale
4	GW4	Sannehi Sigti	24°24'06.10"	81°10'57.78"	Dug	Domestic & Agri	6.57	3.00	6.57	Dry	Dry	3.98	-	Sirbu shale
5	GW5	Sannehi Bothali	24°24'48.50"	81°10'13.81"	Dug	Domestic	9.76	3.15	3.00	3.65	Dry	2.55	-	Sirbu shale
6	GW6	Jhiria	24°27'00.96"	81°11'36.89"	Dug	Domestic	6.93	2.00	4.60	4.90	6.50	3.45	3.05	Nagod limestone
7	GW7	Khajori	24°26'26.61"	81°14'17.70"	Dug	Domestic	10.45	2.13	6.00	7.00	10.00	4.85	5.15	Nagod limestone
8	GW8	Parsiya	24°23'24.34"	81°17'16.53"	Dug	Domestic	10.25	2.00	7.50	7.30	9.40	4.50	4.90	Simrawal shale
9	GW9	Mukundpur	24°24'41.62"	81°15'23.37"	Dug	Domestic	5.65	1.35	-	3.35	5.40	2.85	2.55	Simrawal shale
10	GW10	Hardi Sankar	24°25'52.34"	81°16'11.85"	Dug	Domestic	9.30	2.25	6.00	5.85	8.90	4.55	4.35	Simrawal shale
11	GW11	Ramgarh	24°20'57.13"	81° 8'17.66"	Dug	Domestic	11.50	5.00	11.50	8.10	Dry	5.00	-	Simrawal shale
12	GW12	Amjor	24°19'18.80"	81°09'37.90"	Dug	Domestic	15.00	5.00	15.00	11.80	13.62	7.01	6.61	Rewa Series
13	GW13	Papra	24°19'19.90"	81°13'43.40"	Dug	Domestic	9.25	3.50	9.25	5.40	Dry	3.90	-	Rewa Series
14	GW14	Anandgarh	24°21'56.50"	81°15'51.10"	Dug	Domestic	11.30	4.00	11.30	7.00	Dry	5.00	-	Simrawal shale
15	GW15	Lalithpur	24°23'13.20"	81°13'59.40"	Dug	Domestic	12.30	3.50	12.30	9.50	Dry	6.50	-	Simrawal shale
16	GW16	Bela	24°29'31.30"	81°10'28.20"	Dug	Domestic	10.70	5.00	6.78	9.82	Dry	5.20	-	Sirbu shale
17	GW17	Khaira	24°28'22.10"	81°13'37.20"	Dug	Domestic	9.38	2.70	7.66	Dry	Dry	7.88	-	Nagod limestone
18	GW18	Khutaha	24°27'56.30"	81°08'07.20"	Dug	Domestic	11.50	1.40	9.38	2.92	10.90	1.30	9.60	Sirbu shale
19	GW19	Katra	24°27'05.10"	81°07'23.50"	Dug	Domestic	4.00	1.60	4.00	2.00	Dry	1.00	-	Sirbu shale
20	GW20	Kotra	24°24'11.50"	81°06'21.00"	Dug	Domestic	8.10	1.80	4.40	8.16	Dry	5.30	-	Sirbu shale
21	GW21	Padi Kala	24°23'14.40"	81°08'43.20"	Dug	Agriculture	9.10	1.00	5.00	2.81	8.60	1.50	7.10	Sirbu shale
22	GW22	Tala	24°22'03.90"	81°11'30.80"	Dug	Domestic	10.50	1.40	10.50	7.69	Dry	2.20	-	Simrawal shale
23	GW23	Deu	24°25'29.20"	81°08'48.00"	Dug	Agriculture	9.00	1.50	3.30	4.10	8.10	1.40	6.70	Sirbu shale
24	GW24	Lokhri	24°21'58.60"	81°05'37.60"	Dug	Domestic	8.10	3.40	8.10	2.48	Dry	1.30	-	Sirbu shale
25	GW25	Bachra	24°23'50.80"	81°04'12.90"	Dug	Domestic	19.00	2.70	7.00	12.62	18.00	2.80	15.20	Sirbu shale
26	GW26	Thyordari	24°26'32.30"	81°04'22.60"	Dug	Agriculture	5.00	1.60	3.70	3.30	Dry	2.70	-	Sirbu shale
						Average	**9.91**	**3.04**	**7.46**	**6.34**	**10.11**	**3.95**	**6.53**	

Table-6. CGWB Well Monitoring Data

SITE_NAME	SITE_TYPE	WLCODE	YEAR_OBS	MONSOON	POMRB	POMKH	PREMON	Fluctuation
Mauhari katra	Dug Well	W01096	1996	1.36	4.75	2.69	7.02	5.66
Mauhari katra	Dug Well	W01096	1997	1.50	5.68	1.53	13.40	11.90
Mauhari katra	Dug Well	W01096	1998	2.63	1.42	3.52	5.67	4.25
Mauhari katra	Dug Well	W01096	1999	0.85	5.51	0.65	5.40	4.75
Mauhari katra	Dug Well	W01096	2000	1.13	3.27	3.43	7.24	6.11
Mauhari katra	Dug Well	W01096	2001	0.99	4.65	2.10	6.70	5.71
Mauhari katra	Dug Well	W01096	2002	1.50	4.55	2.45	6.36	4.86
Mauhari katra	Dug Well	W01096	2003	0.85	5.30	1.80	6.65	5.80
Mauhari katra	Dug Well	W01096	2004	1.15	3.95	1.75	5.35	4.20
Mauhari katra	Dug Well	W01096	2005	0.45	3.87	2.15	5.13	4.68
Mauhari katra	Dug Well	W01096	2006	0.85	4.35	2.20	4.75	3.90
Mauhari katra	Dug Well	W01096	2007	1.55	4.75	3.05	5.85	4.30
Mauhari katra	Dug Well	W01096	2008	0.85	5.35	2.00	6.40	5.55
Mauhari katra	Dug Well	W01096	2009	1.95	2.95	2.60	6.45	4.50
Mauhari katra	Dug Well	W01096	2010	2.55	2.95	4.85	6.25	3.70
Mauhari katra	Dug Well	W01096	2011	0.50	5.40	2.95	9.25	8.75
Mauhari katra	Dug Well	W01096	2012	-	4.60	2.45	6.45	-
Mauhari katra	Dug Well	W01096	2013	1.00	6.05	1.60	7.60	6.60
Mauhari katra	Dug Well	W01096	2014	2.05	2.60	2.35	5.25	3.20
Mauhari katra	Dug Well	W01096	2015	1.55	2.85	3.10	6.55	5.00
Mauhari katra	Dug Well	W01096	2016	0.90	4.10	2.10	-	-
Mauhari katra	Dug Well	W01096	2017	1.25	3.15	2.85	6.05	4.80
Mauhari katra	Dug Well	W01096	2018	-	5.85	-	8.15	-
Mukundpur	Dug Well	W28951	2014	9.35	8.55	8.57	9.75	1.20
Mukundpur	Dug Well	W28951	2015	8.75	8.75	9.15	9.95	1.20
Mukundpur	Dug Well	W28951	2016	6.60	9.10	7.09	10.45	3.85
Mukundpur	Dug Well	W28951	2017	8.05	8.35	8.95	10.15	2.10
Mukundpur	Dug Well	W28951	2018	-	9.25	-	10.25	-
Kemar	Dug Well	W28974	2014	4.20	5.10	2.33	7.25	4.92
Kemar	Dug Well	W28974	2015	3.70	2.80	6.58	8.20	5.40
Kemar	Dug Well	W28974	2016	0.90	8.40	2.72	8.69	7.79
Kemar	Dug Well	W28974	2017	2.10	4.80	5.00	8.35	6.25
Kemar	Dug Well	W28974	2018	-	8.10	-	8.50	-
		Average		**2.45**	**5.18**	**3.49**	**7.48**	**5.03**

WLCODE: Well Code **YEAR_OBS:** Year of Observation **POMRB:** Post Monsoon Rabi
POMKH: Post Monsoon Kharif **PREMON:** Pre Monsoon

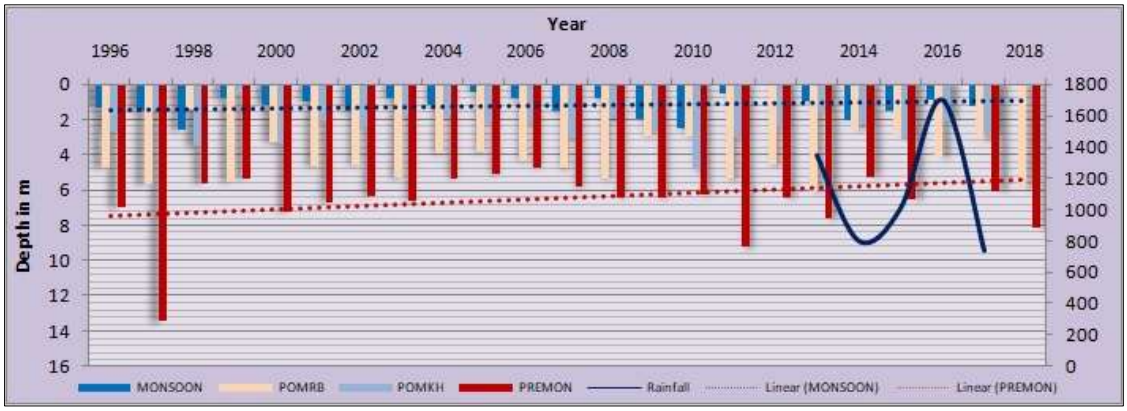


Figure-12. Well Hydrographs of Mauhari Katra Well

4.3 Movement of Ground Water

Ground water movement mainly takes place through the fractures and joints of the crystalline rocks and the ground water is transmitted through voids and interstitial openings in sedimentary rocks and unconsolidated formations. In other words, movement of ground water is controlled by the hydraulic conductivity of the aquifer and hydraulic gradient.

Based on the water level data collected from the study area, ground water level contour maps have been prepared for pre and post monsoon seasons considering water levels reduced to mean sea level and presented in **Figure-12a** and **12b**. The reduced water levels in the study area range from 294 m amsl in the northeast to 457 m amsl in the south during pre monsoon and 300 m amsl in northeast to 464 m amsl in the south during post monsoon. The reduced water levels in the project site range from 302 m amsl in the east to 310 m amsl in the west during pre monsoon to 307 m amsl in the east to 315 m amsl in the west during post monsoon. The average water levels derived from reduced water level data during pre and post monsoon seasons in the ML area are observed to be around 10.95 m bgl and 5.66 m bgl respectively.

A review of the topography and drainage pattern reveals that the regional slope in the study area is towards NE. The water table contours almost follow the topography of the study area showing the direction along surface drainage of Bihar Nadi. The ground water flow in the ML area is towards east. The hydraulic gradient in the study area ranges from 2.02 m/km from SW towards ML area to during pre monsoon to 14.10 m/km from Kaimur hill range towards Bihar Nadi near Lalithpur and from 2.64 m/km to 13.16 m/km during post monsoon.

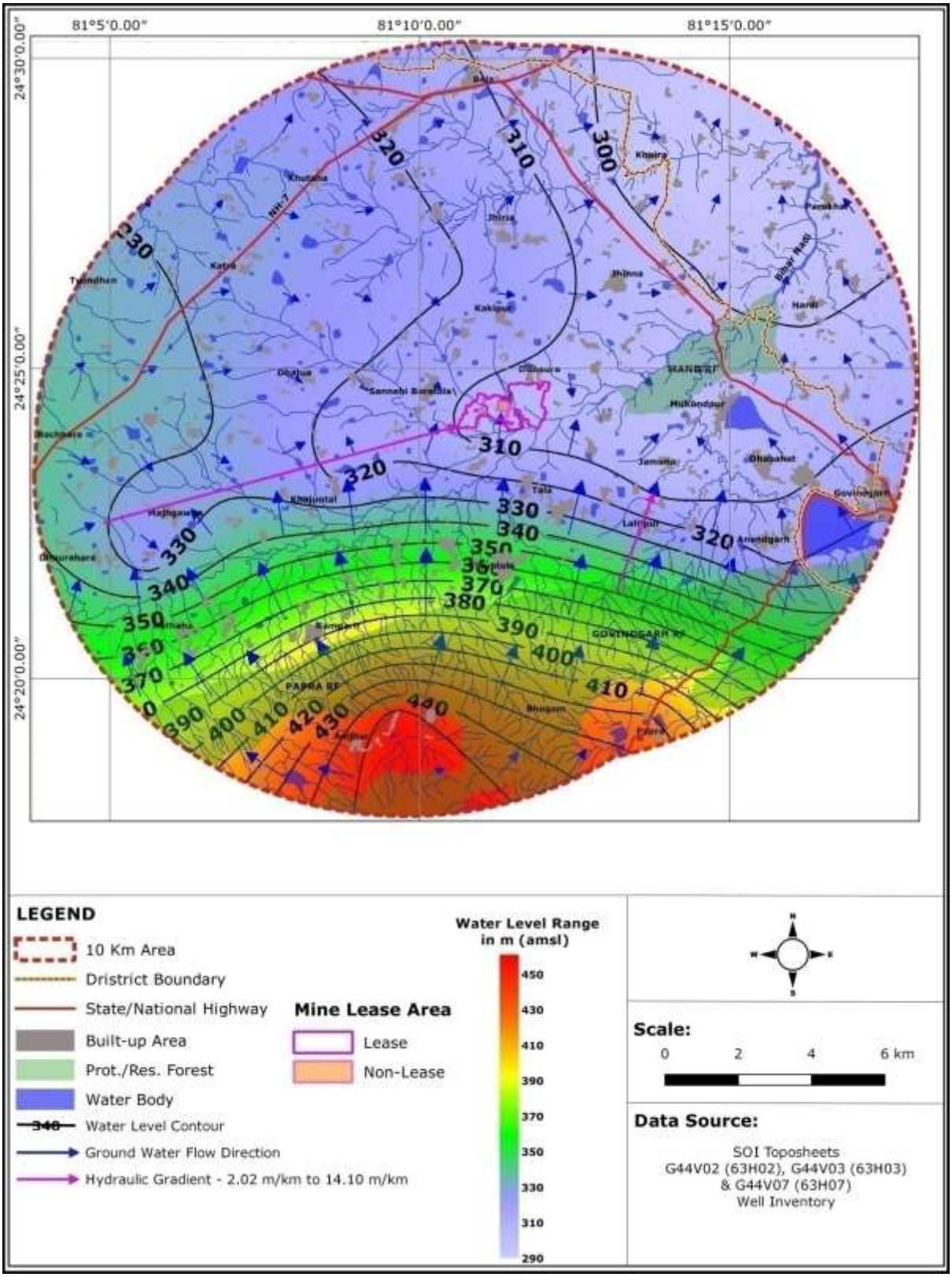


Figure-13a. Water Level Contours – Pre Monsoon

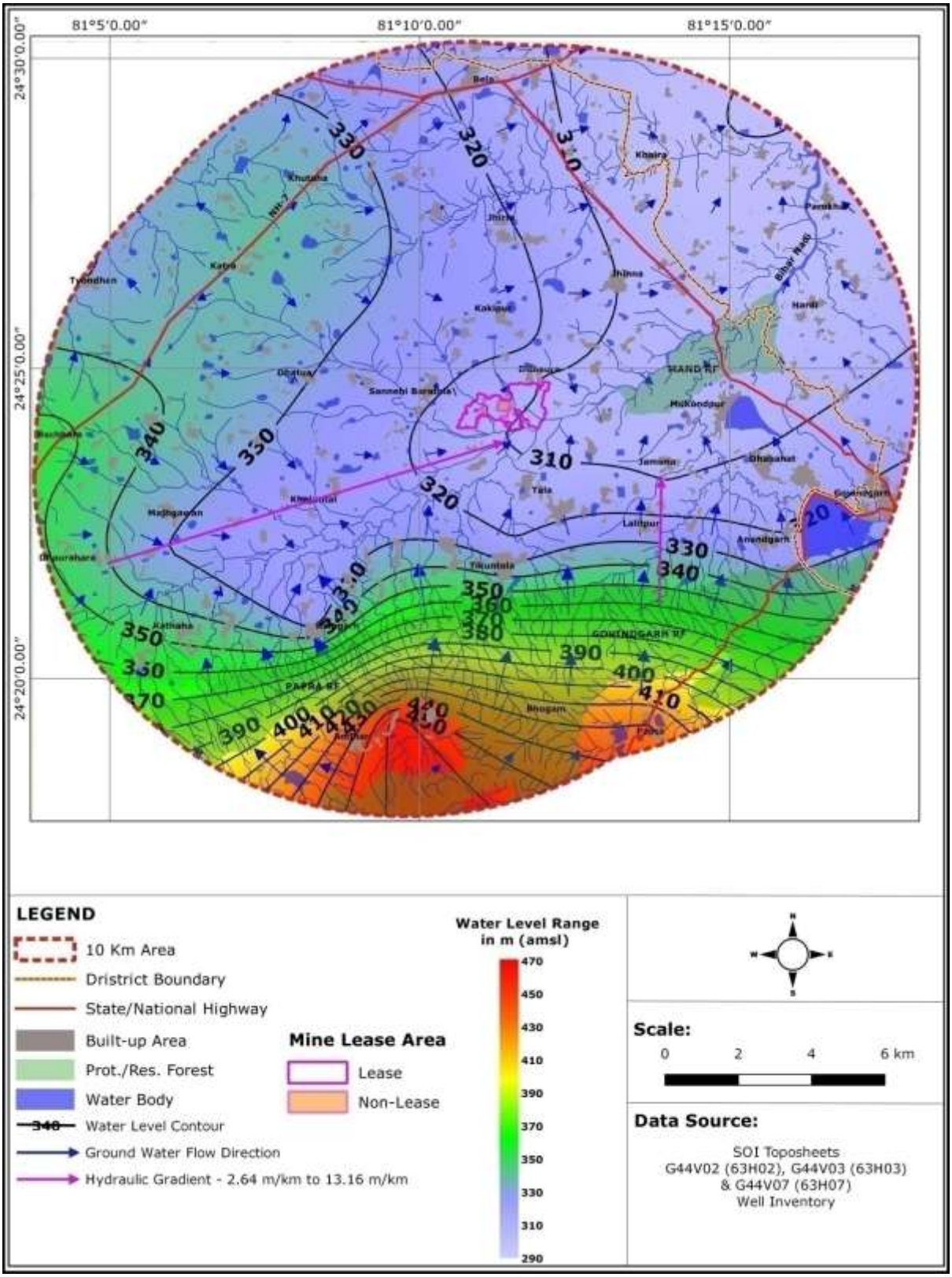


Figure-13b. Water Level Contours – Post Monsoon

4.4 Aquifer Characteristics

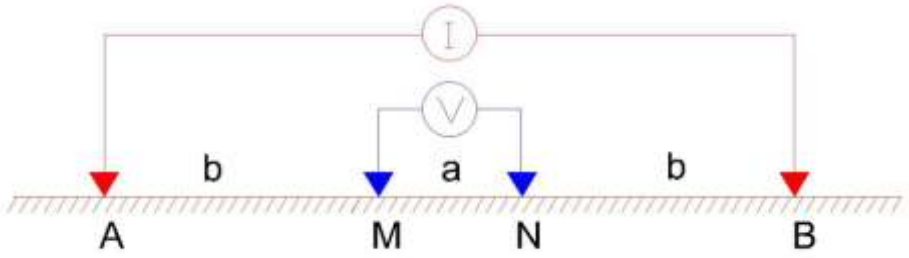
Ground water is stored in the open spaces and fractures within geologic material such as soil, sand and rock that occur beneath the land surface. Aquifers are the geologic layers that are filled with water and that can transmit enough water to supply a well under normal hydraulic gradients. Understanding of depth, thickness and other aquifer characteristics is vital in mining project to assess the impact of mining on water regime. Aquifer characteristics in ML area are studied through Geophysical Investigations carrying out Electrical Resistivity Tests (ERTs) and pumping and recovery tests on an existing bore well.

4.4.1 Electrical Resistivity Tests (ERTs)

Application of geophysical methods will help us to identify the nature and thickness of sub-surface formation by studying the variation of their physical properties through the measurements made at the surface. Several surface geophysical methods are deployed to reach the purpose. All these methods rely upon the principle that each lithological assemblage has independent physical properties and identification of these properties helps to recognize the formation. One such property easily detectable is its electrical character for the passage of known strength of current. These testing methods are applied for arriving information on sub-surface lithological data and vertical layering of water structure in the surveyed area.

In geo-electrical methods, the centre of the configuration (O) is kept at fixed location and measurements are made by successively increasing electrode spacing. In this, current is sent into the ground through a pair of electrodes called current electrodes and resulting potential difference across the ground is measures with the help of another pair of electrodes called potential electrodes. The ratio between the potential difference (ΔV) and current (I) gives the resistance (R), which depends on the electrode arrangement and on the resistivity of the sub-surface formations. The apparent resistivity values obtained with increasing values of electrode separations are used to estimate the thickness and resistivity of the sub-surface formations. The plot between apparent resistivity values obtained with increasing values of electrode separations and corresponding current electrodes separation from the center is used for analysis of thickness and true resistivity of the sub-surface formations.

There are two popular surface electrical methods in geophysical investigations namely Schlumberger and Werner configurations. The Schlumberger method of Electrical Resistivity Test (ERT) was used in the present study with the help of a DC resistivity meter - DDR-3 of IGIS, Hyderabad. In Schlumberger configuration, all the four electrodes (A, B, M and N) are kept in a line. The outer electrode spacing (b) is kept large, compared to the inner electrode spacing (a), usually more than 5 times. Field resistance values will be obtained at every change of electrode spacing for calculating apparent resistivity values. The disposition of electrodes for Schlumberger configuration is shown in below picture and the apparent resistivity ρa for a specified configuration is computed with below mentioned formula.



Schlumberger Configuration

Apparent Resistivity $\rho_a = \pi kR$

where, 'k' is the constant = $\pi/a(AB/2^2-MN/2^2)$
'AB' is current electrode spacing and
'MN' is potential electrode spacing
$R = \Delta V/I$

Electrical Resistivity Tests (ERT) were conducted at 3 different locations following Schlumberger configuration with maximum AB/2 separation of 100.5 m. Locations for conducting ERTs were selected considering topography & space to run electrodes up to 100.5 m on either side, site conditions including surface moisture etc. These locations are designated as ERT1 to ERT3 and shown in below figure.

ERT No.	Latitude	Longitude
ERT1	24°24'14.80"N	81°10'47.60"E
ERT2	24°24'36.10"N	81°11'50.50"E
ERT3	24°24'13.40"N	81°11'13.00"E

The resistivity data obtained is interpreted in terms of physical parameters viz., resistivity and thickness of the formations and these parameters in-turn, along with the geological information are used to interpret the aquifer status. In the present study, Inverse Slope method of interpretation is used to interpret the data acquired from the field. Details of ERT interpretation are presented in **Table-7** and ERT logs are shown in **Figure-14**.

Based on resisitivity and local geological information, layers having resistivity ranges of <10 Ωm, 10 to 25 Ωm, 30 to 80 Ωm, 80 to 300 Ωm and >300 Ωm have been designated as clay, top soil, weathered zone, fractured rock and hard rock respectively. The thickness of top soil varies from 1.00 m at ERT2 and ERT3 to 3.00 m at ERT1. A review of ERT interpretation indicates that the productive aquifer is around 38.00 m bgl as seen in ERT1 and ERT3.

Though ERT2 shows fractured zone between 9.00 m and 24.00 m bgl, this appears to be under phreatic condition having monsoonal recharge with general water table conditions. Hard rock in the area is reported to have minor fractures which are low yielding in few cases.

Table-7. Resistivity and Thickness Details from Electrical Resistivity Tests (ERTs)

Sr.No	ERT No.	Resistivity Ωm	Depth m		Thickness m	Layer
			From	To		
1	ERT1	25	0.0	3.0	3.0	Top Soil
		13	3.0	9.0	6.0	Clay
		1900	9.0	38.0	29.0	Hard Rock
		263	38.0	69.0	31.0	Fractured Rock
		630	69.0	100.0	31.0	Hard Rock
2	ERT2	10	0.0	1.0	1.0	Top Soil
		12	1.0	9.0	8.0	Clay
		122	9.0	24.0	15.0	Fractured Rock
		1177	24.0	100.0	76.0	Hard Rock
3	ERT3	15	0.0	1.0	1.0	Top Soil
		35	1.0	38.0	37.0	Hard Rock
		94	38.0	80.0	42.0	Fractured Rock
		700	80.0	100.0	20.0	Hard Rock

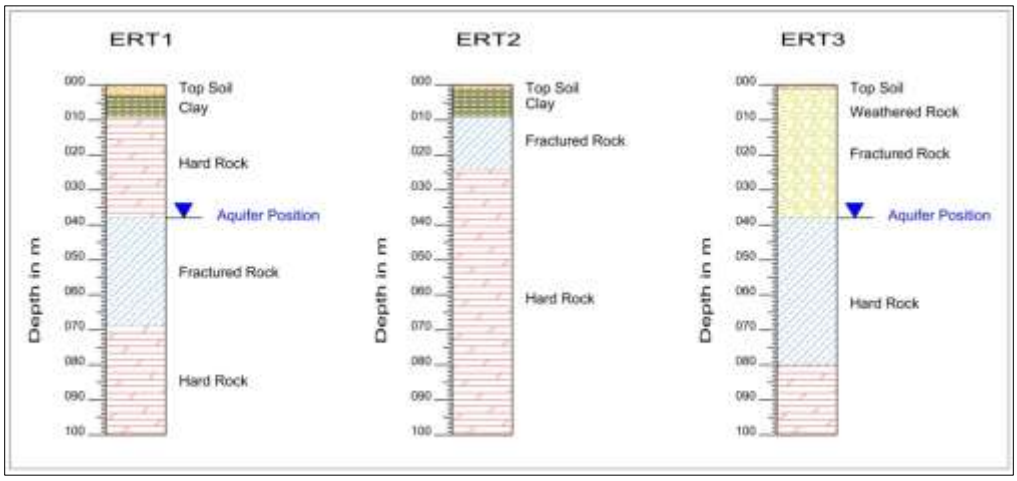


Figure-14. Lithologs Based on Electrical Resistivity Tests (ERTs)

4.4.2 Pumping and Recovery Tests

Pumping tests are conducted to determine the performance characteristics of a well and to determine the hydraulic properties of the aquifer such as permeability/hydraulic conductivity, transmissivity and storage coefficient. Permeability is the ease with which water can flow in a soil mass or a rock. These properties determine how easily water moves through the aquifer, how much water is stored, and how efficiently it produces water. During an aquifer test, the hydraulic head decline, or drawdown, allows for the estimation of aquifer hydraulic properties. There are many pumping test solution methods but most commonly used for different aquifers and conditions have some general assumptions: a) aquifer extends radially and infinitely, b) single pumping well, c) fully penetrating well (except for Neuman method).

A medium duration test was conducted on a bore well in Singti Tola on 29.12.2018 and corresponding drawdown measurements were done on the pumping well. The bore well is 64.92 m deep with a discharge of 2.5 lps. The pump test was conducted for 160 minutes till a near steady state condition was achieved. After stopping the pump, recovery was continued for 80 minutes. In the absence of observation well, interpretation of single well tests with Cooper-Jacob straight line method remains more reasonable than most alternatives. The aquifer parameters were determined using Cooper-Jacob straight line method for pumping and Theis Recovery method for recovery data.

Pumping & Recovery Test
24°24'06.12"N, 81°10'59.98"E

Pumping and recovery data are presented in **Table-8** and **Table-9** respectively and flows are shown in **Figure-15**. The results of pumping and recovery analysis are presented in **Table-10**. The average transmissivity is found as 118.66 m²/day while storage coefficient is 7.96E-01 and hydraulic conductivity is found as 5.93 m/day.

The yields of wells are functions of the permeability and transmissivity of aquifer encountered and vary with location, diameter and depth etc. During the course of ground water exploration by CGWB in Satna district, it was observed that the transmissivity varied from 2.56 to 746.00 m²/day and storage coefficient varied from $1.20x10^{-4}$ to $2.6x10^{-2}$.

Table-8.Pumping Test Data

Project: Reliance Bigodi Mining		Well Type: Bore Well		
Location: Bigodi		Well Dia: 6.5"		
Date: 29.12.2018		Well Depth: 64.92 m		
Time of Test Start: 10.50 AM		Static Water Level: 19.20 m		
Lat: 24°24'06.12"N		Long: 81°10'59.98"E		
Time Since Pump Started T in Min	**Wl Below MP in M**	**Draw Down S in M**	**Discharge (Q) in Lps**	**Remarks**
1	19.72	0.52	2.50	-
2	19.83	0.63	“”	-
3	19.92	0.72	“”	-
4	19.97	0.77	“”	-
5	20.05	0.85	“”	-
6	20.10	0.90	“”	-
7	20.12	0.92	“”	-
8	20.13	0.93	“”	-
9	20.18	0.98	“”	-
10	20.20	1.00	“”	-
15	20.23	1.03	“”	-
20	20.25	1.05	“”	-
25	20.27	1.07	“”	-
30	20.31	1.11	“”	-
40	20.36	1.16	“”	-
50	20.39	1.19	“”	-
60	20.48	1.28	“”	-
80	20.51	1.31	“”	-
100	20.56	1.36	“”	-
120	20.61	1.41	“”	-
140	20.67	1.47	“”	-
160	20.72	1.52	“”	-

Table-9.Recovery Test Data

Time Since Pump Started T In Min	Time Since Pump Stopped T' In Min	T/T'	WI Below Mp In M	Residual Drawdown (S)
161	1	161.00	20.44	1.24
162	2	81.00	20.36	1.16
163	3	54.33	20.30	1.10
164	4	41.00	20.26	1.06
165	5	33.00	20.22	1.02
166	6	27.67	20.19	0.99
167	7	23.86	20.16	0.96
168	8	21.00	20.14	0.94
169	9	18.78	20.12	0.92
170	10	17.00	20.11	0.91
175	15	11.67	20.06	0.86
180	20	9.00	20.03	0.83
185	25	7.40	20.01	0.81
190	30	6.33	19.99	0.79
210	50	4.20	19.94	0.74
220	60	3.67	19.92	0.72
230	70	3.29	19.91	0.71
240	80	3.00	19.90	0.70

Table-10. Pumping and Recovery Analysis Results

Sr.No.	Aquifer Parameter	Pumping Test	Recovery	Average
1	Transmissivity (T) - m²/day	94.19	143.13	118.66
2	Hydraulic Conductivity (K) - m/day	4.709	7.156	5.933
3	Storage Coefficient (S)	7.96E-01	-	7.96E-01

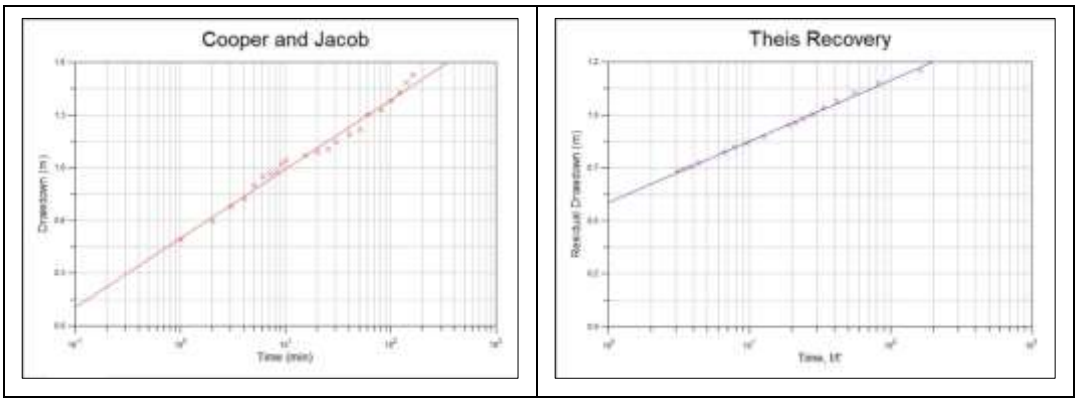


Figure-15. Pumping & Recovery Data Analysis

5.0 GROUND WATER RESOURCES

5.1 Ground Water Recharge

Ground water recharge or deep drainage or deep percolation is a hydraulic process where water moves downward from surface water to ground water. Recharge is the primary method through which water enters an aquifer. This process usually occurs in the vadose zone below plant roots and is often expressed as a flux to the water table surface. Recharge occurs both naturally through the water cycle (rainfall) and through anthropogenic processes (artificial ground water recharge), where rain water and or reclaimed water is routed to the sub-surface. Most of the rainfall flows downstream as run-off and the amount of rainfall reaching ground water naturally after meeting evaporation and evapo-transpiration losses is very limited. The anthropogenic processes of ground water recharge in the study area include return flow from irrigation, check dams etc.

Of the total study area of 438.06 sq km, Sirbu shale, Nagod limestone and Simrawal/Gunargarh shale belonging to Bhander Group are the major geological formations occupying 345.15 sq km (170.61 sq km, 79.62 sq km and 94 92 sq km respectively). Rest of the area in the southern part is with Upper Rewa sandstone and Jhiri shale with conglomerate of Rewa Group covering 92.90 sq km (91.87 sq km and 1.03 sq km). The lighological boundaries in the study area trends NW-SW.

Recharge in the study area has been worked out by rainfall infiltration and increment in ground water storage methods as per the guidelines of Ground Water Estimation Committee (GEC), 1997 and details are presented in **Table-11** and **12**respectively. Recharge by rainfall infiltration is estimated considering average rainfall of IMD, Satna and rainfall infiltration factors of geological units in the study area. The average ground water fluctuation in dug wells between pre and post monsoon and specific yield of geological formations (GEC, 1997) in the study area has been considered to estimate recharge by increment in ground water storage.

Table-11. Recharge by Rainfall Infiltration

Sr.No.	Recharge Unit	Area (sq.km)	Rainfall Infiltration	Annual Rainfall (m)	Recharge (MCM)
1	Sirbu shale	170.61	0.04	1.14	7.79
2	Nagod limestone	79.62	0.06	1.14	5.46
3	Simrawal/Ganurgarh shale	94.93	0.04	1.14	4.34
4	Rewa Group	92.90	0.05	1.14	5.30
5	Recharge from return flow	104.65	0.25	1.14	29.88
6	Water Body	11.71	0.20	1.14	2.67
Total Ground water recharge					**55.44**

Table-12. Recharge by Increment in Ground Water Storage

Sr.No.	Recharge Unit	Area (sq.km)	Specific Yield	Increment in Groundwater Storage (fluctuation) (m)	Recharge (MCM)
1	Sirbu shale	170.61	0.015	8.63	22.07
2	Nagod limestone	79.62	0.020	4.10	6.53
3	Simrawal/Ganurgarh shale	94.93	0.015	3.93	5.60
4	Rewa Group	92.90	0.018	6.61	10.75
5	Recharge from return flow	104.65	0.250	1.14	29.88
6	Water Body	11.71	0.200	1.14	2.67
Total Ground water recharge					**77.50**

The average ground water recharge by rainfall infiltration and increment in ground water storage is 66.47 MCM. However, the difference in recharge by rainfall infiltration method and increment in ground water storage indicate that the ground water draft is more than ground water recharge from rainfall.

5.2 Ground Water Discharge

The ground water discharge in the study area is mainly for domestic and irrigation purposes. The annual ground water draft has been estimated as per GEC 97 guidelines and is given in **Table-13**.

The major crops grown in the region are rice, pigeon pea and soya bean in kharif season and wheat, chickpea and lentil in rabi season. All these crops are water intensive with average water requirement ranging from 4.04 m^3/day to 4.79 m^3/day.

The total ground water draft for different purposes in the study area is 40.69 MCM.

Table-13. Annual Ground Water Draft/Discharge

Sr.No.	Purpose	Usage in Days	Requirement/Usage m^3/day	No. of Units	Ground water draft (MCM)
1	Domestic human population and livestock	365	0.075	138851	3.801
2	Irrigation - average water requirement per ha per crop growing period of major irrigated crops	117.50	43.70	7848	36.888
3	Water usage by existing industries	365	0	0	0.000
4	Water requirement for Bigodi Mining Project	365	5	1	0.001
Total groundwater draft					**40.689**

5.3 Ground Water Balance

Ground water balance in respect of the study area has been estimated as per GEC 97 guidelines and is indicated in **Table-14**. Ground water balance flow diagram is placed as **Figure-16**. As per GEC 97 norms, areas where ground water resources assessment shows stage of ground water development at 70% or lower and there is no significant long term decline of pre or post monsoon ground water levels are categorized as “Safe” areas with potential for development; more than 70%, but less than 90% and either pre or post monsoon ground water level shows a significant long term decline are categorized as “Semi Critical” areas with cautious ground water development; more than 90% but less than 100% are categorized as “Critical”; more than 100% are categorized as “Over-exploited”.

The study area forms part of Amarpatan tehsil of Satna district and Rewa tehsil of Rewa district. The average stage of ground water development in these tehsils as per CGWB assessment is 82.00% and categorized as “Semi Critical” (Amarpatan – Semi Critical with 98% and Rewa - Safe with 66%).

The present stage of ground water development in the study area including proposed project requirement is estimated as 68.02% and can be categorized as “Safe”.Considering the following factors:

- There are no industries in the study area;
- Ground water abstraction in the study area is only for domestic and agriculture purposes through bore wells;
- Study area is towards Rewa district with northeastern part falling in Rewa tehsil categorized as “Safe” in terms of ground water development; and
- 16% of the study area in the southern and eastern part covered by forest and Govindgarh Reservoir in the SE supporting irrigation to a reasonable extent.

categorizing study area as “Safe” in terms of ground water development is justified.

Table-14. Ground Water Balance

Sr.No.	Particulars	Quantity (MCM)
I	Gross groundwater recharge	66.47
ii	Natural discharge to drain and other losses – 10% of (i)	6.65
Iii	Net groundwater availability (i-ii)	59.82
iv	Annual groundwater draft for all uses	40.69
v	**Groundwater balance (iii-iv)**	**19.13**
vi	Water requirement for the proposed project (after 5 years)	0.001
Vii	Balance of groundwater left for development	19.13
viii	**Present stage of groundwater development in study area**	**68.02%**
iX	Present stage of groundwater development in Amarpatan tehsil (98% - Semi Critical), Satna district and Rewa tehsil (66% - Safe), Rewa district as per CGWB District Profiles	82.00% Semi Critical
X	**Stage of ground water development including use for proposed project**	**68.02%**

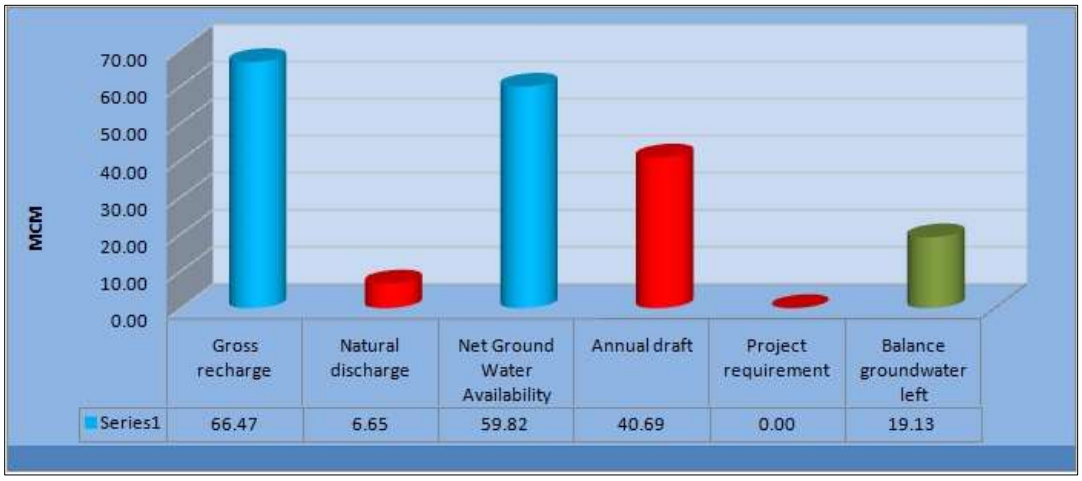


Figure-16. Ground water Balance in Study Area

Hydrogeology study to assessment of the impact on ground water and its percolation effects on adjacent area

The average water levels derived from reduced water level data during pre and post monsoon seasons in the ML area are observed to be around 10.95 m bgl and 5.66 m bgl respectively. A review of CGWB monitoring well data in the study area indicate that the average monsoon, post monsoon rabi, post monsoon kharif and pre monsoon water levels at these locations are 2.45 m, 5.18 m, 3.49 m and 7.48 m bgl respectively with an average fluctuation of 5.03 m.

The present stage of ground water development in the study area including proposed project requirement is estimated as 68.02% and can be categorized as “Safe”.

Impact of proposed mining project on ground water will be due to abstraction of ground water for the project use and de-watering ground water inflow into the mine pits.

Water requirement of the project is 183 KLD (183 m^3/day – 54,900 m^3/300 working days in a year – 0.055 MCM/300 working days in a year) for dust suppression, washing of mining machinery, plantation and domestic purposes, initially up to 5^{th} year from ground water. Of the total water requirement, domestic water requirement at the mine site for mine office, mine workers etc., is 5 KLD (5 m^3/day) which will be met from bore well till the end of mining period. Break-up of water consumption is as given under:

Purpose	Water requirement KLD	Source
Dust suppression at mine	128	Initially from groundwater and subsequently from mine pit reservoir
Dust suppression at crusher	10	
Green belt	30	
Domestic	5	
Workshop	10	
Total	**183**	

Hence the long term ground water withdrawal will be only 5 KLD (5 m^3/day) and it will not have any adverse impact.

De-watering ground water inflow in to the mine pits will have impact on ground water levels in the area up to the resulting radius of influence. Estimation of ground water inflow in to the mine pit at different stages is not done as the mine plan is yet to be finalized. Ground water inflow in to the mine pits will start after mine workings intersecting the then water table/aquifer position at later stages of mining. The pumped out ground water from the mine pit inflows will be utilized for the project needs, domestic supply to the nearby villages and irrigation to the surrounding agriculture lands. Any excess pumped out water will be discharged into Bihar Nadi with appropriate filtration arrangements to allow clean water. Removing top soil and weathered zone if any, which is the natural recharge zone and de-watering from the mine working area to keep the mine surface dry allowing mining activity will alter the percolation/recharge conditions in the mine working area.

However, to neutralize the ground water withdrawal, it is proposed to undertake necessary rain water harvesting and recharge measures. Considering 80% of the run-off as available volume after evaporation, spillage and first flush wastage, 7,766 m^3 is the run-off volume estimated as available for project activities from the roof top rain water harvesting. The amount of rainfall available from plantation/green belt and undisturbed area of 77.917 ha for rain water harvesting and ground water recharge is 1,33,471 m^3.

ANNEXURE-5
RESETTLEMENT & REHABILITATION

RCCPL Private Ltd. obtained Letter of Intent (LoI) for ML area in villages Sannehi Singti, Dithoura and Karaundi (184.149 Ha) of Tehsil: Amarpatan, District: Satna from Department of Mineral Resource, Govt. of Madhya Pradesh vide letter no. F 3-1 / 2018 / 12 / 1 dated 24/03/2018. LOI copy stating the village and block wise details given in Enclosure-1. Summarised village wise Khasra details are provided in **Table-1**.

TABLE-1
VILLAGE WISE KHASRA DETAILS

Sr. No.	Name of Village	Survey No.	Area (Ha)
1	Dithora	478-492, 695-713, 716, 726, 728, 733, 734, 736-799, 803, 804, 807-809, 811, 815-819, 821-825, 827, 828, 841-844, 847-875, 878-882, 886-891, 893, 894, 896-899	125.313
2	Sannehi Singti	8-12, 20-24, 26-32, 35, 38-46, 54, 55, 71, 72, 75, 77-101, 152-155, 158, 159, 219, 220	31.777
3	Karaundi	692-703, 705-710, 713, 717-732, 736, 738-742, 744-746, 748-779	27.059
Total			184.149

Land Use Details:

Land use details of the proposed mining lease area are mentioned in **Table-2**.

TABLE-2
LAND USE OF ML AREA

District	Tehsil	Village	Govt. Land (Ha)	Private Land (Ha)	Area (Ha)
Satna	Amarpatan	Sannehi Singti	0.105	31.672	31.777
		Dithora	9.053	116.260	125.313
		Karoundi	5.251	21.808	27.059
		Total	14.409	169.740	184.149

- **Private Land:**

The major crops are paddy, wheat & gram. Cropping data of Bigodi ML area, Amarpatan Tehsil and Satna District was collected on-line from the Govt. records for the year 2018 –19. The same are summarised as **Table-3**.

TABLE-3
CROPPING DETAILS

Area	Cropping Area (Ha)	
	Rabi	Kharif
Inside Mine Lease	151	134
Amarpatan Tehsil	36,772	31,218
Satna District	3,30,102	2,98,261

From the above table, it is evident that total area under Rabi and Kharif crops within ML is only 0.42% of total crop area of Amarpatan Tehsil and 0.045% of total crop area of Satna District. Thus, diversion of agriculture land in Bigodi ML is not likely to have any significant impact on cropping area on regional scale.

- **Government Waste Land:**

  The government land is 14.409 ha. Government Land shall be used as per the prevailing rules and after proper permission from the Dist. Collector.

- **Resettlement & Rehabilitation Studies**

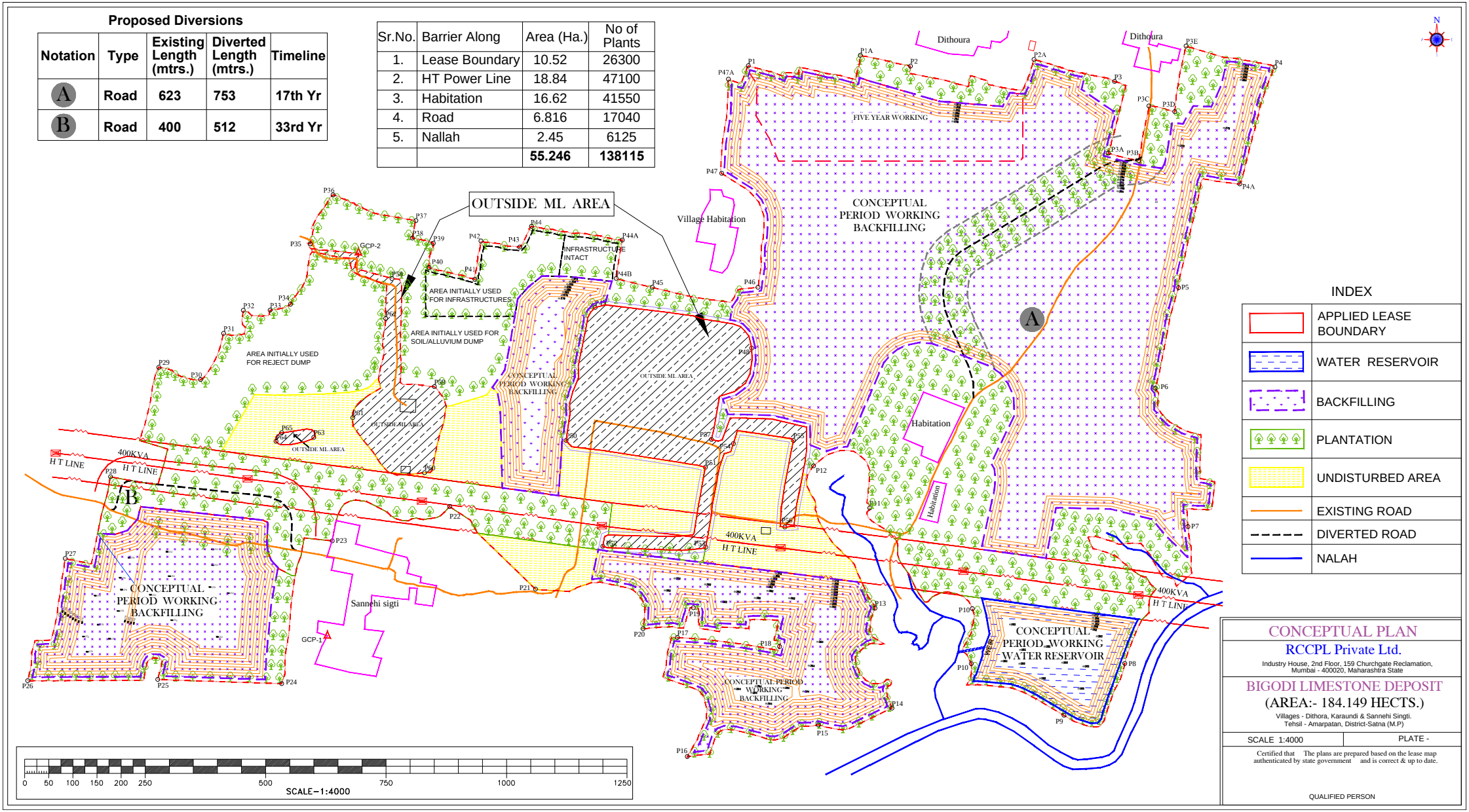
There are no homestead oustees within the lease area and land outstees will be around 306 nos. Detailed Resettlement & Rehabilitation Studies will be carried out and submitted along with Final EIA-EMP report. The R&R studies will be carried out with below objectives:

- To assess the socio-economic conditions of the project affected families/people;
- To examine both positive and negative impacts of the proposed project on socio- economic conditions of the project affected families/people;
- To prepare a general demographic profile of the Project Affected Village;
- To assess the existing resources (natural and common property) and possible impact on them;
- To examine the pros and cons of the project on social and economic lives of the people due to displacement and alienation of their agricultural land and other means of livelihood;
- To understand the mood, perception, demand, and extent of preparedness of the people living in the affected villages and command area of the project.

Proposed Diversions

Notation	Type	Existing Length (mtrs.)	Diverted Length (mtrs.)	Timeline
A	Road	623	753	17th Yr
B	Road	400	512	33rd Yr

Sr.No.	Barrier Along	Area (Ha.)	No of Plants
1.	Lease Boundary	10.52	26300
2.	HT Power Line	18.84	47100
3.	Habitation	16.62	41550
4.	Road	6.816	17040
5.	Nallah	2.45	6125
		55.246	**138115**



INDEX

	APPLIED LEASE BOUNDARY
	WATER RESERVOIR
	BACKFILLING
	PLANTATION
	UNDISTURBED AREA
	EXISTING ROAD
	DIVERTED ROAD
	NALAH

CONCEPTUAL PLAN

RCCPL Private Ltd.

Industry House, 2nd Floor, 159 Churchgate Reclamation, Mumbai - 400020, Maharashtra State

BIGODI LIMESTONE DEPOSIT

(AREA:- 184.149 HECTS.)

Villages - Dithora, Karaundi & Sannehi Singti.
Tehsil - Amarpatan, District-Satna (M.P)

SCALE 1:4000 | PLATE -

Certified that The plans are prepared based on the lease map authenticated by state government and is correct & up to date.

QUALIFIED PERSON

ANNEXURE - 7

PROTECTION MEASURES FOR RIVER AND NALLAH IN THE VICINITY OF MINE

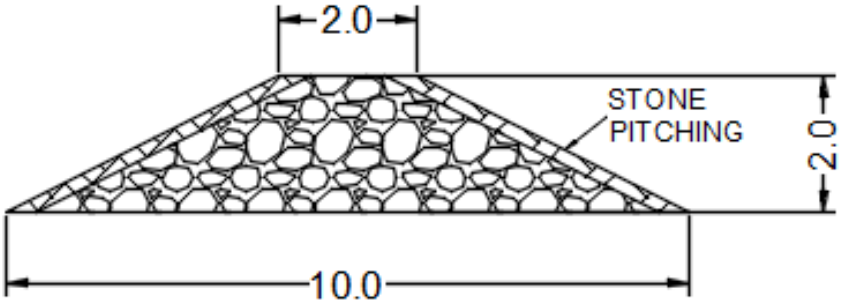
For Bihar Nadi (Seasonal River)

- Bihar nadi flows around 50 m away along the lease boundary towards SE direction. It is a seasonal nadi
- One pit towards Southern side of the lease area has been proposed to be converted to water reservoir after exhaustion of mineral. Area of the pit is 5.54 ha.
- Safety barrier of 50 m will be left from the HFL.
- There is a water stream flowing close to proposed water reservoir pit, which connects to the Bihar Nadi.
- Maximum holding capacity of water reservoirs would be about 1.55 Million CuM.
- Weir will be constructed within the lease area in the mining pit up to the elevation of 312 m RL. Overflow from the water reservoir, if any, would be diverted above the weir, having top RL of 312 m. It would allow mine water sediments to settle down and only clean water would overflow the weir and join the water course to the Bihar Nadi.
- Thick plantation will be done in the safety barrier @ 2500 trees per ha. Total number of trees will be around 1500.

Protection measures and Proposed Diversion for Nallahs flowing across the Lease Area (Seasonal Nallah)

- Three seasonal nallahs flow inside lease area towards East, West and South-East side, as seen on the Topo-sheet, but actually only one small nallah exists on ground towards SE side
- Water flows in Nallah during rainy season only.
- These nallahs are not well-developed stream courses
- These are discontinuous due to agricultural activity, seasonal and carrying mainly sheet flow from the agricultural fields downstream joining Bihar nadi

- No mining is proposed around streams flowing in the West and south-East side. Thus, these two streams will not be disturbed.
- A small portion of water stream flowing in N-S direction towards East side of the lease area would be diverted on the western side in the non-mining area. Existing length of proposed diversion is 783 m whereas after diversion it would be 949 m.
- Mining is proposed after leaving safety barrier of 50 m from the water stream.
- Strong embankment of following dimension will be constructed along the water stream on either side within lease area between water stream and mine pits:
    - Length: 2140 m
    - Bottom width: 10 m, Top width: 2 m
    - Height: 2 m
    - Side slopes $<30^0$
    - Stone pitching will be done on the slope of embankment
- Thick plantation will be done in the safety barrier @ 2500 trees per ha. Total number of trees will be around 27,425.
- Schematic sectional design of the embankment is shown here. Top RL of the embankment will be kept two meter above the existing ground RL so as to arrest flooding.



Annexure - 8

Top Soil Management Plan

- Thickness of soil and alluvium is from 1 to 13.5 m
- Soil will be scrapped carefully and stacked separately
- Soil dump will be suitably terraced at 10 m height to keep ultimate dump slope $<28^0$
- Retention wall and garland drains will be provided around the soil dump
- Dump will be covered with temporary cover with shrubs
- Soil will be utilized for plantation purpose and spreading over the backfilled area which will be on an average 2.31 m thick layer
- Typical Soil dump is shown below along with garland drain, retention wall and plantation of shrubs to maintain fertility.