केन्द्रीय भूमि जल बोर्ड

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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

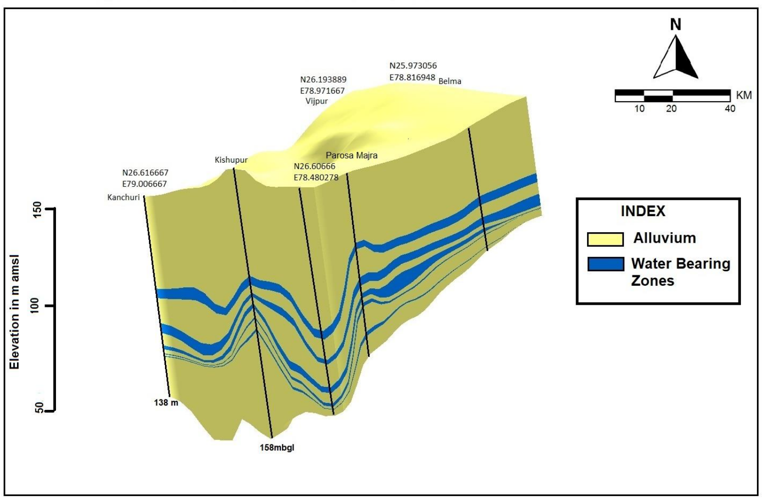
Bhind District
Madhya Pradesh

उत्तर मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

MINISTRY OF JAL SHAKTI
Department of Water Resources
River Department & Ganga Rejuvenation

CENTRAL GROUND WATER BOARD
AQUIFER MAPPING AND MANAGEMENT PLAN OF BHIND DISTRICT, MADHYA PRADESH



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PREFACE

Aquifer mapping is as a multi-disciplinary scientific process, wherein combinations of geological, geophysical, hydrological and geochemical studies are applied to characterize the quantity, quality and sustainability of ground water resources. Systematic aquifer mapping is a procedure to improve our understanding of the hydrogeological framework of aquifer system.

Under the project on National Aquifer Mapping (NAQUIM) in XII & XIII Plan to formulate sustainable aquifer management plan, Central Ground Water Board (CGWB), North Central Region, Bhopal has taken up Bhind district to prepare the Aquifer Maps for the Bhind district and formulate Block-wise Aquifer Management Plan during the AAP 2021-22. Bhind district occupies an area of 4459 sq. kms. out of which 89sq. km. is covered with forest area. The major rivers flowing through the area includes the rivers Chambal, Kunwari,Vaisali,Sind and Pahuj falling in **Chambal sub basin of Yamuna basin**. The district is covered by the Alluvium followed by Vindhayan and Gwalior series. On the basis of the 32 exploratory wells and 1 Piezometers constructed in Bhind district by CGWN/NCR under its exploratory program, it has been observed that the yield varies from 0.14 lps at Machand to 54.07 lps at Arusi in Alluvium. As per the Dynamic Ground Water Resource Assessment Report (2020), there are six assessment units (blocks) in the district and all the blocks falls under safe category. The **Annual Extractable Ground Water Resource** in the district is **88746.59** ham and ground water extraction for all uses is **2875.17** ham, making stage of ground water extraction 32.41 % as a whole. The Bhind district falls under **safe category**. After the interventions suggested in the report, the stage of extraction is expected to go up from **32.41** % to **33.31** % for the Bhind district. As per the Management plan prepared under NAQUIM of all the Blocks of Bhind District, a total number of 198 Percolation Tanks, 1378 Nala Bunds, 1735 Check Dams and 675 farm ponds have been proposed.

Results of these comprehensive studies will contribute significantly to sustainable development and management of ground water resources. It will not only enhance the long-term aquifer monitoring networks but also help in building the conceptual and quantitative regional ground water flow models for planners, policy makers and other stakeholders.

(Rana Chatterjee)
Regional Director
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BHOPAL

1. INTRODUCTION

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

1.1. Objectives:

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

- Delineation of lateral and vertical disposition of aquifers and their characterization on 1: 50,000 scale.
- Quantification of ground water availability and assessment of its quality to formulate aquifer.
- Management plans to facilitate sustainable management of ground water resources at appropriate scales through participatory management approach with active involvement of stakeholders.

1.2. Scope of the Study:

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

- Involvement of community and stakeholders would enable the State Governments to manage their resources in an efficient and equitable manner, thereby contributing to improve overall development.

- Demystification of science will result in better understanding of aquifers at community level. The amalgamation of scientific inputs and traditional wisdom would ensure sustainable ground water resource management.

- Community participation and management would ensure sustainable cropping pattern, thereby contributing towards food security.

1.3 Approach and Methodology:

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

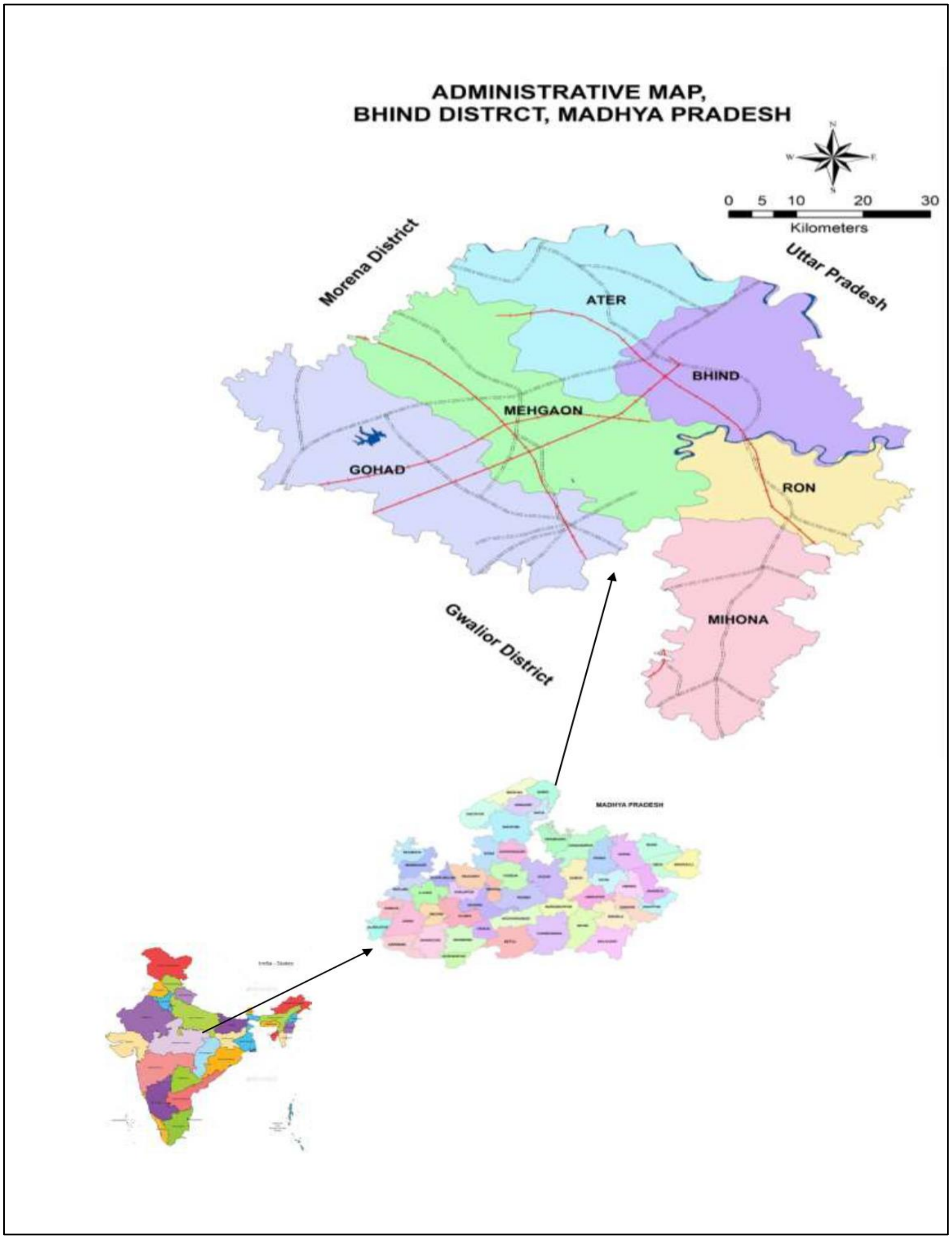
1.4 Study Area:

Bhind district is located in the northern part of the state of Madhya Pradesh and occupies as area of 4459 sq km.with a population of 1703562 as per census 2011. The district extends between the North latitudes 25º55´ and 26º45´ and East longitude 78º12´ and 79º05´ falling in survey of India topo sheet nos.54 J & 54 N. It is bounded in the North and east by Uttar Pradesh (Etawah, Jalaun & Auraiya), in the south by the district Gwalior & Datia and in the west by the district Morena MP.**Fig.1.**The district is well connected by road and railway network. Details of blocks in the study area are given in Table No. 1.

Table 1: Block wise number of villages.

S. No	Block	Area in sq. km	No of villages
1.	Ater	447.37	190
2.	Bhind	687.43	778
3.	Mehgaon	968.16	145
4.	Gohad	1026.74	134
5.	Ron	425.34	147
6.	Lahar	656.48	125

Fig.1: Location Map of Bhind District



1.5 Rainfall & Climate

The climate of Bhind district characterised by a hot summer and general dryness except during the southwest monsoon. A year may be divided into four seasons. Cold season December to February followed by the hot season from March to about middle of June. The period from Middle of June to September is the south-western monsoon season. October & November forms the post monsoon or transition period. The normal rainfall of the district is 705.1 mm. District receives maximum rainfall during south west monsoon period i.e. June to September. About 91.9% of the annual rain fall precipitats during the monsoon season. thus surplus water for ground water recharge is available during the period from June to September. The maximum rainfall precipated in Gohad is 820.7 mm and minimum 640.8 mm at Mehgaon.

During the southwest monsoon season the relative humidity generally exceeds 83% (August month). The rest of the period is dry. The driest period is summer season, when relative humidity is less than 26%. May is the driest month of the year.

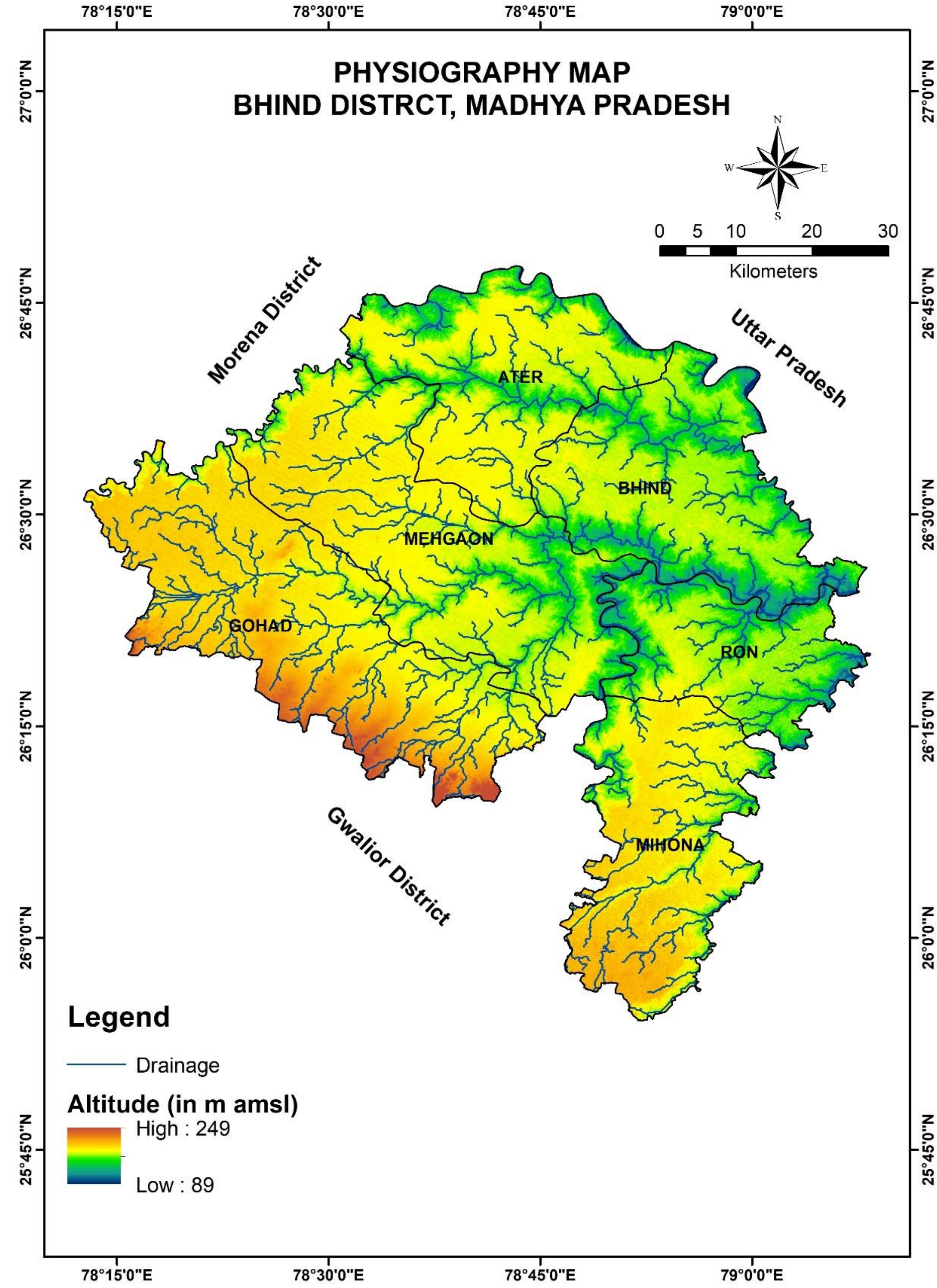
Normal maximum temperature during the month of May is 42°C and minimum during January month is 7.1°C. Normal mean maximum & minimum temperature is 32.5°C & 21.8°C respectively.

Wind velocity is higher during the pre monsoon period as compared to the post monsoon period. The maximum wind velocity is 11.3 km/h during the month of June and minimum is 3.1 km/h during the month of November.

1.6 Physiography:

Physiographically, a large area of the district forms part of the vast older plains including riverbeds with structural plains, structural hills and valleys with denudation slope are restricted to south-western part. The area has very gentle slope towards northeast with high elevation of 190 m above MSL in the south-western part and the lowest elevation of 149 m above MSL in the north-western part.

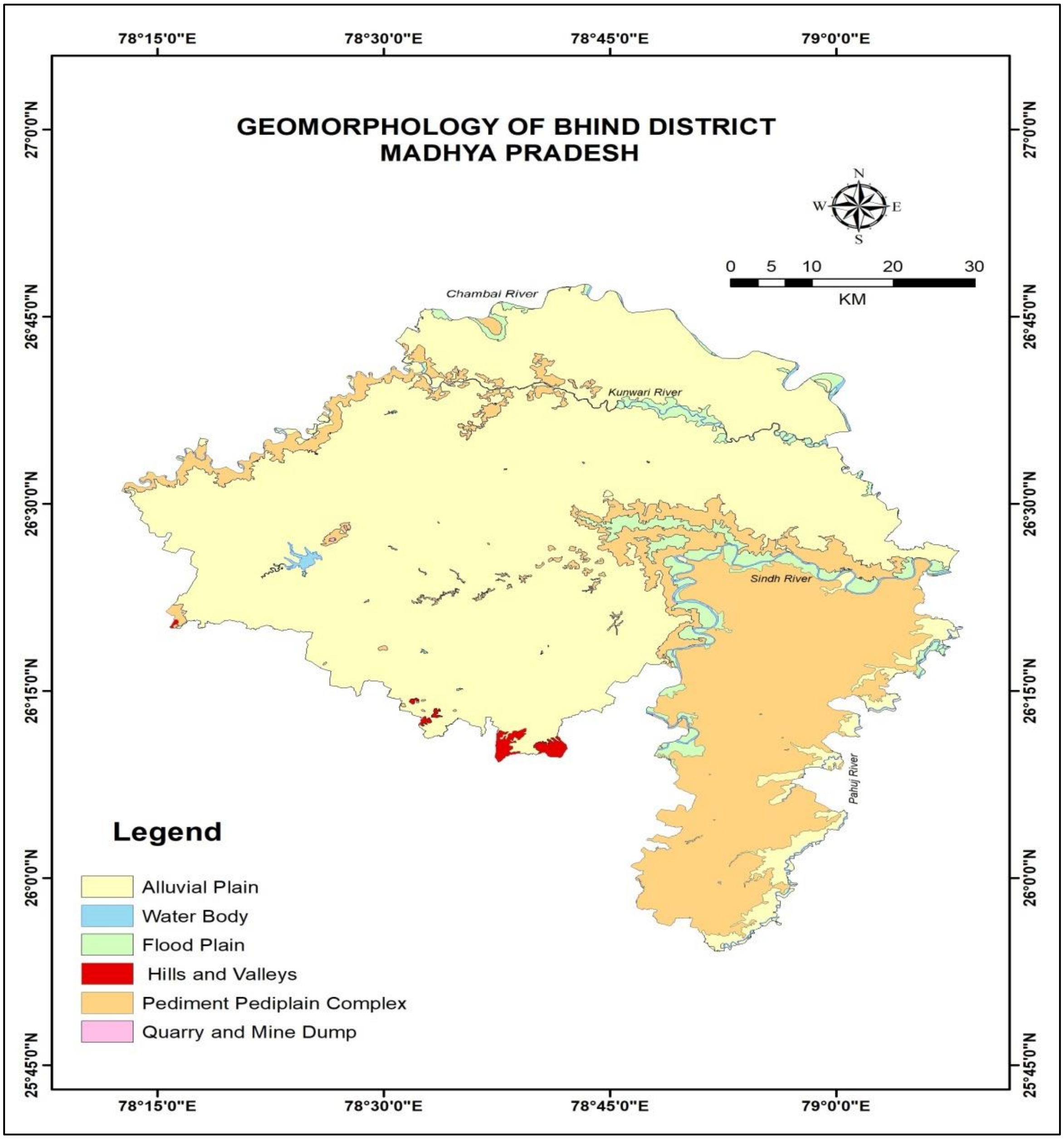
Fig 2. Physiographical Map of Bhind District



1.7 Geomorphology:

2 The north west area of the district forms vast alluvial plains .The south eastern area forms pediment pediplain complex. A small area in the southern part forms hills and valleys. The geomorphological map of Bhind district is given in Fig 3.

Fig 3. Geomorphological Map of Bhind District



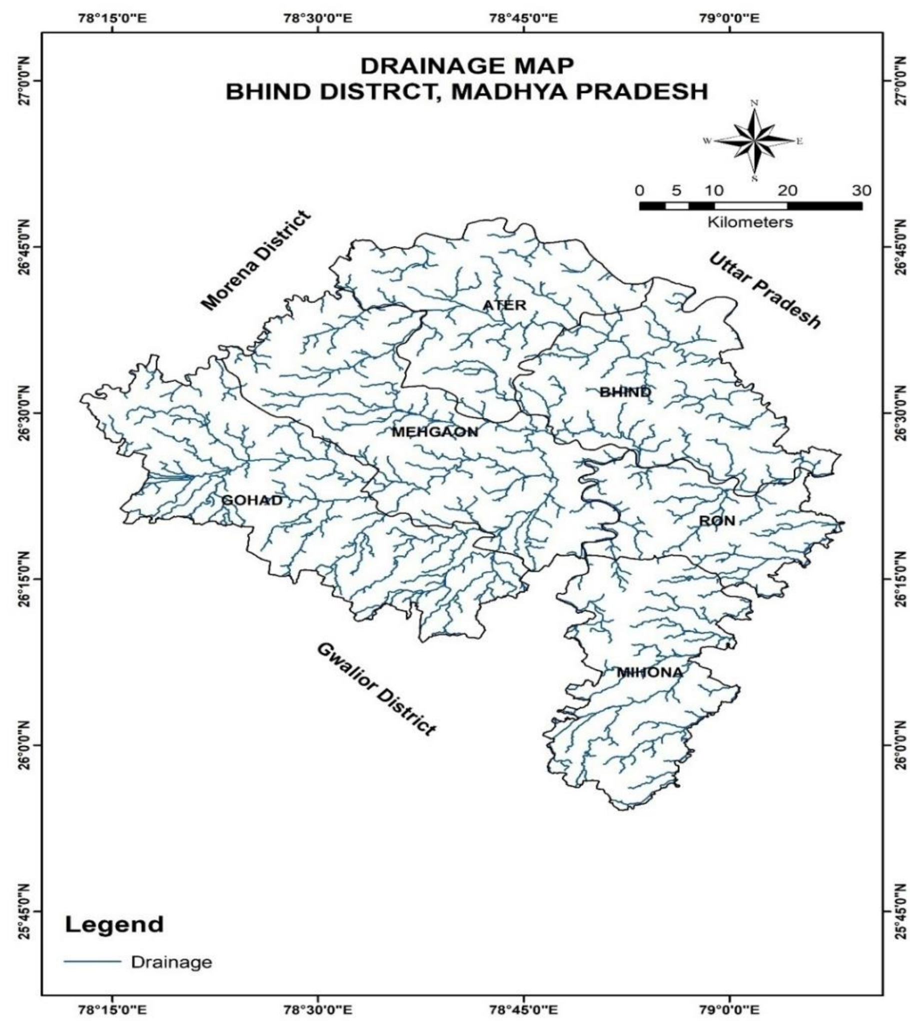
1.8 Soil cover:

The soil in the district generally falls under the group of deep alluvial soils. Color of the soil varies from brown, yellowish brown to dark gray brown. Texture of soils varies from sandy loam (below 20% clay), loam (20 – 30% clay), clay loam (30 – 40% clay) & clay (more than 40% clay). Clay loam soil found in some parts of Gohad & Mehgaon blocks and sandy loam soil is usually found in other blocks.

1.9 Hydrology and Drainage:

Chambal, Asad, Kunawari, Besali, Sindh & Pahuj rivers drain the area. Ravines & Gullies have developed along the course of all rivers particularly along the flood plains. A very fine network of gullies and forming dendritic drainage network characterizes these. The depth of dissection by gullies is more intense along the river Chambal as compared to others.

Fig. 4: Drainage Map of Bhind District



1.10 Land Use, Cropping Pattern and Irrigation

As per the district statistical book 2015, the total area of Bhind district is 4459 sq.kms. Out of which forest area is 8 9 sq.kms.. The district falls in **Lower Chambal Sub Basin of Yamuna Basin.** Rivers of Chambal, Asad, Kunawari, Besali, Sindh & Pahuj drains the entire area. The area irrigated by tube wells is 739.94 sq kms, by open-wells 542.47 sq.kms, by canals 759.94 sq.kms and by ponds 12.70 sq.kms. The total area under irrigation from various sources is 2062.01sq.kms. About 62 % area is irrigated by Ground water of total irrigated area.

The principal crops grown are Wheat, Rice, Maize, Jowar and others.

However the major part of the area fall in the Ganga basin. The drainage of the district is towards north and north east. The five rivers, from west to east are the Bina, the Dhasan, the Bewas, the Sonar and the Bamner. The Bina takes its course upto several Kilometer to the south of the district and enters it near village Mahura. After flowing through Rahatgarh, the river takes a north easterly course and at places forms the boundary with Vidisha district.

Hydrology & Irrigation

The entire Bhind district lies in lower Chambal basin. Major tributaries are Kunwari, Asad, Besali, Sindh & Pahuj rivers.The details of the catchment area of each river is given in table no. 2.

Table No. 2 Catchment Area of the Major Rivers

Sub Basin	Catchment area in the district (sq. Km.)	% of the Catchment area in the district	Length of river in the district (Km)
Direct Catchment of River Chambal	257.87	5.79	46.3
Asad & Kunwari	896.14	20.13	85.0
Besali	1729.28	38.84	57.0
Sindh	785.76	17.65	64.0
Pahuj	783.17	17.59	30.0
Total	4451.96	100.00	282.30

Surface Water availability

The water availability at 75% dependability of major rivers is given in table no. 3.

Table No. 3 Surface Water Availability of the major rivers

Sub Basin	Yield in MCM/Sq. Km	Total yield in MCM
Direct Catchment of River Chambal	01406	36.22
Asad & Kunwari	0.1406	126.00
Besali	0.1176	203.35
Sindh	0.1288	101.21
Pahuj	0.1288	100.87
Total		**567.65**

The gross irrigated area by all sources is 1189.10 Sq. Kms. The Irrigation by different sources is given in Table No. 4

Table No.4 Irrigation by different sourcesYr.2014-15 (Area in Hec)

Tahsil	Canal nos.	Irrigated area	H/P nos.	Irrigated area	D/W nos.	Irrigated area	Tanks nos.	Irrigated area	Total irrigated area
Ater	01	4790	653	7503	654	3623	&	&	15916
Bhind	01	5083	1204	29044	1031	6187	&	&	40693
Mehgaon	01	18018	770	12514	1820	13219	&	&	43751
Gohad	01	25305	481	17522	1069	9000	1270	&	53097
Ron	01	192	123	3198	598	4640	&	&	8030
Mihona	01	3017	160	1622	1101	6286	&	&	11052
Lahar	01	19589	399	2544	1280	11292	&	&	33662
District Total		**75994**	**3790**	**73947**	**7553**	**54247**	**1270**	**-**	**206201**

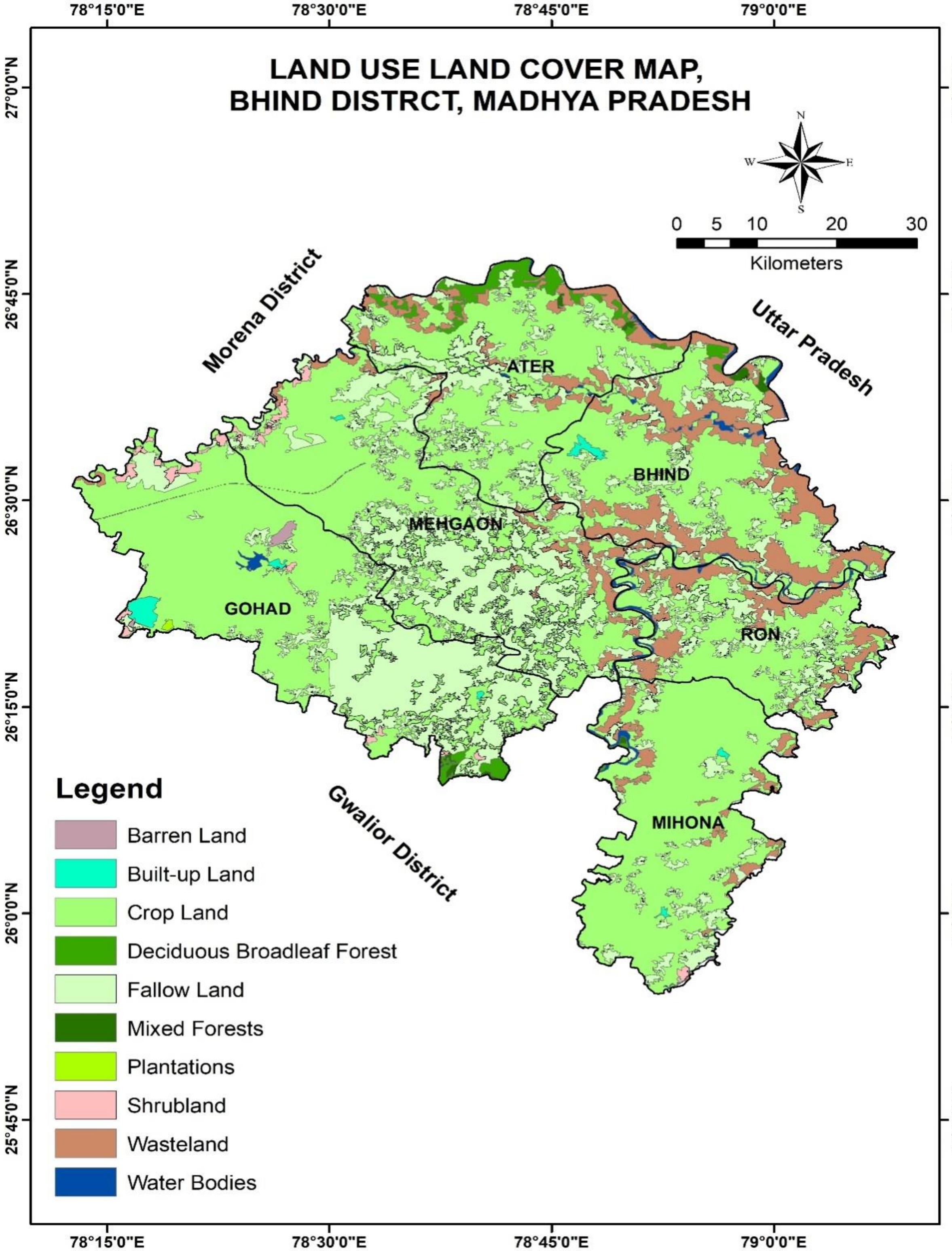
Table No.5 Land use of Bhind District 2014-15 (Hec)

Tahsil	Geographical Area	Forest Area	Land not available for Agriculture	Other Non-Agriculture Land	Land available for Agriculture
Ater	**44740**	**3002**	**9735**	**2154**	**1318**
Bhind	**92598**	**4665**	**15103**	**4355**	**2855**
Mehgaon	**96820**	**-**	**9580**	**2906**	**5425**
Gohad	**102855**	**1129**	**11485**	**3376**	**2286**
Ron	**26671**	**-**	**4140**	**1228**	**465**
Mihona	**25260**	**-**	**3515**	**856**	**451**
Lahar	**56260**	**-**	**6560**	**2295**	**1322**
District Total	445204	8796	60118	17170	14122

Table No.6 Drinking water Problem villeges and Hand pump/ tape water facilited villages of Bhind District 2014-15

Block	No. of Problem villeges	No. of H/P facility villeges	No. of Tape water facility villeges	No. of water supply facilited villeges
Ater	**175**	**148**	**27**	**175**
Bhind	**96**	**51**	**45**	**96**
Mehgaon	**202**	**164**	**42**	**202**
Gohad	**196**	**156**	**41**	**196**
Ron	**71**	**52**	**19**	**71**
Lahar	**151**	**116**	**35**	**151**
District total	**891**	**687**	**209**	**891**

Fig. 5 Land use Map of Bhind District



2. DATA COLLECTION AND GENERATION

2.1. Hydrogeology:

The District is characterised by variety of geological formations representing vast period of geological time.

Alluvium

The alluvial formation covers the major part of the district. Thickness varies from 70 to 250 m underlain by Vindhyan & Archaeans rocks. Alluvium consists of clay, sand, kanker & gravels. The thickness of the clay overburden generally decreases towards north and underlain by sand and gravel aquifers of the thickness vary from 3 to 17 m. The thickness of the overburden more than 60 m is occurring in south of Mehgaon.

Ground Water in this formation occurs under unconfined (up to a depth of 50 to 60 m.b.g.l.) and semi confined to confined conditions in the deeper aquifers i.e. below 60 m. The dug wells & shallow tube wells tap mainly kankary horizon. The deeper tube wells especially in the northern part tap sandy & gravelly aquifers underlying the clays. The grain size of the sand varies so the porosity & permeability of the sandy horizon also varies.

1. Fine Sand: - In this aquifer yield is not more and encounter mostly in dug wells & shallow tube wells. The thickness of this is about 5 m. and forms the upper most aquifer system in the district.
2. Medium Sand: - This aquifer system generally occurring under the thick clay beds therefore the ground water in this aquifer occurs under semi confined to confined conditions.
3. Coarse Sand: - This aquifer system is important as it has good porosity, permeability and yielding capacity. Ground water in this formation occurs under confined condition because it is generally occurs at the depth.

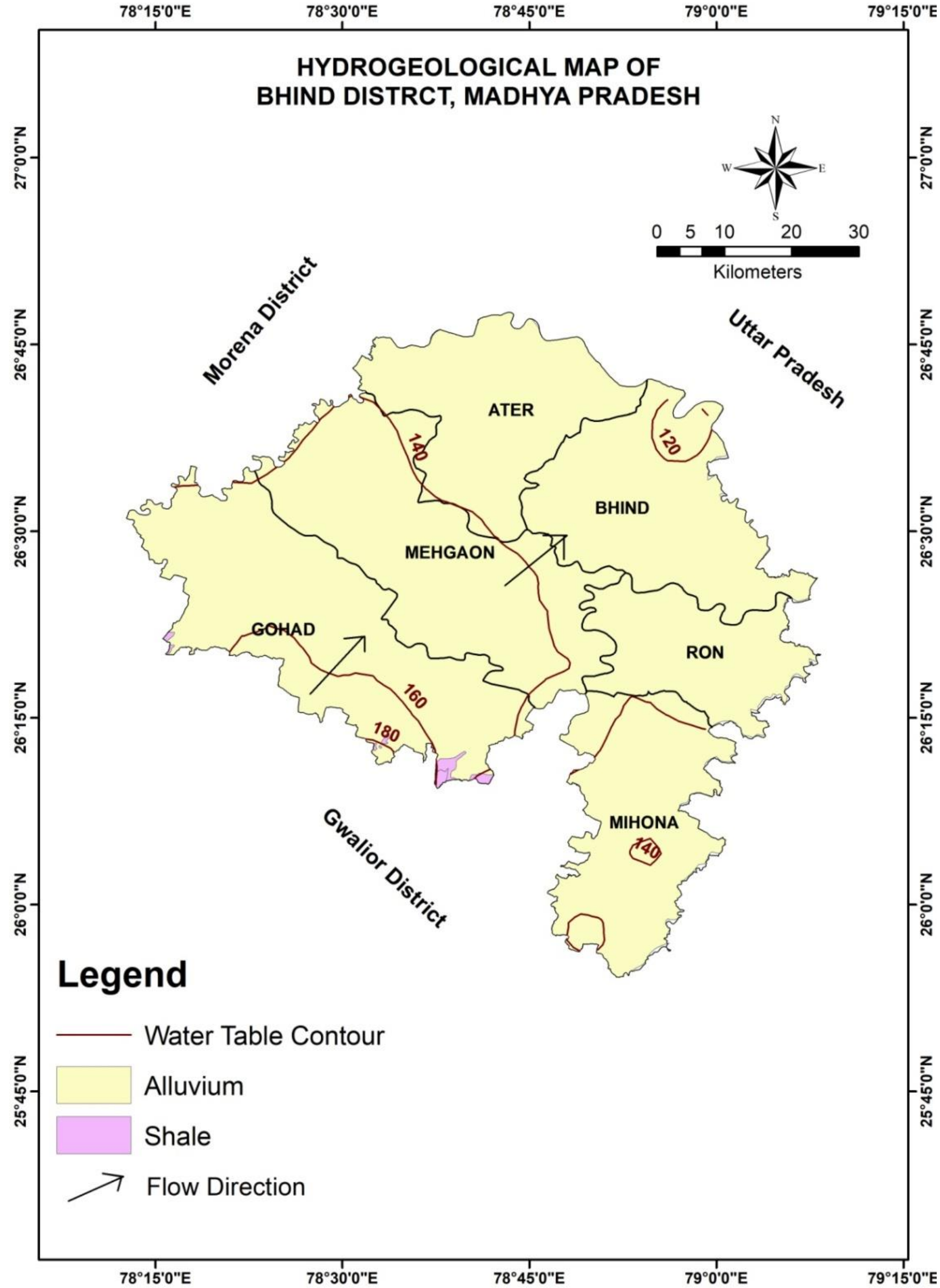
Vindhyan Formation

Some outcrops of this formation are exposed in the western parts of the district in Gohad tehsil. The sand stone & shales of Vindhayan formation are encountered between 86 to 172 m b.g.l. (Source CGWB, Ground water Exploration). As these rocks are hard & compact therefore the ground water occurrence is meager and ground water development in this formation is less. The depth to water level varies from 4.6 m to 13.00 m b.g.l and seasonal fluctuation ranges from 2.5 to 5.00 m. (in normal monsoon years).

Gwalior Series

Gwalior series is exposed in south-western part of the district and consist of Banded Hematite Quartzite. Ground water occurs under semi confined to confined conditions having moderate yield potential.

Fig. 6 Hydrogeological Map of Bhind District



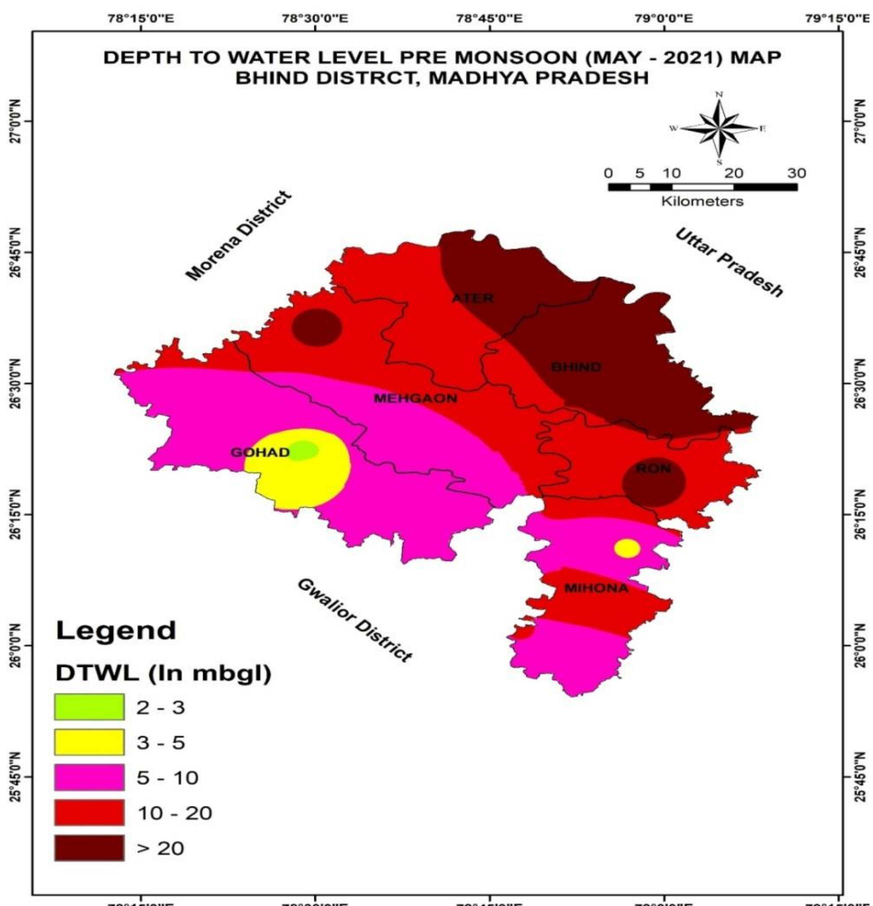
2.2. Ground water scenario

The monitoring of ground water levels of the area gives a picture of the behavior of ground water regime over space and time. It is a very important parameter that is used in assessing the ground water resources and clearing area for future development. In Bhind district, CGWB is monitoring ground water levels four times a year. There are 19 national hydrograph stations (NHS) and 1 piezometer. The behavior of ground water regime for the pre-monsoon and post-monsoon period of 2020 is discussed herewith.

Pre-monsoon (May 2021)

The Pre-monsoon depth to water level (DTWL) ranged between 2.4 mbgl (Khader block Gohad) to 35.76 (Malanpur block Gohad) m.bgl. In major part of the area, water level ranges from more than 12 m.bgl.

Fig.7 Pre-monsoon (May 2021) DTWL Map of Bhind district



Post-Monsoon (Nov 2021)

The depth to water levels during the post monsoon period varies from 179 mbgl (Meroli block Mehgaon) to 29.98 m.bgl (Malanpur block Gohad). In major part of the district, water level ranges more than 6 m.bgl.

Fig.8 Post-monsoon (May 2021) DTWL Map of Bhind district

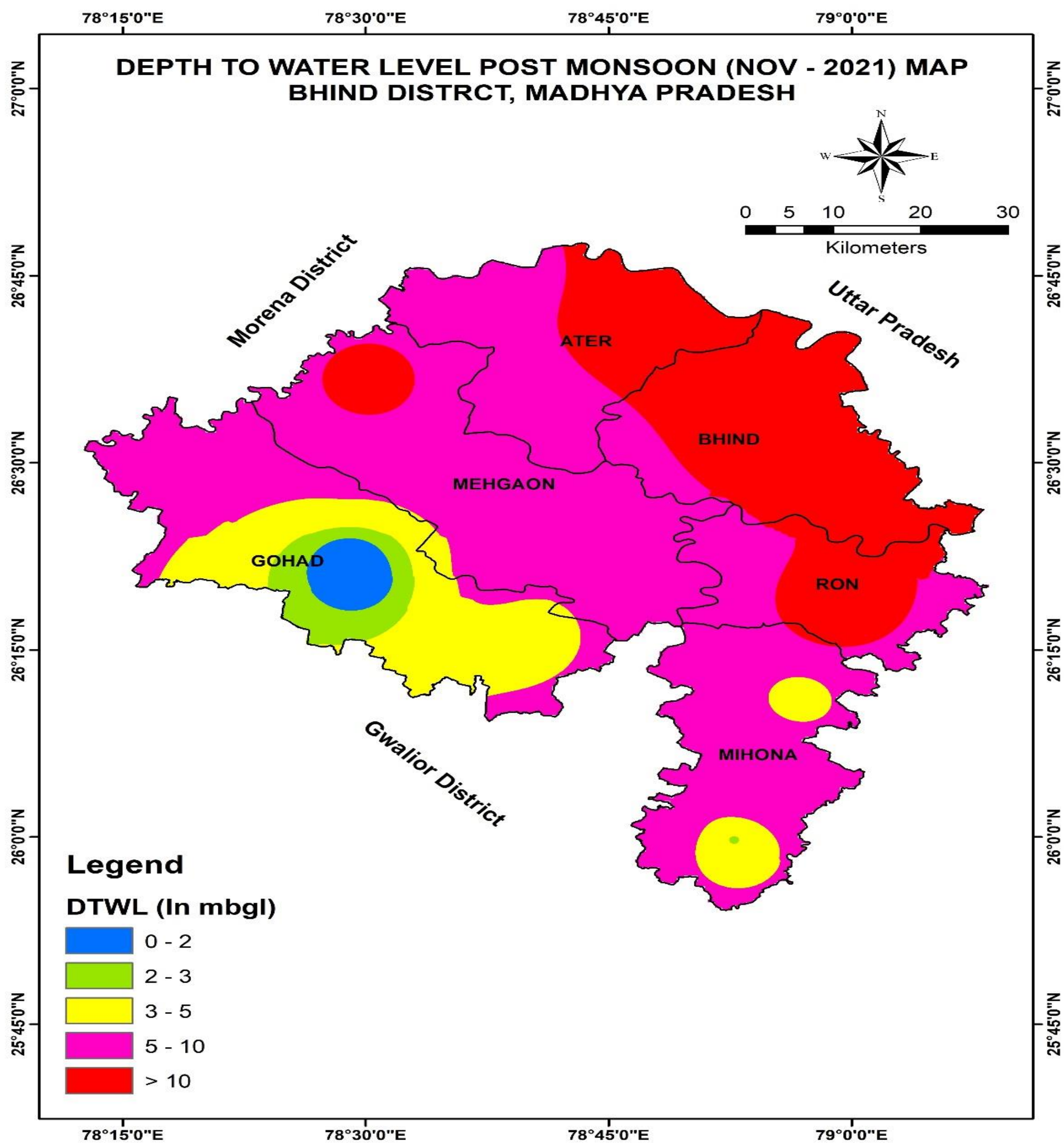
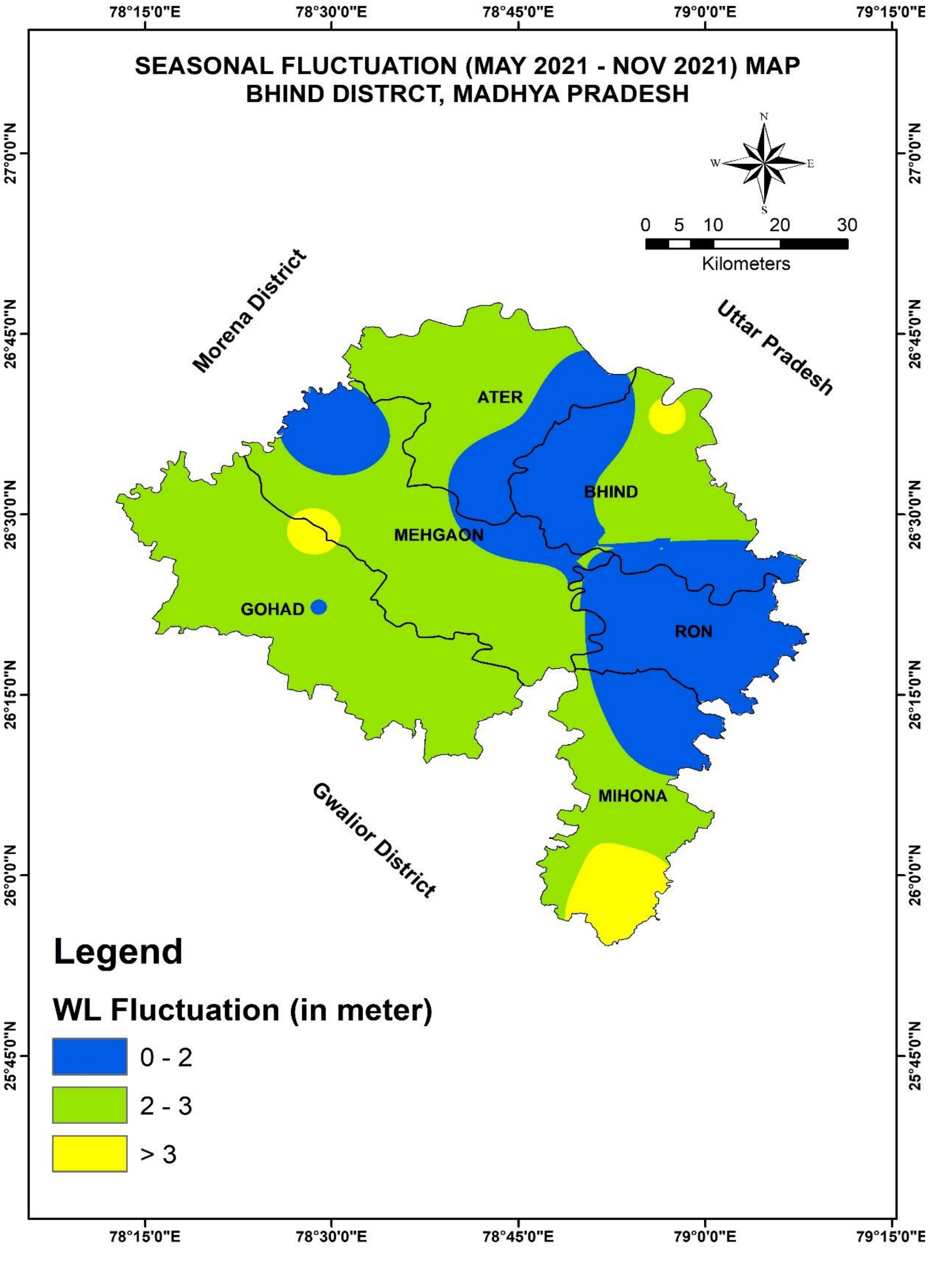


Fig.9 Water Level Fluctuation (May 2021-Nov 2021) Map of Bhind district



Groundwater level trend 2011 to 2020

Analyses of Groundwater level data of pre-monsoon period indicate that there is rising trend in the range of 0.09 to 1.06 m/yr in the parts of Ater,Bhind and Gohad blocks and falling trend in the range of 0.06 to 2.25 m/yr.in the parts of Lahar and Mehgaon blocks. While the post-monsoon period indicate that there is rising trend in the range of 0.003 to 0.90 m/yr in the parts of Ater,Bhind and Gohad blocks and falling trend in the range of 0.17 to 1.84 m/yr.in the parts of Gohad,Lahar and Mehgaon blocks.It is observed that only some parts of the blocks Lahar and Mehgaon showing falling trend more than 2 m/yr.in pre monsoon period.

Ground Water Regime Monitoring: 2021

Central ground Water Board (CGWB), Bhopal, Madhya Pradesh is monitoring 17 dug wells and 1 piezometer in the Bhind District. The depth to water level (DTWL) and seasonal water level fluctuation during the Year 2021 is studied to understand ground water regime of the area. Ground water level trend have been studied to understand the changes in the ground water regime. DTWL and seasonal fluctuation is given in Table 7.

1. Depth to Water Level (DTWL):

During pre-monsoon (May) 2021 the depth to water level ranges from 4.1 mbgl at Bhagathar Village to 25.64 mbgl at Phuph Village. Average DTWL in the district is 11.33 mbgl. Out of 18, 9 monitoring wells are showing water level more than 10 mbgl.

During post monsoon 2021, DTWL ranges from 1.3 mbgl at Bhagathar Village to 24.49 mbgl at Nahrakapura Village. Average post monsoon depth to water level in the study area is 8.09 mbgl. 10 monitoring wells are noticing DTWL less than 10 mbgl.

2. Seasonal Water Level Fluctuation

To understand changes in ground water regime, the seasonal water level fluctuation (Nov 2021 wrt May 2021) was studied. Total 18 wells are analyzed. An overall rise is observed except two wells. The rise in water level ranged from 0.9 m at Gormi to 3.41 m at Nahrakapura Village. The average rise of about 2.51 m is observed in the region.

Table No.7 Pre and Post monsoon Ground Water Level and Seasonal Fluctuation 2021.

DISTRICT	BLOCK	LOCATION	WELL_ TYPE	2021 Pre-monsoon_GWL_mbgl	2021 Postmonsoon_GWL_mbgl	Seasonal Fluctuation in (m)
BHIND	ATER	Ater	Dug Well	15.2	12.9	2.3
BHIND	ATER	Lavan	Dug Well	11.5	10.4	1.1
BHIND	BHIND	Nahrakapura	Dug Well	27.9	24.49	3.41
BHIND	BHIND	Phuph	Dug Well	25.65	26.15(dry)	-0.5
BHIND	GOHAD	Bhagathar	Dug Well	4.1	1.3	2.8
BHIND	GOHAD	Bhirkhari	Dug Well	8.9	5.4	3.5
BHIND	GOHAD	Khader	Dug Well	2.4	1.07	1.33
BHIND	GOHAD	Mau	Dug Well	7.1	4.4	2.7
BHIND	LAHAR	Alampur	Dug Well	10.15	7.95	2.2
BHIND	LAHAR	Balaji	Dug Well	16.95	17	-0.05
BHIND	LAHAR	Daboh	Dug Well	7.75	3.25	4.5
BHIND	LAHAR	Dewri	Dug Well	13.45	11.15	2.3
BHIND	LAHAR	Lahar	Dug Well	4.8	3.8	1
BHIND	MEHGAON	Chirole	Dug Well	7.6	6.05	1.55
BHIND	MEHGAON	Gormi	Dug Well	16.37	15.47	0.9
BHIND	MEHGAON	Meroli	Dug Well	6	1.7	4.3
BHIND	RON MIHONA	Ratanpura	Dug Well	6.85	3.05	3.8
BHIND	GOHAD	Malanpur(S)	Bore Well	35.76	29.98	5.78

Table No.8 Bhind W L Trend Pe-monsoon

				From Year	2011	To Year	2020
State		**:**	**Madhya Pradesh**				
District		**:**	**BHIND**				
Block		**:**	**ATER**				
Sl No.		**Location**		**Rise(m/year)**		**Fall(m/year)**	
1	Ater			0.5501			
2	Lavan			0.6878			
Block		**:**	**BHIND**				
1	Nahrakapura			1.0668			
2	Phuph			0.2335			
Block		**:**	**GOHAD**				
1	Bhagathar			0.5631			
2	Bhirkhari			0.3476			
3	Khader			0.0507			
4	Malanpur(S)					2.2522	
5	Mau					0.3777	
Block		**:**	**LAHAR**				
1	Alampur					0.0791	
2	Balaji			0.0998			
3	Daboh					0.0807	
4	Dewri			0.3081			
5	Lahar					0.2162	
Block		**:**	**MEHGAON**				
1	Chirole			0.2083			
2	Gormi					0.5697	
3	Mehgaon					0.0659	

Table No.9 Bhind WL Trend Post-monsoon

			From Year	**2011**	**To Year**	**2020**
State		**Madhya Pradesh**				
District		**BHIND**				
Block		**ATER**				
Sl No.	**Location**			**Rise (m/year)**		**Fall(m/year)**
1	Ater			0.5769		
Block		**BHIND**				
1	Nahrakapura			0.0714		
Block		**GOHAD**				
1	Bhagathar			0.9002		
2	Bhirkhari					0.1786
3	Khader			0.1377		
4	Malanpur(S)					1.8486
5	Mau					0.3422
Block		**LAHAR**				
1	Alampur					0.5922
2	Balaji			0.3001		
3	Daboh					0.3971
4	Dewri			0.0031		
5	Lahar					0.2298
Block		**MEHGAON**				
1	Chirole					0.2089
2	Gormi					0.8992
3	Mehgaon			0.1131		

2.3. Ground Water Exploration:

CGWB has drilled 32 exploratory wells and 1 Piezometer in Bhind district. On the basis of samples collected during drilling, lithologs have been prepared. The aquifer parameters are evolved by conducting pumping tests. The salient details of these bore wells are given in Table No. 11.

Fig.10 Ground Water Exploration Map of Bhind District

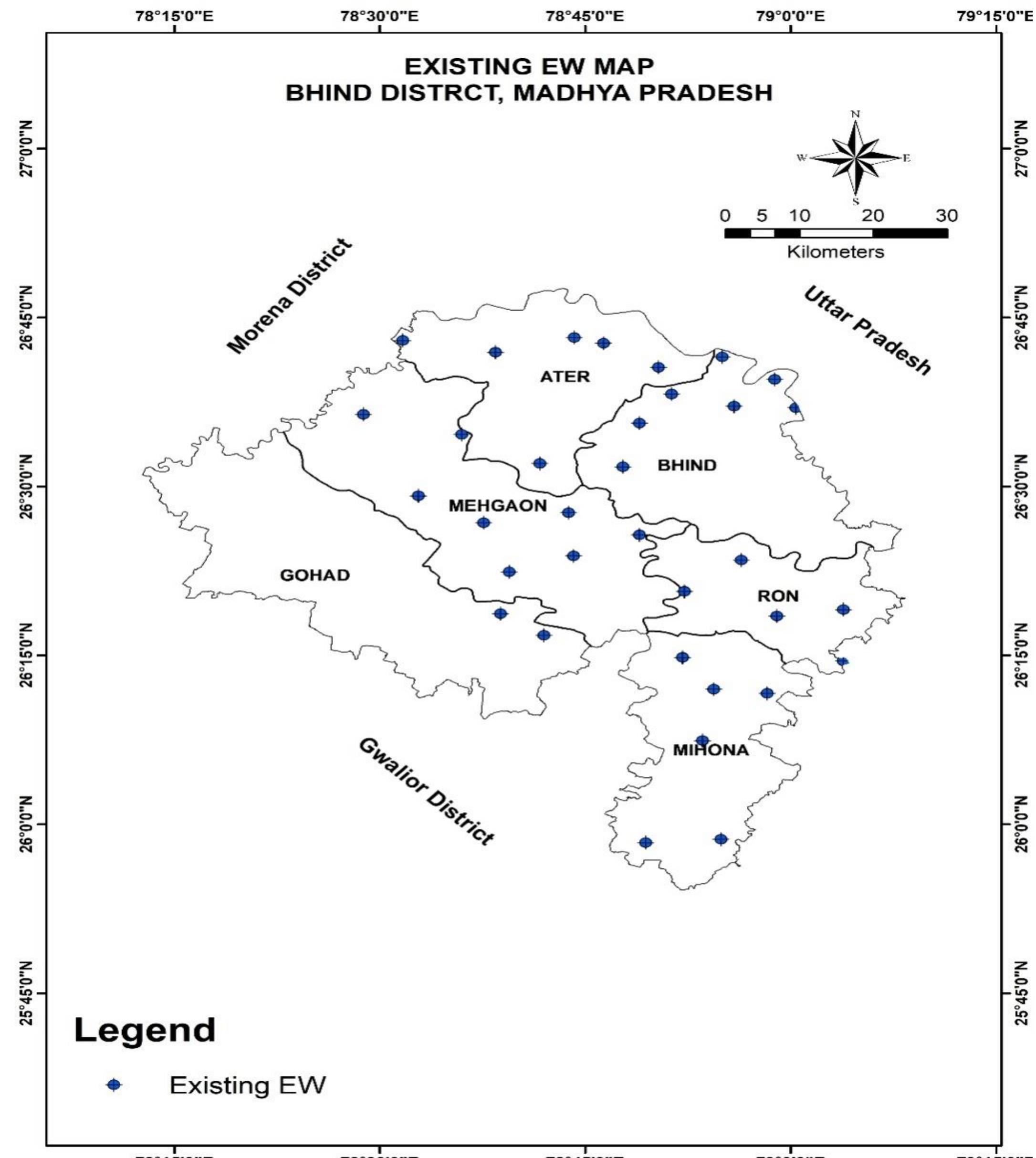


Table No.11 : Details of Exploratory Wells district Bhind.

Location	Latitude	Longitude	Year of Drilling	Depth drilled (mbgl)	Depth constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl) / Date	Discharge (lps)	Drawdown (m)	T (m² / day)	S
1.Udotgarh	26.716111	78.528056	1987	141	138	0-138.0 Alluvium Vindhyan Sandstone at 138.0	92.5-97.5 110-112 126-129 136-139	26.92	12.42	3.6	393	
2.Udotgarh	26.716111	78.528056	1987	72	72	Alluvium	35-37.5 40.5-45 47.5-53.5 62.5-69	21.73	4.17	0.48		
3.Kishupura	27.786944	78.736667		159	158	0158.5 Alluvium Vindhyan Sandstone at 158.5	84-87 94-97 101-105 116-128 130-140 143-155		0.00			
4.Choumhon	26.698611	78.640833		135	131	0132.00 Alluvium Vindhyan Sandstone at 132	52-57 67-73 111-117 121-123 128-130	26.1	4.07	12.26		
5.Surpura	26.711944	78.741346		171	47	169Alluvium Vindhyan Sandstone at 169	36-44	23.55	15.30	2.68	1844	$2.3x10^{-3}$
6.Safedpura	26.618889	78.931111	1988	118.75	72	Alluvium	42-49 63-69	32.5	8.30	11.68	194	$073x10^{-4}$
7.Bharoli	26.428333	78.816111		118.75	88	0-80.86 Alluvium Basic Rock at 80.86	80-86	26.06	3.42	1.5		
8.Barhi	26.691667	78.916667		188.7	112	0-172.00 Alluvium vindhyan sandstone at 172.0	52-62 100-109	35.46	14.20	10.7	2042	$2.77x10^{-4}$
9.Machand	26.317778	79.064167		130.6	46	Alluvium	33-33.75 41-43	16.56	0.14	15		
10.Khurd	26.241667	79.064167		94.85	55	0-91.00 Alluvium Morar shales at 91.0	45-52	7.16	3.33	25.53	41	$0.69x10^{-2}$
11.Bishne ka	26.391111	78.94	1989	84.3	83	0-82 Alluvium,	45-47 49-53	35.47	14.50	1.33	6644	$0.28x10^{-4}$

Location	Latitude	Longitude	Year of Drilling	Depth drilled (mbgl)	Depth constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl) / Date	Discharge (lps)	Drawdown (m)	T (m² / day)	S
pura						Dolerite sill at 82.00	64-69 79-81					
12.Ghamouri	26.311944	78.646944		59	56	Alluvium	50-54	5.5	4.40	18.78	48	$0.9x10^{-5}$
13.Rawatpura(sani)	26.247222	78.868611		80.62	73	0-74.6 Alluvium Dolerites Sill at 74.6	48-72	16.64	1.50	17		
14.Prithipura	26.534167	78.695		121.7	78	0-114.7 Alluvium Morar Shale at 114.7	54.5-60 66-75	12.42	23.90	19.38	968	$4.8x10^{-3}$
15.Indurkhi	26.345	78.870833		83.85	51.5	0-80 Alluvium Dolerites Sill at 80.0	44-48.5	27.72	9.50	3.87	1753	$1.8x10^{-6}$
16.Amritpura	26.486389	78.561763	1990	88.37	81	Alluvium	41-46 49-54 60-78	6.47	14.50	7.24	559	$0.67x10^{-4}$
17.Kemokhedi	26.373889	78.657778		97.5		Alluvium	33-39 50-56	21.06	8.23			
18.Deenpura	26.593611	78.816111		161.78	161.78	0-140.0 Alluvium Vindhyan sandstone at 140.0	78-83 104-116 126-134 145-147 149-152	24	45.80	5.98	1968	$6.73x10^{-5}$
19.Sakraya	26.676111	78.839167		110	108	Alluvium	99-100 103-107	28.27	11.80	10.2		
20.Kanchuri	26.616667	79.006667		79.7	73	Alluvium	38-40.5 45-49.5 67-70	31.55	2.00	7.53	29	
21.Gohar	26.446389	78.626389		103.5	67	0-91 Alluvium Morar shale at 91.0	44-46 50-53 62-65 79.5-83 88-91	10.95	0.50	350		
22.Chaurai	26.123889	78.893056		78	78	Alluvium Granite	61.5-66 70.5-78	16.79	14.20	21.05	161	$1.41x10^{-4}$
23.Parosa majra Rawatpura	26.606667	78.480278		104.2	95	Alluvium Vindhyan Sandstone	PZ26-29 33-36 55-60 63-65 67.5-70.5 72-84 89-92	22.2	17.00	1.58	6710	$0.1x10^{-3}$
24.Belma	25.973056	78.816948		69.5 68.0	15.5 PZ	0-63.7 Alluvium Granite at 63.7	PZ12.5-15.5 42-53 59-66	8.73	27.75	9.06	1063	$1.68x10^{-4}$
25.Mau (kitti)	26.286324	78.709843		55.2 39	54.5	Alluvium Dolerite Sill	S 29-37.5 D46-53	4.13 5.02	0.44	4.36		
26.Arusi	27.396667	78.255278	1990	73.6	63	Alluvium Granite	38-40 46-55	13.47	54.07	4.83	2924	$0.21x10^{-3}$

Location	Latitude	Longitude	Year of Drilling	Depth drilled (mbgl)	Depth constructed (mbgl)	Lithology	Aquifer zones tapped (mbgl)	SWL (mbgl) / Date	Discharge (lps)	Drawdown (m)	T (m² / day)	S
							59-61					
27.Pawai	26.636667	78.645		108.7	79	Alluvium Quartz Sandstone	48.5-53.5 60-65.5 69-77.5	21.48	50.78	4.27	3174	$4.58x10^{-4}$
28.Meopur	25.978056	78.915278	91-92	78.1	72	0-76 Alluvium granite at 76.0	56-70	16.54	37.53		2553	$0.11x10^{-2}$
29.Chauraria ka pura	26.461111	78.729722	91-92	64	58	0-103 Alluvium Vindhyan Sandstone at 103	40-44 49-52 55-58	18.45	0.00			
30.Bara-kalan	26.529167	78.795833	92-92	123.7	120	0-144.7 Alluvium Vindhyan sandstone at 144.7	57-66 72-78 94-100 106-112 115-118	25.52	48.95	4.82	4808	$6.36x10^{-2}$
31.Vijpur	26.193889	78.971667	91-92	64.5	62.5	0-96 Alluvium Bundelkhand granite at 96.0	46.5-58.5	19.25	28.80	4.2	1469	$9.9x10^{-4}$
32.Nunhad	26.577222	78.6	91-92	93.65	92	0-96 Alluvium Vindhyan sandstone at 96.5	69-77 83-89	12.87	50.78	16.39	1086	

2.4. Hydro-Chemical:

Ground Water Quality of Bhind District

The water samples were collected from National Hydrograph Stations in clean double stoppered poly ethylene bottles from 19 different locations of Bhind district during May 2020.

Quality of Ground Water for Drinking Purpose:

The ground water samples from Bhind district have varied range of pH from 7.22 to 8.03. As per BIS (IS 10500:2012) recommendation, all the water samples have pH recorded within the permissible limits of 6.5 to 8.5, the maximum pH recorded in the water sample of Daboh (8.03). The pH of ground water can be assessed as neutral to slightly alkaline in nature. The electrical conductivity of ground water samples in Bhind district varies from 689 to 4069 µS/cm at 25°C. The electrical conductivity from Bhind district shows variability, 9 locations of sample shows EC less than 1500 µS/cm; 5 locations of sample shows EC in between 1500 to 2000 µS/cm; 3 locations of sample shows EC in between 2000 to 3000 µS/cm while two locations from Chirole and Ater villages shows EC more than 3000 µS/cm i.e. 3903 and 4069 µS/cm respectively. So, overall ground water quality of Bhind district is good except some parts which are saline in nature in few pockets of the districts viz Kishupura – Surpura&Sakraya saline zone, Saraya – Kanchuri Saline zone, Machand – Vijpura – Banpura Saline zone and Kemokheri – Chauraria – Bharoli – Amayan – Mau Saline zone.

The fluoride concentration in Bhind district lies in between 0.03 to 1.43 mg/l, which represent that all the samples are within the permissible limit i.e. 1.5 mg/l of BIS standard. The maximum concentration of fluoride has been recorded in the village of Balaji i.e. 1.43 mg/l. The nitrate concentration in the Bhind districts ranges in between 3 to 140 mg/l. It is observed that 10.5% samples have nitrate concentration more than the acceptable limit i.e. 45 mg/l, while rest 89.5% samples have concentration less than acceptable limit. Highest nitrate have been recorded in the village of Mehgaon (77 mg/l) and Ater (140 mg/l). The total hardness in the ground water of the districts ranges between 213 to 1115 mg/l. In the district, 89.5% of ground water samples recorded less than BIS permissible limit while 10.5% of ground water samples recorded more than BIS permissible limit i.e. 600 mg/l. The maximum concentration of total hardness has been observed in the village of Balaji (825 mg/l) and Ater (1115 mg/l).

Piper diagram has three parts: a Cation triangle, an Anion triangle, and a Central diamond-shaped field. In Cation triangle, the relative percentages of the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) are plotted. In Anion triangle the major anions (HCO_3^{-}+CO_3^{2-}, SO_4^{2-}, Cl^{-}) are plotted. These points are then projected to the central diamond shaped field.

In the district; piper diagram shows that the 63% samples shows Calcium-Bicarbonate type (temporary hardness) of water; 21% of samples are Mixed type of water whereas 16% samples are Sodium Chloride type (Saline) of water.

Quality of Ground Water for Irrigation Purpose:

In classification of water for irrigation purpose, it is assumed that the water will be used for irrigation purpose based upon its soil texture, infiltration rate, drainage and climate. The chemical data of all the water samples from Bhind district is plotted on U.S. Salinity Laboratory diagram.

The USSL diagram shows that the districts falls under C_2-S_1 Class (Medium Salinity & Low Sodium); C_3-S_1 Class (High Salinity & Low Sodium); C_3-S_2 Class (High Salinity & Medium Sodium); C_4-S_1 class (Very High Salinity & Low Sodium); C_4-S_2 class (Very High Salinity & Medium Sodium) and C_4-S_3 class (Very High Salinity & High Sodium) of water. Very High Salinity & Medium to High Sodium classes of water may be used for irrigation with proper soil management.

Fig 11 Piper Diagram of water samples collected from National Hydrograph Stations, Bhind District

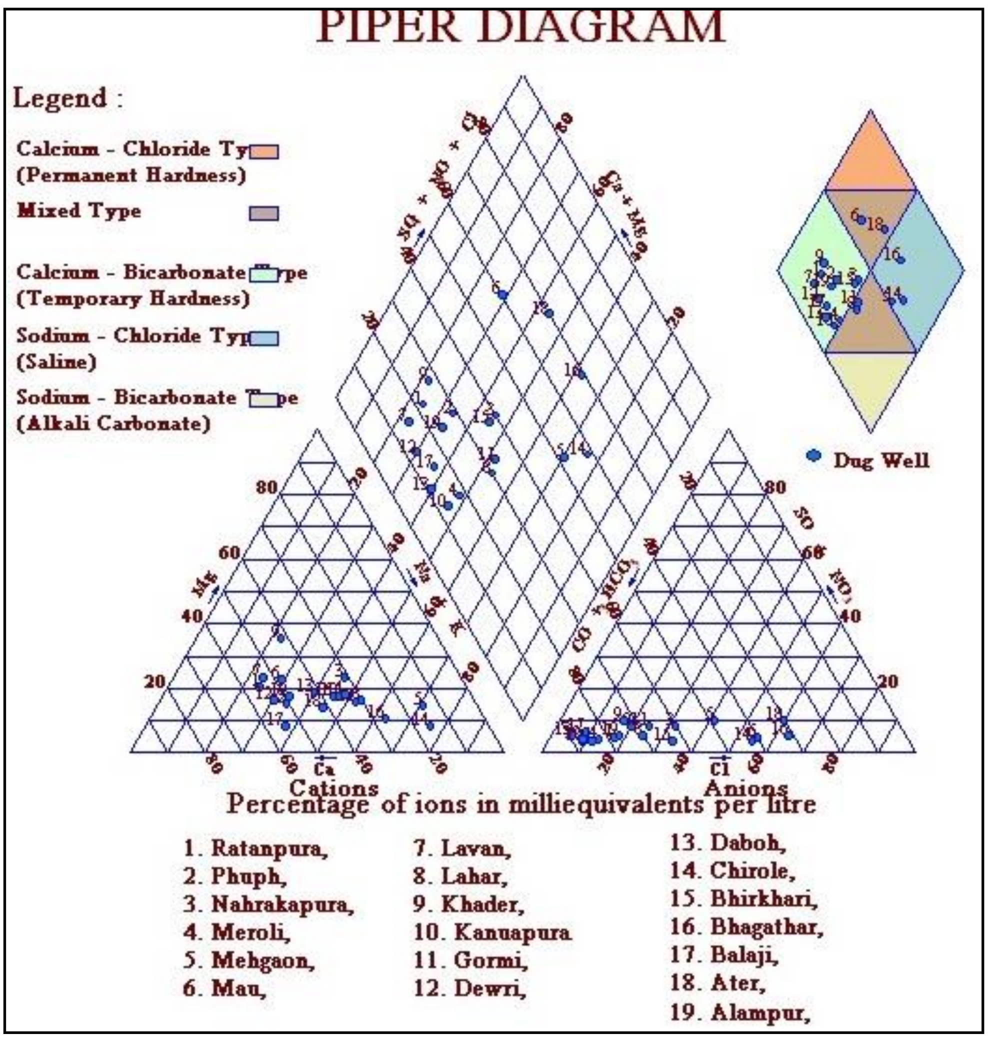


Fig. 12 US Salinity Diagram for water samples collected from National Hydrograph Stations of Bhind District, Madhya Pradesh

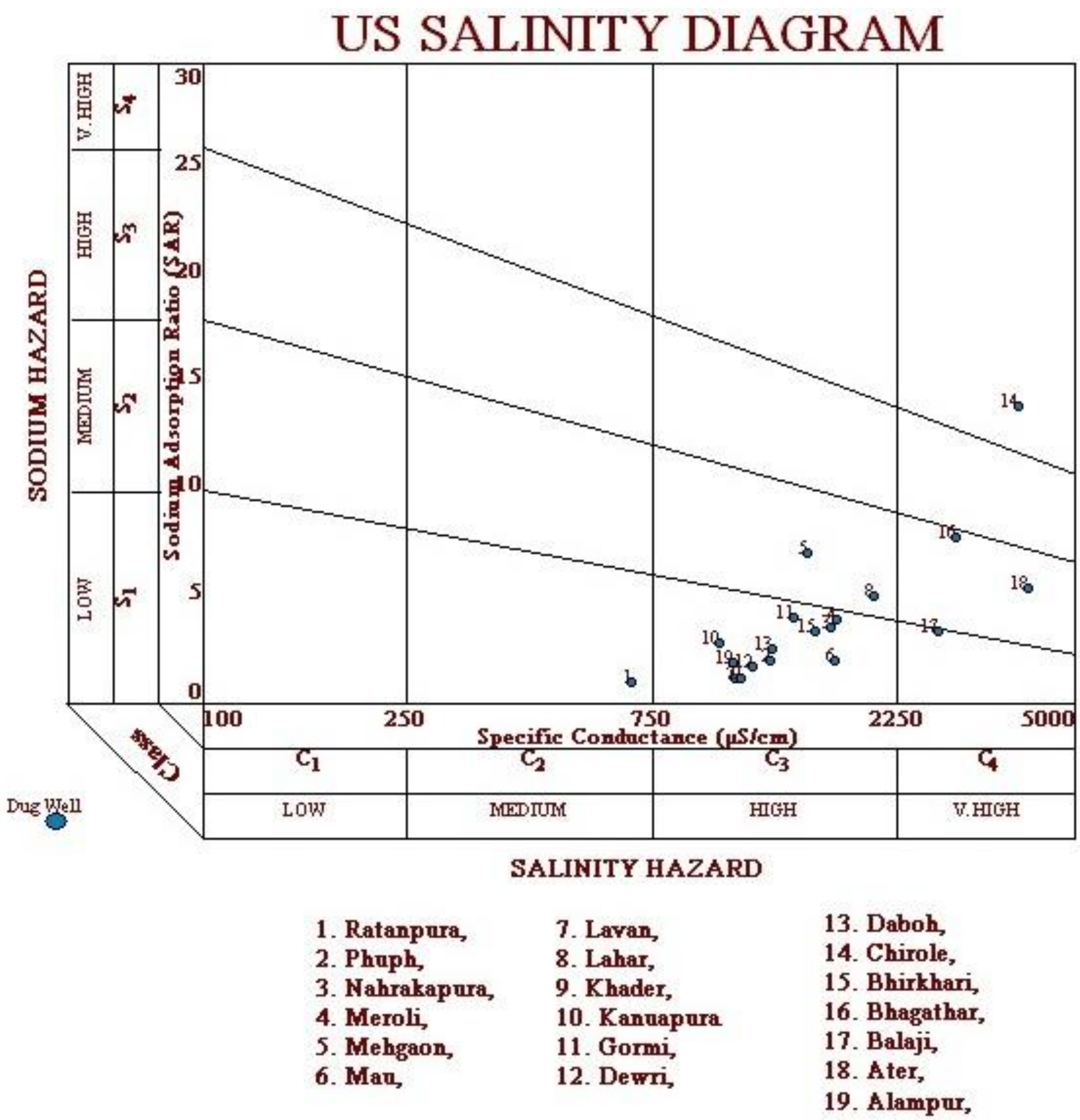


Table No.12 Ground Water Chemical Quality Report

S. No.	District	Block	Location	Lat.	Long.	pH	EC	CO_3	HCO_3	Cl	SO_4	NO_3	F	PO_4	SiO_2	TH	Ca	Mg	Na	K
						at 25 °C	μS/cm at 25 °C	mg/l												
1	BHIND	LAHAR	Alampur	26.0294	78.7972	7.23	1089	0	464	67	15	14	0.55	BDL	22	355	104	23	82	1.2
2	BHIND	ATER	Ater	26.7500	78.6442	7.89	4069	0	708	837	85	140	1.05	0.1	47	1115	332	70	412	2.3
3	BHIND	LAHAR	Balaji	26.2961	78.9800	7.62	2712	0	1336	85	65	23	1.45	BDL	24	825	286	27	225	3.1
4	BHIND	GOHAD	Bhagathar	26.3444	78.4919	7.83	2934	0	512	627	45	37	0.65	BDL	34	535	152	38	415	1.9
5	BHIND	GOHAD	Bhirkhari	26.4753	78.4783	7.42	1565	0	543	172	22	6	1	BDL	27	415	112	33	158	1.6
6	BHIND	MEHGAON	Chirole	26.3553	78.6342	8.02	3902	0	921	712	65	7	1.35	0.1	46	450	118	38	675	3.3
7	BHIND	LAHAR	Daboh	25.9961	78.8792	8.03	1298	0	647	27	22	11	0.5	BDL	19	370	102	28	112	3.5
8	BHIND	LAHAR	Dewri	26.0806	78.9031	7.46	1189	0	586	37	15	9	0.45	BDL	23	405	124	23	80	2.9
9	BHIND	MEHGAON	Gormi	26.5989	78.5017	7.58	1423	0	506	112	45	5	0.9	BDL	27	325	86	27	165	2.7
10	BHIND	ATER	Kanuapura	26.6111	78.6472	7.45	1023	0	519	35	13	5	0.3	BDL	20	260	70	21	106	1.6
11	BHIND	GOHAD	Khader	26.3683	78.4839	8.02	1122	0	464	67	15	45	0.8	BDL	22	425	92	48	56	2.3
12	BHIND	LAHAR	Lahar	26.1861	78.9472	7.76	2031	0	836	175	35	23	1.3	BDL	28	455	118	39	245	2.6
13	BHIND	ATER	Lavan	26.5214	78.7306	7.92	1098	0	543	47	12	9	0.8	0.1	22	405	112	31	56	3.5
14	BHIND	GOHAD	Mau	26.2700	78.6667	7.76	1712	0	366	302	23	19	0.65	BDL	34	595	162	46	111	2.8
15	BHIND	MEHGAON	Mehgaon	26.4978	78.6011	7.56	1509	0	436	225	12	77	1.35	BDL	44	213	42	26	237	2.9
16	BHIND	MEHGAON	Meroli	26.5619	78.5297	7.86	1723	0	823	80	25	14	1.4	BDL	22	431	111	37	185	3.6
17	BHIND	BHIND	Nahrakapura	26.6369	78.9417	7.22	1689	0	557	175	35	34	0.9	BDL	27	441	101	46	171	3.8
18	BHIND	BHIND	Phuph	26.6428	78.8794	7.96	1285	0	514	87	29	26	1	0.1	31	401	123	23	94	4.2
19	BHIND	RON MIHONA	Ratanpura	25.9675	78.8250	7.67	689	0	297	40	12	3	0.5	BDL	19	243	71	16	36	1.1

2.5 Geophysical

Surface Geophysical Surveys for Ground Water Investigation in Bhind District

Bhind District forms a part of the Indo-Gangetic alluvium comprising of fine sediments, i.e. clay, silt and sand. This alluvium is deposited over the Vindhyan basement. It is observed that the deeper aquifer resting over doleritic formations having poor quality of water. In this regard geophysical surveys were planned to see the possibility of aquifers below doleritic formation and to estimate the thickness of alluvial formations.

In this context twenty three vertical electrical soundings covering 17.8 line km, were observed along three regional traverses of the district during FSP 87-88. Fourteen VES were conducted along Bhind-Lahar section, 3 VES were conducted along Bhind-Mehgawan section and 6 VES were conducted along Mehgawan-Mau section.

A geoelectrical cross-section between Umari and Lahar clearly indicates presence of two to three geoelectrical layer systems. It is observed that the last layer having the resistivity of the order of more than 50 ohm-m is indicative of bedrock. The occurrence of bed rock at deeper depth (more than 250m) in northern part of the section and at shallow depths (less than 100m) in southern part of the section is indicating the presence of sub-surface fault along Sindh river. Pseudo resistivity depth section and Schlumberger resistivity profile along the section also support the presence of sub-surface fault. It is also indicated that the presence of lower range of resistivity in the southern part of the section may be due to the poor quality of groundwater. **In general geophysical surveys reveal that the bed rock is deeper towards Bhind and Lahar and shallower towards Mau**. It is also observed that the resistivity surveys could not delineate any low resistivity zone /aquifers below doleritic formation.

Electrical Logging

The electrical logging conducted during AAP 1992-93 in the exploratory wells of distract Bhind at various locations. The summarised results are given in the table.

Table No.13: Summarised data of Electrical logging

S.No.	Location	Granular zones deciphered(mbgl)		Thickness(m)
		From	To	
1	Banthri	21	24	3
		28	33	5
		46.5	52	5.5
2	Sayna	42	44.5	2.5
		59	65	6

		67	78	11
		85	89	4
3	Bainspura	22	27.5	5.5
		32	34	2
		74.5	85.5	11
4	Mihona	21	24	3
		28	33	5
		46.5	52	5.5

Fig.13 Section based on Electrical Logging

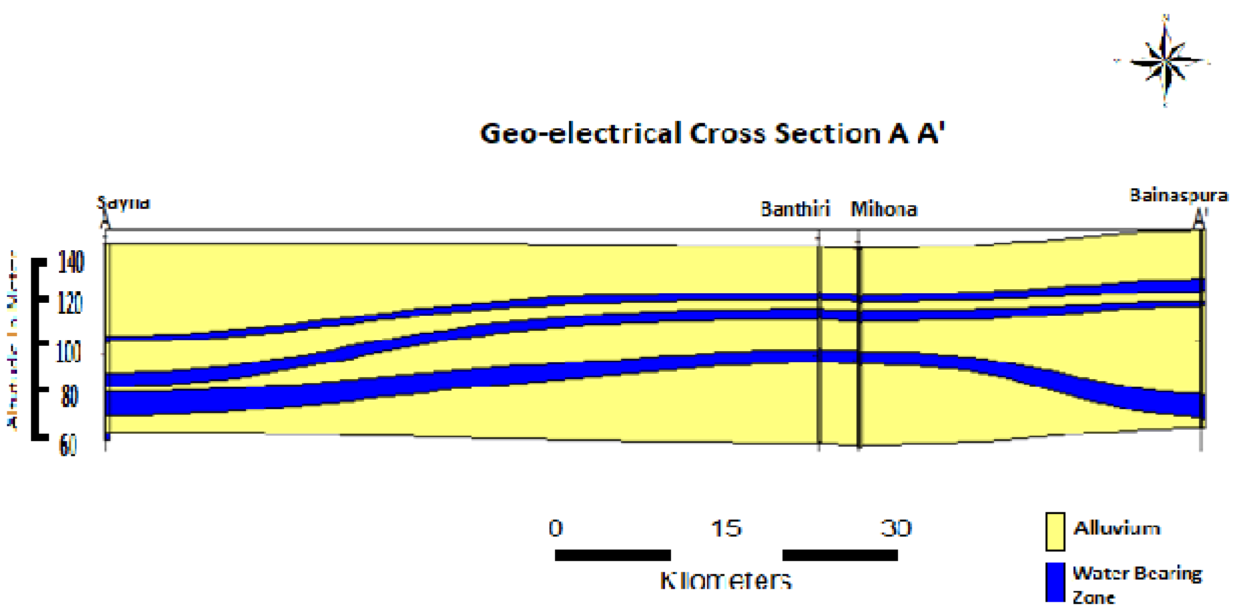
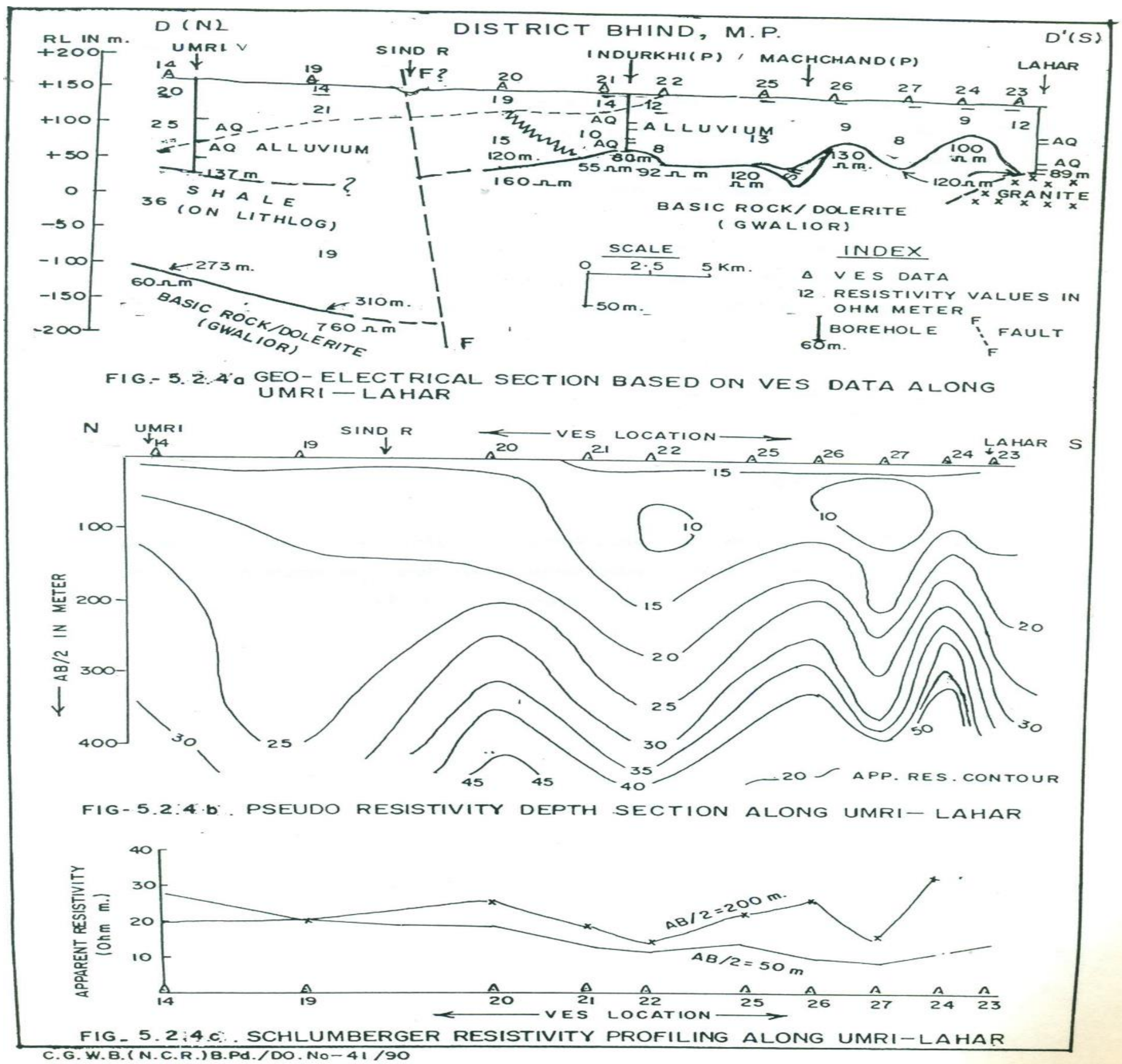


Fig. 14. Geo-Electrical Section of the Bhind District



3. DATA INTERPRETATION AND INTEGRATION

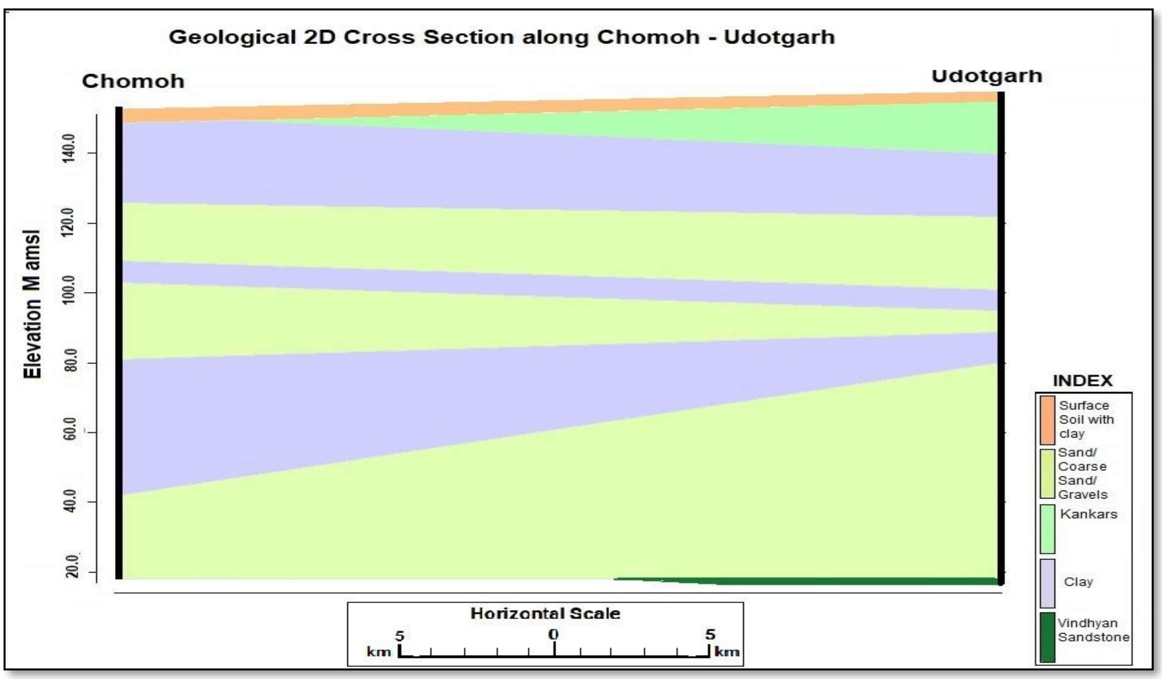
The litho logical data collected from CGWB exploratory bore wells were studied, compiled and integrated as per 2-Dimensional Cross section. From the 2-D Section is presented in the fig 15 it has been interpreted that the major water bearing zones has been encountered in Alluvium.

The region is dominantly occupied by Alluvium. The sub-surface litho logy has been broadly classified into Alluvium underlain by Sandstone/Shale and Granite.

3.1 2-D Cross Section of the Bhind District

The 2-Dimensional cross-section along the section line Chomoh-Udotgarh has been prepared. The cross-section shows that the shallow aquifer as well as deeper aquifer continuing for the whole region in Alluvial areas. Whereas the deeper aquifers in hard rock occurs not throughout the section line and can be encountered at depth where fractures are present.

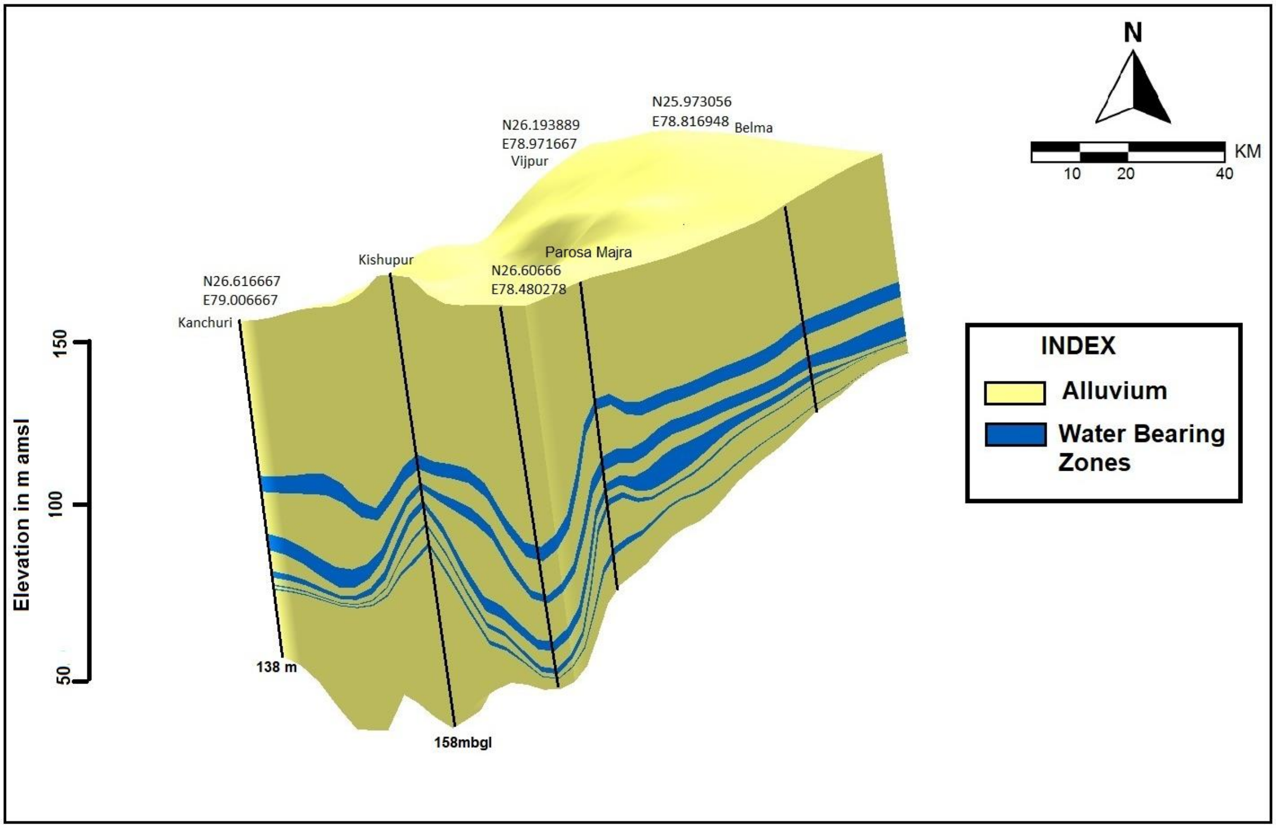
Fig.15 Hydrogeological Cross-Section I



3.2 3-D Model of the Bhind District

The 3-Dimensional Model has been prepared based on GW Exploration data. The model shows that the deeper aquifer continuing for the whole region in Alluvial areas.

Fig 16: 3-D Model of Bhind district based on Ground Water Exploration Data



4.0 GEOPHYSICAL STUDY

4.1 Introduction

Bhind district is situated in the northern part of Madhya Pradesh in Central India. Most part of the district is occupied by thick sequence of Quaternary alluvium. A major part of the district is affected by inland salinity. The problem of salt deposition due to leaching of Soil is a common phenomenon in the district, the reason being water-logging situation being developed due to canal irrigation and poor drainage (Singh, 2000). The surface resistivity surveys have been conducted between the area of Besli and Jhilmil River to study the subsurface hydro-chemical characteristics of the area. The study area lies between north latitude (26° 15' 06'' to 26° 27'), and east longitude (78° 37' 30° to 78° 48' 30'') in Survey of India toposheet No54 J/11 and 54 J /15 covering an area of 200 km^2.In general the alluvium plains are forming a flat terrain with few undulating high lands. The maximum elevation with reference to M.S.L. in the study area is about 152 m near village Mau whereas the minimum elevation is 140 m near village Siyapura. The east direction flowing Besli and northeast flowing Jhilmil River drain the area. They join together near village Siyapura and ultimately merge to perennial Sind River. The climate of the study area is characterized by general dryness except during the southeast monsoon season.

The prime objective of the study was to demarcate the area affected by inland salinity. The other objectives include delineation of depth of occurrence of potential fresh water aquifers, estimation of thickness of alluvium, delineation of basement topography and identification of areas suitable for artificial recharge of groundwater. The paper embodies a synoptic view of the results of investigation.

4.1.1 Surface Resistivity Measurements

To have an idea about the quantitative variations in subsurface resistivity, surface resistivity surveys were initiated by observing Vertical Electrical Sounding (VES) in the area. Twenty-one numbers of VES with maximum current electrode separation of 800 m were conducted by using Schlumberger configuration. VESs were placed normally along the visible local lineaments. But due to limitation of topographical situation and approachability, the VESs could be conducted mainly along the roads. However, an attempt has been made to conduct VESs in planned manner so that the generalized subsurface picture of whole study area could be visualized. Resistivity measurement have been made with GGA-30 (West Germany) DC resistivity meter, which gives the digital display of current and voltage values separately to get the subsurface apparent resistivity.

The apparent resistivity values are plotted on the log-log paper against the half current electrode separation. Most of the VES curves obtained from study area are H and KH type in the nature. The quantities interpretations of VESs have been made using conventional curve matching techniques. In same curve has interpreted layer parameters have been modeled with computer software. In case where the exact match between field curve and computed curves has not been obtained, the layer parameters have been modified on basis of available hydrogeoloogical and geophysical parameter.

4.1.2 Discussion of Result

Electrical resistivity of sedimentary formation is mainly controlled by the resistivity of the formation of water and the lithological character. The effect of former becomes more pronounced where electrical resistivity of formation water is low due to the concentration of total dissolved solids. The variation in bulk resistivity of formation with the resistivity of formation water is complex. It can be estimated easily for clean sands with uniform inter modular possibility while it is not so far sands mixing with clays. Addition of clays reduces the formation resistivity but the reduction by increasing clay content is marked by that due to poor quality of formation water.

Vertical Electrical Sounding presents average or equivalent resistivity for thick geo-electrical layer, from which an average groundwater quality could be asserted. For fixing the geophysical parameters in local hydrogeological framework, they have been standardized with the local sub-surface lithological and geophysical well log data. In interpretation of multi-layer VES curves, additional information such as litho-logical well descriptions and geophysical logs has been considered for reducing the problems of equivalence.

On the basis of synthesized layer parameters of VES's, the results of the study are being described in the following paragraphs.

4.2 Geo-electrical cross-section

The section reveals the presence of 4 major geo-electrical layer sequence. It is evident from the section that the top unsaturated zone, having the resistivity values of 6-8 ohm.m, is about 2-6 m thick. The second geo-electrical layer, having the thickness of about 10 to 30 m and resistivity of the order of 12 to 25 ohm.m, is indicative of saturated aquifer zone. This layer having maximum thickness of about 30 m near VES 2 is almost absent in extreme southeastern part of the section near VES 8. The third prominent geo-electrical layer having the very low resistivity of the order of 2 to 8 ohm.m is thickening towards northwest. The lower values of this layer clearly demonstrate the possibility of poor water quality occurrence in this layer. This low resistivity layer having the thickness of about 28 m (8 mbgl to 36 mbgl) in southeastern part attains the thickness of more than 100 m in northwestern part of the section. The resistivity value of this layer is also increasing towards northwest, which indicated the increased percentage of sand in the layer. The fourth layer having the resistivity of the order of 80 to 192 ohm.m is indicative of hard and consolidated rock formation. This layer may be designated as bedrock. The geo-electrical section reveals that the bedrock, occurring at about 40 m at Mau (near Jhilmil River) and more than 100 m near Besli River, is dipping towards the north-west.

4.3 Estimation of alluvium thickness

The wide difference of resistivity’s between overlying alluvium formation and consolidated rock formation form the basis for estimation of alluvium thickness from surface resistivity measurements. The interpreted layer parameters of VES's clearly indicate the presence of thick alluvium cover overlying basement. The study reveals that the thickness of alluvium formation varies from 40 m (in southwestern part near Jhilmil River) to 120 m (in the northern part along Besli Nadi). The contours of bedrock resistivity have also been drawn which indicated two different contour patterns. One done with resistivity of the order of 200 ohm.m near village Chhekluri. Correlation of resistivity values of this trough with lithological details of bedrock reveals that the bedrock around village Syna is comprised of Vindhyan sandstone and of dolerite in other parts of the area.

4.4 Delineation of fresh/saline Ground water interface

The significant and detectable contrast in physical properties of the subsurface litho logy in the study area enabled the application of electrical resistivity method for delineating poor quality groundwater zone. On correlation of groundwater quality with the aquifer resistivity, it is observed that the aquifer having the resistivity less than 10 ohm.m is holding poor quality groundwater. The depth of occurrence of poor quality aquifer, having resistivity less than 10 ohm.m at each VESs location. .It clearly manifests that the occurrence of brackish/saline water is not uniform. It starts from very shallow depth, about 5 m near village Kemokheri, to about 24 mbgl near villa e Piproli. It is evident from the panel diagram that the area around village Kanather and S^ na, in north central part of study area, are not affected by inland salinity.

4.5 Identification of potential aquifer zones

On correlation of aquifer resistivity with its groundwater quality, the intermediate range of resistivity's (more than 10 ohm.m) is characterized as fresh water aquifer. The increase in aquifer resistivity indicates increase of sand percentage in aquifer lithology. On this, the potential aquifer zones holding potable water have been identified. According to the depth to the occurrence of fresh water aquifer and their thickness, the area has been categorized for different drilling depths to tap the fresh groundwater. It is evident that the borehole could be drilled down to the depths of 80 to 110 m in northern part of the study area where as the drilling should be restricted within 20 m depth in eastern and western part. In other parts of the area, only the dug well could be constructed within 10 m depth range to get potable water.

4.6 Conclusions

The area between Besli and Jhilmil River in Bhind district is occupied by Quaternary alluvium, which constitutes the fluvial terraces and the recent flood plains. The uneven distribution of brackish/saline groundwater is creating water scarcity problems in the area. Surface resistivity studies continued in the area reveals the present area 40 to 120 m thick alluvium cover overlying bedrock. It is evident from the Geo-electrical cross-section that the bedrock topography is dipping towards northwest direction. The inferred fresh/brackish groundwater interface varies in the depth range of 5 to 30 m bgl. It is observed that the resistivity surveys are unable to decline any aquifer zone within or below the dolerite formation.

The study suggest to stop the over exploitation of fresh groundwater aquifers otherwise it may cause lateral and/or upcoming of salinity from deeper aquifers. The artificial recharge structures like recharge shafts, by piercing entire thickness of aquiclude by Hume pipe down to top of aquifer. The availability of fresh groundwater can also be increasing by construction shallow tube-wells by putting cement seals at appropriate depths after verifying the saline/brackish zones through geophysical logging and packer test.

The delineation of fresh and saline groundwater zones only on the basis of resistivity contrast obtained from surface resistivity technique may be ambiguous at time. The technique faces limitation in investigating at greater depths, which is more affected with highly conductive overburden, causing ambiguous interpretation.

(Source: An Understanding of Subsurface Inland Saline Environment through Surface Resistivity Measurements in Parts of Bhind District (Madhya Pradesh.This study carried out in year 1997BySubhash C. Singh and B. P. SinghCentral Ground Water Board, NCR)

5.0. GROUND WATER RESOURCES

Bhind district is mainly underlain by Alluvium followed by Kaimur series (Vindhayan system) and Gwalior series. Dynamic ground water resources of the district have been estimated for year 2020 on block-wise basis. Out of **4459 sq.kms** of geographical area 100 % is ground water recharge worthy area. There are six numbers of assessment units (blocks) in the district. The area falls under non-command 59.65 % and command 40.35 %.All the six blocks of the district falls under **Safe** category of Ground water extraction.

The highest stage of ground water extraction is computed as 35.82 % in Ater block. The **Annual Extractable Ground Water Recharge in ham is 88746.59** and ground water extraction for all uses is **28758.94** ham, making stage of ground water extraction **32.41** % as a whole for the district. The net ground water available for future use would be **59643.88 ham.**

5.1 DYNAMIC GROUND WATER RESOURCE

Table No.14A: (As per Dynamic GW Resource estimation 2020)

Sl No.	Name of Assessment Unit (Block)	Type of rock formation	Recharge worthy area of formation in hect	Areal extent (in hectares)						
				Total Geographical Area	Hilly Area	Ground Water Recharge Worthy Area			Shallow Water Table Area	Flood Prone Area
						Command area	Non-command area	Poor ground water quality area		
1.	Ater	Alluvium	61200	61200	0	16074	45126	0	0	0
2.	Bhind	Alluvium	76200	76200	0	25614	50586	0	0	0
3.	Gohad	Alluvium	102800	102800	0	42770	60030	0	0	0
4.	Lahar	Alluvium	65600	65600	0	31112	34488	0	0	0
5.	Mehgaon	Alluvium	96900	96900	0	31257	65643	0	0	0
6.	Ron	Alluvium	43200	43200	0	33064	10136	0	0	0
DISTRICT TOTAL			**445900**	**445900**	**0**	**179891**	**266009**	**0**	**0**	**0**

Table no.14B: ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES DISTRICT BHIND (As on March' 2020)

Assessment Unit Name	Recharge from Rainfall-Monsoon Season (Ham)	Recharge from Other Sources-Monsoon Season (Ham)	Recharge from Rainfall-Non Monsoon Season (Ham)	Recharge from Other Sources-Non Monsoon Season (Ham)	Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
ATER	13274.43	137.12	0	2184.44	15595.99	1559.61	14036.38
LAHAR	9485.86	205.74	0	3800.33	13491.93	1349.2	12142.73
BHIND	12870.56	46.15	0	1988.94	14905.65	1490.56	13415.09
RON	9370.18	99.11	0	458.98	9928.27	992.82	8935.44
GOHAD	17163.86	506.47	0	3355.16	21025.49	1511.68	19513.81
MEHGAON	18757.93	579.63	0	3665.93	23003.49	2300.35	20703.14
DISTRICT TOTAL	80922.82	1574.22	0	15453.78	97950.82	9204.22	88746.59

Table no.14C: ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES DISTRICT BHIND (As on March' 2020)

Assessment Unit Name	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization
Ater	4369.858	0	657.4183	5027.28	723.61	8942.91	35.82	safe
Lahar	3669.848	0	467.1708	4137.02	514.21	7958.67	34.07	safe
Bhind	3653.4016	0	564.1133	4217.51	620.9	9140.79	31.44	safe
Ron	2078.268	0	331.8967	2410.16	365.31	6491.87	26.97	safe
Gohad	6221.572	0	617.9742	6839.55	680.2	12612.03	35.05	safe
Mehgaon	5351.588	0	775.825	6127.42	853.94	14497.61	29.60	safe
District Total	25344.54	0	3414.4	28758.94	3758.17	59643.88	32.41	Safe

6. GROUND WATER RELATED ISSUES

Ground water related issues and problems

6.1 Ground Water Depletion

. The district falls in safe category. However there are many parts in the district having water scarcity. The decline in water level also observed in decadal ground water level trend in the parts of Lahar, Mehgaon and Gohad blocks in pre-monsoon as well as in post monsoon trend from the year 2011to year 2020.

6.2 Ground Water Quality

The overall ground water quality of Bhind district is good. However it is saline in nature in few pockets of the districts.

6.3 Salinity

The salient features of the salinity affected villages are given below:

Table No.15: Salinity affected villages

S.No.	District	Salinity Affected Villages	Salinity Affected Sources	Number of Non affected sources available in the villages
1	Bhind	120	388	118

It has been observed that except four isolated patches entire Bhind district is yielding potable ground water. The salient features of the four saline zones are as follows: -

1. Kishupura – Surpura & Sakraya saline zone; - This zone is located North of Bhind along the Chambal river. Saline zone occurs at the depth ranges from 84 to 140 mbgl with EC ranges from 2400 to 3430 m. mhos/cm at 25^0c.The phreatic aquifer in this zone is non-saline and yields potable water.
2. Saraya – Kanchuri Saline zone: - Located NE of the Bhind town along the Chambal river. Saline zone occurs at a depth ranges from 30 to 184 m bgl with electrical conductivity ranges from 3550 to 3875 m. mhos/cm at 25^0c.
3. Machand – Vijpura – Banpura Saline zone; - located west and north of Sind river along the border of Madhya Pradesh & Utter Pradesh. Saline zone occurs at a depth ranges from 65 to 114 m bgl with electrical conductivity ranges from 3720 to 3954 m. mhos/cm at 25^0c.

4. Kemokheri – Chauraria – Bharoli – Amayan – Mau Saline zone: - Located west of the river Sind and along along the river. The electrical conductivity in this zone ranges from 2000 to 14000 m. mhos/cm at 25^0c. and increase from phreatic aquifer to down below.

6.4 Water Logging

The water logging problem exists in the parts of the Chambal canal command areas of the district especially in Mohgaon & Gohad Tehsils. The problem is attributed to:

1. Canal seepage
2. Presence of impermeable or poorly permeable sandy loam and clayey alluvium soils.
3. Occurrence of soils with poor drainage capacity.
4. Lack of proper drainage or slope in the affected areas.
5. Insufficient ground water extraction causing gradual rise in water levels in phreatic aquifer.

The list of waterlogged villages in the year 1999 is given in table no. 17.

Table No. 16: Waterlogged villages

S.No.	Name of village	Effective area (Ha)
1.	Katwa Gujar	50.94
2.	Taton	98.31
3.	Baron	25.23
4.	Bara	71.84
5.	Sarwa	98.89
6.	Tukeda	142.06
7.	Khaririya	67.00
8.	Chhinoka	144.98
9.	Sherpur	24.34
10.	Nohera	6.87
11	Chak Shankarpur	1.05
12.	Andori	14.13
13.	Rai Ki Pali	9.47
14	Phtehpur	15.47
15.	Amarpur	2.17

16	Lodhe Ki Pali	12.23
17.	Chak Tekheda	25.86
	TOTAL	**810.84**

7.0 GROUND WATER MANAGEMENT STARTEGIES AND AQUIFER MANAGEMENT PLAN

Bhind district falls in safe category. However there are many parts in the district having water scarcity and it is also observed that decadal ground water level trend is declining. This has led to evolve sustainable water conservation and management practices through an integrated approach. The ground water management plan for Bhind district has been made keeping in view the area specific details and includes the strategies like enhancing the ground water resources through construction of artificial recharge structures such as percolation tanks, check dams/nala bunds, recharge shafts, etc. and ensuring water use efficiency through maintenance/ renovation of existing water bodies/water conservation structures. Also, adoption of micro-irrigation techniques such as sprinkler irrigation has been proposed, that would not only conserve ground water resources by reducing the draft, but would also increase the net cropping area thereby augmenting the agricultural economy of the district. The Ground water extraction is less than 70% in all the blocks .Therefore, the areas falling under these blocks may be taken up for further extraction of the Groundwater.

7.1 Supply Side Management

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

The supply side management plan for Bhind district has been formulated using the basic concepts of hydrogeology. Sub-surface storage is calculated by multiplying the total area with the respective specific yield (considering the variable lithology) and the unsaturated zone thickness obtained by subtracting 3 mts. from the post-monsoon water level. The volume of ground water recharge generated through pre-existing rain water harvesting/water conservation structures is subtracted from the sub-surface storage to assess the available storage potential. Thus, the surface water requirement to completely saturate the sub-surface storage is obtained by multiplying a factor of 1.33 to available storage potential. A runoff coefficient factor of 0.118 has been considered for Bhind district to calculate the total surface water runoff, 30% of which accounts to the non-committed runoff which is available to sustain the proposed artificial recharge structures. Further, the number of structures has been calculated by allotting 35%, 20% and 35% of non-committed runoff to Percolation tanks, Recharge shafts and Nala bunds/Check dams/Cement Plugs respectively. The remaining 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 no.17. The map showing feasible Artificial Recharge structures in Bhind district is given in Figure

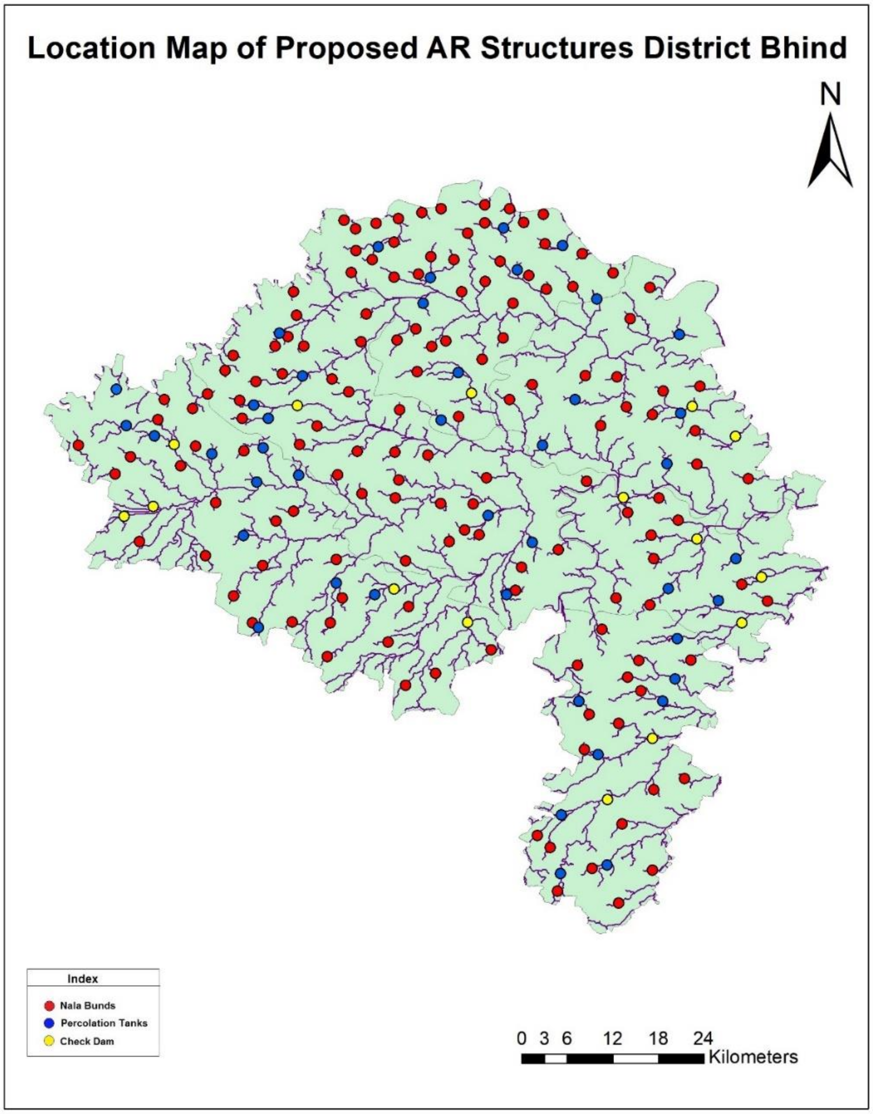


Figure 17 Map showing proposed Artificial Recharge structures in Bhind area, Madhya Pradesh

Table no. 17 Supply side management plan

Sl. No	District	Assessment Unit Name	Area (Sq. Km.)	Normal Annual Rainfall (mm)	Average Post-monsoon Water Level (m bgl)	Suitable Area for AR (sq.km)	no of Existing percolation tanks	no of Existing Check Dams	no of Existing nala bunds/cement plugs	no of Existing village ponds/ Farm Ponds	no of percolation tanks Proposed	no of Check Dams	no of nala bunds/ cement plugs	no of village ponds/ Farm Ponds
1	Bhind	Ater	612	754.00	13.88	612.00	2	16	15	0	36	309	310	169
2	Bhind	Bhind	762	754.00	13.83	762.00	0	13	59	0	47	392	346	94
3	Bhind	Lahar	656	754.00	18.03	656.00	12	34	593	0	29	314	0	151
4	Bhind	Mehgaon	969	754.00	13.79	969.00	1	20	18	0	59	495	497	193
5	Bhind	Ron	432	754.00	17.68	432.00	0	4	4	0	27	225	225	68
6	Bhind	Gohad	1028	951	4.84	0	-	-	-	-	0	0	0	0
	District		4459		13.675	3431	15	87	689	0	198	1735	1378	675

7.2. Demand Side Management

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

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

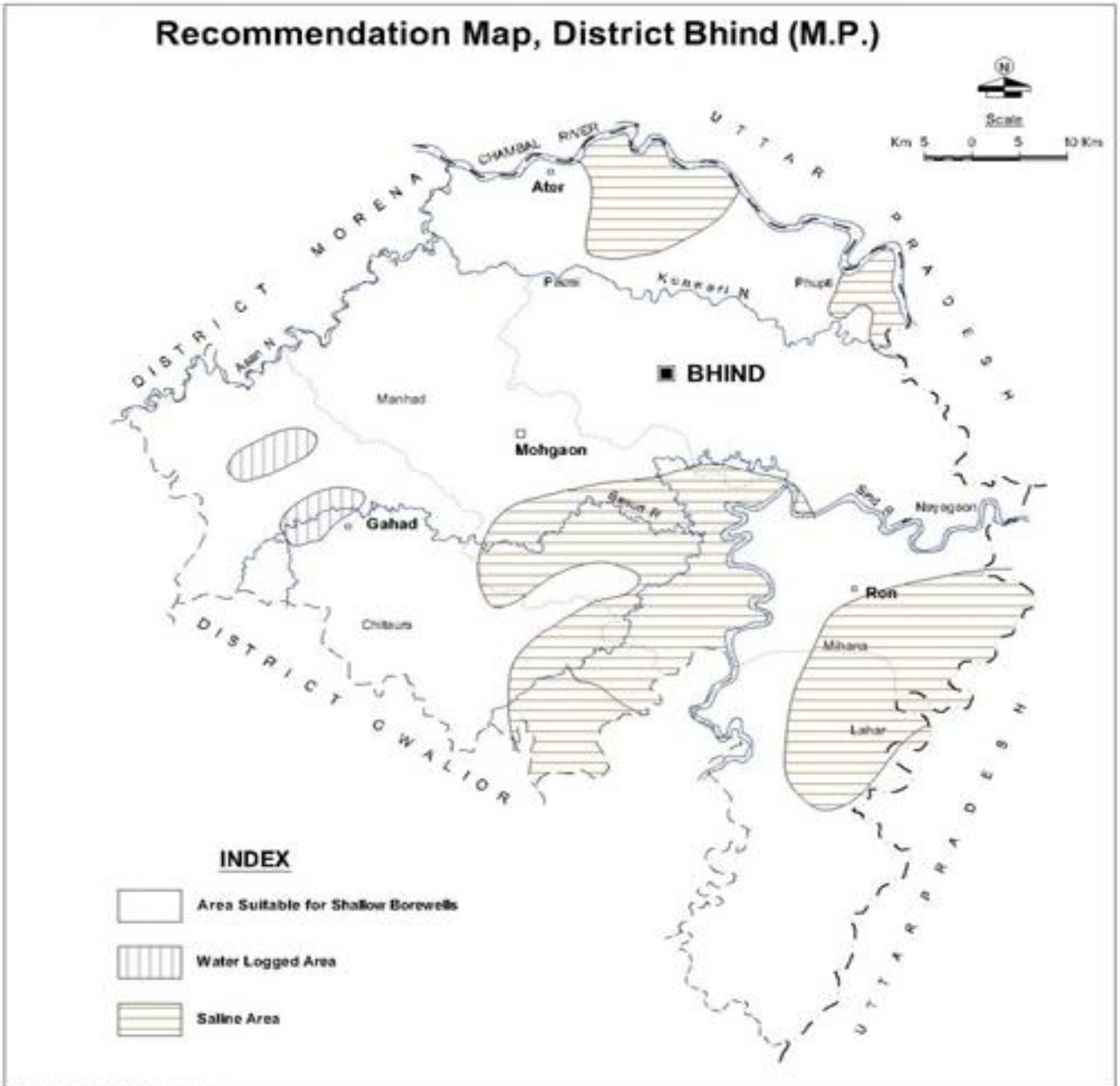
1. It enables farmers to grow crops which would not be possible under conventional systems since it can irrigate adequately with lower water quantities.
2. It saves costs of hired labour and other inputs like fertilizer.
3. It reduces the energy needs for pumping, thus reducing energy per ha of irrigation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

Adoption of Sprinkler irrigation techniques would save 20% of gross ground water draft for irrigation. Also, the 60% of additional recharge created by construction of artificial recharge structures can be utilized to increase the total cropping area, thereby enhancing the productivity and economy of the district. A summarized table for the demand side management is included in the Table no.18.

7.3. Management plan for Ground water Development

The stage of ground water extraction of the district is 32.41% (GW resource 2020) and about 46 % area is irrigated of total area of the district. Therefore the ground water extraction may be enhanced in all the blocks of Bhind district. The south-western and southern parts of the district covering blocks of **Gohad** and **Mihona** identified for central sector/state schemes like **PMKSY** as these areas having water level less than 15 mbgl during pre-monsoon 2021, normal annual rainfall is more than 750 mm. (GW Resource 2020) and stage of GW extraction is less than 60% (criteria for Pradhan mantra krishi sichai yojna) .Presently about 50% area of the total area of these blocks are irrigated through all sources. The suitable ground water abstraction structure recommended for the area is shallow tube wells. It is also estimated that a tube well of 3 lps discharge can irrigate approximately 3 hec. of land. As per the PMKSY report available in the GoI website, the unirrigated irrigated area in Bhind district is 163746 hecatare. Assuming that a tubewell in the area can irrigated on an average 3 hectare, the total number feasible tubewells for irrigation is around 54580.

Fig.17 Area Recommended for Shallow Tubewells.



7.4 Management plan for Water-logged areas

The waterlogged areas in small pockets of the Gohad & Mehgaon blocks should be paid more attention where canal irrigation facilities are available. The following measures are recommended in these areas: -

1. Lining of canals
2. Conjunctive use of surface & ground water.
3. Runoff of surface water through nadi & nalas should be made easy by cleaning & maintaining of slope of the stream channels.
4. Changing of cropping pattern by growing the high water requirement crops.

In the saline ground water areas the following measures are recommended:-

1. Depending on the agro climatic condition, rainfall pattern and quality of ground water in ground water salinity areas tolerant & semi tolerant crops are suggested.
2. Drip and sprinkler irrigation, despite of limitation have better control over salinity.
3. Use of saline water should be avoided during the germination and flowering stages of plants as far as possible.
4. In areas where canal irrigation is available the saline water can be blended for greater choice of crops i.e. conjunctive use of water should be in practice.
5. Gypsum can be used to improve the sodic soil.

7.5. Post-Intervention Impact

The expected outcome of the proposed interventions from both supply side and demand side has been described in Table no20. It can be envisaged that the stage of ground water extraction for the Bhind district, would increase to **33.31%** as compared to the present stage of ground water extraction of **32.40**% after implying and successful implementation of proposed interventions.

Table 18: Post-Intervention Impact Bhind District, Madhya Pradesh

Block	Net GW Availability (MCM)	GW Draft for Irrigation (MCM)	GW Draft for Domestic & Industrial (MCM)	Gross Draft (MCM)	Stage of GW extraction %	Saving by Sprinkler in MCM	Additional recharge created by AR(MCM)	After intervention of AR Structure Net GW AvL.(MCM)	After intervention of AR Structure & utilisation of 60% of additional GW created. (MCM)	Draft after sprinkler & additional area created for agriculture (MCM)	Stage of GW extraction W/O GW use for additional Area Irrigation%	Additional area irrigated by GW after intervention (Sq.Km)
Ater	**140.36**	**43.7**	6.570	50.270	**35.815047**	8.74	21.66	162.0200	12.9960	54.53	**33.65**	32
Bhind	134.15	**36.53**	5.640	42.180	**31.4424152**	7.31	26.97	148.40	16.1820	51.05	**34.40**	40
Lahar	**121.43**	**36.7**	4.670	41.370	**34.069011**	7.34	23.22	230.25	13.9320	47.96	**20.83**	35
Mehgaon	**207.03**	**53.52**	7.760	61.270	**29.5947447**	10.70	34.30	241.33	20.5800	71.16	**29.48**	51
Ron	**89.35**	**2.78**	3.32	24.100	**26.9725797**	0.56	15.29	104.64	9.1740	14.72	**14.07**	23
Gohad	**195.14**	**62.22**	6.180	68.400	**35.0517577**	12.44	0		0	55.956		0
District	887.470	**253.45**	34.140	287.590	**32.4056024**	50.69	121.440	886.640	72.864	295.364	**33.31**	182

CONCLUSIONS AND RECOMMENDATIONS

- Bhind district is located in the northern part of the state of Madhya Pradesh and occupies an area of 4459sq km. and recharge worthy area is **4459** sq km.
- **More stress on Groundwater 62 % area is irrigated by Ground water while 36 % area is irrigated through surface water in the district.**
- For a fertile and prosperous district like Bhind, management of ground water is of utmost necessity. Though, all the blocks of the district are showing safe category of ground water extraction, but there is need for regulation of indiscriminate boring and withdrawal of ground water on scientific manner.
- Average DTWL in the district is around 11 mbgl. In general rise in water level has been observed in the observations wells in the district. The average rise in the region is about 2.50 m.
- The overall ground water quality of Bhind district is good.
- In general the alluvium aquifer is having prolific yield. The ground water exploration carried out in the area reveals that more than 50% of the wells are having yield of more that 5 lps, maximum being 54 lps.
- As per the Dynamic Ground Water Resource Assessment Report (2020), there are six assessment units (blocks) in the district and all the blocks falls under safe category. The **Annual Extractable Ground Water Resource** in the district is **88746.59** ham and ground water extraction for all uses is **28758** ham, making stage of ground water extraction 32% as a whole.
- As per the Management plan prepared under NAQUIM of all the Block of Bhind District, a total number of 198 Percolation Tanks, 1378 Nala Bunds, 1735 Check Dams and 675 farm ponds have been envisaged.
- The ground water extraction may be enhanced in all the blocks of Bhind district. The block of **Gohad** and **Mihona** identied for central sector/state schemes like **PMKSY,** as these areas fulfilling the criteria.
- The waterlogged areas in small pockets of the Gohad & Mehgaon blocks should be paid more attention where canal irrigation facilities are available. Water logging mitigation measures proposed in the area include lining of canals, conjunctive use of Surface and Ground water etc.
- Micro irrigation technologies such as drip and sprinkler systems are proposed as Demand side management measures in the area.

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