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Hydrogeological analysis of trival area of Thandla area, Jhabua District, Madhya Pradesh, India.

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Abstract
The paper is focused on hydrogeological analysis of Trival area of Thandla tehsil, located in Jhabua district of Madhya Pradesh, India. The study area is characterized by geological formations of Aravalli super group, Lameta and Bagh beds, Deccan Traps and Alluvium. The major portion of Thandla area is covered by quartzites, phyllites, granite-gneiss, of Aravalli Super group. The rest of Thandla area is occupied by limestone, sandstone of Lametas and Bagh beds overlain by the flows of Deccan traps. Alluvium is well exposed along the course of Padmavati River.
The hydrogeological examination of 35 open dug wells reveals well diameter range from 3.65-7.95 m, static water levels range from 1.10-9.60 m. bgl and depth of wells range from 6.50-12.25 m. bgl. The seasonal monitoring of water level. Indicator a fluctuation range of 2.15-6.38 m. bgl. The ground water level maps of post and pre monsoon periods indicate that in general the ground water movement is towards the Padmavati River The suitable sites for ground water development has been suggested in the villages of Timarwani, Udepuriya, Miyati, Bhimkund, Khokhar khandan, Dhamni and Junwaniya..

Keywords: Hydrogeological analysis, Trival area, Thandla tehsil, Jhabua, Madhya Pradesh, India

Introduction
The term Hydrogeology has been applied to study of science of the occurrence, movement and distribution of water under the surface of the Earth. It is the study of geological conditions controlling the occurrence and movement of ground water (Davis and Dewiest, 1966, Todd, 1980) [1, 5]. Karanth (2003) [2] has defined hydrogeology as the "evaluation of hydraulic properties of aquifers and those of adjoining formation is an important aspect of any scheme of ground water resource assessment." The main objective of paper is to study the characteristics of the ground water occurrence and movement of the Thandla area which is facing the problem of sustained water supply throughout the year. Hydrogeological analysis involves the examination of open dug wells, recording of relevant data and interpretation of analyzed data to understand the nature of ground water system. Katara and Dev (2016) [4] have analyzed the rainfall and discussed the role on ground water recharge of Thandla area of Jhabua district, Madhya Pradesh.

Location and Physiographic Features of Study Area
The present study Trival area is situated in the Thandla tehsil of Jhabua district, Madhya Pradesh, within the Latitude $23^0$0' to $23^0$5' N and Longitude 74^0 30' to 74^0 40' E, (Survey of India Toposheet No. 46 I/12, on the scale 1:50,000, Figure 1). The present study area is located in Thandla town of the Jhabua district, Madhya Pradesh, India. It covers a area of 144.85 sq. km. The town is located at a distance of 5 km South of Thandla Road railway stations (Western Railway). The study is connected by both by road and rail. It is approachable throughout the year.
The physiographic features of the area are developed due to the denudation brought by the water and wind as main agents. The area has been divided in to three physiographic regions - Hilly Terrain, Undulating country, and Plain country. The climate of the area is tropical - monsoon type. The temperature ranges from 7^0 to 44 ^{0}C. The rainfall ranges from 423.0 to 1655.6 mm with an average annual rainfall as 905.1 mm. In the study area, three types of soils eg. Black cotton soil, Lateritic soil, and Red loam are observed.

Geology of Study Area
The geology plays an important role in the ground water exploration. The field set-up of different rock formations, their lithological character, minor and major structural features and others, control the hydrological condition landforms, drainage pattern and inflow of water into the subsurface. The rock types including quartzites, phylites and others met within the northern part of Thandla area, dominate in this sequence. This formations show continuity with the Aravalli Super group (Archaean) of Rajasthan. The sandstone and limestone units of the Lametas and Bagh beds (Upper Cretaceous) period are exposed in Thandla area. The lava flows belonging to the Deccan traps (Cretaceous to Eocene) activity covers an area of about 144.85 sq. km of Thandla study area. The rocks comprising Deccan traps are predominantly basalt with little variation of composition.

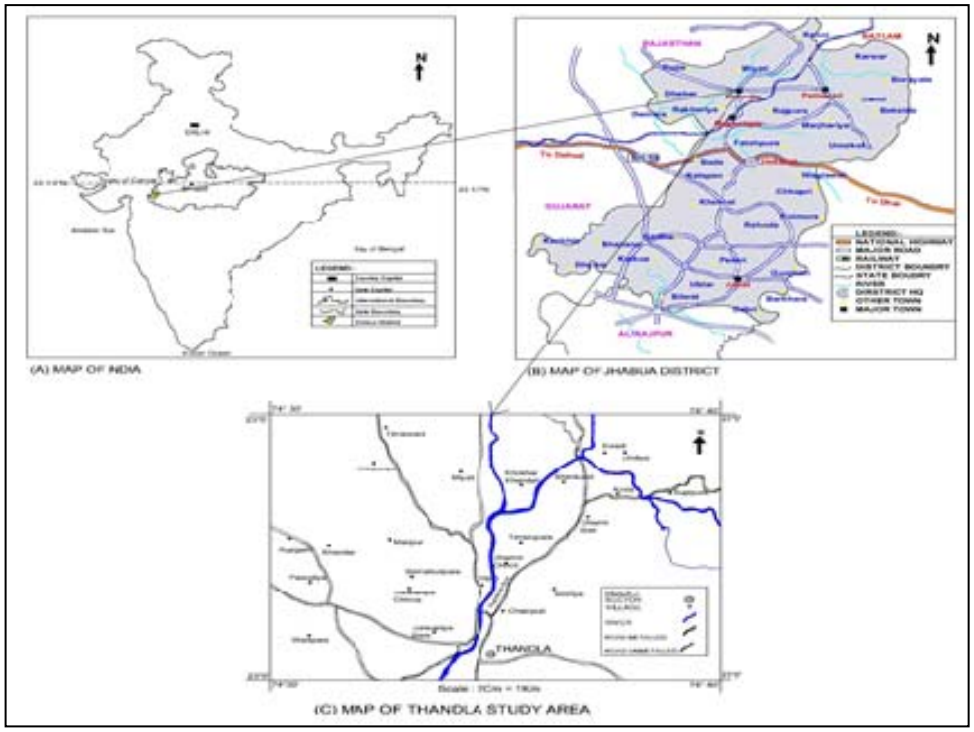

Fig 1: Location map of Thandla Study Area, Jhabua District, Madhya Pradesh, India. (www.Google.com)

Hydrogeological Survey of Study Area

The systematic Hydrogeological survey is conducted to determine the nature of ground water conditions of a particular area. The procedure for the systematic hydrogeological survey, with the help of topographic sheet, base map, along with detailed study in respect of existing different wells, in the area of investigation has been conducted. The well inventory involves the collection of well data, such as the, location, name of village, owner of well, type of well, bench mark and measurements of well diameter, depth of well, static water level, and yield of water is different types of wells.

The study area, covers about 144.85 sq. km in and around Thandla town (Toposheet No. 46 I/12), Jhabua district, Madhya Pradesh. 35 open dug well have been inventoried during the months of October 2011 and April 2012. The detailed well inventory includes recording of the location of well, type of well, diameter of well, total depth of well, static water level, and mode of water lifting water (Table 1). The water level measurements in open dug wells, were taken up during post-monsoon (October, 2011) and pre-monsoon (April, 2012) periods to observe the seasonal variations in water levels to study the movement of ground water by preparing water level contour maps for different seasons. (Figure 2, Table 1).

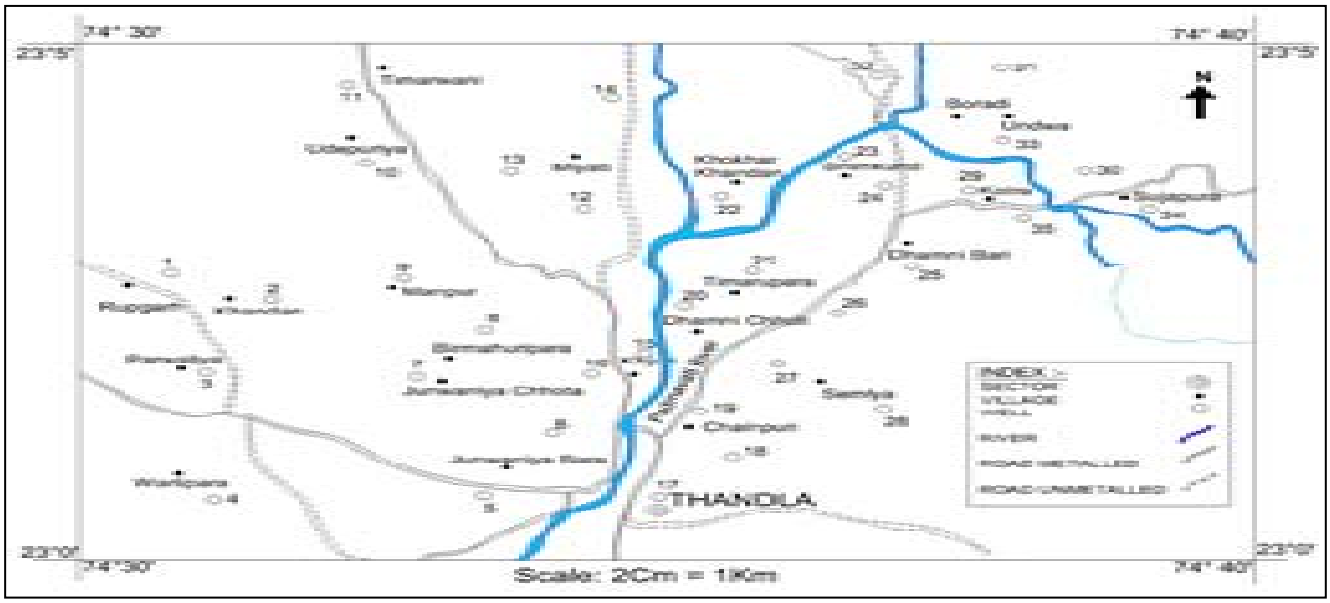

Fig 2: Location of dug wells in Thandla study area, Jhabua district, M. P.

Table 1: Showing the detailed the well inventory and water level fluctuation of Thandla Area, Jhabua district, Madhya Pradesh.

S.No.	Name of Village	Name of Owner	Ground level (m.) AMSL	Total Depth of Well (BGL)	Diameter of Well (m.)	S.w.l.		Reduced level		Fluctuation (m.)	Purpose
						Post-monsoon	Pre-monsoon	Post-monsoon	Pre-monsoon		
1.	Rupgarh	Narhingh Maida	315	8.50	5.75	1.25	6.95	313.75	308.05	5.7	A
2.	Khandan	Kheema Damor	310	11.25	7.76	3.25	8.75	306.75	301.25	5.5	A
3.	Parwaliya	Tejiya Damor	300	8.95	5.50	2.95	6.55	297.05	293.45	3.6	A+D
4.	Warlipara	Jitahing Bhuriya	290	9.15	6.50	2.75	7.50	287.25	382.5	4.75	A
5.	Junwaniya Bara	Govt.	315	12.15	7.50	2.50	8.45	312.5	306.55	5.95	A
6.	Junwaniya Bara	Govt.	310	8.25	4.25	1.50	6.90	308.5	303.1	5.4	A+D
7.	Junwaniya Chhota	Govt.	310	8.58	6.50	2.15	7.25	307.85	302.75	5.1	A+D
8.	Birmahuripara	Govt.	320	10.50	7.50	2.25	6.50	317.75	313.5	4.258	A+D
9.	Manpur	Bijiya Maida	320	12.25	7.40	3.58	9.60	316.42	310.4	6.02	A
10.	Udepuriya	Ramshu Singad	325	8.93	6.75	1.55	7.60	323.45	317.4	6.05	A+D
11.	Timarwani	Rajiya Amaliyar	330	9.50	6.35	2.75	7.21	327.25	322.79	4.46	A+D
12.	Miyati	Hurji vasuniya	320	6.50	5.25	1.95	4.10	318.05	315.9	2.15	A+D
13.	Miyati	Govt.	325	9.75	6.20	1.52	7.15	323.48	317.85	5.63	A+D
14.	Miyati	Gulchand Bhabar	325	7.90	5.10	1.75	6.10	323.25	318.9	4.35	A
15.	Khajuri	Walchand Ninama	310	11.50	6.25	3.95	8.35	306.05	301.65	4.4	A
16.	Khajuri	Bhagwaniya Rathore	310	8.61	6.30	2.60	7.23	307.4	302.77	4.63	A
17.	Chainpuri	Govt.	315	10.51	7.95	3.75	9.20	311.25	305.8	5.45	A+D
18.	Chainpuri	Mawji Khatija	310	9.95	6.12	3.50	7.55	306.5	302.45	4.05	A+D
19.	Chainpuri	Premchand Ninama	310	10.53	7.25	1.76	5.45	308.24	304.55	3.69	A
20.	DhamniChhoti	Parsingh Vasuniya	310	10.61	7.51	3.60	8.85	306.4	301.15	5.25	A+D
21.	Timrupara	Govt.	320	9.70	6.16	1.90	4.35	318.1	315.65	2.45	A+D
22.	Khokhar Khandan	Govt.	325	10.52	7.26	1.96	8.76	323.04	316.24	6.8	A
23.	Bhimkund	Raisingh	325	9.71	6.58	1.15	4.90	323.85	320.1	3.75	A+D
24.	Bhimkund	Govt.	320	11.51	7.14	1.26	6.51	318.74	313.59	5.25	A
25.	Dhamni Bari	Tolya Makhodiya	320	10.63	6.23	2.26	5.50	317.74	314.5	3.24	A+D
26.	Dhamni Bari	Govt.	310	8.20	5.32	2.58	6.85	307.42	303.15	4.27	A+D
27.	Symlya	Govt.	315	6.51	5.48	1.85	4.50	313.15	310.5	2.65	A+D
28.	Symlya	Govt.	320	9.51	7.15	2.19	6.60	317.81	313.4	4.41	A+D
29.	Kotra	Govt.	325	10.63	6.63	1.10	4.46	323.9	320.54	3.36	A
30.	Kotra	Ramu Parmar	325	11.60	7.24	2.70	8.50	322.3	316.5	5.8	A+D
31.	Bordi	Toliya Bhuriya	335	10.91	4.26	2.17	8.55	332.83	326.45	6.38	A+D
32.	Bordi	Govt.	325	8.17	3.65	1.91	5.82	323.09	319.18	3.96	A+D
33.	Undwa	Ramsu Pargeei	330	11.20	7.12	3.31	9.25	326.69	320.75	5.94	A
34.	Sujapura	Badiya Vasuniya	335	8.50	4.86	2.29	7.17	332.71	327.83	4.88	A
35.	Sujapura	Govt.	330	7.50	3.97	2.45	6.13	327.55	323.87	3.68	A+D

Well Data Analysis

The hydrogeological data in respect of 35 dug wells have been collected during October, 2011 and April, 2012 (Table 1) and analyzed. The analysis of dug well parameters are given below-

(a) Diameter of Well

The diameter measurements of wells range from 3.65 to 7.95 m (Table 2). It has been noted that minimum 2 dug wells are in the diameter range of 2 to 3 m. The maximum number of 12 dug wells each are within the diameter range of 6 to 7 and 7 to 8 m.

Table 2: Diameter range of dug wells in Thandla area Jhabua District, Madhya Pradesh

S. No.	Diameter range (m.)	Number of well	Percentage (%)
1.	3-4	2	5.71%
2.	4-5	3	8.57%
3.	5-6	6	17.14%
4.	6-7	12	34.28%
5.	7-8	12	34.28%
Total		35	99.98%

(b) Total Depth of Well

The total depth of open dug wells range from 6.50 to 12.25 m. b. g. l. (below ground level). The data analysis of total depth of wells is recorded (Table 3).

The analysis indicates that minimum number of 2 dug wells each is within the total depth range of 6 to 7 and 7 to 8 m. The maximum number of 9 dug wells has a depth range of 8 to 9 m. 2 wells are within depth range of 12 to 13 m. (Table 3).

Table 3. Total depth of dug wells in the study area, Jhabua District, Madhya Pradesh.

S. No.	Total Depth Range of Well m. b. g. l.	Number of Well	Percentage (%)
1.	6-7	2	5.71%
2.	7-8	2	5.71%
3.	8-9	9	25.71%
4.	9-10	7	20%
5.	10-11	8	22.85%
6.	11-12	5	14.28%
7.	12-13	2	5.71%
Total		35	99.97%

(c) Static Water Level

Static water levels have been measured in 35 dug wells of the study area during. The post-monsoon and pre-monsoon periods. Analysis of measured values of depth of static water levels have been recorded (Table 4).

Table 4. Showing analysis of the static water level in dug wells of the study Area, Jhabua District, Madhya Pradesh.

S.No.	Rang of Static Water Level (m.)	Number of well (%)	
		Post-monsoon	Pre-monsoon
1.	1-2	14 (40 %)	-
2.	2-3	14 (40 %)	-
3.	3-4	7 (20 %)	-
4.	4-5	-	5 (14.28 %)
5.	5-6	-	3 (8.57 %)
6.	6-7	-	9 (25.71 %)
7.	7-8	-	8 (22.85 %)
8.	8-9	-	7 (20 %)
9.	9-10	-	3 (8.57 %)
Total		35 (100 %)	35 (99.98 %)

The minimum number of 3 dug wells each is within the static water level range of 5 to 6 m and 9 to 10 m. The maximum number of 14 dug wells is within the static water level range of 1 to 2 m.

(d) Water Level Fluctuation

The fluctuation of ground water level of the study area has been determined on the basis of static water level data collected from the dug wells during the period of post-monsoon and pre-monsoon (Table 1).

Table 5. Showing the Fluctuation range of water level of the Study Area, Jhabua District, Madhya Pradesh.

S. No.	Fluctuation Range (m)	Number of Well	Percentage (%)
1.	2-3	3	8.57%
2.	3-4	7	20%
3.	4-5	10	28.57%
4.	5-6	11	31.42%
5.	6-7	4	11.42%
Total		35	99.98%

The maximum numbers of 11 wells reveal fluctuation of water levels within the range of 5 to 6 m (Table 5).

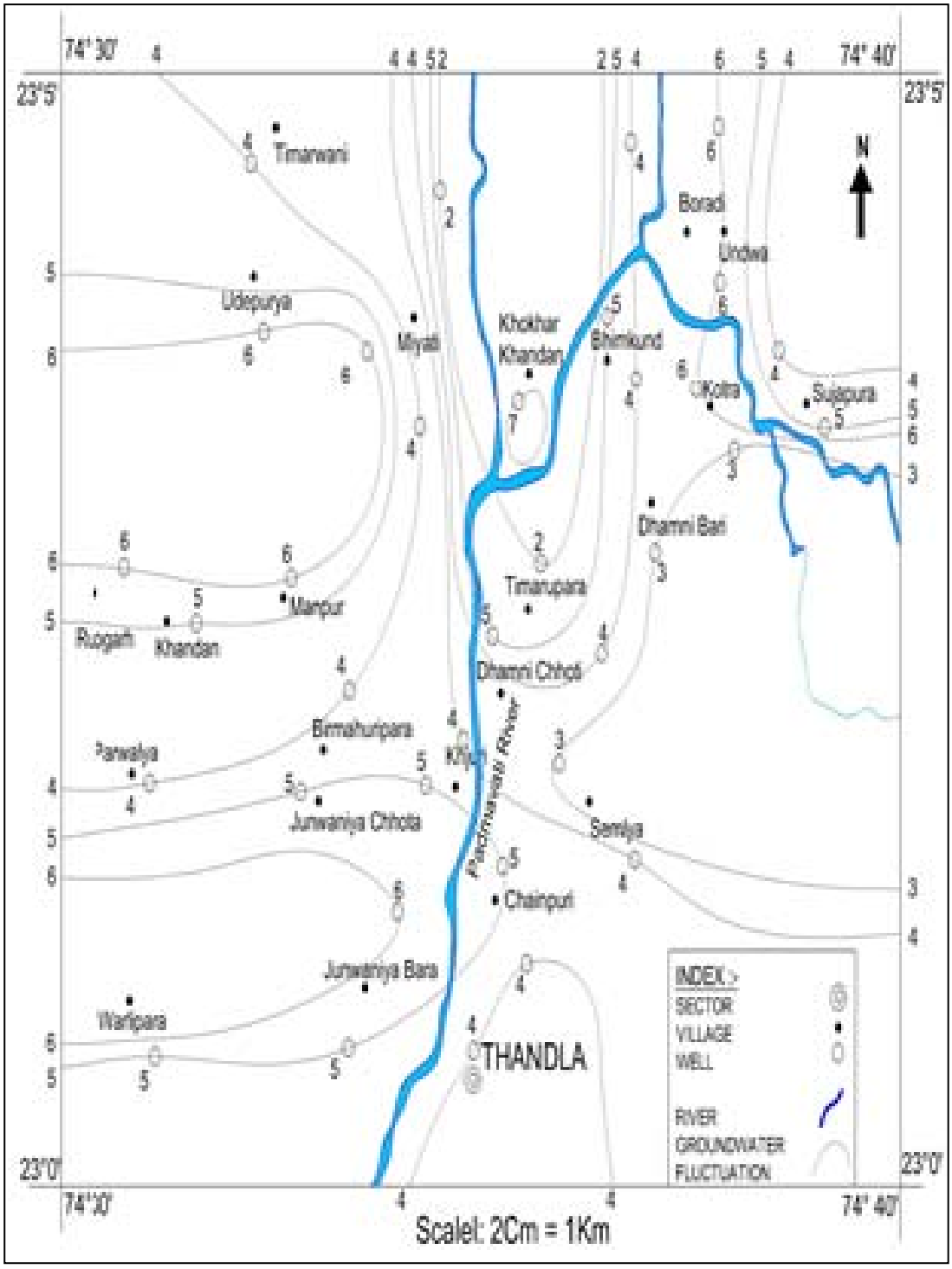

Fig 3: Ground water level fluctuation map of Study Area, Jhabua District, Madhya Pradesh

Ground water Level contour map

The ground water level contour maps have been prepared with help of base map by locating the wells and reduced water levels for determining the ground water level contours. The directions of ground water movement are determined by drawing perpendicular lines from the higher ground water level contour to lower level contour. The directions of ground water movement are marked by arrow on the map.

(A) Post-monsoon ground water level contour map

The ground water level contour map of the study area has been prepared on the basis of the collected well data during post-monsoon period. Ground water flow direction has been marked, with the help of a symbol "arrow", on the ground water level contour (Figure 4). The villages of Timarwani, Udepuriya, Miyati, Khokhar khandan, Khajuri and Junwaniya indicate widely spaced ground water level contours pointing the favorable zone of ground water recharge. The direction of ground water movement has been determined by drawing the perpendicular lines from the higher level contour to lower level contour and marked by the arrows on map.

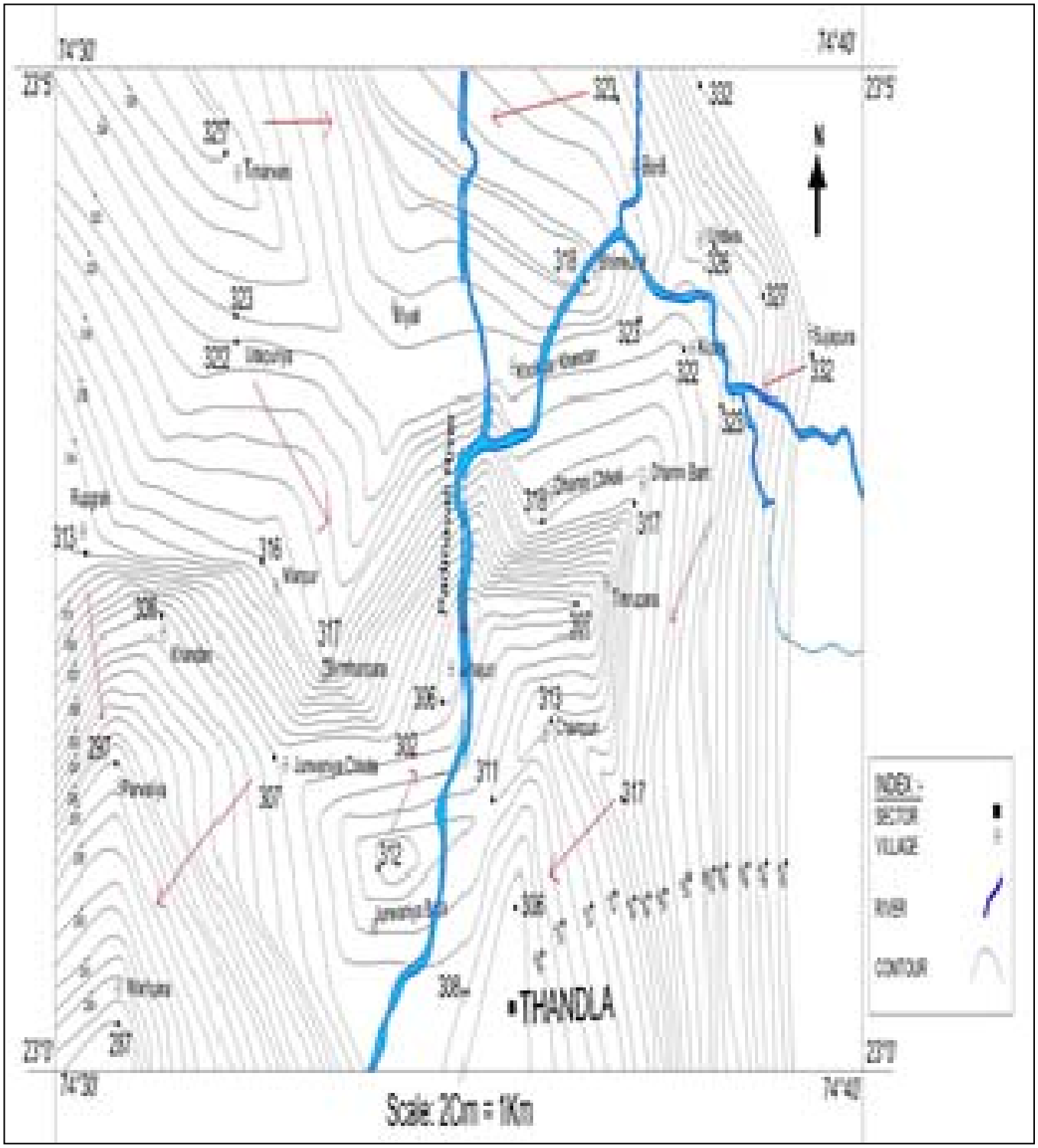

Fig 4: Post-monsoon ground water level contour map of Study Area, Jhabua District, Madhya Pradesh.

(B) Pre-monsoon ground water level contour map

The ground water level contour map of the study area has been prepared on the basis of the collected well data during pre-monsoon period. Ground water flow direction has been marked, with the help of a symbol "arrow", on the ground water level contour (Figure 5). It has been noted that the ground water level contour exhibits rather narrow spaced almost throughout the study area. The direction of ground water movement determined drawing perpendicular lines from higher level contour to lower level contour and marked by arrows on map. The villages of Birmhuripara, Manpur, Khandan, Rupgarh, Parwaliya, Warlipara, Timrupara, Dhamni, Chainpuri, Bhimkund, Bordi, Undwa, Kotra and Sujapura indicate more closely spaced ground water level contours pointing the poor condition for ground water recharge.

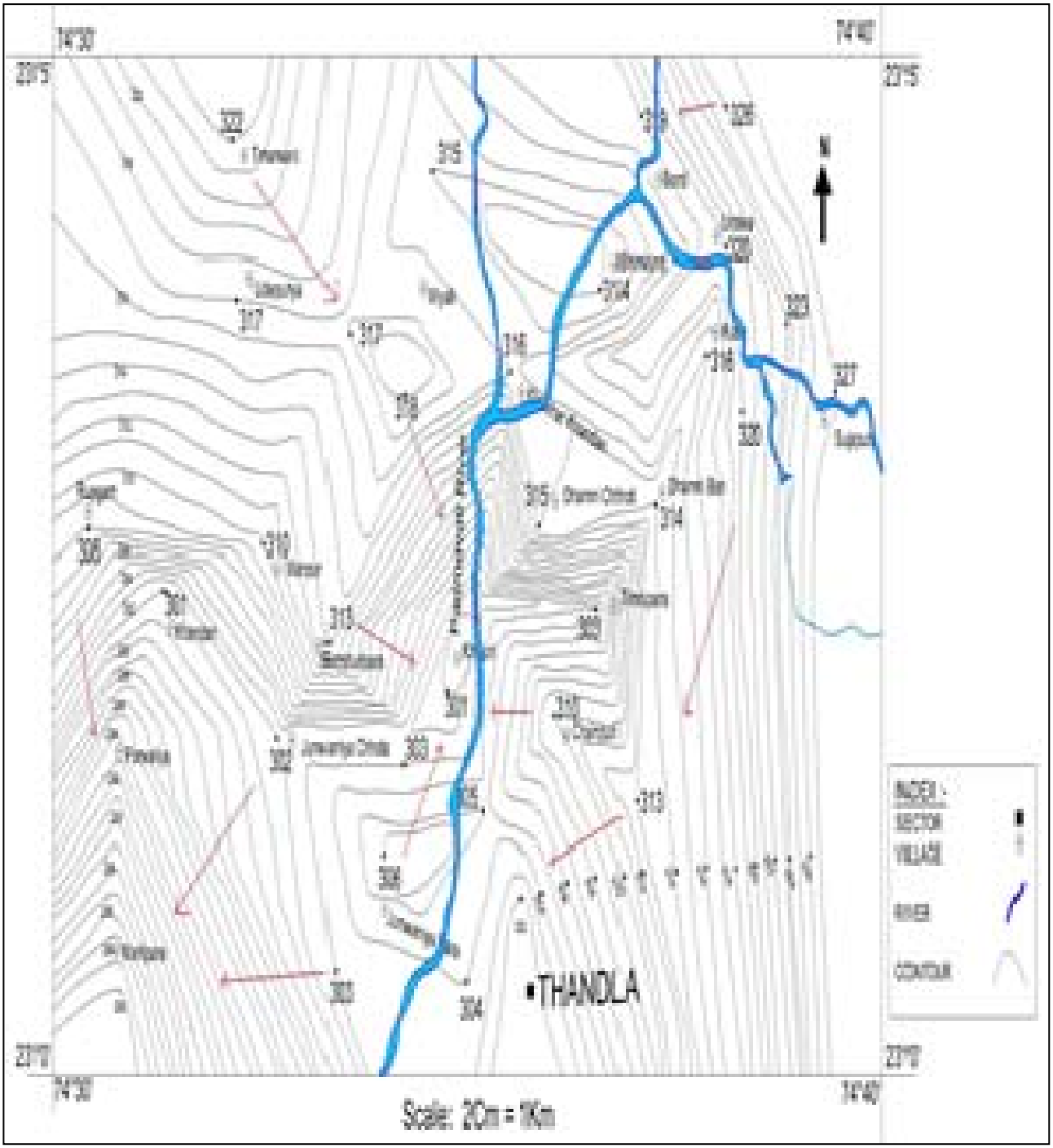

Fig 5: Pre-monsoon ground water level contour map of Study Area, Jhabua District, Madhya Pradesh

Movement of Ground Water

Ground water movement through pore space or interstices of weathered and vesicular zones as well as through fractured and jointed zone of basaltic lava flow is mostly as the laminar flow. The author has examined 35 open dug wells for seasonal monitoring during post-monsoon and pre-monsoon periods to observe the trend of ground water movement based on the ground water level contour maps (Figure 4, 5) prepared for monsoon intervals. Ground water moves from the higher levels to levels of lower levels. The ground water flow is towards the Padmavati River in the villages of Timarwani, Udepuriya Miyati, Manpur, Birmhuripara, Junwaniya, Khajuri, Bordi, Undwa, Sujapura, Bhimkund, Khokhar khandan, Dhamni, Timrupara, and Chainpuri. The water table contour map has been used to determine the direction of ground water movement and also to demarcate favorable ground water potential sites.

Conclusion

The data in respect of 35 open dug wells have have been monitered and analyzed. The well data reveal a fairly good range of variation. Based on static ground water levels the seasonal ground water level maps have been prepared, which exhibit the trend of ground water levels and movement of ground water towards the Padmavati River. The ground water level fluctuation, trend of ground water level contours and direction of groundwater help in demarcation of favourable ground water potential sites.

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