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

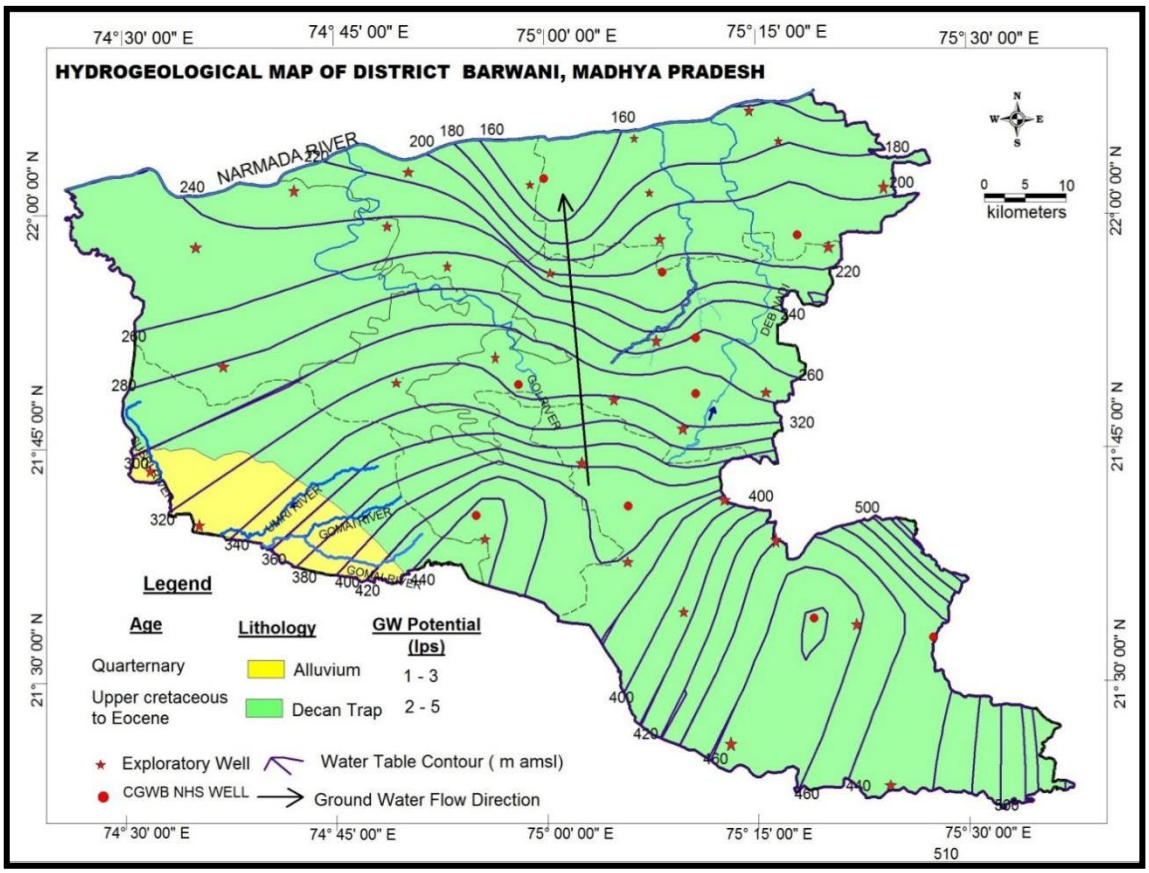
AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

BARWANI DISTRICT
MADHYA PRADESH

उत्तर मध्य क्षेत्र, भोपाल
North Central Region, Bhopal

Central Ground Water Board
Department of Water Resources,RD& GR
Ministry of Jal Shakti
Government of India

Aquifer Mapping and Ground Water Management Plan of Barwani District, Madhya Pradesh



BY
Naresh Kumar Jatav
Scientist - B

NORTH CENTRAL REGION
BHOPAL

2021-2022

CONTENTS

1.	**INTRODUCTION.**	**Page No**
1.1	Objective and Scope	1
1.2	Study area	2
1.3	Climate and Rainfall	3
1.4	Physiography	4
1.5	Land Uses	5
1.6	Geology.	10
1.7	Soil Cover	12
1.8	Hydrology and Drainage	14
2.	**DATA COLLECTION AND GENERATION**	
2.1	Data Collection and Compilation	16
2.2	Ground Water Exploration	17
2.3	Ground Water Monitoring Wells	19
2.4	Geophysical Survey	24
2.4.1	Ground water quality	27
2.4.2	Thematic layers	27
3.	Data Interpretation, Integration and Aquifer Mapping	
3.**1**	Hydrogeology	28
3.2	Aquifer Parameters	29
3.3	Ground Water Levels	30
3.3.1	Pre-monsoonGround Water Level	30
3.3.2	Post –monsoon Ground Water Level	34
3.4	Water level fluctuation	35
3.5	Long water level trend	36
3.6	Ground Water Quality	39
3.6 a	Ground Water quality of aquifer-I(Shallow aquifer).	44
3.6 b	Ground Water quality of aquifer-II (Deep aquifer)	47
3.7	3-D and 2-D Aquifer Disposition	47
3.7a	Hydrogeological Cross Sections	48
3.8	Aquifer Characteristics	52
3.9	Geophysical Study	53
3.10	Geo-Electrical Cross Sections, Lithological 3d Model and Fence Diagram	56
4.0	**Ground Water Resources**	
4.1	Ground Water Resources – Aquifer-I	59
4.2	Recharge Component	59
4.3	Ground Water Resources – Aquifer-II	65
5.0	**Ground Water Related Issues**	
5.1	Decline in Water Level	66
5.2	Low Ground Water Potential / Limited Aquifer Thickness / SustainabilitySoil	67
5.3	Increasing Stage of Ground water Extraction	67

5.4	Extensive Soil Erosion	57
6.0	Proposed Management Strategy.	
6.1	Supply Side Management	68
6.2	Demand Side Management	72
6.3	Management Plans for Extensive Soil Erosion	73
6.4	Post-Intervention Impact	73
7.0	Block Wise Aquifer Maps and Management Plans	
7.1	Aquifer Maps and Management Plan of Pansemal Block	74
7.2	Aquifer Maps and Management Plan of Rajpur Block	77
7.3	Aquifer Maps and Management Plan of Barwani Block	81
7.4	Aquifer Maps and Management Plan of Pati Block	84
7.5	Aquifer Maps and Management Plan of ThikriBlock	87
7.6	Aquifer Maps and Management Plan of Niwali Block	90
7.7	Aquifer Maps and Management Plan of SendhwaBlock	93
8.0	Conclusions and Recommendations	96

LIST OF TABLES

	Title	Page No
1.1	Annual Rainfall Data - 2016-2020(in mm)	3
1.2	Land utilization in study area, 2000-2016 (Area in Ha)	5
1.3	Cropping Patterns& Crop Water Requirements of Barwani district	6
1.4	Crop wise Area Details (Irrigated & Rain fed area details)	7
1.5	Sources of Irrigation (2019-2020)	8
1.6	Land Use (in sq.km)	9
2.1	The details of exploratory in Barwani district	18
2.2	Details of the NHS –CGWB monitoring wells	20
2.3	Details of the Key observation wells in Barwani District	21
2.4	Details of VES Survey points of Barwani district	25
3.1	Details of the NHS well with Pre &Post-Monsoon water level	32
3.2	Analysis of Water Level Fluctuation fluctuation	34
3.3	Chemical Quality of Ground Water for Shallow Aquifer	37
3.4	Chemical Quality of Ground Water of Aquifer-II	37
3.5	Aquifer wise ranges of chemical constituents	39
3.6	Ground Water quality of aquifer-I(Shallow aquifer) & aquifer-II(Deeper aquifer)	53
3.7	Aquifer- resistivity characteristiccs of weathered zone and deeper succession in Deccan Trap Basalt	54
4.1	Ground Water Recharge worthy Areas for Resource Estimation	59
4.2	Ground Water recharge from various Components	60
4.3	Ground Water Resource 2020 , Barwani District	62
4.4	Dynamic Ground Water Resources Availability, Draft and Stage of GW Development	63
4.5	Blockwise Ground Water Resource of district	64
4.6	Static Ground Water Resources of Aquifer-I	64
4.7	Ground Water Resources of Aquifer-II	65
5.1	Annual Ground water Trends	65
6.1	Blockwise Proposed Artificial Recharge Structures	69
6.2	Proposed Numbers of AR structures with cost	71
6.3	Proposed demand Side Interventions	72
6.4	Management Plan of Pansemal Block	74
7.1	Management Plan of Rajpur Block	78
7.2	Management Plan of Barwani Block	81
7.3	Management Plan of Pati block	84
7.4	Management Plan of ThikriBlock	87
7.5	Management Plan of Niwali Block	90
7.6	Management Plan of Sendhwa Block	93

LIST OF FIGURES

	Title	Page No
1.1	Index Map of Barwani	2
1.2	Base Map of Barwani district	3
1.3	Physiographic Map of Barwani Dist	4
1.4	Land Use and Land Cover Map	9
1.5	Land use Pie Chart	10
1.6	Soil Classification, Barwani Dist	13
1.7	Drainage with basin map of Barwani Dist	14
2.1	Locations of Exploratory Wells	17
2.2	Locations of GW Monitoring Wells	19
2.3	Location of Key observation Wells	19
2.4	Location of VES points in Barwani District	24
3.1	Hydrogeological Map of the BarwaniDist	29
3.2	Pre-monsoon (May 2020) Depth to Water Level of shallow Aquifer	31
3.3	Post monsoon (November 2020) Depth to Water Level of Shallow	31
3.4	Fluctuation of Water Level	34
3.5	Pre-monsoon Water Level Trend (May 2012-21) of Aquifer-I	35
3.6	Post-monsoon Water Level Trend (Nov 2012-21) of Aquifer-I	35
3.7	Piper Diagram	40
3.8	US Salinity diagram	41
3.9	Electrical Conductivity of Aquifer-I (Shallow Aquifer	41
3.10	Fluoride Concentration map of Aquifer-I (Shallow Aquifer)	42
3.11	Nitrate Concentration map of Aquifer-I (Shallow Aquifer)	42
3.12	Chloride Concentration map of Aquifer-I (Shallow Aquifer	43
3.13	Total Hardness map of Aquifer-I (Shallow Aquifer)	43
3.14	Electrical Conductivity of Aquifer-II (Deep Aquifer)	44
3.15	Fluorides concentration of Aquifer-II (Deep Aquifer)	45
3.16	Nitrate Concentration map of Aquifer-II (Deep Aquifer)	45
3.17	Chlorides Concentration map of Aquifer-II (Deep Aquifer)	46
3.18	3-D Aquifer Disposition	47
3.19	Aquifer Disposition from Bori to Pichori	48
3.20	Aquifer Disposition from Khampani to Segavi’	49
3.21	Aquifer Disposition from Khadikham to Rakhikhurd	49
3.22	Aquifer Disposition from Khadikham to Rakhikhurd	50
3.23	Aquifer Disposition from Jhapdipdla to Dhawal	50
3.24	Aquifer Disposition from Jhapdipdla to Dhawal	51
3.25	Aquifer Disposition form Jahoor to Nihali of Rajpur Block	51
3.26	Aquifer Disposition form Siwai to Salikalan of Rajpur Block	52
3.27	Geo electrical Cross Section Along A-A’, Barwani District	59

	Title	Page No
3.28	Geo electrical Cross Section Along B-B',Barwani District	60
3.29	Geo electrical Cross Section Along C-C',Barwani District	61
4.1	Recharge from various sources	63
4.2	GW availability and Draft	63
4.3	Block wise Categorisation of Barwani district	64
5.1	Hydrograph showing decline trend	69
7.1	Hydrogeology, Aquifer Disposition and Tentative location of proposed AR structures inPansemal block	74
7.2	Hydrogeology, Aquifer Disposition and Tentative location of proposed AR structures in Rajpur Block	75
7.3	Hydrograph (2012-21 VillagePalsud Block- Rajpur, Barwani District	77
7.4	Hydrograph (2011-2012), Barwani Block- Barwani Barwani District	82
7.5	Hydrograph (2011-21), Village-Baruphatak&Borlai, Block- Thikri	89
7.6	Hydrograph (2011-21), Niwali, Block- Niwali, Barwani District	91
7.7	Hydrograph (2011-21), Village-, Block- Sendhwa, Barwani District	95

PREFACE

'Aquifer mapping' is a holistic approach for aquifer-based groundwater management. It may not be construed as aquifer geometry mapping only. In a broader perspective it can be defined as understanding the aquifers, ascertaining and establishing their quantity and quality sustainability through multi-disciplinary scientific approach integrating the techniques of geology, remote sensing, hydrogeology, geophysics, borehole drilling, hydrochemistry, hydrology, hydrometeorology, mathematical modelling, agriculture and soil science, water treatment and remediation, economics and social and environmental sciences. Under the project on National Aquifer Mapping (NAQUIM to formulate sustainable aquifer management plan, Central Ground Water Board (CGWB), North Central Region, Bhopal has taken up Barwani district to prepare the 3-Dimensional Model and 2-Dimensional Aquifer Maps for the entire district and formulate Block-wise Aquifer Management Plan.

The geographical area of the district is **5422.00** Sq. Km. and recharge worthy area is 3668 sq.km It is divided into, seven administrative blocks viz Barwani,Pansemal, Rajpur, Thikari, Pati, Niwali and Sendhwa, Maximum part of the Barwani district is covered by Deccan Trap and marginal alluvium(Southern part), forming different types of aquifers in the area. Main geological; units of the area are Deccan trap.

The pre-monsoon depth to water levels during May 2020 ranged between 3.9 m to 17.89 mbgl recorded at Niwali, Niwali Block and at Nehgun Barwani Block respectivelyThe water level ranges between 5-10mbgl are observed in major part of the district The seasonal water level fluctuation studied, the water level fluctuation varies 0.004m to 7.49 m.The minimum water level fluctuation recorded 0.004m at Niwali,whereas, maximum water level fluctuation recorded at Rehgun 7.49 m.

Supply side and demand side Management plan prepared under NAQUIM. Artificial recharge structure has been proposed based on the available sub-surface storage of all the Block of Barwani District, a total number of 586 Percolation Tanks, 5026 Recharge Shafts/Checkdam and Nala Bunds/Gully plug and 700Village pond Cement Plugs have been proposed.

Results of these comprehensive studies will contribute significantly to ground water sustainable management tools. It will not only enhance the long-term aquifer monitoring networks and but would also help in building the conceptual and quantitative regional ground-water-flow models for planners, policy makers and other stakeholders. I would like to place on record my appreciation for ***Naresh Kumar Jatav, Scientis-B*** to compile this report. I fondly hope that this report will serve as a valuable guide for sustainable development of ground water in the Hoshangabad District, Madhya Pradesh

Rana Chatterjee
(Regional Director)

AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN FOR BARWANI BLOCK, BARWANI DISTRICT

CHAPTER -1

INTRODUCTION

The development activities over the years have adversely affected the groundwater regime in many parts of the country. Hence, there is a need for scientific planning in development of groundwater under different hydrogeological situations and to evolve effective management practices with involvement of community for better groundwater governance. As India is largest user of groundwater in the world, there is urgent need for an accurate and comprehensive picture of groundwater resources in different hydrogeological settings through aquifer mapping, which will enable robust groundwater management plans. Aquifer Mapping has been taken up in Barwani District in Madhya Pradesh in a view to formulate strategies for sustainable management of the dynamic groundwater resource which help in drinking water security and improved irrigation facility.

National project on Aquifer Mapping (NAQUIM) had been taken up by CGWB to carry out detailed hydrogeological investigation on toposheet scale of 1:50,000. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers

Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. The proposed management plans will provide the **"Road Map"** for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus, the crux of NAQUIM is not merely mapping, but reaching the goal-that of ground water management through community participation. The aquifer maps and management plans will be shared with the Administration Barwani District for its effective implementation.

1.1 Objective and Scope

The important aspect of the aquifer mapping programme is the synthesis of the large volume of data already generated during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe the aquifer system. The available generated data are assembled, analysed, examined, synthesized and interpreted from available sources. These sources are predominantly non-computerized data, which is to be converted into computer-based GIS data sets.

Aquifer mapping itself is an improved form of groundwater management – recharge, conservation, harvesting and protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e, the aquifer map and management plan. The activities under NAQUIM are aimed at:

- Identifying the aquifer geometry,
- Aquifer characteristics and their yield potential
- Quality of water occurring at various depths,
- Aquifer wise assessment of ground water resources
- Preparation of aquifer maps and
- Formulate ground water management plan.

This clear demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and implementable ground water management plan will provide a **"Road Map"** to systematically manage the ground water resources for equitable distribution across the spectrum.

1.2 Study area

Barwani district is located in the western part of Madhya Pradesh, Total geographical area of the district is 5422 sq km. The district is bounded the North by Dhardistrict, the South and West by Maharashtra state, the East by Khargone, The district extends between the parallels of latitude 21°22' to 22°07'"north and the longitude E 74°26' to 75°37' and falls in Survey of India toposheet Nos. 46J, 46K, 46N and 46O. The district is divided into four sub divisions; Barwani, Rajpur, Sendhawaand Pansemal. Seven development block Barwani, Pati, Sendhawa,Pansemal, Niwali, Thikri and Rajpur. According to the census of 2011, the total population of the Barwani 1642934. Density of the Population is 255/km²as per 2011 census.

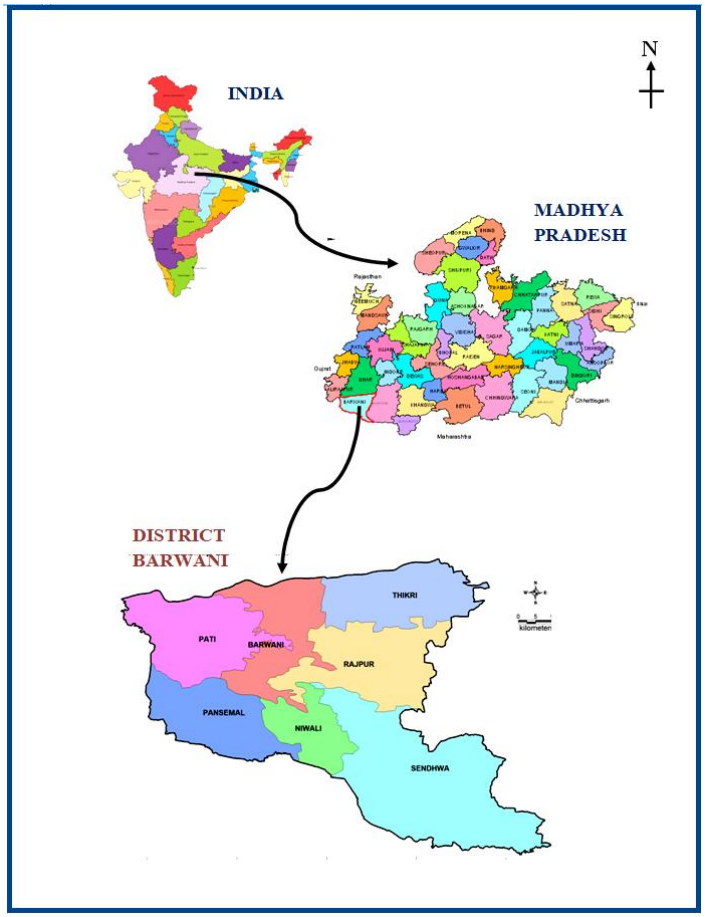


Fig 1.1 Index Map of Barwani

The Barwani district is located in SW part of the Madhya Pradesh shown in **fig no.-1.1**, and Base map shown in **fig no-1.2**

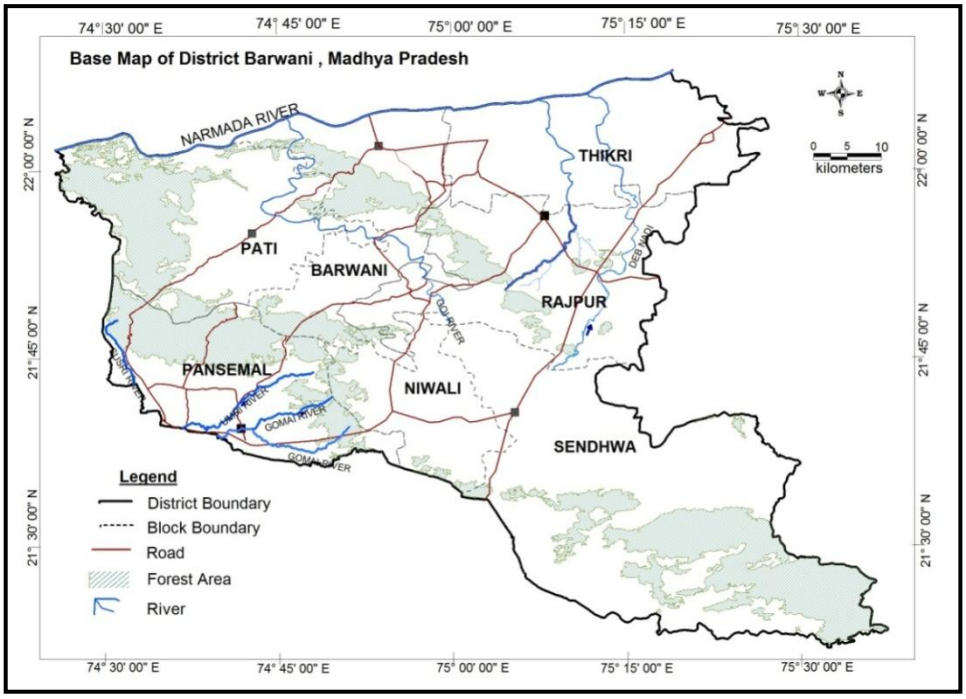


Fig1.2: Base Map of Barwani distric

1.3 Climate and rainfall

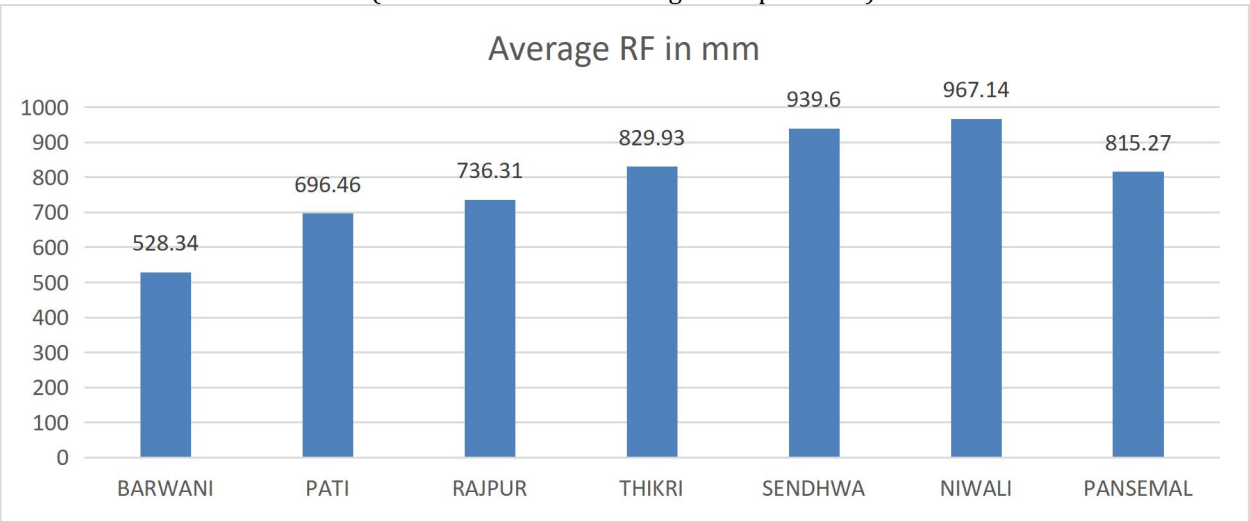
The average annual rainfall data since 2016 to 2020 of Barwani distrThe climate of the district on the whole is tropical and dry, except during south west monsoon season (middle of June to September). Winter Season is between November to February. Summer season starts from March and ends by June.The district is influenced by South-West Monsoon which extends from June to September. The mean annual rainfall is 787.57 mm. There is very little rainfall in the winter season. The monsoon rainfall accounts for 80% - 85% of the annual rainfall.May is the hottest month of the year when general temperature goes upto 42º C, occasionally, it goes upto 47º C. December is the coldest month of the year when the mean daily temperature comes down to about 11º C. Relative humidity is maximum in the monsoon season and is very low in dry months. It is as low as 10% in dry months and as high as 94% in the monsoon season.
ict is shown in table no- 1.1

Table 1.1: Annual Rainfall Data - 2016-2020(in mm)

S. No.	Block	2011 Rainfall in mm	2012 Rainfall in mm	2013 Rainfall in mm	2014 Rainfall in mm	2015 Rainfall in mm	2016 Rainfall in mm	2017 Rainfall in mm	2018 Rainfall in mm	2019 Rainfall in mm	2020 Rainfall in mm
1	BARWANI	402.8	245.3	603.8	489.6	472.8	423.1	442.1	525.4	866.6	811.9
2	PATI	619	416	1024	669	809	523	521	472	1134.1	777.5
3	RAJPUR	793	507	1086	834	662	694.8	654	426.6	928.8	776.9
4	THIKRI	836.6	695	1129.3	911.5	839	662	706	647.7	1165.6	706.6
5	SENDHW	765	672	1108	978	636	564.2	1703.2	676	1256.3	1037.3
6	NIWALI	901	800	1213	1067	922.1	810.2	927.5	713	1275.2	1042.4
7	PANSEMA	615	361.4	1296	841	533	428	792	617	1420.3	1249
Average		704.629	528.1	1065.73	827.157	696.271	586.471	820.82	582.529	1149.56	914.51

						10 years average 787.57

(Source: Indian Meteorological Department)



1.4 Topography and Physiographic: -

Geomorphology is one of the critical theme information for all the application projects. Hence, the geomorphic maps proposed to be prepared would cater to the different resource information needs of the country like geo-environment, geo-engineering, geohazards, mineral and ground water exploration and also interdisciplinary themes like soil, land use / land cover and forest, etc. Geomorphology plays an important role in various fields of planning. One of the major themes is the irrigation development where in the geomorphological guides are used as one of the indicator zone for site selection. The understanding of subsurface geology is a primary requirement for planning exploration and exploitation strategies. The basement structure highs manifest itself on the surface as geomorphic anomaly like annular drainage pattern, radial pattern, sudden change in the river course etc. Physically, the district comprises of three distinct natural

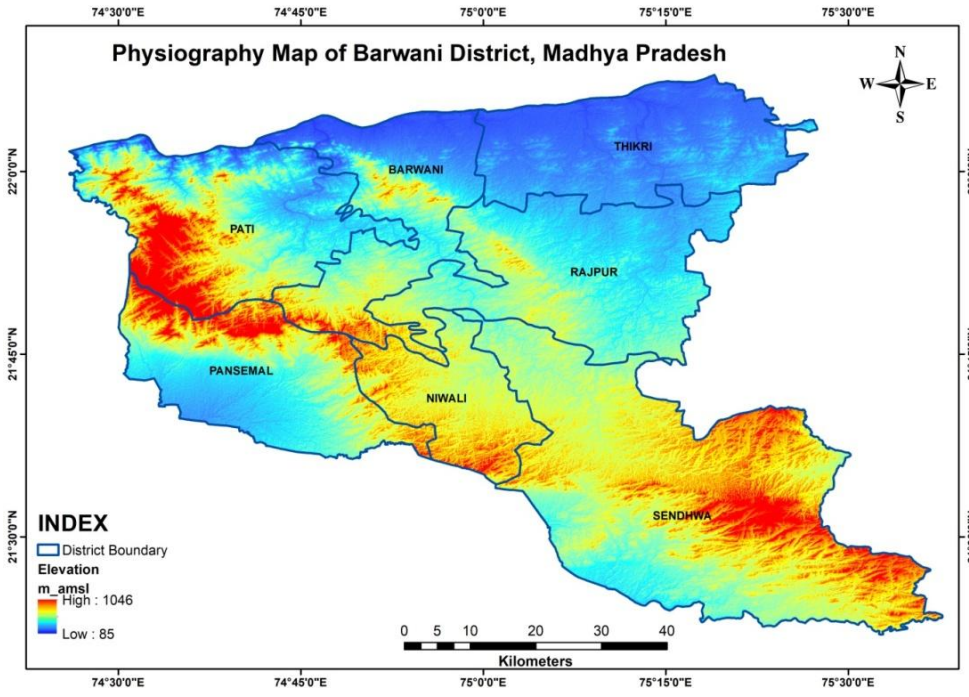


Fig 1.3: Physiographic Map of Barwani Dist

divisions viz. Narmada valley in the northern part, uplands along southern and western margins (Satpura Range and highly dissected Deccan Plateau) and Narrow belt of scarp ridges (Vindhyan Hill Range). The area of the district displays undulatory topography which includes highly dissected plateau, linear ridges, residual hills and low lying plains. The highest elevation in the district is 1033 m amsl south of Ramgarh fort in Sendhwa Block. The lowest point is at elevation 149 m amsl near Talwda Deb in Rajpur Block.

The basement structure highs manifest itself on the surface as geomorphic anomaly like annular drainage pattern, radial pattern, sudden change in the river course etc.physigramphy of the Barwani district is shown in **fig no-1.3.**

1.5 Land Uses

The details of the land use statistics for year 2000-2016 is given in Table-1.2 and the cropping pattern is given in Table – 1.3. Land uses and Land Cover shown in map of Barwani district is shown as **Figure-1.4.**

Table 1.2: Land utilization in study area, 2000-2016 (Area in Ha)

Land Use in Ha	Barwani	Pati	Rajpur	Thikri	Sendhwa	Niwali	Pansemal
Total Geographical area	76710	71220	77390	75700	122530	59610	59040
Forest area	26388	20997	12647	6563	40009	23548	29319
Area under Agriculture	29408	24586	34594	45867	54785	23733	24395
Community land and area under other uses	20077	25054	29028	21936	26458	11822	4854
Waste land	837	583	1121	1334	1278	507	472

Table 1.3 Cropping Patterns& Crop Water Requirements of Barwani district

S. No.	Crop Type	Names of crops	Area Sown (ha.)	Crop Water Demand (M)	TOTAL Water Requirement (MCM)	Existing water potential (MCM)	Water potential to be created (MCM)
1	Cereals Kharif	Paddy	1013	1.2	12.156	0.000	0
2	Coarse Cereals	Maize	48008	0.45	216.036	0.000	108.018
		Jwar	34493	0.45	155.218	0.000	77.609
		Bajra	7480	0.45	33.66	0.000	8.228
3	Pulses	Moong,	6849	0.5	34.245	0.000	8.218
		Urd	8009	0.4	32.036	0.000	8.000
		Arhar	4325	0.5	21.625	0.000	10.812
		Kulthi	4446	0.4	17.784	0.000	0.000
4	Oil Seeds	Soyabean	27494	0.4	109.976	0.000	54.988
		Groundnut	10129	0.65	65.8385	0.000	32.412
5	Fibre	Cotton	64358	1.05	675.759	518.532	157.227
6	Any other crops	other crops	20764	0.65	134.966	107.146	28.210
TOTAL Kharif			**237368**		**1509.2995**	**625.678**	**493.722**
1	Cereals Rabi	Wheat	79270	0.6	475.612	216.336	259.284
2	Coarse Cereals	Maize	94400	0.45	424.800	27.000	397.800
3	Pulses	Gram	10600	0.4	42.400	24.240	18.160
		Groundnut	3000	0.65	19.500	9.522	9.978
4	Any other crops	Sugarcane	10000	1.2	120.000	48.000	72.000
	Vegetable & Fruits	Vegetable	15166	0.5	75.830	37.500	38.330
		Fruits	6393	0.8	51.144	24.000	27.144
		Spices	15515	0.6	93.090	45.000	48.090
		Flowers	1862	0.6	11.172	4.800	6.372
	Total Rabi		**236206**		**1313.548**	**436.398**	**877.158**
	Grant Total		**473574**		**2822.848**	**1062.076**	**1370.880**

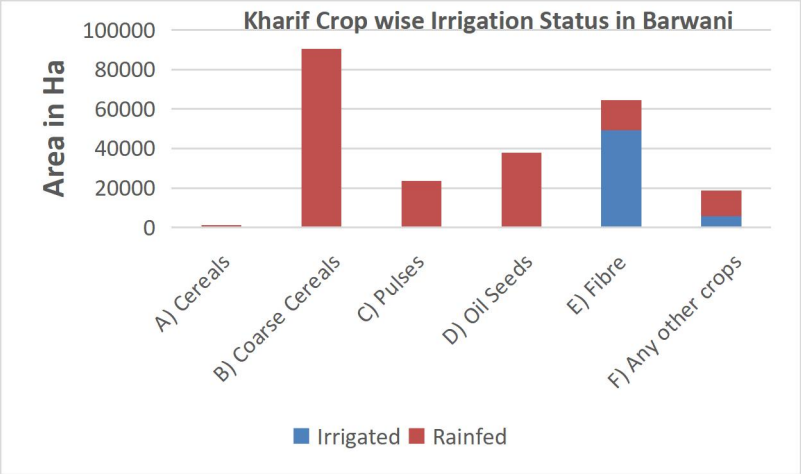
(Source:PMKSY)

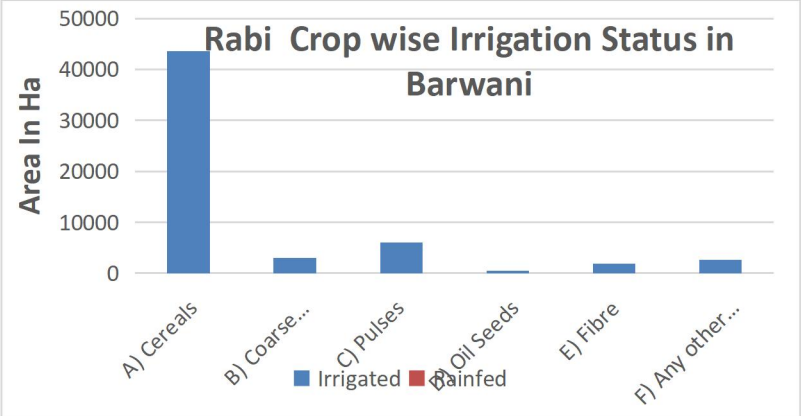
Table 1.4 : Crop wise Area Details (Irrigated & Rain fed area details)

Crop wise Irrigation Status in Barwani

Crop Type	Kharif (Area in ha)			Rabi (Area in ha)			Summer Crop (Area in Ha)			Total (Area in Ha)		
	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
A) Cereals	0	1013	1013	43564	0	43564	0	0	0	43564	1013	44577
B) Coarse Cereals	0	90504	90504	3000	0	3000	824	0	824	3824	90504	94328
C) Pulses	0	23629	23629	6033	0	6033	518	0	518	6551	23629	30180
D) Oil Seeds	0	37950	37950	486	0	486	1123	0	1123	1609	37950	39559
E) Fibre	49384	14974	64358	1841	0	1841	0	0	0	51225	14974	66199
F) Any other crops	5630	13122	18752	2697	0	2697	428	0	428	8755	13122	21877
Total	**55014**	**181192**	**236206**	**57621**	**0**	**57621**	**2893**	**0**	**2893**	**115528**	**181192**	**296720**

The total district irrigated area is 2967.20 sq km, out which maximum area irrigated during Kharif season around80% and minimum area irrigated summer season around 1%. The main kharif crops of the district are maize and Cotton and It is cultivated in 480.08 Sq. km and 644 sq.km area respectively, Groundnut, Til, Ramtil are other oilseed crops grown in Kharif season and Linseeds and Mustard are major oilseeds of Rabi season in the district. Oilseeds area is 376.13 Sq. km in Barwani district. There are 10.13sq. Km rainfed and 445.77 sq. Km irrigated area covered by cereals in the district. Coarse cereals in the district have third position in term of area of production. It covers total 943.28. Km including kharif and rabi area. Jowar, Maize, Kodo-Kutki are major coarse cereals cultivated in the district. Coarse cereals contribute of Barwani. Other Crops (Mainly sugarcane) also cultivated in 100 sq. Km in the district. Other crops of the district. Horticultural crops cover 207 sq. Km of the district. Fiber crops also major crop in the area is 642. sq.km





In the district.The total area irrigated by canals, tanks and ponds is 213.58 sq km,total area irrigated by dug wells and tube wells are 48607 ha and 24219 ha respectively and area irrigated by other sources is 21240 ha. The source of irrigation (2019-2020) is shown in Table -1.5.

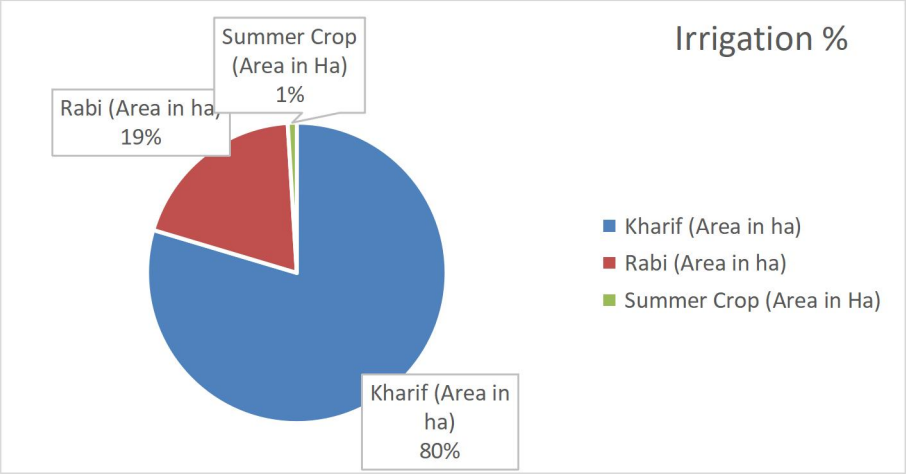


Table –1.5: Sources of Irrigation (2019-2020)

S. No.	Blocks	No. of canal	No of tube well	Area irrigated (Ha)	No. of dug wells	Area irrigated (Ha)	No of Tanks	Area irrigated (Ha)	Area irrigated from other sources (Ha)	Net area irrigated (Ha)	Gross area irrigated (Ha)	Percentage of net area irrigated to net sown area
1	**Barwa**	61	979	1828	5493	8074	7	1899	6496	18297	18297	7.753
2	**Pati**	5	170	294	1792	2825	10	1697	1706	6522	6522	2.763
3	**Rajpur**	35	3202	4780	1236	6826	28	2773	9561	23940	26125	11.069
4	**Thikri**	74	3020	7115	7548	13643	7	6278	1424	28460	26275	11.133
5	**Sendh**	11	1198	2408	5374	7844	21	5062	0	15314	15314	6.489
6	**Niwali**	3	785	1378	5412	4295	3	617	345	6635	6635	2.811
7	**Pansem**	9	3303	6416	4646	5100	8	3032	1708	16256	16256	6.888
TOTAL		**106**	**1265**	**24219**	**4263**	**48607**	**84**	**21358**	**21240**	**115424**	**115424**	**48.91**

Data Source (GWRE2020&PMKSY)

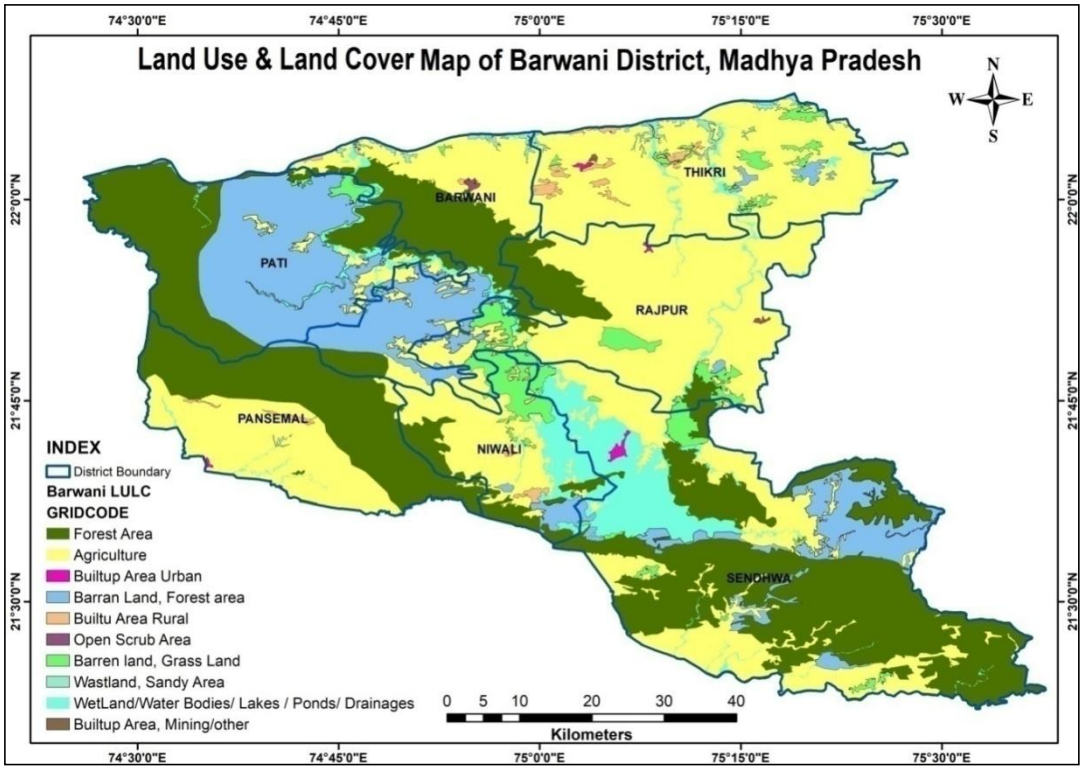


Fig.1.4: Land Use and Land Cover Map.

Land use and land cover data is shown in table No-1.6 and pie diagram shown in figure no.- 1.5 are given below:

Table1. 6: Land Use (in sq.km)

Built up Area	Agricultural Crop Land	Agricultu re, Fallow	Forest	Barren/ waste Land	Water bodies/ Wetlands	Total area
51.61	2328.30	606.41	1819	476.37	140.39	**5422**

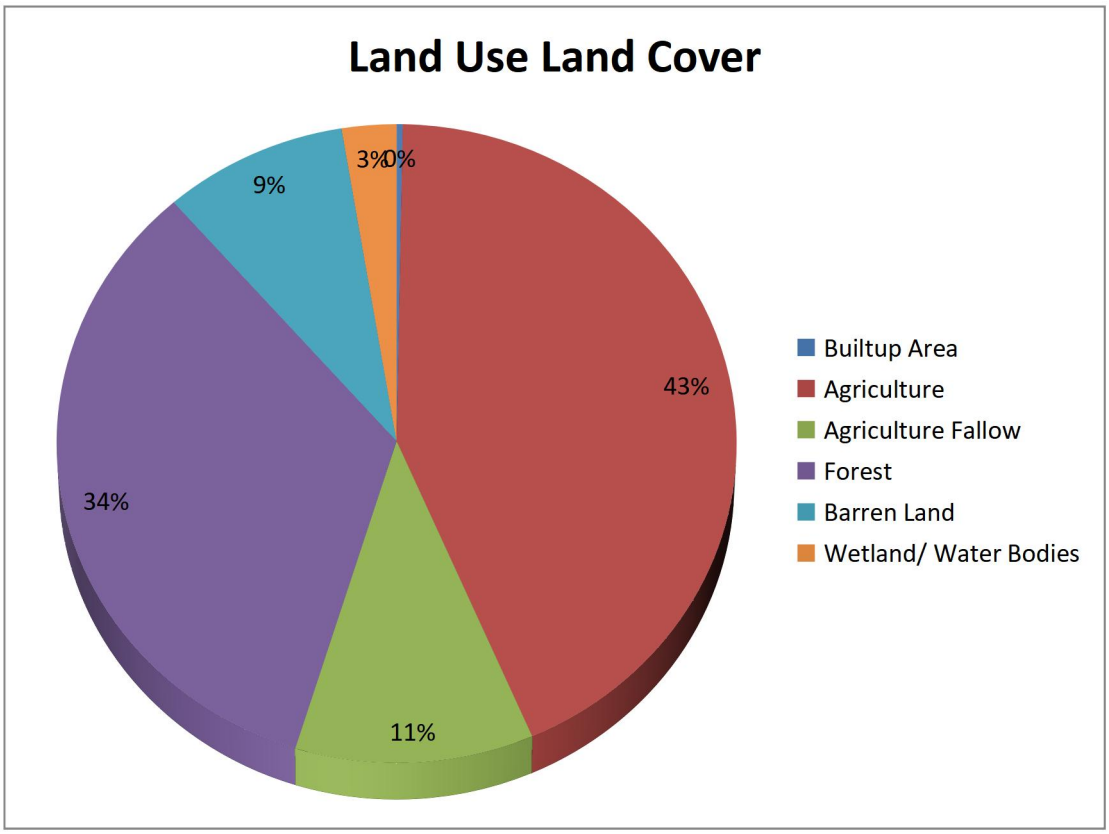


Fig.1.5: Land use Pie Chart.

1.6 Geology

The study area is entirely occupied by consolidated formation, excepting isolated patches of this alluvium pockets occurring along course of streams and rivers.

The general geology of the area is as follows:

Lithology	Formation	Age
Clay+silts+sands	Soil and alluvium	Recent
…… Unconformity……..		
Basaltic lava flows with red bole	Deccan trap	Upper cretaceous to Eocene
…… Unconformity……..		

Deccan Trap

These are basaltic lava flows and form the most predominant and widespread hydrogeological formations in the district. The top weathered mantle where thickness and presence of secondary porosity change according to geomorphic situation offer ground water occurrence under unconfined condition. However, fractures, joints are the pre-dominant

features to form the occurrence of water under semi-confined conditions. The weathered, jointed, fractured and vesicular units of basalts form moderately potential aquifers. The zeolitic basalt, in fractured form also makes good aquifers. The red bole bed is predominantly clay. This formation has highly variable yields, being higher in dug wells. In the unconfined phreatic basaltic aquifer, the ground water is extracted by open wells (depth range 5 –20m) whose diameter varies from 2-9 m. Depending on the type of ground water extraction device, the ground water yields vary between 10 cu. m/dayto 432 cu. m/day.

These flows occur as hummocky and billowy tops and shining outer surfaces, this type of lava flow is called pa-hoe-hoe lava flows.

The individual lava flows is characterized by on upper vesicular zone and a lower unit which may be either jointed and or fractured or totally massive, sometimes the top vesicular zone is filled by secondary minerals viz. Zeolites, Calcite, quartz etc. (called amygdaloidal). The upper vesicular zone is grey, brownish medium to coarse grained; the vesicles are rounded or oval shaped. The vesicular and/or amygdaloidal zone of individual lava flows ranges between 1-5 to 7-5 m in thickness. The lower unit of basaltic flow if fine to medium grained, greenish black to brownish grey in colour, hard, compact and vary in thickness from place to place. Very rarely and individual flow is marked by a basal greyish to purple colour basalt containing pipe amygdales as observed in the hillock west of Barwani and Pati. Though rare in occurrence, this unit containing pipe amygdales serves as marker horizon.

Red Bole bed occurs as marker horizon separating two successive flows. This is red coloured ferruginous material generally attains a distinguishable thickness and sometimes it may attain a thickness as much as 2 m. However, this red bole is often discontinuous and even totally absent. This bed is invariably followed by vesicular/amygdaloidal unit of successive flow under beneath.

Soil and alluvium

The alluvial deposits are confined mainly to Narmada &Goi Rivers and are not very extensive in thickness. The thickness of alluvium in the piezometer at Khetiahas been found to be 10 m. The ground water in alluvium occurs under pheratic conditions. The specific capacity of the wells located in phreatic zone is about 490 lpm/meter of drawdown.

Sub Surface Geology

Central Ground Water Board, constructed 35 exploratory wells in the district. The state agencies and private drilling agencies have constructed some shallow as well as deep tube wells. However Central Ground Water Board, has constructed piezometers at different

places under hydrology project in parts of study area. lithology of these piezometers enclosed in Annexure II.

Phreatic Aquifer

Controlled pumping tests results on number of dug wells in the district shows that theyield of wells tapping vesicular basalts and massive traps ranges from 24 to about 70cu.m/day. The specific capacity of wells varies from 25 lpm/m of drawdown to 285lpm/m of drawdown in weathered vesicular basalt. The specific capacity of wells in alluvial aquifer is about 490 lpm/m of drawdown.

Confined Aquifer

Depending upon the intensity of fractures and its areal extent, the basaltic aquifers arefound to be yielding as low as 12 lpm to as high as 119 lpm in the district. The transmissivity characteristics of confined aquifer ranges from 2 m2 /day to as high as 312 m^2 /day.

Structural Characteristics

The basaltic flows of deccan trap of the present area are horizontally diposed. The primary structural unit is the columnmer joints which is the characteristic feature of the lower point and irregular joints and fractures that of the “Entablature Zone” or middle part of basaltic flow. The secondary joints/fracture are not uniform in distribution. The major lineaments and/or weak planes of the area are EW-NE, WSW to NS and NW-SE trending.

1.7 Soil cover

Generally, five types of soils are found in the district namely Kali–I, Kali–II, Kali-III, Halki Khadri and Bardi. The soils of Barwani district are classified as medium black cotton soils containing nearly 50% silt and clay together. Mostly the soils are lighter, open and drained. Alluvial type of soil is found on both the sides of the river Narmada and in some patches on the banks of its tributaries like Goi, Deb & Bour. This type of soil is deep fertile & well drained. The so is of the rest of the district are mostly shallow & poor in fertility. The soils of Barwani district are classified as medium black cotton soils containing nearly 50% silt and clay together. Mostly the soils are lighter, open and drained. Alluvial type of soil is found on both the sides of the river Narmada and in some patches on the banks of its tributaries like Goi, Deb & Bour. This type of soil is deep fertile & well drained. The soils of the rest of the district are mostly shallow & poor in fertility.Generally, five types of soils are found in the district namely CIass II, Class III ClassIV, Class VI and Class VII.(Fig.6)

Class I soils have slight limitations that restrict their use.

Class II soils have moderate limitations that restrict the choice of plants or that require Moderate conservation practices.

Class III soils have severe limitations that restrict the choice of plants or that require Special conservation practices, or both.

Class IV soils have very severe limitations that restrict the choice of plants or that require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to Remove that restricts their use mainly to pasture, rangeland, forestland, or wildlife Habitat.

Class VI soils have severe limitations that make them generally unsuitable forCultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlifehabitat.

Class VII soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat.

Class VIII soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.The soils of Barwani district are classified as medium black cotton soils containing nearly 50% silt and clay together. Mostly the soils are lighter, open and drained. Alluvial type of soil is found on both the sides of the river Narmada and in some patches on the banks of its tributaries like Goi, Deb & Bour. This type of soil is deep fertile& well drained. The soils of the rest of the district are mostly shallow & poor infertility.

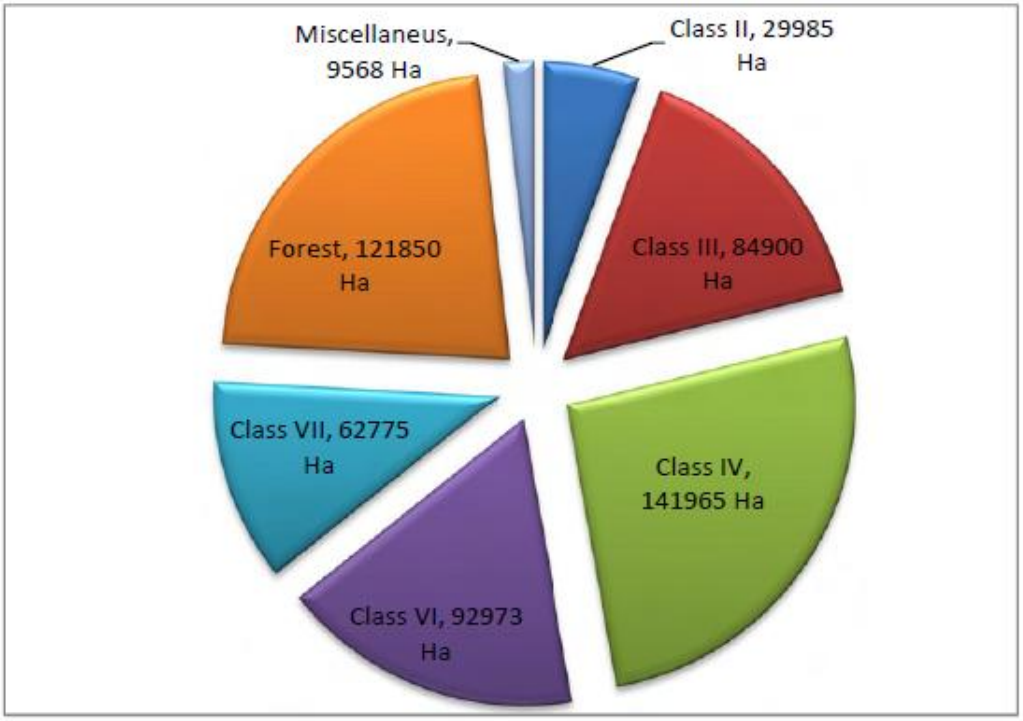


Fig.1.6: Soil Classification, Barwani District

1.8 Hydrology and Drainage

Rivers/streams are natural course of water flowing on the land surface along a definite channel/slope regularly or intermittently towards a sea in most cases or a lake or an inland basin in desert areas or a marsh or another river. Depending upon the nature of availability of water, rivers are sub-divided into perennial or seasonal. They appear in light to dark blue in color, long, narrow to wide depending on the size of the river. They appear in contiguous, at times nonlinear pattern and associated with drainage pattern on hill slopes, flood plains or uplands, at times with vegetation along the banks. There are eight major and minor tributaries of Narmada and Tapti river are flowing through the entire Barwani district.(Fig.1.7)

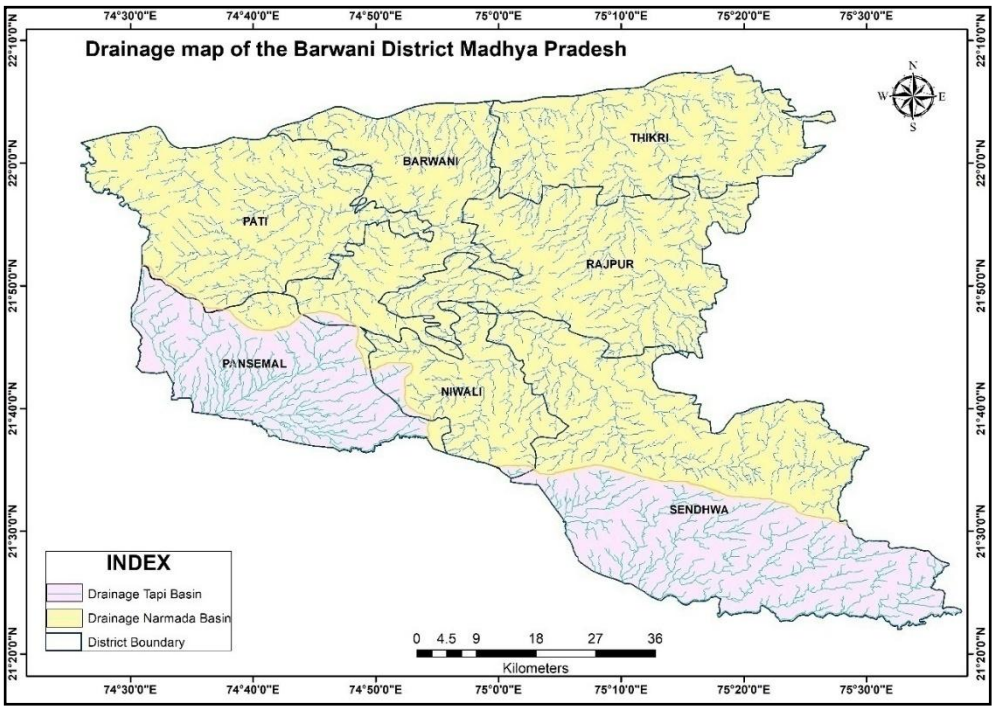


Fig1..7: Drainage with basin map of Barwani

About 88% of the district lies in Narmada Basin and 12% in Tapti Basin at Maharashtra Border. The major tributaries of Narmada are Deb and Goi. No major tributary of Tapti flows in the district. The surface water availability at 75% dependability for both the Basins is 966.70 MCM of which 921.95 MCM is from Narmada Basin and 44.75 MCM from Tapti Basin. The district area is drained mainly by the Narmada River and its tributaries like Goi and Deb. All of these tributaries flow from south to north and join Narmada. Similarly, tributaries like Tori, Churi, Dudhikheda etc. flow from north to south. Major rivers are perennial to semi-perennial.

There are eight major and minor tributaries of Narmada and Tapti River are flowing through the entire Barwani district.

1. Goi river is originating at Latitude 21°40'48.438"N and Longitude 75°21'7.413"E near village Amkiyapani in the block Sendhwa and the length of the river flowing in the

Barwani district is 147 Km.TheGoi river flowing through the Barwani,Niwali,Rajpur,Pati&Sendhwa blocks.

2. Deb river is originating at Latitude 21°37'46.852"N and Longitude 75°18'59.87"E near village Palaspani and the length of the river flowing in the Barwani district is 91 Km.The Deb river flowing through the Sendhwa,Rajpur&Thikri blocks.
3. Nahali river is originating at Latitude 21°48'29.315"N and Longitude 75°4'6.342"E near village Balwani and the length of the river flowing in the Barwani district is 48 Km.TheNahali river flowing through the Rajpur &Thikri blocks.
4. Telar river is originating at Latitude 21°56'13.715"N and Longitude 74°58' 20"E near village Saktipani and the length of the river flowing in the Barwani district is 23 Km.TheTelar river flowing through the Pati & Barwani blocks.
5. Sorar river is originating at Latitude 21°54' 09"N and Longitude 75°1' 08"E near village Talwada and the length of the river flowing in the Barwani district is 10 Km.TheSorar river flowing through the Barwani block.
6. Susri river is originating at Latitude ,21°51'41.636"N and Longitude 74°31'4.484"E near village Segmal and the length of the river flowing in the Barwani district is 21 Km.TheSusri river flowing through the Pansemal block.
7. Umri Nadi river is originating at Latitude 21°44'14.395"N and Longitude 74°49'27.819"E near in the Forest and the length of the river flowing in the Barwani district is 33 Km. The Umri Nadi river flowing through the Niwali & Pansemal blocks.
8. Kharak river is originating at Latitude 21°32'24.787"N and Longitude 75°23'53.365"E near village Bhanpura and the length of the river flowing in the Barwani district is 17 Km. The Kharak river flowing through the Sendhwa block. PMKSY - Barwani AI Planners Pvt. Ltd.

CHAPTER: 2

DATA COLLECTION AND GENERATION

Hydrogeological data includes quality and quality from existing data were collected and analysed in GIS platform to validate and avoid discrepancy while preparing the aquifer mapping in the district. The date collected from allied department such as WRD, PHED and Agriculture departments and administrative department were also included in the data collection and analysis.

The data collection and compilation for various components was carried out as given below.

- Hydrogeological Data – Current and historical water levels along with water level trend data of monitoring wells representing Aquifer-I (Shallow aquifer) of CGWB. The weathered zone thickness (aquifer-I), Lithology and details of deeper aquifers (aquifer-II) of exploratory wells were also collected and compiled.
- Hydro chemical Data - Ground water quality data of monitoring wells of CGWB representing shallow aquifer and data from exploratory wells representing deeper aquifer.
- Exploratory Drilling – Ground water exploration data of exploratory wells of CGWB.
- Hydrometeorological Data - Long term rainfall data for the whole district and for each block from Indian meteorological Department and Water Resource Department.
- Water Conservation Structures – Numbers, type and storage potential of water conservation structures prevailing in the area from Jilla Panchayat, Barwani.
- Cropping Pattern Data – Data on prevailing cropping pattern from Krishi Vigyan Kendra, Barwani district.

2.1 Data Adequacy and Data Gap Analysis:

The available data such as Exploratory wells, Vertical Electrical Sounding (VES), ground water monitoring stations and ground water quality stations of Central Ground Water Board North Central Region, Madhya Pradesh, WRD Govt. of MP and other allied State Surface and Ground Water departments were compiled and analysed as per the nomenclature for adequacy of the data.

2.2 Ground Water Exploration

Central Ground water Board Bhopal has been constructed exploratory wells under Ground water exploration to assess the lateral and vertical lithological disposition of shallow aquifer (Aquifer-I) and deeper aquifer (Aquifer-II). The Hydrogeological parameters have also been estimated through different hydrogeological test (Pumping test, Yield and slug yest). The locations of constructed exploratory wells are shown in **Fig. 2.1**. The details of exploratory are given in **Table no-2.1**

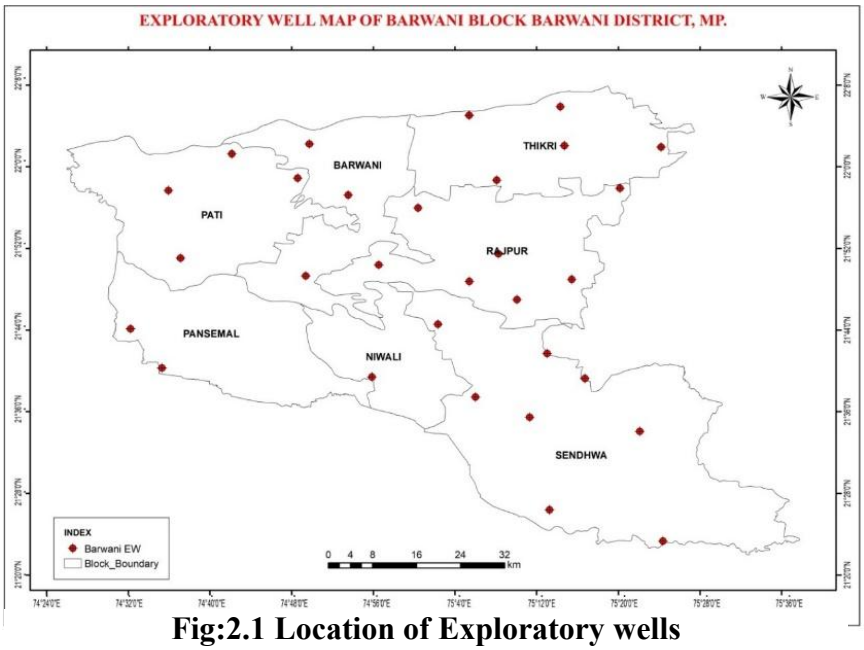


Fig:2.1 Location of Exploratory wells

The exploratory well drilled/constructed by CGWB through outsourcing project in 2018 and 2021 under "National AquiferManagement Program". In the 2018 ,05 Nos of wellsand in 2021 30 nos of EW have been constructed up to todepth of 200 mbgl, the ranges of discharge in Exploratory well between 0.01 lps to 9.87 lps. The maximum discharge is found atSiwai Village of Rajpur block and the minimum discharge found also in Rajpur block atNihali village. The most potential aquiferzone encountered at depth ranges 88-103, 136-158 and 190-200mbgl.

Table :2.1 The details of exploratory in Barwani district

District	Block	Location	Latitude	Longitude	Depth Drilled (m bgl)	Discharge in lps	SWL (m)	Formation
Barwani	Barwani	Pichori	N22.0371	E 74.8291	200.00	0.43	48.66	Basalt
Barwani	Barwani	Ambapani	N21.9537	E 74.8924	200.00	0.75	69.65	Basalt
Barwani	Barwani	Bori	N21.8216	E 74.8229	183.00	6.71	51.57	Basalt
Barwani	Pati	Rosar	N21.9612	E 74.5987	200.00	3.75	71.00	Basalt
Barwani	Pati	Angrada	N21.9815	E 74.8097	185.00	8.20	47.00	Basalt
Barwani	Pati	Bokrata	N21.8508	E 74.6187	200.00	3.27	93.00	Basalt
Barwani	Barwani	Gothaniya	N21.9327	E 75.0062	200.00	3.70	29.00	Basalt
Barwani	Pati	Nalti	N22.0208	E 74.7022	200.00	1.74	30.00	Basalt
Barwani	Barwani	Chikliya	N21.8397	E 74.9420	200.00	-	15.80	Basalt
Barwani	Rajpur	Indarpur	N21.8578	E 75.1374	200.00	0.08	115.30	Basalt
Barwani	Rajpur	Ghusgaon	N21.8159	E 75.2572	200.00	-	88.00	Basalt
Barwani	Rajpur	Nihali	N21.8128	E 75.0902	200.00	0.01	86.00	Basalt
Barwani	Rajpur	Salikalan	N21.7830	E 75.1679	153.00	1.74	64.50	Basalt
Barwani	Rajpur	Siwai	N21.9782	E 75.1349	147.00	9.87	23.00	Basalt
Barwani	Thikri	Bunderkachh	N22.0345	E 75.2451	200.00	5.40	5.90	Basalt
Barwani	Rajpur	Jahoor	N21.9648	E 75.3357	200.00	-	151.00	Basalt
Barwani	Thikri	Gawla	N22.0980	E 75.2384	200.00	3.65	51.00	Basalt
Barwani	Thikri	Samartalai	N22.0321	E 75.4032	200.00	-	22.00	Basalt
Barwani	Thikri	Dattawada	N22.0840	E 75.0898	200.00	0.91	12.30	Basalt
Barwani	Niwali	Jogwada	N21.7427	E 75.0389	200.00	0.43	40.00	Basalt
Barwani	Sendhwa	Jhapdipadla	N21.6952	E 75.2170	200.00	1.91	8.40	Basalt
Barwani	Sendhwa	JhireeJamli	N21.6544	E 75.2787	200.00	0.35	61.50	Basalt
Barwani	Sendhwa	Khurmabad	N21.5679	E 75.3681	200.00	-	121.50	Basalt
Barwani	Sendhwa	Mohala	N21.5910	E 75.1886	200.00	-	83.00	Basalt
Barwani	Sendhwa	Balwadi	N21.4426	E 75.2211	200.00	2.44	22.00	Alluvium and Basalt
Barwani	Sendhwa	Dhawali	N21.3887	E 75.4061	200.00	-	51.00	Basalt
Barwani	Niwali	Segavi	N21.6240	E 75.1000	200.00	-	6.00	Basalt
Barwani	Niwali	Khampani	N21.6568	E 74.9310	200.00	-	28.00	Basalt
Barwani	Pansemal	Khetia	N21.6752	E 74.5896	200.00	0.75	53.00	Alluvium and Basalt
Barwani	Pansemal	Rakhi Khurd	N 21.7574	E 74.5243	200.00	6.71	57.00	Basalt

2.3 Ground Water Monitoring Wells

Central ground water board has been established fifty key observation wells in the district during data generation and carrying out water level monitoring of NHS wells and key observation wells (dug wells and piezometers). The wells are being monitored four times in a year during the month January, May, August and November. The Ground-water systems are dynamic and adjust continually to short-term and long-term changes in climate, ground-water withdrawal, and land use. Water-level measurements from observation wells are the principal source of information about the hydrologic stresses acting on aquifers and how these stresses affect ground-water recharge, storage, and discharge. Long-term, systematic measurements of water levels provide essential data needed to evaluate changes in the resource over time, to develop ground-water models and forecast trends, and to design, implement, and monitor the effectiveness of ground-water management and protection programs.The locations of NHS and Key wells are shown in Fig.2.2 & Fig: 2.3and details of NHS and Key wells given in in Table no.-2.2& Table no.-2.3

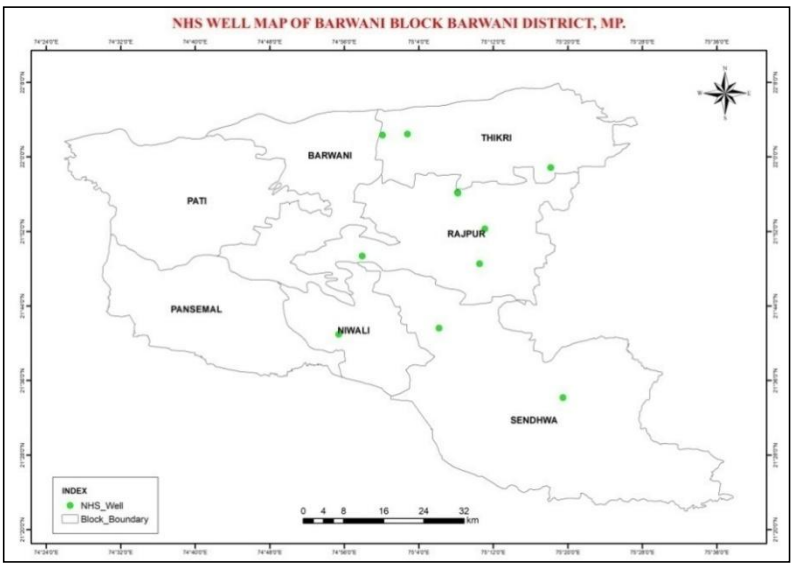


Fig.2.2: Locations of NHS Wells

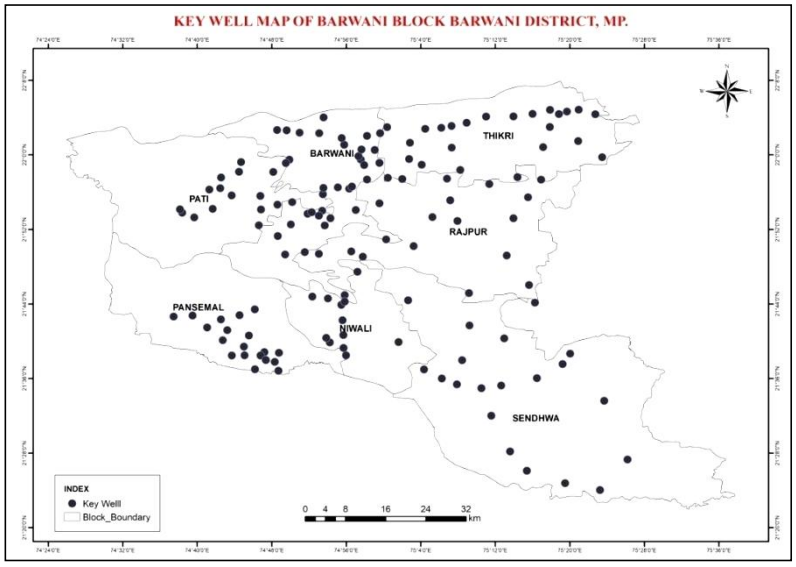


Fig.2.3: Locations of Key Observation Wells

Table 2.2: Details of the NHS wells

DISTRICT	LATITUDE	LONGITUDE	SITE_TYPE	BLOCK_NAME	VILLAGE	DEPTH_m	Water Level mbgl
BARWANI	21°40'57" N	74°55'24" E	Dug Well	NEWALI	Niwali	16.2	5.76
BARWANI	21°48'32" N	75°10'31" E	Dug Well	RAJPUR	Balsamond	12.5	4.42
BARWANI	21°52'17" N	75°11'5" E	Dug Well	RAJPUR	Julwania	13.35	2
BARWANI	21°49'22" N	74°57'55" E	Dug Well	RAJPUR	Palsud	13.5	7.18
BARWANI	21°56'11" N	75°8'10" E	Dug Well	RAJPUR	Rajpur	11.5	5.42
BARWANI	21°56'5" N	75°8'11" E	Bore Well	RAJPUR	Rajpur(D)	62.78	12.96
BARWANI	21°34'10" N	75°19'28" E	Dug Well	SENDHAWA	Chachariya	12.5	3.01
BARWANI	21°41'37" N	75°6'10" E	Dug Well	SENDHAWA	Sendhwa	10.8	3.97
BARWANI	22°2'27" N	75°2'47" E	Bore Well	THIKRI	Anjad(D)	60.04	7.1
BARWANI	21°58'51" N	75°18'9" E	Dug Well	THIKRI	Baruphatak	15	3.18
BARWANI	22°2'20" N	75°0'6" E	Dug Well	THIKRI	Borlai	22.3	4.55

Table:2.3 Details of the Key observation wells

District	Block	Village	Latitude	Long	Date of Collection	Irrigation / Domestic	Geology	Weathering Thickness (M)	Depth of well (m)	Diameter of well (m)	Casing Length (m)	S WL (m) BMP
Barwani	Barwani	Kukra	22.06688	74.8927	16.12.2021	Irrigation	Alluvial, Basalt	5.19	8.96	7.12		5.89
Barwani	Barwani	Kalyanpura	22.03858	74.8849	16.12.2021	Irriagtion	Weatherd/ Fractured	7.85	17.4	7x8	9	8.1
Barwani	Barwani	Pachodi	22.03966	74.8497	16.12.2021	Irriagtion	Weatherd/ Fractured Basalt	7.89	17.3	6.91	7.7	9.6
Barwani	Barwani	Kothra	22.04387	74.8266	16.12.2021	Irrigation	Weatherd/ Fractured	5.62	11	7	5.65	8.6
Barwani	Barwani	Nainpur	22.04425	74.8094	16.12.2021	Irrigation	Weatherd/ Fractured	4.12	10.7	6.95	3.2	8.16
Barwani	Pati	Semli	21.96973	74.7415	16.12.2021	Irrigation	Weatherd/ Fractured	4.96	12.6	7.2	4.58	3.57
Barwani	Pati	Bamnali	21.95936	74.7092	16.12.2021	Irrigation	Weatherd/ Fractured	4.35	17.5	7.86x8.1	4.1	12
Barwani	Pati	New Osda	21.99128	74.8313	16.12.2021	Irrigation	Basalt	2.8	9	5.4*5.4	2.74	2.74
Barwani	Barwani	Rehgun	21.99158	74.9593	17.12.2021	Irrigation	Weatherd/ Fractured	11	25	8	11	10.4
Barwani	Barwani	RehgunPalsud	21.98154	74.9652	17.12.2021	Irrigation	Basalt	5.75	11.1	7.29	7.24	10.12
Barwani	Barwani	Dhaba Bawdi	21.95600	74.9703	17.12.2021	Domestic	Basalt	4.25	10.1	8x5	9.05	7.2
Barwani	Barwani	Silawad Near	21.92936	74.8914	17.12.2021	Irrigation	Basalt	5.18	10.9	6.82	5.55	3.1
Barwani	Barwani	Sindhi Khgodri	21.94081	74.8923	17.12.2021	Irrigation	Basalt	2.15	11.8	7.1	2.1	10.1
Barwani	Barwani	DongariyaKhod	21.94190	74.9180	17.12.2021	Irrigation	Basalt	3.15	10	7.86	0	6.1
Barwani	Barwani	SemaliyaKhodr	21.93935	74.9385	17.12.2021	Irrigation	Basalt	2.1	13.4	9.56	2.32	2.37
Barwani	Barwani	Dongliyapani	21.89458	74.8641	17.12.2021	Irrigation	Basalt	2.46	12.5	7.12x6.5	2.74	4.2
Barwani	Barwani	SapaiDuwali	21.87555	74.8341	17.12.2021	Irrigation	Basalt	3.75	10.2	7.12	3.82	5.4
Barwani	Barwani	Dongargao	21.85482	74.8107	17.12.2021	Irrigation	Basalt	6	11.0	6.84	2.95	5.45
Barwani	Barwani	Bori	21.82163	74.8238	17.12.2021	Irrigation	Basalt	4.1	6.1	7.25		4.82
Barwani	Barwani	Charankhera	21.82603	74.8589	17.12.2021	Irrigation	Basalt	3	15	7.2	3.26	10.65
Barwani	Niwali	Wajhar,	21.70402	74.9266	17.12.2021	Drinking	Basalt	4.12	8.75	6.83	4.51	2.7
Barwani	Niwali	Wajhar	21.73183	74.9244	17.12.2021	Drinking	Basalt	3.84	10.5	7.69	4.9	4.2
Barwani	Pati	Werwada	21.94018	74.7077	18.12.2021	Irrigation	Basalt	6	8	6.91	1.83	2
Barwani	Pati	Kundra Road	21.93779	74.6883	18.12.2021	Irrigation	alluvial, Basalt	4	6.86	6.94	2.14	1.46
Barwani	Pati	Chouki	21.88804	74.6614	18.12.2021	Irrigation	Basalt	5.12	9.68	7.96	1.95	7.56

District	Block	Village	Latitude	Long	Date of Collection	Irrigation / Domestic	Geology	Weathering Thickness (M)	Depth of well (m)	Diameter of well (m)	Casing Length (m)	S WL (m) BMP
Barwani	Pati	UbadaggadJod	21.89642	74.6395	18.12.2021	Irrigtion	Basalt		5.75	5.25	1.1	1.5
Barwani	Pati	Ubadaggad	21.90248	74.6358	18.12.2021	Irrigation	Basalt	2.8	5.6	5.73x7.2	1.75	3.4
Barwani	Pati	Thikari	22.07253	75.3788	19.12.2021	Irrigation	Basalt	7	15.8	6.94	7.92	11.11
Barwani	Thikri	Khurampura	22.02447	75.3481	19.12.2021	Irrigation	Basalt	3	8.87	3.70x4	4.1	5.78
Barwani	Thikri	Rupkheda	21.99583	75.3909	19.12.2021	Irrigation	Basalt	2	6.38	5.87	2	2.1
Barwani	Rajpur	PipariBuzurg	21.94786	75.1892	19.12.2021			3.12	9.6	6.94	4	8.78
Barwani	Rajpur	Siwai	21.97303	75.1373	19.12.2021	Irrigation	Basalt	5.73	7.86	6.34	6.32	6.3
Barwani	Rajpur	Sakad	22.01276	75.1219	19.12.2021	Irrigation	Basalt	3	12.6	5.95	5.1	9.86
Barwani	Rajpur	Mundla	21.95993	75.2396	19.12.2021	Irrigation	Basalt	4	6.47	5.95	1.96	2.1
Barwani	Sendhwa	Jamli Toll Gate	21.75285	75.1527	20.12.2021	Irrigation	Basalt	2.5	8.61	6.93	2.14	4.13
Barwani	Sendhwa	Inayki	21.53340	75.1927	21.12.2021	Irrigation	Basalt	4.1	10.3	5.86		6.24
Barwani	Sendhwa	Kermali	21.46939	75.2263	21.12.2021	Irrigation	Basalt	3.86	8.1	4.46	3.75	6.7
Barwani	Sendhwa	Rajangao	21.43504	75.2562	21.12.2021	Irrigation	Basalt	4.5	9.96	3.85x3.9	4.78	7.1
Barwani	Sendhwa	Jamti	21.41265	75.3246	21.12.2021	Irrigation	Basalt	7	8.9	5.89	7.2	7.5
Barwani	Sendhwa	Dhawali	21.40031	75.3872	21.12.2021	Irrigation	Basalt	2.65	10.5	5.46	3.86	7.12
Barwani	Sendhwa	Mahitgaon	21.69467	75.1536	22.12.2021	Irrigation	Basalt	5.86	8.93	6.1	6.49	4.6
Barwani	Sendhwa	Pipalyadev	21.67161	75.2157	22.12.2021	Irrigation	Basalt	3	6.98	5.93	2.78	5.1
Barwani	Sendhwa	Kumthana	21.60067	75.2742	22.12.2021	Irrigation	Basalt	3.9	12	12	4.17	10.1
Barwani	Sendhwa	Dhawdi	21.62579	75.3201	22.12.2021	Irrigation	Basaly	1.86	6.66	6.78	2.15	4.1
Barwani	Sendhwa	Dhawadi	21.64431	75.3338	22.12.2021	Irrigtaion	Basalt	2.97	7.36	6	3.6	5.8
Barwani	Sendhwa	Ramgarhi	21.56021	75.3946	22.12.2021	Irrigation	Basalt	2	8.56	6.1	2.1	4.12
Barwani	Sendhwa	Chichpani	21.54898	75.4865	22.12.2021	Irrigation	Basalt	5.9	11.6	6	5.1	7.02
Barwani	Sendhwa	OzharYashwant	21.81999	75.2204	22.12.2021	Drinking	Basalt	6.65	13.5	5.89*6.2	8	10.63
Barwani	Sendhwa	Nangalwadi	21.76714	75.2602	22.12.2021	Irrigation	Basalt	5.65	8.11	4.67*12.	5	4.06
Barwani	Sendhwa	Teeri	21.73553	75.2708	22.12.2021	Irrigation	Basalt	4.89	7	6.12	4.5	2.56

2.4 Geophysical Survey:

Geophysical survey has been conducted in 2020 in Barwani district. In this study, surface geophysical method comprised of Vertical Electrical Sounding (VES). Electrical resistivity is one of useful geophysical methods for determining depth (Aquifer) water saturated zone. Location of VES points are shown in **fig 2.4.**

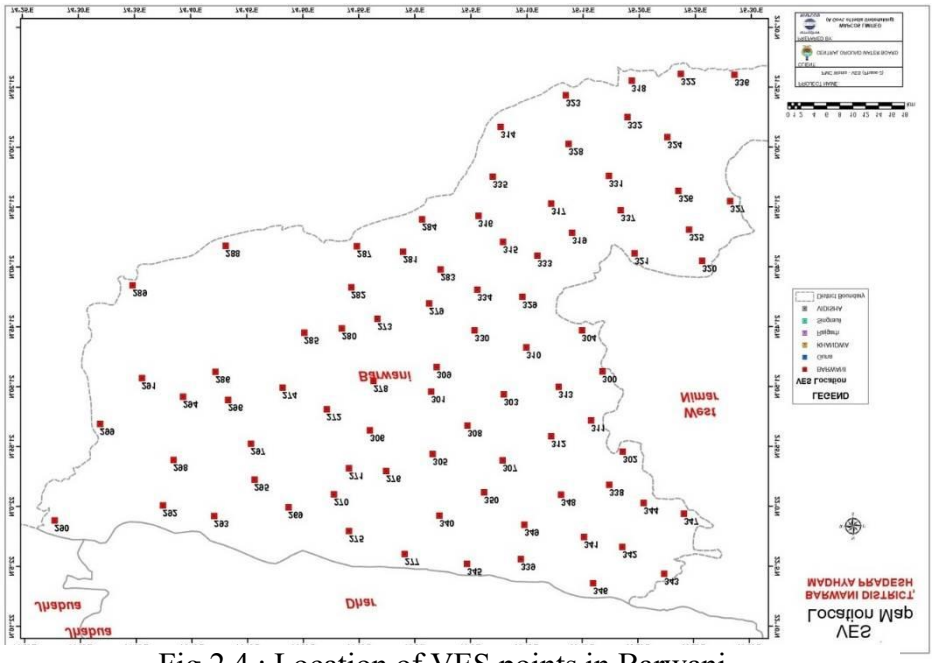


Fig 2.4 : Location of VES points in Barwani

A total of 82 VES were conducted in Barwani district.

The occurrence and movement of groundwater is governed and conditioned by geomorphic configuration of the place and water bearing properties of the litho units like porosity, permeability etc.

The basaltic lava flows form the most predominant and widespread hydrogeological formations in the district. Top weathered mantle where thickness and presence of secondary porosity change according to geomorphic situation offers ground water occurrenceunder unconfined condition. However, fractures, joints are the pre-dominant features to form the occurrence of water under semi-confined conditions. The weathered, joint, fractured and vesicular units of basalts form moderately potential aquifers. The zeolitic basalt, in fractured form also makes good aquifers. The red bole bed is predominantly clay. This formation has highly variable yields, being higher in dug wells.

In the unconfined phreatic basaltic aquifer, the ground water is extracted by open wells (Average depth ranges varies from 5 –16m), diameter varies from 2-9 m. Depending on the type of groundwater extraction device, the ground water yields vary between 10 cu. m/day to 432 cu.m/day.

The alluvial deposits are confined mainly to Narmada &Goi rivers and are not very extensive in thickness. The thickness of alluvium in the piezometer at Anjad has been foundtobe10m. The ground water in alluvium occurs under phreatic conditions. The results are discussed below.

Resistivity Sounding

Resistivity sounding is a process by which the depth investigation is made. In this, the centre of configuration is kept fixed and the measurements are made by successively increasing the electrode spacing. The apparent resistivity values obtained with increasing

values of electrode separations are used to estimate the thickness and resistivity of the subsurface formations.

The main purpose of applying geophysical method for ground water exploration is to help and assess the unknown sub-surface hydrogeological conditions economically, adequately and speedily. Generally the prime task is to compliment the exploratory drilling programme. Mostly it is employed to narrow down the target zone to pin point the probable borehole site for drilling and its proper design.

Geophysical Survey was organized by the Central Ground Water Board, North Central Region, Bhopal. In all, Eighty four (82) Vertical Electrical Soundings were conducted. Wherever the spread/pace length was available, attempts of conducting the type of the array used was SCHLUMBERGER Resistivity meter GGA-30 (Germany made) was deployed for measurements. Details of VES survey points are given in **table no-2.4.**

Table 2.4: Details of VES Survey points of Barwani district

SN_VES	District	Village	Taluka	long	lat	Elevation
1	BARWANI	Junadih(Talwada)	Barwani	74.95495	21.94689	370m
2	BARWANI	Jogwada	Barwani	74.94237	21.73952	418
3	BARWANI	Kalakhet(Amba Pani)	Barwani	74.87994	21.98732	378m
4	BARWANI	AmliyaPani	Barwani	74.89531	21.94372	311m
5	BARWANI	Gothanya(Vedpuri)	Barwani	74.8632	21.86172	390m
6	BARWANI	Osada	Barwani	74.81147	22.00166	218m
7	BARWANI	Seagaon	Barwani	74.9196	22.038	152m
8	BARWANI	Segawan	Barwani	74.98166	22.06677	144m
9	BARWANI	Samarkheda	Barwani	74.79882	21.84585	296
10	BARWANI	Guljwari	Niwali	74.89638	21.7443	443
11	BARWANI	Pichhodi	Niwali	74.90692	21.69037	411
12	BARWANI	Titaliya(Ekalbara)	Niwali	74.93739	21.82555	341m
13	BARWANI	Sidadi	Niwali	74.85494	21.78536	442
14	BARWANI	Pipaldhar	Niwali	75.04257	21.67099	373
15	BARWANI	Borli	Niwali	75.02622	21.71484	341
16	BARWANI	Ummariyapani	Niwali	75.01251	21.6103	505
17	BARWANI	Kunjari	Niwali	74.98569	21.64767	403
18	BARWANI	Kalaamba	Pansemal	74.70482	21.81201	567
19	BARWANI	Godiyapani	Pansemal	74.91363	21.62858	520
20	BARWANI	Matrala	Pansemal	74.72236	21.64432	204
21	BARWANI	Khetia	Pansemal	74.57818	21.69214	175
22	BARWANI	Bhaisari	Pati	74.64589	21.83748	425
23	BARWANI	Chikalkuwa Badi	Pati	74.70313	21.84425	375
24	BARWANI	Budi	Pati	74.7605	21.96776	181m
25	BARWANI	Chakliya(Palwat)	Pati	74.74765	21.91059	275m
26	BARWANI	BaidiFalya	Pati	74.6283	21.93885	468m
27	BARWANI	Kodwani(BaidiFalya)	Pati	74.46999	22.01877	316m
28	BARWANI	Kuli(Bamnali	Pati	74.61062	22.01409	163m
29	BARWANI	Nalati(BaidiFalya)	Pati	74.69968	22.01877	187m
30	BARWANI	Van	Pati	74.54029	21.87694	555
31	BARWANI	BaidiFalya	Pati	74.58253	21.84101	582

SN_VES	District	Village	Taluka	long	lat	Elevation
32	BARWANI	Chitwal	Rajpur	75.31102	21.92566	227m
33	BARWANI	Padala	Rajpur	75.2637	21.88198	245m
34	BARWANI	Nilkanth	Rajpur	75.28378	21.81839	255
35	BARWANI	Khapar Kheda	Rajpur	75.25883	21.75489	284
36	BARWANI	Bhorwada	Rajpur	75.21512	21.82903	214
37	BARWANI	Haldad	Rajpur	75.13752	21.84853	310m
38	BARWANI	Sungaon	Rajpur	75.12888	21.93679	234m
39	BARWANI	ChotiKhargaon(Waswi)	Rajpur	75.21015	21.90416	255m
40	BARWANI	Raipura(Singum)	Rajpur	75.03111	21.93002	276m
41	BARWANI	Danod(Narawala)	Rajpur	75.08798	21.88656	393m
42	BARWANI	Savardha(Chautariya)	Rajpur	75.02387	21.838	350m
43	BARWANI	Gharkheda(Nihali)	Rajpur	75.04351	21.80668	370m
44	BARWANI	Gothanya	Rajpur	74.92793	21.87921	302m
45	BARWANI	Naded	Rajpur	75.1706	21.77894	307m
46	BARWANI	Dhanora	Sendhwa	75.23491	21.61714	409
47	BARWANI	Dhawadi	Sendhwa	75.32863	21.64023	510
48	BARWANI	Mordad	Sendhwa	75.18759	21.64079	383
49	BARWANI	MendalyaPani	Sendhwa	75.10596	21.51603	268
50	BARWANI	Ghegaon	Sendhwa	75.23293	21.43809	236
51	BARWANI	Kermala	Sendhwa	75.21655	21.48803	281
52	BARWANI	Peeranaval(Lavani)	Sendhwa	75.08829	21.75466	380m
53	BARWANI	Dhawada	Sendhwa	75.40119	21.63826	496
54	BARWANI	Julwaniya	Sendhwa	75.39632	21.6027	494
55	BARWANI	Bawadad	Sendhwa	75.13607	21.63777	374
56	BARWANI	Achhali	Sendhwa	75.09443	21.5991	429
57	BARWANI	Bhawargarh	Sendhwa	75.20212	21.58181	429
58	BARWANI	Kamod	Sendhwa	75.45777	21.55602	427
59	BARWANI	Khapar Kheda	Sendhwa	75.38789	21.5626	524
60	BARWANI	Surani	Sendhwa	75.30627	21.59439	453
61	BARWANI	Dhamanya	Sendhwa	75.32018	21.41434	269
62	BARWANI	Dhawali	Sendhwa	75.39602	21.39375	308
63	BARWANI	Sonkhedi	Sendhwa	75.46811	21.40164	352
64	BARWANI	Solwan	Sendhwa	75.12453	21.54495	290
65	BARWANI	Ramgrhi	Sendhwa	75.37664	21.46828	375
66	BARWANI	Mohan Padwa	Sendhwa	75.29068	21.54139	475
67	BARWANI	Jamati	Sendhwa	75.33788	21.43908	316
68	BARWANI	Kusami	Sendhwa	75.15702	21.70866	338m
69	BARWANI	Sendhwa	Sendhwa	75.08872	21.70648	386m
70	BARWANI	Patelpura(Badsalaya)	Thikri	75.28681	21.97089	208m
71	BARWANI	Kakariya	Thikri	75.31409	22.05924	186m
72	BARWANI	Bhuwaniya(Jhiranya)	Thikri	75.34105	21.99551	225m
73	BARWANI	Rahadkot	Thikri	75.40302	22.00922	218m
74	BARWANI	Haribad	Thikri	75.107	21.98348	192m
75	BARWANI	Fatyapur	Thikri	75.14822	22.0667	140m
76	BARWANI	Harangaon	Thikri	75.16695	22.02214	180m

SN_VES	District	Village	Taluka	long	lat	Elevation
77	BARWANI	Hasola(Bhatgawala0	Thikri	75.24954	22.03973	185m
78	BARWANI	Jarwai	Thikri	75.37223	22.08877	167m
79	BARWANI	Padala(Rangaondeb)	Thikri	75.22141	21.98095	201m
80	BARWANI	Anjad	Thikri	75.04344	22.01193	172m
81	BARWANI	Datwada	Thikri	75.08142	22.08311	150m
82	BARWANI	Chainpura	Thikri	75.26571	22.10524	158m

2.4.1 Ground Water Quality

The suitability of ground water for drinking/irrigation/industrial purposes is determined keeping in view the effects of various chemical constituents present in water on the growth of human being, animals, various plants and also on industrial requirement. Though many ions are very essential for the growth of plants and human body but when present in excess, have an adverse effect on health and growth. For assessment of ground water quality, samples from 9 wells (shallow dug wells representing phreatic aquifer) have been collected during pre-monsoon. Similarly for Aquifer – II, the ground water quality data of 35 exploratory/observation wells drilled during earlier exploration and current exploratory drilling activities were utilised. Detail of ground water quality is discussed in Chapter 3 in sub headings.

2.4.2 Thematic Layers

The following 5 thematic layers were also generated on GIS platform which supported the primary database and provided precise information to assess the present ground water scenario and also to propose the future management plan.

- Drainage and Basin
- Soil
- Land Use – Land Cover
- Geology and Structure
- Physiography

The thematic layers such as geology, drainage, soil, land use-land cover have been described in Chapter - I.

CHAPTER -3

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

The data collected and generated on various parameters viz., water levels, water quality, exploration, aquifer parameters, geophysical, hydrology, hydrometeorology, irrigation, thematic layers was interpreted and integrated. Based on this the various aquifer characteristic maps on hydrogeology, aquifer wise water level scenario both current and long-term scenarios, aquifer wise ground water quality, 2-D and 3-D sub surface disposition of aquifers by drawing fence and lithological sections, aquifer wise yield potential, aquifer wise resources, aquifer maps were generated and as discussed in details.

3.1 Hydrogeology

The occurrence and movement of ground water is governed and conditioned by geomorphic configuration of the place and water bearing properties of the lithounits like porosity, permeability etc.

DeccanTraps:

These are basaltic lava flows and form the most predominant and widespread hydrogeological formations in the district. The top weathered mantle where thickness and presence of secondary porosity change according to geomorphic situation offer ground water occurrence under unconfined condition. However, fractures, joints are the pre-dominant features to form the occurrence of water under semi-confined conditions. The weathered, jointed, fractured and vesicular units of basalts form moderately potential aquifers. The zeolitic basalt, in fractured form also makes good aquifers. The red bole bed is predominantly clay. This formation has highly variable yields, being higher in dug wells. In the unconfined phreatic basaltic aquifer, the ground water is extracted by open wells (depth range 5 –16m) whose diameter varies from 2-9 m. Depending on the type of ground water extraction device, the ground water yields vary between 10 cu. m/day to 432 cu. m/day.

Alluvium:

The alluvial deposits are confined mainly to Narmada &Goi rivers and are not very extensive in thickness. The thickness of alluvium in the piezometer at Anjad has been found to be 10 m and the maximum alluvium thickness is encountered upto 30 m. The ground water in alluvium occurs under pheratic conditions. The specific capacity of the wells located in pheratic zone is about 490 lpm of drawdown.

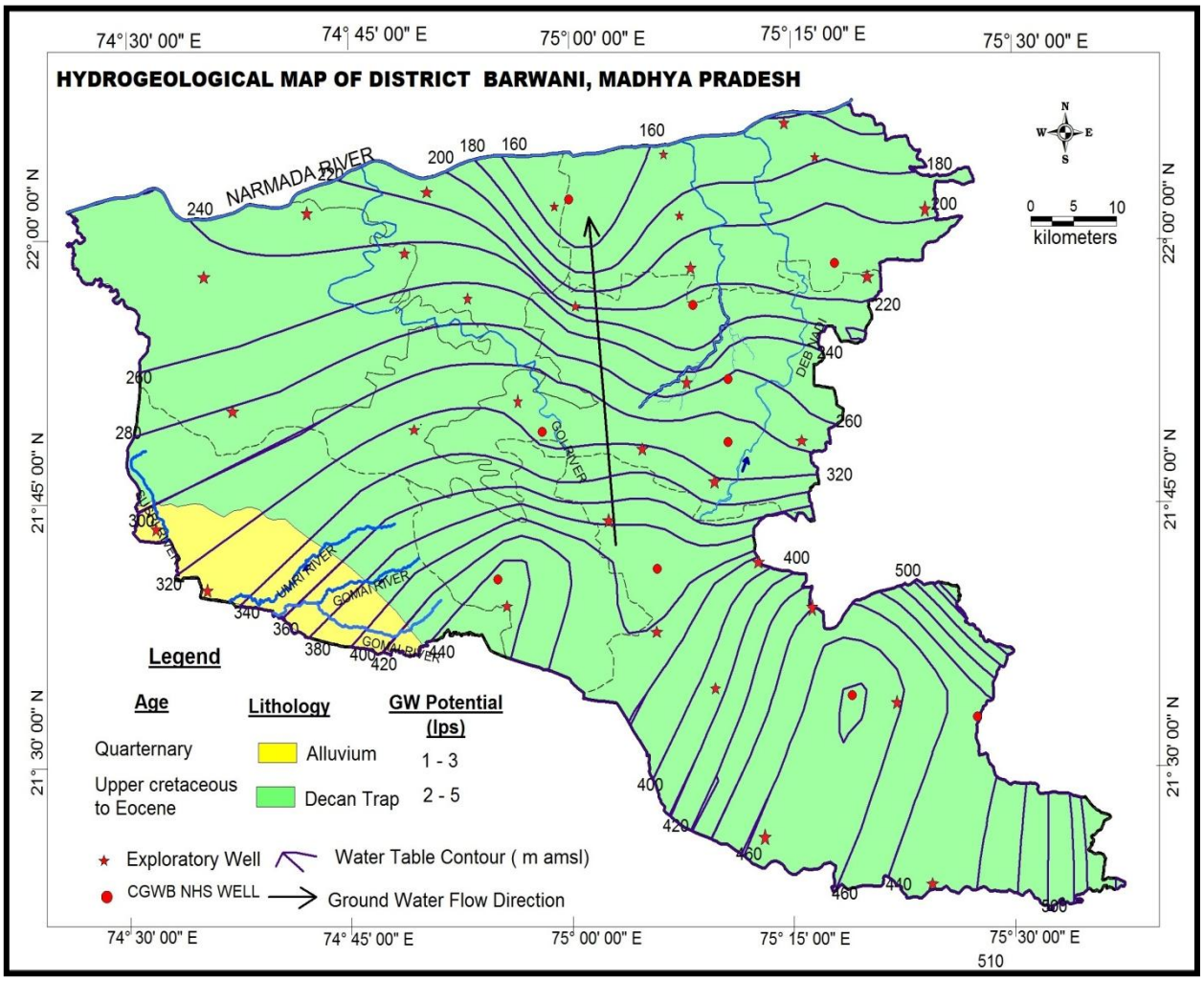


Fig 3.1: Hydrogeological Map of the BarwaniDist

3.2 Aquifer Parameters

The water table contour map was also prepared (**Fig:3.1**) on the basis water level data to understand the ground water flow directions. In Northern part, the major groundwater flow towards the Narmada River, In western part,regional ground water flow direction is towards Tapi Rivers. The whole district is divided into two aquifer system, shallow aquifer considered up to 30 mbgl and deeper aquifer aquifer is considered upto to depth of 200 m bgl. The occurrence of ground water is different geological formations is described below

Phreatic Aquifer

Deccan traps comprising numbers of basaltic lava flows and most widespread rocks in the district. There deccan trap exposed in all seven (7) blocksBarwani,Thikri, Pati, Pansemal, Rajpur, Niwali and Sendhwa and some part of the district is covered by marginal alluvium.The main potential phreatic aquifer are weathered, jointed and fractured basalts under Unconfined conditions. The unconfined aquifer is restricted up to 30 m bgl

The Alluvium formations comprise succession of sand silt and clays which deposited by rivers. Formations are mainly present in part of Pansemal block. In Alluvium formations the yield potential of ranges from 60 lpm to 180 lpm tapping unconfined aquifers.

The specific capacity of wells in alluvial aquifer is about 490 lpm/m of drawdown.

Confined and Semi-Confined Aquifer:

Semi- confined and confined aquifers are encountered between 40 to 200mbgl. Depending upon the intensity of fractures and its areal extent, the basaltic aquifers are found to be yielding as low as 5 lpm to as high as 300 lpm in the district. The transmissivity characteristics of confined aquifer ranges from 2 m2 /day to as high as 312 m^2 /day.

3.3 Ground Water Levels

3.3.1Pre-monsoon Ground Water Level

The pre-monsoon depth to water levels during May 2020 ranged between 3.9 m to 17.89mbgl recorded at Niwali, Niwali Block and at Nehgun Barwani Block respectively. The water level ranges between 2 -5 mbgl are observed in isolated patches of the district, water level ranges between 5-10 mbgl observed in major part of the district, around 68% wells are fall this category, the water levels ranges between 10-15 m recorded in 14 wells, around23% and water level more than 15mbgl are observed in 2 wells. The major part of the district falls under the ranges between 10-15 mbgl. Thekey observation wells details and pre-monsoon& post-monsoon water level data is given in Table: 2.3 &3.1, whereas depth to water level map is given in Fig.3.2.

3.3.2 Post –monsoon Ground Water Level

The post-monsoon depth to water levels during Nov 2021 ranged between 1.5 (Ubadaggad village) at Pati Block to11.11mbgl (Thikari) at Thikari Block. The water level ranges between 5-10mbgl are observed in major part of the district around 44% wells , water level ranges between 2-5mbgl observed in 37% wells and the water levels of more than 10 mbgl are observed in some patches of northern eastern parts of the district. The pre-monsoon water level data is presented as Table:3.2,3.3, whereas depth to water level map is given in Fig.3.3.

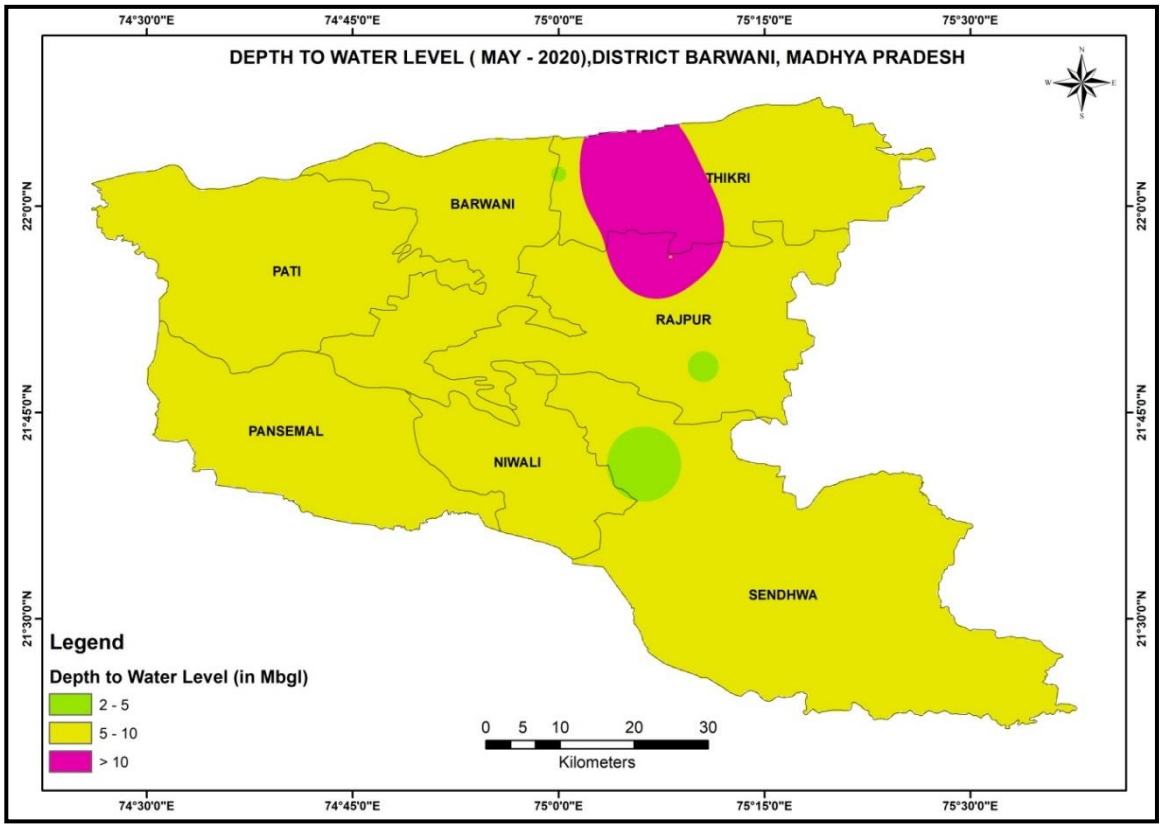


Fig. 3.2: Pre-monsoon (May 2020) Depth

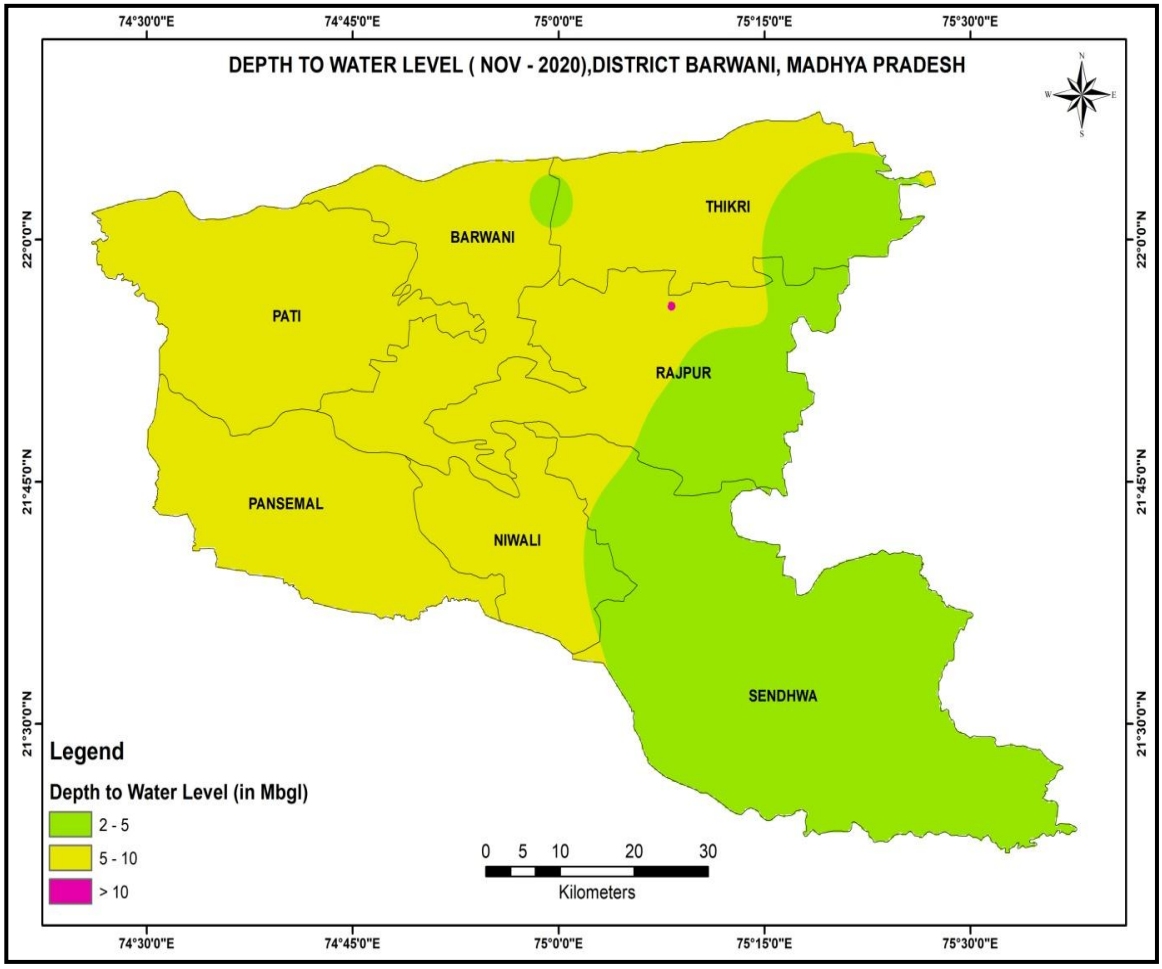


Fig.3.3: Post monsoon (November 2020) Depth

.

Table. 3.1: Pre &Post-monsoon water level data

Block	Village	Latitude	Long	Depth of well (m)	Post-m0nsoon W.L in m	Pre-monsoon W.L in m	Fluctuation in m
Barwani	Kukra	22.06688	74.8927	8.96	5.89	8.89	3
Barwani	Kalyanpura	22.03858	74.8849	17.42	8.1	13.6	5.5
Barwani	Pachodi	22.03966	74.8497	17.3	9.6	12.78	3.18
Barwani	Kothra	22.04387	74.8266	11	8.6	11	2.4
Barwani	Nainpur	22.04425	74.8094	10.79	8.16	10.8	2.64
Pati	Semli	21.96973	74.7415	12.6	3.57	8.9	5.33
Pati	Bamnali	21.95936	74.7092	17.5	12	15	3
Pati	New Osda	21.99128	74.8313	9	2.74	6.7	3.96
Barwani	Rehgun	21.99158	74.9593	25	10.4	17.89	7.49
Barwani	RehgunPalsud	21.98154	74.9652	11.15	10.12	11	0.88
Barwani	Dhaba Bawdi	21.956	74.9703	10.1	7.2	10.1	2.9
Barwani	Silawad Near	21.92936	74.8914	10.95	3.1	6.1	3
Barwani	Sindhi Khgodri	21.94081	74.8923	11.8	10.1	13.1	3
Barwani	DongariyaKhodra	21.9419	74.918	10	6.1	7.5	1.4
Barwani	SemaliyaKhodra	21.93935	74.9385	13.45	2.37	6.6	4.23
Barwani	Dongliyapani	21.89458	74.8641	12.5	4.2	7.2	3
Barwani	SapaiDuwali	21.87555	74.8341	10.23	5.4	9	3.6
Barwani	Dongargao	21.85482	74.8107	11.01	5.45	9.2	3.75
Barwani	Bori	21.82163	74.8238	6.1	4.82	6	1.18
Barwani	Charankhera	21.82603	74.8589	15	10.65	13	2.35
Niwali	Wajhar, KantabenSamdhi	21.70402	74.9266	8.75	2.7	5.7	3
Niwali	Wajhar	21.73183	74.9244	10.56	4.2	7.2	3
Pati	Werwada	21.94018	74.7077	8	2	5	3
Pati	Kundra Road	21.93779	74.6883	6.86	1.46	7	5.54
Pati	Chouki	21.88804	74.6614	9.68	7.56	9	1.44
Pati	Ubadaggad	21.89642	74.6395	5.75	1.5	5.6	4.1
Pati	Ubadaggad village	21.90248	74.6358	5.6	3.4	5.6	2.2
Thikri	Thikari	22.07253	75.3788	15.8	11.11	15.8	4.69
Thikri	Khurampura	22.02447	75.3481	8.87	5.78	8.78	3
Thikri	Rupkheda	21.99583	75.3909	6.38	2.1	5	2.9
Rajpur	PipariBuzurg	21.94786	75.1892	9.6	8.78	9.6	0.82
Rajpur	Siwai	21.97303	75.1373	7.86	6.3	7.86	1.56
Rajpur	Sakad	22.01276	75.1219	12.65	9.86	12	2.14
Rajpur	Mundla	21.95993	75.2396	6.47	2.1	5.5	3.4
Sendhwa	Jamli Toll Gate	21.75285	75.1527	8.61	4.13	7.13	3
Sendhwa	Inayki	21.5334	75.1927	10.33	6.24	9.24	3
Sendhwa	Kermali	21.46939	75.2263	8.1	6.7	7.98	1.28
Sendhwa	Rajangao	21.43504	75.2562	9.96	7.1	9.96	2.86
Sendhwa	Jamti	21.41265	75.3246	8.9	7.5	8.7	1.2
Sendhwa	Dhawali	21.40031	75.3872	10.5	7.12	10.12	3
Sendhwa	Mahitgaon	21.69467	75.1536	8.93	4.6	7.6	3
Sendhwa	Pipalyadev	21.67161	75.2157	6.98	5.1	6.98	1.88

Block	Village	Latitude	Long	Depth of well (m)	Post-m0nsoon W.L in m	Pre-monsoon W.L in m	Fluctuation in m
Sendhwa	Kumthana	21.60067	75.2742	12	10.1	12	1.9
Sendhwa	Dhawdi	21.62579	75.3201	6.66	4.1	6.66	2.56
Sendhwa	Dhawadi	21.64431	75.3338	7.36	5.8	7	1.2
Sendhwa	Ramgarhi	21.56021	75.3946	8.56	4.12	7.12	3
Sendhwa	Chichpani	21.54898	75.4865	11.65	7.02	10.02	3
Sendhwa	OzharYashwantpura	21.81999	75.2204	13.54	10.63	13.54	2.91
Sendhwa	Nangalwadi	21.76714	75.2602	8.11	4.06	7.06	3
Sendhwa	Teeri	21.73553	75.2708	7	2.56	6	3.44
Niwali	Niwali	21.6825	74.92333	8	5.76	5.8	0.04
	Balsamond	21.808889	75.17528	6.42	2.75	4.42	1.67
	Julwania	21.871389	75.18472	9.42	2	7.42	5.42
	Palsud	21.822778	74.96528	9.8	7.18	7.8	0.62
Rajpur	Rajpur	21.936389	75.13611	9.02	5.42	7.02	1.6
	Chachariya	21.569444	75.32444	8.45	3.01	6.45	3.44
Sendhwa	Sendhwa	21.693611	75.10278	5.97	3.45	3.97	0.52
	Baruphatak	21.980833	75.3025	11.47	3.18	9.47	6.29
	Borlai	22.038889	75.00167	6.55	3.83	4.55	0.72

3.4 Water level Fluctuation

The water level measured during pre and post monsoon period (2020) was used to compute the seasonal fluctuation. The water level fluctuation varies 0.004m to 7.49 m.The minimum water level fluctuation recorded 0.004m at Niwali,whereas, maximum water level fluctuation recorded at Rehgun7.49 m. The water level fluctuations were grouped under three categories i.e., less, moderate and high and the % of wells in each category was analysed (**Table 3.2**).

Table.3.2 : Analysis of Water Level Fluctuation.

S. No.	Category	Fluctuation Range	% of Wells
1.	Less water level fluctuation	0 to 2 m	17%
2.	Moderate water level fluctuation	2 to 5 m	36%
3.	High water level fluctuation	>5 m	6%

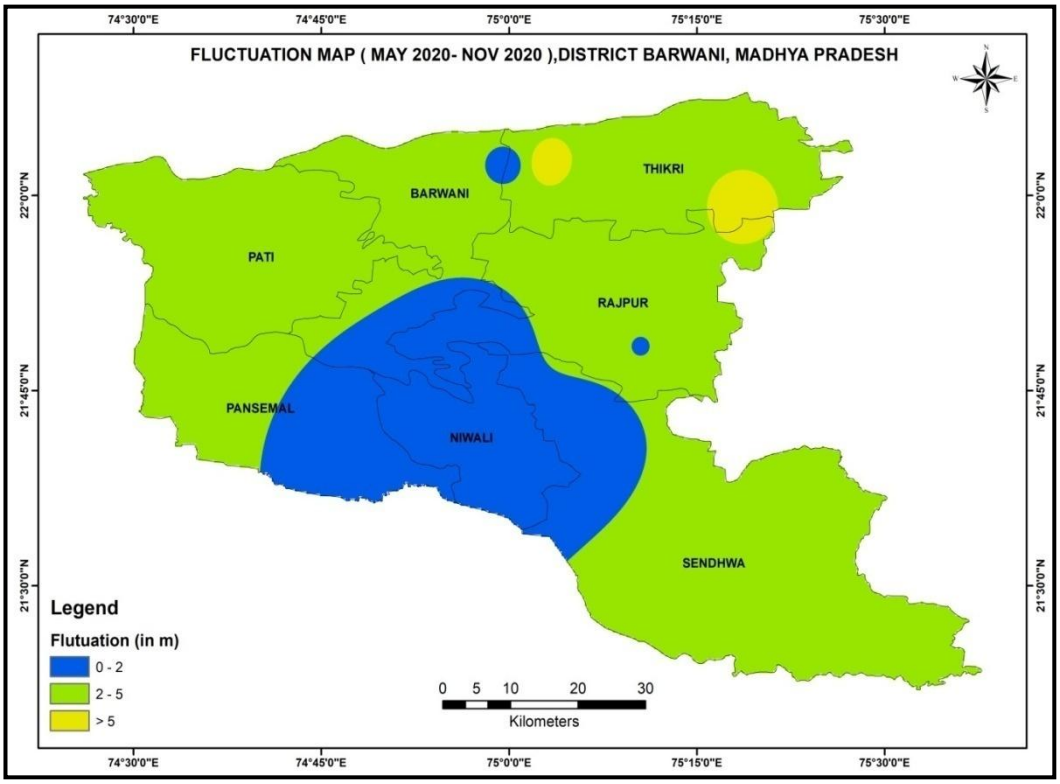


Fig.3.4: Water Level Fluctuation Map.

The water level fluctuation analysis indicates that majority of the wells are fall under the ranges between 2 to 5 m (36%)and it is indicating aquifer storage is not good, whereas low water level fluctuation are observed in 17 % wells. The seasonal fluctuation map is presented as **Fig.3.4**.

3.5 Long Water Level Trend (2012-21)

In order to study long term behavior of the water levels and also the effect of various developmental activities with time, the data for the period 2012-21 have been computed and analyzed and presented in Fig 3.5 & 3.6.

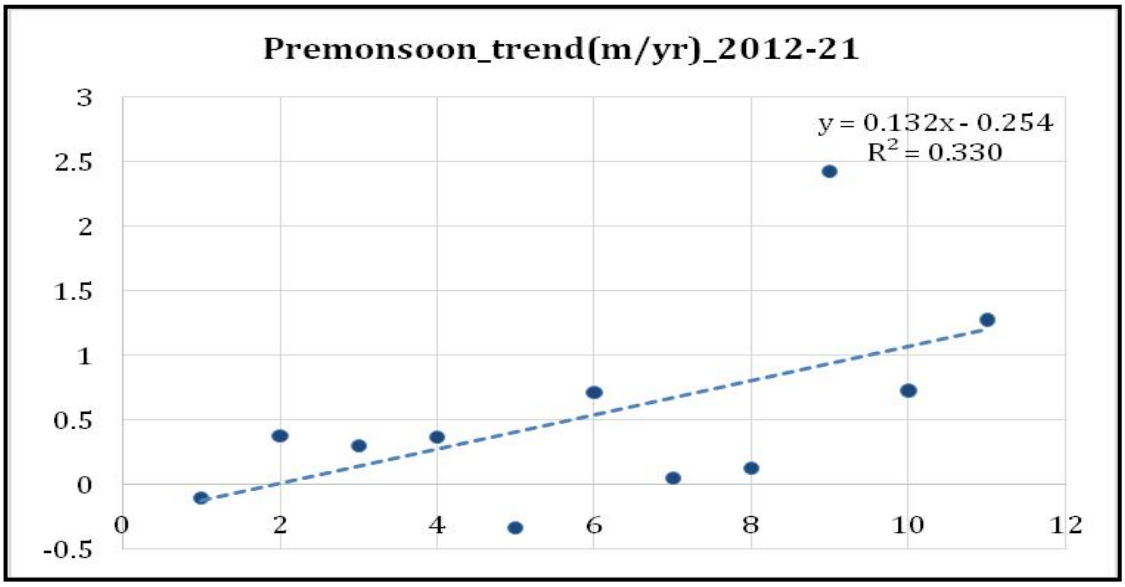


Fig.3.5: Pre-monsoon Water Level Trend (May 2012-21) of Aquifer-I (Shallow Aquifer).

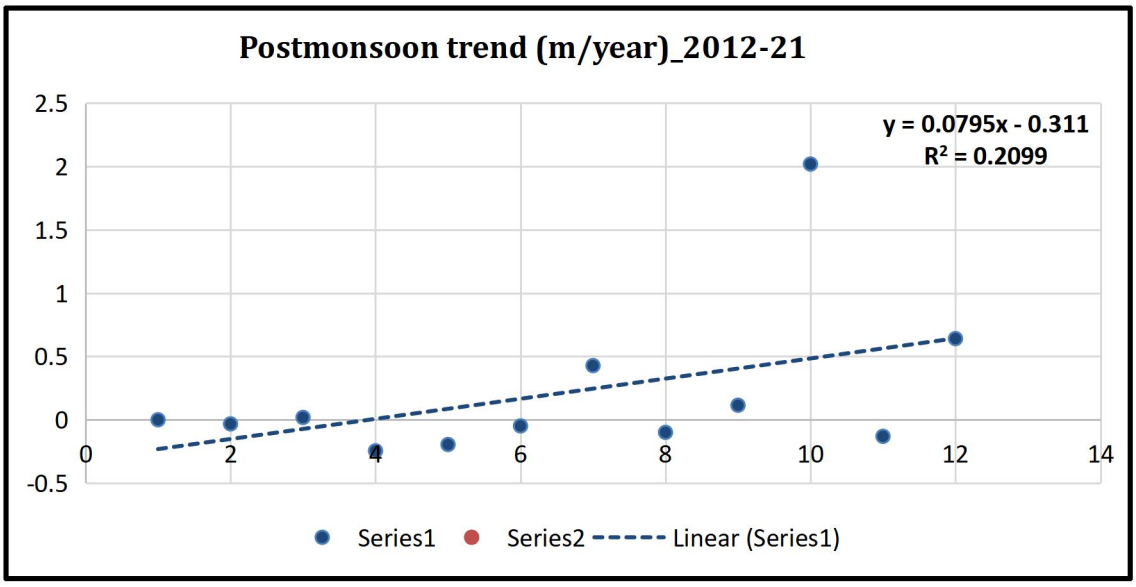


Fig.3.6 : Post-monsoon Water Level Trend (November 2012-21) of Aquifer-I (Shallow Aquifer).

3.6 Ground Water Quality

As per chemical analysis data of pre-monsoon, 2020, ground water in the area is generally alkaline in nature and the pH values are within acceptable limits. The Chloride concentration in the area is below 325 mg/l. The higher chloride values generally coincide with areas having high EC thus indicating that the salinity in ground water is mainly due to chloride. Concentration of magnesium and calcium in Barwani district are within permissible limits. The nitrate concentration in the district ranges between 18 – 195mg/l with only Julwaniya having a value of 18 mg/l. Rajpur & Niwali Having 177 & 195 mg/l of nitrate concentration. The fluoride concentration in the district ranges between 0.25 to 1.10 mg/l. The total hardness in the district ranges between 354 to 1380 mg/l falling within permissible limit. The plot of the Piper diagram indicates that alkaline water is found at Baruphatak, Julwania, Niwali and Rajpur. At Sendhwa, ground water is of alkaline earth sulphate and chlorite type, having permanent hardness, which can be removed by ion-exchange method. At Palsud, the water is alkali sulphate and chloride type.

The Wilcox diagram of Barwani district indicates that the ground water has low sodium hazard and medium to high salinity hazard. Thus, the ground water is chemically fit for drinking as well as agriculture purposes.

The ground water samples were analysed for major chemical constituents. The aquifer wise ranges of different chemical constituents present in ground water are given in **Table 3.3.** The details of water quality analysis of Aquifer-I and II are given in **Table-3.4 and table -3.5**.

Table.3.3: Chemical Quality of Ground Water for Shallow Aquifer

District	Block	Village	Long	Lat	PH	EC	CO	HCO3	Cl	SO4	NO3	F	PO4	SiO2		Ca	Mg	Na	K	TDS
					at 25°C	µS/cm at 25°C	mg/l													
Barwani	Rajpur	Balsamun	21.806	75.1	7.72	1235	0	399	120	12	92	0.25	BDL	22	470	103	52	57	2.2	803
Barwani	Thikri	Baruphata	21.984	75.3	7.42	745	0	272	42	24	27	0.50	0.1	26	208	50	20	65	3.5	484
Barwani	Thikri	Borlai	22.038	74.9	7.78	1212	0	303	145	28	60	0.35	BDL	31	490	125	43	42	1.2	788
Barwani	Sendhawa	Chachariy	21.576	75.1	7.46	545	0	212	12	5	54	0.40	BDL	23	208	53	18	15	1.9	354
Barwani	Rajpur	Julwania	21.872	75.1	7.26	565	0	206	27	22	18	1.10	BDL	17	210	50	21	22	0.9	367
Barwani	Newali	Niwali1	21.684	74.9	7.14	1942	0	424	280	45	195	0.30	0.1	35	675	184	52	127	1.5	1262
Barwani	Rajpur	Palsud	21.825	74.9	7.76	912	0	218	127	25	58	0.25	BDL	26	317	105	13	57	2.1	593
Barwani	Rajpur	Rajpur	31.936	75.1	8.02	2123	0	460	325	45	177	0.50	BDL	46	723	224	40	142	2.2	1380
Barwani	Sendhawa	Sendhwa	21.700	75.1	7.72	965	0	284	110	27	46	0.30	BDL	25	322	105	14	62	3.7	627

Table.3.4: Chemical Quality of Ground Water of Aquifer-II

Name	PH	E_Conductivity	Total Hardness as CaCO3	Chlorides as Cl	Total Dissolved Solid	Nitrate as NO3	Calcium as Ca	Magnesium as Mg	Sulphates as SO4	Iron as Fe	Fluoride as F	Bi carbonate alkalinity (as CaCO3)	carbonate alkalinity (as CaCO3)	Sodium as Na	Potassium as K
Pichori	7.54	806.8	244	34.99	312	31.11	37.68	36.45	28.46	<0.05	<0.10	266	<2.00	65.24	4.3
Ambapari	7.05	1256	184	215.93	545	3.83	72.14	0.97	84.85	<0.05	<0.10	54	<2.00	109.85	1.18
Bori	7.82	542.4	66	40.99	284	1.28	23.25	1.94	25.04	<0.10		130	<2.00	82.1	1.18
(Rosar)	6.86	484.5	58	67.98	258	0.3	23.25	2.92	36.73	<0.05	<0.10	46	<2.00	72.29	0.66
Angrada	7.36	854.9	170	89.97	455	10.36	44.89	15.55	34.99	<0.05	<0.10	162	<2.00	84	2.61

Name	PH	E_Conductivity	Total Hardness as CaCO3	Chlorides as Cl	Total Dissolved Solid	Nitrate as NO3	Calcium as Ca	Magnesium as Mg	Sulphates as SO4	Iron as Fe	Fluoride as F	Bi carbonate alkalinity (as CaCO3)	carbonate alkalinity (as CaCO3)	Sodium as Na	Potassium as K
Bokrata	7.66	587.2	80	46.99	313	12.33	32.06	2.92	51.98	<0.05	<0.10	134	<2.00	82.07	1.59
(Gothanya)	7.13	596.5	72	54.98	318	19.25	27.25	0.97	63.48	1.29	<0.10	128	<2.00	83.99	3.13
(Nalti)	7.65	914	114	58.98	485	43.9	19.24	16.04	47.24	4.38	<0.10	154	<2.00	98.22	0.86
Jndarpup	6.82	1716	234	323.9	938	39.27	91.38	1.46	55.37	<0.05	<0.10	54	<2.00	201.6	1.07
Ghusgaon	7.96	726.6	80	95.97	381	7.31	28.86	1.94	72.81	1.29	<0.10	66	<2.00	88.66	0.73
Nihali	7.23	726.4	128	58.99	381	29.17	42.48	5.35	56.13	0.6	0.19	124	<2.00	74.64	0.93
Siwai	7.5	786.2	130	58.99	407	35.66	24.85	16.52	54.4	<0.05	0.27	130	<2.00	67	0.46
BunderKachh	7.47	804.8	162	36.99	418	39.9	18.44	28.19	38.55	<0.05	<0.10	202	<2.00	38.26	0.24
Jahoor	6.82	1869	372	235.93	963	45.49	125.05	14.58	96.62	<0.05	<0.10	54	<2.00	112.75	5.95
Gawla	7.13	1059	160	131.96	545	23.78	49.7	8.75	66.03	1.49	<0.10	140	<2.00	99.41	0.71
Dattawad	7.41	1677	266	140.96	862	45.04	4.81	61.72	58.45	<0.05	<0.10	190	<2.00	106.72	0.74
Jogwada	7.1	620.4	96	59.98	320	15.09	29.66	5.35	71.08	0.66	<0.10	122	<2.00	74	0.72
Jhapdipadla	7.6	539.4	164	19.99	278	15.15	9.65	8.74	100.47	1.1	<0.10	164	<2.00	71.18	0.55
Jhireejamli	7.6	539.4	164	19.99	278	15.15	9.65	8.74	100.47	1.1	<0.10	164	<2.00	71.18	0.55
Mohala	7.96	726.6	80	95.97	381	7.31	28.86	1.94	72.81	1.29	<0.10	66	<2.00	88.66	0.73
Balwadi	7.19	757	118	27.99	391	33.33	12.02	21.38	25.06	<0.05	<0.10	218	<2.00	52.19	0.76
Khetia	7.1	594	88	69.98	307	15.06	20.84	3.89	28.79	0.38	0.1	88	<2.00	77.94	0.73
Rakhikurd	6.66	382.5	32	38.99	197	3.67	8.82	2.43	27.44	0.74	<0.10	74	<2.00	64.17	0.91

Table.3.5: Aquifer wise ranges of chemical constituents.

Constituents	BIS standards for drinking water	Aquifer – I (Shallow aquifer)			Aquifer-II (Deeper Aquifer)	
		Min.	Max.	No. of samples above MPL	Min.	Max.
pH		7.14	8.02		6.66	7.96
EC		545	2123		382.5	1869
TH		208	723		32	372
Calcium		50	224		4.81	125.05
Magnesium		14	52		0.97	61.72
Potassium		0.9	3.5		0.24	5.95
Sodium	10:500	15	142		38.26	201.60
Carbonate		0	0		<2	<2
Bi-carbonate		206	460		46	266
Chloride		12	325		19.99	323.9
Nitrate		18	195		0.30	45.49
Fluoride		0.25	1.10		0.1	0.27

Note: All values except EC (µS/cm @ 25°C) and pH are in mg/l.

As per the piper diagram (**Fig.3.7**), water samples are Calcium Chloride (permanent hardness), Calcium Bi-carbonate (temporary hardness) and Mixed (Calcium-Magnesium-Chloride) types of water. The US Salinity Diagram**(Fig.3.8)** shows the ground water is medium to high salinity classes i.e. C_2S_1 and C_3S_1. The C_2S_1 and C_3S_1 classes of water may be used for irrigation purpose with proper soil management.

3.6a Ground Water quality of aquifer-I(Shallow aquifer):

As per chemical analysis of pre-monsoon 2020 of Barwani District, the ground water of shallow aquifer in the area of Barwani district is slightly acidic to neutral in nature and the pH of ground water ranged in between 7.14 to 8.02; the highest value of pH (8.02) has been observed in Rajpur dug well. The electrical conductivity of ground water in Barwani district ranged between 545 to 2423µS/cm at 25°C and the maximum EC value atRajpur (2123 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.Balsamond, Niwali, and Rajpur (1235µS/cm, 1942µS/cmand 2123 µS/cm at 25°C).The EC value map is presented in **Fig. 3.9.** The fluoride concentration was ranged in between 0.05 to 1.35 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. The maximum concentration of fluoride has been recorded in the dug well of Julwania village i.e. 1.1 mg/l. In the district**Fig-3.10**, nitrate concentration in ground water ranged in between 18 to 195 mg/l. About 33.3% ground water samples recorded nitrate concentration within the acceptable limit of 45 mg/l and 78.79% water samples recorded more than 45 mg/l as per BIS recommendation. The high nitrate concentration has been recorded in ground water ofBalsamond (92mg/l), Borlai (60mg/l), Chahriya (54mg/l), Niwali (195 mg/l), Palsud (58 mg/l) Raipur (177mg/l), Sendhwa (46mg/l).the nitrate concentration map of Barwani district presented in**Fig.3.11.**Chlorideranges between the 12mg/l and 325mg/l in shallow aquifer the maximum value found in Rajpur and minimum value is in Chachriya village of sendhwa block shown in **Fig.3.12.** Total hardness of ground water in the study area ranged in between 353 to 1380mg/l. The high concentration has been observed in the dug well of Rajpur(1380mg/l) shown in **Fig.3.13.**

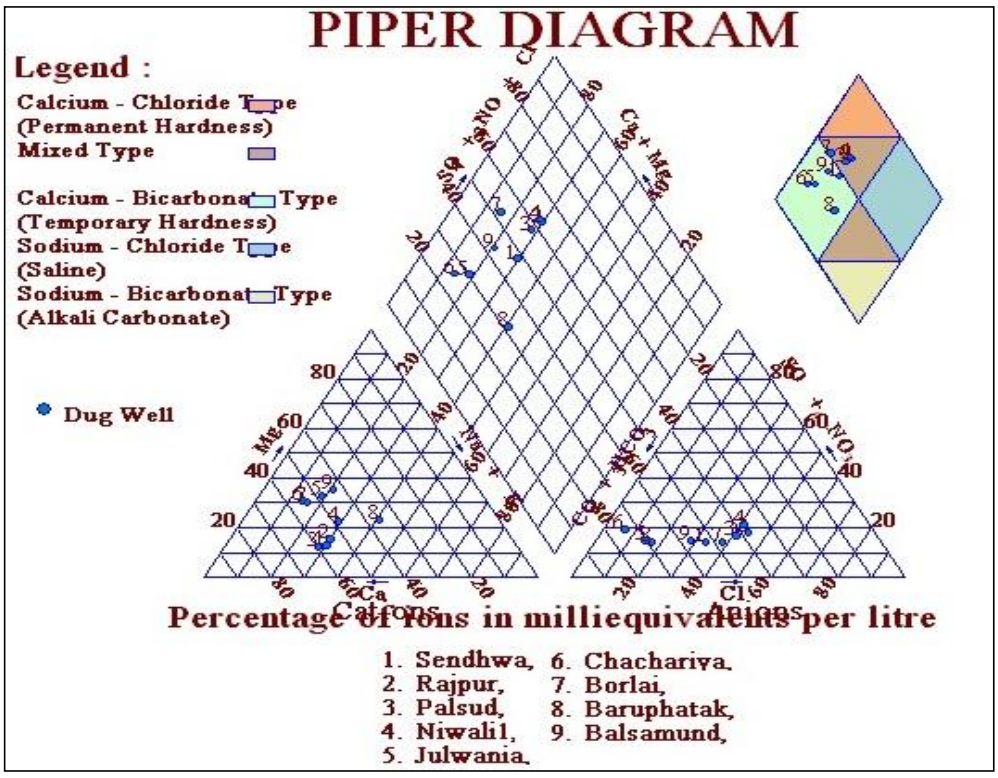


Fig.3.7 : Piper Diagram

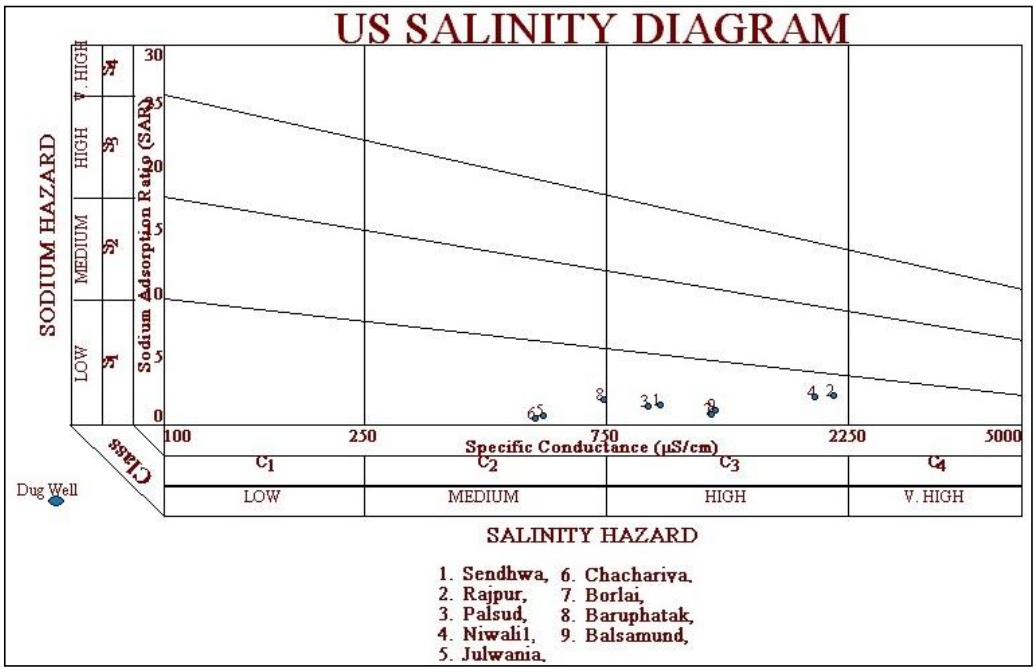


Fig.3.8: US Salinity diagram

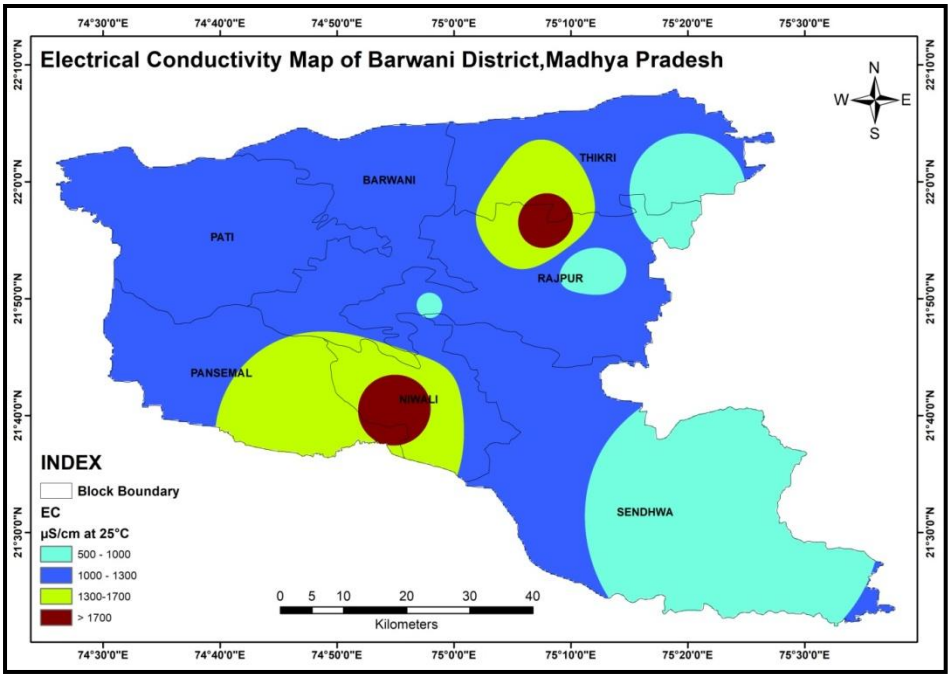


Fig 3.9: Electrical Conductivity of Aquifer-I (Shallow Aquifer)

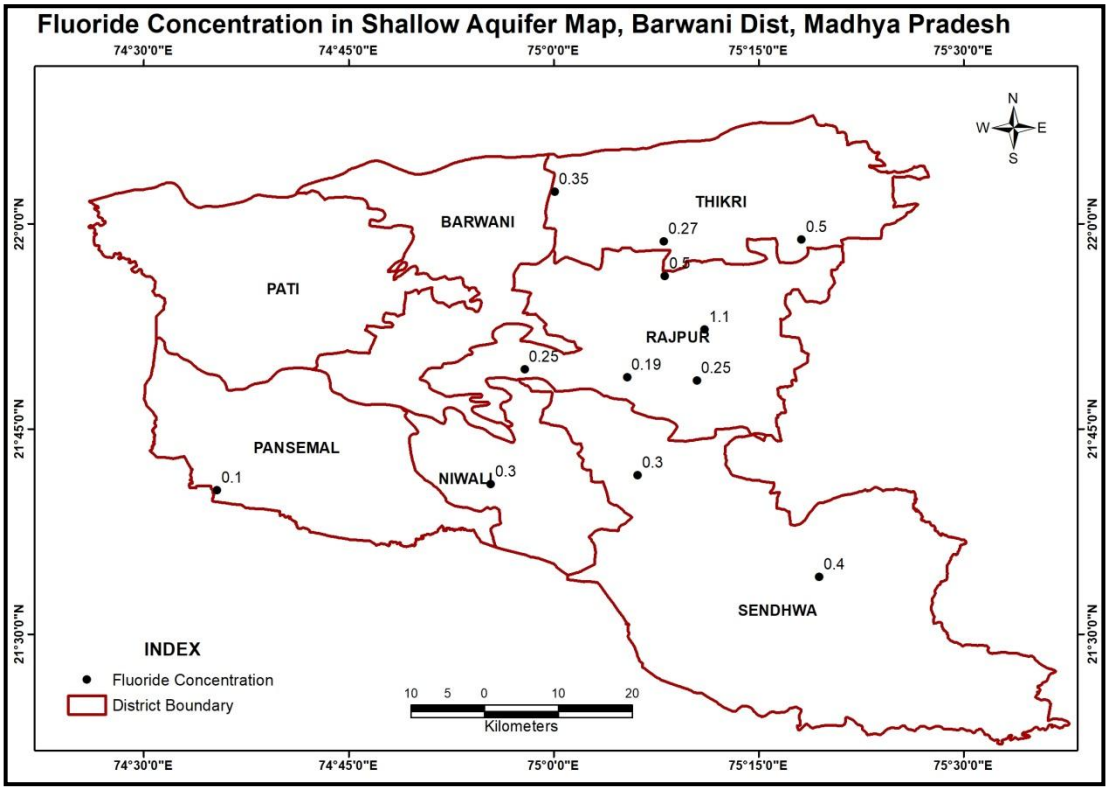


Fig.3.10: Fluoride Concentration map of Aquifer-I (Shallow Aquifer)

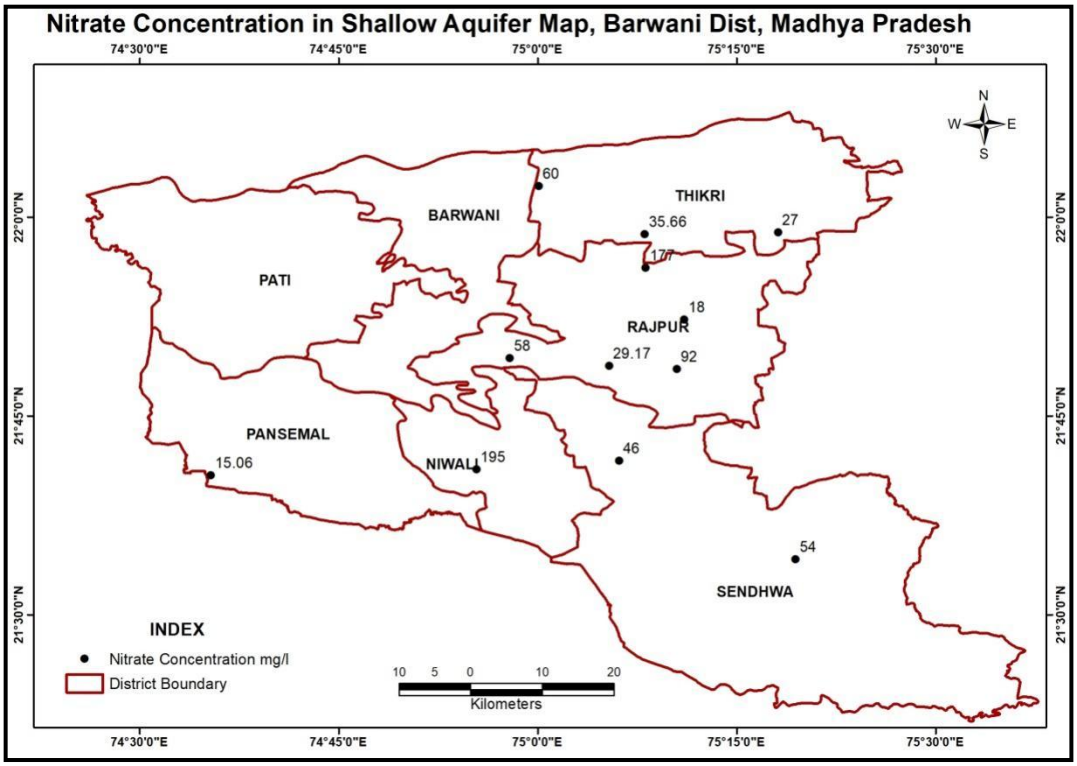


Fig.3.11: Nitrate Concentration map of Aquifer-I (Shallow Aquifer)

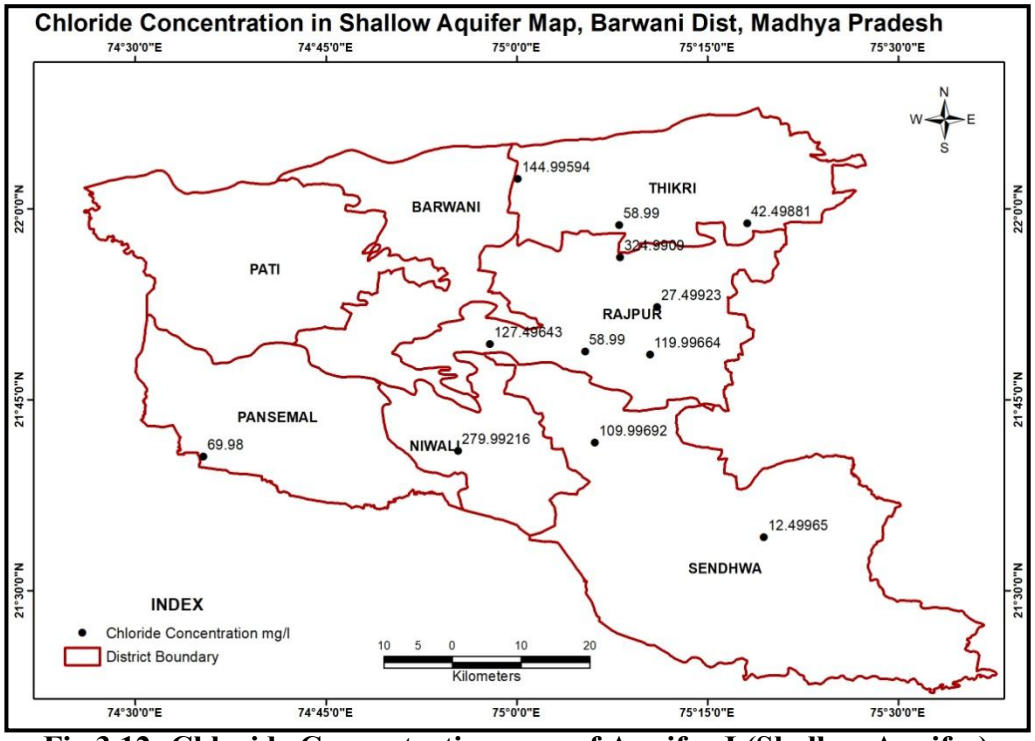


Fig 3.12: Chloride Concentration map of Aquifer-I (Shallow Aquifer)

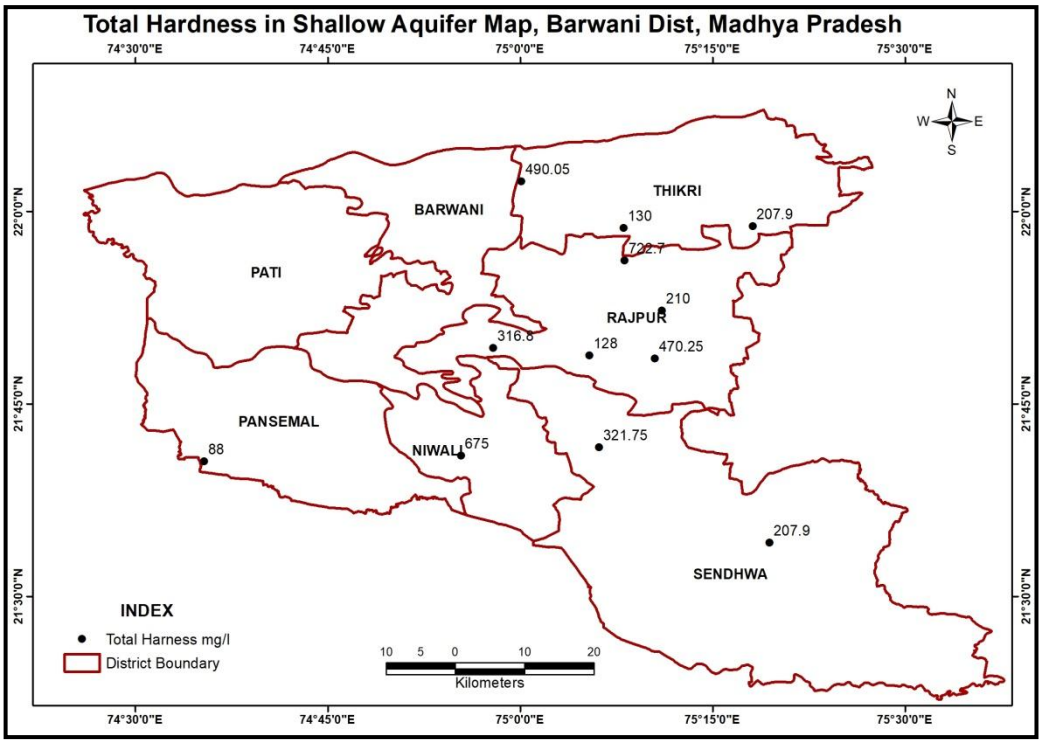


Fig.3.13: Total Hardness map of Aquifer-I (Shallow Aquifer)

3.6b Ground Water quality of aquifer-II (Deep aquifer):

As per the chemical analysis of the Groundwater samples collected during exploration, the ground water of deep aquifer in the area of Barwani district is slightly acidic to neutral in nature and the pH of ground water ranged in between 6.66 to 7.96; the highest value of pH (7.96) has been observed in Mohala EW. The electrical conductivity of ground water in Barwani district ranged between 382.50 to1869 µS/cm at 25°C and the maximum EC value at Jahoor (1869 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.Jahoor (1869 µS/cm at 25°C)**.** The fluoride concentration was ranged in between 0.10 to 0.27 mg/l. In the district, in 10 water samples the Fluoride value found above permissible limiti.e. 1.5 mg/l. The maximum concentration of fluoride has been recorded in the EW of Bhimpuri.e. 4.84 mg/l. In the district, nitrate concentration in ground water ranged in between 1 to 155 mg/l. About 21 ground water samples recorded nitrate concentration within the acceptable limit of 45 mg/l and rest 2 water samples recorded more than 45 mg/l as per BIS recommendation. /l. Total hardness of ground water in the study area ranged in between 32 to244 mg/l.

In case of Aquifer-II, it is observed that Total Hardness, pH and Magnesium are within permissible limit. Out of 23 samples taken from exploratory/observation wells, in 2 samples the Nitrate value found above permissible limit. The electrical-conductivity of Aquifer-II has been prepared and presented as **Fig.3.14,15,16 and 17**respectively.

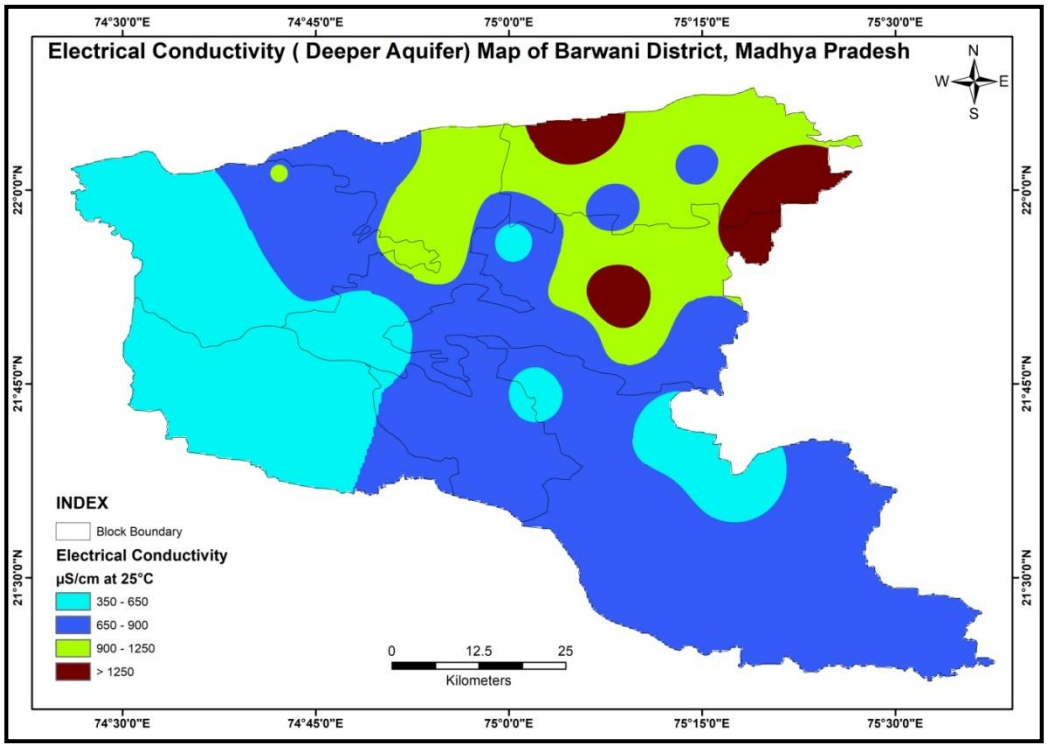


Fig.3.14: Electrical Conductivity of Aquifer-II (Deep Aquifer)

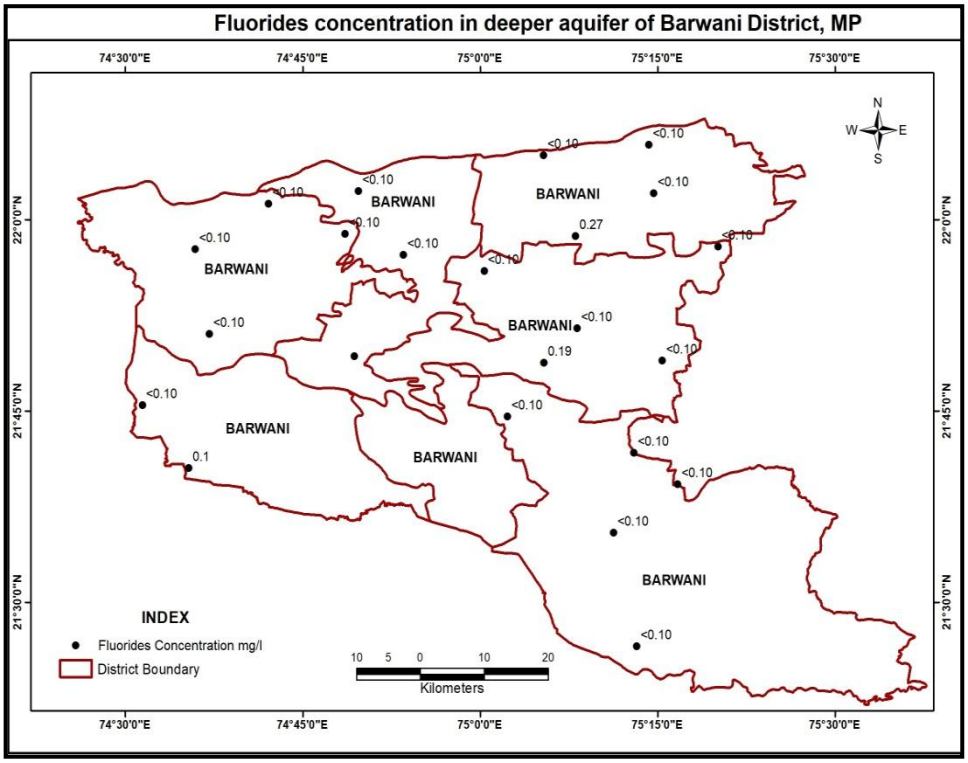


Fig.3.15 Fluorides concentration of Aquifer-II (Deep Aquifer

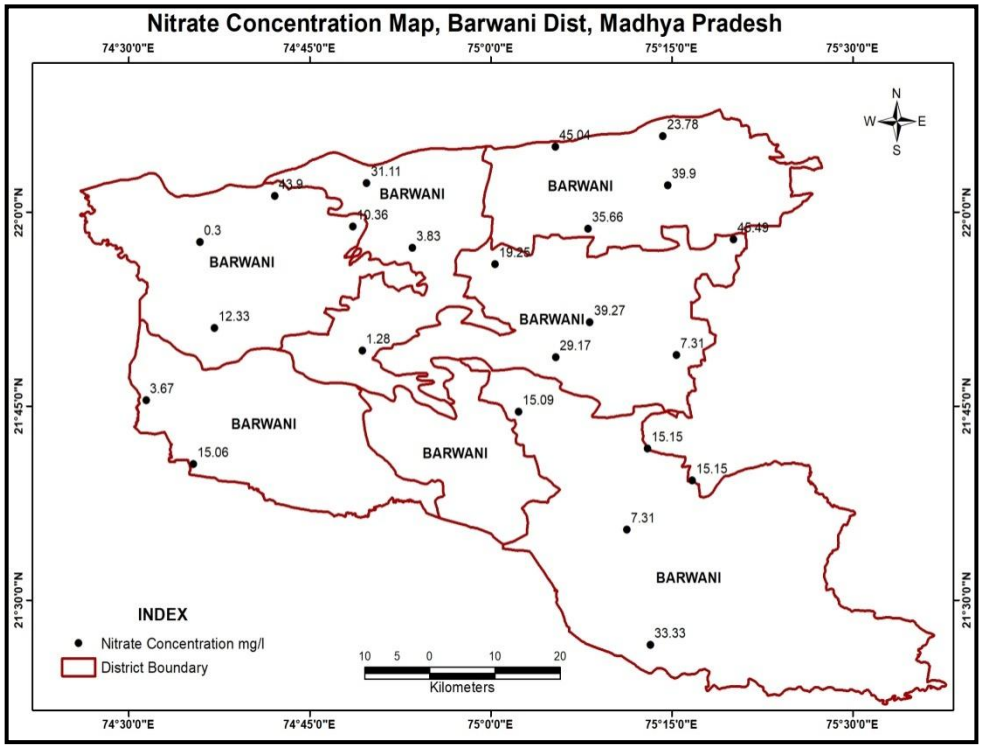


Fig.3.16 : Nitrate Concentration map of Aquifer-II (Deep Aquifer

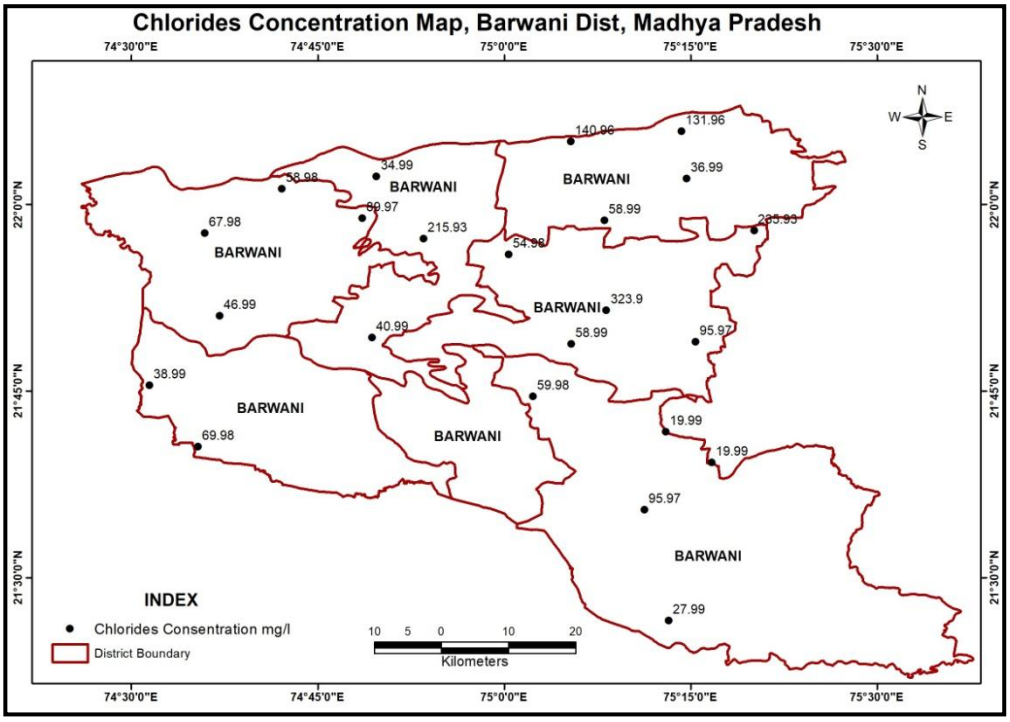


Fig.3.17 : Chlorides Concentration map of Aquifer-II (Deep Aquifer)

3.7 3-D and 2-D Aquifer Disposition

The data generated from ground water monitoring wells, micro level hydrogeological inventories, exploratory and observation wells, various thematic layers were utilized to decipher the aquifer disposition of the area. This particularly includes the information on geometry of aquifers and hydrogeological information of these aquifers. In the area the two aquifer systems has been deciphered as listed below:

Aquifer –I (Shallow Aquifer)

Aquifer – II (Deeper Aquifer)

Central Ground Water Board has been carried out ground water exploration through outsourcing and constructed 35 exploratory wells and also carried out Vertical electrical sounding (VES) under NAQUIM data generation through outsourcing.

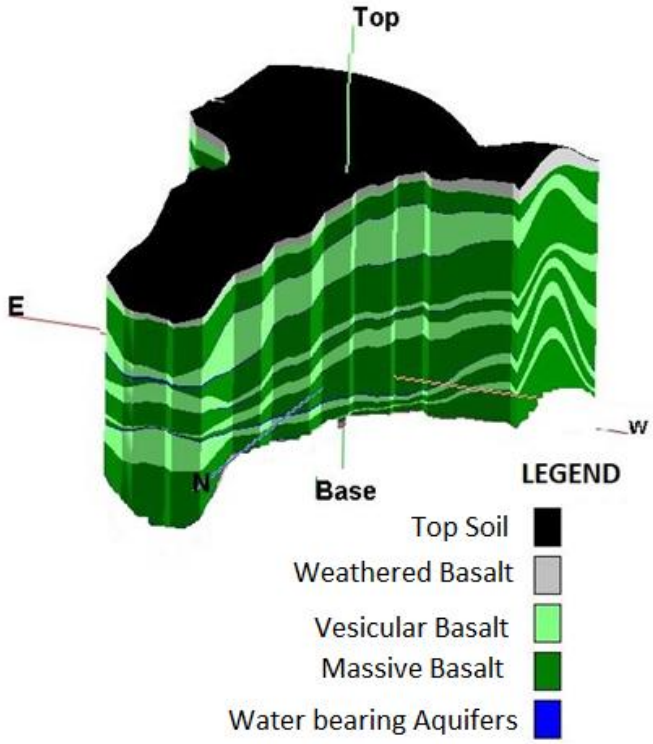


Fig:3.18, 3-D Aquifer Disposition

In the study area, two aquifer systems have been demarcated based on the groundwater water occurrence and movement. The first aquifer (Aquifer-I) is weathered layer of all three lithology.The second aquifer (Aquifer-II) is fractured layers and vesicular Basalt. The bottom of the aquifer-II is demarcated using the lower most fractured depth encountered in the bore well. Aquifer-II is generally extending latterly in uniform thickness and fallowed the general topography of the area. The thickness of Aquifer-II is varying some places whenever secondary aquifer encountered like fractured and also

depend on the thickness of particular flow and also been conducted slug. PYT and pumping test during ground water exploration to decipher hydrogeological properties of aquifer. The different hydrogeological test and exploration data reveal that the main aquifer system in Barwani district is vesicular and fractured basalt, which is very good yielding during July to December and gradually decrease or dry during lean period. The average thickness aquifer in the area is varies form 5 m to 35 m in 200 m exploratory wells which is create good subsurface storage. The details and outcome of exploratory and observation wells are given in **Annexure II.** The aquifer disposition of the area is demarcated based on the groundwater exploration data which depicts the lateral and vertical configuration of the aquifers using Rockworks software. such as Basalt, Sandstone, Limestone and Granite formation

3.7a Hydrogeological Cross Sections

To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. A-A' representing north west – south east direction and B-B' representing north – south direction.

Hydrogeological cross section A-A'(Fig.3.19) represents aquifer disposition in North West – South East direction and data of following exploratory wells and Vertical Electrical Sounding i.eBori, Chikliya, Gothaniya, Ambapaniand Pichorihas been utilised of Barwani Block.

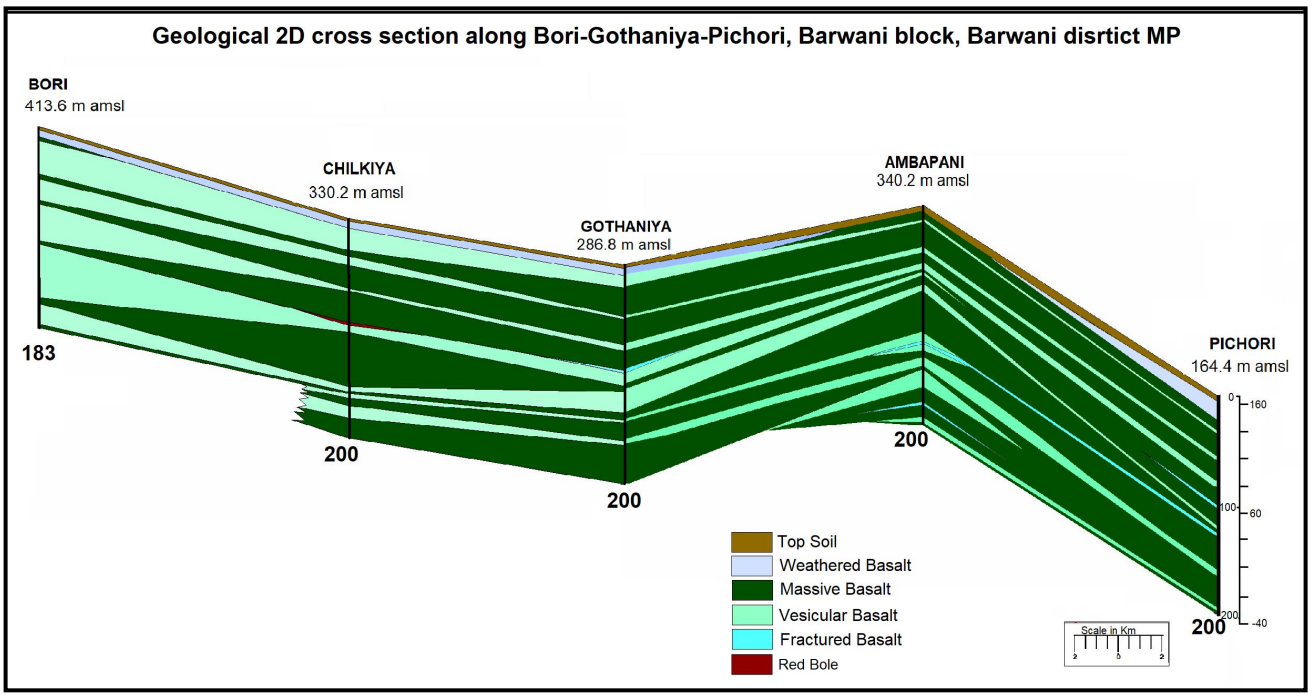


Fig.3.19: Aquifer Disposition from Bori to Pichori

Hydrogeological cross section B-B' (Fig.3.19) represents aquifer disposition in east – west direction and data of following exploratory wellsi.e.Khampani,Jogwada and Segavi has been utilised of Niwali Block.

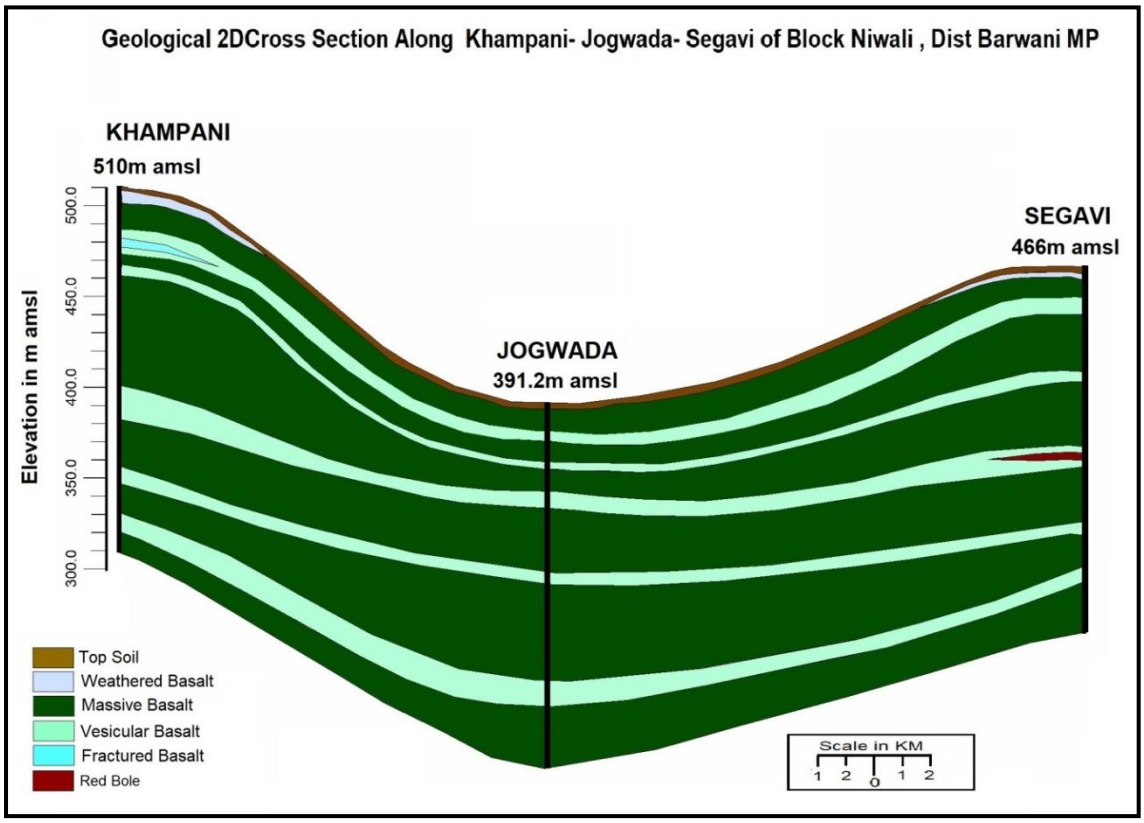


Fig.3.20:Aquifer Disposition from Khampani to Segavi'.

Hydrogeological cross section (**Fig.3.21**) represents aquifer disposition in north – south direction and data of following exploratory i.e., Khadikham, SakraliBuzurg, Pansemal, Khetia, and Rakhikhurd of Pansemal Block has been utilised.

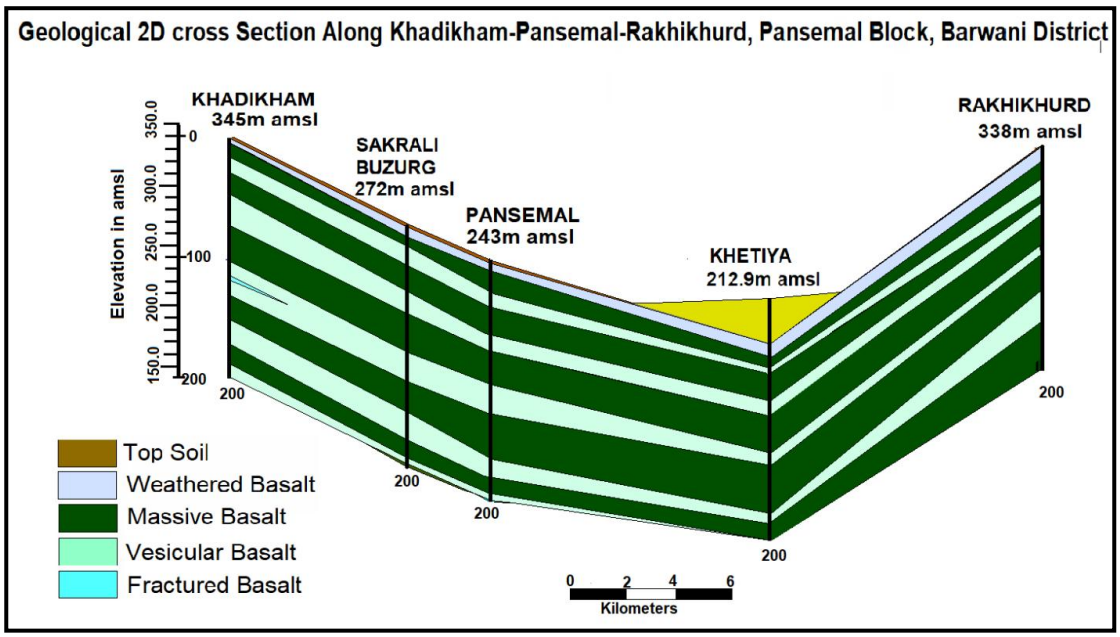


Fig.3.21:Aquifer Disposition from Khadikham to Rakhikhurd

Hydrogeological cross section (**Fig.3.22**) represents the aquifer disposition fromnorth – south direction and data offollowing exploratory i.e., Bokrata,Roasar, Nalti, and Angrada, Patiblock has been utilised.

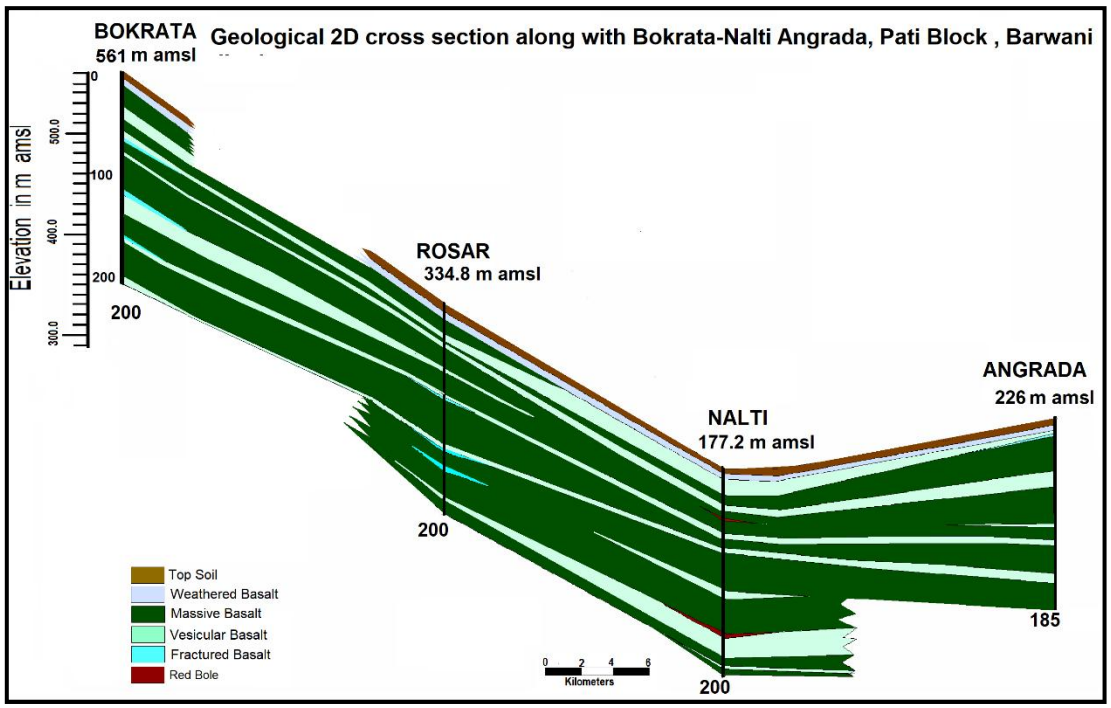


Fig.3.22: Aquifer Disposition from Khadikham to Rakhikhurd

Hydrogeological cross section (**Fig.3.23**) represents the aquifer disposition from north – south direction and data of exploratory i.e., Jhapdipadla, JheeriJhamli, Khurmabad, and Dhawli of SendhwaBlock has been utilised.

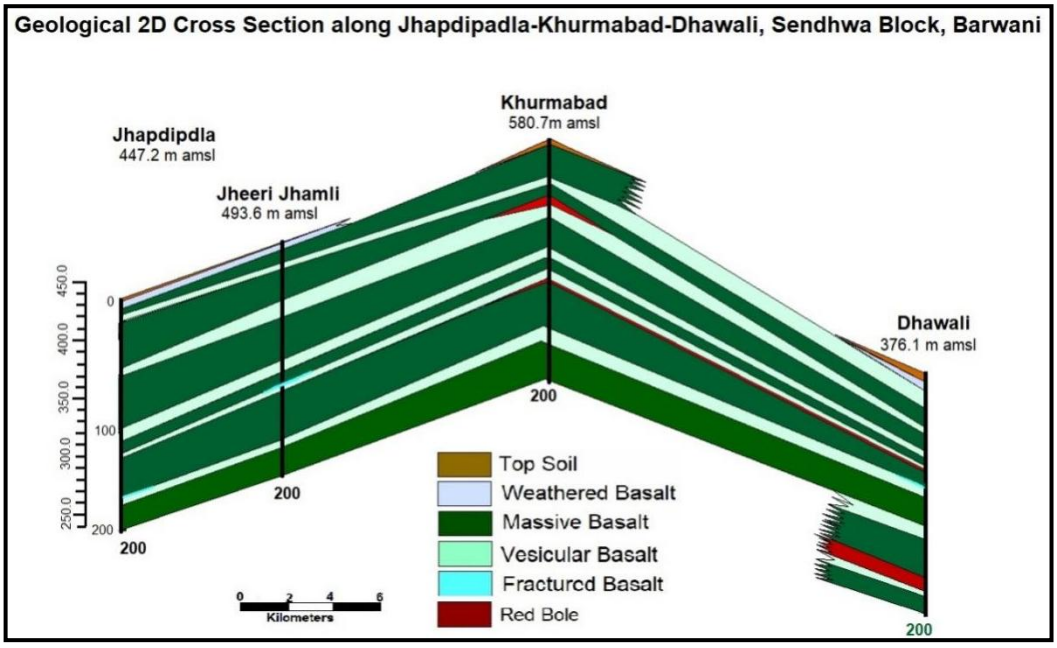


Fig 3.23 :Aquifer Disposition from Jhapdipdla to Dhawal

Hydrogeological cross section (**Fig.3.24**) represents the aquifer disposition from north – south direction and data of following exploratory i.e., Jhapdipadla, Mohala, Balwadiand Dhawali ofSendhwa Block has been utilised.

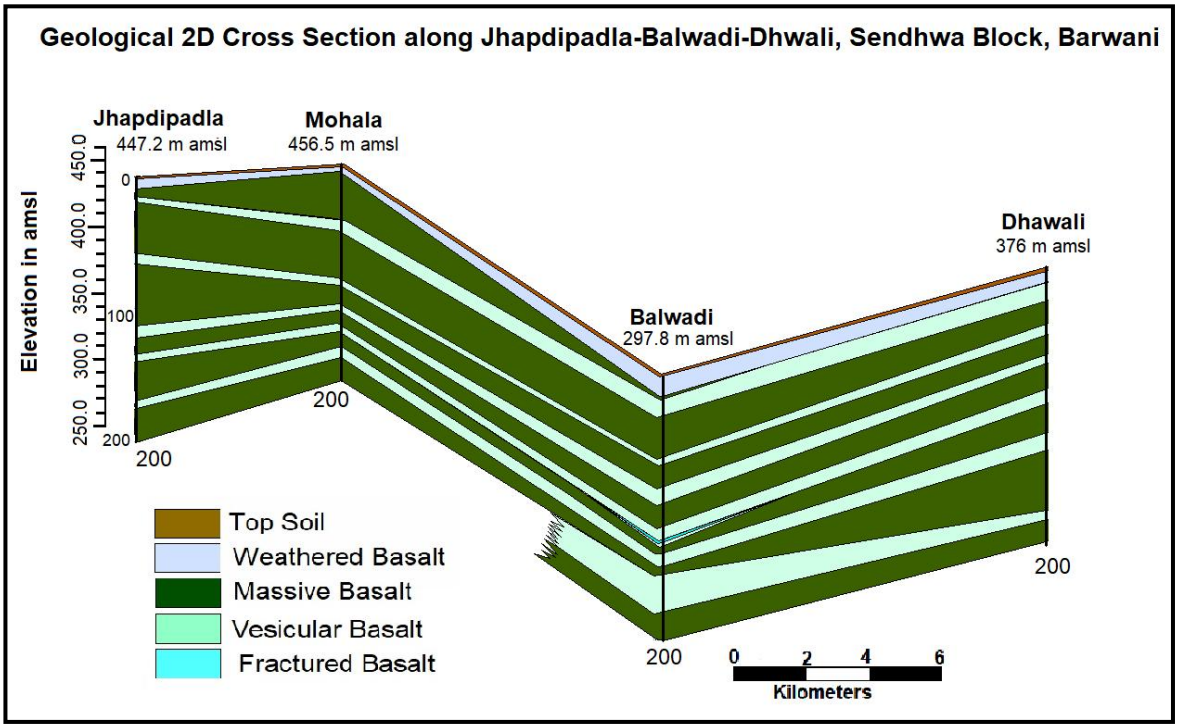


Fig 3.24 :Aquifer Disposition from Jhapdipdla to Dhawal

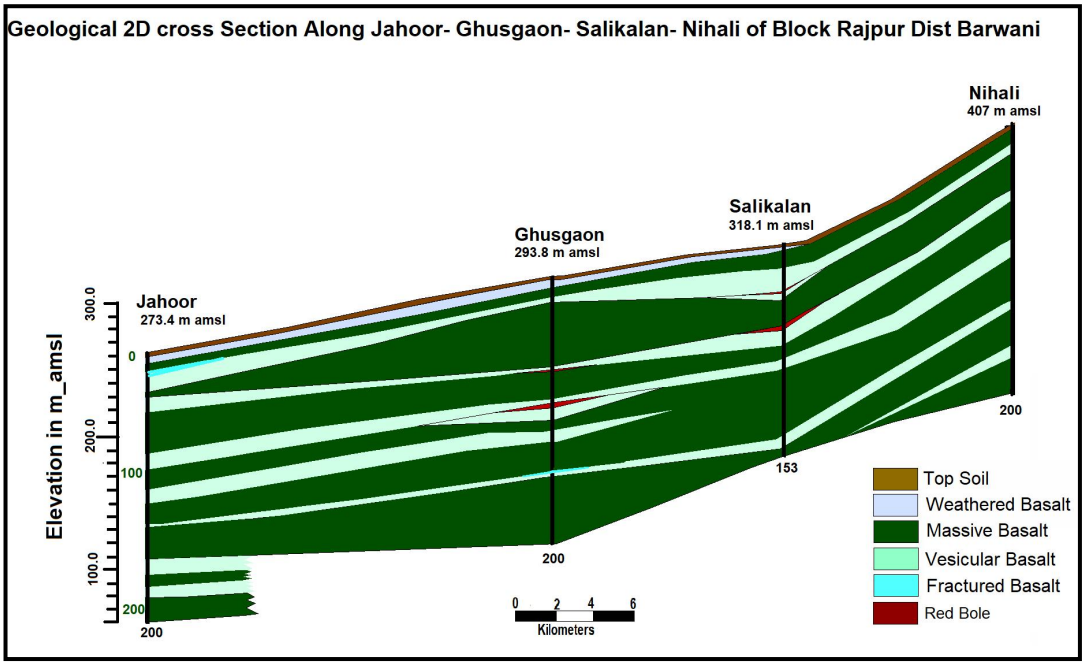


Fig.3.25 Aquifer Disposition form Jahoor to Nihali of Rajpur Block.

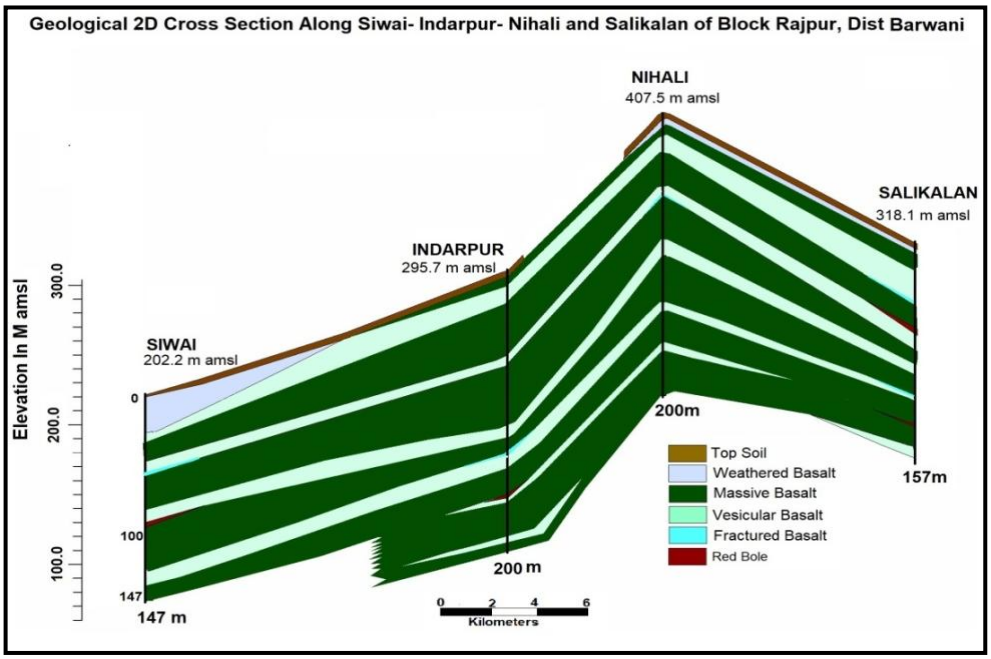


Fig 3.26: Aquifer Disposition form Siwai **to** Salikalan **of Rajpur Block.**

3.8 Aquifer Characteristics

Basalt formation of the area comprises two distinct units viz, upper vesicular unit and lower massive unit. The massive basalt is hard, compact and does not have primary porosity and is impermeable. Weathering, jointing and fracturing induces secondary porosity in massive unit of basalt. In vesicular basalt, when vesicles are interconnected constitutes good primary porosity and when the vesicles are filled/ partly filled the porosity is limited. Ground water occurs under phreatic/ unconfined to semi-confined conditions in basalts.

Based on the ground water exploration carried out in the Barwani district, the following two types of aquifers can be demarcated and the details are given below in **Table 3.6**.

Table.3.6 : Aquifer Characteristics.

Major Aquifer	**Alluvium &Deccan Trap Basalt**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Alluvium/Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 30	31 to 200
SWL (mbgl)	2.9- 15.85	5.5-18.30
Weathered / Fractured rocks thickness (m)	1.82-14.92	1- 4.5
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	Up to 8.29lps
Transmissivity (m^2/day)	-	
Specific Yield/ Storativity (Sy/S)	-	
Suitability for drinking/ irrigation	Suitable for both drinking and agriculture, except high Nitrate at places	Suitable for both drinking and agriculture, except high Nitrate and Fluoride at places

3.9 Geophysical Study

The interpreted results of the 82 nos. of VES are given in Annexure-I. Maximum portion of the district falls under Deccan trap formation. In this Deccan trap basalt occupied area of the district81 VES were conducted. In one place there may be alluvium cover i.e at VES 289.The alluvial deposits are confined mainly to Narmada &Goi rivers and are not very extensive in thickness. As the basalts are easily understood to be present on the top the map is showing maximum places are covered with basalt. Hence in the report the discussion made in the light of characteristics of weathered and fractured basalt only without making complications. Out of these82 VES at 48 VES sites weathered zone is delineated (Table:3.7).The resistivity of the weathered zone ranges from 8 to 62ohm.m. It extends to a maximum depth of 28 m at VES 338. At 45 sites the resistivity is more than 10 ohm m. But depth to the bottom is more than 10 m and resistivity more than 10 ohm m for only18 sites and can be tapped by dug wells. However, out of these 48 sites at 3 sites the resistivity is less than 10ohm.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 resitivities. Instead, a geo-electrical layer of varied thickness is delineated which cumulatively represents the succession of vesicular-massive–fractured basalt. The resistivity of this geoelectrical layer could be 20 ohm. m, an indicator for the possible presence of fractured basalt. Total 78sites this vesicular- fracture basalt layer is detected. A range of resistivity value obtained for this layer is 8 to 232ohm.m. A resistivity value less than 50ohm.m for this geoelectrical layer is preferred. At 30 sites this geoelectrical layer was delineated. At 52 sites the resistivity which is lesser than 50ohm. m and

little higher than 50 ohm m is detected. At 1VES 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). Interpreted Ves Graphs are Given below in Annexure-01 and Resultant depth of Fractured/ Vesicular zones in given below in table 3.7.

The qualitative analysis has indicated the presence of thin fractured zones at 60VES at different depths (Annexure I).

Table.3.7 :Aquifer-Resistivity characteristics of weathered zone and deeper succession in Deccan Trap basalt.

Resistivity Characteristics				Possible presence of thin fractured zone in the depth range (m)
Weathered Zone Aquifer		Aquifer in vesicular/fractured basalt sequence		
Resistivity(oh m.m)	Depth to bottom (m)	Resistivity (ohm.m)	Depth to the top and bottom(m)	
-	-	129	31- 190	85-95,110-120,140-150,160-170
-	-	62 140	9-18 39 - 175	70-80,90-100,130-140,160-170
18	5	102	5 - 157	50-60,75-85,120-130,160-170
47	4	66	15- 149	90-110,130-150
18	18	59	45- 129	90-95,150-160,170-180
-	-	25	17- 37	120-130,160-170
-	-	16	156-?	-
17	4	23 32	11- 26 51 - 133	-
9	27	25	26-63	-
49	18	98	39- 179	-
-	-	98	40 - 71	-
-	-	202	8- 95	85-90,185-190
49	4	25	9- 39	170-190
-	--	40	3 - 41	-
-	-	61	17 - 34	130-140,150-160,180-190
-	-	60	20- 48	-
29	26	-	-	100-110,150-160
-	-	59	142 -?	70-75,100-110,150-160
14	8	60 106	8- 79 79 -?	95-110,120-130,140-160,170-180
20	9	66	8- 39	-
53	8	33	82 -?	150-160,170-180
-	-	141	3 - 81	60-65,85-90
13	2	21	5 - 11	65-70,75-85,150-160,170-180
46	9	84	86- 179	50-55,80-90,95-100,120-130,170-180
53	10	17	20 - 42	90-100,150-160,190-200
-	-	65 180	2 – 9 31 -?	-
-	-	89 54	1-9 18 - 83	130-140,150-160,180-190
-	-	53	7- 52	140-150
41	9	130	9-177	60-70,100-140,150-160,170-180
57	12	108	12- 166	85-100,150-170
18	17	-	-	45-55
58	5	40	43 -?	-

Resistivity Characteristics				Possible presence of thin fractured zone in the depth range (m)
Weathered Zone Aquifer		Aquifer in vesicular/fractured basalt sequence		
Resistivity(oh m.m)	Depth to bottom (m)	Resistivity (ohm.m)	Depth to the top and bottom(m)	
15	6	75	6 - 126	55-60,70-80,90-95,120-130,170-180
41	9	32	41- 84	130-150,160-170
14	6	8	16- 64	-
62	11	87	11- 95	80-85,95-100,150-160,180-190
8	4	13	18- 39	50-60,70-75,95-100
-	-	26	40 - 77	-
27	9	22	40- 84	80-90,95-100,120-140,180-190
57	5	36	5 - 40	45-50,75-90,140-160
38	9	102	84- 176	65-70,75-80,85-90,140-160,170-180
23	9	32	18- 74	75-85,100-110,120-130,140-150
-	-	98	25 - 201	60-70,75-80,90-100,120-130,150-160
--	--	133	5- 189	55-65,70-85,120-130,140-150,170-180
-	-	66 84	22 -43 54 -?	80-85,130-140,160-170,180- 190
-	-	51	3- 31	-
44	19	75	19- 83	50-55,65-70,85-95,110-120,140-150
-	-	213	6 - 64	85-90,110-120,130-140
-	-	64 13	2 – 19 19- 40	100-110,130-140,170-180
14	4	150	9 -?	-
26	9	114	9 - 83	130-140,150-170
-	-	18	239-?	-
10	3	-	-	-
-	-	75 76	1-16 34 - 49	60-65,80-85,150-160
-	-	27	3 - 32	-
16	4	232	16 -?	60-70,80-90,140-150,170-180
-	-	135 41	1 -11 20 - 32	90-140,170-180
9	4	170	4 - 176	90-120,130-140,150-160
10	17	98	17 -?	60-65,80-85,120-130
-	-	72 124	4 – 27 63 - 117	50-55,70-75,90-110,160– 170,180- 190
-	-	100	2 - 114	45-50,80-90,150-160
-	-	52	41 - 81	80-90,100-110,140-150
17	16	70	34 - 108	110-120,130-140,160-170
17	3	128	3 - 53	110-120,150-160
-	-	180 60	6 – 50 50 -?	-
53	9	23	39 - 83	70-80,85-95,110-120, 140-150,170-180
15	18	126	18 - 204	90-100,120-130,170-180
31	12	18	12 - 26	-
11	4	58	9 - 26	60-70,80-85,100-110, 120-130,140-150,180-190
36	28	22	99	50-55,70-75,150-160,170- 180
-	-	33	4 - 49	-
-	-	38	11 - 81	150-170
-	-	110	44 - 282	120-130,140-150
30	33	23	78 - 167	55-60,70-75,130-140, 150-160,170-180
16	13	86	13 - 106	65-70,80-100,120-130
-	-	160	4 - 12	40-45,60-80,110-120,180-190
15	9	11	9 - 39	--

Resistivity Characteristics				Possible presence of thin fractured zone in the depth range (m)
Weathered Zone Aquifer		Aquifer in vesicular/fractured basalt sequence		
Resistivity(oh m.m)	Depth to bottom (m)	Resistivity (ohm.m)	Depth to the top and bottom(m)	
11	11	71	11 - 252	55-60,80-85,110-120, 130-150,180-190
39	4	47 61	9- 18 69 - 83	70-90,130-140
34	19	166	19 - 179	100-120,130-140,150-160
20	26	-	-	-
--	--	33	87 - 160	100-120,130-140,150-160

3.10 Geo-Electrical Cross Sections, Lithological 3d Model and Fence Diagram of Barwani District:

In hardrock areas comprising basalt, granite gneiss, schist, quartzite, and phyllite etc. Preparation of cross-sections and fence diagram has no usefulness and not justified because of the rapid hydrogeological variations. However, Cross sections, Fence Diagram and 3Dmodel have been generated with very limited practical applicability. The Cross sections, Fence Diagram and 3D model analysis upto depth 200m bgl shown below.

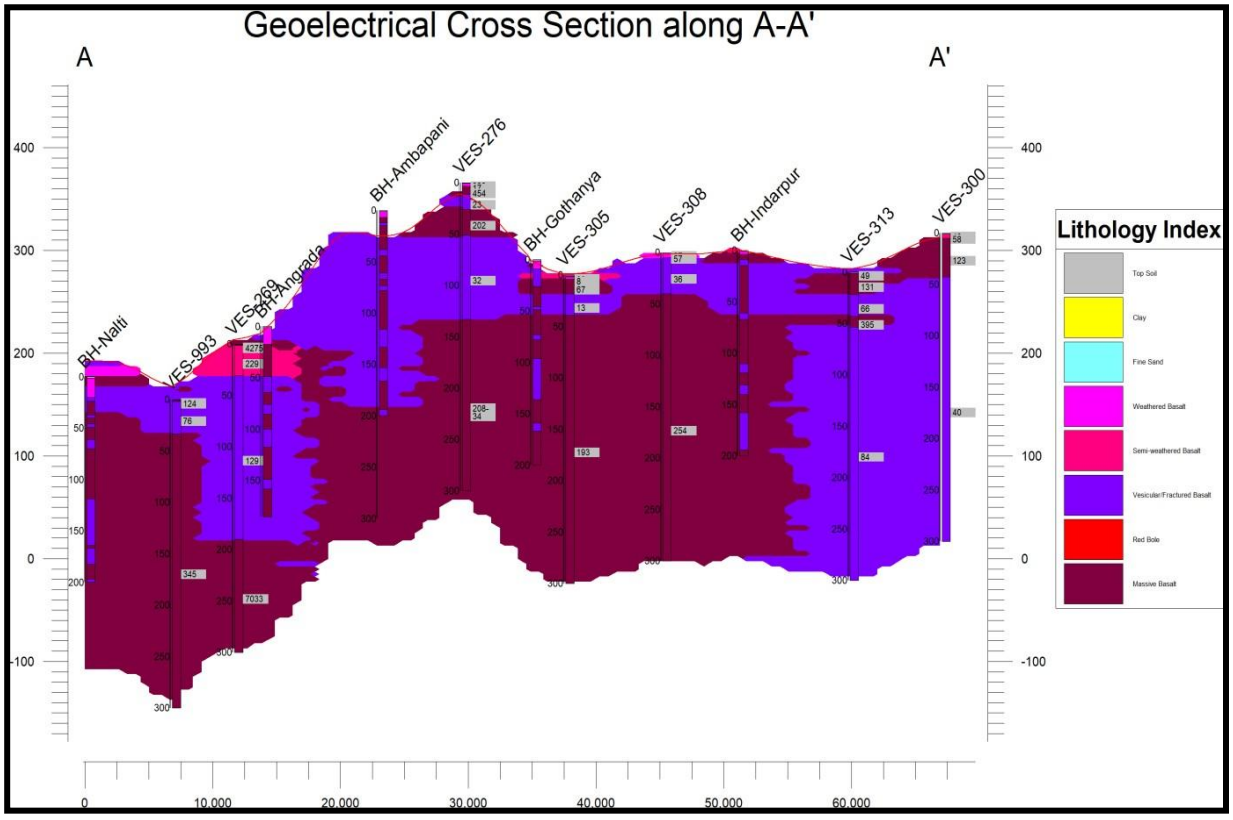


Fig.3.27: Geo electricalCrossSectionAlongA-A',BarwaniDistrict

Cross section AA’ has been prepared in Barwani district passing through the VES Nos 993,269,276,305,308,313and300inW-Edirection.InthissectionVESnos.993,269,276,305, 308, 313 and 300 are conducted in the basalt formation (weathered, vesicular/fractured basalt). The weathered basalt formation resistivity range 4 - 48 ohm. m and depth range 5- 43mbgl, the maximum depth of weathered basalt formation found 43 mbgl at VES 422. Below this layer found another layer vesicular/fractured basalt formation depth range 8- 200mbgland resistivity range 18 - 90 ohm.mat VES no. 417, 153, 162 and 165. Overall Cross section AA’ found that shallow weathered, deep vesicular/fractured basalt formation and massive basalt formation.(Fig.3.27)

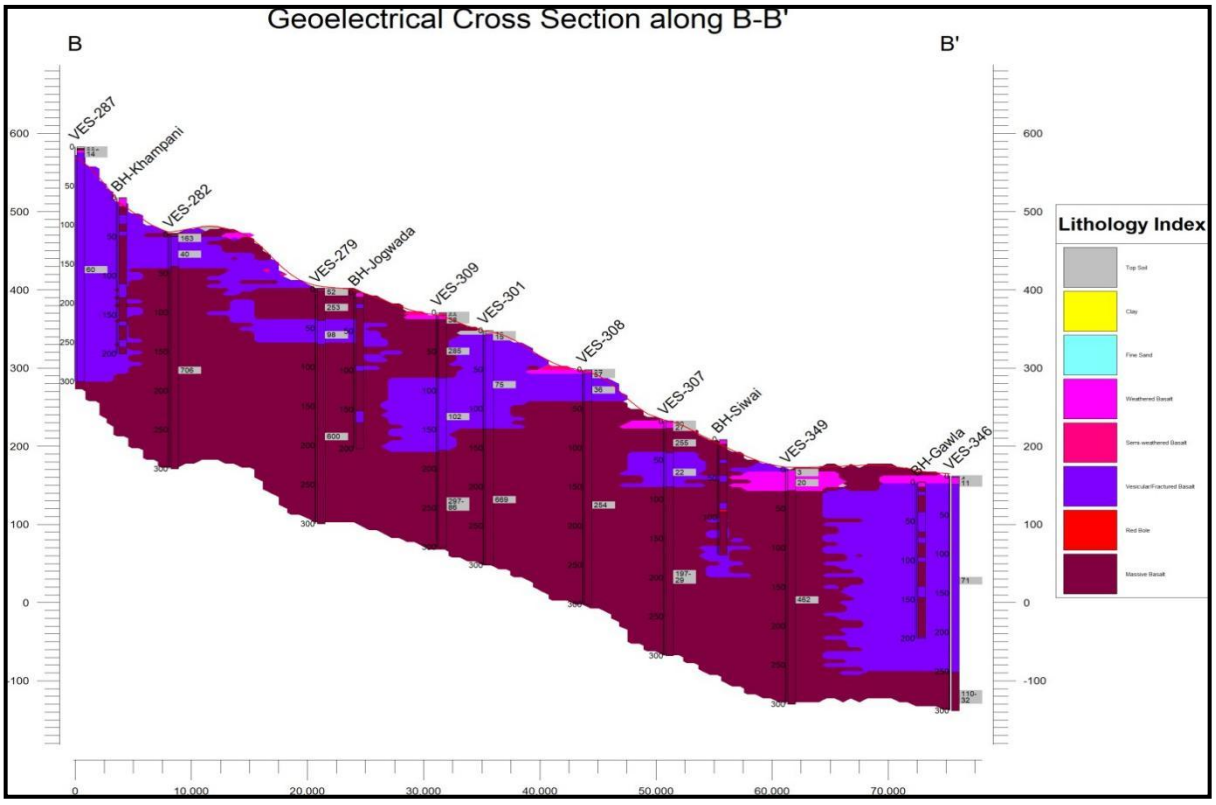


Fig.3.28 : GeoelectricalCrossSectionAlongB-B’,BarwaniDistrict.

Cross section BB’ has been prepared in Barwani district passing through the VES Nos 287,282,279,309,301,308,307,349and346inSW-NEdirection.InthissectionVESnos.287,282, 279, 309, 301, 308, 307, 349 and 346 are conducted in the basalt formation (weathered, vesicular/fractured basalt). The weathered basalt formation resistivity range 4 - 48 ohm. m and depth range 5- 43 mbgl , the maximum depth of weathered basalt formation found 43 mbgl at VES 422. below this layer found another layer vesicular/fractured basalt formation depth range 8- 200mbgl and resistivity range 18 - 90 ohm.mat VES no. 417, 153, 162 and 165.Overall Cross section BB’ found that shallow weathered , deep vesicular/fractured basalt formation and massive basalt formation. .(Fig.3.28)

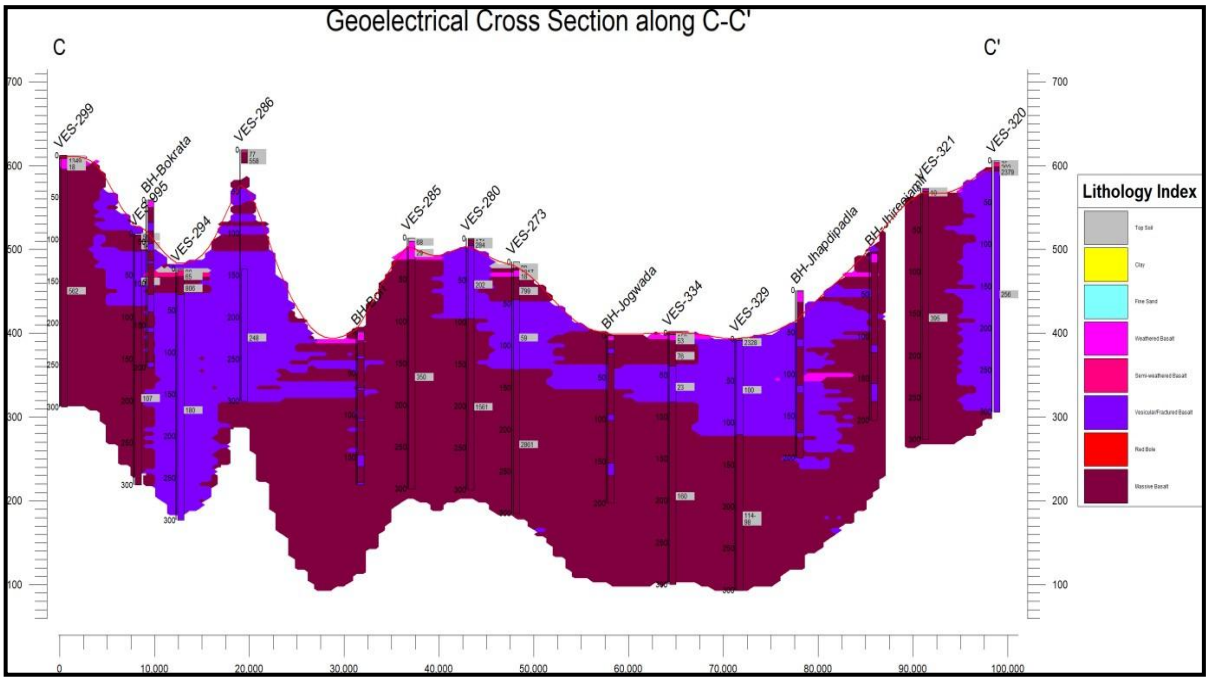


Fig.3.29:GeoelectricalCrossSectionAlongC-C',Barwani District

Cross section CC' has been prepared in Barwani district passing through the VES Nos 299,995,294,286,285,280,273,334,329,321and320inW-Edirection.InthissectionVESnos. 299, 995, 294, 286, 285, 280, 273, 334, 329, 321 and 320 are conducted in the basalt formation (weathered, vesicular/fractured basalt). The weathered basalt formation resistivity range 4 - 48 ohm m and depth range 5- 43 mbgl , the maximum depth of weathered basalt formation found 43mbgl at VES422. Below this layer found another layer vesicular/fractured basalt formation depth range 8- 200mbgl and resistivity range 18 - 90ohm.mat VES no. 417, 153, 162 and 165. Overall Cross section CC' found that shallow weathered, deep vesicular/fractured basalt formation and massive basalt formation. .(Fig.3.29)

CHAPTER -4

GROUND WATER RESOURCES

The ground water resources have been assessed for two types of aquifer existing in the area i.e., Aquifer-I and Aquifer-II. The details of the assessment are discussed below.

4.1 Ground Water Resources – Aquifer-I

As per Table.4.1 out of the total 542200 ha area, recharge worthy areas is366831 ha, command areas is 68721 ha and non-command areas298119 ha, whereas 175369 ha area is not worthy for recharge on account of its hilly nature.

The ground water resource assessment has been carried out for Barwani district and the salient features of the resources are given in Table.4.2**.**

Table.4.1: Ground Water Recharge Worthy Areas for Resource Estimation 2020.

District	Predominant Formation	Total Geographical Area (ha)	Hilly Area (ha)	Recharge worthy area in ha	Ground Water Recharge Worthy Area	
					Command area (ha)	Non-command area (ha)
Barwani	Deccan Trap, Bagh Formation	542200	175369	366831	68721	298119

4.2 Recharge Component

During the monsoon season, the rainfall recharge is the main recharge parameter, which is estimated as the sum total of the change in storage and gross draft. The change in storage is computed by multiplying groundwater level fluctuation between pre and post monsoon periods with the area of assessment and specific yield. Monsoon recharge can be expressed as:-

$R = h \times Sy \times A + DG$ Where,

h = rise in water level in the monsoon season, Sy = specific yield

A = area for computation of recharge, DG = gross ground water draft

The monsoon ground water recharge has two components- rainfall recharge and recharge from other sources. The other sources of groundwater recharge during monsoon season include seepage from canals, surface water irrigation, tanks and ponds, ground water irrigation, and water conservation structures.

During the non-monsoon season, rainfall recharge is computed by using Rainfall Infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-monsoon recharge.

The season wise assessment of recharge from various components such as rainfall and other sources was done and presented in **Table.4.2** and **Fig.4.1 &4.2**

Table4.2: Ground Water recharge from various Components 2020

District	Recharge from rainfall during monsoon season (ham)	Recharge from other sources during monsoon season (ham)	Recharge from rainfall during non-monsoon season (ham)	Recharge from other sources during non-monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Environmental flow in non-monsoon period (ham)	Net Annual Ground Water Availability (ham)
Barwani	34944.34	3415.72	0	18550.63	56910.69	5165.15	51745.54

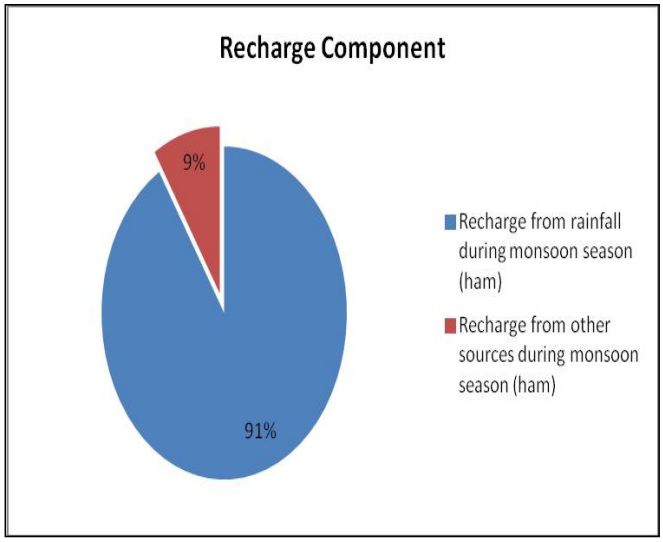


Fig.4.1: Recharge from various sources

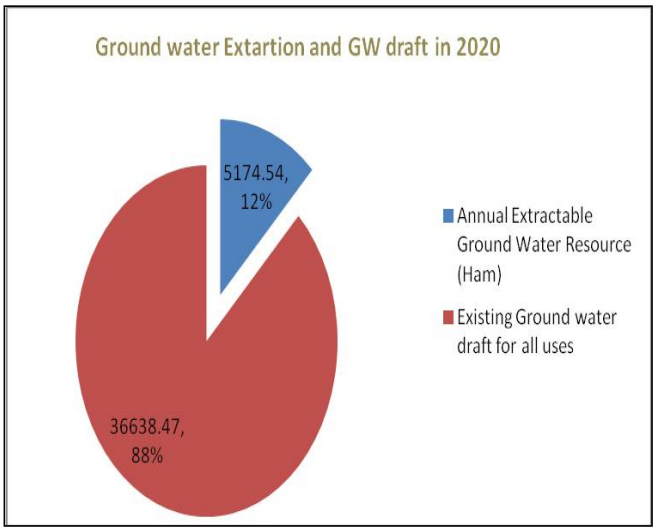


Fig.4.2: GW availability and Draft

The utilisation of available ground water resources for various purposes is provided in **Table 4.3 & 4.4**. The annual gross draft for all uses is estimated at 36638.47 ham with irrigation sector being the major consumer having a draft of 33147.22 ham and stage of ground water extraction/Development is 70.80 %. Ground water available for future irrigation is 19221.59 ham. The stage of ground water. As per Dynamic Ground water resource 2020 the Pansemal block is categorised as over exploited, groundwater extraction is 143.63% and Rajpur block is semi critical with ground water extraction is 86.58%. Category wise blocks are shown in Barwani District map in **Fig-4.3.**

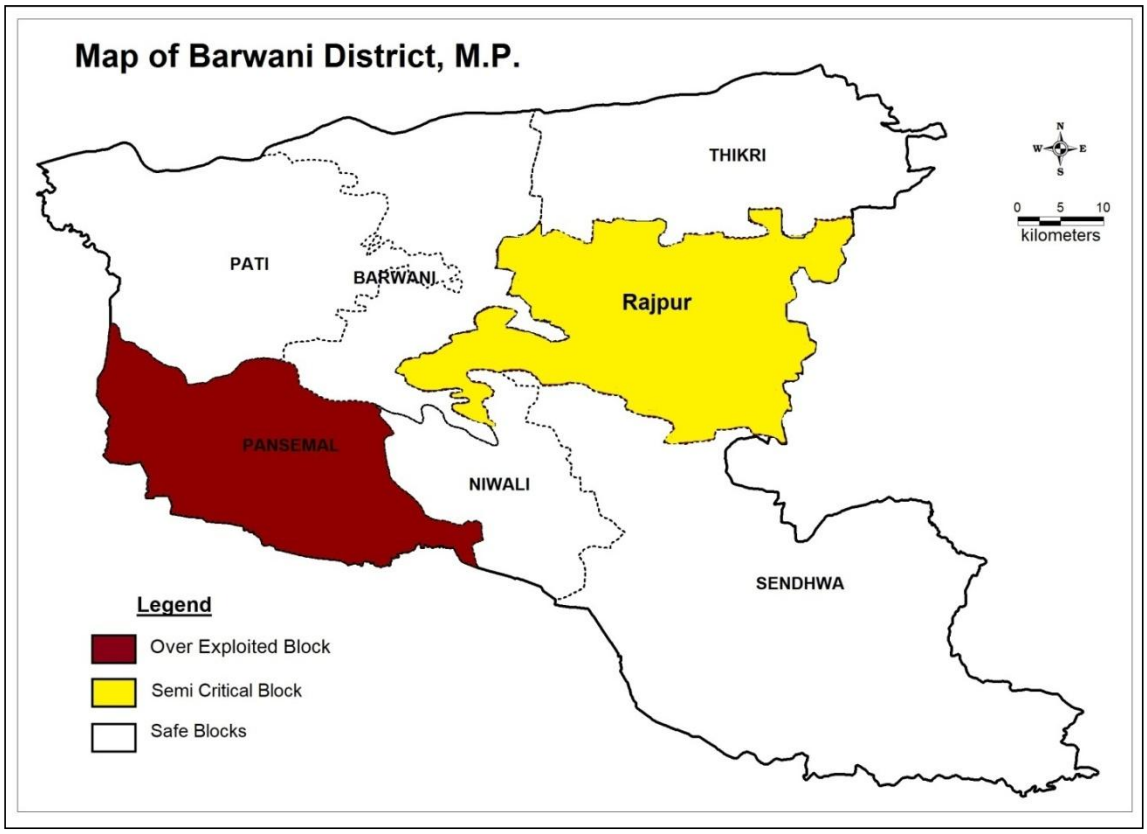


Fig4.3: Block wiseCategorisation of Barwani district

Table.4.3: Ground Water Resource 2020 , Barwani District

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)
RAJPUR	6825.34	996.39	0	3698.69	11520.4	1152.04	10368.4
BARWANI	4894.27	382.91	0	1798.55	7075.73	651.68	6424.05
NIWALI	3323.24	147.65	0	584.71	4055.6	405.56	3650.04
PANSEMAL	3906.49	543.14	0	2084.5	6534.13	653.42	5880.71
PATI	2097.14	220.61	0	482.71	2800.46	275.23	2525.23
THIKARI	6786.25	571.09	0	7967.81	15325.2	1109.53	14215.6
SENDHWA	7111.61	553.93	0	1933.66	9599.2	917.69	8681.51
DISTRICT TOTAL	**34944.3**	**3415.72**	**0**	**18550.6**	**56910.7**	**5165.15**	**51745.5**

Table 4.4 : Dynamic Ground Water Resources 2020of Barwani district.

District	Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area (Ha)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization
BARWANI	RAJPUR	77390	73036	10368.38	8411.13	566.14	8977.27	631.60	2666.67	86.58	semi critical
BARWANI	BARWANI	76710	55800	6424.05	3108.91	472.03	3580.94	530.53	2784.61	55.74	safe
BARWANI	NIWALI	59610	35561	3650.04	2188.18	318.39	2506.58	359.87	1101.98	68.67	safe
BARWANI	PANSEMAL	59040	29180	5880.71	8028.42	416.44	8444.86	476.48	597.6	143.60	overexploited
BARWANI	PATI	71220	22592	2525.23	1220.88	486.67	1707.54	561.97	742.39	67.62	safe
BARWANI	THIKARI	75700	71915	14215.62	5898.75	369.15	6267.89	412.77	7904.11	44.09	safe
BARWANI	SENDHWA	122530	78747	8681.51	4290.95	862.43	5153.39	966.32	3424.23	59.36	safe
Total		542200	366831	51745.54	33147.22	3491.24	36638.47	3939.54	19221.59	70.80	

Dynamic ground water resources of the district have been estimated for base year-2019-20, on block-wise basis. There are seven number of assessment units (block) in the district which fall under command and non-command sub-unit. Barwani, Niwali, Pati, Thikari and Sendhwa blocks of the district are categorized as safe blocks, Rajpur as semi critical, and Pansemal as over exploited with highest stage of ground water development which is computed as 143.60% (100.03% in 2016-17).

Table: 4.5 Blockwise Ground Water Resource 2020 of district

		Barwani	Niwali	Pansemal	Pati	Rajpur	Sendhwa	Thikri
Recharge worthy Area	Sq km	558	355.61	291.80	225.92	730.36	787.47	719.15
Pre-monsoon (average) depth to water level	m	9.67	7.72	11.36	6.95	8.55	9.88	11.43
Av. depth of Dug well	m	11.57	12.90	14.24	8.22	9.12	15.78	18.16
Specific yield(Sy)%	Fraction	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Saturated thickness of aquifer (ST)	m	3.46	5	4.69	4.30	4.50	4.12	3.58
Resource (A * Sy * ST)	MCM	38.61	35.56	27.37	19.42	65.73	64.88	51.49

Table 4.6 : Static Ground Water Resources of Aquifer-I.

	Units	**Total**
Recharge worthy Area	Sq. km	3668.31
Pre-monsoon (average) depth to water level	m	10.87
Av. depth of Dug well	m	12.85
Specific yield(Sy)%	Fraction	0.02
Saturated thickness of aquifer (ST)	m	1.98
	mcm	**145**

4.3Ground Water Resources – Aquifer-II

During the NAQUIM study, aquifer wise ground water resource were also assessed to have the correct quantification of resources so that proper management strategy can be framed. To assess these resources, the average thickness of fractures in deeper aquifers from exploratory wells was calculated and the following formula for static ground water resources was utilised i.e.,

GWR =Recharge worthy Area x Thickness of fractures in deep aquifer x Specific yield

By applying above formula, the ground water resource of Aquifer-I or In-storage is estimated 145 mcm and deeper aquifer was estimated as 93.90 MCM and is presented below in **Table 4.7.**

Table4.7: Static Ground Water Resources of Aquifer-II.

	Units	**Total**
Recharge worthy Area	Sq.km	3668.31
Thickness of fracture in deeper aquifer	M	1.28
Specific yield (Sy)%	Fraction	0.02
Resource (A * Sy * ST)	MCM	**93.90**

CHAPTER - 5

GROUND WATER RELATED ISSUES

In the district there are many Groundwater issues both in quantity and quality wise. All the issues are described as follows.

5.1 Decline Water Level in the district:

The decline in the water level observed in major part of the district. The pre and post monsoon declining trend of one hydrograph prepared and presented in the **Fig.5.1**. The block wise decline in the trend (**Table: 5.1)** of the hydrographs has been shown in the **Part-II**

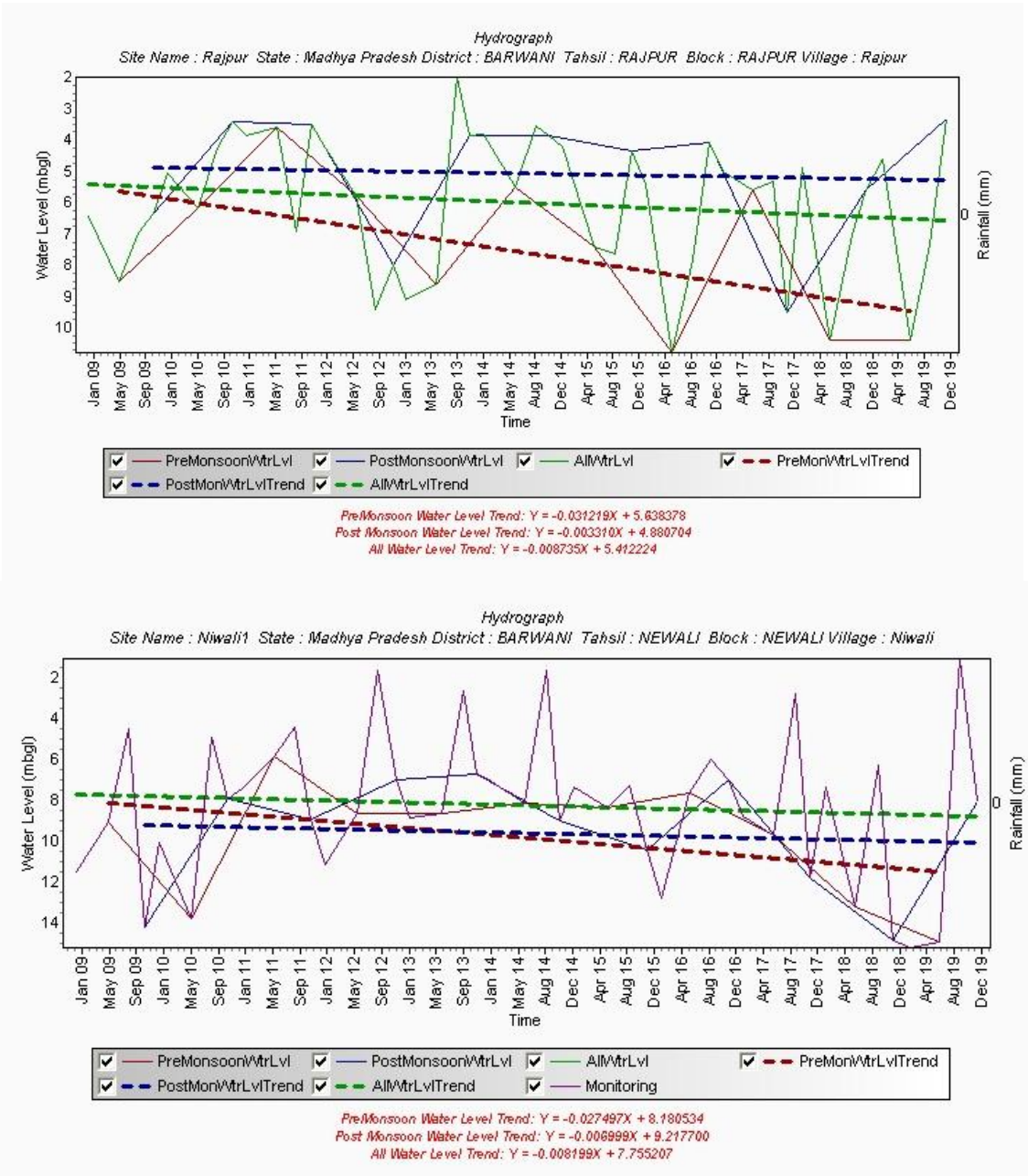


Fig:5.1 Hydrograph showing decline trend

Table: 5.1 Annual Ground water Trends					
Sl No.	**Block**	**Location**	**Data Points**	**Rise (m/year)**	**Fall (m/year)**
1	Thikri	Anjad(D)	32		0.0725
2	Rajpur	Balsamund	40		0.0250
3	Thikri	Baruphatak	37		0.0212
4	Thikri	Borlai	23		
5	Sendhwa	Chachariya	24		0.3177
6	Rajpur	Julwania	40	0.0808	
7	Niwali	Niwali1	40		0.1570
8	Rajpur	Palsud	32		0.0895
9	Rajpur	Rajpur	40		0.1254
10	Rajpur	Rajpur(D)	35		0.5410
11	Sendhwa	Sendhwa	39	0.1343	

5.2 Low Ground Water Potential / Sustainability

The district is covered mostly with hard rock i.e. Deccan trap basalt, and some part of the district covered by marginal alluvium. Central Ground Water Board have been constructed 30 exploratory wells in the district and conducted hydrological test to decipher aquifer parameters in the study area. It is indicated that the aquifer sustainability or discharge are gradually decrease during lean period and sustainability of both the aquifers (I &II) are limited.

5.3 Increasing stage of Ground Water Extraction

Out of the7 blocks, Pansemal and Rajpur blocks have the stage of groundwater extraction are 143.60% and 86.58 % respectively which are categorised as Over exploited and semi-critical, other5 blocks are come under safe category. However, the stage of extraction for each block are increasing. However, the stage of extraction for each block are increasing in every year.

5.4Extensive Soil Erosion

The maximum part of the district is covered by undulating basaltic hills therefore, the high intensity weathering and erosion take place simultaneously high sediments/eroded material also be generated and deposited to low lying area or discharged area that create the hindrance to artificial recharge structures

CHAPTER - 6
PROPOSED MANAGEMENT STRATEGY

As discussed in previous chapter, there are many groundwater related issues owing to many socio-economic and hydrogeological reasons. The groundwater management plan for Barwani district has been made keeping in view the area specific details and includes the strategies like enhancing the ground water resources through the 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. Also, adoption of micro irrigation technique 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.

6.1 Supply side Management

Artificial recharge to ground water is one of the most efficient, scientifically proven andcost-effective technology to mitigate the problems of over exploitation of ground water resources. The artificial recharge techniques simultaneously rejuvenate the depleted ground water storage, reduces the ground water quality. The supply side management plan forBarwani district has been formulated usingthe basic concepts of hydrogeology. Sub-surface storage is calculated by multiplying the totalarea with the respective specific yield (considering the variable lithology) and the unsaturatedzone thickness obtained by subtracting 4.23 m from the post-monsoon water level. 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 0.2 has been considered for Barwani district to calculate the total surface water runoff, 20% 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/Tube wells and Nala bunds/Check dams/Cement Plugsrespectively.The remaining runoff is 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 6.1.**

Out of 5422 sq.km geographical area of Barwani district, about 1765.50 sq.km., area has been identified for ground water development, wherein586.00percolation tank (@ Rs.18 lakh/percolation tank), 5026 nala bund, Cement plug, 5026recharge shaft/tube well(700 number of ponds/ village tanks to be renovated (@2.50 lakh/structure), 5026 check dam are recommended to be constructed in feasible areas. This accounts to a total of Rs. 534 crore to successfully implement the supply side management strategy.

In Barwani district already many recharge structures are constructed (as per the data collected from Jilla Panchayat office, Barwani). But due to non-availability proper coordinates of the already constructed recharge structures, the feasible sites for the proposed recharge structures cannot be pinpointed. The total numbers of recharge structures with cost to be constructed in the district are presented in the **Table.6.1 & 6.2.** Block wise supply side management strategy will be discussed in block wise management plan.

Table.6.1 Blockwise proposed artificial recharge structures

Block	Area (Sq.KM)	Normal Annual Rainfall (mm)	Average Post-monsoon Water Level - 2021 (m bgl)	Suitable Area for AR (sq.km)	Un-Saturated Zone (m)	Sub-surface storage (mcm)	Sub-Surface water required (mcm)	Non-Commuted Runoff (mcm)	No of percolation tanks col 15/.2	No of Check Dams col 18/0.03	No of Recharge shaft in each CD 18/.03	No of nala bunds/cement plugs Col 23/0.01	No of village ponds/ Farm Ponds in each village
Pansemal	590.4	746.6	8.58	291.80	5.58	48.85	64.97	40.74	71	611	611	611	83
Rajpur	773.9	746.6	8.07	730.36	5.07	74.00	98.42	53.40	93	801	801	801	95
Sendhwa	1225.3	746.6	14.44	787.47	11.44	180.17	239.63	84.55	148	1268	1268	1268	150
Thikri	757	746.6	14.40	719.15	11.40	163.92	218.01	52.23	91	783	783	783	93
Barwani	767	746.6	5.80	558	2.80	31.25	41.56	52.92	73	623	623	623	93
Pati	712	746.6	6.50	226	3.50	15.82	21.04	49.13	37	316	316	316	93
Niwali	596	746.6	7.39	356	4.39	31.26	41.57	41.12	73	624	624	624	93
Total	5421.60	5226.20	65.17	3668.78	44.17	545.26	725.20	374.09	586.00	5026.00	5026.00	5026.00	700.00

Table6.2: Proposed Numbers of AR structures.

Structures	Number	Cost in Crores
Percolation Tanks	586	117
Check dam (CD)	5026	301
Recharge shaft/ Tube well	5026	50.26
Nalla Bund	5026	50.26
Renovation of Village Ponds	700	17.50
Total Cost		**534**

6.2 Demand Side Management

However, considering the low storage potential of hard rock aquifer in the area the above ground water development plan should also be coupled with ground water augmentation plan, so that there is no stress on ground water regime of the area. (**Table6.4)**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).
- It enables farmers to grow crops which would not be possible under conventional systems since it can irrigate adequately with lower water quantities.
- It saves costs of hired labour and other inputs like fertilizer.
- 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.

Table6.4: Proposed demand Side Interventions

Block	Net GW Availability	GW Draft for Irrigation	GW Draft for Domestic & Industrial	Gross Draft	Stage of Development	Saving by Sprinklar in MCM	Additional recharge created by AR	After intervention of AR Structure Net GW AvL.	After intervention of AR Structure & utilisation of 60% of additional GW created.	Draft after sprinkler & additional area created for agriculture	Stage of Development W/O GW use for addidtional Area Irrigation
RAJPUR	103.68	84.11	5.66	89.77	86.58	26.93	50.3948	154.0748	30.2369	98.74	**64.08**
BARWANI	64.24	31.08	4.72	35.8	55.74	10.74	129.957	194.1970	77.9742	107.75	**55.49**
NIWALI	36.5	21.88	3.18	25.06	68.67	7.52	67.52	104.0240	40.5144	61.24	**58.87**
PANSEMAL	58.8	80.28	4.16	84.44	143.60	25.33	79.416	138.2160	47.6496	110.92	**80.25**
PATI	25.25	12.2	4.86	17.07	67.62	5.12	75.813	101.0630	45.4878	62.30	**61.64**
THIKARI	142.15	58.98	3.69	62.67	44.09	18.80	63.14	205.2850	37.8810	85.44	**41.62**
SENDHWA	86.81	42.9	8.62	51.53	59.36	15.46	68.53	155.3360	41.1156	85.81	**55.24**
Total	517.43	331.43	34.89	366.34	70.81	109.902	534.7658	1052.1958	320.85948	612.18748	**59.6**

Adoption of Sprinkler irrigation techniques would save approx. 10 to 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 especially safe block of the area, thereby enhancing the productivity and economy of the district.

6.3 Extensive soil erosion

It is the major issues in the district, generate and deposit huge sediments in and around recharge area.Following is some of the methods can be adopted to prevention soil erosion's

- Use land according to its capability -The steeper slopes and shallower soils suitable for growing pastures, and the lower slopes and deeper soils suitable for growing crops.
- Trees plantation at discharge and intermediate recharge zone can be control or reduce soil erosion. Tree roots help prevent landslides on steep slopes and stream bank erosion.

6.4 Post-Intervention Impact

The expected outcome of the proposed interventions from both supply side and demand side has been described in Table no 6.1 &6.2. It can be envisaged that the Stage of ground water extraction for the entire Barwani district. The stage of ground water extraction will be improved implying and successful implementation of proposed interventions.

CHAPTER - 7

BLOCK WISE AQUIFER MAPS AND MANAGEMENT PLANS

7.1. Aquifer Maps and Management Plan of OCS Block PANSEMAL BLOCK

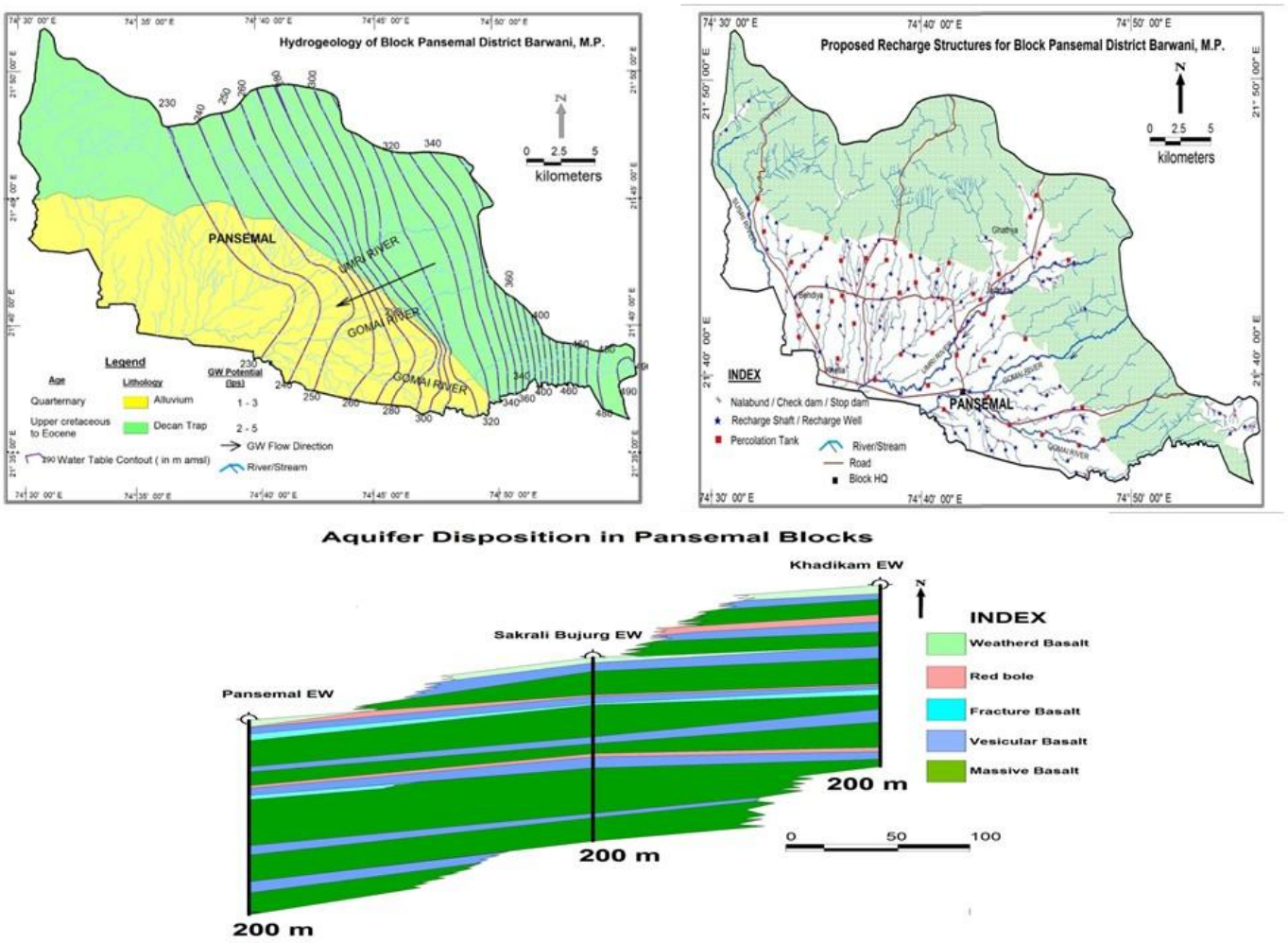


Fig: 7.1 Hydrogeology, Aquifer Disposition and Tentative location of Proposed AR structures

Table:7.1 Aquifer Maps and Management Plan of Pansemal block **SALIENT INFORMATION**			
Block	**Pansemal**		
Area		Sq Km	620
Population (2011 CENSUS)			157975
Normal Rainfall (2017-20		millimeter	746.3

Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, Kodokutki
	Gross cropped area	Sq Km	243.95
	Net sown area		243.95
	Area sown more than once		769.30
	Cropping intensity	%	131
	Area under forest	Sq Km	37.41
	Area under Waste land		4.72
Data Utilised	Monitoring Wells for Water Level		Dw-1 , Pz-2
	Monitoring Wells for Quality		Dw-1
Water level behavior	Pre-monsoon WL	meter	15.7
	Post-monsoon WL		7.20
	Pre-monsoon WL Trend	(m /yr)	Falling- 0.4222
	Post-monsoon WL Trend		Falling- 0.1772

AQUIFER DISPOSITION		
Major Aquifer	**Alluvium/Basalt**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt/Alluvium	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 30	30 to 200
SWL (mbgl)		
Weathered / Fractured rocks thickness (m)	2 to 12	0.50 to 3
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES			
DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	291.80
	Command area		44.89
	Non-Command area		246.91
	Recharge From Rain Fall During Monsoon Season	MCM	39.06
	Recharge From other sources During Monsoon Season		5.43

	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		20.84
	Total Recharge		65.34
	Annual Extractable Groundwater Recharge		58.60
	Existing Gross Ground Water Draft for Irrigation		80.28
	Existing Gross Ground Water Draft for Industrial Water Supply		00
	Existing Gross Ground Water Draft for Domestic Water Supply		4.16
	Existing Gross Ground Water Draft for All Uses		84.44
	Annual GW Allocation for for Domestic Use as on 2025		4.76
	Net Ground Water Availability for Future Irrigation Development		00
	Stage of Ground Water Extraction	**%**	143.60
	Category		**Over Exploited**
Static Resource of Shallow Aquifer		MCM	40.450
Static Resource of Deep Aquifer			33.032

Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block.
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with alluvium and hard Deccan trap basalt there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

MANAGEMENT PLAN FOR Pansemal BLOCK		
Rainfall	meter	0.746
Area	Sq Km	590.4
Area suitable for recharge		291.80
Average post-monsoon water level	Meter	9.18
Unsaturated zone		4.69
Average SP Yield	%	0.03
Sub-surface storage	MCM	41
Surface water required		54.60
Surface water (Run-off) available		264.72
Non-committed Run-off		79.41

Percolation Tanks	Numbers	71
Check dam (CD)		611
Recharge shaft/ Tube well		611
Nalla Bund		611
Village /Farm pond		83

7.2 **Aquifer Maps and Management Plan of Rajpur Block**

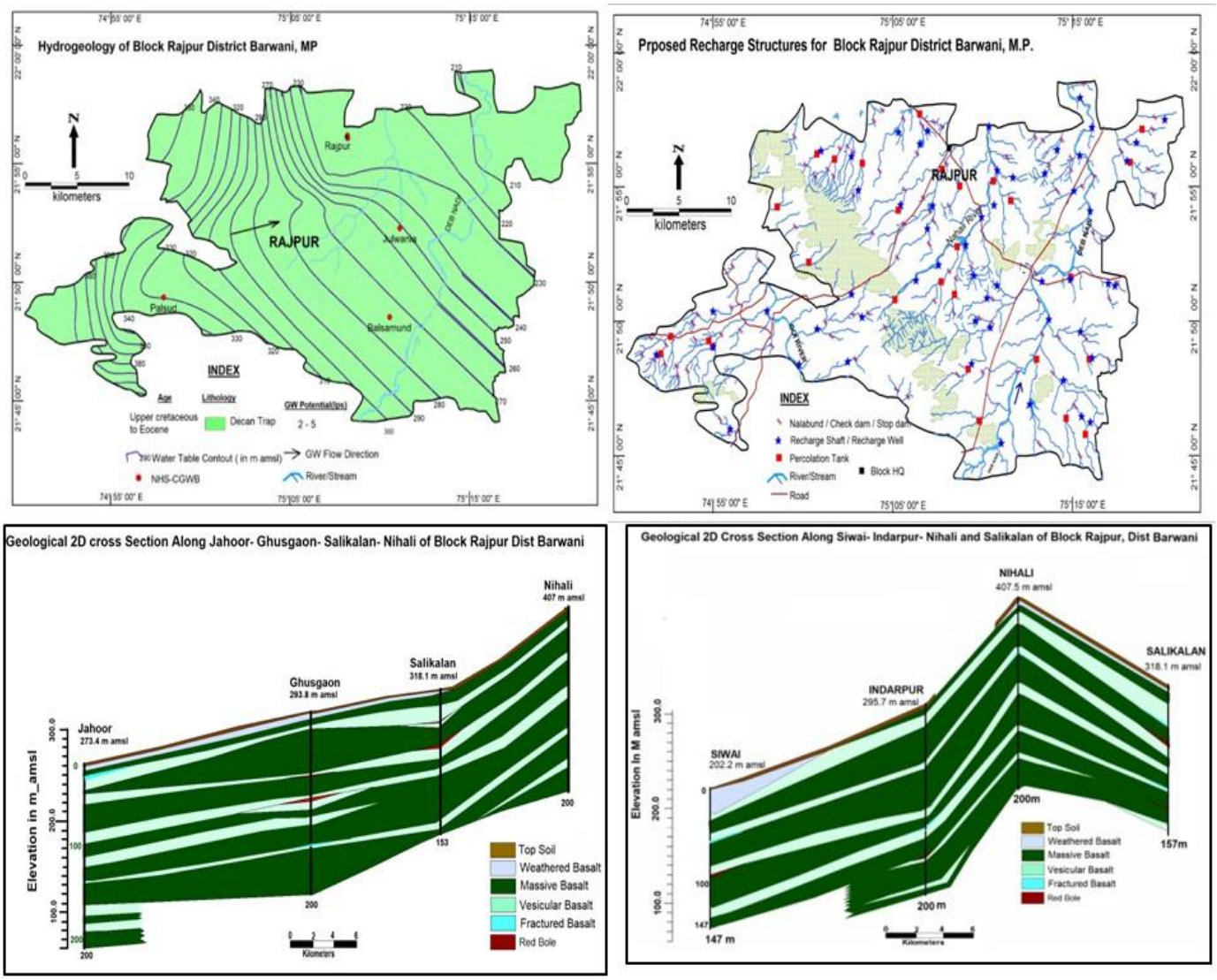


Fig:7.2 Hydrogeology, Aquifer Disposition and Tentative location of proposed AR structures in Rajpur Block

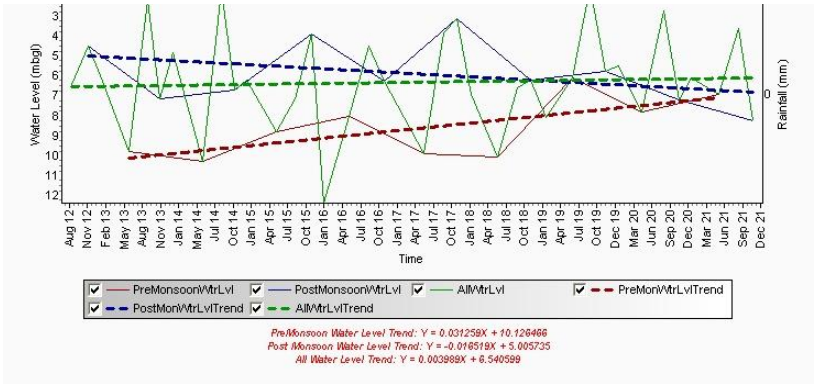


Fig.7.3: Hydrograph (2012-21 VillagePalsud Block- Rajpur, Barwani District.

Table.7.2 Management Plan of Rajpur Block SALIENT INFORMATION			
Block	**Rajpur**		
Area		Sq Km	773.90
Population (2011 CENSUS)			213219
Normal Rainfall(2016-20)		millimeter	746.60
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, , Mustard, , Wheat, Jowar, Maize, cotton
	Gross cropped area	Sq Km	45.86
	Net sown area		45.92
	Area sown more than once		109.60
	Cropping intensity	%	124
	Area under forest	Sq Km	2.29
	Area under Waste land		13.34
Data Utilised	Monitoring Wells for Water Level		Dw-4 , Pz-1
	Monitoring Wells for Quality		Dw-4
Water level behavior	Pre-monsoon WL	meter	9.02
	Post-monsoon WL		3.25
	Pre-monsoon WL Trend	(m /yr)	Fall 0.13955
	Post-monsoon WL Trend		Fall 0.0.554

AQUIFER DISPOSITION		
Major Aquifer	**Basalt**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 20	86-112,141-155, 181-200
SWL (mbgl)		
Weathered / Fractured rocks thickness (m)	0-9	0.50 to 20
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES			
DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	730.36
	Command area		259.44
	Non-Command area		470.92
	Recharge From Rain Fall During Monsoon Season	MCM	68.25
	Recharge From other sources During Monsoon Season		9.96
	Recharge From Rain Fall During Non-Monsoon Season		00.
	Recharge From other sources During non-Monsoon Season		36.98
	Total Recharge		115.20
	Annual Extractable Groundwater Recharge		103.68
	Existing Gross Ground Water Draft for Irrigation		84.11
	Existing Gross Ground Water Draft for Industrial Water Supply		0.0
	Existing Gross Ground Water Draft for Domestic Water Supply		5.66
	Existing Gross Ground Water Draft for All Uses		89.77
	Annual GW Allocation for for Domestic Use as on 2025		6.31
	Net Ground Water Availability for Future Irrigation Development		20.35
	Stage of Ground Water Extraction	**%**	86.58
	Category		**Semi-Critical**
Static Resource of Shallow Aquifer		MCM	40.450
Static Resource of Deep Aquifer			33.032

Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block (**Fig.7.3**)
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

MANAGEMENT PLAN FOR Rajpur BLOCK		
Rainfall	meter	0.69
Area	Sq Km	773.90
Area suitable for recharge		730.36
Average post-monsoon water level	Meter	5.6
Unsaturated zone		4.5
Average SP Yield	%	0.02
Sub-surface storage	MCM	65.73
Surface water required		87.42
Surface water (Run-off) available		167.98
Non-committed Run-off		50.39
Percolation Tanks	Numbers	93
Check dam (CD)		801
Recharge shaft/ Tube well		801
Nalla Bund		801
Village /Farm pond		95

7.3 Aquifer Maps and Management Plan of Barwani Block

Table.7.3: Management Plan of Barwani Block SALIENT INFORMATION			
Block	**Barwani**		
Area		Sq Km	767.10
Population (2011 CENSUS)			211061
Normal Rainfall(2017-20)		Millimeter	742.50
Land use and Agriculture	Principal crops		Soyabean, Cotton Groundnut, Til, Ramtil, Pulse, Mustard, Wheat, Jowar, Maize,
	Gross cropped area	Sq Km	294.08
	Net sown area		282.08
	Area sown more than once		104.60
	Cropping intensity	%	137
	Area under forest	Sq Km	32.689
	Area under Waste land		837
Data Utilised	Monitoring Wells for Water Level		Dw-1 , Pz-2
	Monitoring Wells for Quality		Dw-1
Water level behavior	Pre-monsoon WL	Meter	9.60
	Post-monsoon WL		5.58
	Pre-monsoon WL Trend	(m /yr)	Rising 0.0692
	Post-monsoon WL Trend		Rising 0.00187

AQUIFER DISPOSITION		
Major Aquifer	**Basalt**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 30	30 to 200
SWL (mbgl)		
Weathered / Fractured rocks thickness (m)	2 to 14	0.5 to 2.4
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield(M^3/day)		
Transmissivity (m^2/day)		

GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES			
DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	**Deccan trap**	
	Recharge worthy area	Sq Km	558
	Command area		145.52
	Non-Command area		412.48
	Recharge From Rain Fall During Monsoon Season	MCM	48.9427
	Recharge From other sources During Monsoon Season		3.8291
	Recharge From Rain Fall During Non-Monsoon Season		0
	Recharge From other sources During non-Monsoon Season		17.985
	Total Recharge		70.75.73
	Annual Extractable Groundwater Recharge		64.24
	Existing Gross Ground Water Draft for Irrigation		31.08
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		4.72
	Existing Gross Ground Water Draft for All Uses		35.80
	Annual GW Allocation for Domestic Use as on 2025		5.30
	Net Ground Water Availability for Future Development		27.84
	Stage of Ground Water Extraction	**%**	55.74
	Category		**SAFE**
Static Resource of Shallow Aquifer		MCM	
Static Resource of Deep Aquifer			33.032

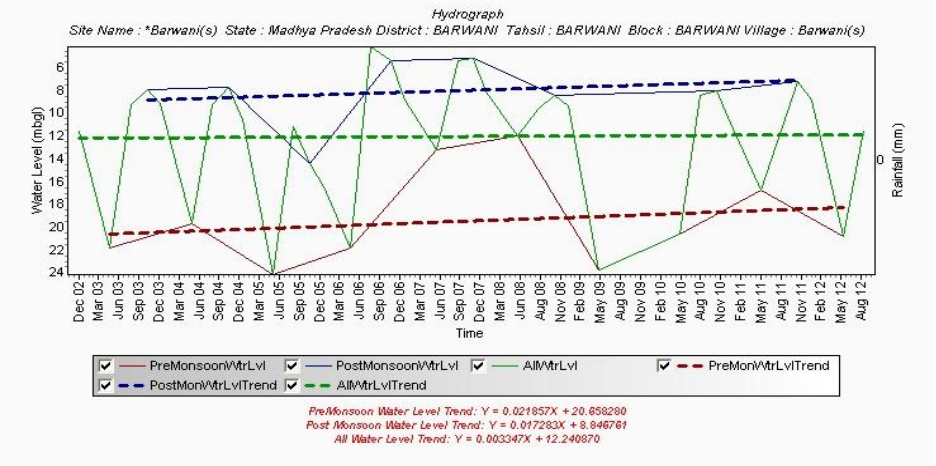


Fig.7.4 Hydrograph (2011-2012), Barwani Block- Barwani Barwani District

Ground Water Related Issues	
Declining water level	Declining water level observed both in pre &post-monsoon in major part of the block (**Fig.7.4**)
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap basalt there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

MANAGEMENT PLAN FOR BARWANI BLOCK		
Rainfall	meter	
Area	Sq Km	767.10
Area suitable for recharge		558.0
Average post-monsoon water level	Meter	5.73
Unsaturated zone		3.46
Average SP Yield	%	0.02
Sub-surface storage	MCM	38.61
Surface water required		51.35
Surface water (Run-off) available		433.19
Non-committed Run-off		129.95
Percolation Tanks	Numbers	73
Check dam (CD)		623
Recharge shaft/ Tube well		623
Nalla Bund		623
Village /Farm pond		93

7.4 Aquifer Maps and Management Plan of Patiblock

Table.7.4: Management Plan of Patiblock SALIENT INFORMATION			
Block	**PATI**		
Area		Sq Km	512
Population (2011 CENSUS)			**162432**
Normal Rainfall (2015-19)		millimeter	769.30
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize,
	Gross cropped area	Sq Km	245.88
	Net sown area		245.73
	Area sown more than once		32.19
	Cropping intensity	%	113
	Area under forest	Sq Km	76.25
	Area under Waste land		5.83
Data Utilized	Monitoring Wells for Water Level		DW-1 , Pz-2
	Monitoring Wells for Quality		Dw-1
Water level behavior	Pre-monsoon WL	meter	9.60
	Post-monsoon WL		5.58
	Pre-monsoon WL Trend	(m /yr)	Rising 0.0692
	Post-monsoon WL Trend		Rising 0.0187

AQUIFER DISPOSITION		
Major Aquifer	**Basalt /Deccan Trap**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 12	50-53,80-82, 145-150
SWL (mbgl)	3.40-12.60	10-22
Weathered / Fractured rocks thickness (m)	0-14	0.50 to 5.45
Fractures encountered (mbgl)	Upto20	Upto150
Yield	-	
Transmissivity (m^2/day)	-	

GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES			
DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	225.92
	Command area		10.40
	Non-Command area		215.52
	Recharge From Rain Fall During Monsoon Season	MCM	20.97
	Recharge From other sources During Monsoon Season		2.20
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		4.82
	Total Recharge		28.00
	Annual Extractable Groundwater Recharge		25.25
	Existing Gross Ground Water Draft for Irrigation		12.20
	Existing Gross Ground Water Draft for Industrial Water Supply		00
	Existing Gross Ground Water Draft for Domestic Water Supply		4.86
	Existing Gross Ground Water Draft for All Uses		17.07
	Annual GW Allocation for for Domestic Use as on 2025		5.61
	Net Ground Water Availability for Future Irrigation Development		7.42
	Stage of Ground Water Extraction	**%**	67.62
	Category		**Safe**
Static Resource of Shallow Aquifer		MCM	40.450
Static Resource of Deep Aquifer			33.032

Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block.
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap basalt there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

MANAGEMENT PLAN FOR PATI BLOCK		
Rainfall	meter	0.769
Area	Sq Km	712.20
Area suitable for recharge		225.92
Average post-monsoon water level	Meter	7.32
Unsaturated zone		4.3
Average SP Yield	%	0.02
Sub-surface storage	MCM	19.43
Surface water required		25.84
Surface water (Run-off) available		252.71
Non-committed Run-off		75.81
Percolation Tanks		37
Check dam (CD)		316
Recharge shaft/ Tube well		316
Nalla Bund		316
Village /Farm pond		93

7.5 Aquifer Maps and Management Plan of Thikri Block

Table.7.5: Management Plan of ThikriBlock SALIENT INFORMATION			
Block	**THIKRI**		
Area		Sq Km	565.75
Population (2011 CENSUS)			**175340**
Normal Rainfall(2015-2019)		millimeter	769.30
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil,Sugarcan, Mustard, Rice, Wheat, Jowar, Maize, Cottoni
	Gross cropped area	Sq Km	345.94
	Net sown area		344.32
	Area sown more than once		115.10
	Cropping intensity	%	133
	Area under forest	Sq Km	147.20
	Area under Waste land		11.21
Data Utilised	Monitoring Wells for Water Level		Dw-2 , Pz-1
	Monitoring Wells for Quality		Dw-2
Water level behavior	Pre-monsoon WL	meter	6.65
	Post-monsoon WL		3.86
	Pre-monsoon WL Trend	(m /yr)	Rising 0.5795
	Post-monsoon WL Trend		Falling 0.8497

AQUIFER DISPOSITION		
Major Aquifer	**Basalt**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 30	110-135,141-155,
SWL (mbgl)		
Weathered / Fractured rocks thickness (m)	0-15	0.50 to 17
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES			
DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	719.15
	Command area		109.19
	Non-Command area		609.96
	Recharge From Rain Fall During Monsoon Season	MCM	67.86
	Recharge From other sources During Monsoon Season		5.71
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		79.67
	Total Recharge		153.25
	Annual Extractable Groundwater Recharge		142.15
	Existing Gross Ground Water Draft for Irrigation		58.98
	Existing Gross Ground Water Draft for Industrial Water Supply		0.0
	Existing Gross Ground Water Draft for Domestic Water Supply		3.69
	Existing Gross Ground Water Draft for All Uses		62.67
	Annual GW Allocation for for Domestic Use as on 2025		4.12
	Net Ground Water Availability for Future Irrigation Development		58.59
	Stage of Ground Water Extraction	**%**	44.09
	Category		**Safe**
Static Resource of Shallow Aquifer		MCM	40.450
Static Resource of Deep Aquifer			33.032

Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block(**Fig.7.5**)
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Management Plan For Thikri Block		
Rainfall	meter	0.770
Area	Sq Km	757.00
Area suitable for recharge		719.15
Average post-monsoon water level	Meter	8.35
Unsaturated zone		4.69
Average SP Yield	%	0.02
Sub-surface storage	MCM	56.23
Surface water required		74.79
Surface water (Run-off) available		210.45
Non-committed Run-off		63.135
Percolation Tanks		91
Check dam (CD)		783
Recharge shaft/ Tube well		783
Nalla Bund		783
Village /Farm pond		93

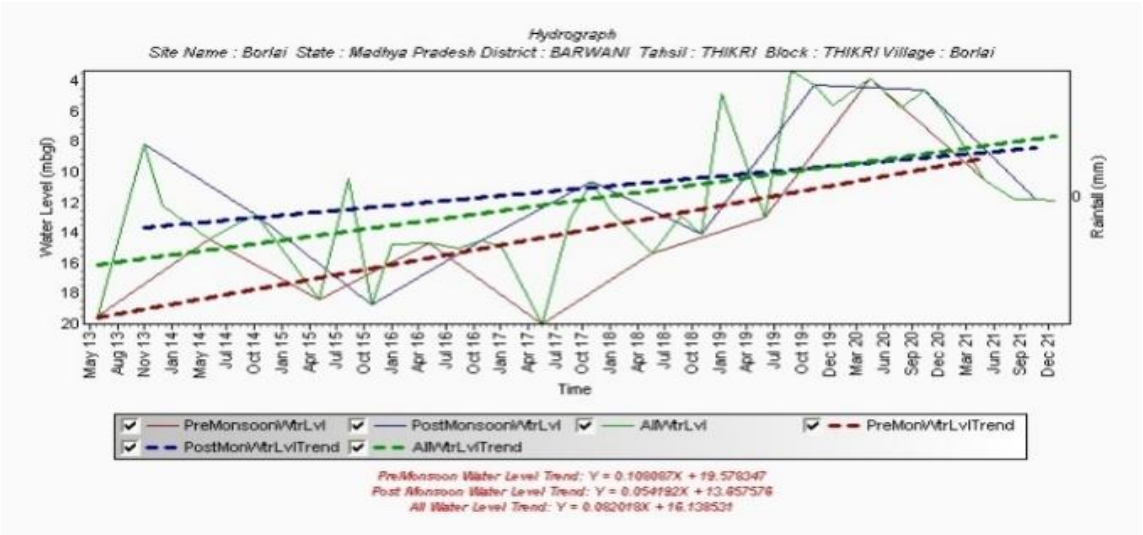


Fig.7.5 : Hydrograph (2011-21), Village-Baruphatak&Borlai, Block- Thikri,

7.6 Aquifer Maps and Management Plan of Niwali Block

Table.7.6: Management Plan of Niwali Block
SALIENT INFORMATION

Block	**NIWALI**		
Area		Sq Km	352.39
Population (2011 CENSUS)			**112639**
Normal Rainfall(2017-21)		millimeter	746.3
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, cotton
	Gross cropped area	Sq Km	237.33
	Net sown area		227.40
	Area sown more than once		43.65
	Cropping intensity	%	119
	Area under forest	Sq Km	21.75
	Area under Waste land		5.07
Data Utilised	Monitoring Wells for Water Level		DW-1
	Monitoring Wells for Quality		Dw-1
Water level behavior	Pre-monsoon WL	meter	5.80
	Post-monsoon WL		5.76
	Pre-monsoon WL Trend	(m /yr)	Falling- 0.4256
	Post-monsoon WL Trend		Falling-0.1463

AQUIFER DISPOSITION		
Major Aquifer	**Basalt**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured
Depth of Occurrence (mbgl)	1 to 35	50-54,141-160, 181-200
SWL (mbgl)	3.40-17.40	10-22
Weathered / Fractured rocks thickness (m)	0-14	0.50 to 4
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	355.61
	Command area		4.70
	Non-Command area		350.91
	Recharge From Rain Fall During Monsoon Season	MCM	33.23
	Recharge From other sources During Monsoon Season		1.47
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		5.84
	Total Recharge		40.55
	Annual Extractable Groundwater Recharge		36.50
	Existing Gross Ground Water Draft for Irrigation		21.88
	Existing Gross Ground Water Draft for Industrial Water Supply		0.0
	Existing Gross Ground Water Draft for Domestic Water Supply		3.18
	Existing Gross Ground Water Draft for All Uses		25.06
	Annual GW Allocation for for Domestic Use as on 2025		3.59
	Net Ground Water Availability for Future Irrigation Development		7.42
	Stage of Ground Water Extraction	**%**	68.67
	Category		**Safe**
Static Resource Of Shallow Aquifer		MCM	40.450
Static Resource Of Deep Aquifer			33.032

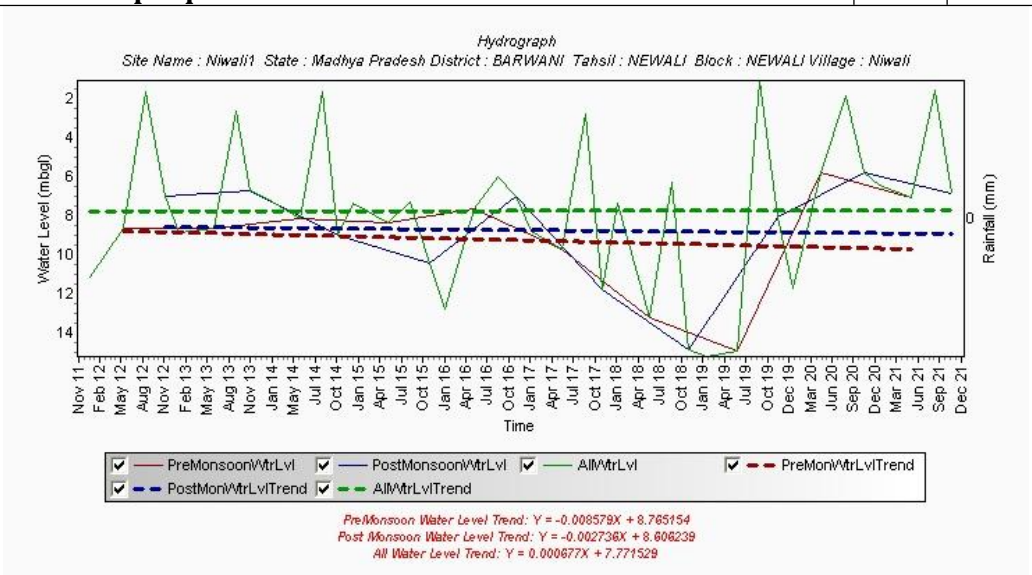


Fig.7.6: Hydrograph (2011-21), Niwali, Block- Niwali, Barwani District.

Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block (**Fig.7.6**)
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap basalt is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Management Plan For Niwali Block		
Rainfall	meter	0.95
Area	Sq Km	596.10
Area suitable for recharge		355.61
Average post-monsoon water level	Meter	7.39
Unsaturated zone		5
Average SP Yield	%	0.02
Sub-surface storage	MCM	35.56
Surface water required		47.29
Surface water (Run-off) available		225.08
Non-committed Run-off		67.52
Percolation Tanks		73
Check dam (CD)		624
Recharge shaft/ Tube well		624
Nalla Bund		624
Village /Farm pond		93

7.7 Aquifer Maps and Management Plan Of Sendhwa Block

SALIENT INFORMATION			
Block	**Sendhwa**		
Area		Sq Km	343
Population (2011 CENSUS)			**360039**
Normal Rainfall(2017-21)		millimeter	0.746
Land use and Agriculture	Principal crops		Soyabean, Groundnut, Til, Ramtil, Linseeds, Mustard, Rice, Wheat, Jowar, Maize, Kodokutki
	Gross cropped area	Sq Km	547.85
	Net sown area		557.39
	Area sown more than once		53.58
	Cropping intensity	%	116
	Area under forest	Sq Km	193.45
	Area under Waste land		12.78
Data Utilised	Monitoring Wells for Water Level		DW-2 ,
	Monitoring Wells for Quality		Dw-2
Water level behavior	Pre-monsoon WL	meter	4.95
	Post-monsoon WL		3.49
	Pre-monsoon WL Trend	(m /yr)	Falling - 0.009492
	Post-monsoon WL Trend		Rising 0.01614

AQUIFER DISPOSITION		
Major Aquifer	**Basalt**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Basalt	Jointed / Fractured Basalt
Depth of Occurrence (mbgl)	1 to 30	30-200
SWL (mbgl)		
Weathered / Fractured rocks thickness (m)	0-13	1-5
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Deccan trap	
	Recharge worthy area	Sq Km	787.47
	Command area		92.75
	Non-Command area		694.72
	Recharge From Rain Fall During Monsoon Season	MCM	71.11
	Recharge From other sources During Monsoon Season		5.53
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		19.33
	Total Recharge		95.99
	Annual Extractable Groundwater Recharge		86.81
	Existing Gross Ground Water Draft for Irrigation		42.90
	Existing Gross Ground Water Draft for Industrial Water Supply		0.0
	Existing Gross Ground Water Draft for Domestic Water Supply		8.62
	Existing Gross Ground Water Draft for All Uses		51.53
	Annual GW Allocation for for Domestic Use as on 2025		9.66
	Net Ground Water Availability for Future Irrigation Development		24.57
	Stage of Ground Water Extraction	**%**	59.36
	Category		**Safe**
Static Resource of Shallow Aquifer		MCM	40.450
Static Resource of Deep Aquifer			33.032

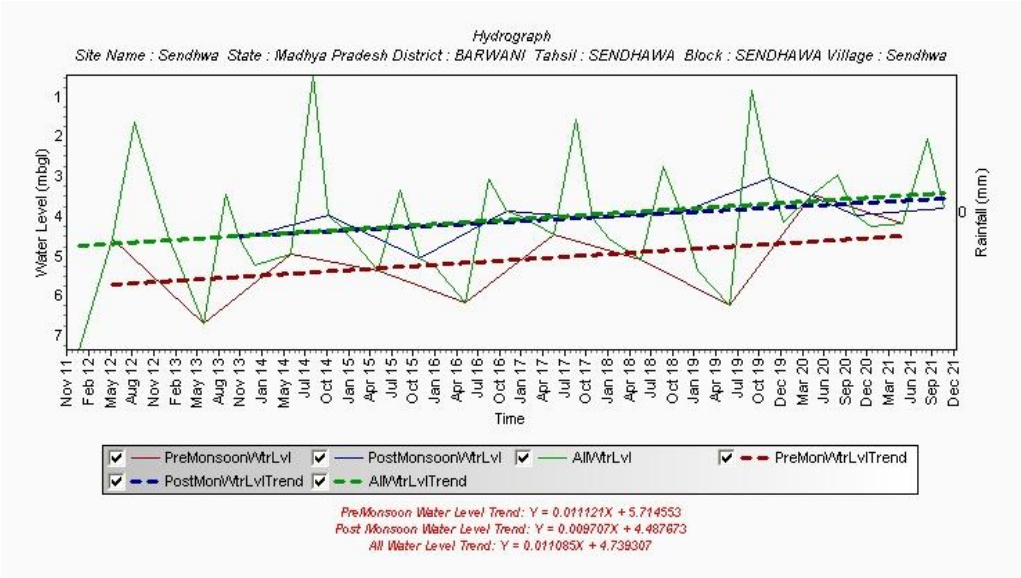


Fig.7.7: Hydrograph (2011-21), Village-, Block- Sendhwa, Barwani District.

Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block (**Fig.7.7**)
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Deccan trap basalt is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

MANAGEMENT PLAN FOR Sendhwa		
Rainfall	meter	0.90
Area	Sq Km	1225.30
Area suitable for recharge		787.47
Average post-monsoon water level	Meter	8.48
Unsaturated zone		4.20
Average SP Yield	%	0.02
Sub-surface storage	MCM	66.14
Surface water required		87.97
Surface water (Run-off) available		228.42
Non-committed Run-off		68.526
Percolation Tanks		148
Check dam (CD)		1268
Recharge shaft/ Tube well		1268
Nalla Bund		1268
Village /Farm pond		150

CHAPTER - 8

CONCLUSIONS AND RECOMMENDATIONS

- Barwani district occupies an area of 5422 sq km out of which the ground water recharge worthy area is 83668.31 sq. km. and the rest is covered by hilly and forest area. The northern part of the district lies in Narmada basin while the southern part lies in Tapti in Tapti Basin. The total catchments areas of the Narmada Basin is 4771 sqkm and Tapi Basin 651 sq.km
- Pansemal and Rajpur are fall under the OCS category as per dynamic ground water resource estimation, Barwani district occupies an area of 1364 sq km out of which the ground water recharge worthy area is 1022 sq. km. and the rest is covered by hilly and forest area .NE and SE part of the Pansemal blocks is covered by forest more than 50% area and 50% area of SW and NW is covered by weathered basalt, alluvium and The thickness of alluvium is vary from 5 m to 70 m.
- The main problem in Pansemal block is not so much due to non-availability of ground water, but lack of natural replenishment to ground water in valley area aquifer and There is ample scope for increasing the potential of these zones by implementation of following measures in Pansemal block - construction of contour bund, Subsurface dyke, check dam over these dykes for impounding surface water for recharge. and other structures in forest area, Increasing the density of forest by plantation, all these measures can be very useful for reducing runoff and recharge valley area aquifer during monsoon period and increase the aquifer sustainability in lean period and drought conditions can also be reduce.
- The Maximum part of the district is covered by Deccan trap, western part it is covered by Marginal alluvium. Exploratory borewells constructed and estimated hydrogeological parameter through Pumping test. Discharge / yield varies from 0.1-9.87 lps in Basalt formation and varies from 1 to 5 lps in marginal alluvium formation is .
- Deccan Traps in Barwani district constitute aquifers mainly with low to moderate permeability.
- On account of extreme temperature and climatic variations, weathering in shallow zones is quite intense, creating an overburden with moderate to high infiltration rates. Although the weathered zones are not present over the entire aerial extent of Trap, yet fracture porosity of the rocks also gets increased due to weathering action. Such high weathered overburden having moderate to high infiltration rates are ideally suitable for construction of Artificial recharge structures.
- Decline in ground water level trend is observed **0.0212 to** 0.5410 **m/yr in the district. Maximum decline is observed in Pansemal and Rajpur Blocks.**
- Supply side Management plan prepared under NAQUIM for all the blocks of Barwani District, a total number 8018 Recharge Shafts/Tube wells and Check dam and 932 percolation tank and 716

village ponds under RRR have been suggested after implementation of supply and demand side management plan, stage of ground water extraction may be improved

- Streams that generally flow on weak surface zones having high permeability also constitute good recharge zone. Numerous volcanic dykes cutting across surface drainage are seen in the Blocks. The sub surface continuation of these dykes is generally impermeable, resulting in impounding of some water in the stream channel on the upstream side.
- The phreatic aquifer is recharged during monsoon and sustains for 3 to 4 months
- The weathered and fractured zone overlying the fresh rock constitutes a profitable zone for development. The thickness of weathered zone varies from negligible to a maximum of about 20 meters.
- Barwani district is mostly occupied by rocks belonging to mainly Deccan trap basalts occur in the district as lava flow. Basaltic lava flows form the most predominant and widespread hydrogeological formations in the district. The weathered, joint, fractured and vesicular units of basalts form moderately potential aquifers. The alluvial deposits are confined mainly to Narmada &Goi rivers and are not very extensive in thickness. Sometimes in some places the top resistivities are showing the presence of alluvium deposit. For example at VES 289 the VES results and Lithology are explained as alluvium deposit in the same table (Table 3.7) of basalt formation. All the VES interpreted results in this formation are discussed in table Table 3.7 and annexure. Hence it is observed from the map that the total of 82 VES were conducted in basalt area of this district including the places where top alluvium formation exists. Among these VES according to the depth variations the dug wells, dug well and bore well and borewells are recommended. Mainly dugwells are in weathered zone, borewells are in deeper fractured zones and dug wells and bore wells are in weathered as well as deeper fracture zone are considered. As such based on the interpreted results of VES sites are recommended for borehole drilling and dug well. The list of sites is given in Table Annexure-01 for recommendation of groundwater structure in Basalt formation.

ACKNOWLEDGEMENTS

I would like to take an opportunity to thank **Shri Rana Chatterjee, Regional Director,** CGWB, NCR, Bhopal for issuance of this NAQUIM study.

I would like to take an opportunity to thank **Shri Padam Kumar Jain, Former Regional Director & Member (South) (I/C),** CGWB for providing the necessary facilities to complete the NAQUIM study report.

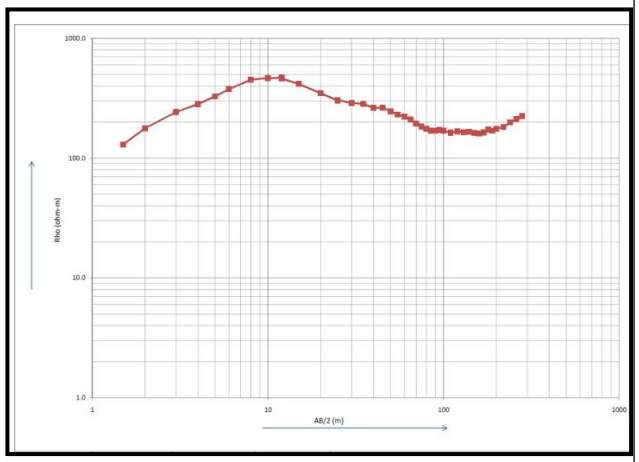
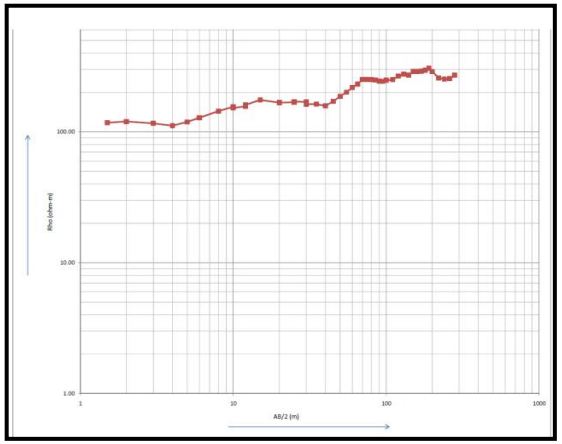
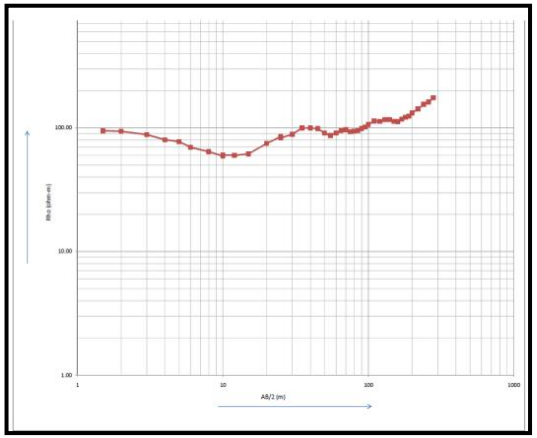
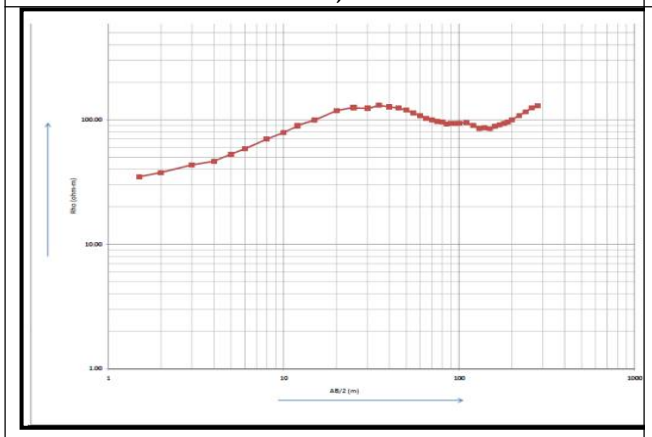
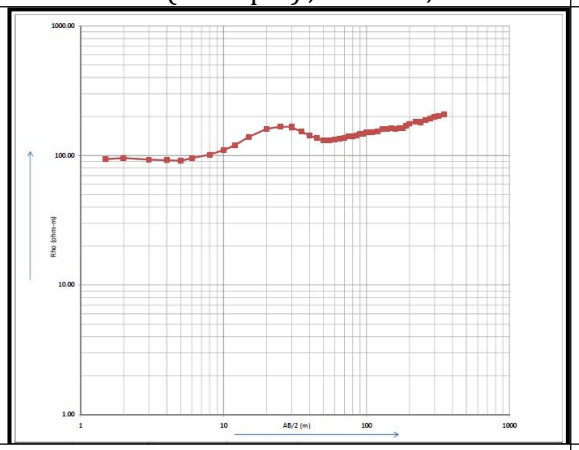
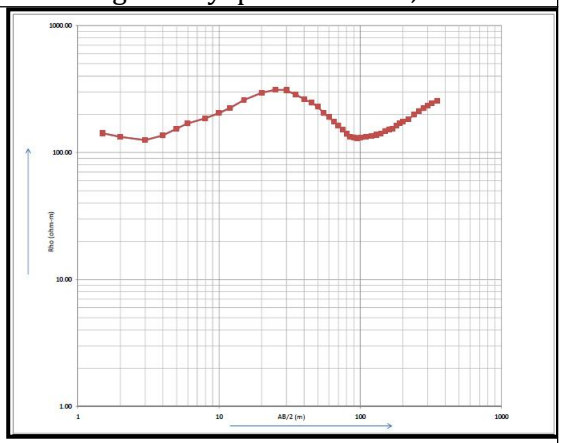
I am very much delighted to express my deep sense of gratitude and regards to my respected **Smt. Rose Anita Kujur, Sc.E,** CGWB, NCR, Bhopal for his valuable and meticulous guidance during the study and scrutiny of the report.

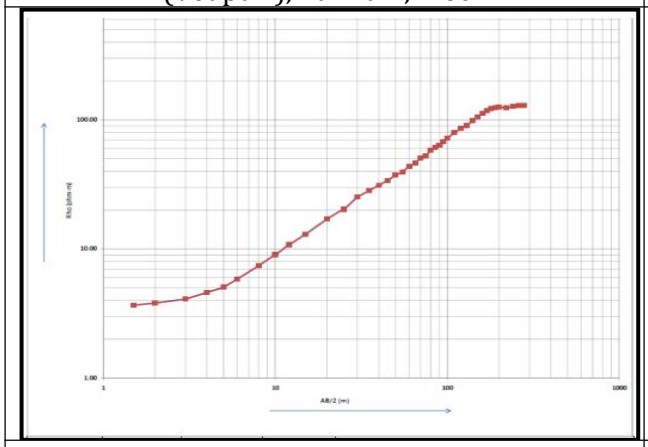
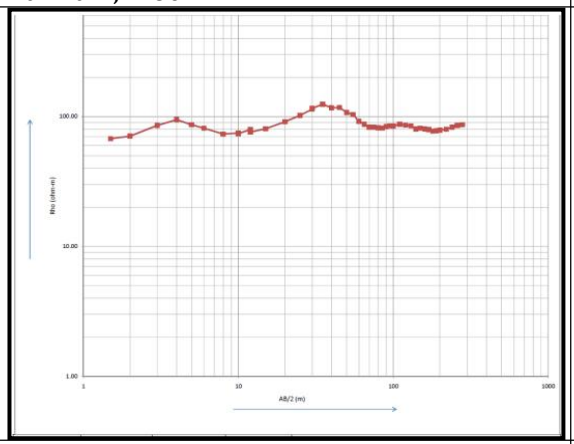
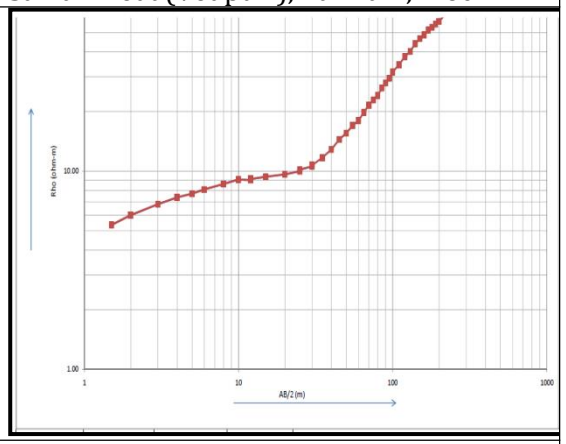
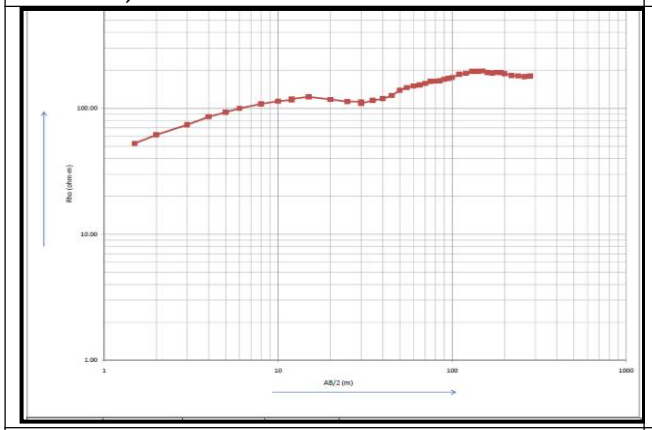
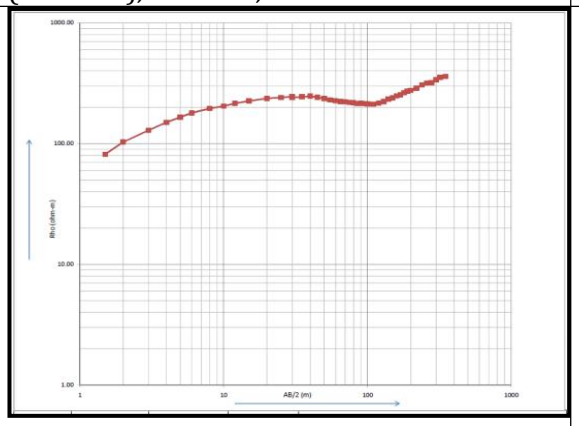
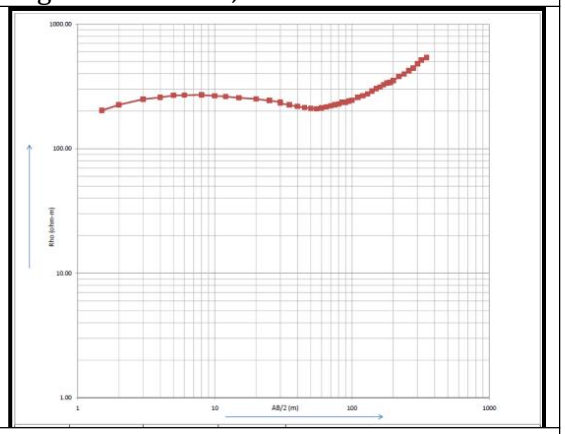
I am thankful to all the officers and officials of CGWB, NCR, Bhopal for help and co-operation supported in completing the study.

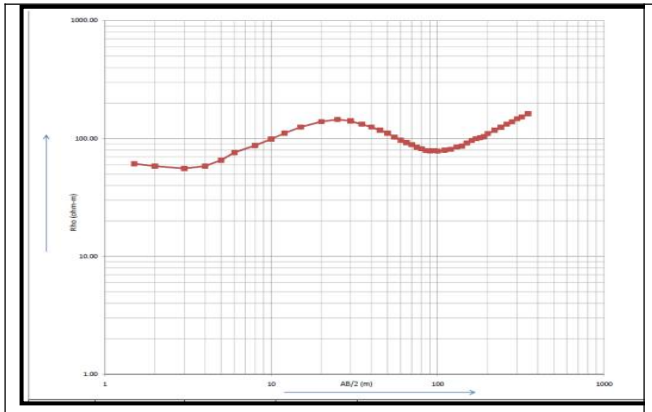
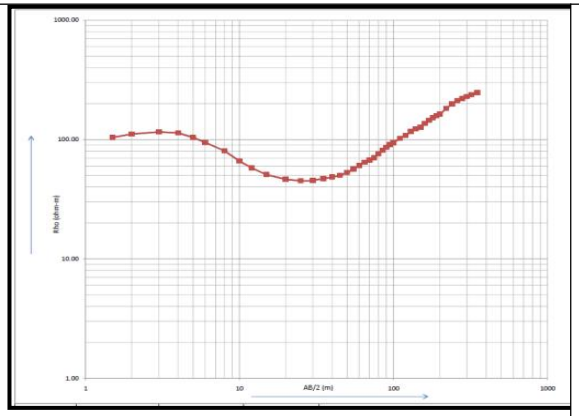
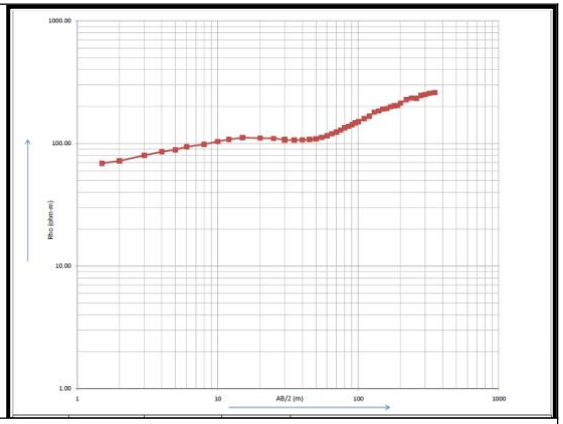
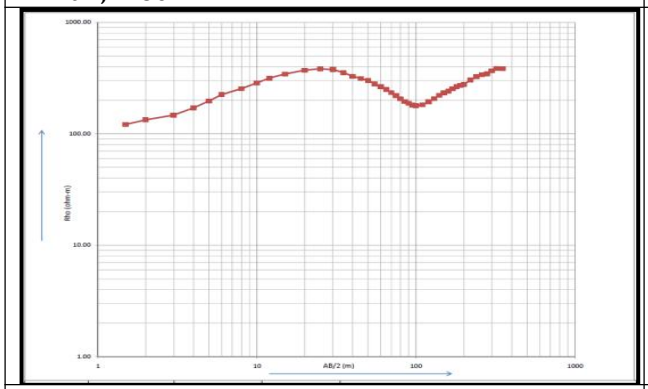
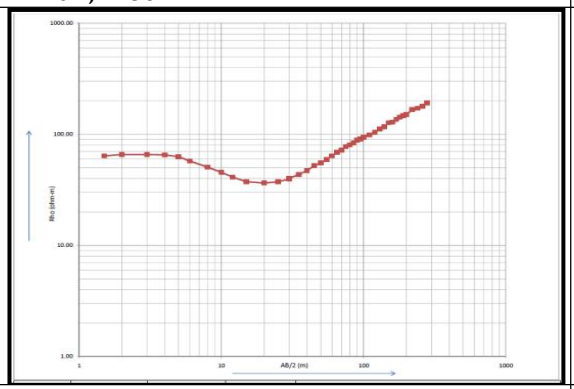
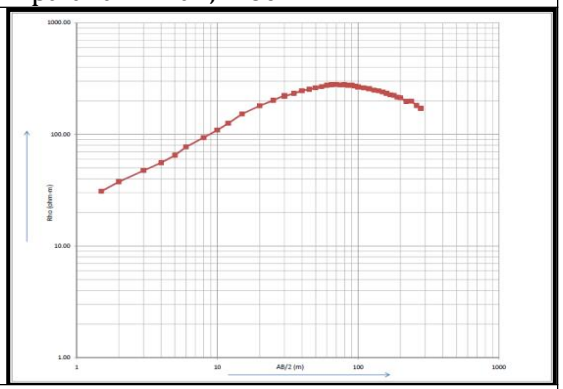
ANNEXURS

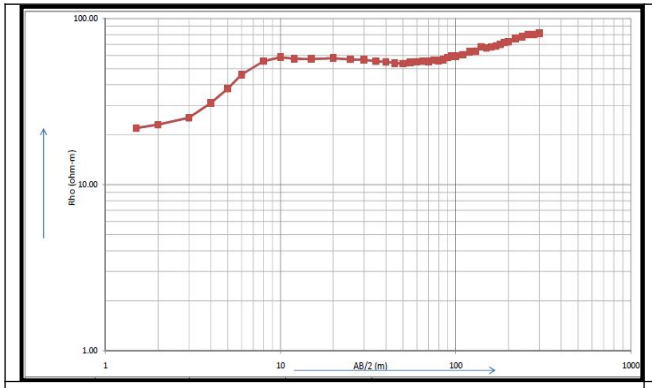
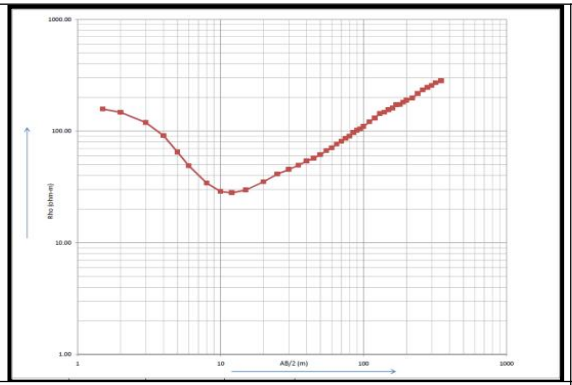
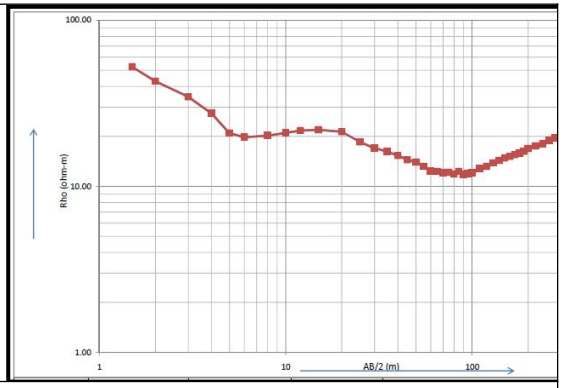
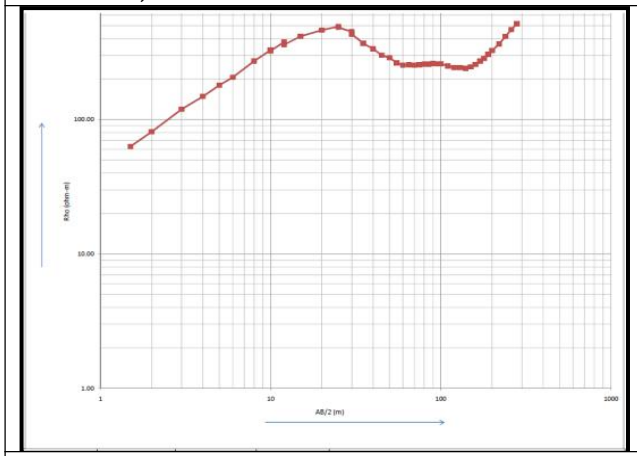
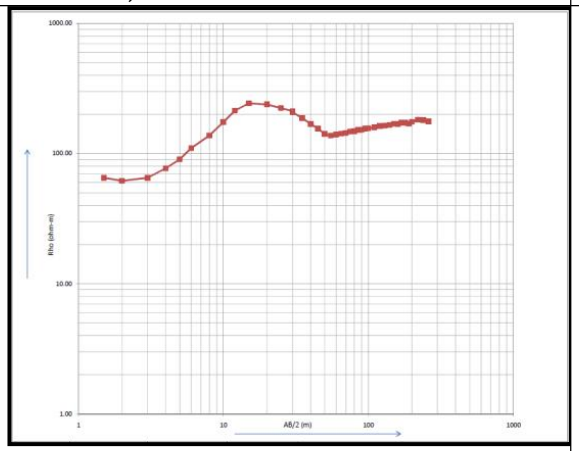
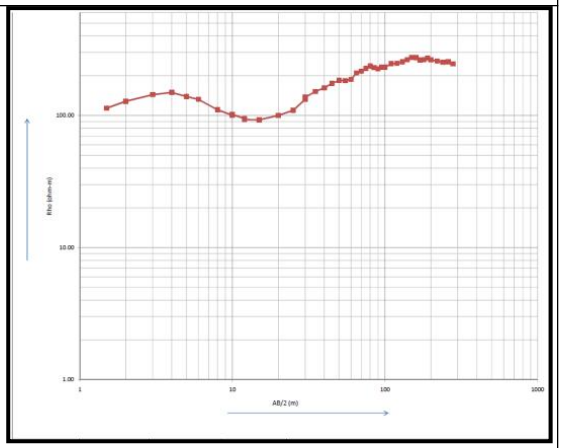
Annexure - I

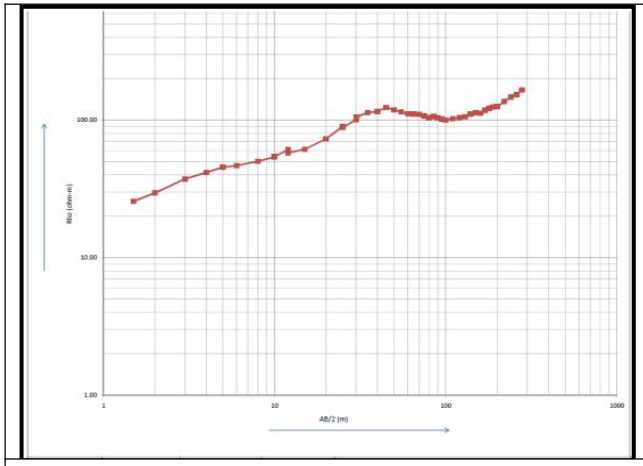
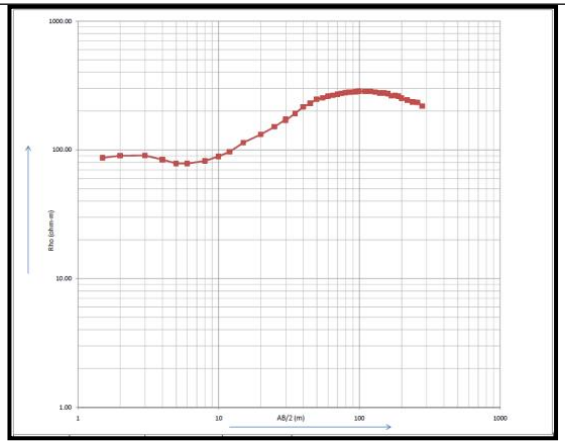
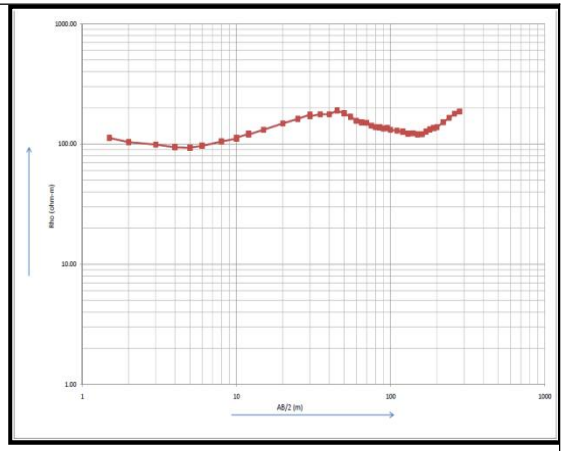
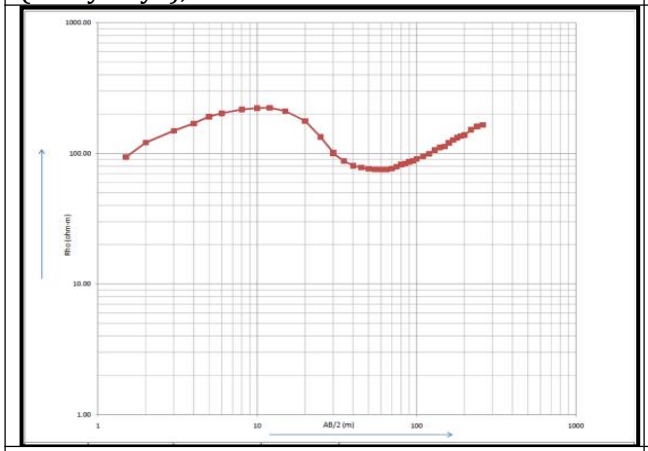
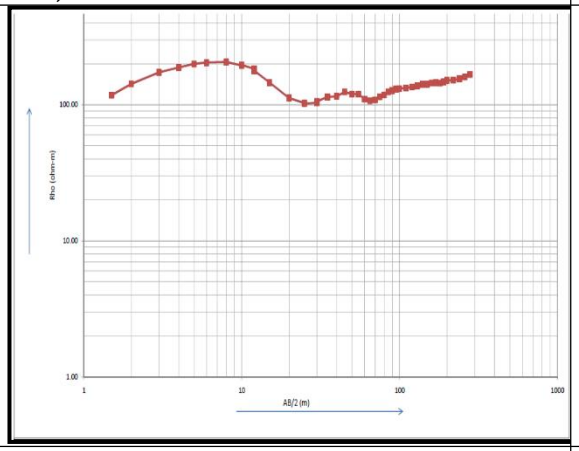
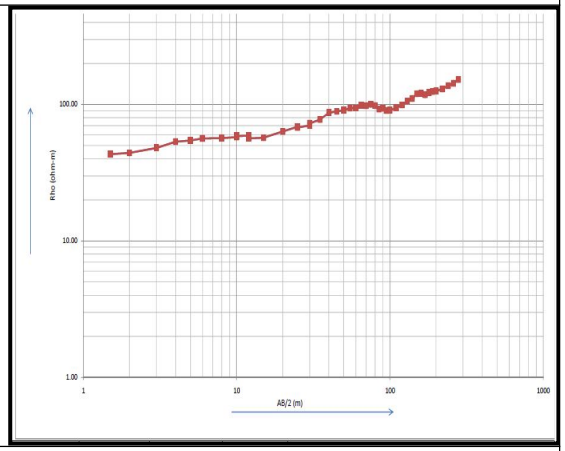
THE QUALITATIVE ANALYSIS OF 60VES AT DIFFERENT DEPTHS

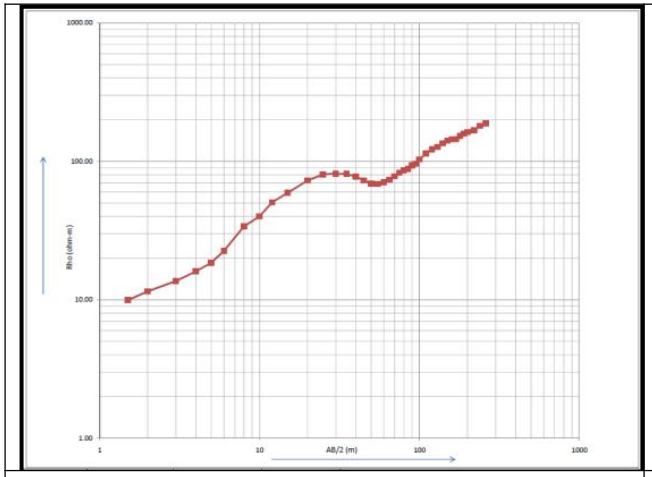
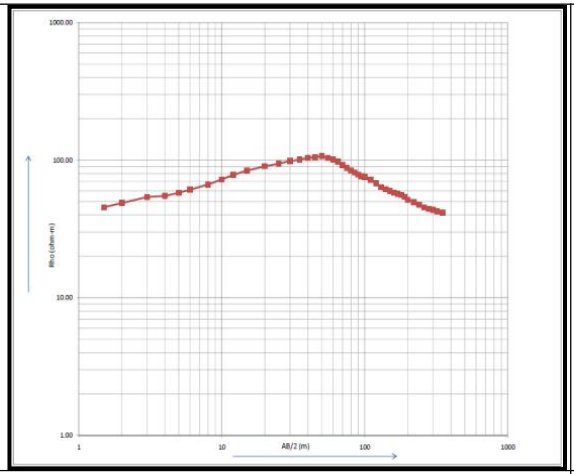
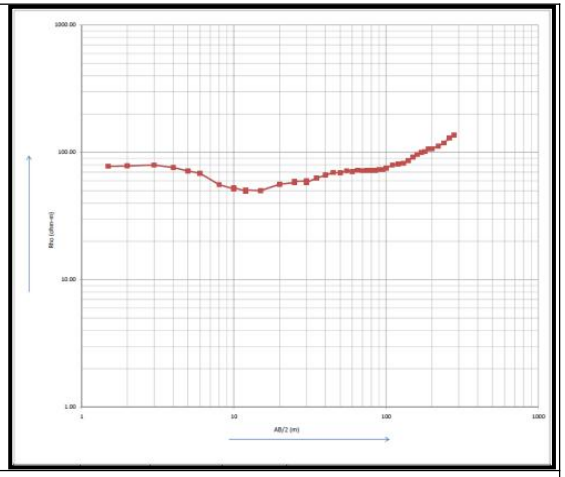
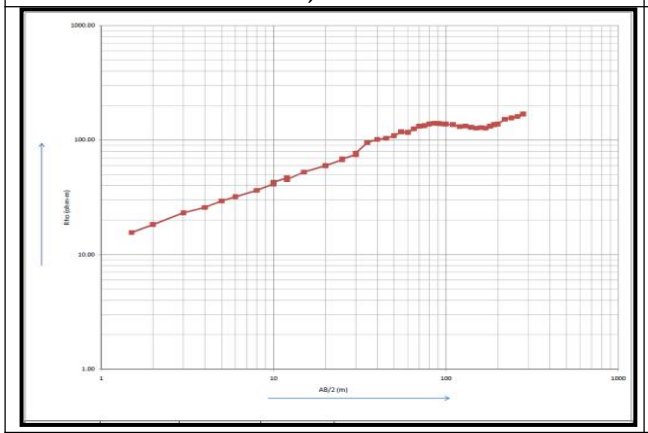
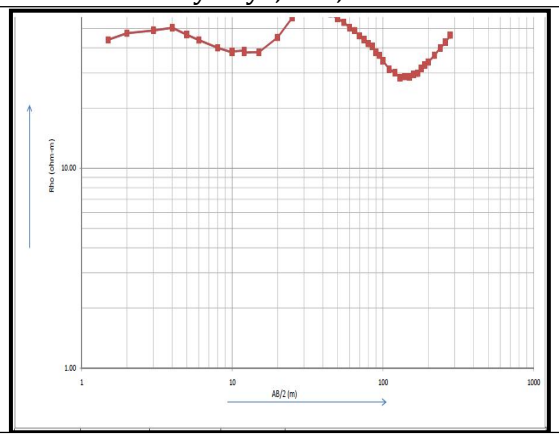
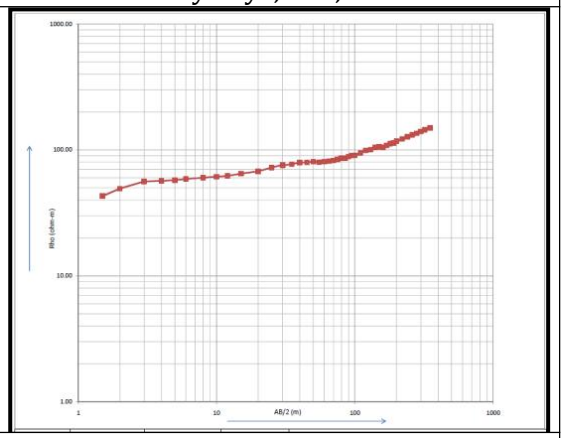
		
Interpreted Graph Ves-01 Village: Osada, Barwani, Block	Interpreted Graph Ves-02 Village: Kalakhet(Ambapni) , Barwani, Block	Interpreted Graph Ves-03 Village:Amliyapani Barwani, Block
		
Interpreted Graph Ves-04 Village: Gothaniya	Interpreted Graph Ves-05 Village: Jogwad	Interpreted Graph Ves-06 Village:

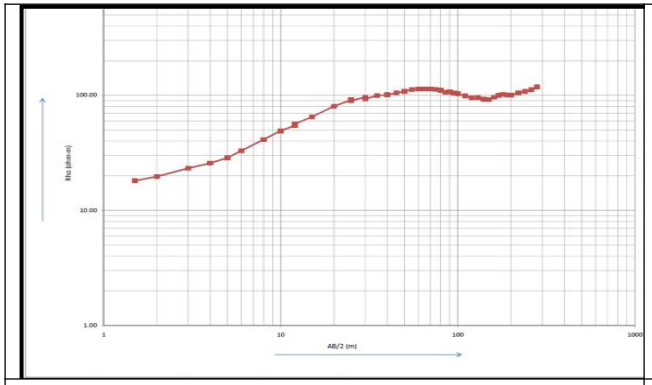
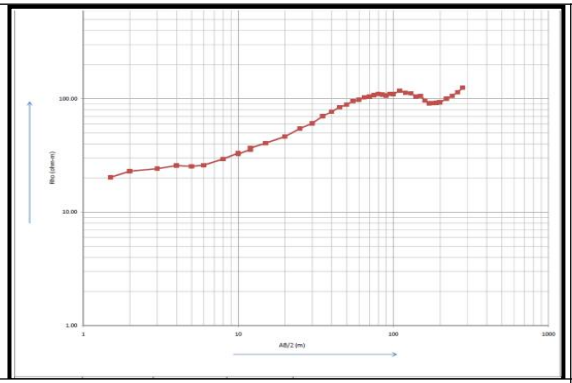
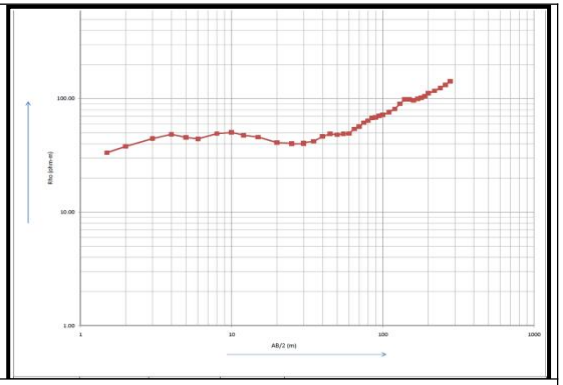
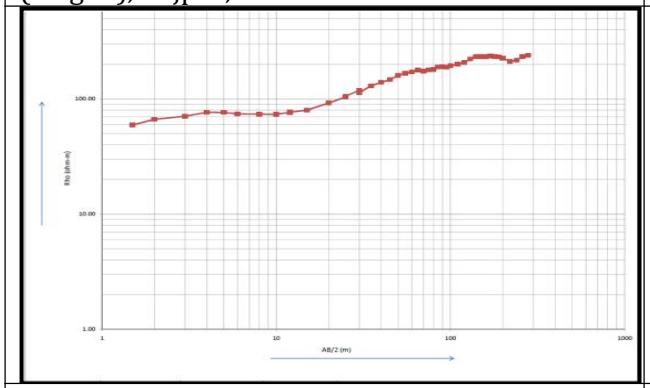
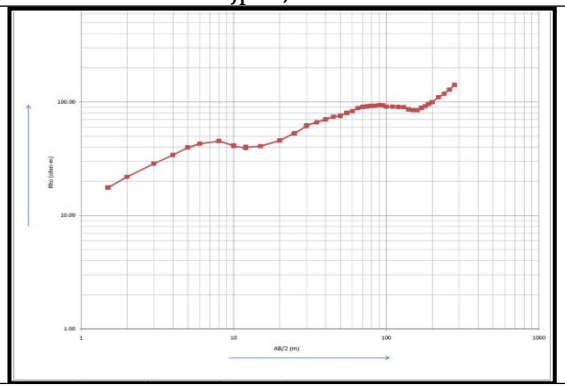
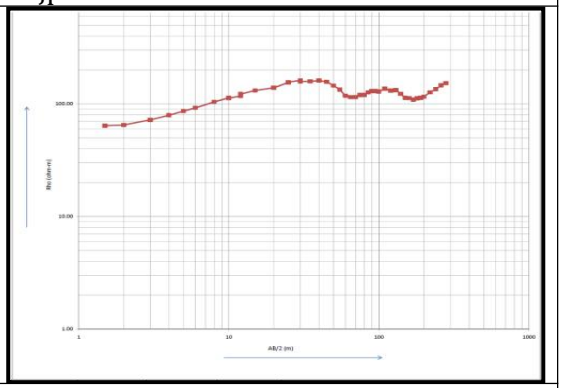
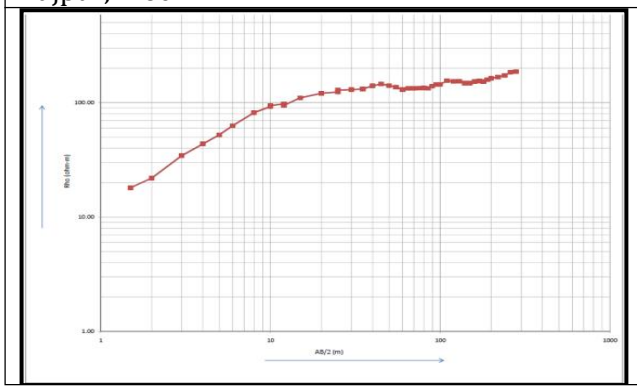
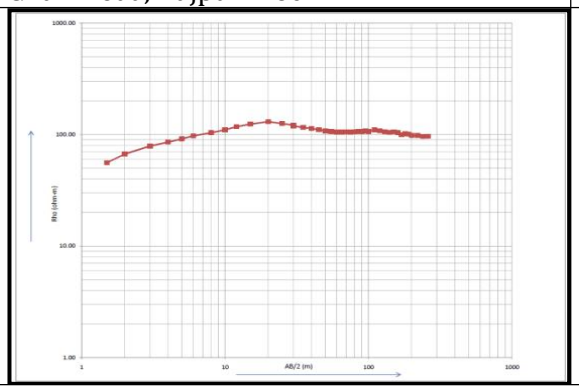
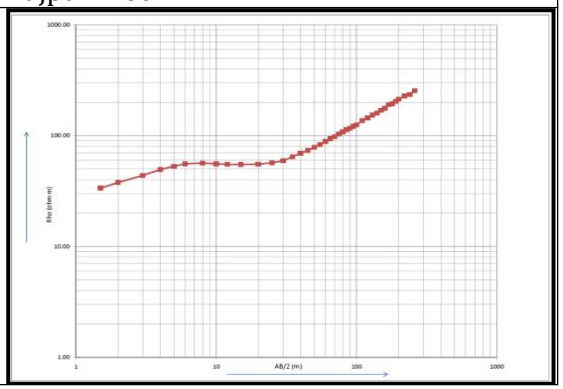
(Vedpuri), Barwani, Block	Barwani, Block	Samarkheda(Vedpuri), Barwani, Block
		
Interpreted Graph Ves-07 Village: Seagaon , Barwani, Block	Interpreted Graph Ves-08 Village: Junadih (Talwada), Barwani, Block	Interpreted Graph Ves-09 Village: Segawan Barwani, Block
		
Interpreted Graph Ves-10 Village: Titliya (Ekalbara), Niwali, Block	Interpreted Graph Ves-11 Village: Borli, Niwali Block	Interpreted Graph Ves-12 Village: GuljwariNiwali Block

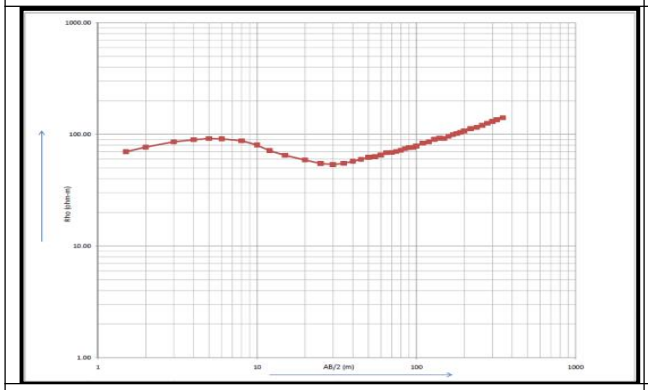
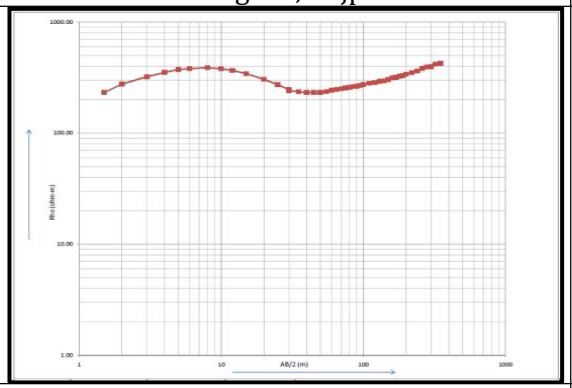
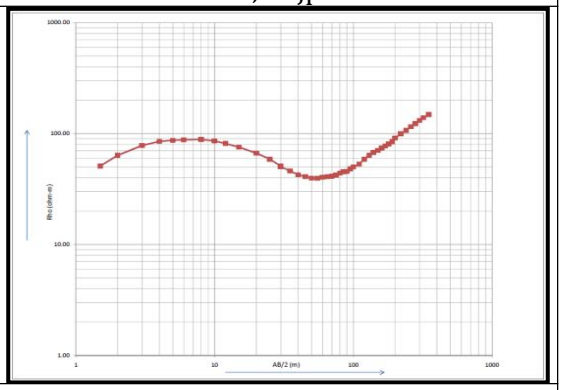
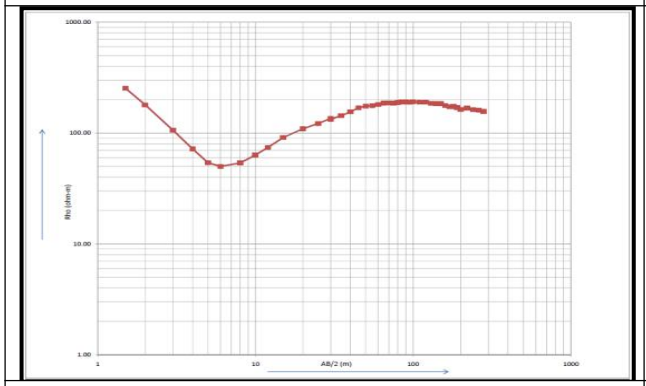
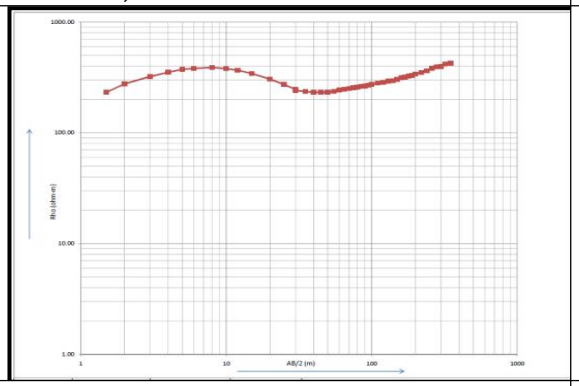
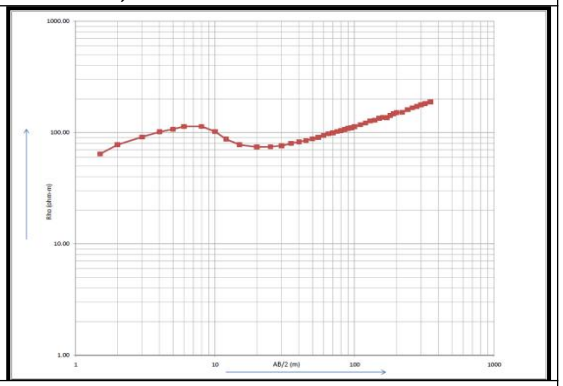
		
Interpreted Graph Ves-13 Village: Kunjari, Niwali, Block	Interpreted Graph Ves-14 Village: Pichodi, Niwali, Block	Interpreted Graph Ves-15Village: PipaldharNiwali, Block
		
Interpreted Graph Ves-16 Village: Umariyapani, Niwali, Block	Interpreted Graph Ves-17 Village: Sidadi, Niwali, Block	Interpreted Graph Ves-18 Village: Kalaamba, Pansemal, Block

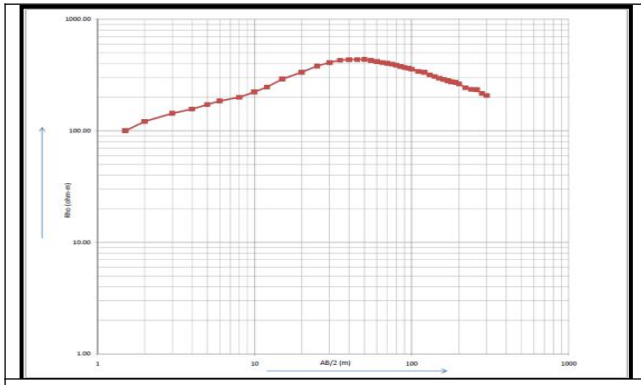
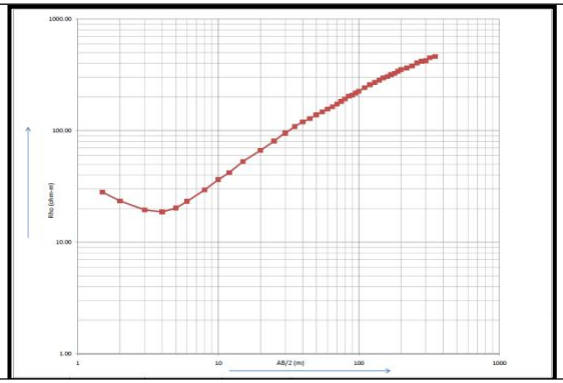
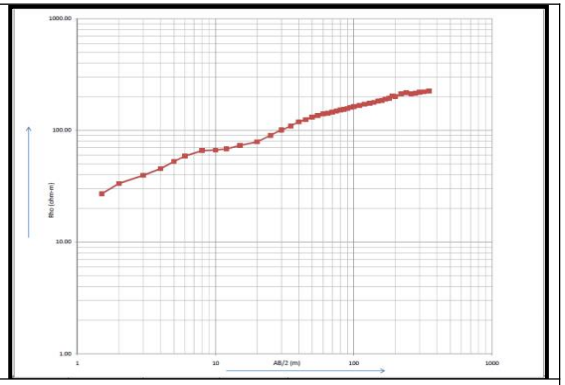
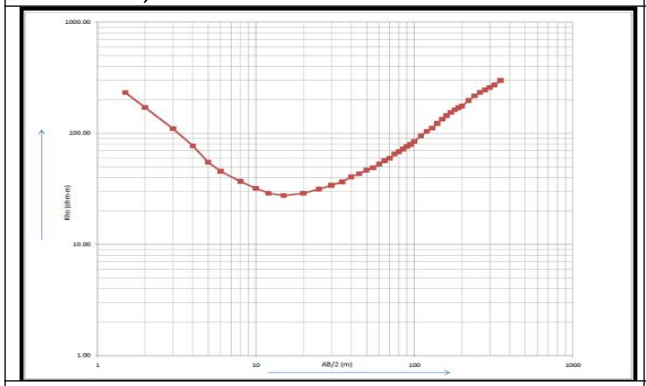
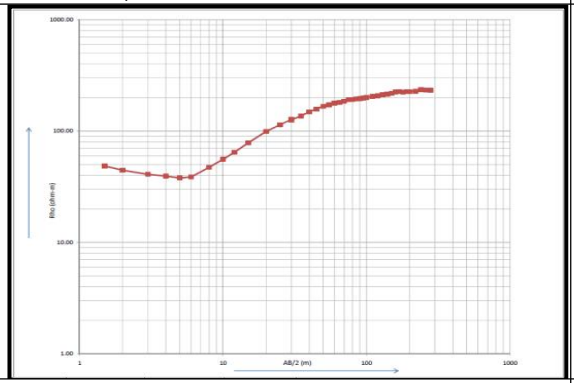
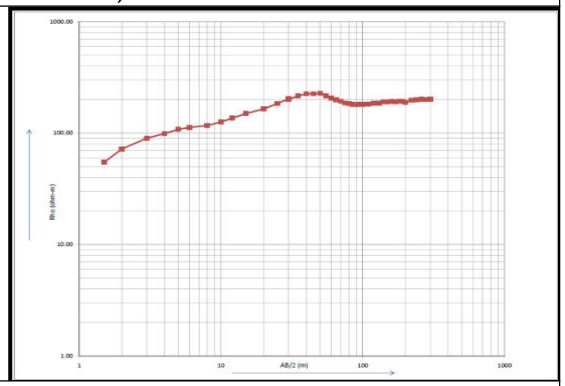
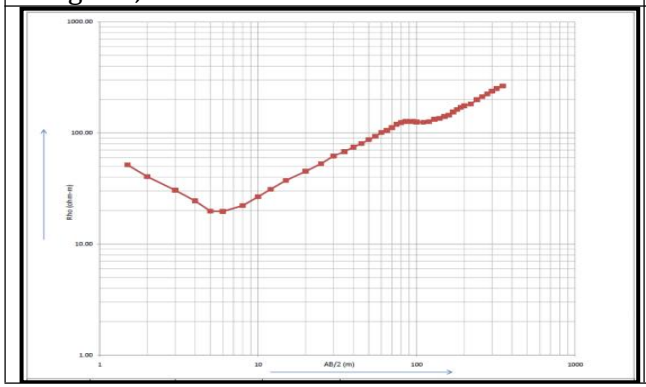
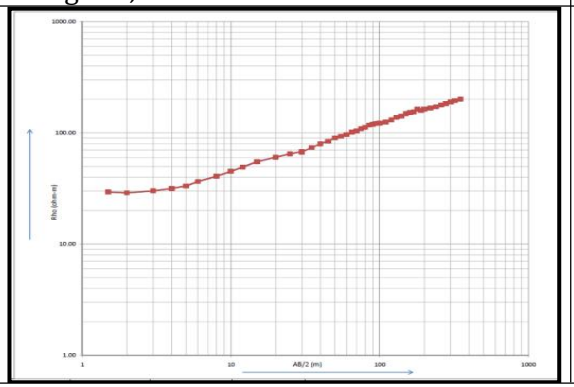
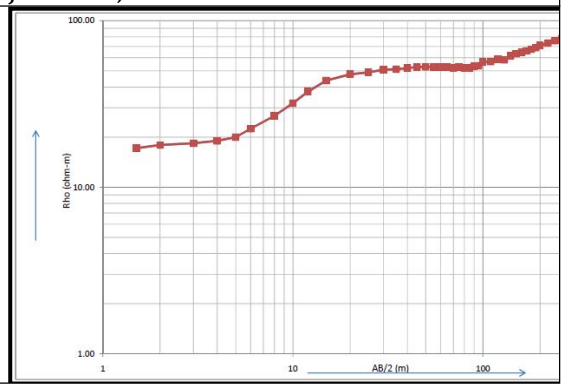
		
Interpreted Graph Ves-19 Village: Godiyapani, Pansemal, Block	Interpreted Graph Ves-20 Village: Matrala, Pansemal, Block	Interpreted Graph Ves-21 Village: Khetia, Pansemal Block
		
Interpreted Graph Ves-22 Village: Kodwani (BaidyFalya), Pati, Block	Interpreted Graph Ves-23 Village: BaidyFalya, Pati Block	Interpreted Graph Ves-24 Village: KuliBamnali, Pati Block

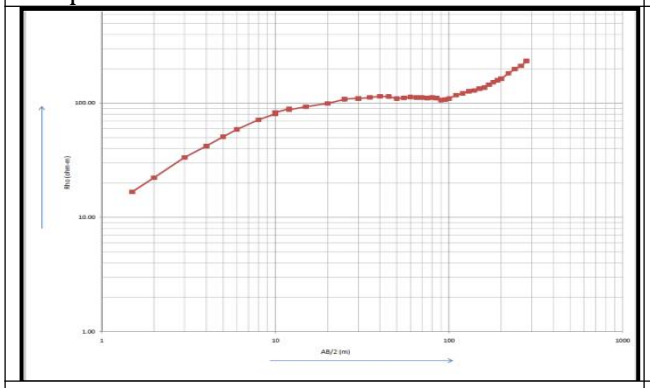
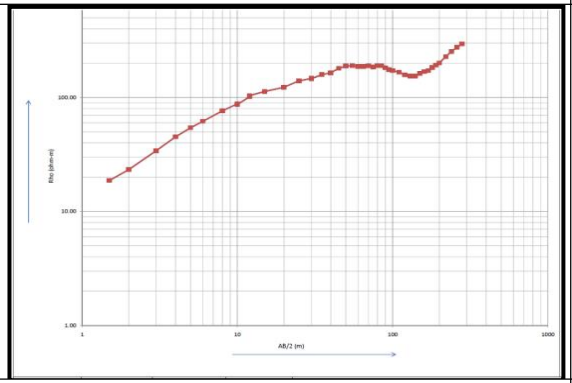
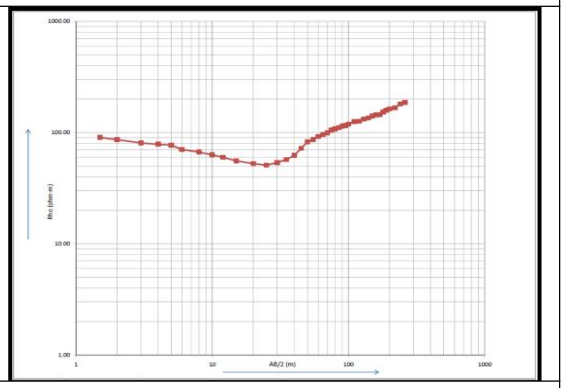
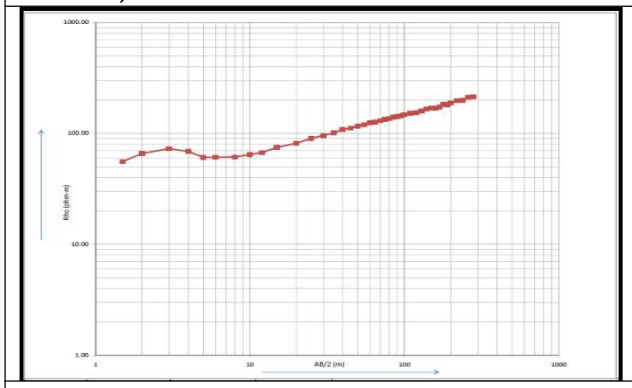
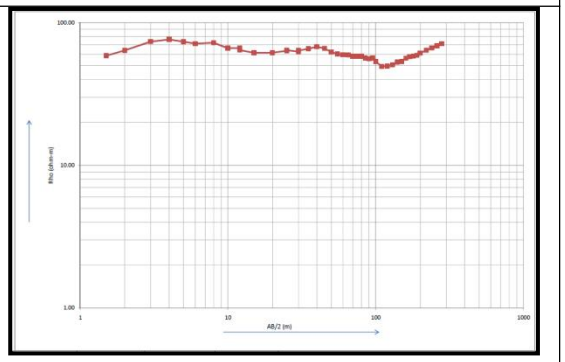
		
Interpreted Graph Ves-25 Village: Nalati (BaidyFalya), Pati Block	Interpreted Graph Ves-26 Village: Bhaisari, Pati, Block	Interpreted Graph Ves-27 Village: Budi, Pati Block
		
Interpreted Graph Ves-28 Village: Chikalkua Badi, Pati, Block	Interpreted Graph Ves-29 Village: ChakliyaPalwat, Pati, Block	Interpreted Graph Ves-30 Village: BaidyFalya, Pati, Block

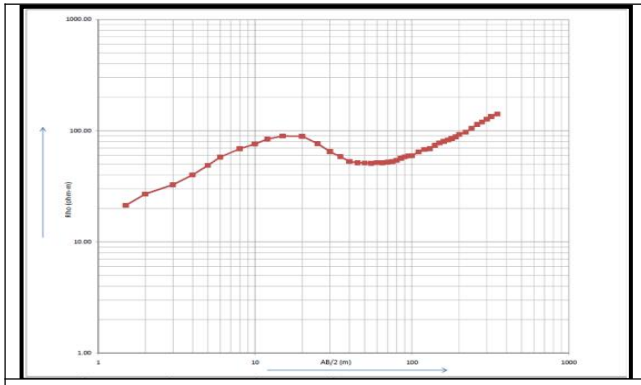
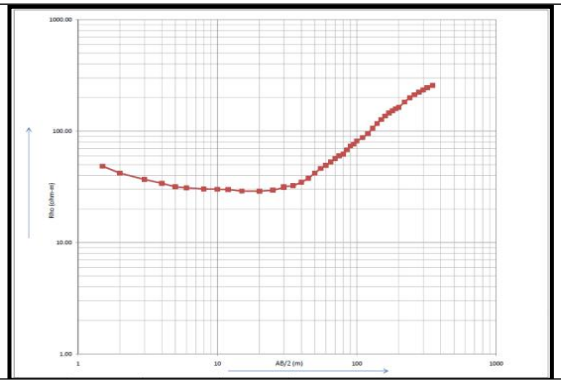
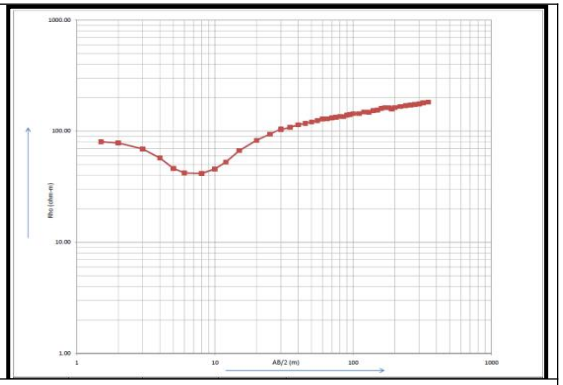
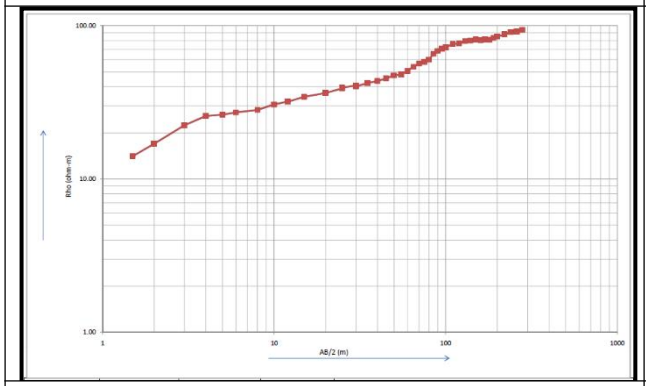
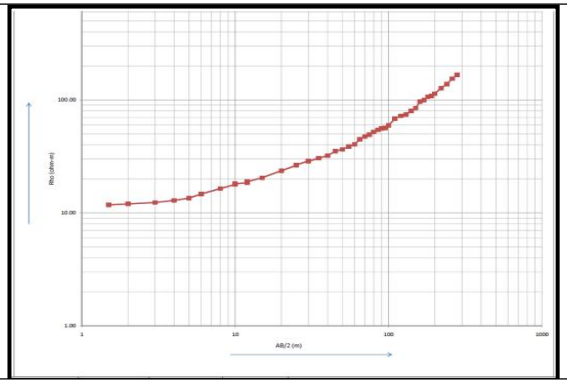
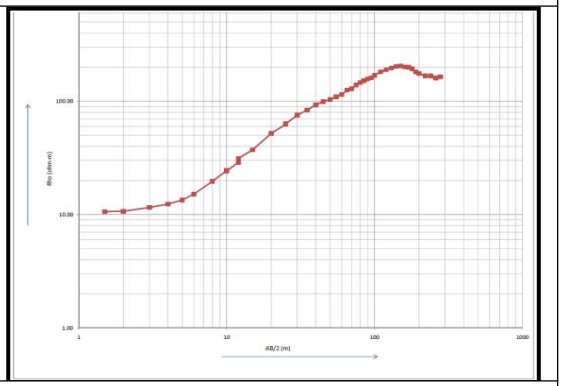
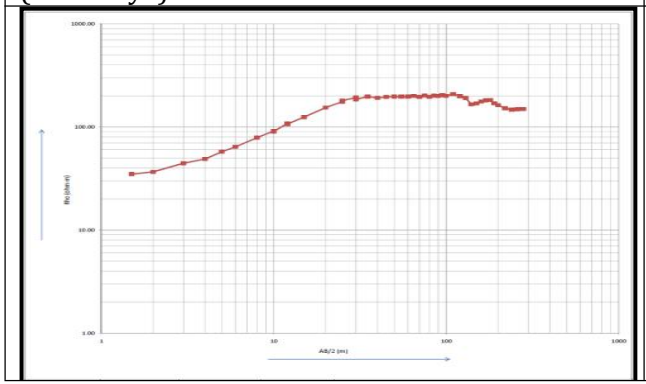
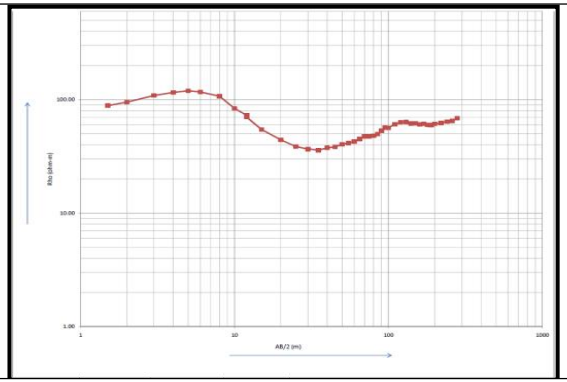
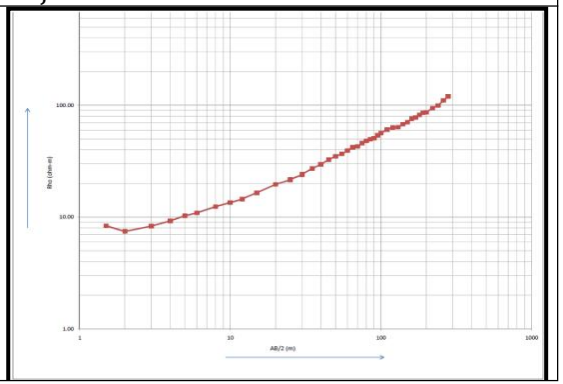
		
Interpreted Graph Ves-31 Village: BaidyFalya, Pati, Block	Interpreted Graph Ves-32 Village: BaidyFalya, Pati, Block	Interpreted Graph Ves-33 Village: BaidyFalya, Pati, Block
		
Interpreted Graph Ves-34 Village: Chitwal, Rajpur, Block	Interpreted Graph Ves-35 Village: Haldad, Rajpur Block	Interpreted Graph Ves-36 Village: Khaparkheda Rajpur Block

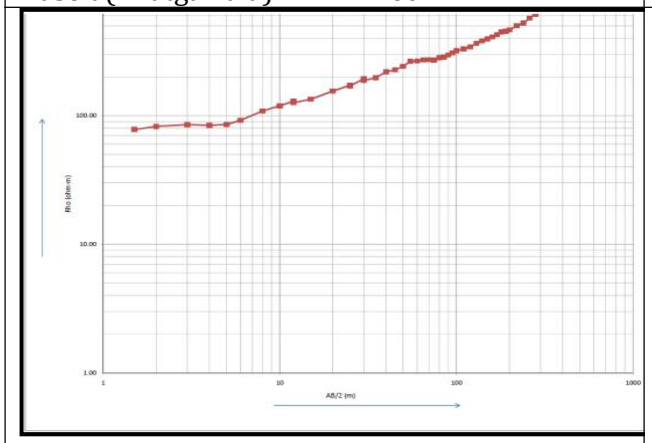
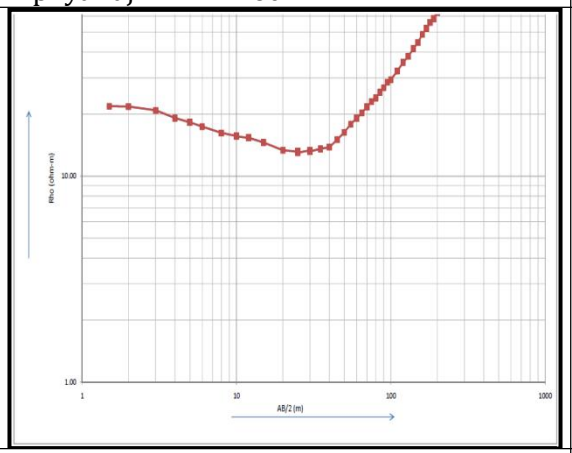
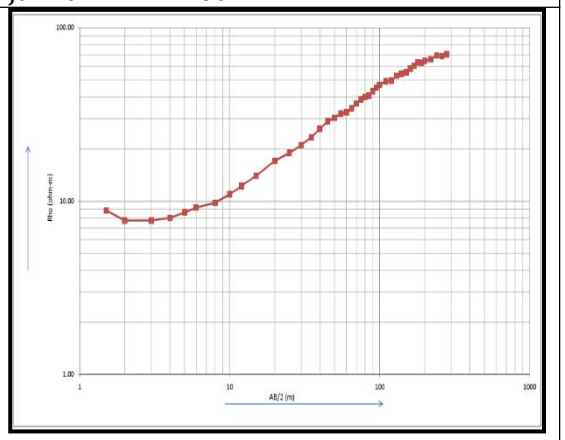
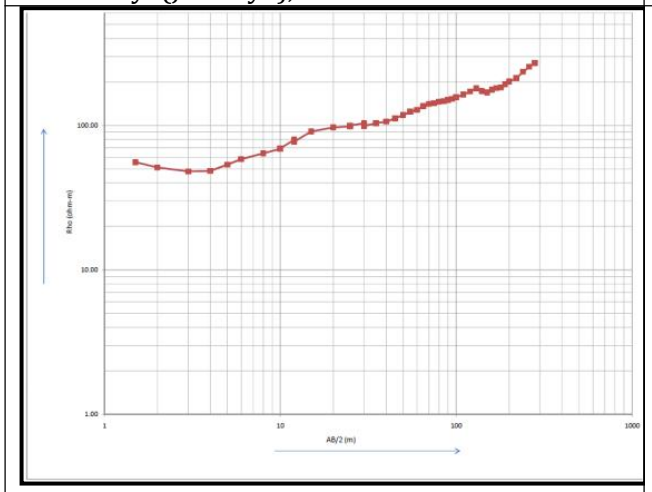
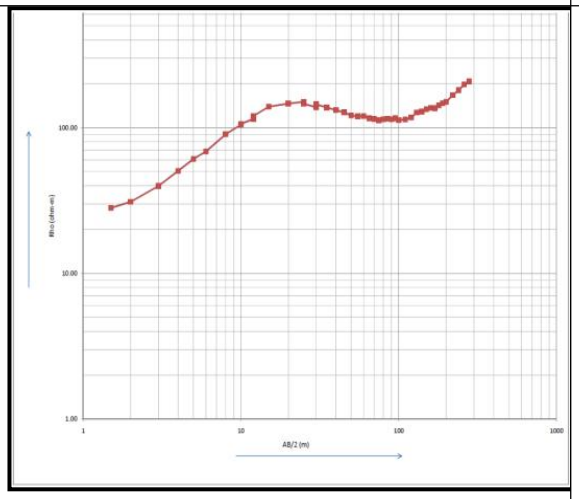
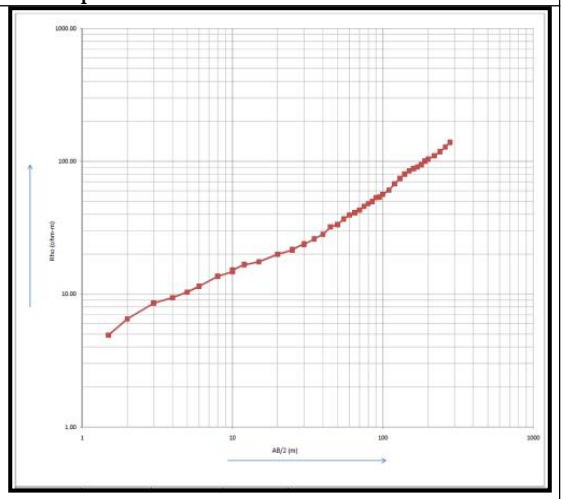
		
Interpreted Graph Ves-37 Village: Rajpura (Singun), Rajpur, Block	Interpreted Graph Ves-38Village: Gothanya Rajpur, Block	Interpreted Graph Ves-39 Village: Sungaon Rajpur Block
		
Interpreted Graph Ves-40 Village: Danod, Rajpur, Block	Interpreted Graph Ves-41 Village: Gharkheda, Rajpur Block	Interpreted Graph Ves-42 Village: Nadeed Rajpur Block
		

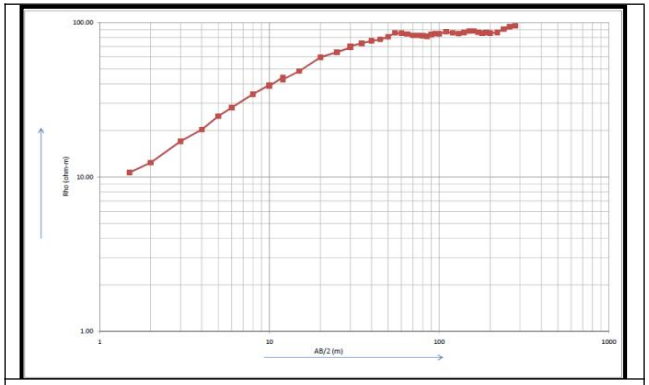
Interpreted Graph Ves-43 Village: Padala, Rajpur Block	Interpreted Graph Ves-44 Village: Chhotikhargone, Rajpur Block	Interpreted Graph Ves-45Village: Bhorwada, Rajpur Block
		
Interpreted Graph Ves-46 Village: MendlyaPani, Sendhwa Block	Interpreted Graph Ves-47 Village: Badawad, Sendhwa Block	Interpreted Graph Ves-48 Village: Achhli, Sendhwa, Block
		
Interpreted Graph Ves-49 Village: Bhawagarha, Sendhwa Block	Interpreted Graph Ves-50 Village: DhamanyaSendhwa Block	Interpreted Graph Ves-51 Village: Dhanora ,Sendhwa Block

		
Interpreted Graph Ves-52 Village: Dhawada ,Sendhwa Block	Interpreted Graph Ves-53 Village: Dhawadi ,Sendhwa Block	Interpreted Graph Ves-54 Village: Dhawali ,Sendhwa Block
		
Interpreted Graph Ves-55 Village: Ghegaon ,Sendhwa Block	Interpreted Graph Ves-56 Village: Ramgarhi, Sendhwa Block	Interpreted Graph Ves-57 Village: Julwania, Sendhwa Block
		

Interpreted Graph Ves-58 Village: KhaparKhedaSendhwa Block	Interpreted Graph Ves-59 Village: Kamod, Sendhwa Block	Interpreted Graph Ves-60 Village: KermalaSendhwa Block
		
Interpreted Graph Ves-61Village: Kusami ,Sendhwa Block	Interpreted Graph Ves-62Village: Peeranaval(Lavani) , Sendhwa Block	Interpreted Graph Ves-63 Village: Mauza, Sendhwa Block
		
Interpreted Graph Ves-64 Village: Jamati ,Sendhwa Block	Interpreted Graph Ves-65Village: Mordad, Sendhwa Block	Interpreted Graph Ves-66 Village: SendhwaSendhwa Block

		
Interpreted Graph Ves-67 Village: Solwan, Sendhwa Block	Interpreted Graph Ves-68 Village: SonkhediSendhwa Block	Interpreted Graph Ves-69 Village: Surani, Sendhwa Block
		
Interpreted Graph Ves-70 Village: Patelpura (Badsalaya) Thikri Block	Interpreted Graph Ves-71 Village: Fatyapur, Thikri Block	Interpreted Graph Ves-72Village: AnjadThikri Block
		

Interpreted Graph Ves-73Village: Hasola(Bhatgawala) Thikri Block	Interpreted Graph Ves-74 Village: PipliyaKajiThikri Block	Interpreted Graph Ves-75 Village: JarwaiThikri Block
		
Interpreted Graph Ves-76Village: Bhuwaniya(Jhiranya), Thikri Block	Interpreted Graph Ves-77 Village: Datwada, Thikri Block	Interpreted Graph Ves-78 Village: ChainpuraThikri Block
		
Interpreted Graph Ves-79 Village:Rahadkot, Thikri Block	Interpreted Graph Ves-80 VillagePadala(Rangaondeb), Thikri Block	Interpreted Graph Ves-81 VillageHarangaon, Thikri Block



Interpreted Graph Ves-82 Village: HaribadThikri Block

Annexure-II

LITHOLOGICAL LOGS

Lithological Log of EW Pichori, Barwani Block, Barwani District, M.P			
Top soil, pale brownish, fine to course	0.00	1.00	1.00
Basalt; highly weathered, grey, fine to course	1.00	9.15	8.15
Basalt; weathered, grey, fine to course,	9.15	23.00	13.85
Basalt; dark grey, fine to course, hard and compact	23.00	30.50	7.50
Basalt; dark grey, fine to course, vesicular, hard and compact	30.50	33.55	3.05
Basalt; dark greyblack, fine to course, massive hard and compact	33.55	54.90	21.35
Basalt; grey, fine to course, vesicular with white colour secondary mineral	54.90	57.95	3.05
Basalt; dark greyblack, fine to course, massive hard and compact	57.95	76.25	18.30
Basalt; grey, fine to course,vesicular with white colour secondary mineral	76.25	82.35	6.10
Basalt; dark grey, fine to course, massive hard and compact	82.35	100.65	18.30
Basalt; dark grey, fine to course, poorly fractured, wet	100.65	103.70	3.05
Basalt; dark grey, fine to course, massive hard and compact	103.70	118.95	15.25
Basalt; grey, fine to course, vesicular with white colour secondary mineral	118.95	125.70	6.05
Basalt; grey, fine to course, vesicular - fractured,0.43lps	**125.70**	**126.20**	3.00
Basalt; dark grey, fine to course, massive hard and compact	126.20	161.00	34.80
Basalt; grey, fine to course, vesicular with white colour secondary mineral	161.00	164.00	3.00
Basalt; dark grey, fine to course, massive hard and compact	164.00	194.00	30.00
Basalt; grey, fine to course, vesicular with white colour secondary mineral	194.00	200.00	6.00

Lithological Log of EW Ambapani, Barwani Block, Barwani District, M.P

Lithology	Depth (m)		Thickness
	From	To	
Top soil, pale brownish, fine to course	0.00	1.00	1.00
Basalt; highly weathered, grey, fine to course	1.00	6.50	5.50
Basalt; grey, fine to course, massive hard and compact	6.50	11.60	5.10
Basalt; grey, fine to course, vesicular, hard and compact	11.60	14.50	2.90
Basalt; reddishish black, fine to course, massive hard and compact	14.50	37.70	23.20
Basalt; grey, fine to course, vesicular, hard and compact	37.70	43.50	5.80
Basalt; dark greyblack, fine to course, massive hard and compact	43.50	60.90	17.40
Basalt; grey, fine to course, vesicular with white colour secondary mineral	60.90	66.70	5.80
Basalt; dark greyblack, fine to course, massive hard and compact	66.70	72.50	5.80
Basalt; grey, fine to course, vesicular with white colour secondary mineral	72.50	78.30	5.80
Basalt; dark greyblack, fine to course, massive hard and compact	78.30	116.00	37.70
Basalt; grey, fine to course, vesicular with white colour secondary mineral	116.00	124.55	8.55
Basalt; grey, fine to course, vesicular - fractured (wet)	**124.55**	**127.40**	2.85
Basalt; grey, fine to course, vesicular with white colour secondary mineral	127.40	133.10	5.70
Basalt; greyish black, fine to course, massive hard and compact	133.10	153.20	20.10
Basalt; grey, vesicular with white colour secondary mineral	153.20	166.70	13.50
Basalt; greyish black, fine to course, massive hard and compact	166.70	180.20	13.50
Basalt; grey, fine to course, vesicular - fractured	**180.20**	**183.50**	3.00
Basalt; greyish black, fine to course, massive hard and compact	183.50	194.20	10.70
Basalt; grey, fine to course, vesicular with white colour secondary mineral	194.20	199.70	5.50
Basalt; grey, vesicular with white colour secondary mineral	199.70	200.00	0.30

Lithological Log of EW Bori, Barwani block, Barwani district, M.P

Lithology	Depth (m)		Thickness
	From	To	
Top soil, pale brownish, fine to course	0.00	1.00	1.00
Basalt; highly weathered, pale grey, fine to course	1.00	11.00	10.00
Basalt; dark grey, fine to course, massive, hard and compact	11.00	29.00	18.00
Basalt; grey, fine to course, vesicular	29.00	31.90	2.90
Basalt; dark grey, fine to course, massive, hard and compact	31.90	43.50	11.60
Basalt; grey, fine to course, vesicular	43.50	46.40	2.90
Basalt; dark grey, fine to course, massive, hard and compact	46.40	66.70	20.30
Basalt; grey, fine to course, vesicular	66.70	69.60	2.90
Basalt; dark grey, fine to course, massive, hard and compact	69.60	104.40	34.80
Basalt; grey, fine to course, vesicular	104.40	107.30	2.90
Basalt; dark grey, fine to course, massive, hard and compact	107.30	147.35	40.05
Basalt; grey, fine to course, vesicular	147.35	161.20	13.85
Basalt; dark grey, fine to course, massive, hard and compact	161.20	180.20	19.00
Basalt; fractured, dark grey, fine to course	180.20	**183.20**	3.00

Lithological Log of EW - Rosar, Barwani Block, Barwani District, M.P

Lithology	Depth of [illegible]		Thickness
	From	To	
Top soil, pale brownish, fine to course	0.00	1.00	1.00
Basalt; highly weathered, greyish brown, fine to course	1.00	14.50	13.50
Basalt; brownish grey, fine to course, massive, hard and compact	14.50	24.40	9.90
Basalt; grey, fine to medium, vesicular with white colour secondary mineral	24.40	30.50	6.10
Basalt; dark grey, fine to course, massive, hard and compact	30.50	57.95	27.45
Basalt; grey, fine to medium, vesicular with white colour secondary mineral	57.95	64.05	6.10
Basalt; dark grey, fine to course, massive, hard and compact	64.05	88.30	24.25
Basalt; fractured, grey, fine to medium, vesicular with white colour secondary mineral	**88.30**	**88.80**	**0.50**
Basalt; dark grey, fine to course, massive, hard and compact	88.80	118.95	30.15
Basalt; grey, fine to medium, vesicular with white colour secondary mineral	118.95	136.00	17.05
Basalt; fractured, grey, fine to medium, vesicular with white colour secondary mineral	**136.00**	**136.50**	**0.50**
Basalt; dark greenish grey, fine to course, massive, hard and compact	136.50	156.60	20.10
Basalt; fractured, dark greenish grey, fine to course, hard and compact	**156.60**	**157.10**	**0.50**
Basalt; grey, fine to medium, vesicular with white colour secondary mineral	157.10	167.0	9.90

Basalt; dark greenish grey, fine to medium, massive, hard and compact	167.00	188.00	21.00
Basalt; dark grey, fine to course, massive, hard and compact	**188.00**	**200.00**	**12.00**

Lithological Log of EWAngrada, Pati Block, Barwani District, M.P

Lithology	Depth range(mbgl)		Thickness(m)
	From	To	
Top soil, pale brownish, fine to course	00.00	1.00	1.00
Basalt; highly weathered, pale grey, fine to course	1.00	15.50	14.50
Basalt; grey, fine to course, vesicular	15.50	17.40	1.90
Basalt; dark grey, fine to course, massive hard and compact	17.40	48.80	31.40
Basalt; grey, fine to course, vesicular with secondary mineral	48.80	64.05	15.25
Basalt; dark grey, fine to course, massive hard and compact	64.05	76.25	12.20
Basalt; grey, fine to course, vesicular with secondary mineral	76.25	85.40	9.15
Basalt; dark grey, fine to course, massive hard and compact	85.40	100.65	15.25
Basalt; grey, fine to course, vesicular with secondary mineral	100.65	116.50	15.85
Basalt; Fractured, grey, fine to course, vesicular (6.95lps)	**116.50**	**117.00**	0.50
Basalt; dark grey, fine to course, massive hard and compact	117.00	149.00	32.00
Basalt; Fractured, grey, fine to course, vesicular (8.2lps)	**149.00**	**150.00**	1.00
Basalt; grey, fine to course, vesicular with secondary mineral	150.00	158.00	8.00
Basalt; dark grey, fine to course, massive hard and compact	158.00	185.00	27.00

Lithological Log of EWGhusgaon, Barwani District, M.P

Lithology	Depth(mbgl)		Thickness(m)
Top soil, pale brownish, fine to course	0.00	1.00	1.00
Basalt; weathered, grey, fine to course	1.00	9,15	8.15
Basalt; dark grey, fine to course, hard and compact	9.00	15.25	6.25
Basalt; dark grey, fine to course, vesicular, hard and compact	15.25	18.30	3.05
Basalt; greenish greyblack, fine to course, massive hard	18.30	27.45	9.15
Basalt; dark grey, fine to course, vesicular, hard and compact	27.45	67.10	39.65
Basalt; red Bole vesicular with	67.10	70.15	3.05
dark greyblack, fine to course, massive hard and compact	70.15	91.50	21.35
Basalt; red Bole vesicular with	91.50	97.60	6.10
Basalt; reddish grey, fine to course, vesicular	97.60	100.65	3.05
Basalt; grey, fine to course, vesicular with white colour secondary	100.65	106.75	6.10
Basalt; dark grey, fine to course, massive hard and compact	106.75	118.95	12.20
Basalt; grey, fine to course, vesicular with white colour secondary	118.95	125.00	6.05
Basalt; dark grey, fine to course, massive hard and compact	125.00	143.00	18.00
Basalt; grey, fine to course,-poorly fractured wet	**143.00**	**146.00**	**3.00**
Basalt; grey, fine to course, vesicular	146.00	149.00	3.00
Basalt; dark grey, fine to course, massive hard and compact	149.00	200.00	51.00

Lithological Log of EW- Bunderkanchh, Barwani District, M.P

Lithology	Depth range(mbgl)		Thickness(m)
	From	To	
Top soil, pale brownish, fine to course	00.00	1.00	1.00
Basalt; highly weathered, pale grey, fine to course	1.00	11.60	10.60
Red Bole	11.60	14.50	2.90
Basalt; greyish red, fine to course, vesicular	14.50	17.40	2.90
Basalt; grey,fine to course, vesicular	17.40	28.00	10.60
Basalt; **fractured,** dark grey, fine to course(0.80lps)	28.00	**28.50**	0.50
Basalt; dark grey, fine to course, massive hard and compact	28.50	51.50	23.00
Basalt; **fractured,** dark grey, fine to course(5.40lps) vesicular	51.50	**52.00**	0.50
Basalt; grey, fine to course, vesicular	**52.00**	55.10	3.10
Basalt; dark grey, fine to course, hard and compact	55.10	81.20	26.10
Basalt; grey, fine to course, vesicular	81.20	87.00	5.80
Basalt; dark grey, fine to course, hard and compact	87.00	116.00	29.00
Basalt; Fractured, grey, fine to course, vesicularwith green minerals	116.00	127.40	11.40
Basalt; dark grey, fine to course, massive hard and compact	127.40	165.20	37.80
Basalt; grey, fine to course, vesicular	165.20	177.20	12.00
Basalt; dark grey, fine to course, massive hard and compact	177.20	189.20	12.00
Basalt; grey, fine to course, vesicular	189.20	200.00	10.80

Lithological Log of EW Datawada,Tihkiri Block Barwani District, M.P

Lithology	Depth (m)		Thickness
	From	To	
Top soil, pale brownish yellow, fine to course	0.00	1.00	1
Basalt; highly weathered, pale greyish brown, fine to course	1.00	17.50	16.5
Basalt; grey, fine to course, vesicular with white colour secondary mineral	17.50	20.30	2.8
Basalt; pale grey, fine to course, massive hard and compact	20.30	29.00	8.7
Basalt; grey, fine to course, vesicular with secondary minerals	29.00	34.80	5.8
Basalt; dark grey, fine to course, massive hard and compact	34.80	49.30	14.5
Basalt; grey, fine to course, vesicular with secondary minerals	49.30	63.80	14.5
Basalt; dark grey, fine to course, massive hard and compact	63.80	81.20	17.4
Basalt; fractured, grey, fine to course, vesicular	**81.20**	**84.10**	2.9
Basalt; grey, fine to course, vesicular with secondary minerals	84.10	87.00	2.9
Basalt; dark grey, fine to course, massive hard and compact	87.00	107.30	20.3
Basalt; grey, fine to course, vesicular with secondary minerals	107.30	124.55	17.25
Basalt; dark grey, fine to course, massive hard and compact	124.55	133.10	8.55
Basalt; grey, fine to course, vesicular with secondary minerals	133.10	147.35	14.25
Basalt; dark grey, fine to course, massive hard and compact	147.35	156.20	8.85
Basalt; grey, fine to course, vesicular with secondary minerals	156.20	161.20	5
Basalt; dark grey, fine to course, massive hard and compact	161.20	174.20	13
Basalt; grey, fine to course, vesicular with secondary minerals	174.20	192.20	18
Basalt; dark grey, fine to course, massive hard and compact	192.20	200.00	7.8