केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

AQUIFER MAPPING REPORT

Devas District, Madhya Pradesh

उत्तरी मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

Government of India

Central Ground Water Board

Ministry of Water Resources, River Development & Ganga Rejuvenation

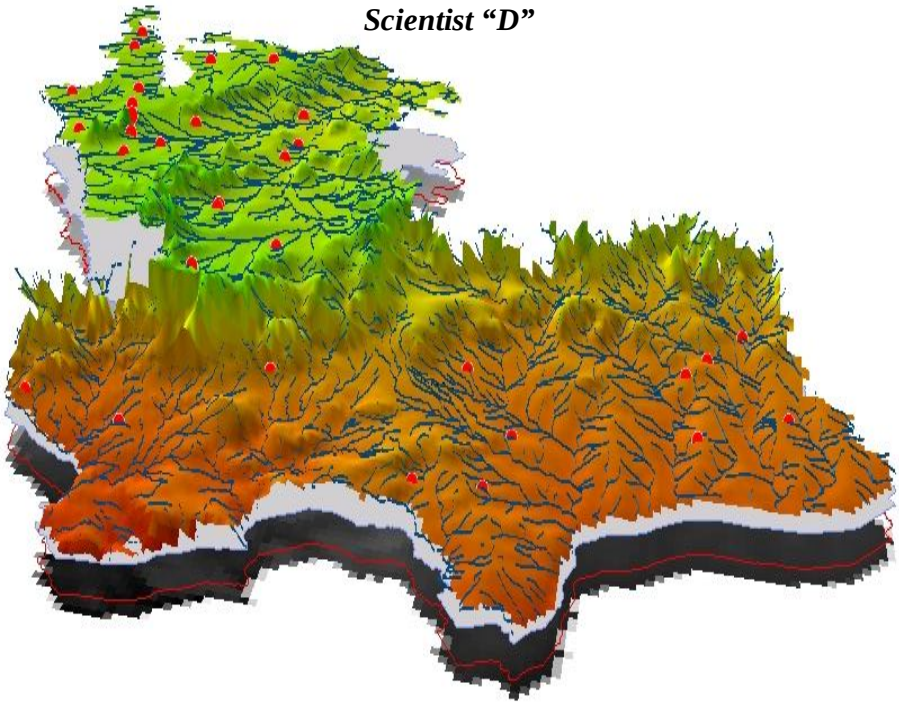
GROUND WATER MANAGEMENT PLAN OF DEWAS DISTRICT MADHYA PRADESH

(2015-2016)

By

Dr L. K. Mathur

Scientist "D"



National Aquifer Mapping Programme

Management Plan of Dewas District,Madhya Pradesh

North Central Region

August, 2016

National Aquifer Mapping Programme
Management Plan of Dewas District,Madhya Pradesh

CONTENT

CHAPTER-I
INTRODUCTION

1.0 Location :

The Dewas district lies in the central part of the state and covers an area of 7020.84 sq km. It lies between North latitude 22°17'00" & 23°20'00" and east longitude 75°50'00" & 77°10'00", falling in Survey of India topo sheet Nos 46M, 46N, 55A, 55B & 55F. The Tropic of Cancer passes through the district near Nemawar village south of Khategaon town. Dewas lies north-east of Indore, south-east of Ujjain and southwest of Shajapur. The city is located on the level plains of the Malwa plateau; to the south, the land rises gently to the Vindhya Range, which is the source of the Chambal and Kali Sindh rivers.

The district is divided into six Tehsils and six development Blocks. There are 1061 villages and 11 towns in the district.

Fig:1 Administrative Map

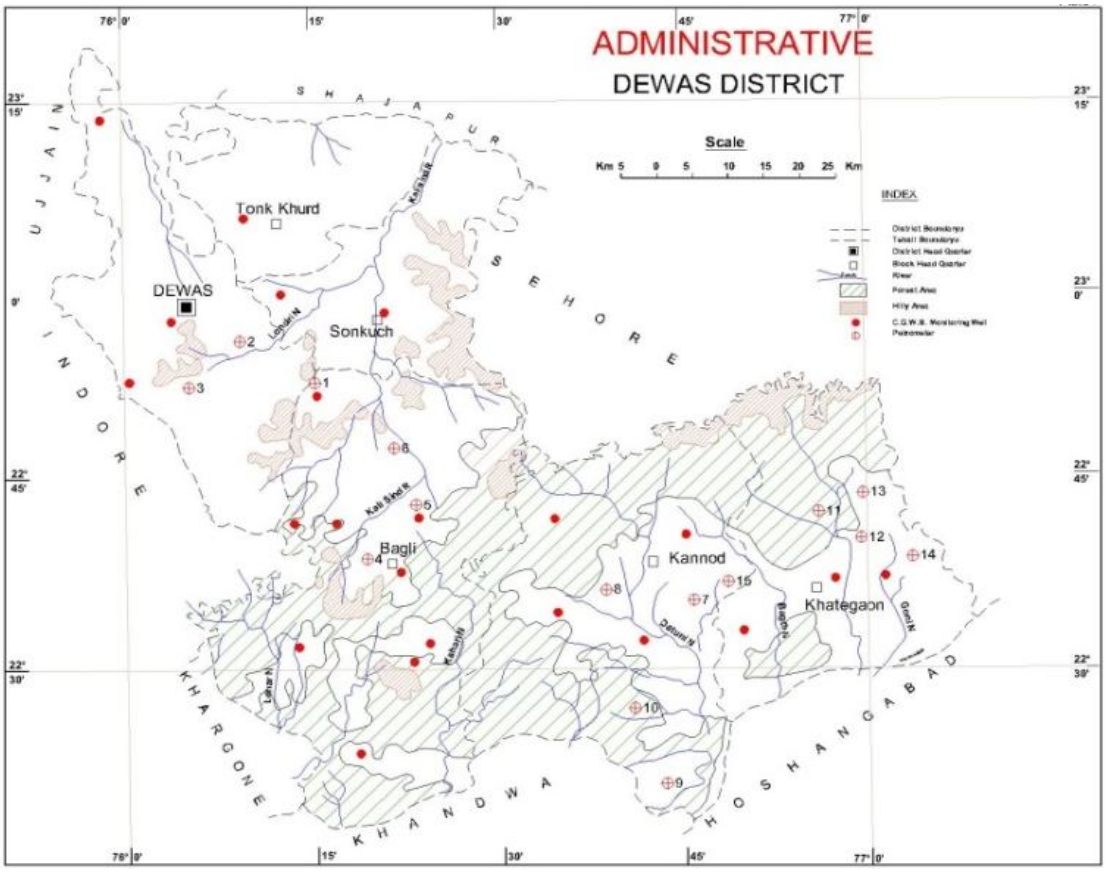


Table 1: Administrative Divisions, District Dewas, M.P.

S No	Block	Area (Sq Km)	No of towns
1.	Bagli	2045.40	3
2.	Dewas	1007.44	1
3.	Kannod	1463.00	4
4.	Khategaon	1145.00	1
5.	Sonkatch	681.00	2
6.	Tonk khurd	679.00	-
	TOTAL	7020.84	11

1.2 Objectives and approach:

The aquifer mapping study primarily depends on the existing data that areassembled, analysed and interpreted from available sources. The data gaps analysis carried out helped to generate data from data-collection activites such as BDR of exploration drilling, water level measurements and groundwater quality analysis done by CGWB & State Department . By analysising the existing data and the data generated, regional hydrogeological maps, thematic maps, water quality maps, cross-sections, 2-D and 3 –D aquifer dispositions and potentiometric maps were generated. The objectives of the Management plan is to define the aquifer geometry, type of aquifers, ground water regime behaviours, hydraulic characteristics and geochemistry of Multi-layered aquifer systems on 1:50,000 scale .

Aquifer Mapping can be envisaged as follows :

1. Data Compilation & Data Gap Analysis:

One of the important aspect of the aquifer mapping programme was the synthesis of the large volume of data already collected during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe an aquifer system. The data were assembled, analysed, examined, synthesized and interpreted from available sources. These sources were predominantly noncomputerized data, which was converted into computer based GIS data sets. On the basis of available data, Data Gaps were identified.

2. Data Generation:

There was also a strong need for generating additional data to fill the data gaps to achieve the task of aquifer mapping.

3. Previous studies:

Prior to this study, the groundwater hydrogeology has been studied only in separate parts with many areas left untouched. As a result, there was no hydrogeologic framework developed so as to understand the regional effects of groundwater development in the area .

4. Preparation of Plan;

Preparation of Block wise ground water management plan of the Dewas district that will guide the planers to manage the ground water resources in judicious manner and improve the ground water scenario of the district.

1.2 Rainfall& Climate:

The average annual rainfall of Dewas district is 1083 mm, based on average of 3 stations. Rainfall increases from west to east and is lowest in the southwestern portion. About 90 % of the rainfall takes place from June to September, only 5 - 8% takes place in the winter months and only about 2% in summer. It is only during the monsoon that surplus water for deep percolation is available in the district. The normal rainfall follows a normal distribution during the year.

The climate of Dewas district is semi- tropical, characterised by hot summer and well distributed rainfall during the south west monsoon season. January is the coldest month with the temperature falling as low as 2^{o} - 3^{o}C. The period from March to first week of June is the summer season. May is the hottest month when the temperature may go upto 45^{o}C.

1.3 Geomorphology & Soil Types :

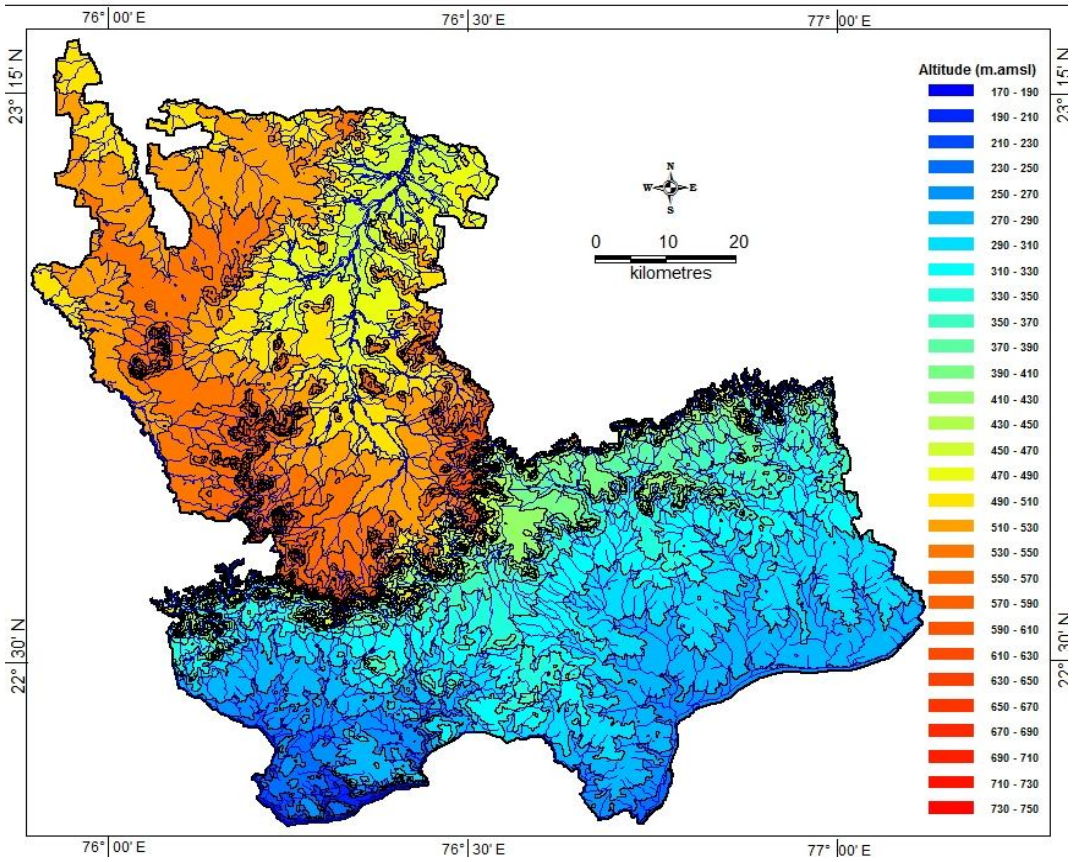
The district can be divided into four broad physiographic divisions (1) Dewas plateau (2) Kali Sindh Basin (3) Vindhyan Range (4) Middle Narmada valley.

The Dewas plateau extends over the north-western part of Sonkatch block and western part of Dewas block. This division is a part of the Malwa plateau with higher elevation in the north and plain land topography in the south. Chhoti Kali Sind and Kshipra rivers drain this region. Dewas town is situated on this plateau. The maximum elevation is 700 m amsl, north of Dewas town. A conical hill housing the shrine of Goddess Chamunda is located in Dewas town.

The Kali Sindh Basin is situated in the northeastern part of the district in a north-south column covering Tonk Khurd and part of Sonkautch blocks. The Kali Sindh river flowing in the centre forms its drainage system. This is the most fertile tract of the district.

The Vindhyan Hill Range passes through the middle of the district in an east-west direction forming a narrow strip. Kshipra and Kali Sindh rivers originate from north of this range, while the tributaries of the Narmada originatefrom south of it.

Fig:2 Physiography



The maximum elevation is 758 m amsl at Bhainsore and minimum is 456 m amsl near village Palasi, both in Bagli Block.

Middle Narmada valley division falls in the Malwa plateau and covers the southeastern part of the district. It covers the Khategaon, Kannod and southern part of Bagli blocks. The Narmada river flowing east-west forms the southern boundary of this division, as well as, of the district. The division is covered by extensive forests. It is a low lying area with a maximum elevation of 405 m amsl near village Serali in Kannod block and minimum 200 m amsl near village Kotmir in Bagli Block.

1.4 Drainage:

The district falls under two major drainage basins - the Ganga in the north and the Narmada in the south. The rivers are rivers of antiquity. They have broad, flat, shallow valleys

with low imperceptible gradients, because their channels have reached the base level of erosion. Vertical erosion has ceased and lateral erosion is taking place.

Fig.3 Drainage

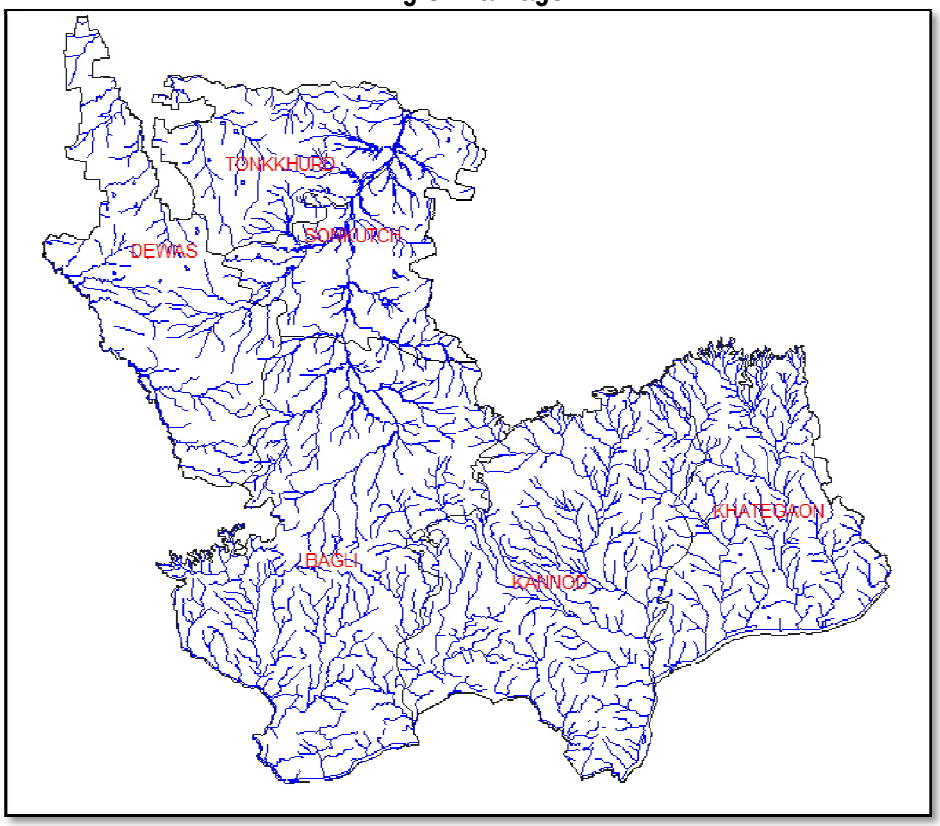
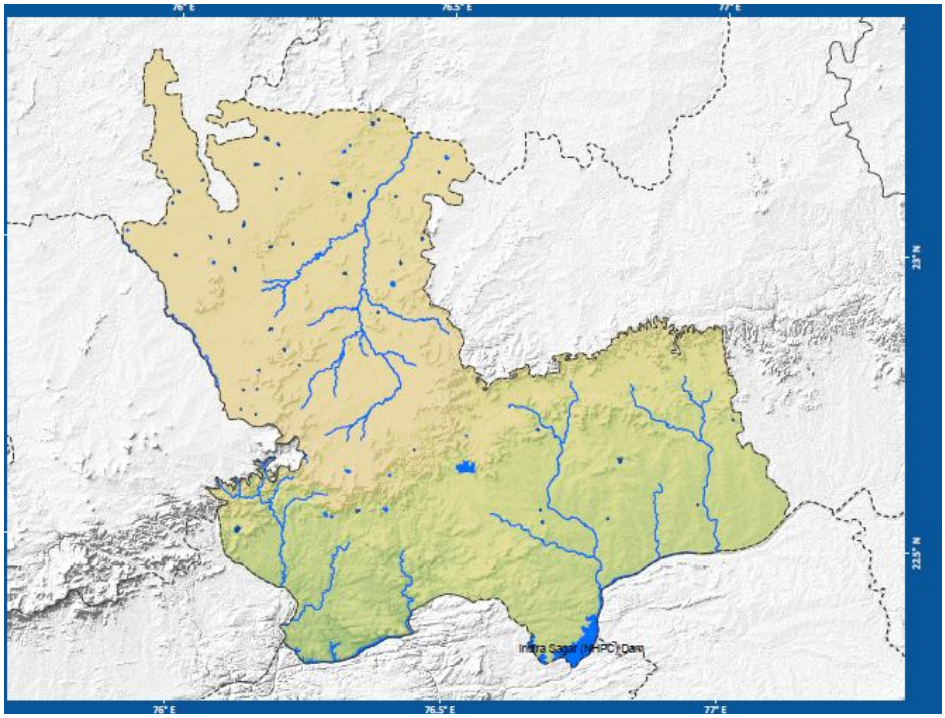


Fig.4 Water Bodies



1.5 Agriculture/Irrigation/Cropping pattern

As shown in table No 2 , Gross sown area of Dewas district is 202341 ha .

Table No.2; Gross Sown Area Of Dewas District

Area	Type of soil	Gross Area sown (ha) (2013-14)	Area irrigated by surface water (ha) (2013-14)	Area Irrigated by GW (ha) (2013-14)
Dewas Distict	Black Cotton soil, mixed soil, gravelly sandy soil and Red Loamy soil	202341	17422	184919

Table No.3: Area Irrigated by Different Source In Dewas District.

Block	Area Irrigated by Dug Well	Area Irrigated by Tube Well	Total Area Irrigated by Ground Water Area in Ha	Area Irrigated by Balram Talab	Area Irrigated by Canals	Total Area Irrigated by Surface Water Area in Ha
Bagli	13534	6186	19720	94	3794	3888

Dewas	14435	48495	62930	2496	402	2898
Kannod	7917	3426	11343	0	0	0
Khategaon	25369	31140	56509	1843	0	1843
Sonkatch	13822	5598	19420	800	563	1363
Tonk khurd	10310	4687	14997	7430	0	7430
Total	**85387**	**99532**	**184919**	**12663**	**4759**	**17422**

1.6 Prevailing Recharge practices

Artificial Recharge Studies by CGWB

The Central Ground Water Board, under the Central Sector Scheme, has been extending technical and financial support to the State Government for implementing practices in rural and urban areas of the district. Five such projects were taken up. Besides, a study for artificial recharge was also conducted in Bank Note Press located in Dewas city.

Artificial Recharge Structures in Londri watershed, Dewas district

The Londri watershed lies in the Sonkutch block of Dewas district. The central part of this watershed is occupied mainly by alluvium, which is primarily a flood plain deposit. Studies had indicated that in the alluvium area, out of 6.35 MCM annual utilizable recharge, the annual ground water draft is only 0.11 MCM. Owing to the valley gradient, there is outflow of water to the Londri river in the form of base flow.

The ground water fluctuation in the area is also high, ranging from 2.0 to 5.0 m. Conservation of base flow will provide additional ground water for irrigation and other uses during the lean season.

In the central part of the Londri river, an area of 34.5 sq. km is covered by alluvium. It occurs along the banks of the Londri river and its thickness generally ranges between 7.0 to 27.0 m. It is predominantly a flood plain deposit comprising sand, gravel, silt, *kankar* and clay. The alluvium is more clayey and shows wide variations in textural characteristics.

These structures have low cost design and demonstrate the applicability of various artificial recharge structures. The approximate distance between the structures is 700 to 750 meters. The salient features of the design are given below

(a) Gabion structure:- a gabion structure of length 24 m, height 1.20m and depth 0.90m has been constructed across the Londri river. The bottom width is 0.60 m and top width is 0.30 m. Boulders have been enveloped in a steel mesh. This structure helps in arresting the soil erosion, reducing the silt content of the surface runoff apart from recharging the phreatic aquifer.

(b) Boulder Check Dam:- A boulder check dam of length 13.10 m, height 1.0 m, slope1:3 m in the upstream side and 1:2 m in the downstream side has been constructed. The puddle filling is down to a depth of 0.6 m.

(c) Stop Dam:-A stop dam of length 24.40 m. top width 1.40 m and bottom width 2.30 m has been constructed across the Londri river. The depth of the dam is 1.50 m while the height is 0.70 m.

(d) Sub-surface dyke:- The length of the subsurface dyke is 26.20 m, depth 4.90 m, top width 3.0 m and bottom width 2.0 m. The puddle filling is of black cotton soil, which has been wrapped in a cross-laminated polythene sheet.

These artificial recharge measures have had a good impact in the area. Due to the construction of the subsurface dyke and related structures, the water level in the area has shown a rising trend. The water level in the existing boreholes increased by 0.30 to 2.00 m. Dug wells, which were drying up by January end have water column till the end of April.

Roof Top Rain Water Harvesting in Dewas city

Dewas is an important city of the Malwa region of the Madhya Pradesh. With coming of industries in the area, demand for water has increased many folds. During summer, water for drinking and industrial use in Dewas city is being supplied by tankers and was even brought by special water trains in the past years.

Due to industrialization, urbanization and overall development process of the city, the paved area has also increased, resulting in reduction of natural ground water recharge and increased rainfall runoff.

Realizing the gravity of the situation, the State government intiated management aspects of ground water through **'Bhujal Samvardhan Mission'** to emphasize mass awareness about water conservation and artificial recharge and executing schemes of artificial recharge through peoples' participation.

In Dewas city and surrounding areas, 1000 houses having service boreholes were selected where the users agreed to implement rooftop rain water harvesting. The roof top rainfall was diverted to the borehole via a drainage pipe. The water of the first rain was allowed to go through the flush drain. An online filter was fitted on the drainage pipe and the outlet of the filter was connected to the borehole.

The filter is of a cylindrical shape having a diameter of 200 mm. This filter is fitted on the drainage pipe with a reducer of 100 mm diameter. There are three wire mesh screens at the inlet, middle part and the outlet. The filter is filled with sand, gravel and pebbles in a graded manner. The outlet of this filter is connected to the borehole. In between, there is an opening with a cap for inspection as well as chlorination of water, if required.

It has been estimated that a recharge of 50,000 m^3 of water was recharged and an area of around one sq. km was benefited (the above figures are for the year 2001 during which period Dewas had a deficit rainfall of around 40%). There was a marked increase of water levels in the bore wells (3-5 m) and the ground water abstraction structures showed increased sustainability. Moreover, there was a perceptible increase in the quality of ground water. Similar figures have been reported from places outside Dewas city where the filter was installed.

Construction of Recharge Shafts in Dewas district

In Dewas district, it was observed that there were a number of dug wells which were dry or had deep water levels, in spite of having a village tank nearby. This condition was attributed to the

deposition of a non-permeable layer at the bottom of the tank, which proved to be a hydraulic barrier between the surface water and the phreatic aquifer. This layer was to be punctured by a recharge shaft providing a connection between the surface water and the phreatic aquifer. As the existing tanks were being used by the villagers for 'nistar' purposes, the shafts would be constructed at 50% RL of the Full Tank Level (FTL). Thus, only 50% of the water would be recharged and 50% would remain in the tank for 'nistar' purposes. Construction of recharge shafts in two tanks viz. Harnawada in Tonkkhurd block and Mendkichak in Dewas block was initially proposed. After that Polay and Agrod in Tonkkhurd block and Randankhedi in Dewas block were selected. Total No of-14 Shafts were constructed.

Artificial Recharge Studies in Dewas Bank Note Press Area

Central Ground Water Board has also extended technical know-how to Bank Note Press authorities in Dewas city for recharging ground water. The Bank Note Press (BNP), which is an undertaking of Government of India, is situated within the municipal limits of Dewas city. It covers an area of 1.95 Sq.km and is situated between elevations 539 and 543 m amsl with a gentle slope towards south west and north east. Thus, a NW-SE water divide runs through the BNP and divides semi-perennial Shipra in the west and Choti Kalisindh in the southeast.

In the BNP premises, around 32 boreholes have been drilled within the depth range of 80 to 150 m. The large number of bore holes in close proximity to each other, and continuous pumping without consideration to the duration of pumping and safe pumping rates has resulted in dewatering of the first and second semi-confined aquifers occurring within the depth of 40 to 70 m.

Hydrogeological studies in and around the BNP complex revealed that there are aquifer systems within the depth range of 527 to 500 m amsl, which had dried up. This was also confirmed through slug tests conducted on a dug well and a defunct tube well.

The only suitable and appropriate method of artificial recharging in the area is to inject water through conduit pipe down to the aquifer at the required depth. In view of the situation in the BNP complex, storm water or surface run off from the ground catchments was managed in such a way that the arrested water found its way through injection wells constructed in recharging pits with inverse gravel sand filter. These structures are basically low cost with simple construction details to facilitate downward journey of water to the aquifers within the depth range of 27-33 m.

Roof Top Rain Water Harvesting in District Hospital Dewas city

Total roof area of the Hospital building is 3850 sq.km, where as normal annual rainfall is about 1045 mm, the total water available for recharging works out to 4023 cubic meter. Roof Top Rain Water of Hospital building passes through Filter Pit and then poured into Dug Well. Depth of dug well is 11m.bgl and diameter is 4.80 m.

Demonstrative Project for Artificial Recharge –"Dewas Watershed"

Under the Central sector Scheme of CGWB one Demonstrative Project "Dewas Watershed" is taken up with Public Health Engineering Department, Dewas, Madhya Pradesh Government.

Ministry of water resources has financed Rs 49.06 Lakhs to construct various artificial recharge structures in the Upper Reaches of Choti Kalisindh River, under this project Stop Dam –11, Gabion-10, Recharge Shaft –01,Percolation tank –01,Sub-Surface Dyke-01 and Rooftop Rain water harvesting –02 is to be constructed and impact analysis is to be done in the year 2007-08.

CHAPTER-II
DATA COLLECTION AND GENERATION

2.1 Hydrogeology - Aquifer System and Aquifer Parameters

Archaean:

These rocks are basically hard and compact with no primary porosity. Ground water occurs in these in the secondary porosity created by weathering, jointing and fracturing. The intensity and depth of weathering and the frequency of joints and fractures control the ground water potential. These formations form poor to moderate aquifers. The depth of weathered mantle varies from a thin film to about 15m in topographic lows. The joints and fractures close down below 25 to 30 m. Ground water occur under water table conditions. These rocks mostly support dug wells with a few tube wells at some places. The tube wells yield 1-2 lps for considerable draw downs. The dug wells range in depths between 5 - 15 m and 2- 8 m in diameter. Open wells yield about 8 lps on an average for about 2 - 3 hours of pumping.

Bijawar:

These rocks are impervious and devoid of joints and fractures. The weathering in these rocks is limited to the upper surface only between 10 to 25 m. Ground water occurs in the weathered portions under water table conditions with limited potential. Dug wells are generally constructed with depths between 8 - 16 m and diameters of the order of 3 - 8 m. The open wells yield about 1 lps or less.

Vindhyan:

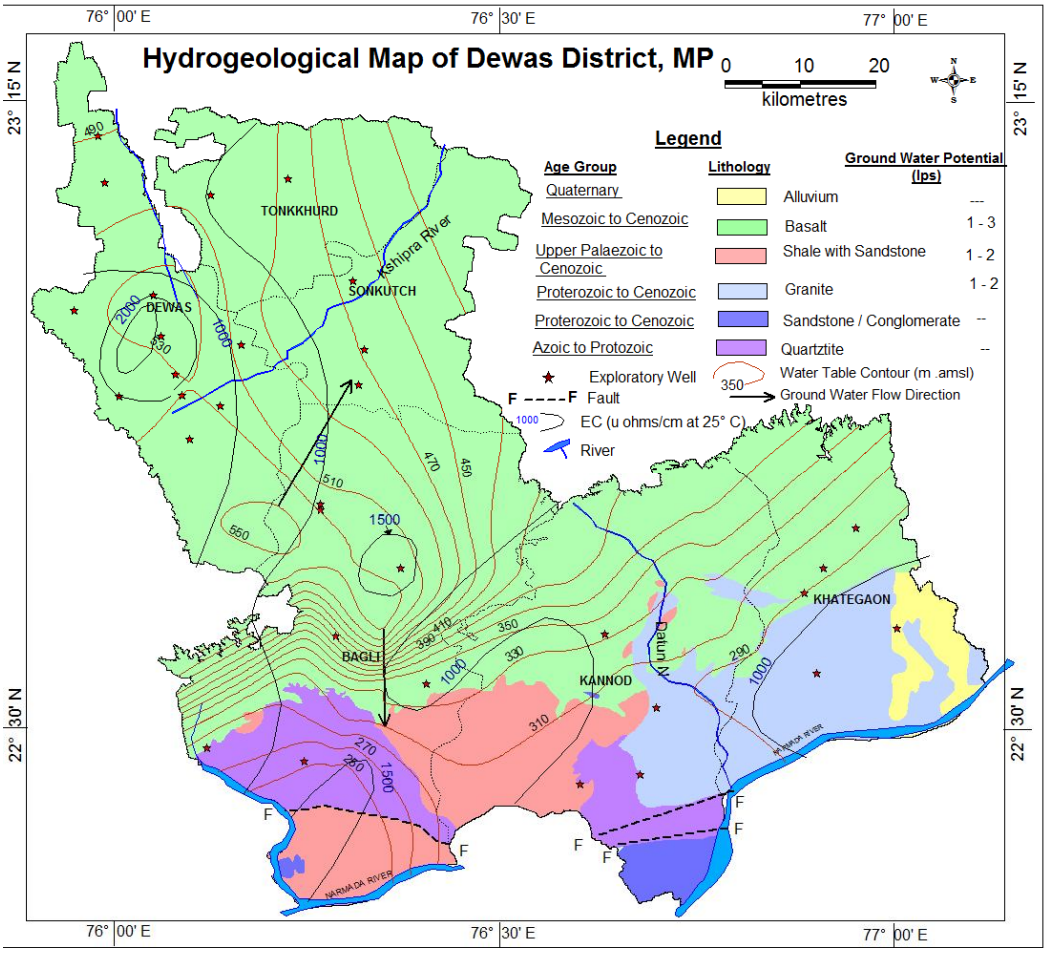
The Vindhyan sandstones have primary porosity, but this depends on the degree of compaction. It could vary from impervious to as high as 30%. Hence again ground water availability is controlled by secondary porosity generated by weathering, jointing and fracturing. Lineaments and their intersections are holders of ground water, which occurs under water table conditions. The open wells may yield about 1lps or less. **Bagh Beds:** These form unconfined aquifers when the sandstone and conglomerate are rendered permeable due to secondary porosity. But as these formations occupy a very small area in the district they are not significant.

Deccan Trap:

These form the most important aquifers due to the large aerial extent in the district. The district is covered by a large number of basaltic lava flows. The weathered, jointed, fractured or vesicular unit of each flow forms moderately potential aquifers. The zeolitic basalt when weathered also forms potential aquifers. The Red Bole is unproductive but forms a confining layer and also indicates the presence of a productive horizon below. Dug wells in this formation range in depth from 4 - 22 m having diameters between 2 - 11m. Ground water occurs mainly under water table conditions.

The discharges vary from 13 - 29 m^3/hr for small draw down, less than 1.7m. The specific capacity ranges from 26 - 170 lpm/m of draw down. It is high in highly weathered basalt, widely variable in weathered basalt and low in jointed massive basalt. The yields are mostly upto 5 lps, being higher, 10 – 12 lps in some cases; the yields are higher in Khategaon block. In multiple flow areas ground water is also found under semi confined to confined conditions sustaining tube wells

Fig2. Hydrogeological map of M.P.



Alluvium:

The alluvium forms good aquifers wherever sufficiently thick. But the occurrence of alluvium in the district is limited and thickness is only between 10 - 25 m. Ground water occurs under water table conditions.

2.2 WATER LEVELS

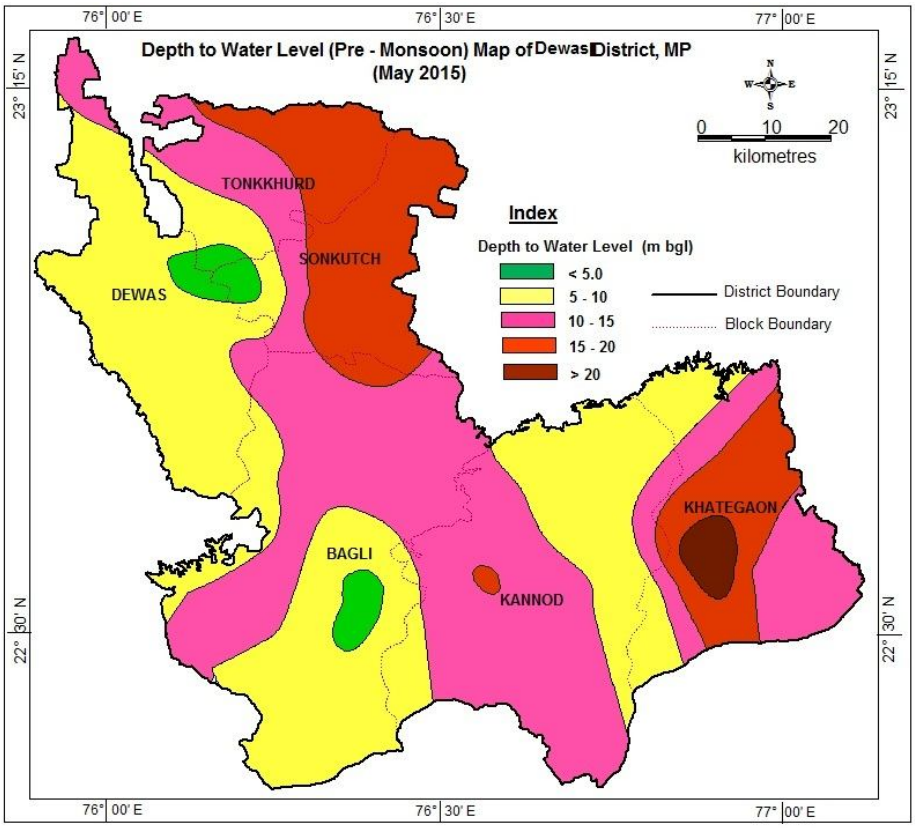
Ground water levels form a very important parameter of the ground water system, as these are its physical reflection. The groundwater balance expresses itself in the change in water levels; hence a continuous record is important and useful. CGWB has 16 National

Hydrograph Stations (NHS) and 11 Peizometers in Dewas district. Due to large-scale ground water development the dug wells are drying up.

Pre-monsoon (May 2015)

Depth to water level during pre-monsoon, 2015r ranged between 2.90m bgl at Pipri and 24.47m bgl at Bhonrasa. Water levels, in general fall between 5 - 20 m bgl. Shallow water levels of less than 5 m bgl occur in a patch in the south-western part of the district falling in Bagli and Kannod blocks. Deeper water levels, more than 20 m occur in Sonkach, Tonk Khurd and Dewas blocks. In Dewas, Sonkach and Tonk khurd blocks wells are fast drying up perhaps due to higher ground water development.During May 2015, pre-monsoon the depth to water level in Dewas districta as shown in Fig 3

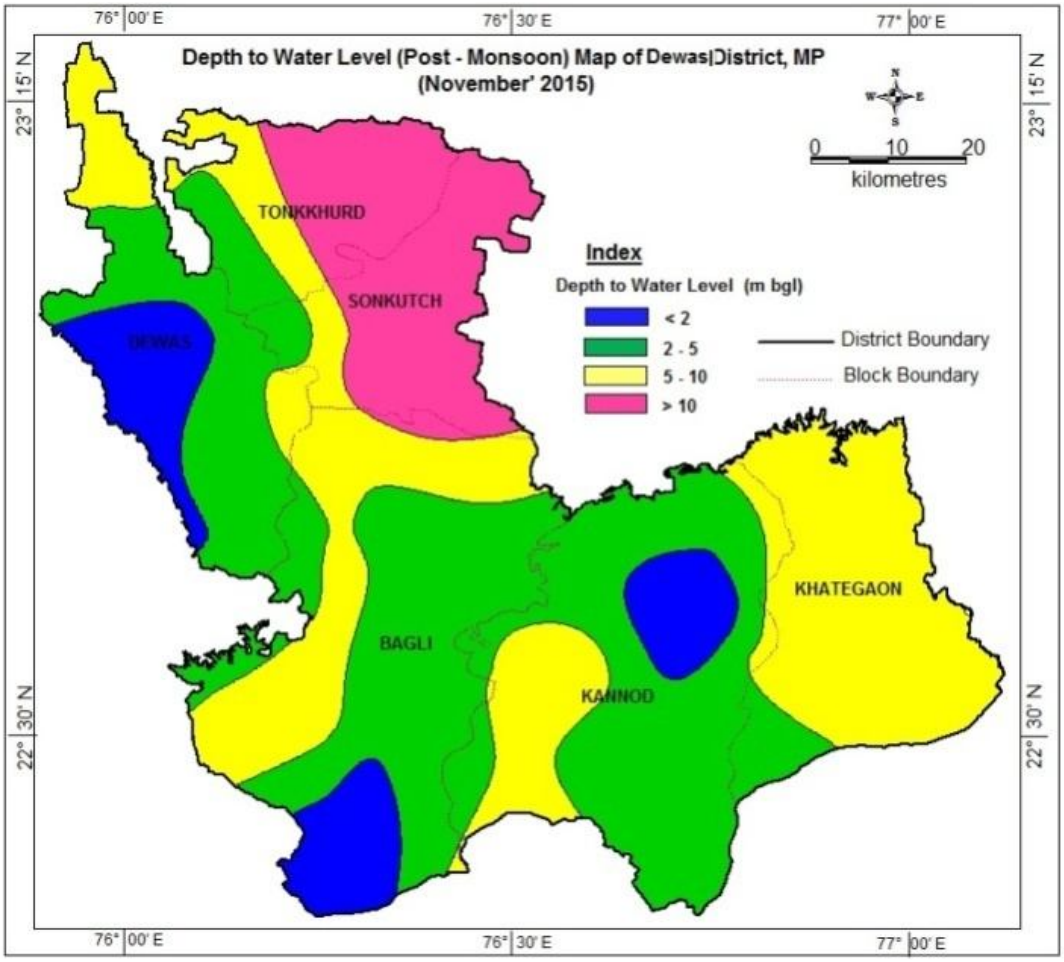
Fig 3. Depth to water Level(Pre-monsoon)



Post-monsoon (November 2015)

During post-monsoon period of the same year, November 2015, the water levels varied from 0.06m bgl at Dhayali to 15.19m bgl at Bhonrasa. The water level, in general lies between 2 to 10 m bgl during this period. Shallow water levels, less than 5 m bgl occur in a small part of the district covering parts of Bagli, Dewas,Sonkutch & Tonkkhurd blocks. Deep water levels above 10 m bgl occur in the northern part in Sonkach, and northnern part of Tonk khurd blocks as shown in Fig 5.

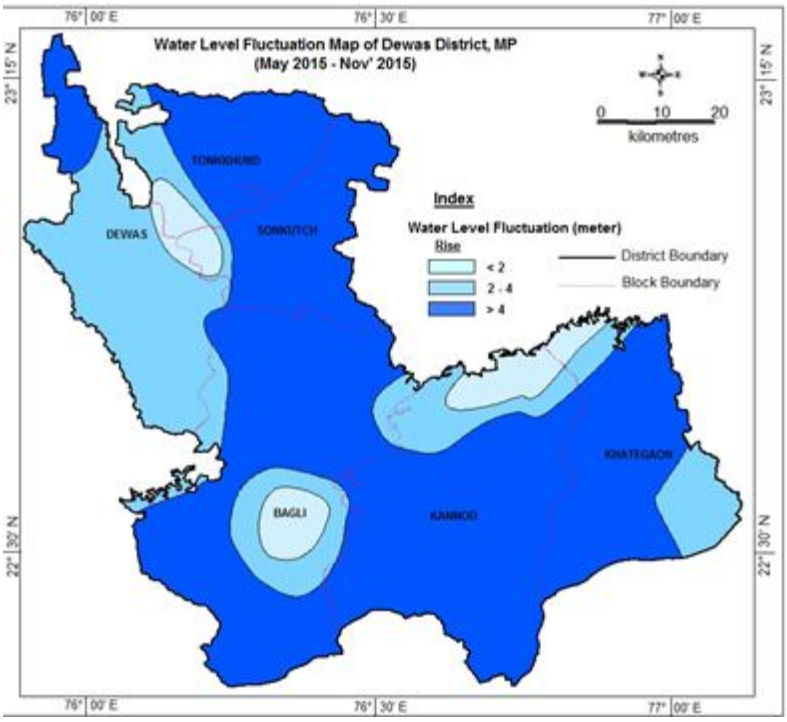
Fig 5. Depth to Water Level (Post-monsoon)



Water level Fluctuation (May 2015-Nov 2015) :

Major part of the district shows seasonal fluctuation more than 4 m and in small parts of block Dewas,Bagli, Kannod and Khategaon shows fluctuation less than 2m and in between 2-4m as shown in Fig 6.

Fig 6. Water Level Fluctuation



2.3 Exploratory Drilling:

CGWB under its exploration programme drilled 35 borewells and 11 Piezometers on the basis of litholog and aquifer perimeter sub surface lithology of the area is inferred and 3-D , Section and Fence of the district has been prepared .and the salient detail of these drilled bore wells is given in Table No2.

Fig 8. Exploration

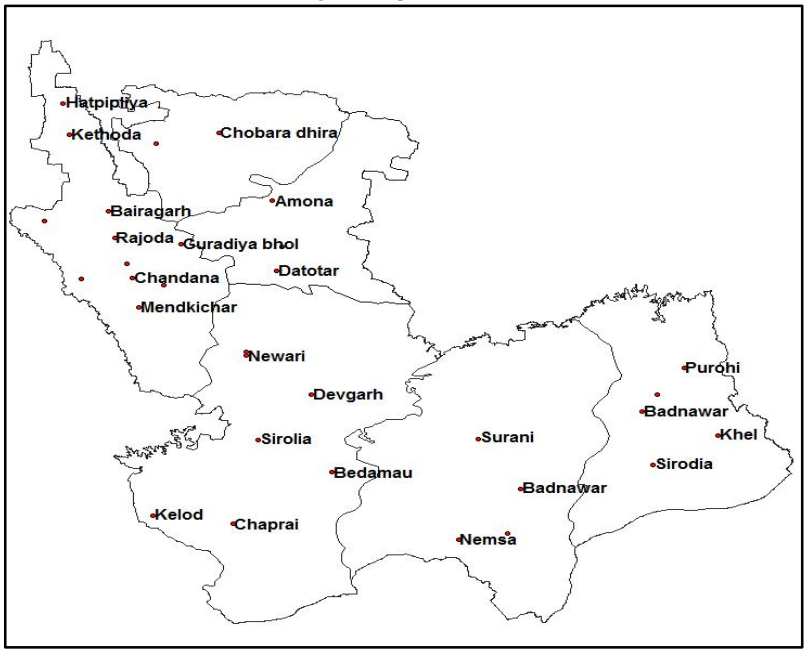


Table 4: Location of Exploratory Bore wells

Location	Longitude	Latitude
Amona	76.2500	23.1400
Badnawar	76.8946	22.6633
Bagli(D)	76.3400	22.6500
Bairagarh	76.0543	23.0182
Barkera	76.3266	22.9541
Badmau	76.4067	22.5553
Besum	76.6826	22.4468
Chandana	76.0000	22.9600
Chaprai	76.2497	22.4636
Chobara dhir	76.3500	23.0900
Datotar	76.1300	23.1600
Devgarh	76.3736	22.6924
Dewas(D)	76.0500	22.9500
Guraria Bhil	76.1000	22.8800
Hatpipliya	76.3000	22.9500
Kanad	76.1239	22.4792
Kelod	76.1100	22.8300
Kethoda	76.3400	22.9600
Khatamba	76.1400	22.9800
Khel	77.0139	22.6208
Lohar Pipalya	76.0000	22.9100
Mendkichak	76.0300	22.9600
Nemsa	76.6058	22.4357
Newari	76.2702	22.7615
Purohi	76.9611	22.7406
Rajoda	76.1000	22.9400
Sanwer	76.3400	22.9800
Sirodia	76.9113	22.5681
Sirolia	76.2897	22.6118
Siroliya	76.1400	22.8700
Surani	76.6367	22.6147
Tiwadia	76.9192	22.6921
Vijayganj mandi	75.9600	23.2100

Table-5: Salient Features of Exploratory Boreholes Drilled in Dewas District

S.N.	District Village	Longitude /Latitude	Month of Drilling	Depth (mbgl)	Aquifer zones (mbgl)		Formation	Discharge during drilling (ips)	SWL (MBGL)	Tested discharge (ips) HP	DD (m)	S.P. Cap L/m/m of d.d
1	**2**	**3**	**4**	**5**	**From**	**To**	**8**	**9**	**10**	**11**	**12**	**13**
1	Khatamba	76 08' 10" 23 57' 35"	Feb., 2002	200	105.06	110.01	Vesicular Basalt	0	92.9	0.9/5	4.07	13.26
2	Mendkichak		Feb., 2002	200	33.15	34.65	Vesicular Basalt	0	>100	1.0/5	0	0
3	Chandana		Feb., 2002	200	24.75	30.7	Weathered basalt	0.5	45	0.9/5	45.33	1.19
4	Lohar/Pipalya	75 59' 46" 22 54' 40"	Feb., 2002	200	44.71	47.55	Weathered basalt	0.78	39.51	5.28/5	7.92	40.02
5	Siroliya	76 08' 10" 23 52' 00"	Feb., 2002	200	64.61	76.96	Weathered basalt	0	>100	1.55/5	0	0
6	Kelod	76 06' 25" 22 50' 00"	Feb., 2002	143.57	23.46	31.36	Weathered basalt	0	89.28	0.2	0	0
7	Guraria bhil	76 06' 04" 22 53' 05"	Feb., 2002	200	63.6	73.2	W/ vesicular basalt	1	51.14	5-Jan	48.72	1.23
8	Rajoda	76 05' 45" 23 56' 40"	Feb., 2002	200	133.65	138.6	Vesicular Basalt	Meagre	63	0	0	0
9	Baiaghar	75 56' 50" 23 02' 00"	Feb., 2002	200	Dry	0		0	0	0	0	0
10	Vijayganj-Mandir	75 57' 30" 23 12' 50"	Feb., 2002	205.15	79.45	91.3	Weathered basalt	0	>100	0.75/ 2.5	0	0

11	Dattotar	75 57' 00" 23 14' 40"	March , 2002	196.25	101.25 126.95 161.6 191.3	116.95 136.85 166.55 195.8	Weathered basalt Vesicular basalt Vesicular basalt Vesicular basalt	0.14 0.78 2 2.5	75.89	2.0/ 5	7.7	155.8 5
12	Barkhera	76 07' 40" 23 09' 28"	March , 2002	200	24.25 64.52	30.18 70.42	Vesicular basalt w/vesicular basalt	0.5 1.5	42.78	1.5/2.5	47.54	1.89
13	Amona	75 15' 12" 23 08' 30"	March , 2002	200	97.65 147.15	112.5 162	Vesicular basalt w/vesicular basalt	0.5 1.5	29.45	2.3/3/ 5	69.76	2
14	Chobara dhir		March , 2002	200	86.37 146.72	92.27 151.67	Weathered basalt Vesicular basalt Vesicular basalt Vesicular basalt	0.2 0.4	65.38	0.3	0	0
15	Sanwar	76 20' 28" 22 58' 30"	March , 2002	200	81.44 106.19 133.34 160.64	91.34 111.14 140.84 185.39	Vesicular basalt Vesicular basalt Vesicular basalt Vesicular	0.14 0.58 1.51 2.14	64.9	2.0/5	31.35	3.82

							basalt Vesicular basalt					
16	Kathoda	76 20' 30" 22 57' 30"	March , 2002	200	107.15	112.1	Vesicular basalt	0.1	85.72	0	0	0
17	Hat Pipalya	76 18' 02" 22 57'03"	March , 2002	200	Dry	0		0	0	0		0
18	Newari				200	22-30	137-145	Vesicular basalt		2		
19	Sirolia				200	115-123	146-152	Vesicular basalt		5		
20	Kelod				200			Vesicular basalt		2.5		
21	Chaprai				150	23-27 92-97	69-80 120-140	Vesicular Fractured basalt		4.76		
22	Bedamou				175	34.5-41	46-55	Vesicular Fractured basalt		46		
23	Devgarh				150	19-25 129-142	92-97.5	Vesicular Fractured basalt		4.76		
24	Surani				150.5			Vesicular Fractured basalt		0.5		
25	Besum				151			Vesicular Fractured basalt		0.5		

26	Nemsa				165.9			Vesicular Fractured basalt		2		
27	Bechkna				101.6			Massive basalt		Dry		
28	Badnawar				170.8	25-29.3	122-133	Vesicular basalt/ sandstone	23.55			
29	Tiwadia				151.6							
30	Puroni				129.3	69.5-80.00		Fractured &Weathered Granite				
31	Khel				163.3	52.90-64.6	120-133	Fractured &Weathered Granite	11.8	0.14		
32	Sirodia				151.9	62.1-64.9 134.4-147.0	78.2-85.1	Fractured &Weathered Granite	12.1			

2.4 Ground Water Quality:

The electrical conductivity (EC) is a measure of total dissolved solids and hence of salinity. Ground water is in general fresh in the district, EC being below 2000 µ S /cm at 25°C except at Bhesuni village where EC is 2930 µ S /cm at 25°C. The EC is below 1000 µ S /cm in large parts of Khategaon and Kannod blocks and patches in the remaining blocks. The EC is higher 1000 - 1500 µ S /cm in four blocks and patches in Khategaon and Kannod blocks. EC between 1500 - 2000 µ S /cm occurs around Dewas, Matmor, Pipri and Kanthaphor. The data shows that the EC of deeper ground water varies from 621 - 4007 µ S /cm at 25°C. However, it is on the higher side of the range, being above 2000 µ S/cm in 55% samples in Dewas, Sonkatch and Tonk Khurd blocks.

Fluoride is high in 10% samples. Use of phosphatic fertilizers and bird droppings might be contributing to fluoride concentration in ground water. Low fluoride concentration is also a health hazard. A minimum of 0.6 mg/l of fluoride should be present in ground water. However, in 52% samples the fluoride concentration is too low. Hence, it may be said that fluoride problem, either way, occurs in a large area represented by 62% samples.

Nitrate pollution in ground water of Dewas district occurs around major towns Dewas, Sonkatch, Bagli, Kanthaphor and Satwas, besides Bhesuni and Pipri. It also occurs at deeper levels in some areas of Dewas block.. Ground water quality of Dewas District is given in Table No6

Table 6 : Ground water quality of Dewas district

Block	Location	Latitude	Longitude	pH	EC	CO3	HCO3	Cl	SO4	NO3	F
BAGLI	Bagli	22.639	76.347	7.42	1096	0	189	167	96	70	0.01
BAGLI	Bamohri	22.709	76.275	7.45	1480	0	195	163	170	176	0.07
DEWAS	Bhesuni	23.233	75.993	7.65	1130	0	24	351	45	3	1.35
BAGLI	Bhikupura	22.539	76.339	7.71	1090	0	226	184	86	12	0
SONKATCH	Bhonrasa	22.988	76.207	7.60	880	0	287	60	35	104	0.21
KANNOD	Bijawad	22.699	76.572	7.68	1368	0	281	89	250	85	0.41
DEWAS	Dewas	22.974	76.068	7.51	2418	0	281	387	230	240	0.22
KHATEGAON	Dhayali	22.546	76.800	7.35	550	0	244	28	16	23	0.67
KANNOD	Kannod	22.664	76.751	7.47	1249	0	293	213	70	15	0.36
KANNOD	Kantaphor	22.576	76.566	7.65	1295	0	311	174	68	95	0.34
BAGLI	Karnawad	22.730	76.229	8.14	895	0	140	78	85	165	0.15
BAGLI	Nevri	22.858	76.250	7.78	747	0	244	57	46	56	0.23
KHATEGAON	Pipilianankar	22.586	77.001	8.39	1000	90	305	32	49	192	0.44
BAGLI	Pipri	22.399	76.278	7.15	1210	0	348	145	80	40	0.97
BAGLI	Punjapura	22.546	76.370	7.90	1204	0	415	85	95	53	0.05
KANNOD	Satwas	22.534	76.682	7.95	887	0	317	71	31	63	0.44
BAGLI	Udainagar	22.538	76.204	7.38	2455	0	232	365	238	341	0.3

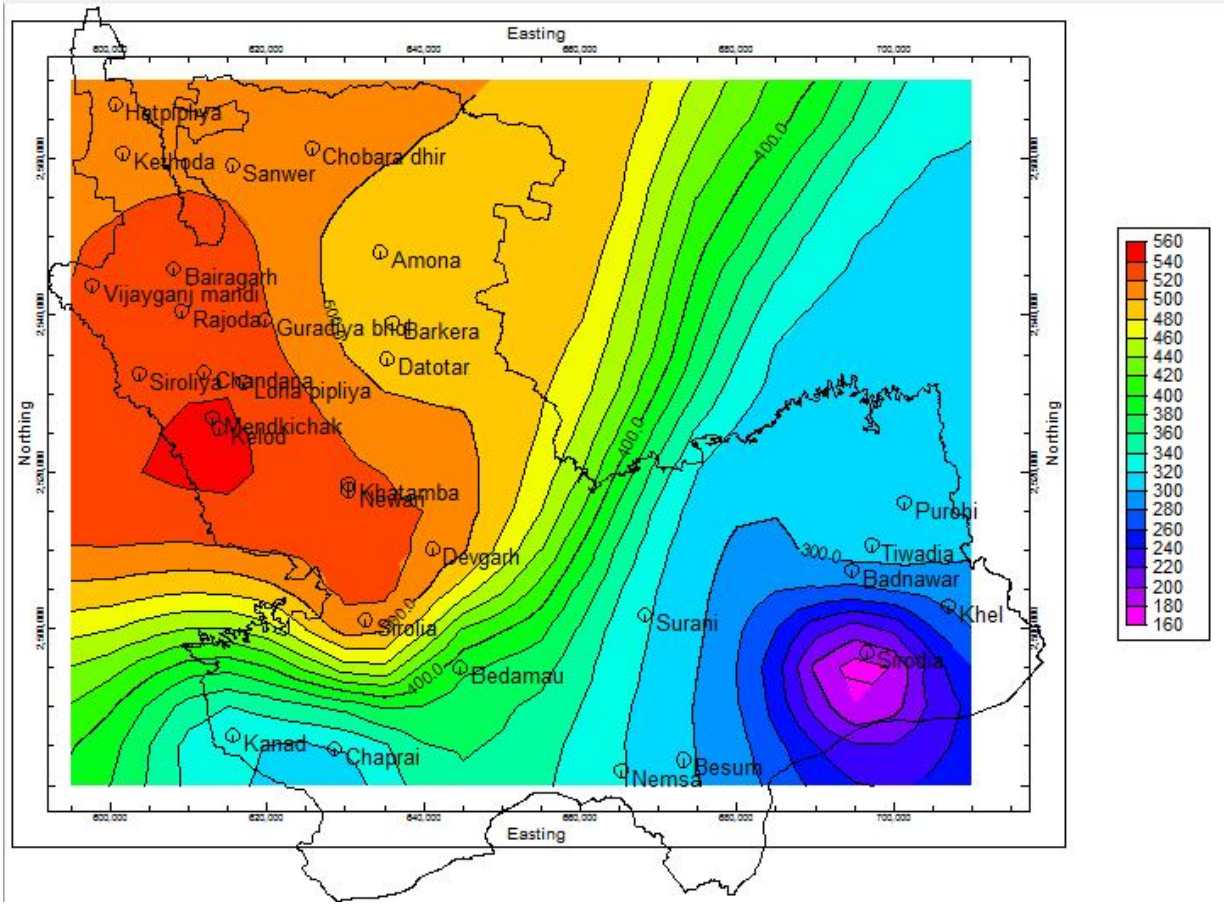
CHAPTER-III
DATA INTERPRETATION AND PREPARATION OF AQUIFER MAP

3.1 Data Interpretation:

Lithological data collected from CGWB bore wells, Piezometers,State ground water Piezometers etc. were studied and aquifer geometry and properties interpreted . Detail Lithologs of boreholes were studied and compressed datain form of Rockworks data sheet.

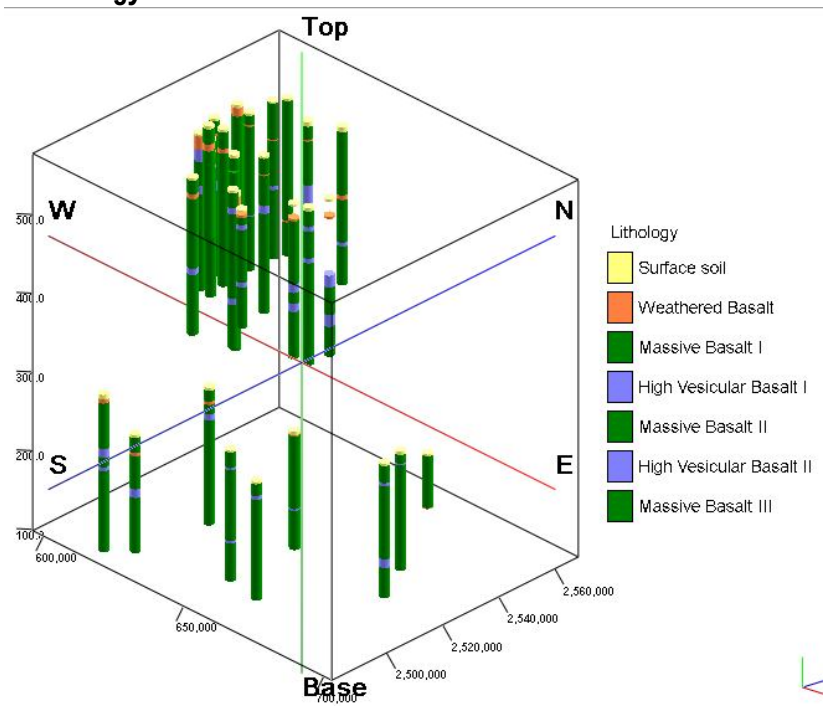
3.2 Lithological Model :

SurfaceElevation with Bore hole location Map

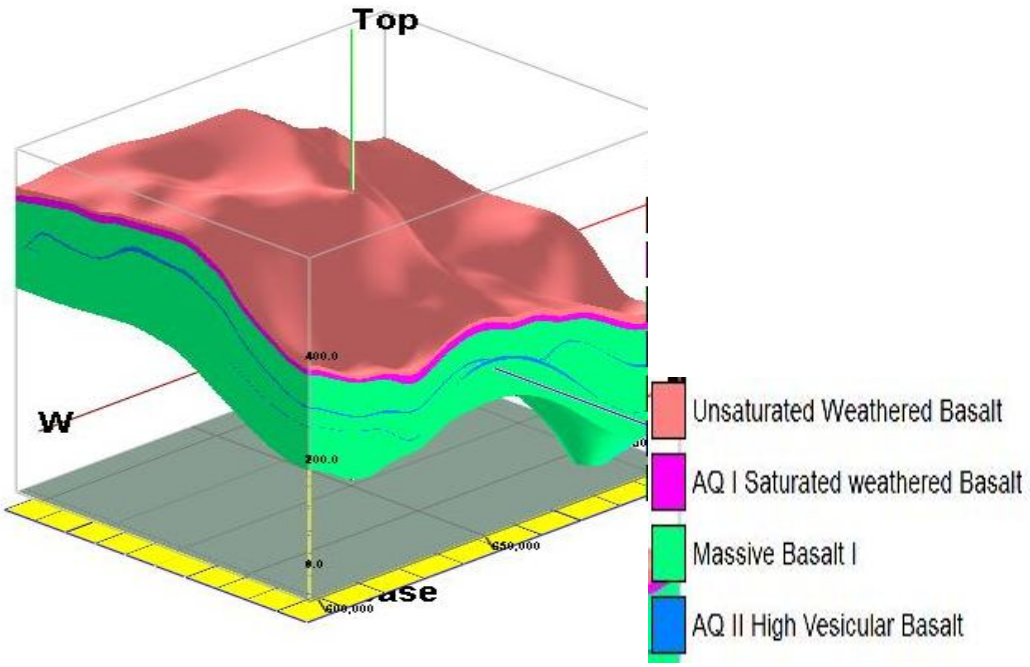


3.3 3D Cross section :

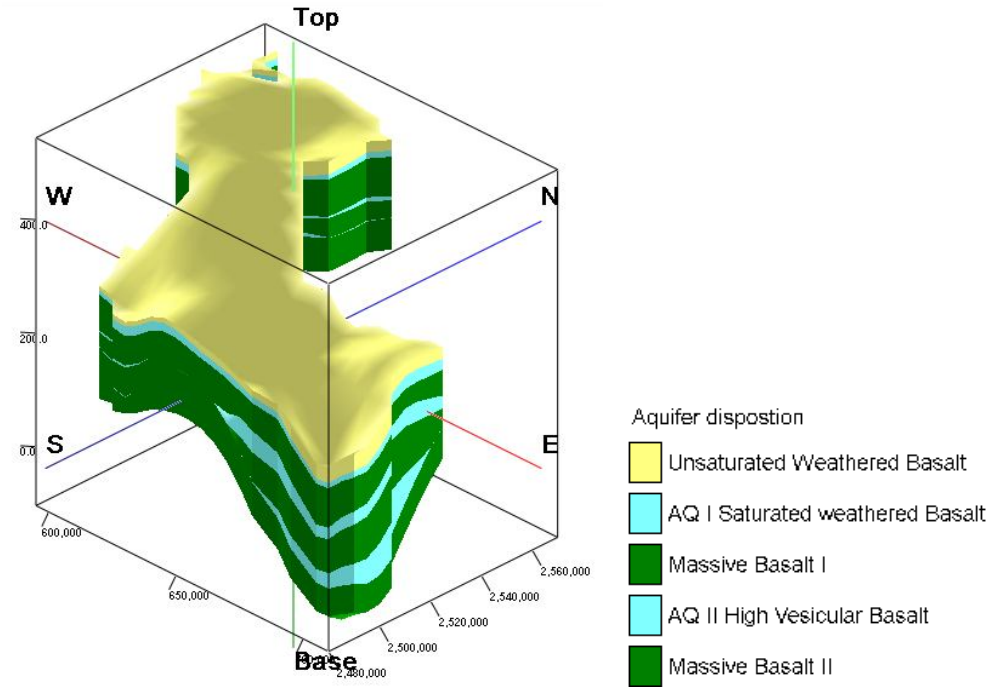
Borehole Lithology



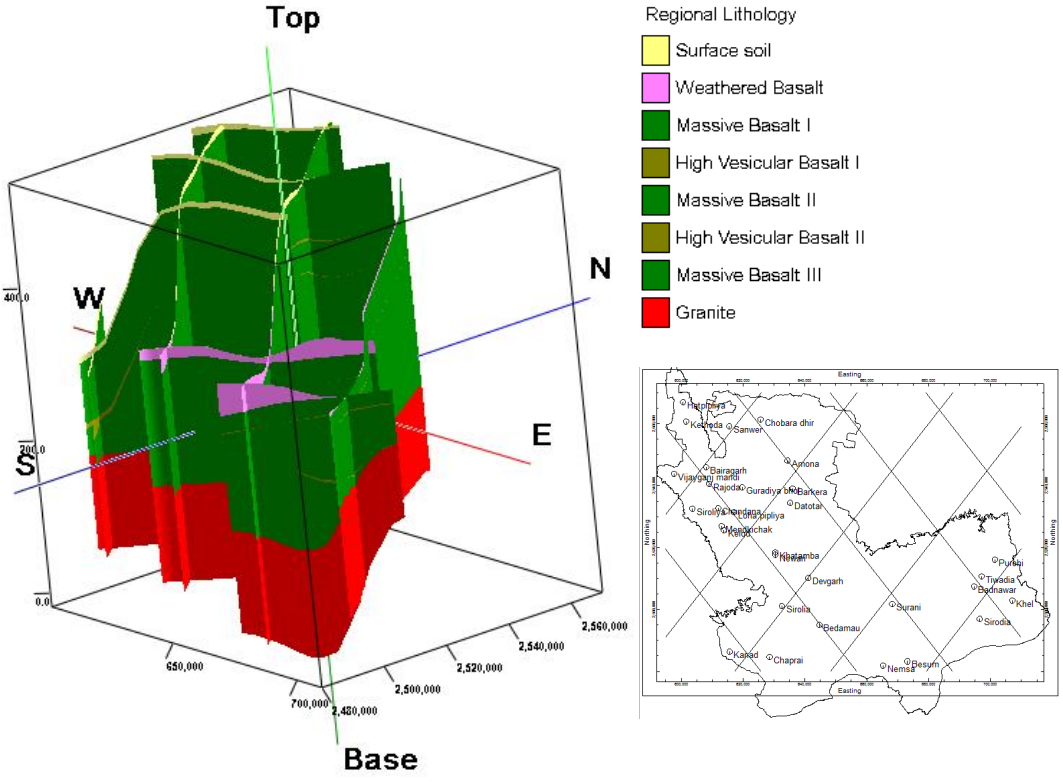
Regional Lithology



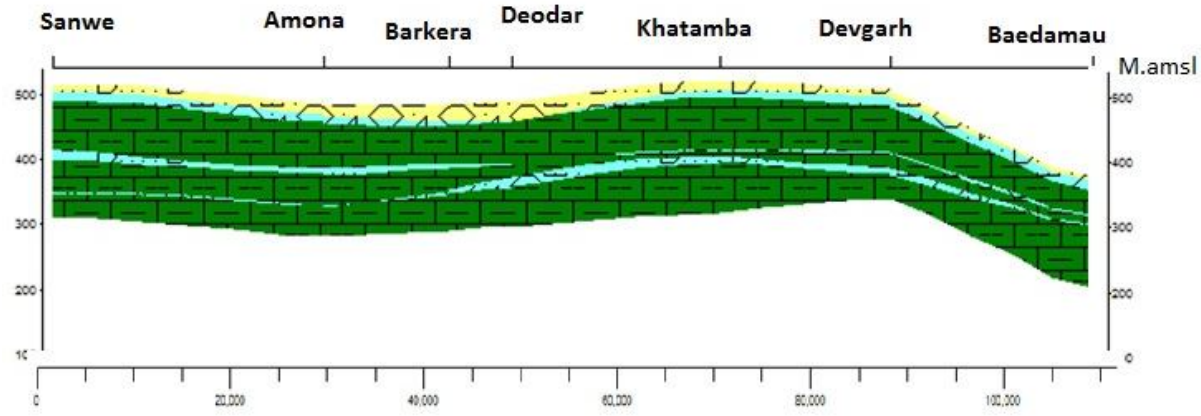
Aquifer disposition

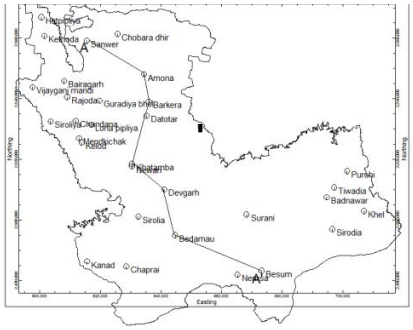


Fence Diagram: 3- Disposition of Lithology

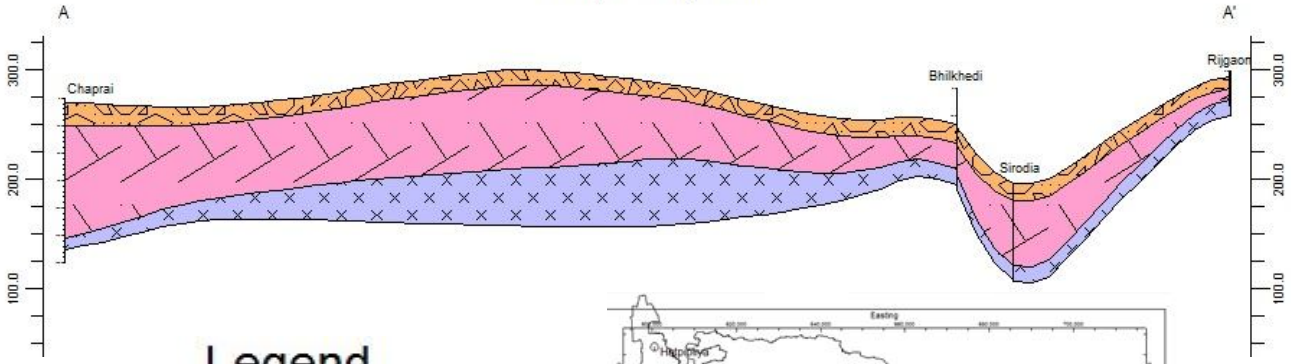


3.4 2D Cross section :





2D Aquifer Dispostion



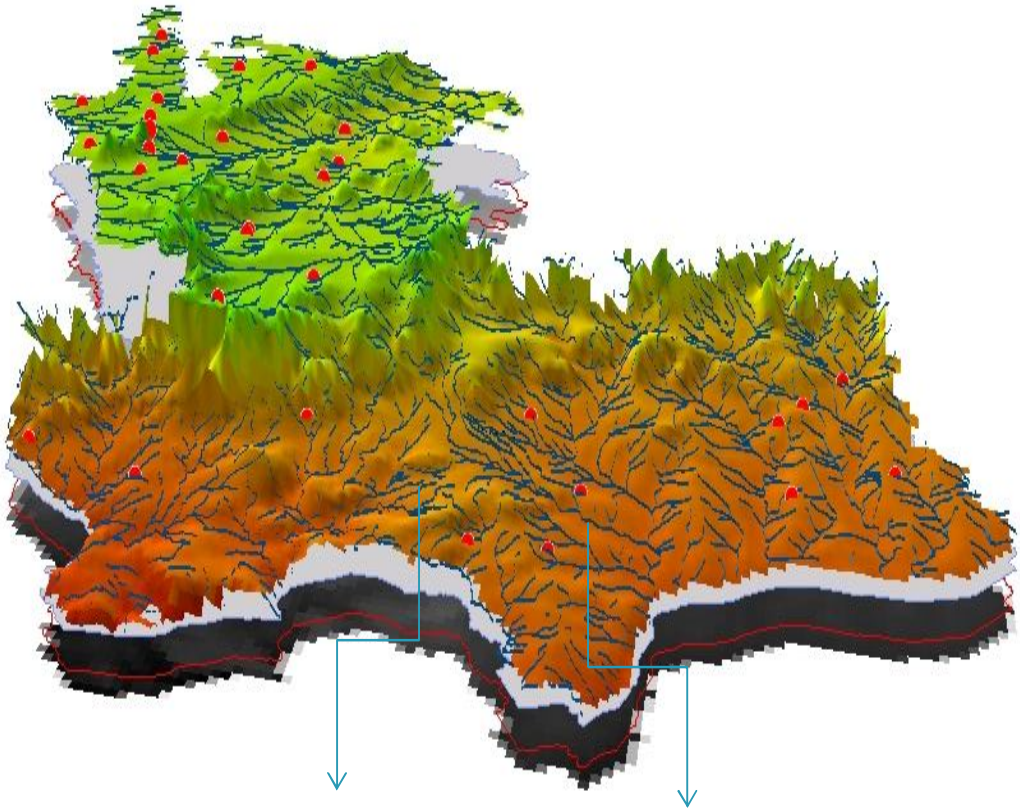
3-D interpretation of lithologs reveals that shallower and deeper weathered /fractured basalt is separated by red bole and massive basalt in the district. Water levels are observed at different depth of shallower as well as deeper fractured formation. The deeper fracture rechargesfrom the leaky upper formations also.The Table No 7.shows that shallow Piezometer/ Dug wells and deeper Piezometer water level.

Table No 7. Shallow Piezometer (S)/ Dug wells and Deeper Piezometer (D) water level.

Village	Pzmt.WL	Village	Dug Well .WL
Tonkkhurd(S)	8.24	Bhesuni	8.11
Dewas(S)	6.99	Dewas	7.11
*Dewas(D)	9.96	Alari	9.01
Sonkutch(D)	25.8	Bhonrasa	16.73
Sonkutch(S)	26.77	Matmore New	10.92
*Hatpipliya(S)	15.02	Nevri	12.07
Bagli(D)	26.34	Karnawad	14.91
Bagli1	11.53	Bamohri	10.52
Khategaon(D)	39.61	Bhikupura	3.71
Khategaon(S)	29.94	Pipri	7.01
Bijawad(D)	21.55	Punjapura	2.76
Bijawad(S)	5.36	UdainagarDW	10.98
		Punjapura	2.82
		Dhayali	8.04
		Pipilianankar	10.82
		Bijawad	5.18
		Kannod	15.18
		Kantaphor	5.53
		Kusumania	5.53
		Satwas New	12.03

3.5 Conceptual Model of Aquifer Deposition :

3-D Model



I - (Shallowaquifer -weathered/fractured)II - (Deeper aquifer - Vesicular/ Fractured)
(0 to 30 m.bgl) (30-200 m.bgl)

CHAPTER-IV
GROUND WATER RESOURCES

4.1 Dynamic Ground Water Resource & Draft :

The dynamic ground water resources of the Madhya Pradesh State assessed jointly by the CGWB and State Ground Water Departments under the supervision of the State level Committees. The base year of computation of the resources is 2012-13.

The dynamic ground water resources are also known as Annual Replenishable Ground Water Resources since it gets replenished/ recharged every year. The Annual Replenishable Ground Water Resource for the Dewas Districthas been assessed as 10985.35 ham. The major source of ground water recharge is the monsoon rainfall. Block -wise Ground Water Resources of Dewas District as on March, 2013 is given in Table No 8 and the presents the over-all scenario of ground water resource utilization and availability of the District. The contribution from other sources such as canal seepage , return flow from irrigation, seepage from water bodies etc in Annual Replenishable Ground Water Resource is more than of 33% in the states.

The assessment of ground water draft is carried out based on the Minor Irrigation Census data and sample surveys carried out by the State Ground Water Departments. The Annual Ground Water Draft of the entire district for 2012-13 has been estimated as 8055.12 ham. Agriculture sector remained the predominant consumer of ground water resources. About 80 % of total annual ground water draft i.e. 678 mcm is for irrigation use. Only 127 mcm is for Domestic & Industrial use which is about 20% of the total draft. An analysis of ground water draft figures indicates that in the district 85.26% is stage of ground water development.

The status of ground water development is very high in the two blocks i.e Dewas and Sonkutch where the Stage of Ground Water Development is more than 100%, which implies that in the block the annual ground water consumption is more than annual ground water recharge. the stage of ground water development is 70% and above. In rest of the block the stage of ground water development is below 70%. The ground water development activities have increased generally in the areas where future scope for ground water development existed. This has resulted in increase in stage of ground water development . List of categorization of Blocks / Districts is given in Table No 8.

Table No 8. Dynamic Ground Water Resource(Zone of Fluctuation)

District	Assessment Unit / District	Command / Non Command	Net Ground Water Availability in Ham	Existing Gross Ground Water Draft for Irrigation in Ham	Existing Gross Ground Water Draft for Domestic & Industrial Water Supply in Ham	Existing Gross Ground Water Draft for All Uses in Ham	Allocation For Domestic & Industrial Water Supply in Ham	Net Ground Water Availability for Future Irrigation Development in Ham	Stage of Ground Water Development in %
DEWAS	Bagli	Command	517.96	88.47	17.06	105.53	28	401.49	20.37
		Non Command	19027.78	12224.22	1125.49	13349.71	1309	5494.56	70.16
		Block Total	**19545.74**	**12312.69**	**1142.55**	**13455.24**	**1337**	**5896.05**	**68.84**
DEWAS	Dewas	Non Command	18164.87	18340.17	1162.04	19502.21	1162.04	-1337.34	107.36
		Block Total	**18164.87**	**18340.17**	**1162.04**	**19502.21**	**1162.04**	**-1337.34**	**107.36**
DEWAS	Kannod	Command	1859.99	381.02	50.51	431.53	89	1389.97	23.2
		Non Command	10605.44	7670.05	419.1	8089.15	726	2209.39	76.27
		Block Total	**12465.43**	**8051.07**	**469.61**	**8520.68**	**815**	**3599.36**	**68.35**
DEWAS	Khategaon	Non Command	11972.11	10254.82	438.27	10693.09	567	1150.29	89.32
		Block Total	**11972.11**	**10254.82**	**438.27**	**10693.09**	**567**	**1150.29**	**89.32**
DEWAS	Sonkutch	Non Command	11197.68	11161.8	555.99	11717.79	555.99	-520.11	104.64
		Block Total	**11197.68**	**11161.8**	**555.99**	**11717.79**	**555.99**	**-520.11**	**104.64**
DEWAS	Tonkkhurd	Non Command	10985.35	7757.1	298.02	8055.12	518	2710.25	73.33
		Block Total	**10985.35**	**7757.1**	**298.02**	**8055.12**	**518**	**2710.25**	**73.33**
		DISTRICT TOTAL	**84331.18**	**67877.65**	**4066.48**	**71944.13**	**4955.03**	**11498.5**	**85.31**

Table No 9. Ground Water Resource& Draft (Above&Below Zone of Fluctuation):

Name of Assessment Unit (Block)	Command / non-Command	Thickness of Aquifer Below Deepest WL	Specific Yield	Net Ground Water Availability in Ham	Ground Water Resources (below Zone of Fluctuation)	Total Resource First Aquifer	Draft from Second Aquifer (Below zone of Fluctuation)	Existing Gross Ground Water Draft for All Uses in Ham
Bagli	Command	6.4	0.02	517.96	488.70	1006.66	53.45	105.53
	Non-Command	2.8	0.01/ 0.02	19027.78	7311.11	26338.89	8181.75	13349.71
Block Total Bagli		0.0		19545.74	7799.81	27345.55	8236.07	13455.24
Dewas	Non-Command	0.9	0.02	18164.87	1707.91	19872.78	5202.68	19502.21
Block Total Dewas		0.0		18164.87	1707.91	19872.78	5202.68	19502.21
Kannod	Command	6.6	0.02	1859.99	1933.41	3793.40	226.04	431.53
	Non-Command	2.3	0.02	10605.44	3416.58	14022.02	3412.18	8089.15
Block Total Kannod		0.0		12465.43	5349.99	17815.42	2526.85	8520.68
Khategaon	Non-Command	2.2	0.02/ .015	11972.11	2922.49	14894.60	3080.27	10693.09
Block Total Khategaon		0.0		11972.11	2922.49	14894.60	3080.27	10693.09
Son kutch	Non-Command	0.4	0.02	11197.68	516.11	11713.79	3758.54	11717.79
Block Total SonKutch		0.0		11197.68	516.11	11713.79	3758.54	11717.79
Tonk khurd	Non-Command	1.6	0.02	10985.35	1935.33	12920.68	3294.19	8055.12
Block Total Tonk Khurd		0.0		10985.35	1935.33	12920.68	3294.19	8055.12
District Total		0.0		84331.18	20231.63	104562.81	26098.60	71944.13

4.2 Static Ground Water Resource &Draft :

Ground Water Resource of fracture formation below zone of fluctuation upto 30m depth is **20231.631 ham**and 30-200 m bgl depth is computed **28854.1.Total Static ground**

water resources of the district is 49085.73 ham and draft of bore well /tube well is also calculated separately a**45845.53ham** and **26098.60 ham** given in table no 9.

4.3 Draft :

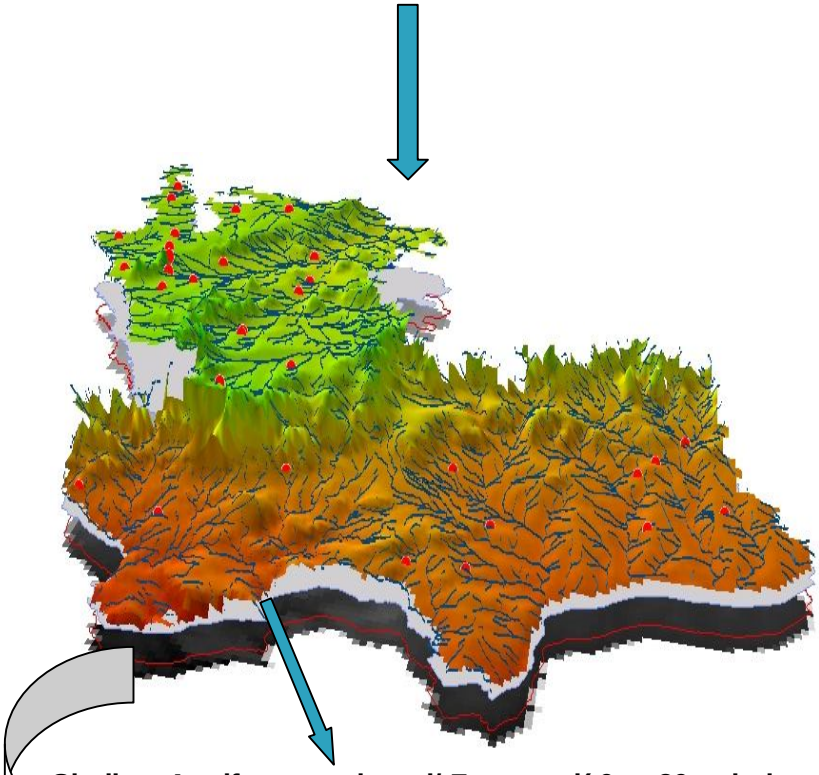
Table No 10. Static Ground Water Resource

Name of Assessment Unit (Block)	Command / non-Command	Net Ground Water Availability in Ham (Zone of fluctuation)	Static Ground Water Resources First Aquifer (Below zone of fluctuation)	Total Resources First Aquifer (0-30m) (Cl 3 +4)	Static Ground Water Resources Fracture zone (30-200m)	Total Static Resources (Cl 4+6) ham	Total Ground water Resources ham	Draft from First Aquifer ham	Draft from Second Aquifer ham
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Bagli	Command	517.96	488.696	1006.66	192.4	681.096	1199.06	52.08	53.45
	Non-Command	19027.78	7311.111	26338.89	8850	16161.11	35188.89	5167.96	8181.75
Block Total Bagli		19545.74	7799.807	27345.55	9042.4	16842.21	36387.95	5219.17	8236.07
Dewas	Non-Command	18164.87	1707.905	19872.78	4998.05	6705.955	24870.83	14299.53	5202.68
Block Total Dewas		18164.87	1707.905	19872.78	4998.05	6705.955	24870.83	14299.53	5202.68
Kannod	Command	1859.99	1933.405	3793.40	734.8	2668.206	4528.20	205.49	226.04
	Non-Command	10605.44	3416.583	14022.02	3669.8	7086.384	17691.82	4676.97	3412.18
Block Total Kannod		12465.43	5349.989	17815.42	4404.6	9754.59	22220.02	5993.83	2526.85
Khategaon	Non-Command	11972.11	2922.493	14894.60	4381.55	7304.044	19276.15	7612.82	3080.27
Block Total Khategaon		11972.11	2922.493	14894.60	4381.55	7304.044	19276.15	7612.82	3080.27
Sonkutch	Non-Command	11197.68	516.105	11713.79	2906	3422.106	14619.79	7959.25	3758.54
Block Total SonKutch		11197.68	516.105	11713.79	2906	3422.106	14619.79	7959.25	3758.54
Tonkkhurd	Non-Command	10985.35	1935.33	12920.68	3121.5	5056.83	16042.18	4760.93	3294.19
Block Total Tonk Khurd		10985.35	1935.33	12920.68	3121.5	5056.83	16042.18	4760.93	3294.19
District Total		**84331.18**	**20231.631**	**104562.81**	**28854.1**	**49085.73**	**133416.91**	**45845.53**	**26098.60**

4.4 Conceptual Model of Recharge &Draft :

Conceptualisation of Aquifer system, Dewas District

Recharge: 843.83 MCM/yr



Shallow Aquifer - weathered/ Fractured(0 to 30 m.bgl

Deep Aquifer –- Vesicular /Fractured(30 to 200 m.bgl)

Surplus runoff Available : 1614.79 MCM

Non Committed run-off :488.44MCM (0.23 MCM/Sq.Km, source CWC)

GW Resource

Shallow Aquifer
Dynamic: 843.31 MCM
Static (Below water level fluctuation) : 236.42 MCM
Deep Aquifer
Static -288.54 MCM
Present Stage of GW Development 85% ,
Stage of GW Development After Intervention 70%

CHAPTER-V
GROUND WATER RELATED ISSUES

5.1 Ground Water Depletion

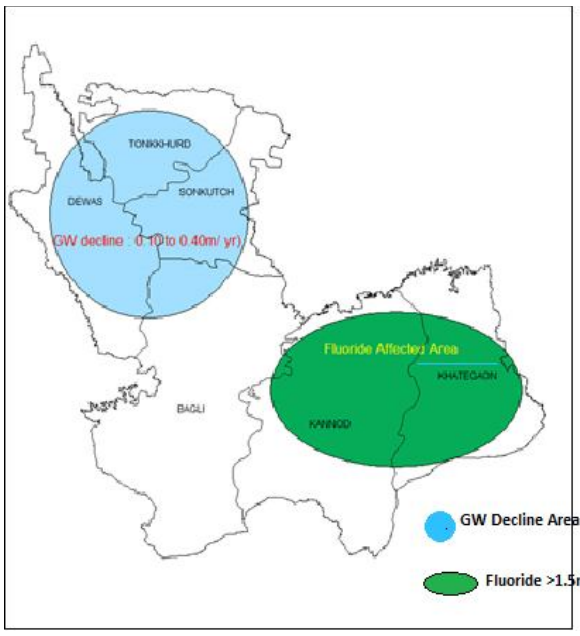
In last two decade Dewas district has shown tremendous growth in Industry as well as in Agriculture sector , resultant is pressure came on ground water utilization ,Groundwater is the only source of irrigation in 80 % of the area except in the Southern part where canal irrigation exists. Farmers solely depend on groundwater for irrigation. Every year number and depth of bore wells are increasing. The yield of the dug wells in shallow aquifer (0-30 mbgl) is l reduced due to over development of deep fractured aquifer by bore wells. The phreatic aquifer is recharged during monsoon and the dug wells sustains for 3 to 4 months only The dug wells sustain only for 2 to 3 hours of pumping with a drawdown of 2 to 5 m. Decline in groundwater level is observed 0.3 to 0.40 m/yr in Sonkutch Block and .0.20 to 0.40 m/yr in Dewas Block. The saturated thickness of the shallow aquifer in monsoon is 3 to 10 m. and Non-monsoon : 0.5 to 6 m. In the year 2012-13 Ground water resource of District was computed and data reveals that Dewas block having stage of ground water development 107.36%,Khategaon Block 89.32% & Sonkatch Block 104.64% and they were categorized Over Exploited, Semi Critical and Over Exploited respectively.

5.2 Ground Water Quality :

Ground water quality of Dewas district is in general good analysis report as given in Table 10 except in two blocks namely Kannod and Khategaon , where PHED has collected samples from hand pump and they found Fluoride concentration >1.5 mg/l in20 villages of Kannod block and 34 villages of Khategaon.These hand pumps are fitted with fluoride filter .Drinking water supply to the villages affected by high concentration of fluoride is being done by assured drinking water scheme from Treatment Plant attached with Hand Pump(Govt. of MP). as shown in Fig No In these two blocks , High fluoride conc. Exists in and Pump/Bore well depth upto 120 m (>400Feet)Maximum Fluoride concentration is 3.8 mg/l.Mostly borewells show high conc. of Fluoride than dug wells. (source : Fluro apatite), Villagers are affected with dental and skeletal fluorosis.

Villages affected by high concentration of fluoride is being done by assured drinking water scheme from Treatment Plant attached with Hand Pump(Govt. of MP

Fig 11



CHAPTER-VI
GROUND WATER MANAGEMENT STRATEGIES

6.1 District Ground Water Management Plan

The demand of fresh water for agriculture, drinking and industrial uses etc. has significantly increased due to population growth and socio-economic development. As surface water resources in the district are in-adequate, the dependability on ground water resources has increased substantially. This has resulted in rapid exploitation of ground water resources vis a vis depletion of ground water levels in various parts of the State.

The **District Dewas** is one of the under stress rapid exploitation of ground water resources in the district , ground water resources in the area are under continuous depletion. Thus there is urgent need for taking up suitable water management interventions based on integrated approach, which on one hand includes augmentation of ground water resources through appropriate techniques, and on the other hand requires the adoption of suitable water conservation measures, such as ensuring water use efficiency through creation of additional water storage facility, maintenance/ renovation of existing water bodies etc. Water awareness and capacity building of the stakeholders are also the important attributes of water management interventions as envisaged in the National Water Policy.

Artificial recharge to ground water is one of the most efficient, scientifically proven and cost effective technology to mitigate the problems of over exploitation of ground water resources. The technology serves as a means for restoring the depleted ground water storage, ameliorate the ground water quality problems and also enhance the sustainability of wells in the affected areas. A detailed knowledge of geology, hydrogeology, land use pattern, geomorphology and hydro-meteorological features are however, essential for selection of appropriate artificial recharge techniques as well as design and sites of ground water recharge structures.

As per directions of Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India, preparation of Aquifer Management Plan for Dewas district in the State has been prepared block wise as shown in Table no12 and financial out lay plan is also shown in Table No13. Each Plan discusses the broad framework of ground water situation in the block, status of water availability (both surface and ground water), identification of feasible areas for interventions, feasibility of artificial recharge and other water

conservation structures, their design considerations, numbers and cost estimates. The expected outcomes of the proposed interventions have also been elucidated and given in table no 17. As Dewas district having **Stage Of Development 85.26%** after proposed intervention **Stage Of Development will be 62.59%.**

Table No 11: Dynamic Ground Water Resource

Block	Net GW Availability	GW Draft for Irrigation	GW Draft for Domestic & Industrial	Gross Draft	Stage of Develop - ment %	Category
Bagli	195.46	123.13	11.43	134.55	68.84	Safe
Dewas	181.65	183.4	11.62	195.02	107.36	Over Exploited
Kannod	125.17	80.51	4.7	85.2	68.07	Safe
Khategaon	119.72	102.55	4.38	106.93	89.32	Critical
Sonkatch	111.98	111.62	5.56	117.18	104.64	Over Exploited
Tonk khurd	109.85	77.57	2.98	80.55	73.33	Semi Critical
Total	843.83	678.78	40.66	719.44	85.26	Crictical

Table No 12:Dewas District , Block Wise Management Plan
(Source Water for Artificial Recharge and number of Recharge Structure)

Block	Area (Sq Km)	Area suitable for recharge (Sq Km)	Rain fall (m)	Average post-monsoon water level (m)	Un saturated zone (m)	Avg. SP Yield (%)	Sub-surface storage (mcm)	GW Recharge through RWH Structures Constructed (MCM)	Available Storage Potential (MCM)	Surface water requi-red (mcm)	Surface water Run-off (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft / Tube well	NB/ CD/ CP	No of Village Ponds
Bagli	2045.4	1808.48	0.84	4.25	1.25	0.02	33.91	0.99	32.92	43.79	470.44	141.13	44	88	307	177
Dewas	1007.44	999.61	0.84	5.07	2.07	0.02	41.38	1.77	39.62	52.69	231.71	69.51	53	105	369	221
Kannod	1463	880.92	0.84	4.17	1.17	0.02	20.61	0.53	20.09	26.71	336.49	100.95	27	53	187	64
Khate gaon	1145	876.31	0.84	5.35	2.35	0.02	30.89	0.47	30.42	40.46	263.35	79.01	40	81	283	168
Son kutch	681	518.2	0.84	5.48	2.48	0.02	25.7	0.96	24.75	32.91	156.63	46.99	33	66	230	128
Tonk Khurd	679	624.3	0.84	4.96	1.96	0.02	24.47	1.77	22.7	30.2	156.17	46.85	30	60	211	108
TOTAL	7020.84	5707.82		4.88	1.88	0.02	176.97	6.48	170.5	226.76	1614.79	484.44	227	453	1587	866

Table No13:Financial Outlay Plan

District	Area Suitable for AR	Volume of Surface Water available for AR (MCM)	Volume of Water required for recharge (MCM)	Percolation Tanks		NB/ CD/ CP		Recharge shaft/ Tube well		Renovation of Village Ponds		Total Cost of RS in crores
				Nos	cost (crores)	Nos	cost (crores)	Nos	cost (crores)	Nos	cost (crores)	
Bagli	1808.48	470.44	43.79	44	8.8	307	30.7	88	4.4	177	3.54	47.44
Dewas	999.61	231.71	52.69	53	10.6	369	36.9	105	5.25	221	4.42	57.17
Kannod	880.92	336.49	26.71	27	5.4	187	18.7	53	2.65	64	1.28	28.03
Khategaon	876.31	263.35	40.46	40	8	283	28.3	81	4.05	168	3.36	43.71
Sonkutch	518.2	156.63	32.91	33	6.6	230	23	66	3.3	128	2.56	35.46
Tonk Khurd	624.3	156.17	30.2	30	6	211	21.1	60	3	108	2.16	32.26
TOTAL	**5707.82**	**1614.79**	**226.76**	**227**	**45.4**	**1587**	**158.7**	**453**	**22.65**	**866**	**17.32**	**244.07**

6.2 INTERVENTION OF TECHNOLOGY

6.2.1 The drip irrigation technology

Rising demand for irrigation water a mid concerns of rowing water scarcity has brought into renewed focus the need for improving water use efficiency and raising crop water productivity. Great emphasis is being made on achieving water conservation through various demand side management interventions encompassing technological options and policy measures. Given the difficulties and political concerns associated with bringing about effective policy reforms to achieve the objective of water conservation, this emphasis has generally focused on technological solutions backed by soft policy interventions to aid and facilitate adoption of technological solutions by farmers.

Micro irrigation technologies such *drip and sprinkler* systems are being increasingly promoted as technological solutions for achieving water conservation. Of the two technologies, drip irrigation, in its various forms, has been a relatively more important mode of micro irrigation in India. Enough empirical evidences available from different parts of the country to suggest that drip technology saves water and is cost effective and has significant economic and social benefits.

Drip irrigation saves water and electricity for pumping water, uses less labor and leads to higher crop productivity.

Farmers in India generally practice flood irrigation resulting in low water application and use efficiency. The estimated surface irrigation water use efficiency in India is 35-40%. With deteriorating surface water infrastructure and rapid declines in ground water tables in large parts of the country, and in the face of increasing demand for water from all sectors of the economy, there is a widespread concern for using the available water more efficiently. Micro irrigation systems, comprised of drip and sprinkler technologies, have emerged as an effective tool for water conservation and improving water use efficiency. While drip irrigation is ideally suited for horticulture crops such as pomegranates, grapes, mangoes, bananas, guava, coconuts, amla, and cash crops such as sugarcane, it is being used for cultivation of other crops as well. Sprinklers are generally useful in undulating land planted with cereal crops. Despite substantial efforts in promoting demands idea management technologies, in practice, drip and sprinkler technologies have been slow to be accepted by farmers. Of the two, drip irrigation is the more preferred technology.

Drip irrigation is an irrigation method which enables saving water by allowing water to drip slowly to the roots of plants, either on the soil surface or directly into the root zone. Drip irrigation methods range from simple bucket kit systems for small farms to automated systems linking release of water to soil moisture conditions measured continuously by tension meters. Drip Irrigation technologies can be categorized into two groups based on their technical, economic and social attributes. These are low cost drip irrigation technologies and pressurized systems. The low cost drip irrigation technologies include the “pep see[3],”easy drip , various kinds of affordable drip irrigation systems designed by IDE, and micro tube rip systems.

Drip Irrigation in India: current status and potential application

It is now possible to use drip and sprinkler irrigation to a wide variety of crops. Various estimates of potential and actual area[4] under micro irrigation technologies have been made available by different researchers and institutions.

Table No14:Selectedareacovered(inhectares)undermicroirrigationasat31October,2008

State	Drip	Sprinkler	Total
Madhya Pradesh	20,432	117,685	138,117

To reduce the ground water draft in Dewas district it is proposed that total irrigated Area 184919 ha which is irrigated by ground water , if 50% of this area i.e. 92460 ha is to be irrigate by using sprinkle then total ground water save in one year is about 74 MCM. The block wise area proposed for irrigation through sprinkles is given in table no15.

Table No 15:Irrigated Area (ha) proposed for irrigation through sprinkler ,DEWAS DISTRICT

Block	Irrigated Area (ha)	50% Irrigated Area (ha) proposed for irrigation through sprinkler	No. of Sprinklers proposed / ha	Unit cost (Rs) of sprinkler /ha	Total cost (Rs in cr)	Saving by Sprinklar in MCM
Bagli		9860	25	2000	49.3	7.88
Dewas	62930	31465	25	2000	157.32	25.17
Kannod	11343	5672	25	2000	28.35	4.53
Khategaon	56509	28255	25	2000	141.27	22.60
Sonkatch	19420	9710	25	2000	48.55	7.76
Tonk khurd	14997	7499	25	2000	37.49	5.99
Total	184919	92460			462.29	73.96

6.2.2 Change In Croping Pattern

Dewas district where as total irrigated area is 184919 ha and Irrigated Area under wheat 21101.5ha ,it is proposed that 50% of this wheat cultivated area change the crop cultivation from wheat to gram then total saving of water will be 10.55 MCM .As Wheat requires minimum four watering and whereas Gram requires only two watering . This change in cropping pattern is block wise proposed in table no 16.

Table no16: Change in cropping pattern (Wheat to Gram)

District	Block	Irrigated Area (ha)	50%Irrigated Area (ha) under wheat proposed for Gram cultivation	Water Saving by change in cropping pattern in mcm @0.1 m
Dewas	Bagli	19720	626	0.63
Dewas	Dewas	62930	2439	2.44
Dewas	Kannod	11343	1230	1.23
Dewas	Khategaon	56509	1853	1.85
Dewas	Sonkatch	19420	1714	1.71
Dewas	Tonk khurd	14997	2690	2.69
Dewas	Total	184919	10551	10.55

Table No 17:Dewas District , Management Plan after Intervention

Block	Net GW Availability	GW Draft for Irrigation	GW Draft for Domestic & Industrial	Gross Draft	Stage of Development %	Additonal GW created by AR str.in mcm	Net GW Availability after construction AR str.	Water Saving by sprinkler in mcm @0.08 m	Water Saving by change in cropping pattern in mcm @0.1 m	Total water saved after Intervention ,Sprinkler+Change in Crop	Gross Draft after intervention	Stage of Development(%) after mangement plan implementation
Bagli	195.46	123.13	11.43	134.55	68.84	32.92	228.38	7.88	0.63	8.51	126.04	55.19
Dewas	181.65	183.4	11.62	195.02	107.36	39.62	221.27	25.17	2.44	27.61	167.41	75.66
Kannod	125.17	80.51	4.7	85.2	68.07	20.09	145.26	4.53	1.23	5.77	79.43	54.68
Khategaon	119.72	102.55	4.38	106.93	89.32	30.42	150.14	22.60	1.85	24.46	82.47	54.93
Sonkatch	111.98	111.62	5.56	117.18	104.64	24.75	136.73	7.76	1.71	9.48	107.70	78.77
Tonk khurd	109.85	77.57	2.98	80.55	73.33	22.7	132.55	5.99	2.69	8.69	71.86	54.21
Total	843.83	678.78	40.67	719.43	85.26	170.5	1014.33	73.97	10.55	84.52	634.91	62.59

MANAGEMENT PLAN OF BAGLI BLOCK

Management Plan

Items	Statics	Amount Rs in Corers	Total Cost Rs in Corers
Area in Sq Km	2045.4		
Rainfall in m	0.8407		
Area Suitable for Recharge in Sq Km	1808.48		
Average Post Monsoon DTW in mbgl	4.25		
Unsaturated Zone in m	1.25		
Average Specific Yield in %	0.015		
Sub Surface Storage Potential (MCM)	32.9		
Surface Water Required (MCM)	43.79		
Runoff Available (MCM)	470.44		
Non committed Runoff available (MCM)	141.13		
No. of Recharge Shaft/ Tube Wells	88	**4.40**	**47.44**
No. of Percolation tanks	44	**8.80**	
No. of NB/CD/CP	307	**30.70**	
No . Of Village Ponds	177	**3.54**	

GROUND WATER RESOURSE(2013)

Shallow Aquifer

1. Dynamic Resources : 195.46
2. Static Resources : 102.37
3. Total Resources : 297.83
4. GW Draft : 52.19

Deep Aquifer

5. Static Resources : 90.42
6. GW Draft :82.36

Total GW Resources : 388.25

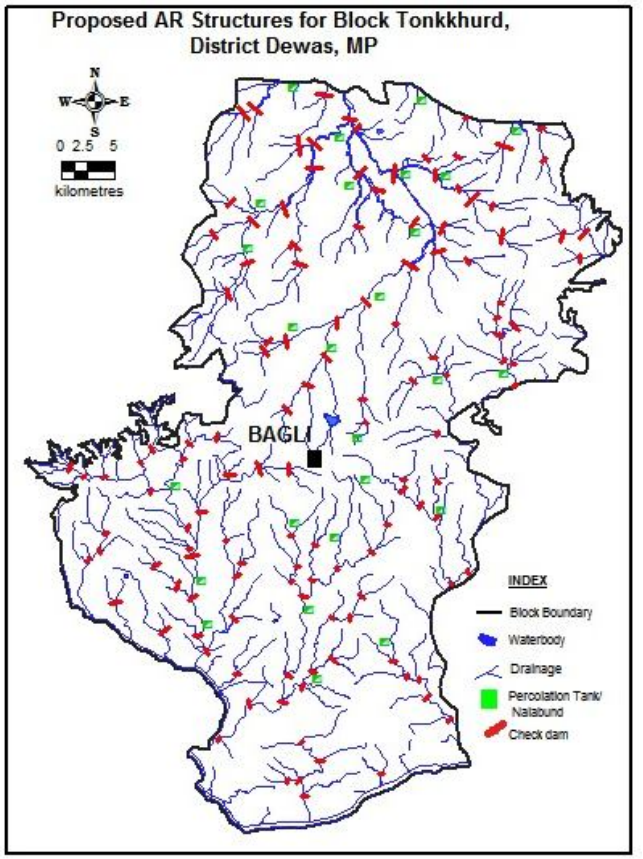
Total Ground Water Draft : 134.55

Stage of Ground Water Development: 68.84 (Command Area 20.37 %, Non Command Area 70.16%)

Category : Safe

Issues: Declining Water Levels in Non Command Area

Proposed Artificial Recharge Structures, BAGLI Block, Dewas District



IMPACT

Block	Net GW Availability	GW Draft for Irrigation	GW Draft for Domestic & Industrial	Gross Draft	Stage of Development %	Additonal GW created by AR str.in mcm	Net GW Availability after construction AR str.	Water Saving by sprinkler in mcm @0.08 m	Water Saving by change in croppin g pattern in mcm @0.1 m	Total water saved after Interv-ention ,Sprinkler+Change in Crop	Gross Draft after intervention	Stage of Development(%) after mangement plan implementation
Bagli	195.46	123.13	11.43	134.55	68.84	32.92	228.38	7.88	0.63	8.51	126.04	55.19

Management Plan of DEWAS Block

Items	Statics	Amount Rs in Corers	Total Cost Rs in Corers
Area in Sq Km	1007.44		
Rainfall in m	0.84		
Area Suitable for Recharge in Sq Km	999.61		
Average Post Monsoon DTW in mbgl	5.07		
Unsaturated Zone in m	2.07		
Average Specific Yield in %	1.5		
Sub Surface Storage Available (MCM)	41.38		
Surface Water Required (MCM)	32.3		
Runoff Available (MCM)	252.11		
Non committed Runoff available (MCM)	75.63		
No. of Recharge Shaft/ Tube Wells	32	**1.6**	**20.52**
No. of Percolation tanks	16	**3.2**	
No. of NB/CD/CP	113	**11.3**	
No of Village Pond	221	**4.42**	

Ground Water Recourse (2013)

First Aquifer

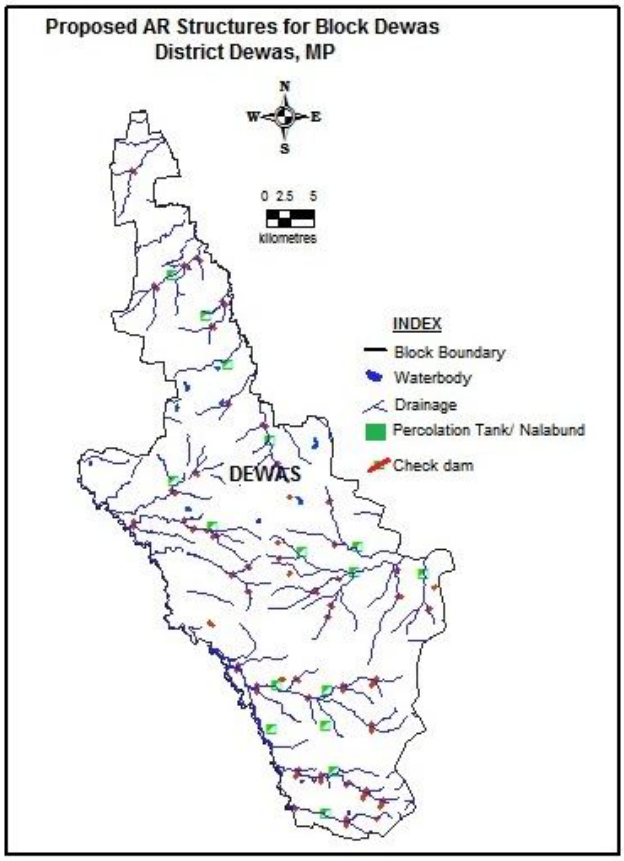
Dynamic Resources MCM	:	181.65
Static Resources MCM	:	17.08
Total Resources MCM	:	198.73
GW Draft MCM	:	143.0

Second Aquifer

Static Resources MCM	:	49.98
GW Draft MCM	:	52.02
Total GW Resources MCM	:	248.71
Total Ground Water Draft MCM	:	195.02
Stage of Ground Water Development:		107.3%
Category	:	Over Exploited

Issues **:** Declining Water Levels in Non Command Area

Proposed Artificial Recharge Structures, DEWAS Block, Dewas District



IMPACT

Block	Net GW Availability	GW Draft for Irrigation	GW Draft for Domestic & Industrial	Gross Draft	Stage of Development %	Additonal GW created by AR str.in mcm	Net GW Availability after construction AR str.	Water Saving by sprinkler in mcm @0.08 m	Water Saving by change in cropping pattern in mcm @0.1 m	Total water saved after Interv-ention ,Sprinkler+Change in Crop	Gross Draft after intervention	Stage of Development(%) after management plan implementation
Dewas	181.65	183.4	11.62	195.02	107.36	39.62	221.27	25.17	2.44	27.61	167.41	75.66

Management Plan of Kannod Block

Items	Statics	Amount Rs in Corers	Total Cost Rs in Corers
Area in Sq Km	1463		
Rainfall in m	0.84		
Area Suitable for Recharge in Sq Km	880.92		
Average Post Monsoon DTW in mbgl	3.71		
Unsaturated Zone in m	0.71		
Average Specific Yield in %	1.5		
Sub Surface Storage Available (MCM)	9.38		
Surface Water Required (MCM)	12.48		
Runoff Available (MCM)	222.18		
Non committed Runoff available (MCM)	66.65		
No. of Recharge Shaft/ Tube Wells	12	5.4	18.08
No. of Percolation tanks	6	8.76	
No. of NB/CD/CP	44	2.64	
No of Village Pond	64	1.28	

GROUND WATER RESOURCES

First Aquifer

Dynamic Resources	MCM:124.65
Static Resources	MCM : 53.45
Total Resources	MCM : 178.15
GW Draft	MCM : 59.94

Second Aquifer

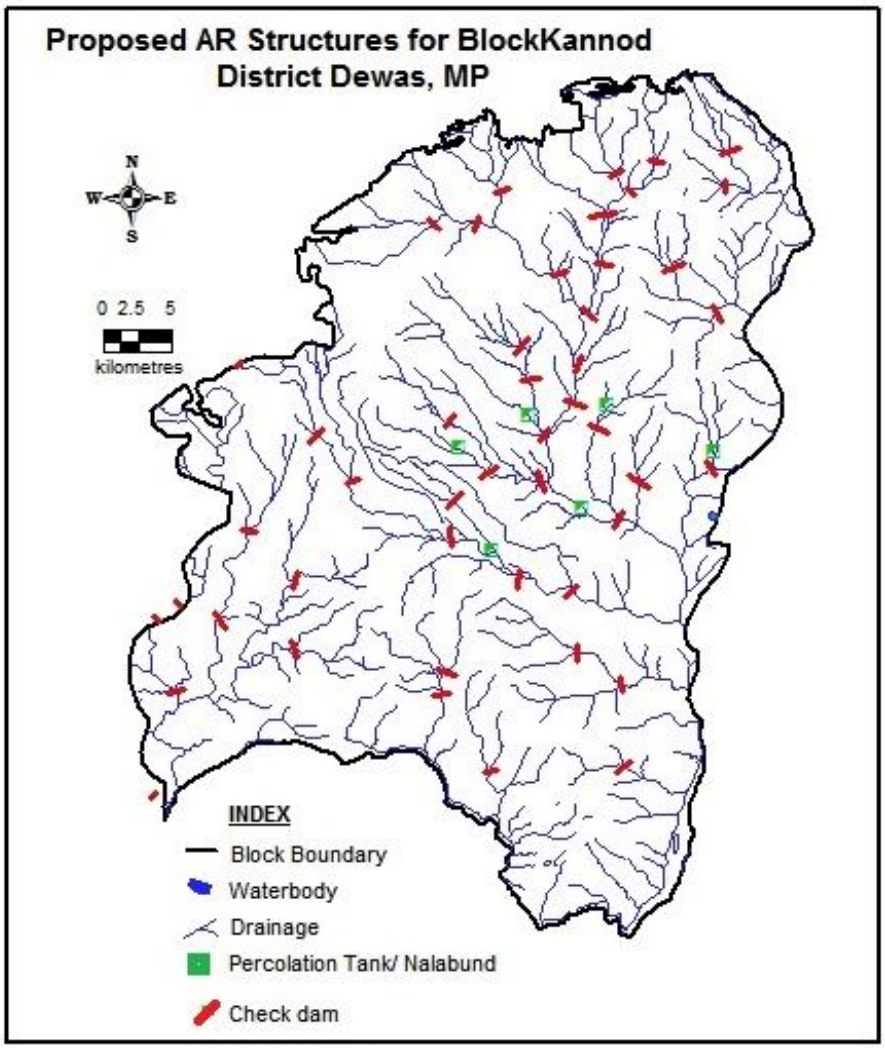
Static Resources	MCM : 44.04
GW Draft	MCM :25.27
Total GW Resources	MCM : 222.20

Total Ground Water Draft MCM : 85.21

Stage of Ground Water Development: 68.35%

Category : Safe

Issues: High Concentration of Fluoride in parts of the block



IMPACT

Block	Net GW Availability	GW Draft for Irrigation	GW Draft for Domestic & Industrial	Gross Draft	Stage of Development %	Additonal GW created by AR str.in mcm	Net GW Availability after construction AR str.	Water Saving by sprinkler in mcm @0.08 m	Water Saving by change in cropping pattern in mcm @0.1 m	Total water saved after Interv-ention ,Sprinkler+Change in Crop	Gross Draft after intervention	Stage of Development(%) after mangement plan implementation
Kannod	124.65	80.51	4.7	85.2	68.07	20.09	145.26	4.53	1.23	5.77	79.43	54.68

Management Plan of Khategaon

Items	Statics	Amount Rs in Corers	Total Cost Rs in Corers
Area in Sq Km	1145		
Rainfall in m	0.84		
Area Suitable for Recharge in Sq Km	876.31		
Average Post Monsoon DTW in mbgl	4.3		
Unsaturated Zone in m	1.3		
Average Specific Yield in %	1.5		
Sub Surface Storage Available (MCM)	17.09		
Surface Water Required (MCM)	12.73		
Runoff Available (MCM)	221.01		
Non committed Runoff available (MCM)	66.3		
No. of Recharge Shaft/ Tube Wells	23	1.15	**14.71**
No. of Percolation tanks	11	2.2	
No. of NB/CD/CP	80	8	
No of Village Pond	168	3.36	

Ground Water Resource

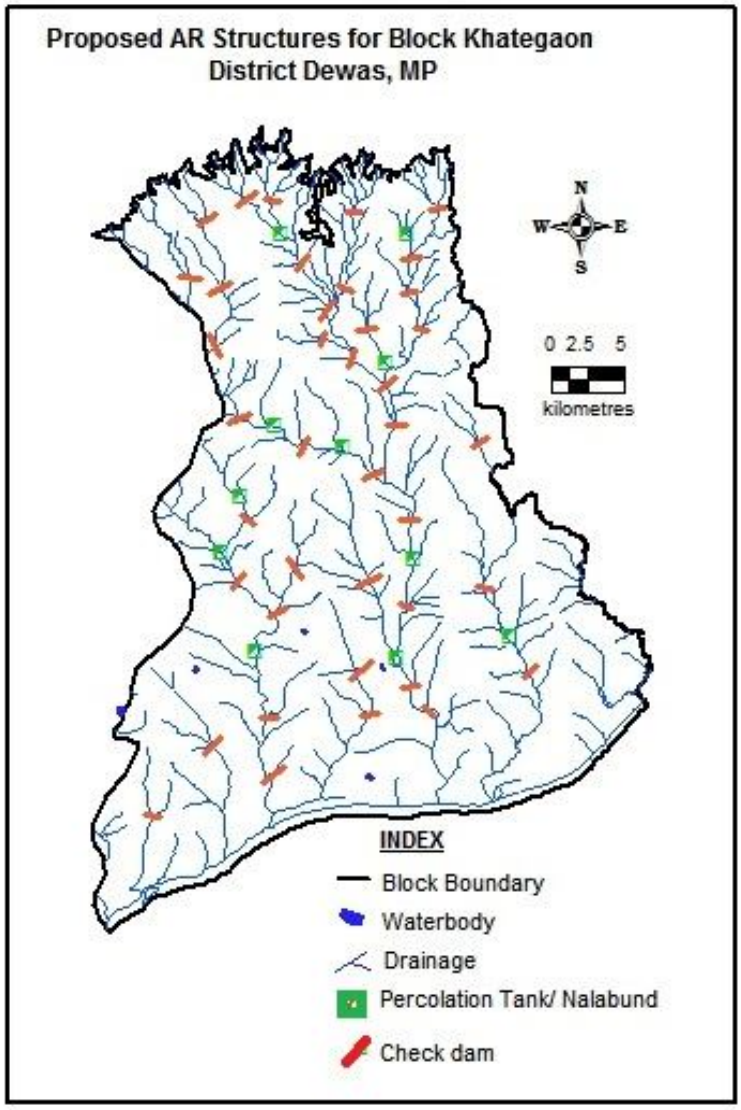
First Aquifer

Dynamic Resources	MCM:119.72
Static Resources	MCM : 29.22
Total Resources	MCM : 148.95
GW Draft	MCM : 76.13

Second Aquifer

Static Resources	MCM :30.80
GW Draft	
Total GW Resources	MCM : 192.76
Total Ground Water Draft	MCM : 106.92
Stage of Ground Water Development	; 89.32%
Category	**: Semi Critical**

Issues: Declining Water Levels and High concentration of Fluoride in parts of the block.



IMPACT

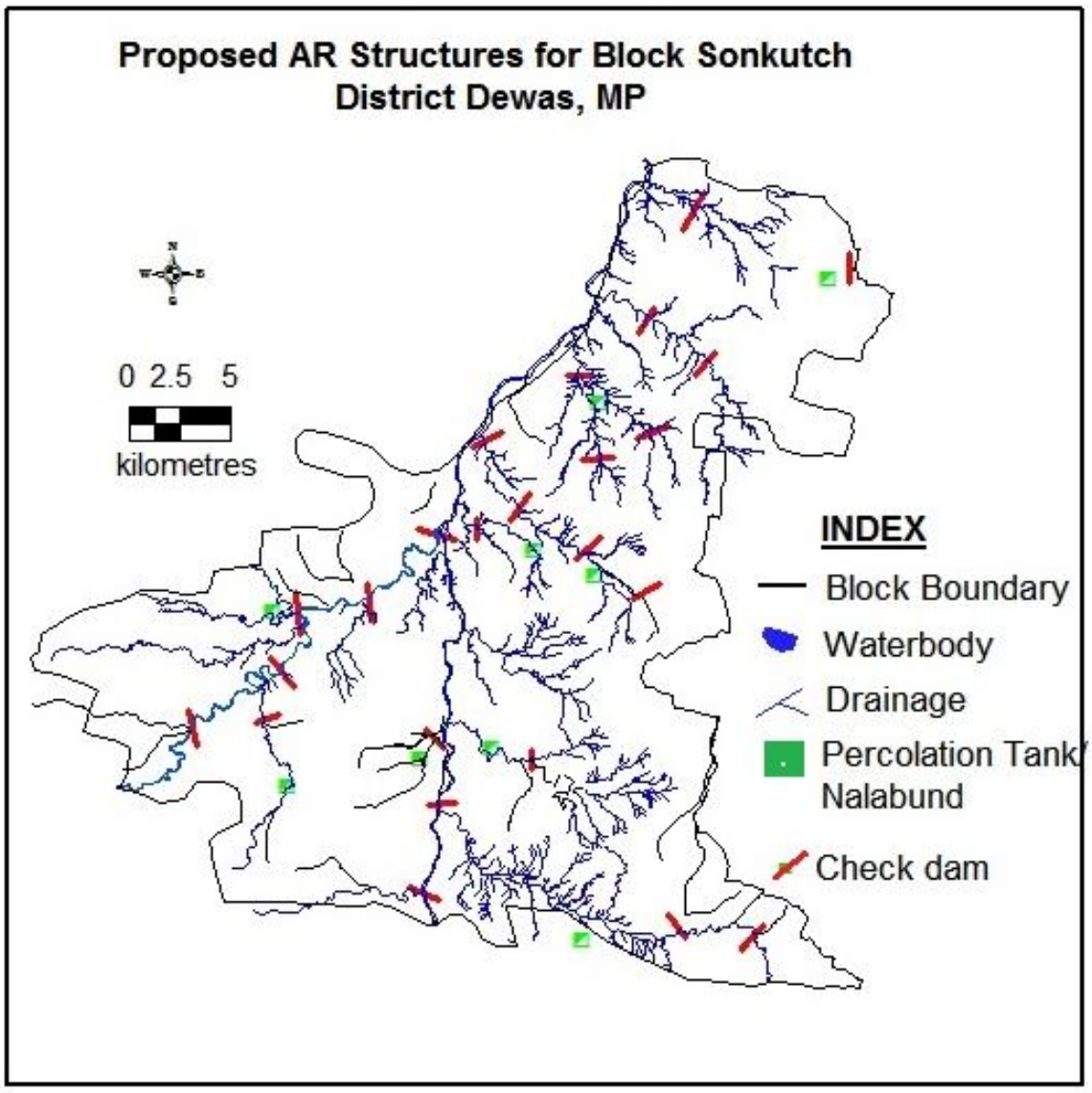
Block	Net GW Availability	GW Draft for Irrigation	GW Draft for Domestic & Industrial	Gross Draft	Stage of Development %	Additonal GW created by AR str.in mcm	Net GW Availability after construction AR str.	Water Saving by sprinkler in mcm @0.08 m	Water Saving by change in cropping pattern in mcm @0.1 m	Total water saved after Interv-ention ,Sprinkler+Change in Crop	Gross Draft after intervention	Stage of Development(%) after mangement plan implementation
Khategaon	119.72	102.55	4.38	106.93	89.32	30.42	150.14	22.60	1.85	24.46	82.47	54.93

Management Plan Of Sonkutch

Items	Statics	Amount Rs in Corers	Total Cost Rs in Corers
Area in Sq Km	681		
Rainfall in m	0.84		
Area Suitable for Recharge in Sq Km	581.2		
Average Post Monsoon DTW in mbgl	4.63		
Unsaturated Zone in m	1.63		
Average Specific Yield in %	1.5		
Sub Surface Storage Available (MCM)	12.67		
Surface Water Required (MCM)	16.85		
Runoff Available (MCM)	130.7		
Non committed Runoff available (MCM)	39.21		
No. of Recharge Shaft/ Tube Wells	17	0.85	**10.91**
No. of Percolation tanks	8	1.6	
No. of NB/CD/CP	59	5.9	
No of Village Pond	128	2.56	

Ground Water Resource

First Aquifer	
Dynamic Resources	MCM:111.98
Static Resources	MCM : 5.16
Total Resources	MCM : 117.14
GW Draft	MCM : 79.59
Second Aquifer	
Static Resources	MCM : 29.06
GW Draft	MCM :37.59
Total GW Resources	MCM : 146.20
Total Ground Water Draft MCM : 117.18	
Stage of Ground Water Development:	: 104.65%
Category	**: Over Exploited**
Issue	**: Declining Water Levels**



IMPACT

Block	Net GW Availability	GW Draft for Irrigation	GW Draft for Domestic & Industrial	Gross Draft	Stage of Development %	Additonal GW created by AR str.in mcm	Net GW Availability after construction AR str.	Water Saving by sprinkler in mcm @0.08 m	Water Saving by change in cropping pattern in mcm @0.1 m	Total water saved after Interv-ention ,Sprinkler +Change in Crop	Gross Draft after intervention	Stage of Development(%) after mangement plan implementation
Sonkutch	111.98	111.62	5.56	117.18	104.64	24.75	136.73	7.76	1.71	9.48	107.70	78.77

Management Plan Of Tonkhurd

Items	Statics	Amount Rs in Corers	Total Cost Rs in Corers
Area in Sq Km	679		
Rainfall in m	0.84		
Area Suitable for Recharge in Sq Km	624.3		
Average Post Monsoon DTW in mbgl	3.78		
Unsaturated Zone in m	0.78		
Average Specific Yield in %	1.5		
Sub Surface Storage Available (MCM)	7.3		
Surface Water Required (MCM)	9.71		
Runoff Available (MCM)	157.45		
Non committed Runoff available (MCM)	47.24		
No. of Recharge Shaft/ Tube Wells	**10**	**0.5**	**7.06**
No. of Percolation tanks	**5**	**1.0**	
No. of NB/CD/CP	**34**	**3.4**	
No of Village Pond	**108**	**2.16**	

Ground Water Resources

First Aquifer

Dynamic Resources	MCM:109.8
Static Resources	MCM : 19.35
Total Resources	MCM : 129.21
GW Draft	MCM : 47.61

Second Aquifer

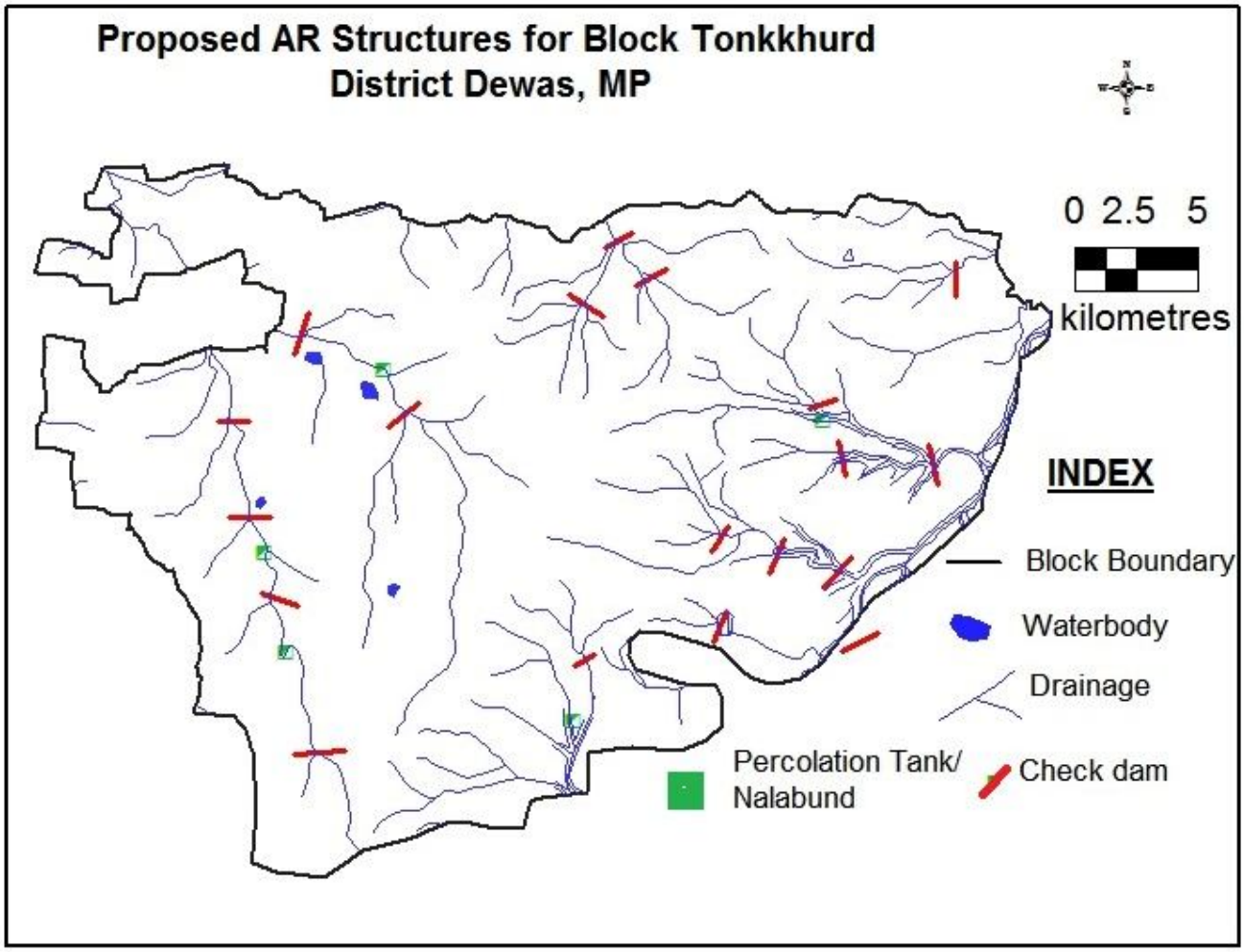
Static Resources	MCM : 31.22
GW Draft	MCM :32.94
Total GW Resources	MCM : 160.42

Total Ground Water Draft MCM 80.55

Stage of Ground Water Development : 73.33%

Category : Safe

Issues: Declining Water Levels in parts of the block



Impact

Block	Net GW Availability	GW Draft for Irrigation	GW Draft for Domestic & Industrial	Gross Draft	Stage of Development %	Additonal GW created by AR str.in mcm	Net GW Availability after construction AR str.	Water Saving by sprinkler in mcm @0.08 m	Water Saving by change in cropping pattern in mcm @0.1 m	Total water saved after Interv-ention ,Sprinkler+Change in Crop	Gross Draft after intervention	Stage of Development(%) after mangement plan implementation
Tonk khurd	109.85	77.57	2.98	80.55	73.33	22.7	132.55	5.99	2.69	8.69	71.86	54.21

AAEXURE-I

LOCATION DETAILS Of EXPLRATION BORE WELLS

Bore	Easting	Northing	Elevation	Total Depth	Long	Lat
Amona	627976	2559567	524	200	76.2500	23.1400
Badnawar	694665	2507488	314.4	171	76.8946	22.6633
Bagli(D)	637686	2505396	554	49	76.3400	22.6500
Bairagarh	608036	2545923	536.1	200	76.0543	23.0182
Barkera	636006	2539053	477.8	200	76.3266	22.9541
Bedamau	644639	2494974	343.9	175	76.4067	22.5553
Besum	673148	2483254	295.8	151	76.6826	22.4468
Chandana	602515	2539441	518	200	76.0000	22.9600
Chaprai	628579	2484678	273.5	150	76.2497	22.4636
Chobara dhir	638267	2554122	465	200	76.3500	23.0900
Datotar	615672	2561681	510	196	76.1300	23.1600
Devgarh	641095	2510122	535.8	150	76.3736	22.6924
Dewas(D)	607649	2538369	536	76	76.0500	22.9500
Guraria Bhil	612834	2530657	540	200	76.1000	22.8800
Hatpipliya	633283	2538574	503	200	76.3000	22.9500
Kanad	615621	2486303	298.4	200	76.1239	22.4792
Kelod	613901	2525129	538	143	76.1100	22.8300
Kethoda	637374	2539719	468	200	76.3400	22.9600
Khatamba	616852	2541760	536	200	76.1400	22.9800
Khel	706990	2502943	300.7	163	77.0139	22.6208

Lohar Pipalya	602553	2533905	523	200	76.0000	22.9100
Mendkichak	605591	2539462	529	200	76.0300	22.9600
Nemsa	665256	2481938	323.8	166	76.6058	22.4357
Newari	630407	2517678	527.8	200	76.2702	22.7615
Purohi	701386	2516137	322.5	129	76.9611	22.7406
Rajoda	612784	2537300	536	200	76.1000	22.9400
Sanwer	637354	2541933	474	200	76.3400	22.9800
Sirodia	696516	2496968	297.2	152	76.9113	22.5681
Sirolia	632553	2501121	577.5	200	76.2897	22.6118
Siroliya	616946	2529581	531	200	76.1400	22.8700
Surani	668220	2501792	317.4	150	76.6367	22.6147
Tiwadia	697152	2510710	327.9	152	76.9192	22.6921
Vijayganj mandi	598233	2567091	511	205	75.9600	23.2100

ANEXURE-I I
LITHOLOGS DETAILS Of EXPLRATION BORE WELLS

Bore	Depth1	Depth2	Lithology
Amona	0	32	Unsaturated Weathered Basalt
Amona	32	36	AQ I Saturated weathered Basalt
Amona	36	53	Massive Basalt I
Amona	53	58	AQ II High Vesicular Basalt
Amona	58	117	Massive Basalt II
Amona	117	122	AQ III High Vesicular Basalt
Amona	122	180	Massive Basalt III
Amona	180	191	AQ IV High Vesicular Basalt
Amona	191	200	Massive Basalt IV
Badnawar	0	19	Unsaturated Weathered Basalt
Badnawar	19	29	AQ I Saturated weathered Basalt
Badnawar	29	130	Massive Basalt I
Badnawar	130	133	AQ II High Vesicular Basalt
Badnawar	133	150	Massive Basalt II

Badnawar	150	162	AQ III High Vesicular Basalt
Badnawar	162	171	Massive Basalt III
Bagli(D)	0	9	Unsaturated Weathered Basalt
Bagli(D)	9	18	AQ I Saturated weathered Basalt
Bagli(D)	18	22	Massive Basalt I
Bagli(D)	22	33	AQ II High Vesicular Basalt
Bagli(D)	33	49	Massive Basalt II
Bairagarh	0	5	Unsaturated Weathered Basalt
Bairagarh	5	17	AQ I Saturated weathered Basalt
Bairagarh	17	120	Massive Basalt I
Bairagarh	120	131	AQ II High Vesicular Basalt
Bairagarh	131	200	Massive Basalt II
Barkera	0	17	Unsaturated Weathered Basalt
Barkera	17	30	AQ I Saturated weathered Basalt
Barkera	30	68	Massive Basalt I
Barkera	68	70	AQ II High Vesicular Basalt
Barkera	70	200	Massive Basalt II
Bedamau	0	4	Unsaturated Weathered Basalt
Bedamau	4	22	AQ I Saturated weathered Basalt
Bedamau	22	38	Massive Basalt I
Bedamau	38	42	AQ II High Vesicular Basalt
Bedamau	42	51	Massive Basalt II
Bedamau	51	55	AQ III High Vesicular Basalt
Bedamau	55	175	Massive Basalt III
Besum	0	12	Unsaturated Weathered Basalt
Besum	12	23	AQ I Saturated weathered Basalt
Besum	23	51	Massive Basalt I
Besum	51	55	AQ II High Vesicular Basalt
Besum	55	151	Massive Basalt II
Chandana	0	14	Unsaturated Weathered Basalt
Chandana	14	31	AQ I Saturated weathered Basalt
Chandana	31	43	Massive Basalt I
Chandana	43	68	AQ II High Vesicular Basalt
Chandana	68	86	Massive Basalt II
Chandana	86	89	AQ III High Vesicular Basalt
Chandana	89	104	Massive Basalt III
Chandana	104	124	AQ IV High Vesicular Basalt
Chandana	124	148	Massive Basalt IV
Chandana	148	161	AQ V High Vesicular Basalt
Chandana	161	200	Massive Basalt V
Chaprai	0	8	Unsaturated Weathered Basalt
Chaprai	8	27	AQ I Saturated weathered Basalt

Chaprai	27	76	Massive Basalt I
Chaprai	76	80	AQ II High Vesicular Basalt
Chaprai	80	130	Massive Basalt II
Chaprai	130	140	AQ III High Vesicular Basalt
Chaprai	140	200	Massive Basalt III
Chobara dhir	0	14	Unsaturated Weathered Basalt
Chobara dhir	14	32	AQ I Saturated weathered Basalt
Chobara dhir	32	145	Massive Basalt I
Chobara dhir	145	151	AQ II High Vesicular Basalt
Chobara dhir	151	156	Massive Basalt II
Chobara dhir	156	161	AQ III High Vesicular Basalt
Chobara dhir	161	181	Massive Basalt III
Chobara dhir	181	186	AQ IV High Vesicular Basalt
Chobara dhir	186	200	Massive Basalt IV
Datotar	0	65	Unsaturated Weathered Basalt
Datotar	65	70	AQ I Saturated weathered Basalt
Datotar	70	81	Massive Basalt I
Datotar	81	87	AQ II High Vesicular Basalt
Datotar	87	136	Massive Basalt II
Datotar	136	146	AQ III High Vesicular Basalt
Datotar	146	161	Massive Basalt III
Datotar	161	166	AQ IV High Vesicular Basalt
Datotar	166	191	Massive Basalt IV
Datotar	191	196	AQ V High Vesicular Basalt
Devgarh	0	10	Unsaturated Weathered Basalt
Devgarh	10	25	AQ I Saturated weathered Basalt
Devgarh	25	92	Massive Basalt I
Devgarh	92	98	AQ II High Vesicular Basalt
Devgarh	98	129	Massive Basalt II
Devgarh	129	142	AQ III High Vesicular Basalt
Devgarh	142	150	Massive Basalt III
Dewas(d)	0	10	Unsaturated Weathered Basalt
Dewas(d)	10	21	AQ I Saturated weathered Basalt
Dewas(d)	21	36	Massive Basalt I
Dewas(d)	36	48	AQ II High Vesicular Basalt
Dewas(d)	48	63	Massive Basalt II
Dewas(d)	63	76	AQ III High Vesicular Basalt
Guraria Bhil	0	12	Unsaturated Weathered Basalt
Guraria Bhil	12	23	AQ I Saturated weathered Basalt
Guraria Bhil	23	53	Massive Basalt I
Guraria Bhil	53	63	AQ II High Vesicular Basalt
Guraria Bhil	63	102	Massive Basalt II
Guraria Bhil	102	112	AQ III High Vesicular Basalt

Guraria Bhil	112	142	Massive Basalt III
Guraria Bhil	142	152	AQ IV High Vesicular Basalt
Guraria Bhil	152	200	Massive Basalt IV
Hatpipliya	0	16	Unsaturated Weathered Basalt
Hatpipliya	16	21	AQ I Saturated weathered Basalt
Hatpipliya	21	65	Massive Basalt I
Hatpipliya	65	72	AQ II High Vesicular Basalt
Hatpipliya	72	99	Massive Basalt II
Hatpipliya	99	131	AQ III High Vesicular Basalt
Hatpipliya	131	141	Massive Basalt III
Hatpipliya	141	151	AQ IV High Vesicular Basalt
Hatpipliya	151	200	Massive Basalt IV
Kanad	0	7	Unsaturated Weathered Basalt
Kanad	7	15	AQ I Saturated weathered Basalt
Kanad	15	72	Massive Basalt I
Kanad	72	80	AQ II High Vesicular Basalt
Kanad	80	90	Massive Basalt II
Kanad	90	97	AQ III High Vesicular Basalt
Kanad	97	200	Massive Basalt III
Kelod	0	11	Unsaturated Weathered Basalt
Kelod	11	25	AQ I Saturated weathered Basalt
Kelod	24	46	Massive Basalt I
Kelod	46	65	AQ II High Vesicular Basalt
Kelod	65	107	Massive Basalt II
Kelod	107	127	AQ III High Vesicular Basalt
Kelod	127	143	Massive Basalt III
Kethoda	0	8	Unsaturated Weathered Basalt
Kethoda	8	26	AQ I Saturated weathered Basalt
Kethoda	26	50	Massive Basalt I
Kethoda	50	58	AQ II High Vesicular Basalt
Kethoda	58	102	Massive Basalt II
Kethoda	102	112	AQ III High Vesicular Basalt
Kethoda	112	146	Massive Basalt III
Kethoda	146	156	AQ IV High Vesicular Basalt
Kethoda	156	176	Massive Basalt IV
Kethoda	176	186	AQ V High Vesicular Basalt
Kethoda	186	200	Massive Basalt V
Khatamba	0	38	Unsaturated Weathered Basalt
Khatamba	38	41	AQ I Saturated weathered Basalt
Khatamba	41	60	Massive Basalt I
Khatamba	60	79	AQ II High Vesicular Basalt
Khatamba	79	105	Massive Basalt II
Khatamba	105	110	AQ III High Vesicular Basalt

Khatamba	110	124	Massive Basalt III
Khatamba	124	134	AQ IV High Vesicular Basalt
Khatamba	134	178	Massive Basalt IV
Khatamba	178	188	AQ V High Vesicular Basalt
Khatamba	188	200	Massive Basalt V
Lohar Pipalya	0	11	Unsaturated Weathered Basalt
Lohar Pipalya	11	20	AQ I Saturated weathered Basalt
Lohar Pipalya	20	34	Massive Basalt I
Lohar Pipalya	34	54	AQ II High Vesicular Basalt
Lohar Pipalya	54	89	Massive Basalt II
Lohar Pipalya	89	98	AQ III High Vesicular Basalt
Lohar Pipalya	98	112	Massive Basalt III
Lohar Pipalya	112	138	AQ IV High Vesicular Basalt
Lohar Pipalya	138	163	Massive Basalt IV
Lohar Pipalya	163	189	AQ V High Vesicular Basalt
Lohar Pipalya	189	200	Massive Basalt V
Mendkichak	0	7	Unsaturated Weathered Basalt
Mendkichak	7	15	AQ I Saturated weathered Basalt
Mendkichak	15	20	Massive Basalt I
Mendkichak	20	30	AQ II High Vesicular Basalt
Mendkichak	30	44	Massive Basalt II
Mendkichak	44	83	AQ III High Vesicular Basalt
Mendkichak	83	98	Massive Basalt III
Mendkichak	98	104	AQ IV High Vesicular Basalt
Mendkichak	104	153	Massive Basalt IV
Mendkichak	153	183	AQ V High Vesicular Basalt
Mendkichak	183	200	Massive Basalt V
Nemsa	0	14	Unsaturated Weathered Basalt
Nemsa	14	25	AQ I Saturated weathered Basalt
Nemsa	25	115	Massive Basalt I
Nemsa	115	118	AQ II High Vesicular Basalt
Nemsa	118	166	Massive Basalt II
Newari	0	10	Unsaturated Weathered Basalt
Newari	10	30	AQ I Saturated weathered Basalt
Newari	30	141	Massive Basalt I
Newari	141	145	AQ II High Vesicular Basalt
Newari	145	200	Massive Basalt II
Purohi	0	17	Unsaturated Weathered Basalt
Purohi	17	44	AQ I Saturated weathered Basalt
Purohi	44	60	Massive Basalt I

Purohi	60	69.5	AQ II High Vesicular Basalt
Purohi	69.5	129	Massive Basalt II
Rajoda	0	10	Unsaturated Weathered Basalt
Rajoda	10	20	AQ I Saturated weathered Basalt
Rajoda	20	50	Massive Basalt I
Rajoda	50	60	AQ II High Vesicular Basalt
Rajoda	60	81	Massive Basalt II
Rajoda	81	94	AQ III High Vesicular Basalt
Rajoda	94	150	Massive Basalt III
Rajoda	150	158	AQ IV High Vesicular Basalt
Rajoda	158	200	Massive Basalt IV
Sanwer	0	11	Unsaturated Weathered Basalt
Sanwer	11	25	AQ I Saturated weathered Basalt
Sanwer	25	81	Massive Basalt I
Sanwer	81	111	AQ II High Vesicular Basalt
Sanwer	111	175	Massive Basalt II
Sanwer	175	185	AQ III High Vesicular Basalt
Sanwer	185	200	Massive Basalt III
Sirodia	0	21	Unsaturated Weathered Basalt
Sirodia	21	30	AQ I Saturated weathered Basalt
Sirodia	30	118	Massive Basalt I
Sirodia	118	123	AQ II High Vesicular Basalt
Sirodia	123	145	Massive Basalt II
Sirodia	145	152	AQ III High Vesicular Basalt
Siroliya	0	21	Unsaturated Weathered Basalt
Siroliya	21	35	AQ I Saturated weathered Basalt
Siroliya	35	65	Massive Basalt I
Siroliya	65	70	AQ II High Vesicular Basalt
Siroliya	70	120	Massive Basalt II
Siroliya	120	129	AQ III High Vesicular Basalt
Siroliya	129	180	Massive Basalt III
Siroliya	180	189	AQ IV High Vesicular Basalt
Siroliya	189	200	Massive Basalt IV
Surani	0	12	Unsaturated Weathered Basalt
Surani	12	30	AQ I Saturated weathered Basalt
Surani	30	92	Massive Basalt I
Surani	92	100	AQ II High Vesicular Basalt
Surani	100	150	Massive Basalt II
Tiwadia	0	18	Unsaturated Weathered Basalt
Tiwadia	18	48	AQ I Saturated weathered Basalt
Tiwadia	45	70	Massive Basalt I
Tiwadia	70	76	AQ II High Vesicular Basalt

Tiwadia	76	152	Massive Basalt II
Vijayganj Mandi	0	62	Unsaturated Weathered Basalt
Vijayganj Mandi	62	70	AQ I Saturated weathered Basalt
Vijayganj Mandi	70	101	Massive Basalt I
Vijayganj Mandi	101	116	AQ II High Vesicular Basalt
Vijayganj Mandi	116	148	Massive Basalt II
Vijayganj Mandi	148	155	AQ III High Vesicular Basalt
Vijayganj Mandi	155	205	Massive Basalt III