केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti

Government of India

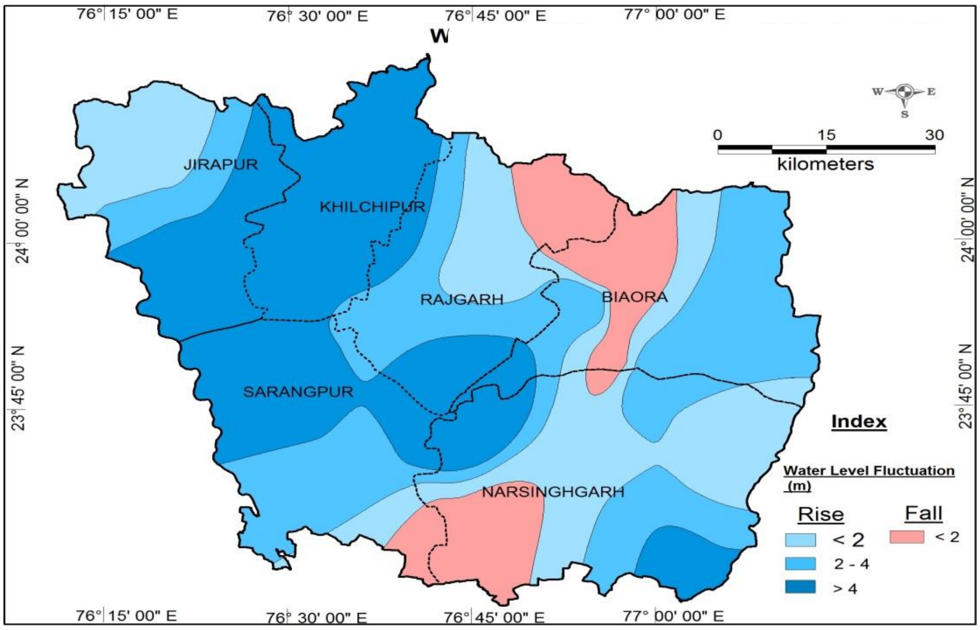
AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

RAJGARH DISTRICT
MADHYA PRADESH

उत्तर मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

AQUIFER MAPPING AND GROUND WATER MANAGEMENT PLAN OF RAJGARH DISTRICT, MADHYA PRADESH



By

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Preface

Aquifer mapping can be defined as a scientific process, wherein a combination of geologic, geophysical, hydrologic, and chemical field and laboratory analyses are applied to characterize the quantity, quality, and sustainability of groundwater in aquifers. Systematic aquifer mapping is expected to improve our understanding of the geologic framework of aquifers, their hydrologic characteristics, water levels in the aquifers and how they change over time, and the occurrence of natural and anthropogenic contaminants that affect the portability of groundwater. Results of these studies will contribute significantly to resource management tools such as long-term aquifer monitoring networks and conceptual and quantitative regional ground-water-flow models used by planners, policymakers, and other stakeholders.

Under the project on National Aquifer Mapping (NAQUIM), Central Ground Water Board (CGWB) North Central Region, Bhopal has taken up Rajgarh district to prepare the Aquifer Maps for the entire district and formulate Aquifer Management Plan. Out of 6155 sq. km of geographical area, 5879 sq. km (100%) is ground water recharge worthy area. Rivers of Chambal Sub-basin drain the entire Rajgarh district. Most part of the district is mainly occupied by Deccan trap; rest by Alluvium and Vindhyan. As per the Dynamic Ground Water Resource Assessment Report (Estimated by CGWB for the year 2020),The net ground water availability in the district is 77503.75 ham and ground water extraction for all uses is 65419.73 ham, making stage of ground water extraction 84.41 % as a whole for the district. After successful implementation of the supply-side and demand-side management plan the stage of extraction in Rajgarh district is expected to improve condition of the district in terms of ground water. The interventions suggested in the report will not only have a positive impact on the groundwater regime but would also play a key role in augmenting the net cropping area and would ultimately enhance the agricultural productivity and economy of the district.

I would like to place on record my appreciation of the untiring efforts **Sh. S. K. Shrivastava, Scientist-D** for preparing the Aquifer maps and Management plan and compiling this informative report. I fondly hope that this report will serve as a valuable guide for the sustainable development of Ground Water in the Rajgarh District, Madhya Pradesh.

Rana Chatterjee
(Regional Director)

CHAPTER-1
INTRODUCTION

Aquifer mapping can be defined as a scientific process, wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. Systematic aquifer mapping can improve our understanding of the geologic framework of aquifers, their hydrogeologic characteristics, water levels in the aquifers and how they change over time, and the occurrence of natural and anthropogenic contaminants that affect the potability of ground water. Results of these studies will contribute significantly to resource management tools such as long-term aquifer monitoring networks and conceptual and quantitative regional ground-water-flow models used by planners, policy makers and other stake holders. Aquifer mapping at the appropriate scale can help to prepare, implement and monitor the efficacy of various management interventions aimed for long-term sustainability of our precious ground water resources, which in turn, will help to achieve drinking water security, improved irrigation facilities and sustainability in water resources development in the country as a whole. Various on-going activities of Central Ground Water Board, such as ground water monitoring, ground water resource assessment, artificial recharge and ground water exploration in drought, water scarcity and vulnerable areas can also be integrated in the aquifer mapping project.

1.1. Objectives:

Aquifer Mapping is an attempt to combine a combination of geologic, hydrologic and chemical analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifer. The major objectives of aquifer mapping are;

- Delineation of lateral and vertical disposition of aquifers and their characterization on 1: 50,000.
- Quantification of ground water availability and assessment of its quality to formulate aquifers. Management plans to facilitate sustainable management of ground water resources at appropriate scales.

1.2. Scope of the Study:

The social outputs and benefits are less tangible but their significance in the contest of sustainable management of ground water resources cannot be underestimated.

- Involvement of community and stakeholders would enable the State Governments to manage their resources in an efficient and equitable manner, thereby contributing to improve overall development.
- Demystification of science will result in better understanding of aquifers at community level. The amalgamation of scientific inputs and traditional wisdom would ensure sustainable ground water resource management.
- Community participation and management would ensure sustainable cropping pattern, thereby contributing towards food security.

1.3. Approach and Methodology:

National Aquifer Mapping Programme basically aims at characterizing the geometry, parameters, behavior of ground water levels and status of ground water development in various aquifer systems to facilitate Major Aquifers for planning of their sustainable management. The major activities involved in this process include compilation of existing data, identification of data gaps and generation of data for filling data gaps and preparation of aquifer maps. The overall methodology of aquifer mapping is presented once the maps are prepared, plans for sustainable management of ground water resources in the aquifers mapped shall be formulated and implemented through participatory approach involving all stakeholders. Methodology is shown in fig.1.1.

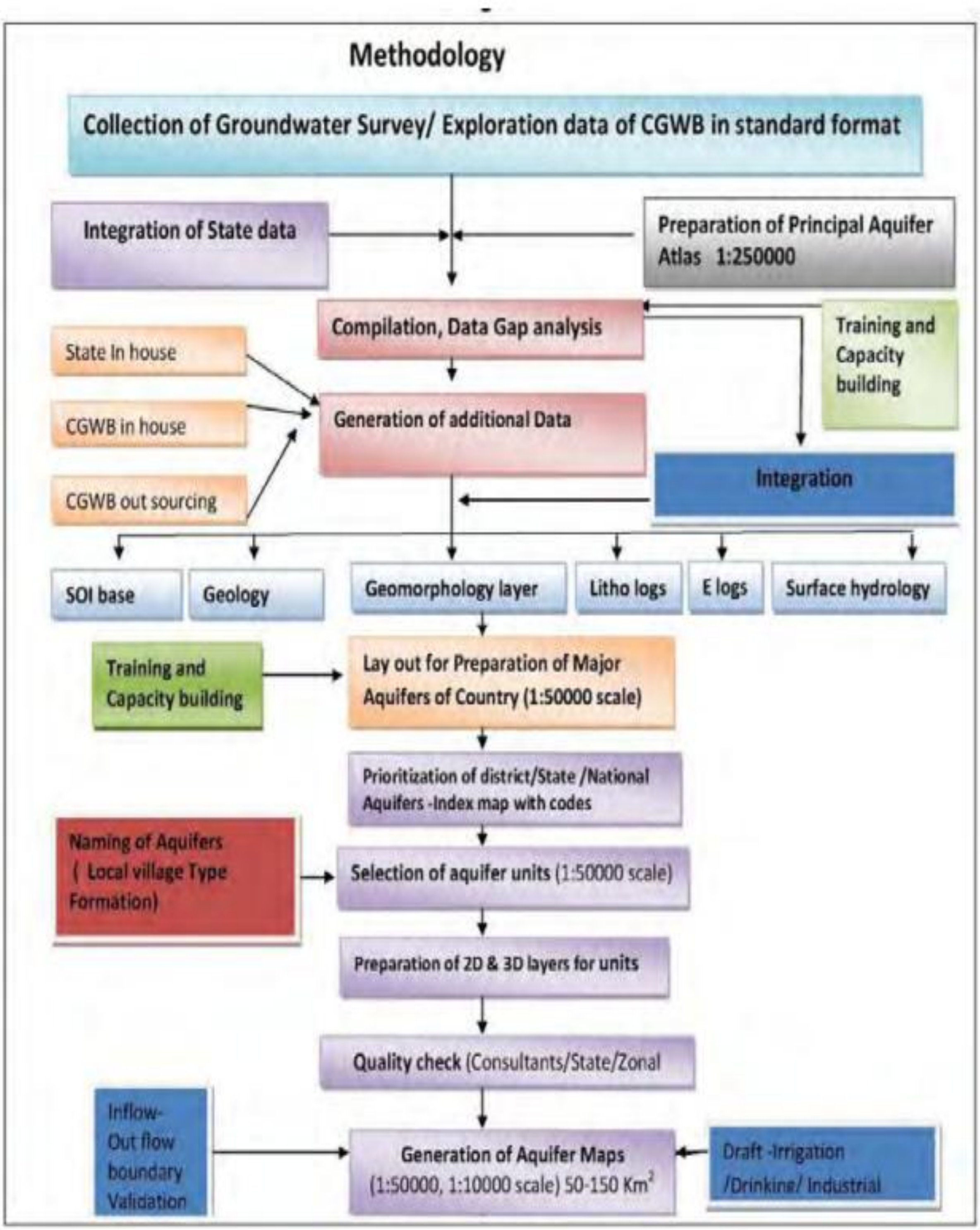

Fig. 1.1 Methodology

1.4. Study Area:

Rajgarh district is located in the western part of the state of Madhya Pradesh and occupies as area of 6,155 sq km.with a population of 15, 46,541 according to census 2011. The district extends between the North latitudes 23^0 27' 12" and 24^0 17' 20" and between the meridians of east longitudes $76^0$11' 15" and 77^0 14'. The district of Sehore, Bhopal, Guna and Jhalawar (Rajasthan) bounded it from the southeast, east, northeast, and north directions respectively. The district is well connected by road NH-3, NH-7 and railway network. The district falls in survey of India toposheet Nos. 55A, 55E and 54D. Details of blocks in the study area are given in Table 1.1 and fig. 1.2 represents administrative map of Rajgarh district.

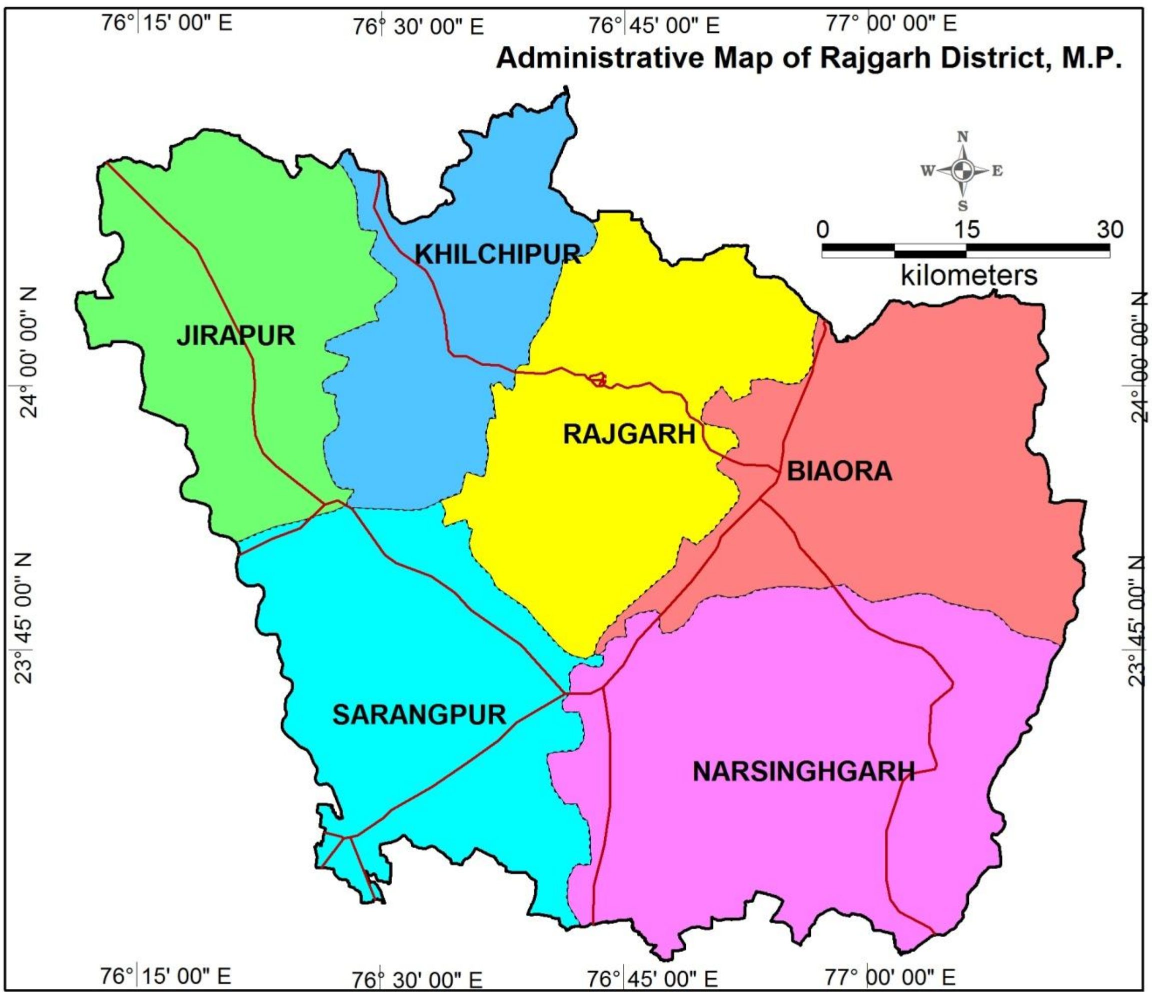

Fig. 1.2 Administrative map of Rajgarh District

Table 1.1: Detail of Blocks in the study area

S. No.	Block	Sub-Division	Area in Sq Km	No. of Villages
1	Rajgarh	Rajgarh	1105	387
2	Khilchipur	Khilchipur	0792	335
3	Zirapur	Zirapur	0845	220
4	Biora	Biora	1148	287
5	Narsinghgarh	Narsinghgarh	1368	306
6	Sarangpur	Sarangpur	0905	192

1.5. Rainfall and Climate:

The climate of the Rajgarh district can be classified mainly into three seasons. Winter season starts from middle of October to end of February. March to May constitute summer season and the monsoon season starts from second week of June to end of September. The normal annual rainfall of Rajgarh district is 985.8 mm. The district receives maximum rainfall during southwest monsoon period i.e. June to November. About 92% of annual rainfall is received during monsoon season. Average annual rainfall of district is given in table 1.2.

During winter season the December is the coldest month with the temperature falling as low as 4.8^0 C and max up to 29.5^0 C. During the month of June, temperature goes up to 45.6^0 C (max.).

Table 1.2: Average annual Rainfall of Rajgarh District

S. No	Block	2010-11 Rainfall (mm)	2011-12 Rainfall (mm)	2012-13 Rainfall (mm)	2013-14 Rainfall (mm)	2014-15 Rainfall (mm)
1	Khilchipur	1372.0	918.0	918.0	1327.8	1278.2
2	Narsinghgarh	1202.2	1132.0	1132.0	1651.2	1209.0
3	Biora	1728.4	1170.6	1170.6	1927.9	1040.1

S. No	Block	2010-11 Rainfall (mm)	2011-12 Rainfall (mm)	2012-13 Rainfall (mm)	2013-14 Rainfall (mm)	2014-15 Rainfall (mm)
4	Rajgarh	1595.3	925.9	925.9	1464.4	917.0
5	Sarangpur	1813.3	1274.4	1274.4	1539.0	975.8
6	Zirapur	1380.0	1082.0	1082.05	1526.5	1022.7
	District Total	1513.1	1084.3	1080.4	1571.9	1073.8

1.6. Physiography:

Rajgarh district forms the part of Malwa plateau, generally an undulating topography. The Vindhyan hill range occupies the south-eastern part of the district. The basaltic rocks of Malwa plateau occupy almost entire district except southeastern part. Recent alluvium deposits are found along the river course. The highest elevation of 576.08 m amsl in the district is recorded near Narsinghgarh, a hillock of Vindhyan ranges.

Rivers of Chambal Sub-basin drain the entire Rajgarh district. All the rivers are almost northerly flowing. Kalisindh and Parwati rivers at western and eastern side bounded the district respectively. The Newaj River flows through the middle portion of the district.

Almost three-fourth area of the district is covered with black cotton soils forms by the weathering of basaltic rocks. The rest part of the district area is covered with yellowish-red, mixed soils derived from sandstone and shale. Thealluvial soils are found along the river courses. The higher elevations i.e. the hilly regions have a cover of murum, which is made up of small rounded pieces of weathered basalts. The Vindhyans have a thin cover of sandy loams. The alluvium is derived from hill slopes by numerous streams and water channels.

1.7. Geomorphology:

Generally in Rajgarh district the landforms have been classified on the basis of genetic factor and the geomorphic processes involved. Further, the geomorphic units have been classified on the basis of differential erosion of rock material, process and relief amplitude.

a) Denudational Landforms

b) Depositional Landforms

c) Structural Landforms

a) Denudational Landforms:

- Denudational Hills, and Volcanic: These are remnants of natural dynamic process of denudation, weathering and fluvial action. The geomorphic forms occur as residual hills, denudational hills with scree or debris. These have high relief and steep sided slopes and are generally highly jointed and fractured. These have poor ground water potential. DNH (M) occupy the central and western parts of the area covering Raigarh town and the area west of it.
- Deccan Plateau: this is the largest landform in the district covering large tracts in the area. It is formed due to volcanic eruption of basaltic lava having very low dip slopes. The upper-most part of the plateau comprises of soil whereas the lower part is hard. Low relief and undulating topography characterize the plateau. This unit has moderate ground water potential, especially along lineaments and in the weathered formation.
- Structural Hills, Vindhyan Sediments: These are mostly composed of sandstones of Vindhyan super group and are associated with folds and are criss-crossed by joints and fractures etc. These occur in the form of linear to actuate hills depicting definite trend lines. These have poor ground water potential.
- Linear Ridge: These are also composed of Vindhyan sandstone and occur as long and narrow ridges and represent areas of high run-off. The ground water potential of this landform is almost negligible.

b) Depositional Landforms:

- Alluvial Plain: This unit occupying a large tract in the eastern parts of the area comprising, sand, silt and clay. This area has a flat to gently undulating topography of low relief and has good to excellent ground water potential.

c) **Structural Landforms:**

- The lineaments and the ridges formed due to folding and faulting form these landforms.

1.8. Soil cover :

Almost three-fourths area of the district is covered with black cotton soils formed by the weathering of basaltic rocks. The rest part of the district area is covered with yellowish-red, mixed soils derived from sandstone and shale. The alluvial soils are found along the river courses. The higher elevations i.e. the hilly regions have a cover of murum, which is made up of small rounded pieces of weathered basalts. The Vindhyans have a thin cover of sandy loams. The alluvium is derived from hill slopes by numerous streams and watercourses.

1.9. Drainage:

Rivers of Chambal Sub-basin drain the entire Rajgarh district. All the rivers are almost northerly flowing. Kalisindh and Parwati rivers at western and eastern side bound the district respectively. The Newaj River flows through the middle portion of the district. The drainage pattern is dendritic type. The southern most tip of the district is drained by the Narmada river. However the major part of the area falls in the Ganga basin. The drainage of the district is towards north and north east. The five rivers, from west to east are the Bina, the Dhasan, the Bewas, the Sonar and the Bamner. The Bina takes its course upto several Kilometers to the south of the district and enters it near village Mahura. After flowing through Rahatgarh, the river takes a north easterly course and at places forms the boundary with Vidisha district. Drainage map of district is given in fig.1.3.

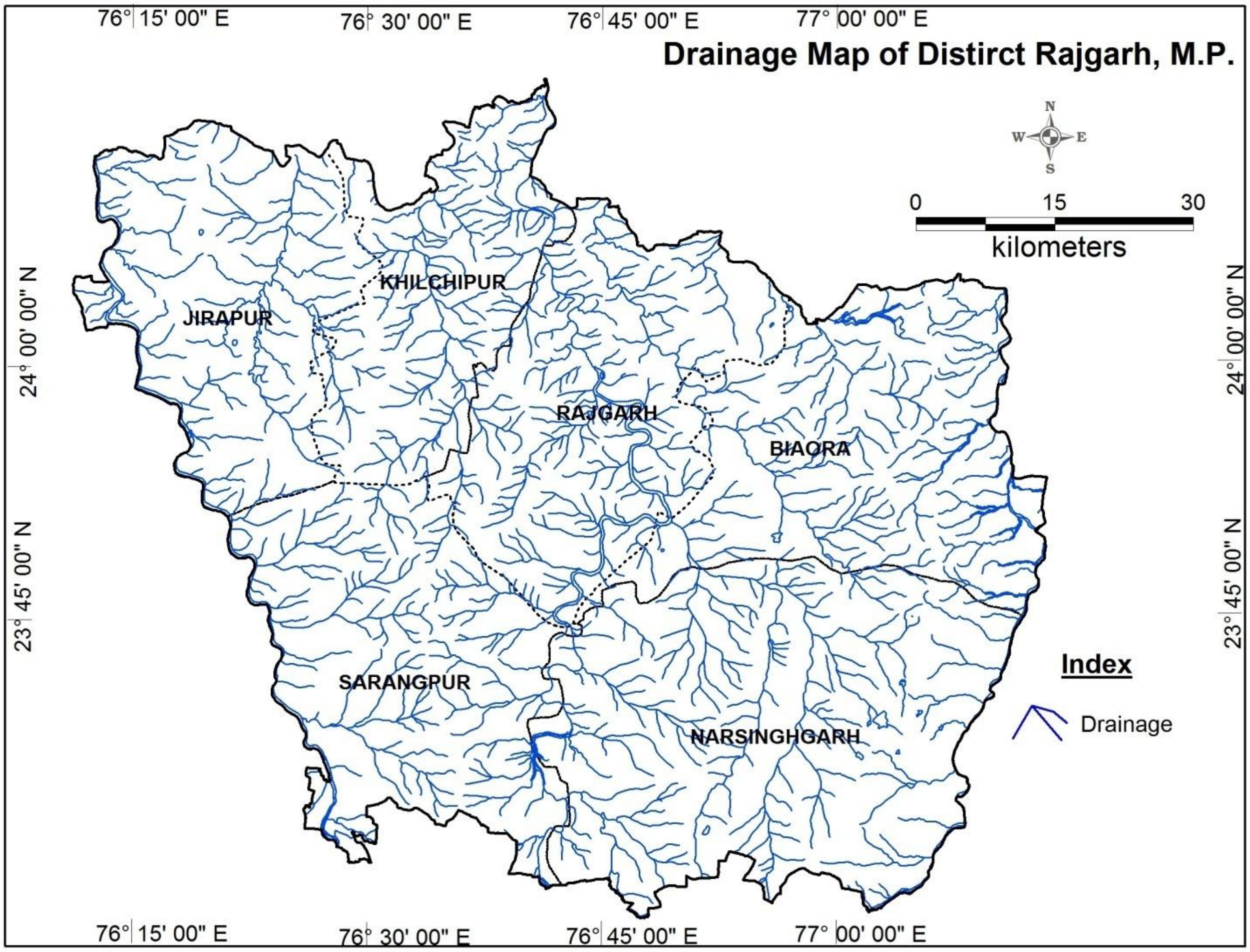

Fig.1.3: Drainage Map of Rajgarh District

1.10. Land Use, Irrigation and Cropping Pattern:

As per the district statistical handbook 2015, the total area of Raigarh district is 6154 sq.km. out of which agricultural area is 267.50 sq.km., 176.36 was under forests,568.51 sq.km. other non-cultivable land excluding barren land and non-cultivable land is 733.78 sq.km; waste land 65.35 sq.km. respectively, Net Shown Area is 4345.78 sq.km. and double crop area is 3504.11 sq. km. Rivers of Chambal Sub-basin drain the entire Rajgarh district. All the rivers are almost northerly flowing. Kalisindh and Parwati rivers at western and eastern side bounded the district respectively. The Newaj River flows through the middle portion of the district.

The area irrigated by tube wells was 65543 ha, by open-wells is 236149 ha, by canals was 3853 ha and by ponds 15395 ha. The total area under irrigation from various sources was only 79.12 % of the net sown area.

The principal crop grown during Rabi season is Wheat. It is sown in an area of 210616 ha. The other major rabi crop is gram under which an area of 74655 ha is sown. Paddy is sown in an area of 261 ha. The total area under cereal crops is 100624 ha and under oilseeds it is 356678 ha. Irrigation details of district is given in table 1.3.

Table 1.3: Irrigation Details

Block	**Tube Well Irrigated Area (Ha)**	**Dug Well Irrigated Area (Ha)**	**Ground Water Irrigated Area (Ha)**	**Canal Irrigated Area (Ha)**	**Pond Irrigated Area (Ha)**	**Other Water Irrigated Area (Ha)**
Khilchipur	2182	29638	31820	-	3973	1477
Narsinghgarh	22418	46122	68540	1848	1137	4819
Biora	4924	49692	54616	97	1888	5182
Rajgarh	2662	28315	30977	211	7082	5217
Sarangpur	11303	25249	36552	-	462	1019
Zirapur	6412	34543	40955	1697	306	1051

CHAPTER-2

DATA COLLECTION AND GENERATION

2.1. Hydrogeology:

- **Geology:**

The general geological succession in the district is given below (Table 2.1):

Table 2.1: General geological succession of Rajgarh district

Age	Stratigraphic Unit	Lithology
Quaternary to Recent		Alluvium and Laterite
---------------------- Unconformity -----------------------		
Upper Cretaceous to Lower Eocene		Deccan Trap Basalt
Upper Proterozoic	Vindhyan Super Group (Bhander Group)	Sandstone and shale

Rajgarh district forms the north western part of Malwa plateau, generally having undulating topography. The Vindhyan hill range occupies the southeastern part of the district. The basaltic rocks of Malwa plateau occupy almost entire district except southeastern part. Recent alluvium deposits are found along the rivers.

- **Hydrogeology:**

The general hydro-geological conditions of the district are depicted in fig. 2.1 and formation wise settings are discussed below:

- **Vindhyan Super Group**

The rocks of the Vindhyan Super Group are exposed in the southern and southeastern part of district. These rocks form NW-SE trending ridges and small isolated hillocks (inliers). The Upper Bhander sandstone is reddish brown to purple in colour, massive, medium to coarse grained, exhibiting well-defined bedding with plenty of current bedding and occasional ripple marks. The sandstone is highly jointed with four sets of prominent vertical joints. Because of its compact nature the Bhander sandstone is poor repository of groundwater. In sandstone, the joints and fractures control the occurrence of groundwater in areas located in topographical depression and adjacent to surface water bodies. The soil and weathered profile developed on the Vindhyan is generally thin and as a result groundwater occurs at shallow depth under unconfined conditions in the areas where the rocks are jointed, fractured and weathered. The Vindhyan rocks underlying the weathered basalts in topographical depressions are often found to form moderate aquifers. The surface water runoff along the slopes of hillocks formed by Vindhyan inliers is recharged to the deeper jointed and fractured sandstone through overlying cover of weathered basalt.

In the Vindhyan sandstone, primary porosity varies from negligible to as high as 30% depending on the degree of compaction. The storage and movement of ground water in these formation is controlled mainly by the secondary porosity and permeability created due to weathering, jointing and fractured. Ground water occurrence is good along the lineaments and occurs under water table condition. The tube wells of these formations yield up to two lps and the dug wells have yields upto 100 m^3/day.

- **Deccan Trap**

The Deccan Trap basalts occur in the district as lava flow infillings in the valleys of pre-existing Vindhyan topography. The Vindhyan sandstone show `baking effect' due to the hot lava coming in contact with sandstones, the lava flows are mostly `*Pahoehoe*' character and less of `*Aa*' character. The individual lava flow ranges from 10 to 30 m in thickness and consist generally of two units i.e. the upper most vesicular/amygdaloidal basalts with their weathered top portion often overlain by grey or red clay and the massive thin amygdular layer (with pipe amygdulars) towards the bottom.

Groundwater occurs in the weathered, vesicular, jointed and fractured basalt under unconfined to semi confined conditions. In areas where the weathered basalt layer is extensive a continuous phreatic aquifer can be traced to some distance. However due to low permeability of weathered basalt the aquifer sustains limited groundwater withdrawal mainly through open wells. On higher grounds the weathered basalts may be thin or even absent. In such condition groundwater occurrence is restricted to the joints and fractures. The groundwater in Deccan Trap at deeper levels occurs under semi-confined to confined conditions, at the different lava flow contacts, at Deccan trap and underlying Vindhyan contact or in the deeper jointed/fractured and vesicular amygdular basaltic horizons.

The thickness of the individual aquifer varies from a few centimeters to a few meters and is generally restricted in their regional extent. The recharge to the deep aquifers takes place from the phreatic aquifers through deep joints, faults and contact zones. The red bole horizons (clay) generally act as semi confining or confining layers for the deeper aquifers

- **Alluvium and Laterite**

Localized patches of alluvium cover occur along the banks of major and minor rivers and streams in the district. In general, it is difficult to differentiate between alluvium and product of black cotton soil underlain by yellow clay with kankar. The thickness of alluvium varies from few metres to 30 m. Laterite capping on top of Deccan Trap basalt are seen in localized patches. The rocks are generally bouldery in nature, highly ferruginous and weathered to yellowish red soil.

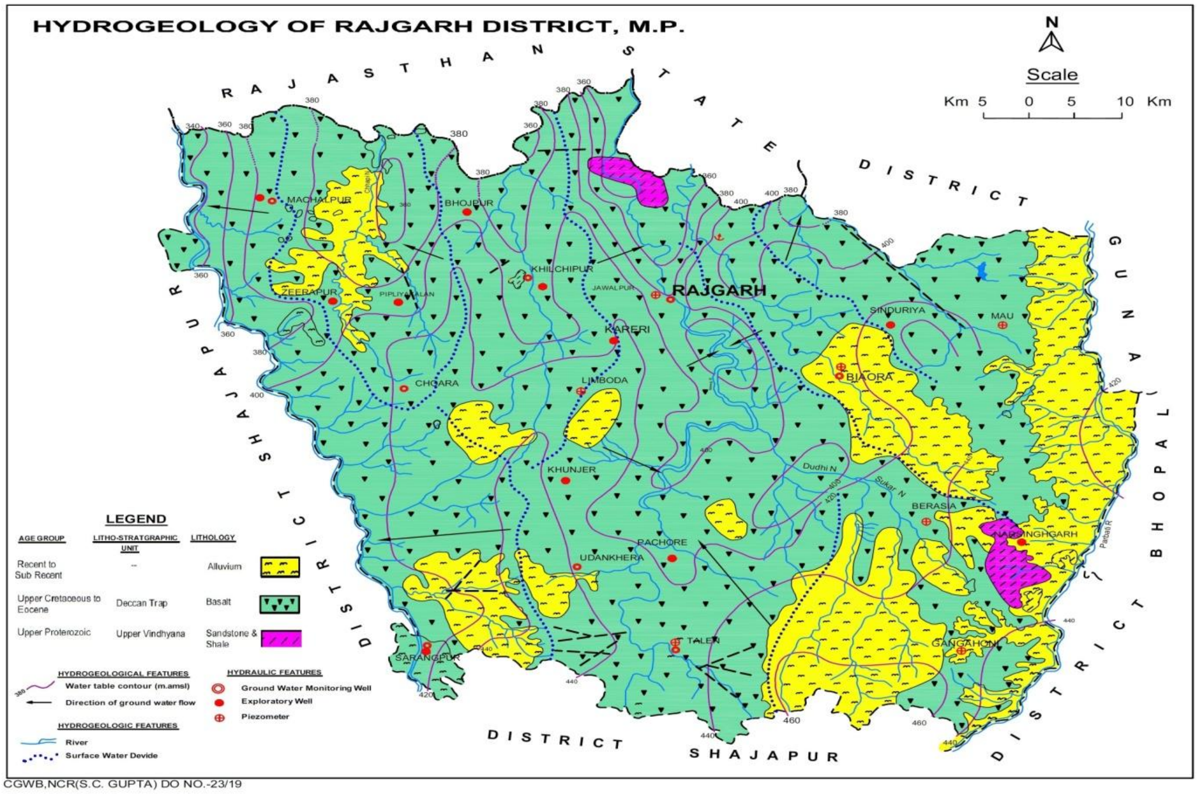

Fig.2.1: Hydrogeological Map of Rajgarh District

2.2. Ground water scenario:

The monitoring of ground water levels of the area gives a picture of the behavior of ground water regime over space and time. It is a very important parameter that is used in assessing the ground water resources and for future development. In Rajgarh district, CGWB is monitoring ground water levels four times a year. There are 21 national hydrograph stations (GWMW) and 12piezometers (7 Sallow + 5 Deep). The behavior of ground water regime for the pre-monsoon and post-monsoon periods of 2018 is discussed herewith.

Pre-monsoon (May 2021):

The Pre-monsoon depth to water level (DTWL) map is presented in fig. 2.2 and it ranges from 3.7 mbgl to 34.43 mbgl. However in major part the district it is more than 5 mbgl. Deeper water levels of more than 20mbgl are observed at Mohan and Machalpur villages in the district.

Post-Monsoon (Nov 2021):

The Post-monsoon depth to water level (DTWL) map is presented in fig.2.3. It ranges from 1.65 to 13.57 mbgl. In major part of the district DTWL was less than 10 mbgl. Deeper water levels of more than 10 mbgl are observed at Rajgarh village in the district. Table 2.2 represents the water level data of Rajgarh district

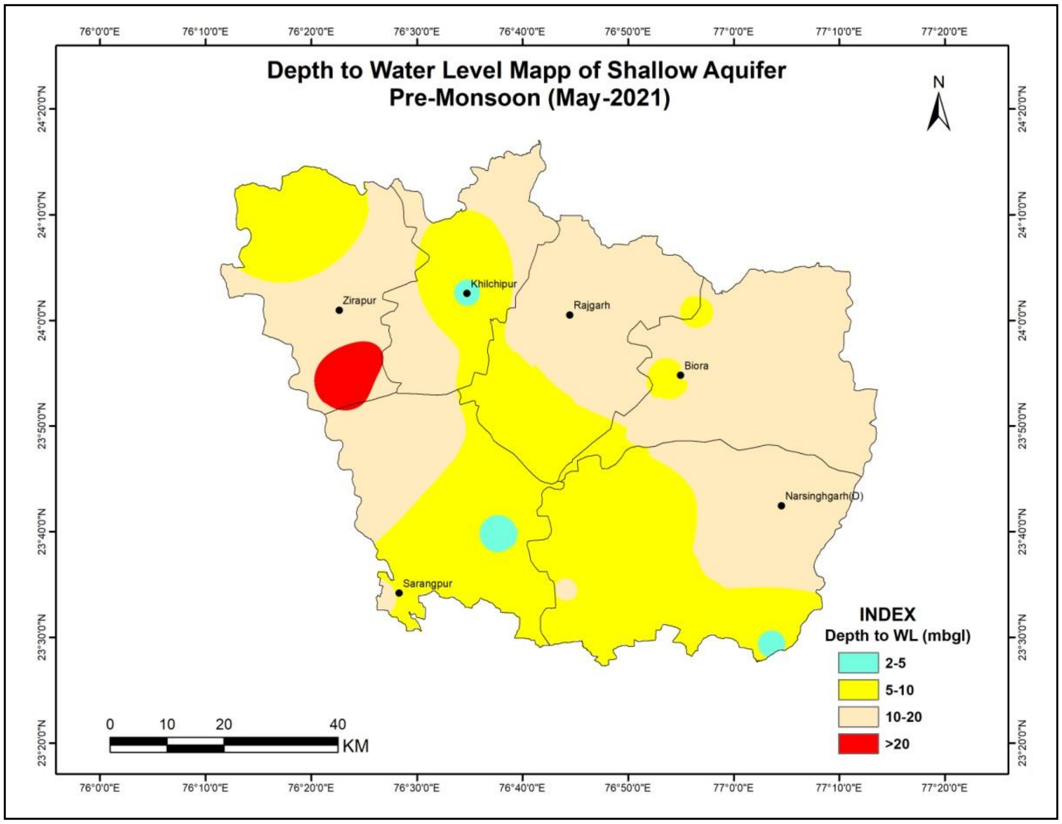

Fig.2.2: Pre-monsoon (May 2021) DTWL Map of Rajgarh district

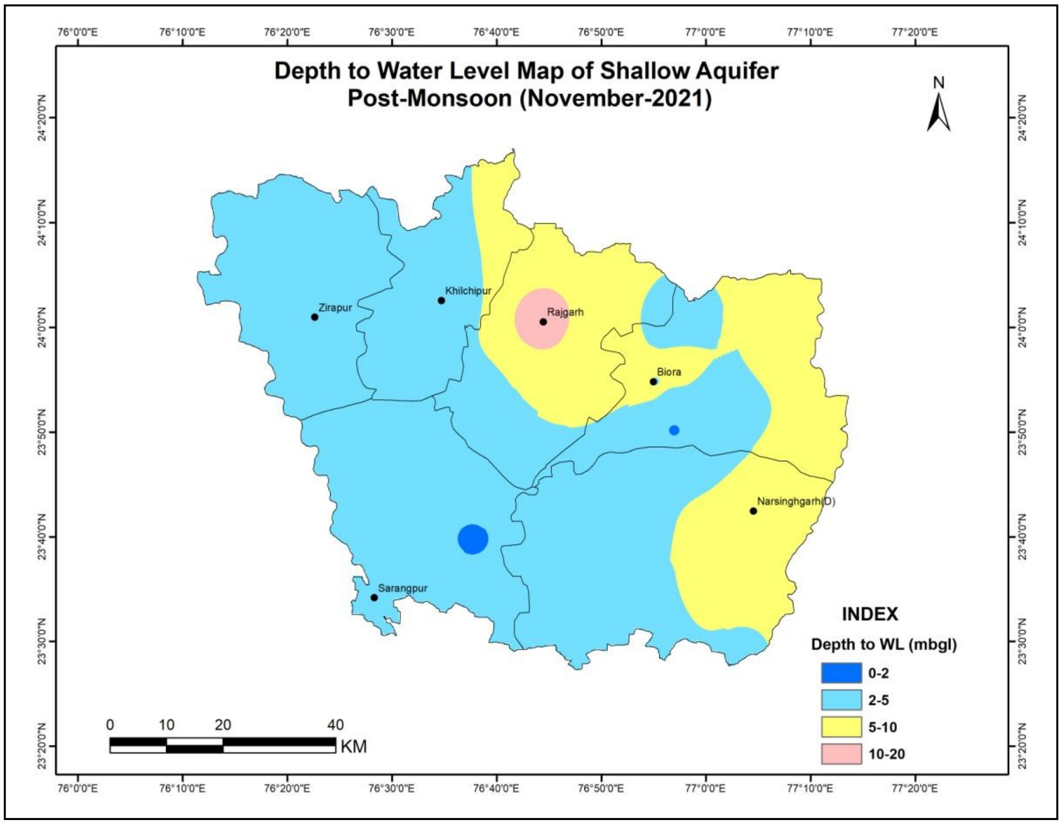

Fig.2.3 Post-Monsoon (Nov 2021) DTWL Map of Rajgarh district

Table . 2.2: Water Level Data (May 2021-Nov 2021)

Sl. No	BLOCK	Village	Lat	Long	Type of Well	Depth	May 2021	NOV 2021
1	BIAORA	Baiheda	23.8361	76.9497	Dug Well	13.9	12.2	1.85
2	BIAORA	Bapchi	24.0061	76.9433	Dug Well	18.3	9.25	3.15
3	BIAORA	Barkheda	23.9419	76.9550	Dug Well	20	14.35	5.7
4	BIAORA	Biora	23.9133	76.9167	Dug Well	15	10.68	4.82
5	BIAORA	Biora (D)	23.9106	76.9083	Piezometer	112	7.66	5.66
6	BIAORA	Biora(S)	23.9106	76.9083	Piezometer	42	10.65	2.98
7	BIAORA	Suthaliya	23.9956	77.1378	Dug Well	13.33		5.9
8	JIRAPUR	Chhapihera	23.8967	76.4533	Dug Well	30	10.6	3.8
9	JIRAPUR	Machalpur	24.1300	76.3139	Dug Well	15.78	5.57	2.8
10	JIRAPUR	Machalpur(D)	24.1300	76.3139	Piezometer	116	34.2	4.35
11	JIRAPUR	Machalpur(S)	24.1300	76.3139	Piezometer	30	4.6	3.55
12	JIRAPUR	Mohan(D)	23.9153	76.4125	Piezometer	90	34.43	4.13
13	JIRAPUR	Mohan(S)	23.9153	76.4125	Piezometer	31	8.12	2.12
14	JIRAPUR	Zirapur	24.0161	76.3775	Dug Well	12.3		3.58
15	KHILCHIPUR	Khilchipur	24.0425	76.5792	Dug Well	9.97	4.2	2.03
16	NARSINGHGARH	Bhagaribunglow	23.7992	76.9847	Dug Well	12.45	11.6	2.2
17	NARSINGHGARH	Ganayari	23.6906	77.0083	Dug Well	13.8	11.5	5.65
18	NARSINGHGARH	Gandhigram	23.6742	77.0694	Dug Well	14.8	13.32	6.47
19	NARSINGHGARH	Mandawar	23.7028	76.8825	Dug Well	17.05	6.6	4.2
20	NARSINGHGARH	Narsinghgarh(D)	23.7075	77.0758	Piezometer	80	14.6	8.8
21	NARSINGHGARH	Narsinghgarh(S)	23.7075	77.0758	Piezometer	31	14.94	6.79
22	NARSINGHGARH	Pachor	23.7089	76.7339	Dug Well	12	7.3	2.1
23	NARSINGHGARH	Pilukhedi	23.4911	77.0603	Dug Well	9	4.6	4.9

Sl. No	BLOCK	Village	Lat	Long	Type of Well	Depth	May 2021	NOV 2021
24	NARSINGHGARH	Talen	23.5761	76.7347	Dug Well	16	10.2	4
25	RAJGARH	Bawari	23.9864	76.8161	Dug Well	15	10.73	8.9
26	RAJGARH	Rajgarh(S)	24.0086	76.7414	Piezometer	28.5	18.82	13.57
27	SARANGPUR	Bamangaon	23.8828	76.6186	Dug Well	16	5.6	2
28	SARANGPUR	Khujner (S)	23.7750	76.6319	Piezometer	31	5.95	3.12
29	SARANGPUR	Khujner(D)	23.7750	76.6319	Piezometer	90	6.4	4.92
30	SARANGPUR	Sandavta	23.8336	76.5256	Dug Well	18.25	13.01	2.11
31	SARANGPUR	Sarangpur	23.5694	76.4722	Dug Well	12.5	7.4	4.9
32	SARANGPUR	Sarangpur(D)	23.5667	76.4611	Piezometer	120	13.08	4.48
33	SARANGPUR	Sarangpur(S)	23.5667	76.4611	Piezometer	37	11.84	3.24
34	SARANGPUR	Udhankheri	23.6644	76.6286	Dug Well	12.5	3.7	1.65

2.3. Ground Water Exploration:

CGWB has drilled 33 exploratory wells and 12 Piezometers in Rajgarh district. On the basis of samples collected during drilling, lithologs have been prepared. The aquifer parameters are calculated on the basis of pumping tests. The salient details of these bore wells are given in table. 2.3.

Table 2.3: Salient Features of the Exploratory Wells Constructed in Rajgarh District

Sl. No.	Location	Latitude	Longitude	Year of Drilling	Depth drilled	Depth Constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	T (m² / day)
1	Bhojpur	24.143056	76.511111	1989-90	146.4	146.4	Vindhyan Sandstone				DRY	
2	Biora	23.925	76.908333	1989-90	153.28	153.28	Jointed/ Fr. Basalt	6.0 - 9.0 15.0 - 18.0 33.0 - 39.0	39.75	2.80		
3	Boda	23.65	76.8	1990 - 91	100.17	100.17	Basalt	30.00 - 45.00 48.00 - 72.00 76.0 - 79.0	27.43	2.35	23	
4	Boda (indira colony)	23.65	76.8	1991 - 92	117.3	117.3	Basalt	73.5 - 77 77.5 - 79 79.5 - 82 107 - 112	22.5	6.00	30.8	
5	Chhota-berasia	23.683333	77.783333	1990 - 91	159.6	159.6	Basalt			Negligible		

Sl. No.	Location	Latitude	Longitude	Year of Drilling	Depth drilled	Depth Constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	T (m² / day)
6	Eklara	23.55	76.870833	1991 - 92	202.6	202.6	Basalt			Negligible		
7	Jwalpapur	24.019444	76.684722	1988 - 89	138.18	138.18	Basalt	33.48 - 36.48 76.18 - 88.38	4.9	2.80	26.97	90
8	Kalipeeth	24.05	76.801389	1990 - 91	79.3	79.3	Basalt	55.0 - 77.0	44.4	5.50	13.9	17.4
9	Karedi	23.931944	76.665278	1988 - 89	116.45	116.45	Basalt	38.0 - 40.0 73.74 - 75.75 108.74 - 109.74 113.74 - 116.45	19.98	13.25		
10	Khajuria	23.829167	76.9125	1989-90	158.6		Basalt	9.1- 12.2 64.1 - 76.3 112.9 - 119.0	5.62	8.20	3.25	

Sl. No.	Location	Latitude	Longitude	Year of Drilling	Depth drilled	Depth Constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	T (m² / day)
								146.4 - 155.6				
11	Khilchipur	24.022222	76.588889	1989-90	109.8	109.8	Basalt	48.0 - 52.0 55.0 -58.0 98.5 - 103.5	8.61	5.00	6.29	
12	Khujner -i	23.7875	76.620833	1988 - 89	138.7	138.7	Basalt			1.00	42	
13	Khujner -ii	23.7875	76.620833	1988 - 89	171	171	Basalt	62.0 - 65.0 68.0 - 71.0 80.0 - 86.0 129.0 - 153.0	33.42	2.80	43	
14	Lasudiaramnath- i	23.533333	77.033333	1990 - 91	184		Basalt	52.8-55.9,70.1-74.2,86.4-95.5,101.6-107.6,150.4-159.6,177.	3.35	1.13	44.95	

Sl. No.	Location	Latitude	Longitude	Year of Drilling	Depth drilled	Depth Constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	T (m² / day)
								9-184				
15	Limachauhan	23.470833	76.476389	Sep-91	122	122	Basalt	76.0 - 98.0 103.0 - 122.00	55.15	4.25		13.37
16	Limboda	23.854167	76.633333	1990 - 91	153.1	151	Basalt	95.5 - 101.5 138.0 - 150.00	7.93	0.70		0.15
17	Machalpur	24.129167	76.3125	1989 - 90	152.5	152.5	Basalt	54.0 - 62.0	1.49	2.30	44.63	0.7
18	Mahu	23.626389	76.570556	1991 - 92	203.3	203.3	Basalt		3.75	2.20	43.8	
19	Mandawar - i	23.7	76.783333	1990 - 91	112.8		Basalt			Negligible		
20	Mandawar - ii	23.7	76.783333	1990 - 91	195.85	195.85	Basalt	62.0 - 83.3 126.0 - 114.3 159.6 -	7.79	2.35	45	

Sl. No.	Location	Latitude	Longitude	Year of Drilling	Depth drilled	Depth Constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	T (m² / day)
								168.7 177.8 - 190.1				
21	Mau	23.704167	77.097222	1990 - 91	170.8	170.8	Basalt	82.0 - 93.0 102.0 - 106.00	17.4	2.50	42.8	
22	Mundla	23.816667	76.8375	Jun-05	178.2	178.2	Basalt	57.0 - 64.0 94.5 - 100.5 149.0 - 152.0	26.5 1	7.00	14.85	44.2 7
23	Narsinghgarh	23.704167	77.097222	1989 - 90	88.5	88.5	Basalt	18.0 - 24.0 30.0 - 36.00	7.58	3.00	10.5	
24	Pachor	23.705556	76.7375	1989 - 90	176.9	70	Basalt	52.0 - 60.5 64.0 - 68.00	6.64	1.00	16.94	2
25	Parsulia	23.853056	76.853333	1991 - 92	172.3	172.3	Basalt	50.7 - 67	.35	1.50	42.25	37.8

Sl. No.	Location	Latitude	Longitude	Year of Drilling	Depth drilled	Depth Constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	T (m² / day)
								72- 96 99 -118 128 - 132 137- 144 147- 152	magl			
26	Mau	23.704167	77.097222	1990 - 91	170.8	170.8	Basalt	82.0 - 93.0 102.0 - 106.00	17.4	2.50	42.8	
27	Mundla	23.816667	76.8375	Jun-05	178.2	178.2	Basalt	57.0 - 64.0 94.5 - 100.5 149.0 - 152.0	26.5 1	7.00	14.85	44.2 7
27	Narsinghgarh	23.704167	77.097222	1989 - 90	88.5	88.5	Basalt	18.0 - 24.0 30.0 - 36.00	7.58	3.00	10.5	
29	Sarangpur	23.574722	76.472778	1989 - 90	110.8	110.8	Basalt	98.6 - 107.7	63.2	10.50	45	

Sl. No.	Location	Latitude	Longitude	Year of Drilling	Depth drilled	Depth Constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	T (m² / day)
30	Sinduria - i	24.023611	76.919444	1989 - 90	29.6	29.6	Basalt	29-32,41-48.5,	27.88	10.40	1.77	
31	Sinduria - ii	24.023611	76.919444	1989 - 90	202.3	202.3	Basalt	29-32,41-48.5	23.68	4.04	4.95	
32	Sinduria - iii	24.023611	76.919444	1989 - 90	49.1	49.1	Basalt	29.0 - 32.0 41.0 -48.5	21.6	1.50		
33	Talen	23.583333	76.7	1990 - 91	150.4		Basalt			Negligible		
34	Zirapur	24.033333	76.325	Mar-89	158.6	158.6	Basalt	12.2 - 15.2 46.0 -48.0	12.49	5.20	36.45	4.65

2.4. Hydrochemistry:

Ground Water Quality of Rajgarh District:

As per chemical analysis of pre-monsoon 2018, the ground water in the area of Rajgarh district is neutral to slightly alkaline in nature and the pH of ground water ranged in between 7.22 to 8.30; the highest value of pH (8.30) has been observed in Bapchi dug well.

The electrical conductivity of ground water in Rajgarh district ranged between 591 to 1571 µS/cm at 25°C and the maximum EC value at Pachor (1571 µS/cm at 25°C). The electrical conductivity shows that the ground water is good to slightly saline in nature and at some locations i.e.Pachor (1571 µS/cm at 25°C). The fluoride concentration was ranged in between 0.19 to 1.93 mg/l. In the district, fluoride concentration has not been observed more than BIS recommendation of fluoride concentration in drinking water i.e. 1.5 mg/l except in the dugwell of Udhankheri (1.93 mg/l), Pilukhedi (1.74 mg/l) and Chhapihera (1.57 mg/l) villages. The maximum concentration of fluoride has been recorded in the dug well of Udhankherii.e. 1.93 mg/l. In the district, nitrate concentration in ground water ranged in between 1 to 217 mg/l. About 84% ground water samples recorded nitrate concentration within the acceptable limit of 45 mg/l and 16% water samples recorded more than 45 mg/l as per BIS recommendation. The high nitrate concentration has been recorded in ground water of Sarangpur (64 mg/l), Pachor (79 mg/l) and Biora (217 mg/l). Total hardness of ground water in the study area ranged in between 50 to 658 mg/l. The high concentration has been observed in the dug well of Suthaliya (658 mg/l) and Pachor (653 mg/l).

As per the piper diagram (fig.2.4), water samples are Calcium Chloride (permanent hardness), Calcium Bi-carbonate (temporary hardness), Sodium Chloride, Sodium Bi-carbonate and Mixed Type (Calcium Magnesium Chloride) of water. The US Salinity Diagram (fig.2.5) shows the ground water is medium to high salinity classes i.e. C_2S_1, C_3S_1, C_2S_2 and C_3S_2. The C_2S_2 and C_3S_2 classes of water may be used for irrigation purpose with proper soil management.

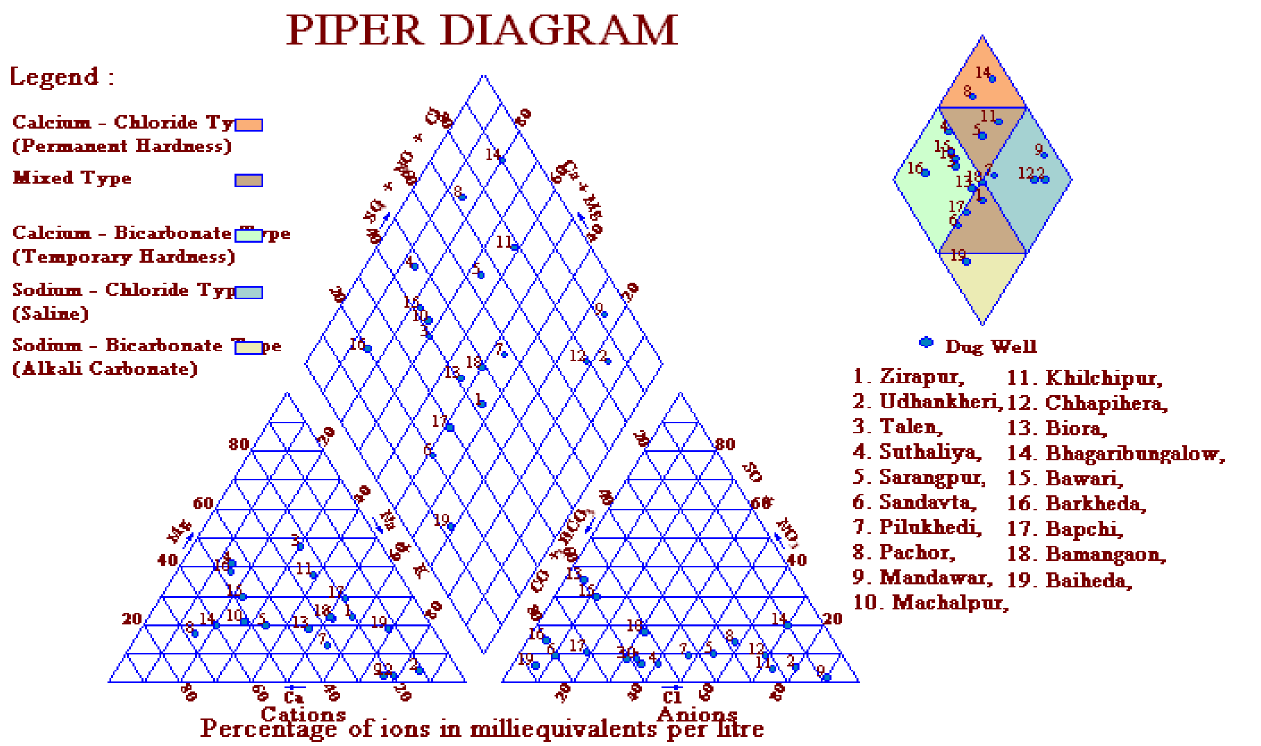

Fig.2.4: Piper diagram for Rajgarh district

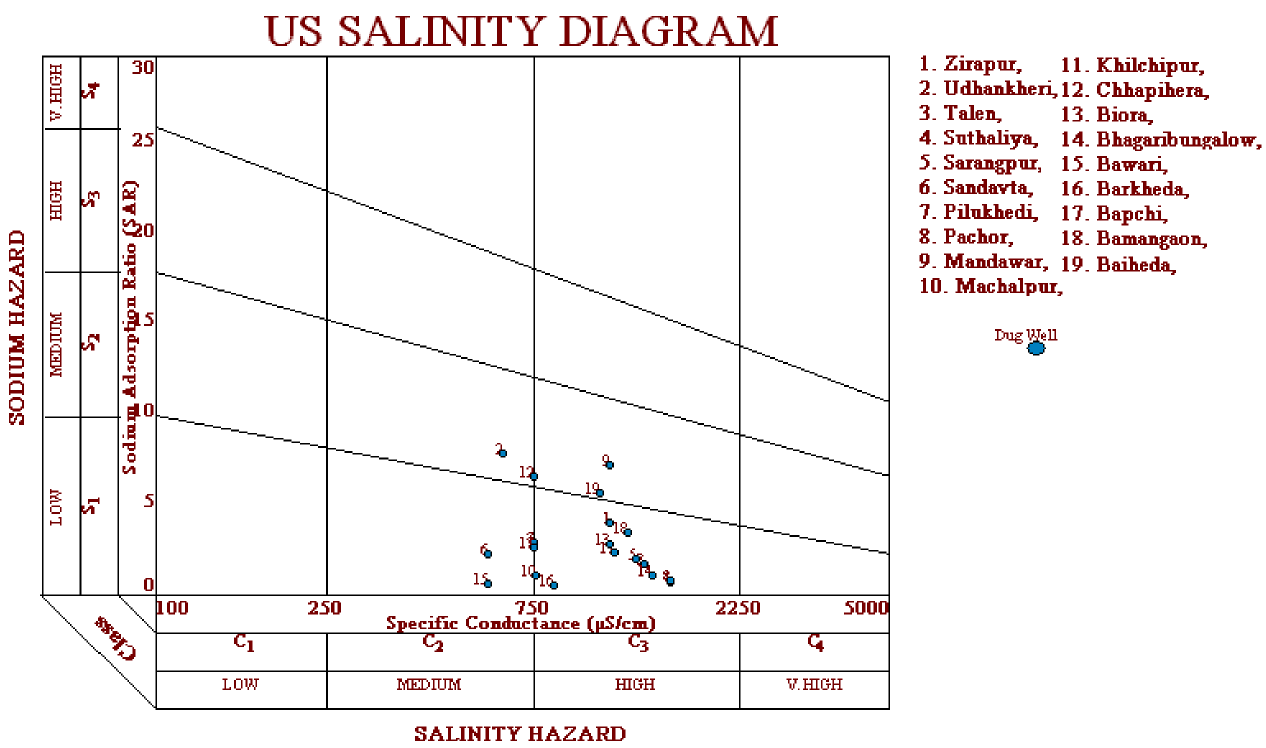

Fig.2.5: US Salinity diagram

2.5 Hydrogeophysics

A total of 145 VES were conducted in this district. The location of the VES shown in the fig. 2.6. The interpreted results of the 145 nos. of VES are given in table 2.4. Out of these 145 VES at 100 VES sites weathered zone is delineated. The resistivity of the weathered zone ranges from 3 to 70 ohm.m. It extends to a maximum depth of 83 m at VES 139. At 51 sites the resistivity is more than 10 ohm m. But depth to the bottom is more than 10 m for only 20 sites and can be tapped by dug wells. However, out of these 100 sites at 49 sites the resistivity is less than 10 ohm.m. It indicates the possible deterioration in water quality or increase in soil salinity.

The weathered zone is underlain either by a highly resistive massive basalt layer or by a layer with resistivity higher than that of the weathered zone. In either case it is not possible to delineate the deeper vesicular and massive fractured basalt associated with lesser resistivities. Instead, a geoelectrical layer of varied thickness is delineated which cumulatively represents the succession of vesicular-massive –fractured basalt. The resistivity of the geoelectrical layer could be 20 ohm.m, indicate the presence of fractured basalt. A resistivity value less than 50 ohm.m indicate Vesicular- fracture basalt at detected at 110 number of VES sites. At 60 sites the resistivity which is lesser than 50 ohm.m and little higher than 50 ohm m is detected. At 2 VES sites resistivity values less than 10 ohm.m was inferred. It could be associated with deeper occurrences of poor quality water as well the presence of Red Bole (clay). The qualitative analysis has indicated the presence of thin fractured zones at 62 different depths.

2.5.1. Geo-Electrical Cross Sections, Lithological 3d Model and Fence Diagram of Rajgarh District:

Based on the interpreted VES results, Geoelectrical Cross Sections, Lithological 3d Model and Fence Diagram have been prepared through Rockwork software.

Cross section AA’ (Fig.2.7) has been prepared through the VES 134, 144, 145, 31, 42, 33, 91,98, 100, 105,5, 17,1 and 28 in West to East direction. This cross section reveals that weathered besalt formation depth ranges from 6 to 35 mbgl with resistivity ranges from 11 to 67 ohm.m and the maximum depth of weathered basalt formation observed in the VES 144. Below this layer vesicular basalt depth ranges 85 o 191 mbgl with resistivity ranges from 42 to 169 ohm.m and maximum depth of the vesicular basalt formation observed in VES 5. From this section weathered basalt followed by massive basalt observed in the western part the section where as weathered basalt followed by massive basalt, Vesicular basalt and massive basalt in eastern part at VES 5, 17, 1 and 28 of the section.

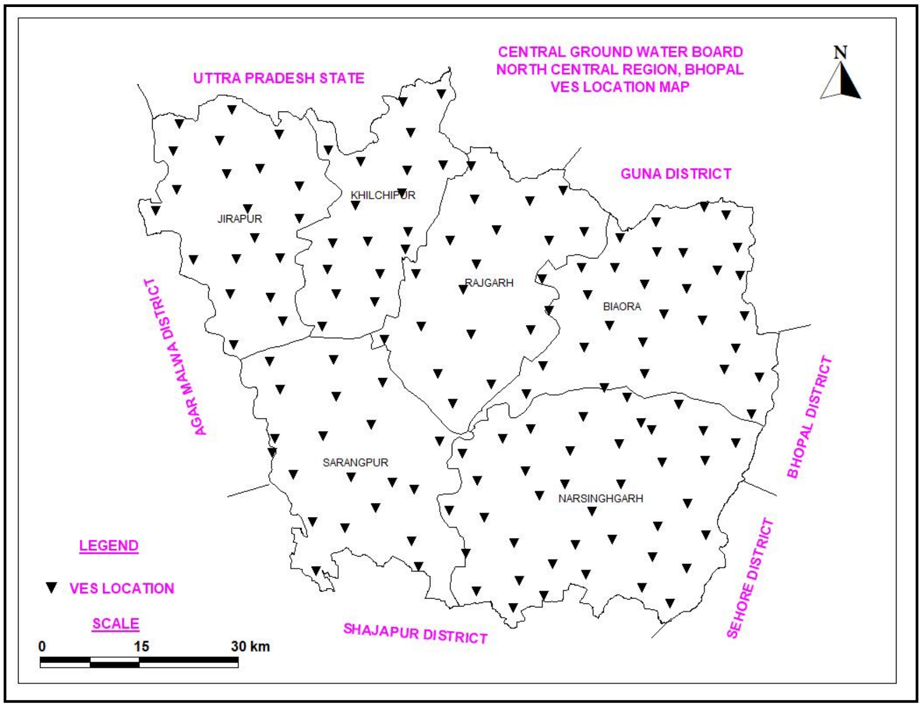

Fig. 2.6. Location of the VES in Rajgarh District

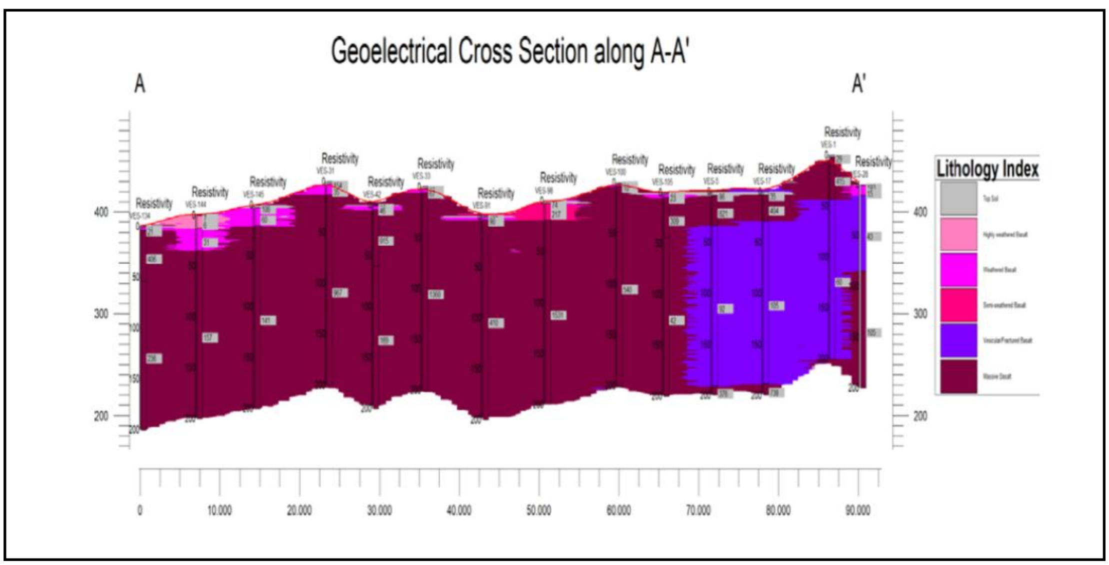

Fig. 2.7. Geoelectrical Cross Section along AA' Rajgarh District

Cross section BB' (Fig.2.8) has been prepared through the VES 119, 115, 88, 114, 64, 90, 59, 73, 69, 76 and 86 in West to East direction. This cross section reveals that weathered basalt formation depth ranges from 6 to 27 mbgl with resistivity ranges from 4 to 51 ohm.m and the maximum depth of weathered basalt formation observed in the VES 90. Below this layer vesicular basalt depth ranges 43 to 191 mbgl with resistivity ranges from 12 to 191 ohm.m and maximum depth of the vesicular basalt formation observed in VES 114. From this section weathered basalt encountered at top layer and followed by massive basalt in the entire section where as Vesicular basalt noticed at VES 90 and 59. Bottom of the layer is demarked massive basalt.

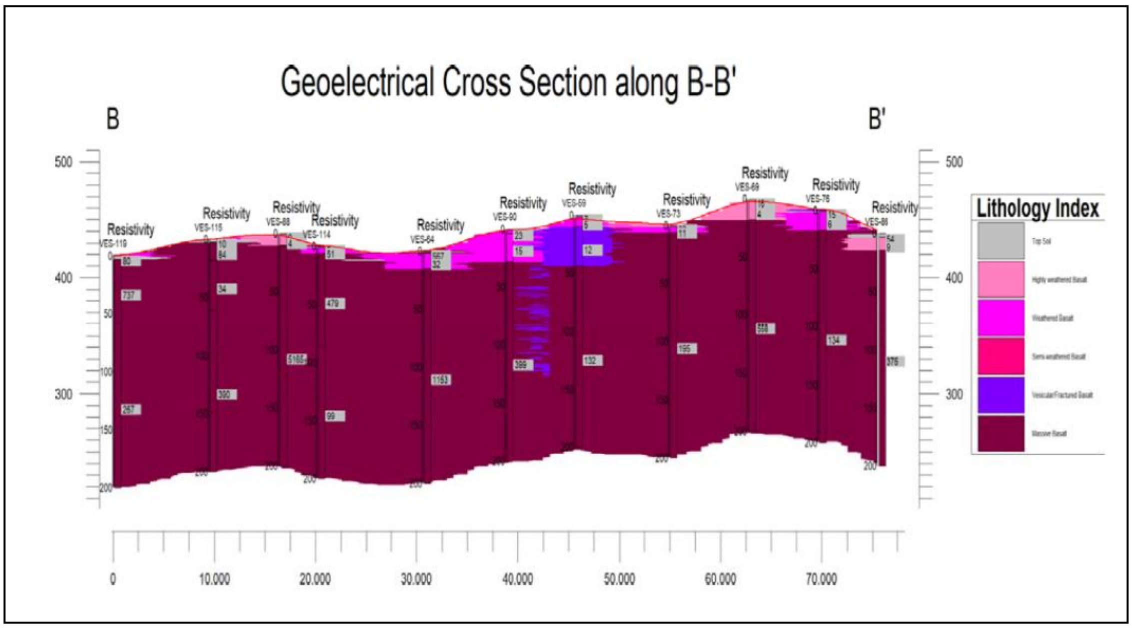

Fig. 2.8. Geoelectrical Cross Section along BB' Rajgarh District

Cross section CC' (Fig.2.9) has been prepared through the VES 44, 37, 41, 35, 49, 33, 99, 97, 102, 96, 121, 82, 64, 72, 89, 63 and 70 in North and South direction. This cross section reveals that weathered basalt formation depth ranges from 4 to 15 mbgl with resistivity ranges from 4 to 110 ohm.m and the maximum depth of weathered basalt formation observed in the VES 64. Below this layer vesicular basalt depth ranges 32 to 66 mbgl with resistivity ranges from 109 to 144 ohm.m and maximum depth of the vesicular basalt formation observed in VES 49. From this section weathered basalt encountered at top layer and followed by massive basalt.

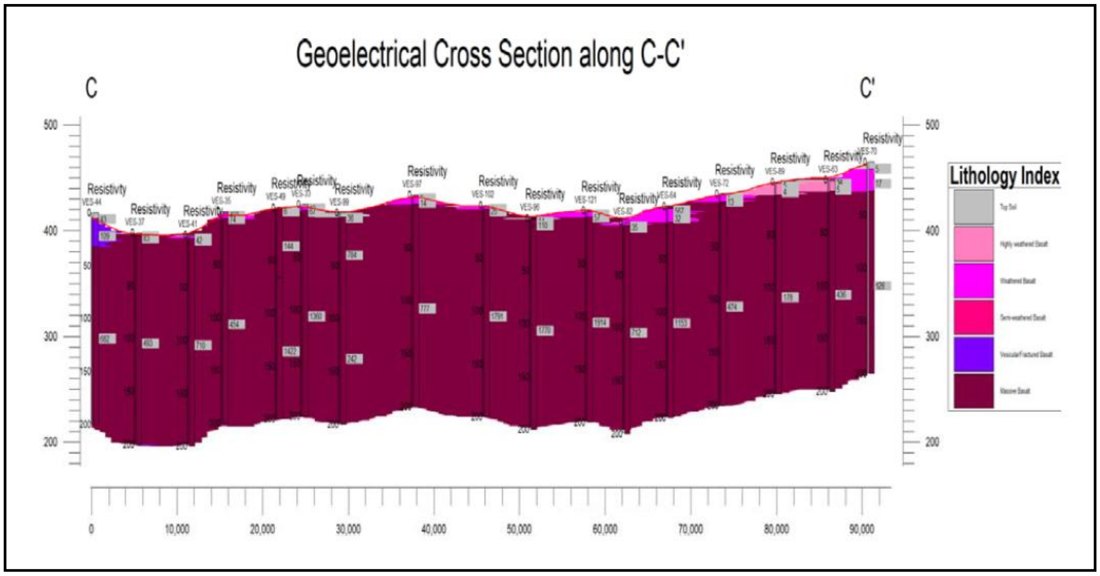

Fig. 2.9. Geoelectrical Cross Section along CC' Rajgarh District

From Lithological Fence Diagram (Fig. 2.13) of Rajgarh District, entire site found that shallow weathered basalt , and in N-E site shallow and deep vesicular basalt and below massive basalt formation.

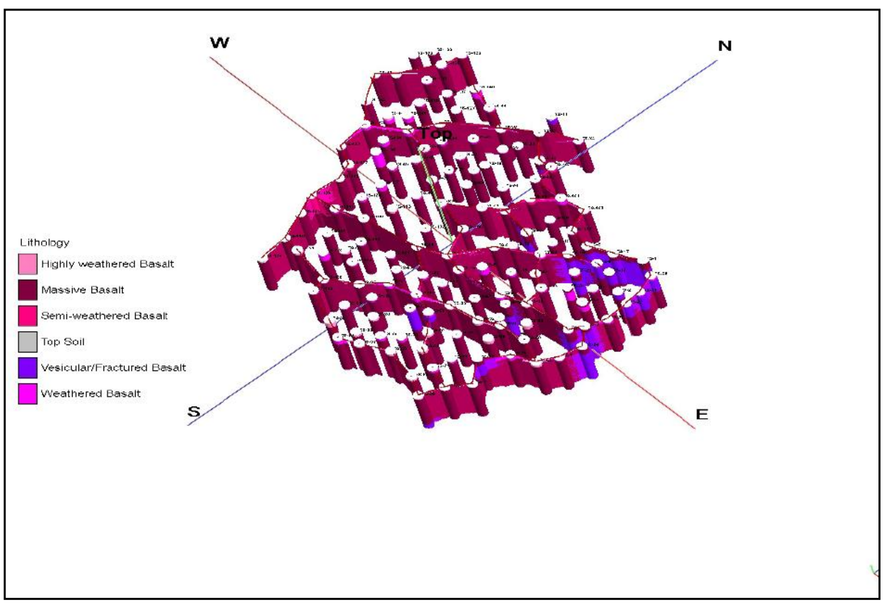

Fig 2.10. Lithological Fence Diagram, Rajgarh District

From Lithological 3D model (Fig. 2.11) of Rajgarh District, entire site found that shallow weathered basalt , and in N-E site shallow and deep vesicular basalt and below massive basalt formation.

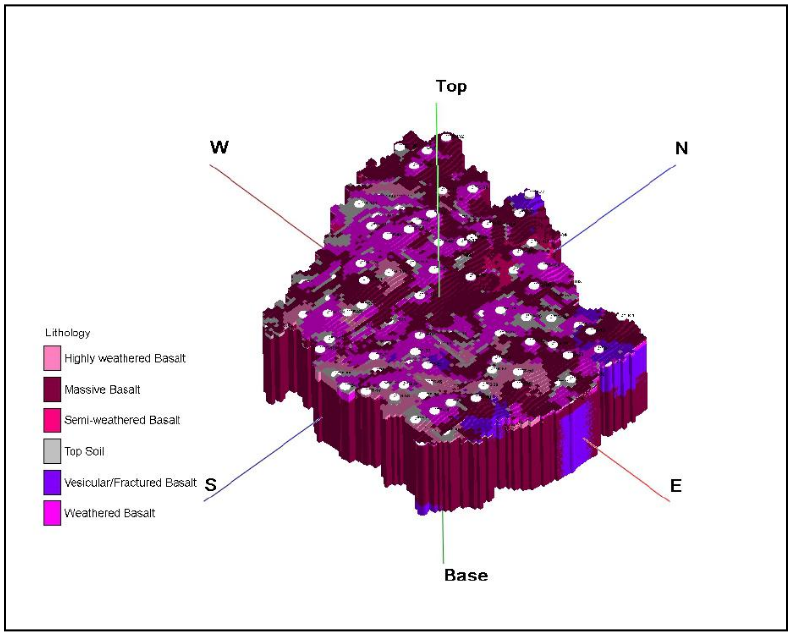

Fig. 2.11. Lithological 3D Model, Rajgarh District

Table. 2.4. Interpreted VES Results in Rajgarh District, Madhya Pradesh State during the year of 2020-21 under outsourcing													
Sr. No.	**Village**	**Block/ Taluk/ Mandal_**	**Latitude**	**Longitude**	**Resistivity in Ohm.m**					**Thickness in meter**			
					p1	**p2**	**p3**	**p4**	**p5**	**h1**	**h2**	**h3**	**h4**
1	Amanpura	Biaora	24.077582	77.105456	29	415	60			1.6	42		
2	Bada Badla	Biaora	23.983751	77.127176	29	9	52	88		1	2	27.1	
3	Maharaj Kheda	Biaora	23.867926	77.155927	11	165	40			1.5	18.8		
4	Motipura	Biaora	23.901977	76.952716	24	9	138	474		0.6	2.4	42.5	
5	Bankpura	Biaora	24.031607	76.970065	86	821	92	376		3.8	29.4	158.2	
6	Raghunathpura	Biaora	23.842386	76.845139	215	22	1318			3.2	32.7		
7	Bhanwas	Biaora	23.771333	77.181672	30	6	910			0.8	6.7		
8	Bhukni	Biaora	24.010955	77.028446	23	12	150	786		0.8	6.2	77.3	
9	Bundakhera	Biaora	23.809453	76.943841	8	7	161			1.1	11.6		
10	Amanpura	Biaora	23.924175	76.853903	10	29	156	30		1.3	6.8	35	
11	Dalapura	Biaora	23.956859	77.076848	23	7	118	53	282	1.0	6.2	69.1	124.1
12	Dehri Kheda	Biaora	24.009016	77.070834	21	80	23	98		2.1	6.2	56.5	
13	Dev Khedi	Biaora	23.830228	77.009362	13	4	119			1.9	6		
14	Gujar khadi	Biaora	23.970719	76.842787	71	122	689	197		2.3	3.5	45	
15	Gujribeti	Biaora	23.800988	76.818343	87	7	479			0.8	5.6		
16	PeepalHeda	Biaora	23.869473	76.911728	4	9	32	208		0.9	3.1	7.6	
17	Lalpuria	Biaora	24.054907	77.027652	35	404	105	738		3.2	25.8	159.6	
18	Kalakheri	Biaora	23.987679	76.907475	80	14	167	320		0.7	4	26.1	
19	Kasorkalan	Biaora	23.987073	76.960591	41	480	72			2.2	27.7		
20	Char Khedi	Biaora	23.918399	77.039756	7	127	46	232		0.7	13	55.3	
21	Madhopura	Biaora	24.017551	77.159527	21	4	45	104		0.8	5.5	94.4	
22	Malawar	Biaora	23.876793	77.00628	20	3	165			0.7	8.7		

Table. 2.4. Interpreted VES Results in Rajgarh District, Madhya Pradesh State during the year of 2020-21 under outsourcing													
Sr. No.	**Village**	**Block/ Taluk/ Mandal_**	**Latitude**	**Longitude**	**Resistivity in Ohm.m**					**Thickness in meter**			
					p1	**p2**	**p3**	**p4**	**p5**	**h1**	**h2**	**h3**	**h4**
23	Morikho	Biaora	23.909462	77.101966	47	63	43	66	39	1.8	10.2	27.6	95.6
24	NalyaKhedi	Biaora	23.826195	77.194492	16	392	75			2.3	27.6		
25	Narjarva	Biaora	23.836679	77.137793	39	10	367	114		1	4.5	58.8	
26	Mohinipura	Biaora	23.947125	76.916604	164	13	2190			1.6	10.2		
27	PardhaniKundal	Biaora	23.975843	77.163272	14	7	45	81		0.6	3.2	66.7	
28	PeeplyPedat	Biaora	24.065021	77.140824	193	15	43	105		0.8	10	74	
29	Silpoti	Biaora	23.963227	77.009542	302	48	623	46	313	1.1	8	31.7	93.3
30	Mau	Biaora	23.91643	77.170294	102	9	78			1.7	9.8		
31	Barikhera	Khilchipur	24.023261	76.50469	154	35	967			1.9	11.2		
32	Barol	Khilchipur	24.138864	76.682862	43	253	44			5	37.4		
33	Bharatpura	Khilchipur	24.014628	76.621493	18	67	1360			1.6	4.5		
34	Bhumariya	Khilchipur	24.244288	76.679913	2	10	157	76	107	0.9	5.5	51.1	84.1
35	Borda	Khilchipur	24.09767	76.61694	468	74	454	720		1.2	6	120.7	
36	Dehra	Khilchipur	24.14386	76.549574	131	49	374	204	1632	1	3.9	42.2	97.3
37	Doriyakhedi	Khilchipur	24.187485	76.630798	110	83	493	5346		0.7	2	75.3	
38	Ganeshpura	Khilchipur	24.161777	76.496969	391	41	868			1.7	7.4		
39	Satpura	Khilchipur	23.936738	76.572762	4	10	8093			1.2	3.4		
40	Khera	Khilchipur	23.948614	76.510505	6	9	337			1.7	7.3		
41	Kherkhera	Khilchipur	24.132009	76.625499	66	42	710	3125		0.7	2.3	179.3	
42	Khilchipur	Khilchipur	24.026162	76.561284	37	46	915	169		1	3.8	55	
43	Kotar	Khilchipur	24.07943	76.540822	49	54	1237			2	7.4		
44	Koyla	Khilchipur	24.232128	76.618063	43	109	682			5.6	26.1		
45	Laturi	Khilchipur	23.901068	76.487508	37	337	18	586		0.4	1.4	10.8	

Table. 2.4. Interpreted VES Results in Rajgarh District, Madhya Pradesh State during the year of 2020-21 under outsourcing													
Sr. No.	**Village**	**Block/ Taluk/ Mandal_**	**Latitude**	**Longitude**	**Resistivity in Ohm.m**					**Thickness in meter**			
					p1	**p2**	**p3**	**p4**	**p5**	**h1**	**h2**	**h3**	**h4**
46	Mannpura	Khilchipur	23.977974	76.581075	12	57	1701			1.1	5.5		
47	Mayakheri	Khilchipur	23.984645	76.49572	12	39	2106			0.8	5.4		
48	Patdi Kheda	Khilchipur	24.088443	76.7338	10	19	943			1.4	2.6		
49	Pitapura	Khilchipur	24.040946	76.626169	6	144	1422			1.1	64.8		
50	Andalheda	Narsingarh	23.785805	77.064201	84	7	259			1.7	17.9		
51	Anwali	Sarangpur	23.60266	76.524251	6	4	179			1.2	9.4		
52	Bairasiya	Narsingarh	23.726769	76.968494	41	6	329			1.6	9.7		
53	Bamohari	Narsingpur	23.565361	76.720033	80	12	350			1	3.8		
54	Banapura	Narsingpur	23.514677	77.004522	48	4	273			2	8.3		
55	Bhawarakhera	Narsingarh	23.50922	76.737212	4	5	1684			4.5	24.3		
56	Bilhari	Narsingpur	23.490556	77.050627	19	6	360	123		0.7	2.4	169.6	
57	Biralkher	Narsingpur	23.503405	76.846309	6	3	72			1.6	5.8		
58	Birgadi	Narsingpur	23.533318	76.913731	5	4	331			1.5	11.7		
59	NipaniyaGarhi	Narsingarh	23.666866	76.879438	7	5	12	132		1.2	8.3	34	
60	Devgarh	Narsingpur	23.639036	77.078336	14	258	128	8250		1.5	26	65.6	
61	Dewalkhera	Narsingarh	23.748527	76.824509	32	5	63064			0.8	5.5		
62	Bakani	Narsingarh	23.650736	76.838363	18	8	90	378		1.2	3.6	124.4	
63	Jangipura	Narsingarh	23.525279	76.806708	26	5	436			1.4	9.5		
64	Jatkheri	Narsingarh	23.672633	76.738219	115	567	32	1153		0.4	1.4	13.2	
65	Jharkiya	Narsingpur	23.542515	77.076639	34	8	644			0.9	3.2		
66	Jharpipalaya	Narsingpur	23.627189	76.923785	5	4	54			1.1	11.2		
67	Kachhipura	Narsingarh	23.758767	77.002985	6	240	167			4.5	59		
68	Khajuriya	Narsingarh	23.747021	77.104126	33	254	32			2.1	24.5		

Table. 2.4. Interpreted VES Results in Rajgarh District, Madhya Pradesh State during the year of 2020-21 under outsourcing														
Sr. No.	**Village**	**Block/ Taluk/ Mandal_**	**Latitude**	**Longitude**	**Resistivity in Ohm.m**					**Thickness in meter**			
					p1	**p2**	**p3**	**p4**	**p5**	**h1**	**h2**	**h3**	**h4**
69	Kundli	Narsingarh	23.699801	77.038147	16	4	558			1.8	16.2		
70	Lakhakhedi	Narsingarh	23.484638	76.796423	5	17	426			7	20.5		
71	Laskhrpur	Narsingpur	23.592474	77.107873	32	187	30			3	19		
72	Mahua	Narsingpur	23.617825	76.749127	5	13	474			0.8	7.6		
73	Mawasa Kalan	Narsingpur	23.667262	76.971111	38	11	195			0.5	5.5		
74	PipliyaKaji	Narsingpur	23.559591	77.021648	63	5	130			1.4	10.6		
75	Motipura	Narsingarh	23.549797	76.86011	7	4	34			0.4	12.8		
76	Narsingarh	Narsingarh	23.70215	77.106759	15	6	134			0.8	16.4		
77	Natki	Narsingpur	23.605063	77.029791	98	9	2059			2	8.2		
78	Neshborda	Rajgarh	23.955321	76.715341	165	77	1243	5258		0.7	2	136.7	
79	Palasi	Narsingarh	23.795629	76.980118	19	8	206	80		0.5	2.4	64.3	
80	Paniya	Narsingarh	23.73505	76.779997	217	6	207			1	7.5		
81	Parliya	Narsingarh	23.747327	77.020995	28	201	460			1.1	19.7		
82	Ralayati	Narsingarh	23.712832	76.714861	157	35	712			0.6	2.8		
83	Rajnipura	Narsingarh	23.717073	76.888071	14	7	70			0.5	6.9		
84	Sahakheri	Narsingpur	23.58528	76.955953	5	6	184			3.1	12		
85	Saraskheri	Narsingpur	23.629017	76.692607	3	570	386			0.6	74		
86	Sawans	Biaora	23.728657	77.155934	54	9	375			2.7	11.2		
87	Daultpura	Narsingarh	23.767029	76.910257	10	357				3.8			
88	Tikriya	Sarangpur	23.669939	76.601093	9	4	5455			0.9	9.6		
89	Umari	Narsingarh	23.580515	76.798049	5	4	178			0.5	11.3		
90	Umariya	Narsingarh	23.687103	76.816468	9	23	15	399		0.6	3.1	23.8	
91	Chhatarpura	Rajgarh	24.028055	76.694127	185	90	410	990		0.9	2.7	21	

Table. 2.4. Interpreted VES Results in Rajgarh District, Madhya Pradesh State during the year of 2020-21 under outsourcing													
Sr. No.	**Village**	**Block/ Taluk/ Mandal_**	**Latitude**	**Longitude**	**Resistivity in Ohm.m**					**Thickness in meter**			
					p1	**p2**	**p3**	**p4**	**p5**	**h1**	**h2**	**h3**	**h4**
92	Balwatpura	Rajgarh	23.993017	76.737197	348	42	337	100	290	0.5	2.7	20.4	85.8
93	Bhopalpura	Rajgarh	23.815632	76.760964	28	215	584			0.9	6.9		
94	Chandarpura	Narsingarh	23.578107	76.897275	9	4	47			0.4	16.2		
95	Doongarpura	Rajgarh	23.896062	76.824944	13	43	1408	855		0.5	1.6	60.7	
96	Gokulpura	Rajgarh	23.786483	76.698261	14	110	1770			0.8	6.3		
97	Gorkhapura	Rajgarh	23.901211	76.647173	5	14	777			1.1	7.5		
98	Rampuria	Rajgarh	24.04395	76.768932									
99	Karera	Rajgarh	23.978115	76.639049	36	784	242			3.5	66.3		
100	Kalipith	Rajgarh	24.027335	76.855252	31	10	540			0.8	3		
101	Pariyakher	Rajgarh	23.881575	76.588426	6	26	3541			1	8.6		
102	Phundiya	Rajgarh	23.831056	76.67492	6	25	1791			1	3.1		
103	Rampuriapati	Rajgarh	24.102057	76.876865	76	209	636	69		1.3	3.7	22	
104	Semlibey	Rajgarh	24.085566	76.82274	38	66	797			2.2	21.9		
105	Sinduria	Rajgarh	24.040761	76.91108	44	23	309	42		1	3.6	40	
106	Sondiya	Rajgarh	23.889447	76.728485	84	44	374	792		0.4	2.8	125.9	
107	Tulsipura	Rajgarh	24.137324	76.727748	57	137	23679			2.7	13.1		
108	Tutiahedi	Sarangpur	23.755261	76.567179	78	23	51	25	311	0.6	1.4	7.5	34.8
109	Alumi	Sarangpur	23.545085	76.642704	4	14	288	73		1.1	5	104.2	
110	Barbariya	Sarangpur	23.611441	76.471509	14	319	80			1.8	78.1		
111	Bawalda	Sarangpur	23.71369	76.407083	8	23	54	276		1.9	6	25.5	
112	Bhatkhedi	Sarangpur	23.738685	76.488297	12	35	283	47		0.7	8.4	72.3	
113	Chatkaya	Sarangpur	23.817845	76.585352	14	6	212			1.5	8		
114	Chhapra	Sarangpur	23.659998	76.636411	5	51	479	99		0.7	4.8	80.7	

Table. 2.4. Interpreted VES Results in Rajgarh District, Madhya Pradesh State during the year of 2020-21 under outsourcing														
Sr. No.	**Village**	**Block/ Taluk/ Mandal_**	**Latitude**	**Longitude**	**Resistivity in Ohm.m**					**Thickness in meter**			
					p1	**p2**	**p3**	**p4**	**p5**	**h1**	**h2**	**h3**	**h4**
115	Dayakheri	Sarangpur	23.677882	76.533623	10	84	34	390		1.6	16.6	42.7	
116	Jhanjahari	Sarangpur	23.807173	76.420136	86	326	58			3	13.8		
117	Kamkariya	Sarangpur	23.851188	76.505799	42	10	194			1.4	23.4		
118	Kishankheri	Sarangpur	23.631967	76.574588	5	35	25	490		0.7	5.9	28.5	
119	Kupa	Sarangpur	23.68118	76.441255	80	737	267			2.6	56		
120	Parharia	Sarangpur	23.582762	76.632199	4	8	271	74		0.5	4.8	107.5	
121	Pathariya	Sarangpur	23.731031	76.676718	4	57	1914			0.6	5.6		
122	Rajpura	Sarangpur	23.848385	76.401812	49	195	1258			3.6	11.6		
123	Sarangpur	Sarangpur	23.539626	76.477448	8	113				8.6			
124	Semali	Sarangpur	23.797049	76.509669	5	27	438			1.3	9.6		
125	Simraul	Sarangpur	23.734734	76.410717	9	184	43			1.8	101.8		
126	Bhagori	Zirapur	24.159412	76.246865	150	913	121			4.3	40		
127	Bhanpura	Zirapur	24.108691	76.450015	107	10	316			0.5	2		
128	Bhikampur	Zirapur	23.948576	76.338395	13	25	829			5	14.8		
129	Brahmangaon	Zirapur	24.175835	76.322328	8	11	103	27		1.1	6.3	68.4	
130	Chilwadi	Zirapur	24.074171	76.367314	7	44	596			1.5	9.5		
131	Duparia	Zirapur	23.944062	76.404023	9	64	298			1.7	21.6		
132	Gadiya	Zirapur	24.221437	76.341124	11	65	484	1429		0.8	3.3	136.7	
133	Goganpur	Zirapur	24.199968	76.25681	5	129	802			1.6	105.6		
134	Kaljakheri	Zirapur	23.998831	76.279315	10	21	406	236		1.2	2.3	50.5	
135	Kotra	Zirapur	24.071645	76.218475	41	129	956			1.0	2.8		
136	Lachmipura	Zirapura	24.102714	76.251717	26	40	70			5.4	114.4		
137	Lakhoni	Zirapur	24.133745	76.386318	83	9	118	37		0.9	3.8	57.3	

Table. 2.4. Interpreted VES Results in Rajgarh District, Madhya Pradesh State during the year of 2020-21 under outsourcing													
Sr. No.	**Village**	**Block/ Taluk/ Mandal_**	**Latitude**	**Longitude**	**Resistivity in Ohm.m**					**Thickness in meter**			
					p1	**p2**	**p3**	**p4**	**p5**	**h1**	**h2**	**h3**	**h4**
138	Machalpur	Zirapura	24.125991	76.333239	15	11	33	302		1.3	5.3	15.2	
139	Mahan	Zirapur	23.908513	76.423166	181	31	422			1.3	81.8		
140	Makampur	Zirapur	24.184915	76.417367	61	114	19	261		2.3	7.1	35.5	
141	Manpura	Zirapura	24.06071	76.451275	152	1545	466			2.8	66.3		
142	Mundi	Zirapur	23.873837	76.344784	19	47	7866			1.9	2.1		
143	Sabhajpura	Zirapur	24.000795	76.348313	7	6	31	157		0.8	12.5	21.3	
144	Sadlpur	Zirapur	24.001399	76.419497	106	60	141			3.4	17.3		
145	Zirapur	Zirapur	24.031036	76.379	113	6	29	407		1	4	24.3	

CHAPTER-3

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

The lithological data collected from CGWB Exploratory Bore wells were studied, compiled and integrated for 2-Dimensional Cross section. From 2-D Section is presented in the fig 3.1, 3.2 and 3.3. It has been interpreted that the major water bearing zones has been encountered in weathered/fractured and vesicular Basalt formation.

3.1. 2-D Cross Section sections of Rajgarh District:

2-Dimensional cross-section along the section line A-A' Pipalia-Khilchipur-Rajgarh-Mundla (fig.3.1), B-B' Khajuria-Biora-Rajgarh-Khilchipur-Machalpur (fig.3.2) and C-C' Machalpur-Pipalia Kalan-Limbora- Pachor-Indira (fig.3.3) has been prepared.

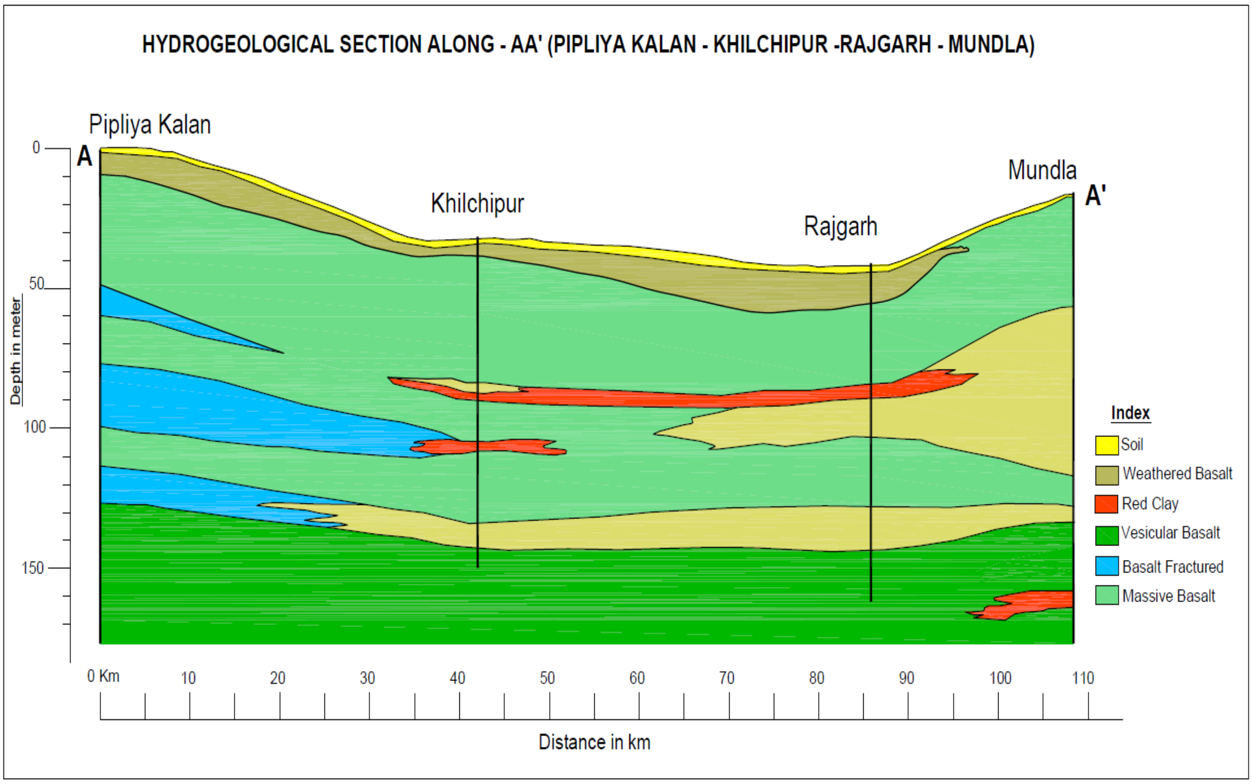

Fig.3.1: 2-D Cross section along AA'

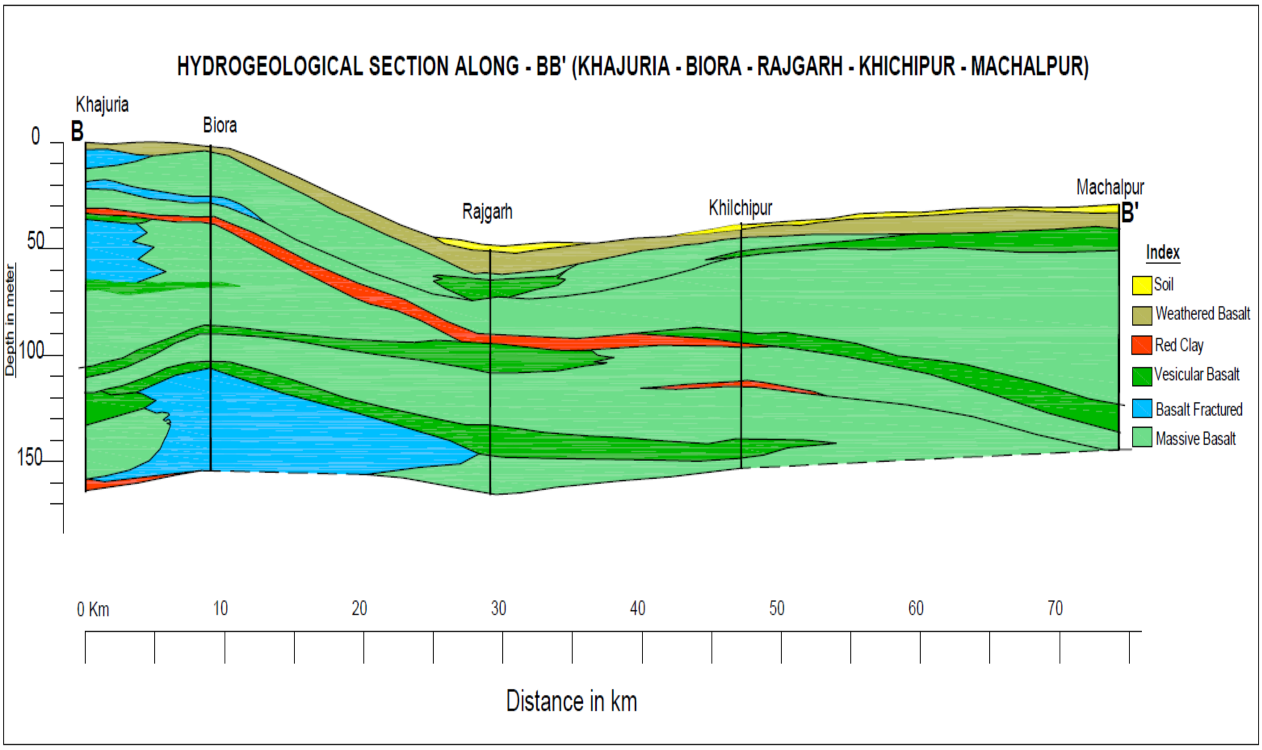

Fig.3.2: 2-D Cross section along BB'

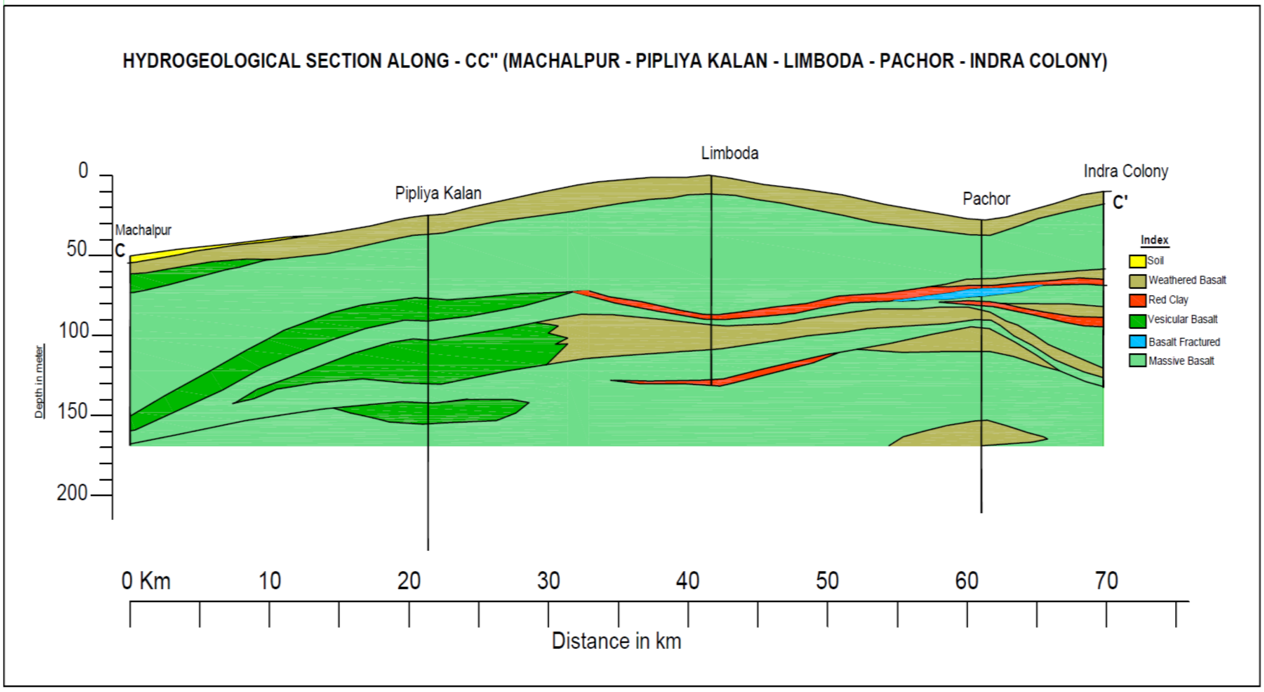

Fig.3.3: 2-D Cross section along CC'

CHAPTER-4

GROUND WATER RESOURCES

4.1 Dynamic Ground Water Resource:

Raigarh district is underlain by Basaltic lava flows of Deccan trap, Vindhyan Sandstone and Alluvium. Dynamic ground water resources of the district have been estimated on block-wise basis. Out of 6155 sq. km of geographical area, 5879 sq. km (97%) is ground water recharge worthy area and 176 sq. km is forest and hilly area (3%). There are six assessment units (block) in the district out of which 1 blocks fall under safe category. Only Rajgarh block comes under safe category with stage of ground water extraction is 69.96 %. The net ground water availability in the district is 77503.75 ham and ground water extraction for all uses is 65419.73 ham, making stage of ground water extraction 84.41 % as a whole for the district. Table 4.3 shows the Dynamic Ground Water Resource Assessment estimated by CGWB for the year 2020.

Dynamic ground water resources of the district have been estimated for base year -2019-20 on block-wise basis. There are six number of assessment units (block) in the district which fall under non-command. Biora, Khilchipur and Zeerapur blocks of the district are categorized as Semi-Critical (same in 2016-17), Narsinghgarh and Sarangpur blocks of the district are categorized as Critical (semi critical in 2016-17), Rajgarh categorized as Safe (same in 2016-17). The highest stage of ground water extraction is computed as 98.18 % (95.36 % in 2016-17) in Sarangpur block. The annual extractable ground water resource in the district is 77503.75 ham and ground water extraction for all uses is 65419.73 ham, making stage of ground water extraction is 84.41 % (83.4 % in 2016-17) as a whole for district. After making allocation for future domestic and industrial supply for year 2025, balance available ground water for future use would be 13335.61 m ham.

Table 4.1 Assessment of Dynamic Ground Water Resources of Rajgarh District
(As on March 2020)

Assessment Unit Name	Recharge from Rainfall-Monsoon Season (Ham)	Recharge from Other Sources-Monsoon Season (Ham)	Recharge from Rainfall-Non-Monsoon Season (Ham)	Recharge from Other Sources-Non-Monsoon Season (Ham)	Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
ZEERAPUR	9446.48	463.63	0	1611.26	11521.37	576.07	10945.3
SARANGPUR	10285.03	631.6	0	2367	13283.63	664.18	12619.45
BIORA	10200.36	590.46	0	1967.67	12758.49	637.92	12120.57
NARSINGH GARH	13490.59	1000.04	0	3236.11	17726.74	886.34	16840.4
RAJGARH	13740.41	705.01	0	2181.84	16627.26	1662.72	14964.54
KHILCHIPUR	8248.62	457.57	0	1834.33	10540.52	527.03	10013.49
DISTRICT TOTAL	**65411.49**	**3848.31**	**0**	**13198.21**	**82458.01**	**4954.26**	**77503.75**

Table 4.2: Block-wise groundwater resources and extraction of Rajgarh district, 2020

Assessment Unit Name	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization
ZEERAPUR	7677.288	0	426.2638	8103.55	487.76	2780.25	74.04	**Semi-critical**
SARANGPUR	11581.08	0	808.7013	12389.78	943.01	95.36	98.18	**Critical**
BIORA	8982.92	0	611.7809	9594.7	711.12	2426.53	79.16	**Semi-critical**
NARSINGHGARH	14990.3	0	1131.209	16121.5	1380.34	469.77	95.73	**Critical**
RAJGARH	9961.974	0	507.0857	10469.05	576.66	4425.92	69.96	**Safe**
KHILCHIPUR	8353	0	388.149	8741.15	436.01	1224.48	87.29	**Semi-critical**
DISTRICT TOTAL	**61546.56**	**0**	**3873.19**	**65419.73**	**4534.9**	**11422.31**	**84.41**	

CHAPTER-5

GROUND WATER RELATED ISSUES

5.1. Declining of water level

The long-term water level trend analysis indicates mixed results. During pre-monsoon season more than 60 percent of the areas are showing declining trend. Similarly, during post-monsoon season more than 70 percent of the areas are showing falling trend in the district. Ground Water Resource Estimation also reveals that out of 6 Blocks of the district 1 Block i.e.Rajgarh has less than 70% stage of ground water extraction. 3 blocks fall in the semi-Critical category and 2 blocks falls in Critical category. Over all stage of ground water extraction of the district is computed as 83.47 % which cautions for further uncontrolled withdrawal of ground water.

5.2. Ground water quality:

About 84% ground water samples recorded nitrate concentration within the acceptable limit of 45 mg/l and 16% water samples recorded more than 45 mg/l as per BIS recommendation. The high nitrate concentration has been recorded in ground water of Sarangpur (64 mg/l), Pachor (79 mg/l) and Biora (217 mg/l). Total hardness of ground water in the study area ranged in between 50 to 658 mg/l. The high concentration has been observed in the dug well of Suthaliya (658 mg/l) and Pachor (653 mg/l).

CHAPTER-6

GROUND WATER MANAGEMENT STRATEGIES

Groundwater has been contributing more to agricultural wealth than surface irrigation since ages. Tube wells are now the largest source of irrigation in the country. Since this sector has almost no dependence on the Government, it is growing at a rapid rate and it is estimated that one million wells are added every year. Being an individually managed source, ground water irrigation is also a more efficient form of irrigation, with crop yields per cubic meter of water being 1.2 to 3 times higher than surface irrigation. However, since this sector has grown through investment by individual farmers with little state involvement compared to canal irrigation, Government support for understanding this sector and improving its performance is negligible. The major issues for the future growth of groundwater irrigation are declining resource base, demand driven growth, and a lack of policy and regulatory framework. Since groundwater extraction is primarily driven by the needs of the population and the density of farmer population and not the quality of resource, groundwater irrigation is scaling up even in such hard rock areas causing irreversible depletion of the resource base.To warrant the current situation effective groundwater management strategies needs to be evolved.

6.1. District Ground Water Management Plan:

Rajgarh district has been facing problems of ground water exploitation which in turn are depleting the ground water resources in the area. This has led to evolve sustainable water conservation and management practices through an integrated approach. The ground water management plan for Rajgarhdistrict has been made keeping in view the area specific details which includes the strategies like enhancing the ground water resources through construction of artificial recharge structures such as percolation tanks, check dams/nala bunds, recharge shafts, etc. and ensuring water use efficiency through maintenance/ renovation of existing water bodies/water conservation structures. Total area of district is given in table 6.2. Also, adoption of micro-irrigation techniques such as sprinkler irrigation has been proposed that would not only conserve ground water resources by reducing the draft, but would also increase the net cropping area thereby augmenting the agricultural economy of the district. Data variables used in assessment of dynamic water resources is given in table 6.3.

6.1.1. Supply Side Management

Artificial recharge to ground water is one of the most efficient, scientifically proven and cost-effective technology to mitigate the problems of over exploitation of ground water resources. The artificial recharge techniques simultaneously augment the ground water storage, reduces the ground water quality problems and also improves the sustainability of wells in the water scarcity areas.

The supply side management plan for Rajgarh district has been formulated using the basic concepts of hydrogeology. Sub-surface storage is calculated by multiplying the total area with the respective specific yield (considering the variable lithology) and the unsaturated zone thickness obtained by subtracting 3 mt. from the post-monsoon water level. The volume of ground water recharge generated through pre-existing rain water harvesting/water conservation structures is subtracted from the sub-surface storage to assess the available storage potential. Thus, the surface water requirement to completely saturate the sub-surface storage is obtained by multiplying a factor of 1.33 to available storage potential. A runoff coefficient factor of 0.23 has been considered for Rajgarh district to calculate the total surface water runoff, 30% of which accounts to the non-committed runoff which is available to sustain the proposed artificial recharge structures. Further, the number of structures has been calculated by allotting 35%, 20% and 35% of non-committed runoff to Percolation tanks, Recharge shafts and Nala bunds/Check dams/Cement Plugs respectively. The remaining run-offis considered to restore the pre-existing village tanks, ponds and water conservation structures. A detailed calculation of the proposed artificial recharge structures is presented in the table 6.4.

6.1.2.Demand Side Management

Micro irrigation technologies such as drip and sprinkler systems are being increasingly promoted as technological solutions for achieving water conservation. Micro-irrigation comprises two technologies-drip and sprinkler irrigation. Both saves conveyance losses and improve water application efficiency by applying water near the root-zone of the plant.Some benefits of the micro-irrigation have been listed below:

The increase in yield for different crops ranges from 27 per cent to 88 per cent and water saving ranges from 36 per cent to 68 per cent vis-à-vis conventional flow irrigation systems (Phansalker and Verma, 2005).

1. It enables farmers to grow crops which would not be possible under conventional systems since it can irrigate adequately with lower water quantities.
2. It saves costs of hired labour and other inputs like fertilizer.
3. It reduces the energy needs for pumping, thus reducing energy per ha of irrigation because of its reduced water needs. However, overall energy needs of the agriculture sector may not get reduced because most farmers use the increased water efficiency to bring more area under irrigation.

Adoption of Sprinkler irrigation techniques would save 20% of gross ground water draft for irrigation. Also, the 60% of additional recharge created by construction of artificial recharge structures can be utilized to increase the total cropping area, thereby enhancing the productivity and economy of the district. Table 6.1 represents the demand side management of district.

Table 6.1: Groundwater Management- Demand Side Management, Rajgarh District

Block	Ground Water Irrigated Area (Ha)	50% of GW Irrigated Area (Sq.Km)	Saving by Sprinkler in MCM
Biora	54616	546.16	23.94
Khilcipur	31820	318.20	20.05
Narsinghgarh	68540	685.40	30.65
Rajgarh	30977	309.77	21.51
Sarangpur	36552	365.52	24.32
Zeerapur	40955	409.55	13.47
TOTAL	**263460**	**2634.60**	**93.65**

Table 6.2 Total area of Rajgarh district

Name of Assessment Unit (Block)	Type of rock formation	Recharge worthy area of formation in (Ha)	Areal extent (in hectares)						
			Total Geographical Area	Hilly Area	Ground Water Recharge Worthy Area			Shallow Water Table Area	Flood Prone Area
					Command area	Non-command area	Poor ground water quality area		
Biora	Deccan trap basalt	114800	114800	0	0	114800	0	0	0
Khilchipur	Deccan trap basalt	78400	78400	0	0	78400	0	0	0
Narsingh garh	Deccan trap basalt	136800	136800	0	0	136800	0	0	0
Rajgarh	Deccan trap basalt	110500	110500	0	0	110500	0	0	0
Sarangpur	Deccan trap	90500	90500	0	0	90500	0	0	0
Zeerapur	Deccan trap basalt	84498	84498	0	0	84498	0	0	0
		615498	**615498**	**0**	**0**	**615498**	**0**	**0**	**0**

Table 6.3:Data variables used in dynamic ground water resources of Rajgarh (as on march 2017)

S. No.	Assessment Unit/ District	Command/ non-Command	Annual Rainfall (mm)	Average Pre-monsoon Water level (mbgl)	Average Post-monsoon Water Level (mbgl)	Average Fluctuation (m)	Type of Structures	Number for Irrigation structures	Number for Domestic/ Industrial structures
1	Biora	Non-Command	1592.0	10.39	3.80	6.59	DW with electric /diesel pump	18918	-/-
							Bore well	1450	-/-
2	Khilcipur	Non-Command	1347.0	11.70	3.20	8.50	DW with electric /diesel pump	14697	-/-
							Bore well	518	-/-
3	Narsinghgarh	Non-Command	1362.0	10.25	3.33	6.92	DW with electric /diesel pump	13335	-/-
							Bore well	5157	-/-
4	Rajgarh	Non-Command	1623.0	10.53	4.53	6.00	DW with electric /diesel pump	14848	-/-
							Bore well	876	-/-
5	Sarangpur	Non-Command	891.0	10.00	4.03	5.97	DW with electric /diesel pump	20625	-/-
							Bore well	6098	-/-
6	Zeerapur	Non-Command	1284.0	8.62	3.52	5.10	DW with electric /diesel pump	10587	-/-
							Bore well	1050	-/-

Table 6.4: Ground Water Management– Supply Side, Rajgarh District

Block	Rain fall (mm)	Rain fall (m)	Area (Sq Km)	Area suitable for recharge (Sq Km)	Average post-monsoon water level (m)	Unsaturated zone (m)	Average SP Yield (%)	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft/ Tube well	NB/ CD/ CP	No of Villages
Biora	1592	1.59	1148	1148	3.8	0.8	0.015	13.78	18.32	264.04	79.21	18	37	128	277
Khilcipur	1347	1.35	784	784	3.2	0.2	0.015	2.35	3.13	180.32	54.10	3	6	22	317
Narsingh garh	1362	1.36	1368	1368	3.33	0.33	0.015	6.77	9.01	314.64	94.39	9	18	63	240
Rajgarh	1623	1.62	1105	1105	4.53	1.53	0.015	25.36	33.73	254.15	76.25	34	67	236	375
Sarangpur	891	0.89	905	905	4.03	1.03	0.015	13.98	18.60	208.15	62.45	19	37	130	135
Zeerapur	1284	1.28	844.98	844.98	3.52	0.52	0.015	6.59	8.77	194.35	58.30	9	18	61	215
Total			**6154.98**	**6154.98**	3.74	0.74		68.83	91.55	1538.75	461.62	92	183	641	1559

6.2. Post-Intervention Impact

The expected outcome of the proposed interventions from both supply side and demand side has been described in table 6.5. It can be envisaged that the Stage of ground water development for the entire Rajgarh district, would reduce to 65.89% as compared to the present stage of ground water development of **84.41**% after implying and successful implementation of proposed interventions.

Table 6.5: Post-Intervention Impact, Rajgarh District

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of Development %	Saving by Sprinkler in MCM	Additional recharge created by AR (MCM)	After intervention of AR Structure Net GW AvL. (MCM)	After intervention of AR Structure &utilisation of 60% of additional GW created. (MCM)	Draft after sprinkler & additional area created for agriculture (MCM)	Stage of Development W/O GW use for additional Area Irrigation%	Additional area irrigated by GW after intervention (Sq.Km)
ZEERAPUR	109.45	76.77	4.26	80.67	**73.70**	15.35	68.76	178.21	41.2560	106.94	**60.00**	103
SARANGPUR	126.19	115.81	8.09	123.90	**98.18**	23.16	59.64	185.83	35.7842	136.52	**73.46**	89
BIORA	121.21	89.83	6.12	95.95	**79.16**	17.97	53.37	174.58	32.0227	110.00	**63.01**	80
NARSINGH GARH	168.40	149.90	11.31	161.22	**95.73**	29.98	64.17	232.58	38.5033	169.74	**72.98**	96
RAJGARH	149.65	99.62	5.07	104.69	**69.96**	19.92	55.40	205.05	33.2410	118.01	**57.55**	83
KHILCHIPUR	100.14	83.53	3.88	87.41	**87.29**	16.71	44.64	144.78	26.7861	97.49	**67.34**	67
TOTAL	775.04	615.46	38.73	654.20	**84.41**	123.0	345.9	1121.02	207.5933	738.70	**65.89**	519

6.3. Block-wise Ground Water Management Plan

The Aquifer Management Plan for Rajgarh district has been prepared block-wise (table 6.7). The plan for each block discusses the broad framework of ground water situation in the block, status of water availability (both surface and ground water), feasibility of artificial recharge and other water conservation structures and their numbers and cost estimates. Table 6.6 represents the aquifer wise groundwater resources of Rajgarh district.

Table 6.6: Aquifer wise Ground Water Resources of Rajgarh District

Block	Biora	Khilchipur	Narsingh garh	Rajgarh	Sarangpur	Zeerapur	Total
First Aquifer							
Dynamic Resources (MCM)	154.37	121.19	175.67	165.42	135.28	93.15	795.07
Static Resources (MCM)	92.13	0.000	71.20	74.09	59.87	136.17	433.41
Total Resources (MCM)	246.50	121.19	246.87	239.51	195.15	229.28	1228.49
Draft : Irrigation	119.68	100.27	153.24	107.56	121.59	67.37	468.26
Domestic+Industries	5.64	3.63	10.25	4.71	7.45	3.95	31.96
GW Draft (MCM)	125.32	103.90	163.49	112.27	129.04	71.32	500.22
Second Aquifer							
Static Resources (MCM)	58.55	39.98	69.79	56.35	46.16	43.09	313.90
GW Draft (MCM	21.61	21.61	21.61	21.61	21.61	21.61	129.66
Total GW Resources (MCM)	**305.05**	**161.17**	**316.64**	**295.86**	**241.30**	**272.37**	**1592.40**
Gross Ground Water Draft (MCM)	**146.93**	**125.51**	**185.10**	**133.88**	**150.65**	**92.93**	**835.00**

Table 6.7: Block-wise total resources of Rajgarh district

1. Block Biora, District Rajgarh

Block	Biora
Dynamic Resources (MCM)	154.37
In-Storage Resources (MCM)	274.37
Total Resources (MCM)	**428.74**
Irrigation	119.68
Domestic+Industries	5.64
GW extraction (MCM)	**125.32**

Area in Sq Km	1148	
Rainfall in m	1.592	
Area Suitable for Recharge in Sq Km	1148	
Average Post Monsoon DTW in mbgl	3.8	

Unsaturated Zone in m	0.8	
Average Specific Yield in %	0.015	
Sub Surface Storage Available (MCM)	13.78	
Surface Water Required (MCM)	18.32	
Runoff Available (MCM)	264.04	
Non committed Runoff available (MCM)	79.21	
Percolation Tanks	18	Rs 20 Lakh Per Structure
Recharge Shaft	37	Rs 5 Lakh Per Structure
NB/CD/CP	128	Rs 10 Lakh Per Structure
Renovation of Village Ponds	277	Rs 2 Lakh Per Structure

Block	Net GW Availability in MCM	GW extraction for Irrigation in MCM	GW extraction for Domestic & Industrial in MCM	Gross extraction in MCM	Stage of extraction %	Saving by Sprinkler in MCM	Additional recharge created by AR in MCM	After intervention of AR Structure Net GW Availability in MCM	After intervention of AR Structure &utilisation of 60% of additional GW created. in MCM	Extraction after sprinkler MCM	Stage of extraction after intervention %	additional area irrigated by GW after intervention (Ha)
Biora	154.37	119.68	5.64	125.32	**81.18**	23.94	13.78	168.14	8.26	109.65	**65.21**	2066

2. Block Khilcipur, District Raigarh

Block	Khilcipur
Dynamic Resources (MCM)	121.19
In Storage Resources (MCM)	185.80
Total Resources (MCM)	**307.00**
Irrigation	100.27
Domestic+Industries	3.63
GW extraction (MCM)	**103.90**

Area in Sq Km	784	
Rainfall in m	1.347	
Area Suitable for Recharge in Sq Km	784	
Average Post Monsoon DTW in mbgl	3.2	
Unsaturated Zone in m	0.2	

Average Specific Yield in %	0.015	
Sub Surface Storage Available (MCM)	2.35	
Surface Water Required (MCM)	3.13	
Runoff Available (MCM)	180.32	
Non committed Runoff available (MCM)	54.1	
Percolation Tanks	3	Rs 20 Lakh Per Stucture
Recharge Shaft	6	Rs 5 Lakh Per Stucture
NB/CD/CP	22	Rs 10 Lakh Per Stucture
Renovation of Village Ponds	317	Rs 2 Lakh Per Stucture

Block	Net GW Availability in MCM	GW extraction for Irrigation in MCM	GW extraction for Domestic & Industrial in MCM	Gross extraction in MCM	Stage of Development %	Saving by Sprinkler in MCM	Additional recharge created by AR in MCM	After intervention of AR Structure Net GW AvL. in MCM	After intervention of AR Structure &utilisation of 60% of additional GW created. in MCM	Extraction after sprinkler MCM	Stage of extraction after intervention %	additional area irrigated by GW after intervention (Ha)
Khilcipur	121.19	100.27	3.63	103.90	**85.73**	20.05	2.35	123.54	1.41	85.26	**69.01**	353

3. Block Narsinghgarh, District Raigarh

Block	Narsinghgarh
Dynamic Resources (MCM)	175.67
In Storage Resources (MCM)	222.43
Total Resources (MCM)	**398.10**
Irrigation	153.24
Domestic+Industries	10.25
GW extraction (MCM)	**163.49**

Area in Sq Km	1368	
Rainfall in m	1.362	
Area Suitable for Recharge in Sq Km	1368	
Average Post Monsoon DTW in mbgl	3.33	
Unsaturated Zone in m	0.33	

Average Specific Yield in %	0.015	
Sub Surface Storage Available (MCM)	6.77	
Surface Water Required (MCM)	9.01	
Runoff Available (MCM)	314.64	
Non committed Runoff available (MCM)	94.39	
Percolation Tanks	9	Rs 20 Lakh Per Stucture
Recharge Shaft	18	Rs 5 Lakh Per Stucture
NB/CD/CP	63	Rs 10 Lakh Per Stucture
Renovation of Village Ponds	240	Rs 2 Lakh Per Stucture

Block	Net GW Availability in MCM	GW extraction for Irrigation in MCM	GW extraction for Domestic & Industrial in MCM	Gross extraction in MCM	Stage of extraction %	Saving by Sprinkler in MCM	Additional recharge created by AR in MCM	After intervention of AR Structure Net GW AvL. in MCM	After intervention of AR Structure &utilisation of 60% of additional GW created. in MCM	Extraction after sprinkler MCM	Stage of extraction after intervention %	additional area irrigated by GW after intervention (Ha)
Narsinghgarh	175.67	153.24	10.25	163.49	**93.07**	30.65	6.77	182.44	4.06	136.90	**75.04**	1016

4. Block Rajgarh, District Raigarh

Block	Rajgarh
Dynamic Resources (MCM)	165.42
In Storage Resources (MCM)	198.34
Total Resources (MCM)	**363.77**
Irrigation	107.56
Domestic+Industries	4.71
GW extraction (MCM)	**112.28**

Area in Sq Km	1105	
Rainfall in m	1.623	
Area Suitable for Recharge in Sq Km	1105	
Average Post Monsoon DTW in mbgl	4.53	
Unsaturated Zone in m	1.53	

Average Specific Yield in %	0.015	
Sub Surface Storage Available (MCM)	25.36	
Surface Water Required (MCM)	33.73	
Runoff Available (MCM)	254.15	
Non committed Runoff available (MCM)	76.25	
Percolation Tanks	34	Rs 20 Lakh Per Stucture
Recharge Shaft	67	Rs 5 Lakh Per Stucture
NB/CD/CP	236	Rs 10 Lakh Per Stucture
Renovation of Village Ponds	375	Rs 2 Lakh Per Stucture

Block	Net GW Availability in MCM	GW extraction for Irrigation in MCM	GW extraction for Domestic & Industrial in MCM	Gross extraction in MCM	Stage of extraction %	Saving by Sprinkler in MCM	Additional recharge created by AR in MCM	After intervention of AR Structure Net GW AvL. in MCM	After intervention of AR Structure &utilisation of 60% of additional GW created. in MCM	Extraction after sprinkler MCM	Stage of extraction after intervention %	additional area irrigated by GW after intervention (Ha)
Rajgarh	165.42	107.56	4.71	112.28	**67.88**	21.51	25.36	190.78	15.21	105.97	**55.55**	3804

5. Block Sarangpur, District Raigarh

Block	Sarangpur
Dynamic Resources (MCM)	135.28
In Storage Resources (MCM)	265.61
Total Resources (MCM)	**400.90**
Irrigation	121.59
Domestic+Industries	7.45
GW extraction (MCM)	**129.04**

Area in Sq Km	905	
Rainfall in m	0.891	
Area Suitable for Recharge in Sq Km	905	
Average Post Monsoon DTW in mbgl	4.03	
Unsaturated Zone in m	1.03	
Average Specific Yield in %	0.015	

Sub Surface Storage Available (MCM)	13.98	
Surface Water Required (MCM)	18.60	
Runoff Available (MCM)	208.15	
Non committed Runoff available (MCM)	62.45	
Percolation Tanks	19	Rs 20 Lakh Per Stucture
Recharge Shaft/ Tube Wells	37	Rs 5 Lakh Per Stucture
NB/CD/CP	130	Rs 10 Lakh Per Stucture
Renovation of Village Ponds	135	Rs 2 Lakh Per Stucture

Block	Net GW Availability in MCM	GW extraction for Irrigation in MCM	GW extraction for Domestic & Industrial in MCM	Gross extraction in MCM	Stage of extraction %	Saving by Sprinkler in MCM	Additional recharge created by AR in MCM	After intervention of AR Structure Net GW AvL. in MCM	After intervention of AR Structure &utilisation of 60% of additional GW created. in MCM	Extraction after sprinkler MCM	Stage of extraction after intervention %	additional area irrigated by GW after intervention (Ha)
Sarangpur	135.28	121.59	7.45	129.04	**95.39**	24.32	13.98	149.26	8.38	113.11	**75.78**	2097

6. Block Zeerapur District Raigarh

Block	**Zeerapur**
Dynamic Resources (MCM)	93.15
In Storage Resources (MCM)	211.67
Total Resources (MCM)	**304.82**
Irrigation	67.37
Domestic+Industries	3.95
GW extraction (MCM)	**71.33**

Area in Sq Km	844.98	
Rainfall in m	1.284	
Area Suitable for Recharge in Sq Km	844.98	
Average Post Monsoon DTW in mbgl	3.52	
Unsaturated Zone in m	0.52	

Average Specific Yield in %	0.015	
Sub Surface Storage Available (MCM)	6.59	
Surface Water Required (MCM)	8.77	
Runoff Available (MCM)	194.35	
Non committed Runoff available (MCM)	58.3	
Percolation Tanks	9	Rs 20 Lakh Per Stucture
Recharge Shaft	18	Rs 5 Lakh Per Stucture
NB/CD/CP	61	Rs 10 Lakh Per Stucture
Renovation of Village Ponds	215	Rs 2 Lakh Per Stucture

Block	Net GW Availability in MCM	GW extraction for Irrigation in MCM	GW extraction for Domestic & Industrial in MCM	Gross extraction in MCM	Stage of extraction %	Saving by Sprinkler in MCM	Additional recharge created by AR in MCM	After intervention of AR Structure Net GW AvL. in MCM	After intervention of AR Structure &utilisation of 60% of additional GW created. in MCM	Extraction after sprinkler MCM	Stage of extraction after intervention %	additional area irrigated by GW after intervention (Ha)
Zeerapur	93.15	67.37	3.95	71.33	**76.58**	13.47	6.59	99.74	3.95	61.80	**61.96**	989

CHAPTER-7

CONCLUSIONS AND RECOMMENDATIONS

- Rajgarh District occupies an area of 6155 Sq.Km in the state of Madhya Pradesh. The water recharge worthy area is also 6155 sq. km.
- The major rivers flowing through the area includes rivers of Chambal Sub-basin drain the entire Rajgarh district. All the rivers are almost northerly flowing. Kalisindh and Parwati rivers at western and eastern side bound the district respectively. The Newaj River flows through the middle portion of the district.
- The major part of the district is covered by the Deccan trap lava flows while the eastern part is covered by recent alluvium.
- Rajgarh district comprises of six blocks, namely Rajgarh, Khilchipur, Zirapur, Biora, Narsinghgarh and Sarangpur.
- The phreatic aquifer is recharged during monsoon and sustains for 3 to 4 months.
- More stress on Groundwater, 94 % of irrigation carried out by Ground water while 6 % of irrigation by surface water. (area)
- Groundwater decline is observed less than 2 m/year in most of the area.
- The high nitrate concentration has been recorded in ground water of Sarangpur (64 mg/l), Pachor (79 mg/l) and Biora (217 mg/l). Total hardness of ground water in the study area ranged in between 50 to 658 mg/l. The high concentration has been observed in the dug well of Suthaliya (658 mg/l) and Pachor (653 mg/l).
- On the basis of the 34 exploratory wells and 9 Piezometers in Rajgarh district, CGWB/NCR under its Exploratory/NAQUIM program, it has been observed that the yield varies from meager to 10.5 lps.
- As per the Dynamic Ground Water Resource Assessment Report (2020),there are six assessment units (blocks) in the district out of which 1 blocks fall under safe category.

- Only Rajgarh block comes under safe category with stage of ground water development being 67.88 %. The net ground water availability in the district is 775.04 MCM) and ground water draft for all uses is 654.20 (MCM), making stage of ground water development to 84.41% as a whole .
- After the interventions suggested in the report, the stage of Ground Water extraction is expected to improve by 1.01 % i.e. from **84.41** % to **83.4 %** for the Rajgarh district.
- As per the Management plan prepared under NAQUIM of all the Block of Rajgarh District, a total number of 92 Percolation Tanks, 183 Recharge Shafts and 641 Nala Bunds/Check Dams/Cement Plugs have been proposed.
- The number of artificial recharge structure and financial estimation has been proposed based on the CGWB Master plan 2013. It may be differ from the field condition as well as Changes in dynamic Ground water recourses.
- It is also recommended that implementation intervention would be in three Phases, First Phase should be in those blocks where stage of Ground Water extraction is more than 90 %.
- The second phase should be in those blocks where stage of GW extraction is 70% to 90 %.
- The third phase should be in those blocks where stage of GW extraction is less than 70 %.

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