地下水資源調査短期専門家報告

昭和５８年１２月

農林水産省構造改善局　　相　場　瑞　夫

農林水産省北陸農政局　　山　本　昭　夫

Report For Technological Guidance

On

The Groundwater Development Program

In Terai Plain of Janakpur Zone.

Dec. 3, 1983.

By

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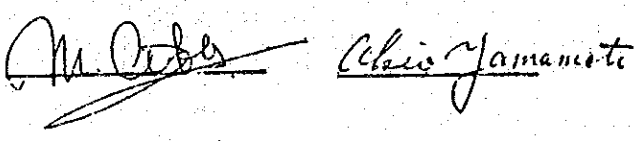
Preface

We have been dispatched by the government of Japan for the technological guidance on groundwater development program in Janakpur Zone, H.M.G. of Nepal. Main objective of this survey was to confirm and review the developing area, estimated discharge and other hydrogeological estimations of shallow groundwater those which Mr. M. Aiba had made in 1980 for the begining of Shallow Tube Well Development programme. We this time have made investigationaand analyzation on hydrogeological circumstances and groundwater ocurrences centering shallow groundwater development and we also reviewed the results of 26 drilling test borings and 591 tube wells installed for irrigation use.

We have suggested further investigations and activities for future development of groundwater in this report.

Finally, we would like to extend our great appreciation to Mr. R.B. Thapa, Project Manager, Mr. M. Lamichhane, Hydrogeologist, Mr. K. Esaki, Project Leader and Nepalese staff and Japanese experts those who have positively cooperated.

MIZUO AIBA AKIO YAMAMOTO



Working schedule (21 days from 18th Nov. to 8th Dec.)

18 Nov. 1983	Departure from Tokyo.
19	Arrival to Kathmandu.
20	Meeting with Mr. P.P. Gorkhali, Director General.
21	Meeting with Mr. K. Nishizawa, Japanese Ambassador
22	Arrival to J.A.D.P., Janakpur Zone.
23	Compiling and reviewing exsisting hydrogeological data, Pumping test of drilling test plots (by Nepalese staff).
24	Same above.
25	Same above.
26	Field observation of shallow groundwater level at Dhanusha district, pumping test of drilling plots (by Nepalese staff).
27	Field observation of the level at Mahottari district, Observation well drilling (by Nepalese staff).
28	Same above, observation at Sarlahi district.
29	Analysing different data on hydrogeology and making the survey report, Observation well drilling (total 8 wells).
30	Same above.
1 Dec. 1983	Field survey on geology and water circumstances at Sindhuli district.
2	Field survey of Nepal red cross groundwater development in Lumbini zone.
3	Making the survey report and its typing.
4	Departure to Kathmandu by car to see geology of Churiya Hill and Siwalik Range.
5	Meeting in Japanese embassy and J.I.C.A.
6	Meeting and report presenting to Ministry of Agriculture.
7	Departure to Bangkok.
8	Arrival in Tokyo.

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I. Outline of shallow tube well development program in Janakpur Zone.

1. The expanded program of shallow tube well development in Janakpur Zone has been framed in the plan of Janakpur Zone Agricultural Development Project (J.A.D.P.) since February 1979.

2. The first stage planned acreage irrigated by shallow groundwater is about 11,000 ha out of the whole 244.000 ha arable land in Janakpur Zone and 1,000 to 1,500 shallow tube wells within 40 meters deep are being set up.

3. A benefited unit of acreage by each well is expected to be from 5 to 8 ha.

The scale of tube wells and the expactable amount of water are shown below.

Case	Comand area	Shallow tube well		Tube		Amount of water
		depth	diameter	casing	strainer	
A	5 ha.	40 m	3 inches	30 m	10 m	8 ℓ/Sec
B	8 ha.	40 m	4 inches	30 m	10 m	12 ℓ/Sec

The scale of pumping equipments is as follows.

Case	Centifugal pump			Engine horse power	Numbers
	diameter	total head	capacity		
A	3 inches	15 m	0.8 m^3/min	6 HP	600 sets
B	4 inches	15 m	1.4 m^3/min	8 HP	400 sets

4. Hydrogeological circumstances in Janakpur Zone has been made partly clear from the studies on the groundwater investigation of the Sunrosi - Terai Project (F.A.O.) and Janakpur Zone Agriculture Development Project.

In succession, Mr. M. AIBA estimated hydrogeological conditions and groundwater occurrences of whole Terai plain in Janakpur Zone from the survey for the shallow groundwater development program in 1980.

In the survey report in 1980, Mr. M. AIBA classified the area concerned into three zones for the convenience of shallow groundwater development as shown in Fig. 1.

Zone I which is extending in the northern part of Terai plain was no available area for shallow groundwater development because of too deep groundwater level for setting up centifugal pump. Zone II which is extending in the central part of the plain was excellent or good area with capable shallow aquifer and proper groundwater level for shallow groundwater development. Zone III which is extending in the southern part of the plain was poor or almost no available area for absence of capable shallow aquifer.

5. I simultaneously at that time suggested to carry out drilling survey of 30 selected plots to confirm the above division and to get more detailed information of hydrogeology and groundwater occurrences.

6. The objective of this survey from November to December 1983 is to review above mentioned estimations and analyse results of drilling survey of test plots.

7. Shallow tube well constructions for farmer's use have already been started by J.A.D.P. drilling section members since 1980 and 591 tube wells of which 509 was success for irrigation water use were implemented.

II. Hydrogeological circumstances for shallow groundwater development in Terai plain of Janakpur Zone.

1. From the features of topographic undulation and distribution of river terraces, the area concerned is divided into five units topographically as follows shown in Fig. 2.

   1) Upper terrace (fan)
   2) Middle terrace (fan)
   3) Lower terrace
   4) Kamla flood area (Lower terrace)
   5) Bagmati flood area (Lower terrace)

   Accumlation of sediments and occurrence of shallow groundwater are closely related with each division of different units.

2. We could make some geologic sections of N-S line and E-W line from 26 drilling test borings and other deep well data as represented in Fig. 3.

   From the correlation of sediments appearing within about 30 meters deep, from surface, shallow aquifer can be distinctively recognized in the area from the central part to the northern part.

3. The shallow aquifer distributes in accordance with the units of upper and middle terraces. It is made up of typical fan deposits of sand and gravel and occurs in the depth of 10 to 30 meters from surface with thickness of 5 to 20 meters. Judging from the pumping test of drilling test plots, it was found the aquifer is capable and available for irrigation water use. However natural water level is steeply going deep toward the direction of north.e Groundwater in the aquifer occurs as unconfined water with water table.

4. The distribution of this aquifer was almost accordant with Zone II of Fig. 1 estimated in 1980's survey except Kamla and Bagmati flood area.

III. Situation of groundwater level

1. Groundwater level from groundsurface appears from 1 meter to more than 20 meters in depth shallow in central to southern part and deep in northern part.

2. On the line from Dumariya and Mahendranagar Dhanusha, via Aurhi and Nigor Mahottari to Bhaktipur and Laxmipur Sarlahi, water level takes place about 3 meters in depth from groundsurface.

   It appears less than 3 meters in the southern part of this line and more than 3 meters in the northern part of the line. It is steeply going deep toward north at the rate of about 1 meter deep to 300 - 500 meters distance.

3. Comparing the time of July 1980, early wet season with the time of November 1983 early dry season, groundwater level of the formere was higher than that of the latter in Dhanusha and Sarlahi districts and almost same in Mahottari district.

4. The depth of groundwater level is very important factor for developing groundwater by centifugal pump. Development of groundwater comes to be difficult in the area exceeding more than 5 meters in natural water level to be unableto get necesarry draw down.

5. We would like to suggest to carry out groundwater level observation in the late dry season of April or May when groundwater level is declining to the lowest.

IV. The result of pumping test and discharge capacity

1. Pumping test was conducted with drilling test wells by Nepalese staff. The results is shown in Table 2. Pumping discharge in test was considerably small for maximum possible discharge because of the necessity of water level measurement into small casing pipe of four inches.

   Permeability co-efficient ranged from 1.1×10^{-2} to 1.9×10^{-1} cm/sec and transmissibility co-efficient ranged from 67 to 1.760 m^2/day. Those values are sufficient for developing groundwater.

2. Already installed tube wells for farmer's use are reaching to 509 as represented in Fig. 5 and in Table 3.

   The discharge of completed wells were from 8 to 18 l/sec as shown in Fig. 6 by connecting casing pipe straight to centifugal pump. Those yields were exceeding amount of volume expected in 1980.

3. The interval between different wells keeps taking distance of more than 200 to 300 meters not to be affected each other.

V. Developing area by shallow tube wells and available discharge.

1. Developing area suitable for developing shallow groundwater is the central part of terai plain in Janakpur Zone. The north limit line is almost put to the contour line of 400 feet that is about 120 meters ground height. The limit is just fitting to the line of 5 meters depth of water level. The south limit is where the shallow aquifer made up of fan deposits goes thin and disappear as shown in Fig. 7.

2. The upper area over the north limit comes to be unsuitable to get water by centrifugal pump. When submersible pump will be able to set into large scale casing pipe considerable amount of water may be pumped up. On the other hand, shallow groundwater for irrigation is not almost available due to the absence of capable aquifer in the lower area of the south limit.

3. Available discharge capacity in the above developing area will be expected between 8 and 18 ℓ/sec. seeing results of already constructed tube wells. The yield may be partly decreasing near the area of the border line for high pump head or decrease of net aquifer.

VI. Setting up of groundwater observation wells and watching groundwater resources.

1. Unconfined groundwater is generally supplied straight by rainfall and such surface water as river water and irrigated water. So water table rises in the period of rainy and irrigated season and goes down in the period of dry and non-irrigated season.

2. The flow velocity of unconfirned groundwater is comparatively high and it may be thought that unconfined groundwater in the monsoon region can be circulating once a year. Judging from those features, consumed resources of shallow groundwater in dry season would recover in wet season recharged by rainwater and irrigated water for paddy field. Paddy field irrigation can be thought as a sort of efficient artifical recharge works for groundwater.

3. To understand available amount of groundwater resources, it is most important to see the situation of groundwater table fluctuation. For this purpose we need to set up some observation stations of groundwater level.

   The site of planned observation wells is pointed in Fig. 8. The wells have been constructed during the stay of our survey team. One was put in the project center to be able to measure the level every day. The others have been set in farmer's field and those measurement of water level need to be conducted once a week.

4. After accumulating the data of those and other necessary hydrogeological data, we could evaluate available groundwater resources by calculating water balance with numerical storage model.

5. We, in addition, would like to recommed to have chemical test of groundwater quality because almost all farmers use groundwater for domestic use from a view point of hygiene.

VII. Developing area by deep tube wells and necessary investigation.

1. Developing shallow groundwater for irrigation is very reasonable economically and technically. The area, however, is limited in the central part of Terai Plain in the zone by conditions of hydrogeology and groundwater occurrences.

2. In the most northern area and the most southern area of Terai plain in Janakpur zone it is impossible to develop shallow groundwater as already mentioned. Accordingly deep aquifer development is necessary to get water in such area in case of no surface water development project.

3. It is thought that deep unconfined groundwater will occur in the aquifer in the most northern area and groundwater level fluctuation will be very great between wet and dry season. Development of this area, however, needs to make great draw down of water level as the result, groundwater of farmer's domestic wells made by brick wall may be decreasing and disappear in the end. Careful consideration become necessary near village for deep tube well development.

4. Confined groundwater occurs at different depths from considerably shallow to very deep aquifer in the most southern area. A lot of yield can be expected in deep aquifer from 100 to 200 meters depth judging from some data of F.A.O. and J.A.D.P. investigations as shown in Table 4.

5. To confirm amount of deep ground water resources and to get more detailed data in whole area concerned. We also would like to suggest to implement drilling survey and water head observation by constructing 16 (sixteen) numbers of deep tube-wells in selected plots as shown in Fig. 10. Suitable diameter of Deep tube well test borings will be 200 m/m and depth range will be 100 m to 200 m. With the result of the test borings, production tube-wells should be drilled in all possible areas in 3 districts and deep groundwater should be extensively exployed for irrigation.

6. In confined groundwater, pressure differences cause flow of water. Under the natural situation, the horizontal flow in the confined aquifer is extremely slow and in some cases almost remains because of a little or little differences of pressure. The flow is mainly caused by artificial draw down

due to withdrawal of water. Accordingly the flow movement of confined groundwater is essentially different from that of unconfined groundwater which is flowing by gravity force.

VIII. Amount of Shallow Groundwater resources.

1. Terai Plain of Janakpur Zone will be able to be divided into 4 area considering water use for irrigation as follow in accordance with topographic classification of Fig. 2.

   1) Bagmati surface water irrigation area V
   2) Kamala surface water irrigation area IV
   3) Shallow groundwater irrigation area II
      (Shallow unconfined groundwater)
   4) Deep groundwater irrigation area ..... I & III
      (deep unconfined groundwater)
      (deep confined groundwater)

2. Total storage volume in the Shallow aquifer may be estimated as 1.8 billion m^3 from Shallow aquifer volume (9 billion m^3) and effective porosity (20 %), in which the flowing groundwater volume within a hydrogic year can be roughly calculated as 170 million m^3 supposing total catchment area of shallow aquifer (1.700 Km^2) and seepage volume into the aquifer out of annual rain water (100 mm/year). This is about one tenth which volume of groundwater can be actually utilized in a year without any obstacle.

3. The future volume for irrigation per a tube well will come to be about 27 thousand cubic meters (average yield 15 ℓ/sec, total pumping hours a year 500 hours in planned cropping pattern). So total possible shallow tube wells installed will be amount to 6,000 (six thousand) number in the shallow groundwater developing area.

Table 1. List of groundwater level observation

No.	Date	Location	Kind of Well	Depth of Bottom m	Depth of Water Level (observed) m	Height of Well from GL. m	Depth of Water Level from GL. m	Remarks (1983)
1	26 Nov.	Lawatala	Brick		6.75	1.00	5.75	1 m-up in rainy season.*
2	26 Nov.	Nardigram	Brick		6.25	1.40	4.85	*
3	26 Nov.	Dumariya - 1	Brick		3.57	0.77	2.80	draw down to 7-8 m in dry season.*
4	26 Nov.	Dumariya - 2	Brick		3.91	0.65	3.26	5-6 m deep in dry season.*
5	26 Nov.	Dumariya - 3	Wood		3.26	0.79	2.47	WL is the same to that of canel.*
6	26 Nov.	Raghunathpur	Brick		2.74	1.50	1.24	* (*: affected by canal)
7	26 Nov.	Raghunathpur-Center	Brick		2.00	1.19	0.81	
8	26 Nov.	Codar	Brick		8.46	0.77	7.69	
9	26 Nov.	Baratpur	Brick	≈ 10.26	8.26	0.83	7.43	
10	26 Nov.	Dharapani - 1	Brick C.C.	17.45	16.95	2.18	14.77	Brick C.C. means Brick Cement Concrete.
11	26 Nov.	Dharapani - 2	Brick C.C.		11.16	0.90	10.26	
12	26 Nov.	Dharapani - 3	Brick		10.83	0.68	10.15	dry up in dry season.
13	26 Nov.	Dharapani - 4	Brick		10.50	0.41	10.09	
14	26 Nov.	Kumrha - 1	Brick C.C.		9.70	0.16	9.54	
15	26 Nov.	Kumrha - 2	Brick		7.93	0.46	7.47	
16	26 Nov.	Kumrha - 3	Brick		7.96	1.20	6.76	
17	26 Nov.	Kumrha - 4	Brick		6.50	1.11	5.39	dry up in dry season.
18	26 Nov.	Yaggabumi - 1	Brick	8.0	2.70	-1.13	3.83	dig down for 1.13 m.
19	26 Nov.	Yaggabumi - 2	Brick		3.35	0.54	2.81	
20	26 Nov.	Yaggabumi - 3	Brick C.C.		3.40	0.80	2.60	
21	26 Nov.	Dhalkabar	Brick		17.50	0.96	16.54	
22	26 Nov.	Naktajhij - 1	Brick		13.55	0.55	13.00	
23	26 Nov.	Naktajhij - 2	Brick C.C.		12.00	0.22	11.78	
24	26 Nov.	Naktajhij - 3	Brick C.C.		11.00	0.48	10.52	
25	26 Nov.	Mahendranagar - 1	Brick		4.09	1.20	2.89	
26	26 Nov.	Mahendranagar - 2	Brick		3.23	1.20	2.03	
27		Hasinapur	Brick		2.60	0.27	2.33	
28		Saphi	Brick		4.30	1.20	3.10	

No.	Date	Location	Kind of Well	Depth of Bottom m	Depth of Water Level (observed) m	Height of Well from GL. m	Depth of Water Level from GL. m	(1983) Remarks
29	26 Nov.	Nikal	Brick		2.80	1.30	1.50	
30	26 Nov.	Bagmatipur	Brick	8.0	2.85	0.28	2.57	
31	26 Nov.	Muzelia	Brick		1.36	0.00	1.36	
32	26 Nov.	Pidari chowck	Brick		3.12	1.50	1.62	
33	26 Nov.	Ramanndachowck	Brick		2.90	1.09	1.81	
34	26 Nov.	Binni	Brick		3.03	0.91	2.12	
35	27 Nov.	Dhalkebar +500 m	Brick C.C.		14.90	0.45	14.45	
36	27 Nov.	Bardibas - 1	Brick C.C.		18.33	0.60	17.73	
37	27 Nov.	bazar - 2	Brick		15.60	0.70	14.90	
38	27 Nov.	- 3	Brick		14.70	0.90	13.80	
39	27 Nov.	Hathilet - 1	Brick C.C.		19.20	0.55	18.65	2 m - down in dry season
40	27 Nov.	Hathilet - 2	Brick C.C.		24.63	0.30	24.33	
41	27 Nov.	Benkhadi	Brick C.C.		18.40	0.00	18.40	
42	27 Nov.	Karamatoki	Brick C.C.		9.30	0.20	9.10	
43	27 Nov.	Aurhi bazar - 1	Brick		4.75	1.00	5.75	
44	27 Nov.	Aurhi near C. - 2	Brick		3.35	0.70	2.65	
45	27 Nov.	Aurhi - 3	Brick		5.40	0.90	4.50	
46	27 Nov.	East of Chepkot	Brick		2.40	0.66	1.74	WL is the same to that of the pond.
47	27 Nov.	Bhwelpipra - 1	Brick		5.35	0.60	4.75	The pond is not dry up even in dry season.
48	27 Nov.	Bhwelpipra - 2	Brick		2	0.50	2.20	
48'	27 Nov.	Bhwelpipra - 3	Brick C.C.		2.70	0.80	1.90	
49	27 Nov.	Timkia	Brick		2.90	0.50	2.40	
50	27 Nov.	Chepkot	Brick		1.65	0.45	1.20	
51	27 Nov.	Tarmarpur	Brick		1.75	0.15	1.60	
52	27 Nov.	Shurpur - 1	Brick		1.95	0.77	1.18	
53	27 Nov.	Shurpur - 2	Brick		2.70	1.00	1.70	
54	27 Nov.	Kahirasa	Brick		2.90	0.60	2.30	
55	27 Nov.	Nigol - 1	Brick		2.98	0.60	2.38	
56	27 Nov.	Nigol - 2	Brick		3.37	1.90	1.47	
57	27 Nov.	main town - 3	Brick		4.12	1.17	2.95	No. 57' 2.05 m from GL.

No.	Date	Location	Kind of Well	Depth of Bottom m	Depth of Water Level (observed) m	Height of Well from GL. m	Depth of Water Level from GL. m	(1983) Remarks
58	27 Nov.	Ghaushala - 1	Brick		3.04	0.70	2.34	
59	27 Nov.	Ghaushala - 2	Brick		4.60	0.70	3.90	
60	27 Nov.	Raghkor - 1	Brick		5.40	0.25	5.15	
61	27 Nov.	Raghkor - 2	Brick		5.40	0.30	5.10	
62	27 Nov.	Raghkor - 3	Brick		6.60	0.80	5.80	
63	27 Nov.	Ramnagar - 1	Brick C.C.		8.80	0.90	7.90	
64	27 Nov.	Ramnagar - 2	Brick C.C.		12.15	0.50	11.65	
65	27 Nov.	Ramnagar - 3	Brick C.C.		15.90	0.90	15.00	
66	27 Nov.	Ramnagar - 4	Brick C.C.		18.90	1.00	17.90	
67	27 Nov.	Ramnagar - 5	Brick		19.80	0.80	19.00	
68	27 Nov.	Ramnagar - 6	Brick		20.25	0.45	19.80	
69	27 Nov.	Ramnagar - 7	Brick C.C.		21.30	0.30	21.00	
70	28 Nov.	Netraganj - 1	Brick		6.30	0.70	5.60	
71	28 Nov.	Netraganj - 2	Brick C.C.		5.35	0.50	4.85	
72	28 Nov.	Jutapani	Wood		2.80	0.40	2.40	
73	28 Nov.	Jogatpur - 1	Brick C.C.		2.70	0.40	2.30	
74	28 Nov.	Haripur - 1	Brick C.C.		3.00	0.70	2.30	
75	28 Nov.	Haripur - 2	Brick		7.80	0.90	6.90	
76	28 Nov.	Haripur - 3	Brick		3.00	0.80	2.20	
77	28 Nov.	Haripur - 4	Brick		6.05	0.50	5.55	
78	28 Nov.	Laxmipur	Brick		4.70	0.80	3.90	
79	28 Nov.	Kabilashi	Brick		2.30	0.40	1.90	
80	28 Nov.	Nawalpur - 1	Brick C.C.		8.50]	1.50	7.00	
81	28 Nov.	Nawalpur - 2	Brick C.C.		7.50	0.60	6.90	
82	28 Nov.	Nawalpur - 3	Brick C.C.		9.42	0.80	8.62	
83	28 Nov.	Nawalpur - 4	Brick C.C.		9.15	0.70	8.45	
84	28 Nov.	Nawalpur - 5	Brick C.C.		14.30	0.90	13.40	
85	28 Nov.	Nawalpur - 6	Brick C.C.		10.50	0.30	10.20	
86	28 Nov.	Pachalkot	Brick C.C.		7.52	0.70	6.82	
87	28 Nov.	Isharpur En. - 1	Brick C.C.		10.80	0.00	10.80	

No.	Date	Location	Kind of Well	Depth of Bottom m	Depth of Water Level (observed) m	Height of Well from GL. m	Depth of Water Level from GL. m	Remarks (1983)
88	28 Nov.	Isharpur En. - 2	Wood		6.60	0.00	6.00	
89	28 Nov.	Isharpur En. - 3	Brick C.C.		5.20	0.50	4.80	
90	28 Nov.	Isharpur En. - 4	Brick		4.50	0.80	3.70	
91	28 Nov.	Isharpur - 5	Brick C.C.		2.50	0.50	2.00	
92	28 Nov.	Isharpur main - 6	Brick C.C.		2.90	0.90	2.00	
93	28 Nov.	Isharpur center-7	Brick		3.00	0.60	2.40	
94	28 Nov.	Sagarnath Project	Brick		5.55	0.40	5.15	
95	28 Nov.	Bhaktipur - 1	Wood		3.50	0.60	2.90	
95'	28 Nov.	Bhaktipur - 2	Wood		3.00	0.80	2.20	
96	28 Nov.	Bhaktipur - 3	Wood		4.10	0.60	3.50	

Table 2. Records on Drilling Test Plots of Shallow Tubewell Program

No.	Location	Ground height	Depth of Well	Diameter of Well	Geology of aquifer	Depth of aquifer	Thickness of aquifer	Pumping Test							
								Natural Water level	Pumping Water level	Draw down	Discharge	Specific capacity	Peamea-bility(k)	Transmis-bility(T)	Maximum discharge
		m	m	inch.		to m	m	m	m	m	ℓ/s (m^3/d)	ℓ/s/m (m^3/d/m)	cm/s (m/d)	cm^2/s (m^2/d)	
1	Dhanusha Kishanpur		20.0	4 (2)	sand & gravel	10.0 ∿18.0	8.0	2.36	4.73	2.37	5.8 (500)	2.44 (210)	3.7×10^{-2} (32)	30 (256)	15 (1,300)
2	Dhanusha Bhtahipatenva		21.0	4 (2)	gravel	14.0 ∿20.0	6.0	3.02	6.14	3.12	6.0 (520)	1.92 (166)	3.8×10^{-2} (33)	23 (198)	20 (1,700)
3															
4															
5	Dhanusha Hashinapur		27.9	4 (3)	sand & gravel	6.0 ∿26.0	20.0	2.30	3.99	1.69	12.25 (1,100)	7.24 (626)	4.3×10^{-2} (37)	86 (740)	19 (1,600)
6	Dhanusha Shaphi		38.8	4 (3)	sand & gravel	8.0 ∿24.0	16.0	2.70	5.58	2.88	10.0 (860)	3.47 (230)	3.2×10^{-2} (28)	51 (448)	15 (1,300)
7	Dhanusha Laxipur Begawa		26.0	3 (2)	sand & gravel	11.0 ∿22.0	11.0	1.51	1.92	0.41	7.0 (600)	17.0 (1,460)	1.9×10^{-2} (160)	17.6 (1,760)	18 (1,500)
8															
9															
10															
11	Mahottari Bijalpura		21.0	4 (2)	sand & gravel	7.0 ∿20.0	13.0	3.40	6.18	2.78	7.0 (600)	2.52 (215)	2.3×10^{-2} (20)	30 (270	20 (1,700)
12															20 (1,700)
13															
14	Mahattari Barauta		20.5	4	sand & gravel	9.0 ∿20.0	11.0	1.10	5.55	4.45	6.0 (520)	1.35 (117)	1.5×10^{-2} (13)	17 (143)	8 (700)

No.	Location	Ground height	Depth of Well	Diameter of Well	Geology of aquifer	Depth of aquifer	Thickness of aquifer	Pumping Test							
								Natural Water level	Pumping Water level	Draw down	Discahrge	Specific capacity	Peamea-bility(k)	Transmis-bility(T)	Maximum discharge
		m	m	inch.		to m	m	m	m	m	ℓ/s (m^3/d)	ℓ/s/m (m^3/d/m)	cm/s (m/d)	cm^2/s (m^2/d)	
15															
16	Mahattari Goshara		27.7	4 (3)	sand & gravel	4.0 ∿22.0	18.0	3.90	5.64	1.74	10.0 (860)	5.74 (496)	3.9×10^{-2} (34)	70 (612)	16.0 (1,400)
17															
18															
19	Mahattari Galdahabhetpur		52.0	4 (2)	sand & gravel	32.0∿36.0 42.0∿50.0	including deep aqui-fer 12.0	0.33	8.72	8.39	4.4 (380)	0.52 (45)	5.2×10^{-3} (4.5)	6.2 (54)	12.0 (1,000)
20															
21															
22															
23	Sarlahi Harpurwa		20.0	4 (2)	sand & gravel	8.0∿13.0 16.0∿18.0	7.0	1.94	8.00	6.06	4.0 (345)	0.66 (57)	1.1×10^{-2} (9.5)	7.7 (67)	7.0 (600)
24	Sarlahi Netraganja		14.0	4 (2)	sand & gravel	8.0 ∿13.0	5.0	2.44	4.84	2.40	6.0 (520)	2.5 (216)	6.0×10^{-2} (51)	30 (255)	15.0 (1,300)
25	Sarlahi Lakshmipur		18.7	4 (2)	sand & gravel	8.0∿12.0 14.0∿19.0	9.0	2.00	6.29	4.29	6.0 (520)	1.4 (121)	1.9×10^{-2} (16)	17 (144)	12.0 (1,000)
26															
27															
28															

No.	Location	Ground height	Depth of Well	Diameter of Well	Geology of aquifer	Depth of aquifer	Thickness of aquifer	Natural Water level	Pumping Water level	Draw down	Discharge	Specific capacity	Peamea-bility(k)	Transmis-bility(T)	Maximum discharge
29		m	m	inch.		to m	m	m	m	m	ℓ/s (m^3/d)	ℓ/s/m (m^3/d/m)	cm/s (m/d)	cm^2/s (m^2/d)	
30	Sarlahi Musaili		68.6	4 (3)	sand & gravel	60.0~68.0 lack of shallow aquifer	8.0	1.80	4.26	2.46	6.0 (520)	2.4 (210)	$3.7x10^{-2}$ (32)	30 (256)	

Table 3. Shallow tube well installation

SHALLOW TUBE WELL PROGRAMME FROM 1980 - 1983

Fiscal year	District	Total Boring	Success	Hole cancell	Failure after fitting	Pump distribution	Target	Progress
80 - 81	Dhanusha	9	6	3		6		
81 - 82	"	88	82	5	1	28		
82 - 83	"	148	122	24	2	41		
	Total:	245	210	32	3	75		
80 - 81	Mahotari	1	1			1		
81 - 82	"	50	48	1	1	31		
82 - 83	"	104	87	16	1	35		
	Total:	155	136	17	2	67		
80 - 81	Sarlahi	1	1			1		
81 - 82	"	80	68	11	1	39		
82 - 83	"	110	94	14	2	44		
	Total:	191	163	25	3	84		
						43	-----	For drought help
	Grand Total:	591	509	74	8	269		

	Target	Progress
80 -81	x	11
81 - 82	200	218
82 - 83	240	362

DEEP TUBEWELL PROGRESS

Dhanusa	18
Mahotari	2
Sarlahi	4
Total:	24

SHALLOW TUBE WELL

District	Panchayat	Total Boring	Success	Hole cancel	Failure
Dhanusa	Mahendra nagar	20	20		
	Harihar pur	7	7		
	Digamber pur	11	11		
	Baninia	2	2		
	Batesar	41	41		
	Umaprem pur	60	54	6	
	Yog Bhumi	36	34	2	
	Bhuthi	20	15	5	
	Mithilesar	8	2	5	1
	Fulgama	2	x	1	1
	Janakpur	5	2	3	
	Binhi	1	x	1	
	Lakshmi pur	2	1	1	
	Sinurjod	1	1		
	Saphi	2	2		

District	Panchayat	Total Boring	Success	Hole cancel	Failure
Dhanusa	Ghorghas	1	x	1	
	Suga Nikas	1	x	1	
	Mangal pur	1	x	1	
	Naktajhij	10	10		
	Govindpur	2	x	2	
	Dhanusa	3	2	1	
	Bhuchakarpur	3	2	1	
	Mujelia	2	x	2	
	Hasinapur	1	1		
Mahotari	Saharwa	3	x	2	1
	Fulhata	2	x	2	
	Parkauli	1		1	
	Gorigama	1		1	
	Banauta	1	1		
	Meghraul	2	2		
	Aurhi	54	50	4	
	Gausala	63	61	1	
	Negaul	6	5	1	
	Bhetpur	2	1	1	
	Raghunath pur	1		1	
	Balwa	1		1	
	Bigal pura	17	15	1	1
	Hati Sarwa	1	1		

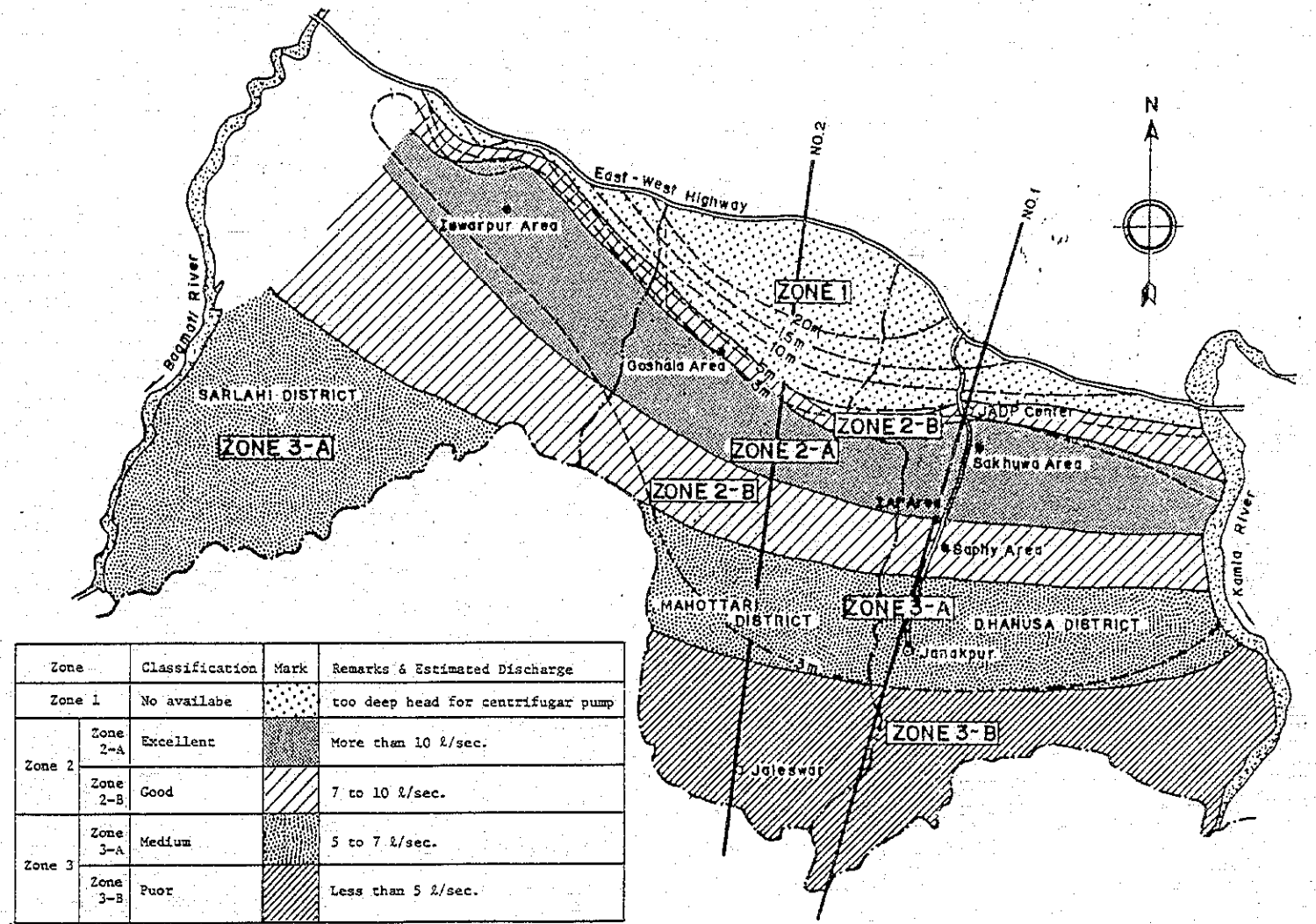
District	Panchayat	Total Boring	Success	Hole cancel	Failure
Sarlahi	Ishawarpur	58	50	7	1
	Babarganj	36	32	4	
	Bela	19	19		
	Kisanpur	6	5	1	
	Gauri Shankar	1	1		
	Bhaktipur	26	22	4	
	Netra ganj	3	3		
	Mohanpur	33	28	4	1
	Basant pur	1	x		1
	Farhaawa	1	x	1	
	Laksmi pur	1	1		
	Salempur	1	x	1	
	Haripurwa	1	1		
	Musauli	1	1		
	Kabilasi	1	x	1	
	Pipria	2	x	2	

Table 4. Chart of deep tube well information

Sl. No.	Tube-well Name	Location	Installation Date	Depth (m)	Diameter (Inch)	Artesian Discharge (ℓ/sec)	Pumping capacity (ℓ/sec)	Pumping water level (m)	Piezo-metric Surface (m)	Coefficient of Trans-missibility T:(m^2/sec)	Coefficient of Permea-bility K:(cm/sec)	Storage Coefficient S:(Dimen-sionless)	Remarks
1	I.A.P. Area No.1	Saphai Dhanusha	21 Mar., 1976	130.0	12/8	28.0	58.0(2nd) 44.0(1st)	-11.360	+1.260	2.42×10^{-3}	8.05×10^{-3}	1.74×10^{-5}	12" Housing
2	I.A.P. Area No.2	Saphai Dhanusha	10 Apr., 1976	130.0	12/8	15.0	36.3	-15.400	+1.300	1.75×10^{-3}	5.83×10^{-3}	1.35×10^{-4}	
3	I.A.P. Area No.3	Saphai Dhanusha	19 Feb., 1977	130.0	12/8	18.0	35.3 46.5	-9.940	+3.200	6.47×10^{-3}	2.16×10^{-2}	4.13×10^{-4}	
4	I.A.P. Area No.4	Saphai Dhanusha	25 Mar., 1975	146.0	12/8	14.4	39.9	-17.022	+5.430	2.94×10^{-3}	9.79×10^{-3}		
5	I.A.P. Area No.5	Saphai Dhanusha	11 May, 1976	130.0	12/8	18.0	35.3 32.9	-20.630	+1.800	8.50×10^{-4}	3.29×10^{-3}	6.32×10^{-5}	
6	I.A.P. Area No.6	Saphai Dhanusha	17 Feb., 1976	131.0	12/8	25.0	30.2	-14.980	+1.330	1.52×10^{-3}	5.05×10^{-3}	1.10×10^{-4}	
7	I.A.P. Area No.7	Saphai Dhanusha	2 Mar., 1975	156.0	12/8	(Estimated) 4.7	-	-	-	-	-	-	
8	I.A.P. Area No.8	Saphai Dhanusha	7 Feb., 1975	201.0	12/8	9.4	21.9 24.0	(Estimated) -11.000	+3.600	2.79×10^{-3}	6.98×10^{-3}	-	
9	I.A.P. Area No.9	Saphai Dhanusha	11 May, 1977	130.30	12/8	29.0	43.9	-6.843	+5.390	5.74×10^{-3}	1.79×10^{-2}	2.40×10^{-4}	
10	Hordinath No.2	Baneniya Dhanusha	1 Apr., 1977	160.0	12/8	10.0	30.0	-27.605	+3.430	1.35×10^{-3}	4.32×10^{-3}	9.50×10^{-5}	
11	Janakpur Hort	Janakpur Dhanusha	2 Dec., 1976	139.0	12/8	4.0	35.0	-15.560	+1.000	4.25×10^{-3}	1.43×10^{-2}	3.56×10^{-4}	
12	Janakpur Fishrjes	Janakpur Dhanusha	16 Feb., 1979	140.0	12/8	12.0	48.0	-13.692	+1.500	-	-	-	
13	Ghorgas No.2	Ghorgas Dhanusha	16 June, 1979	166.0	12/8	12.6	11.0	-25.021	+1.350	-	-	-	
14	Naktajhij No.1	Naktajhij Dhanusha	3 Jan., 1975	135.0	6"	Non Artesian	15.0	-27.500	-14.350	3.71×10^{-3}	3.42×10^{-3}	-	6" Throughout

Sl. No.	Tube-well Name	Location	Installation Date	Depth (m)	Diameter (Inch)	Artesian Diacharge (ℓ/sec)	Pumping capacity (ℓ/sec)	Pumping water level (m)	Piezo-metric Surface (m)	Coefficient of Trans-missibility (T:(m^2/sec)	Coefficient of Permea-bility K:(cm/sec)	Storage Coefficient S:(Dimen-sionless)	Remarks
15	Ram Nagar No.1	Ram Nagar Mahattari	16 Feb., 1978	81.0	6"	Non Artesian	15.0	-54.00	-22.00	-	-	-	
16	Dhalkhebar Test Boring	Dhalkhebar Dhanusha	29 July, 1977	115.0	6/4	Non Artesian	10.0	-68.00	-45.00	-	-	-	
17	Aurahi No.2	Aurahi Mahottari	20 Aug., 1979	111.0	10/6	Semi Artesian 5.0 (-1.0m)	60.0	-7.000 -7.000	-1.00	-	-	-	
18	Nawalpur No.2	Nawalpur Sarlahe	22 Sep., 1979	72.5	12/8	Non Artesian	45.0	-37.500	-21.30	-	-	-	
19	Mahendranagar No.1	Mahendranagar Dhanusha	19 Apr., 1980	116.60	12/8	Non Artesian	20.0	-21.000	-6.0	-	-	-	
20	Hardinath No.3	Baneniya Dhanusha	13 June, 1980	104.50	12/8	25.0	>35.3	-27.000	+2.00	-	-	-	
21	Nawalpur No.3	Nawalpur Sarlahe	14 Nov., 1981	70.0	12/8	Non Artesian	30.0	-29.740	-22.00	-	-	-	
22	Sagarnath No.1	Sagarnath Sarlahe	15 Fev., 1983	114.0	12/8	Non Artesian	30.0	-35.000	-16.500	-	-	-	
23	Sagarnath No.2	Sagarnath Sarlahe	20 Mar., 1983	110.0	12/8	Non Artesian	40.0	-29.000	-15.525	-	-	-	

Fig. 1 Classification on estimated discharge of shallow groundwater



Zone		Classification	Mark	Remarks & Estimated Discharge
Zone 1		No availabe		too deep head for centrifugar pump
Zone 2	Zone 2-A	Excellent		More than 10 ℓ/sec.
	Zone 2-B	Good		7 to 10 ℓ/sec.
Zone 3	Zone 3-A	Medium		5 to 7 ℓ/sec.
	Zone 3-B	Puor		Less than 5 ℓ/sec.

Note: Geological profiles along No.1 and No.2 lines on this figure are shown on FIG. No.

Fig. 2 Topographic Classification of Terai Plain

in Janakpur zone

(contour line : nvile)

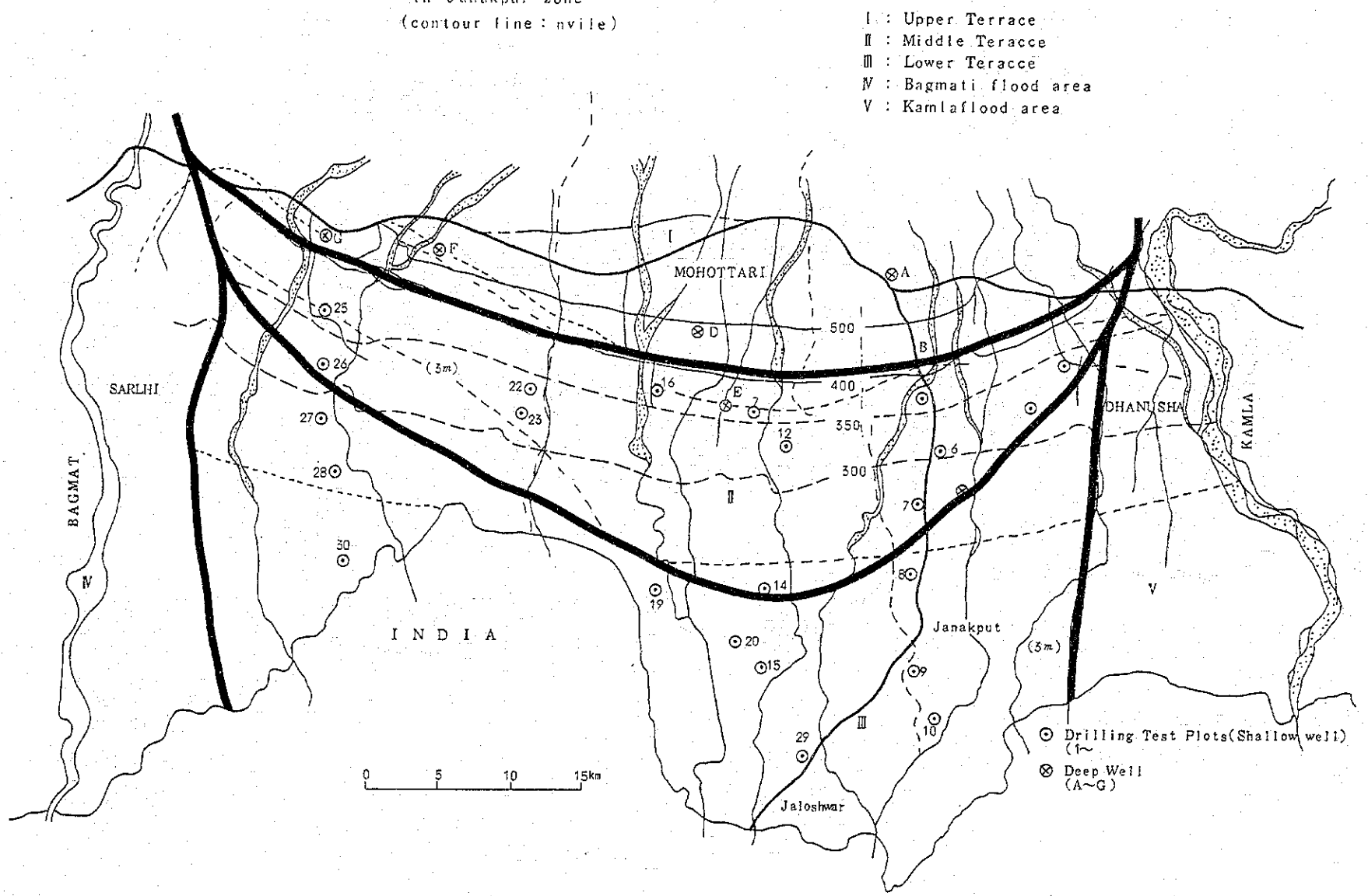


Fig.3－1　Geologic Section of Janakpur Zone

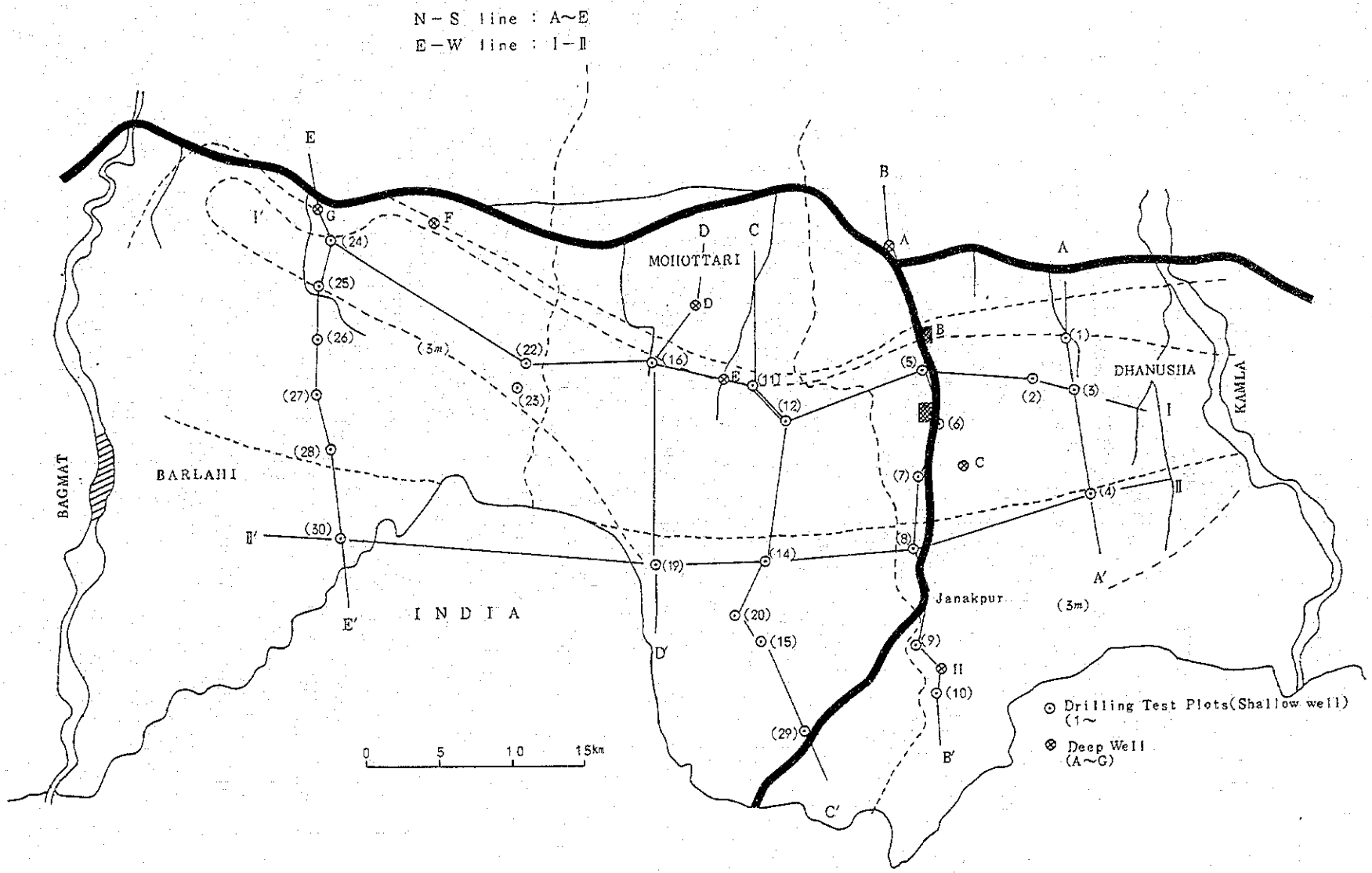


Fig 3 – 2

GEOLOGIC SECTION of A to A′ line

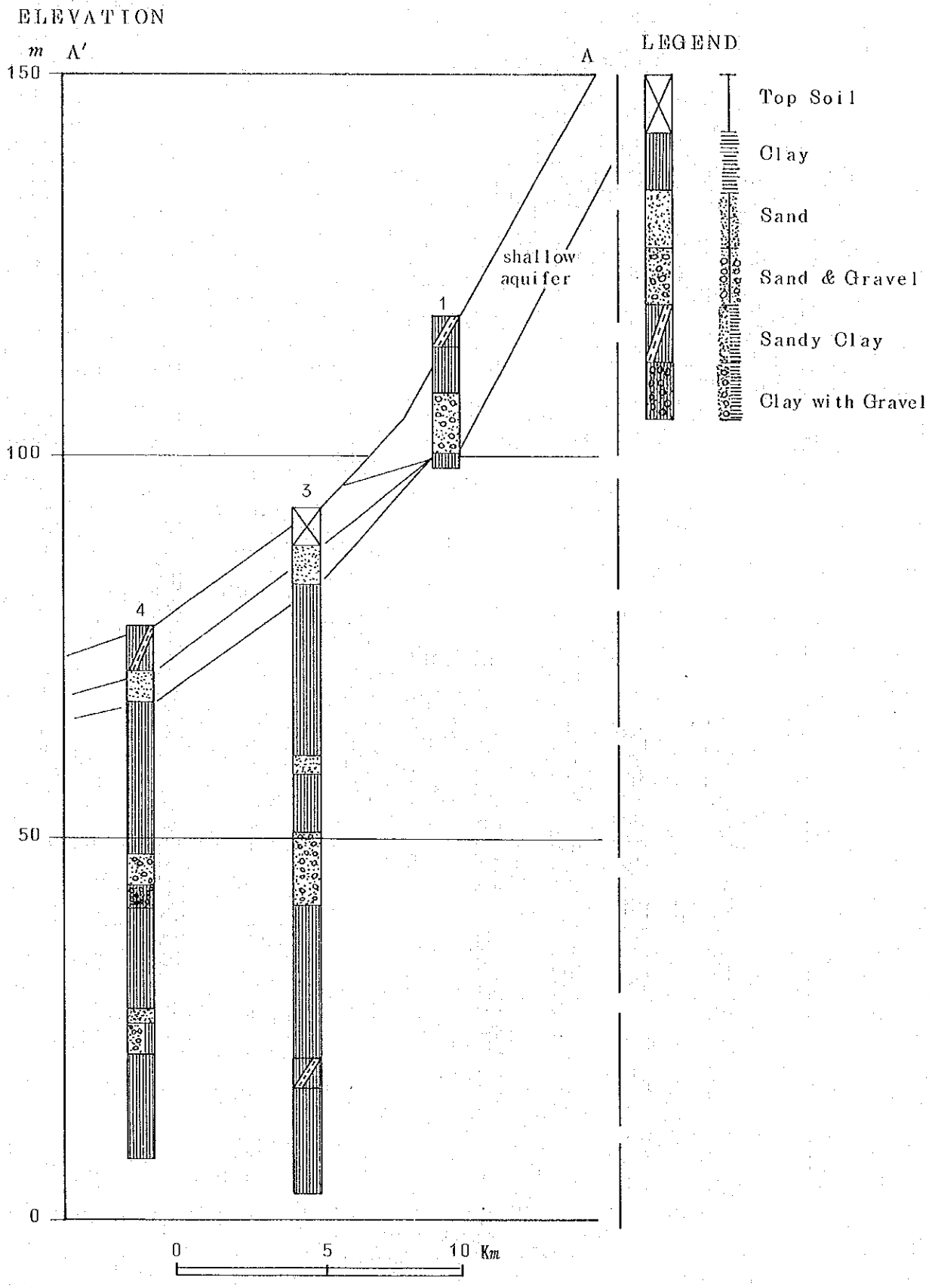


Fig3－3

GEOLOGIC SECTION of B to B'line

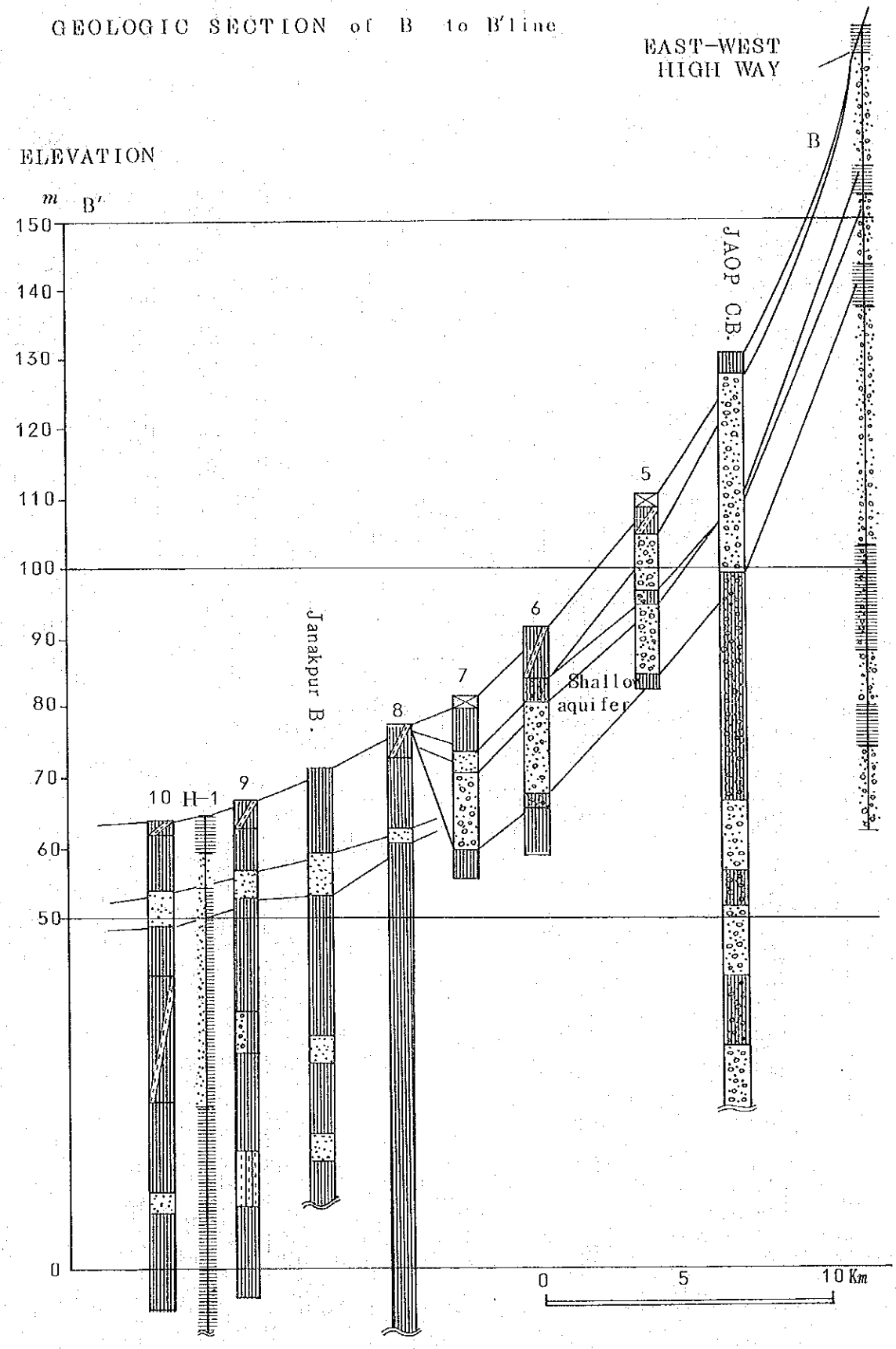


Fig 3 – 4

GEOLOGIC SECTION of C to C′ line

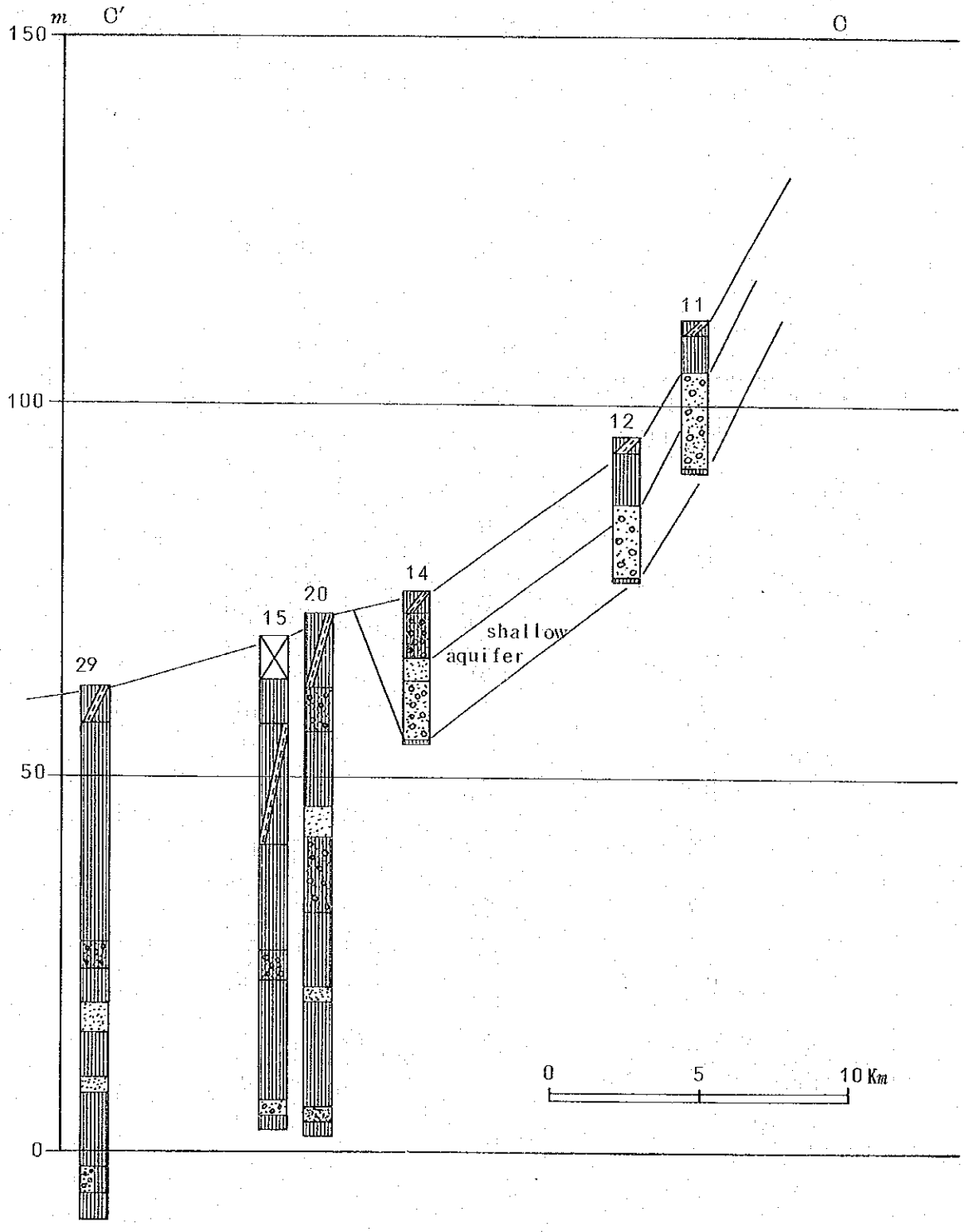


Fig 3 – 5

GEOLOGIC SECTION of D to D′ line

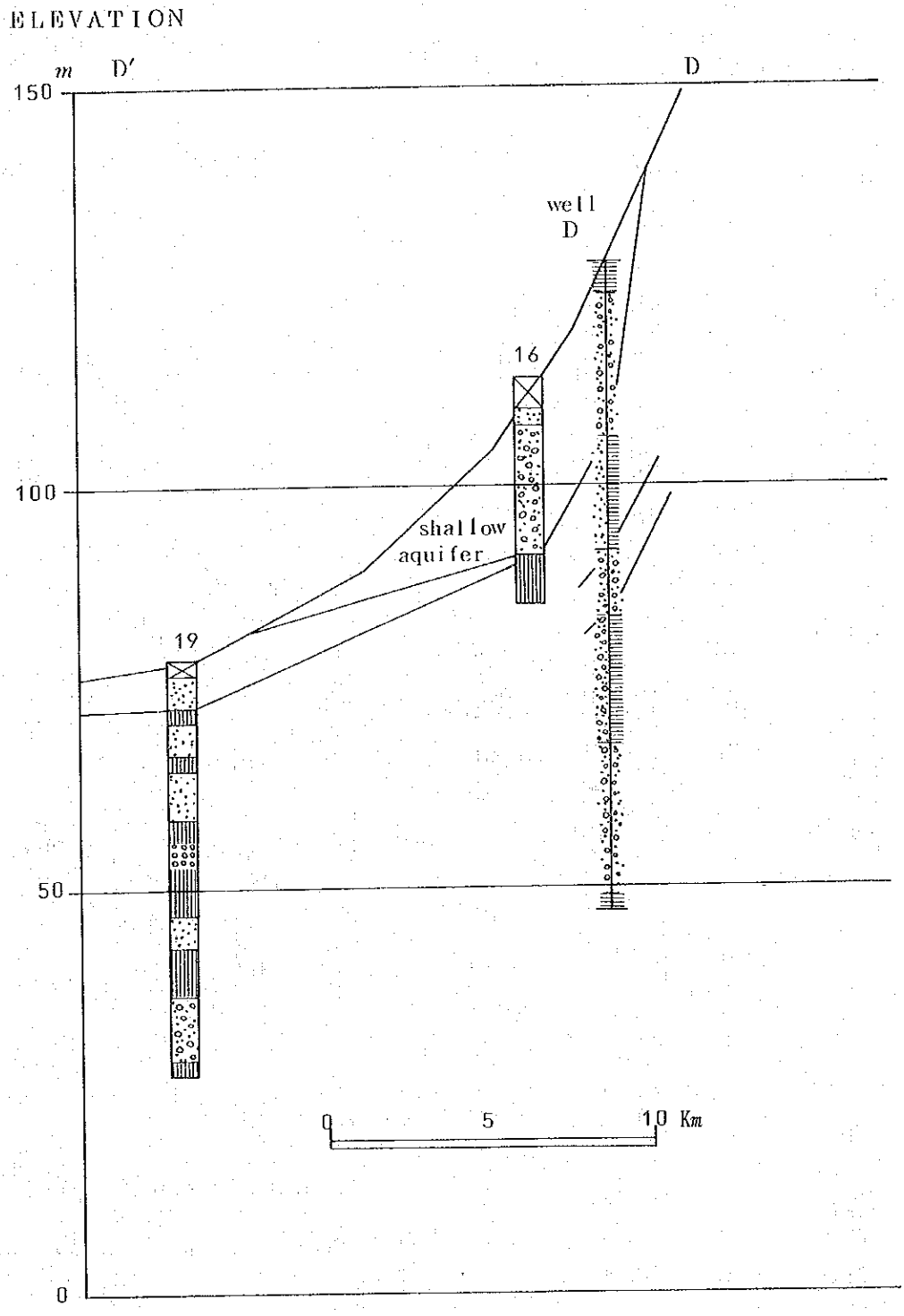


Fig 3 – 6

GEOLOGIC SECTION of E to E′ line

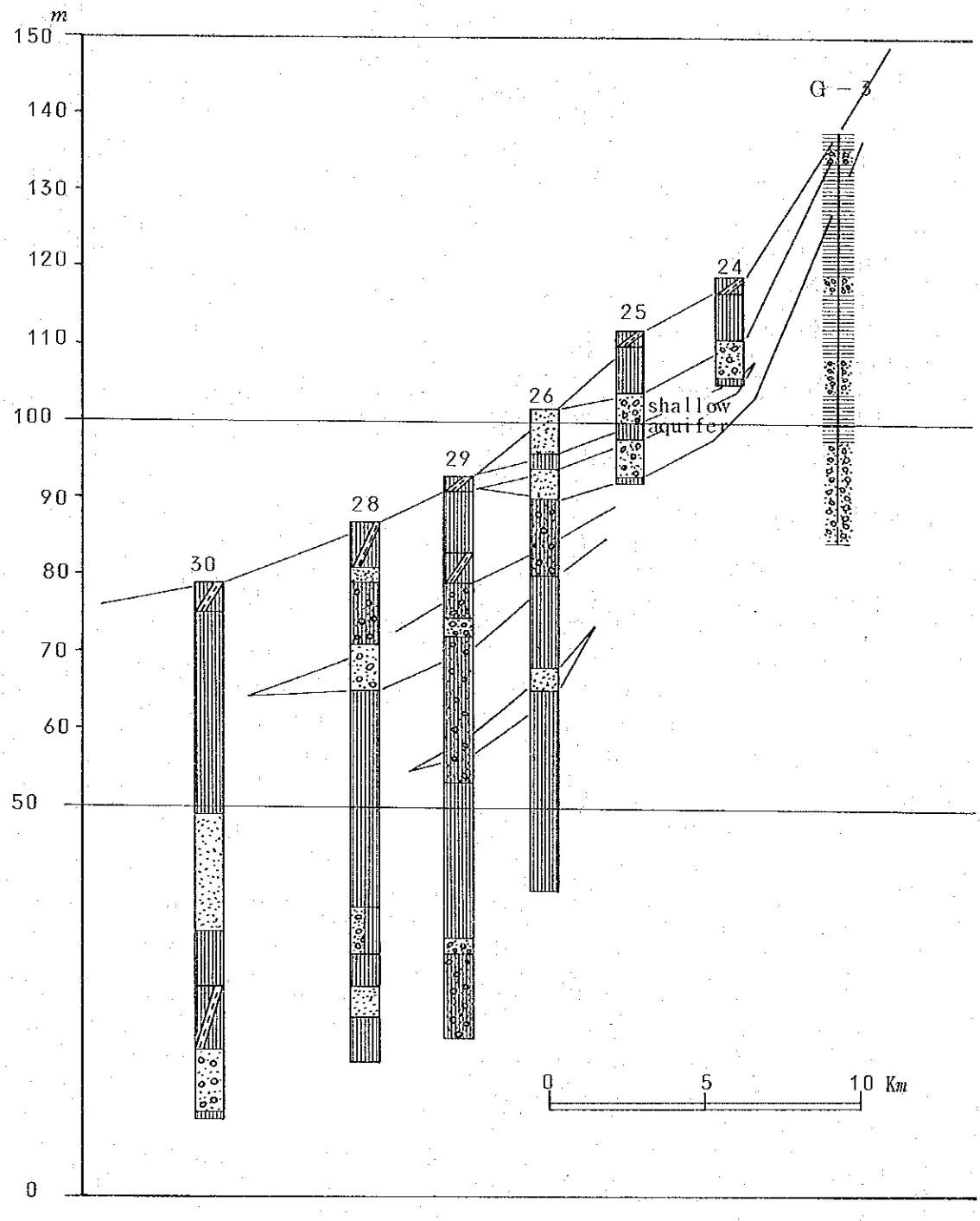
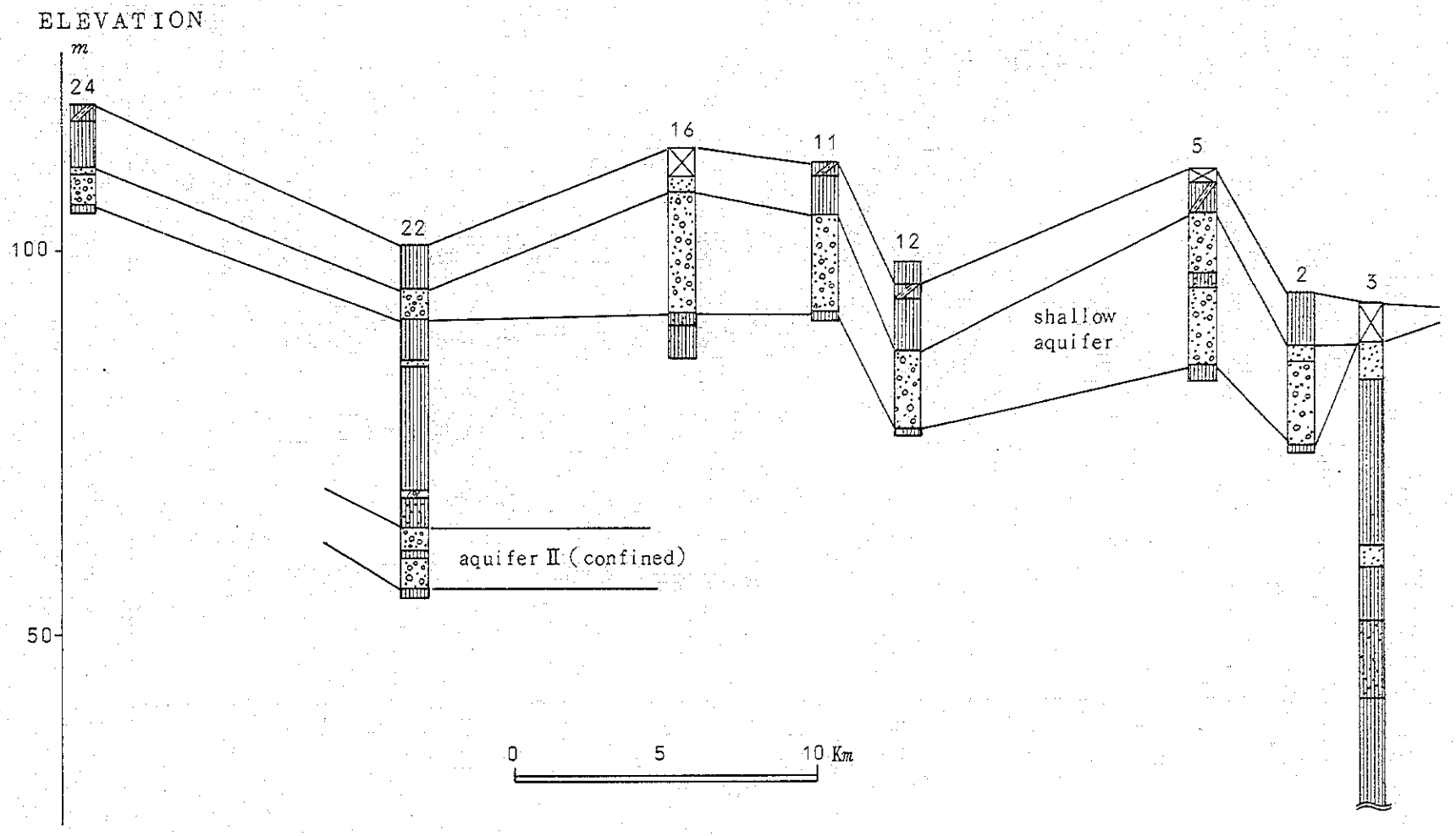


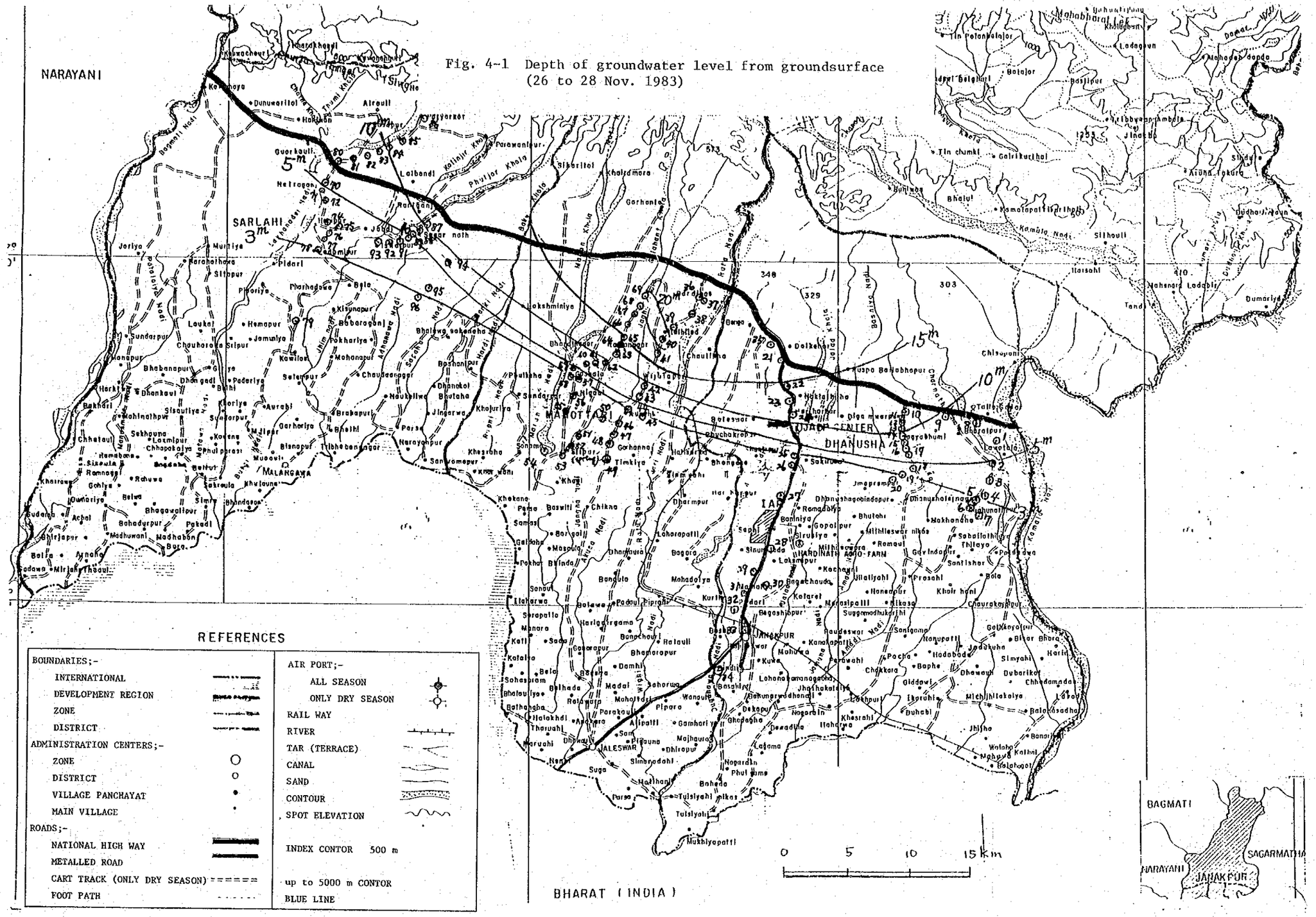
Fig 3 – 7

GEOLOGIC SECTION of I to I′ line



NARAYANI

Fig. 4-1 Depth of groundwater level from groundsurface
(26 to 28 Nov. 1983)



REFERENCES

BOUNDARIES;-	AIR PORT;-
INTERNATIONAL	ALL SEASON
DEVELOPMENT REGION	ONLY DRY SEASON
ZONE	RAIL WAY
DISTRICT	RIVER
ADMINISTRATION CENTERS;-	TAR (TERRACE)
ZONE	CANAL
DISTRICT	SAND
VILLAGE PANCHAYAT	CONTOUR
MAIN VILLAGE	SPOT ELEVATION
ROADS;-	
NATIONAL HIGH WAY	INDEX CONTOR 500 m
METALLED ROAD	
CART TRACK (ONLY DRY SEASON)	up to 5000 m CONTOR
FOOT PATH	BLUE LINE

Fig 4 – 2 Depth of Groundwater Level from ground surface

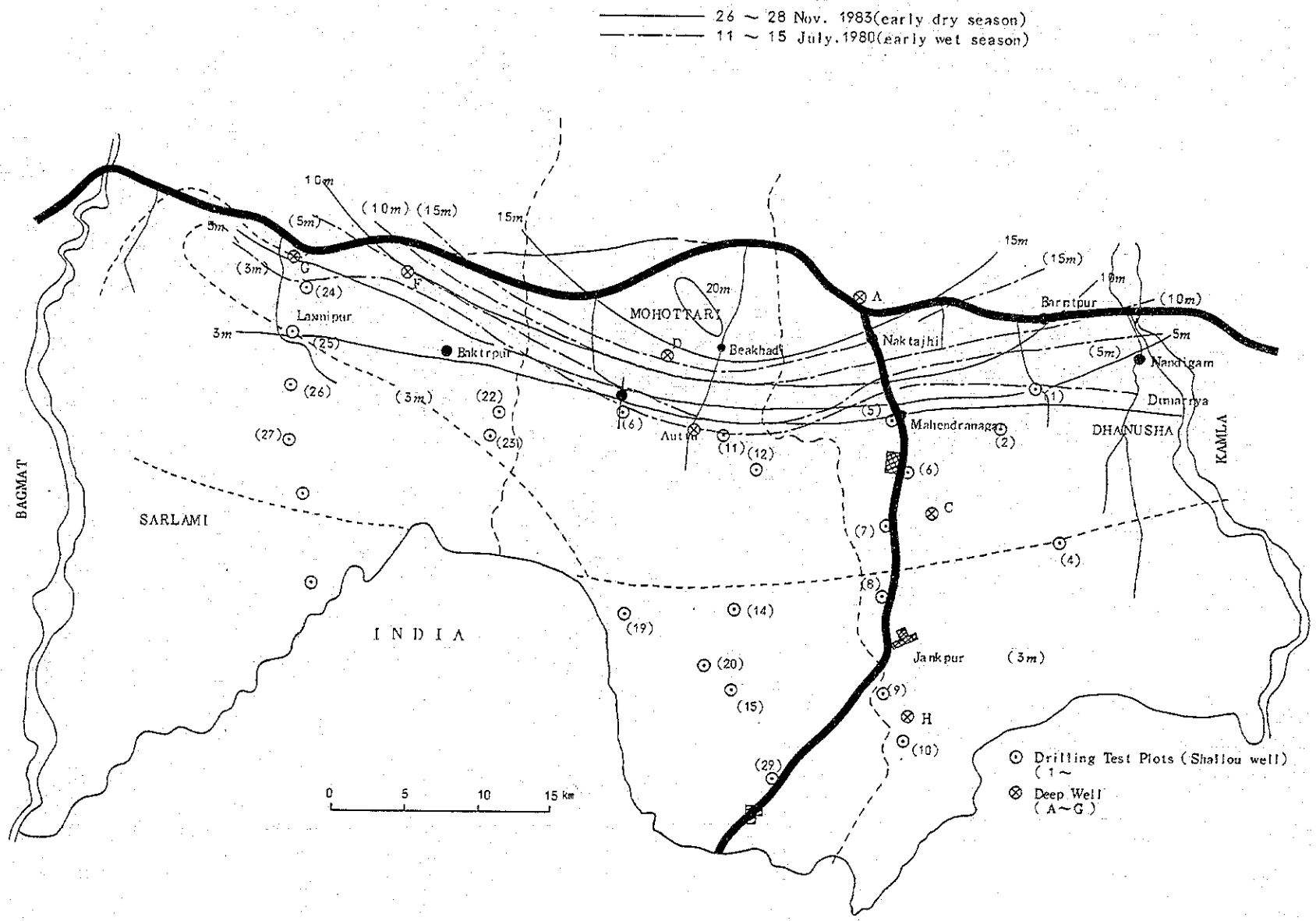


Fig 4 – 3

WATER LEVEL on B to B′ line

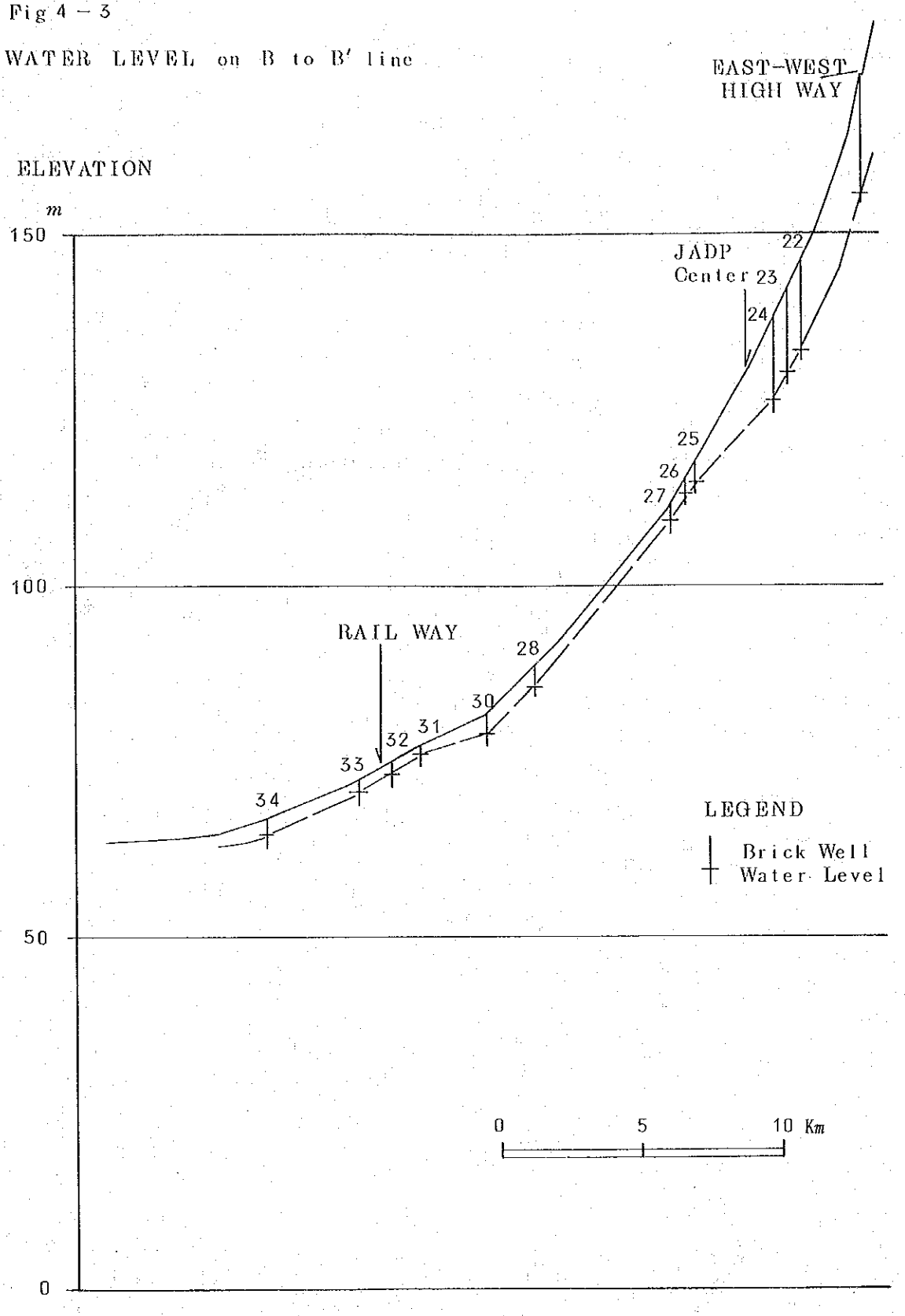


Fig 5 Implementation Area
of Shallow tube well development

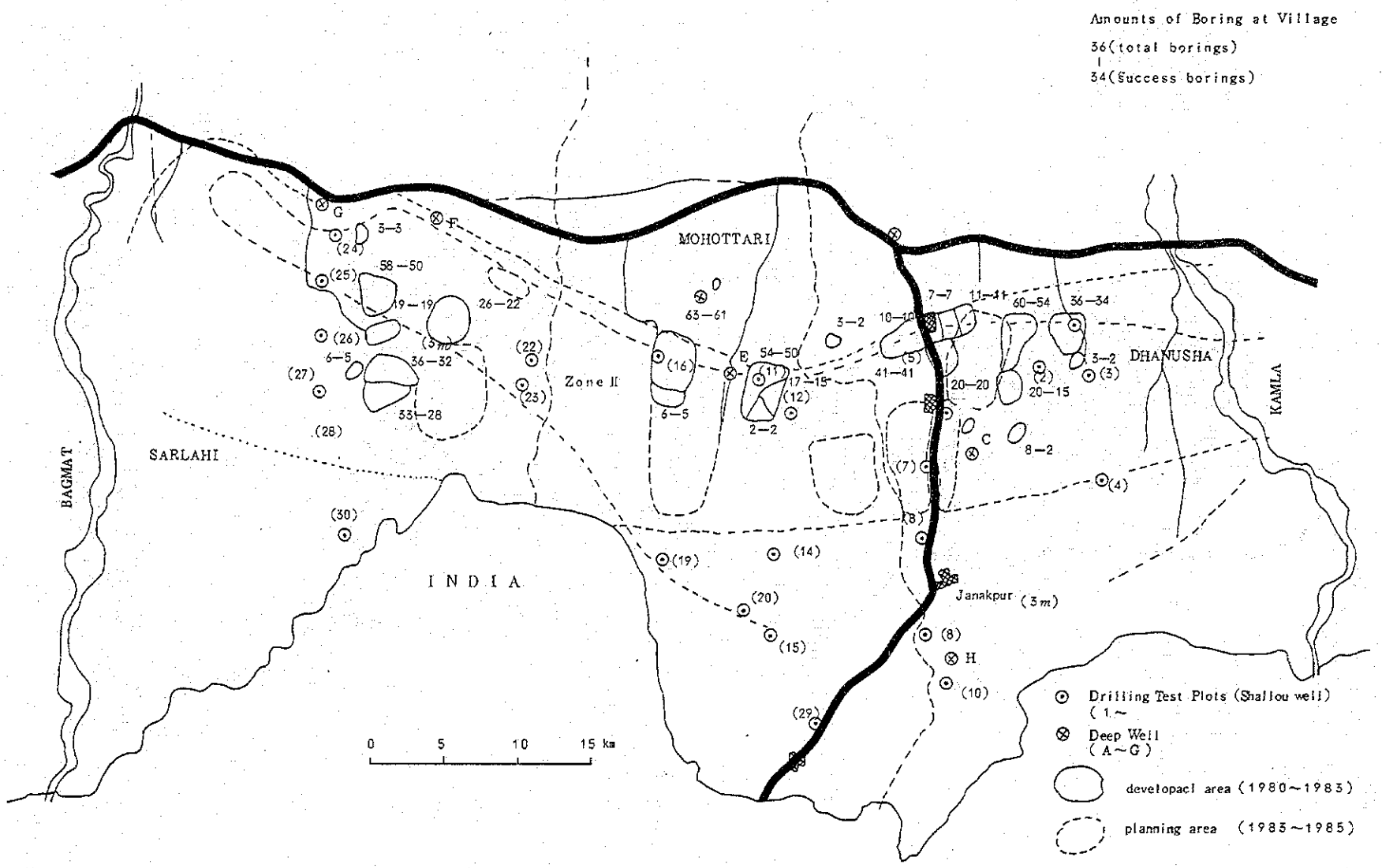


Fig. 6 Distribution of
Discharge Capacity of shollow tube well in each village

unit : l/sec a shallow tube well

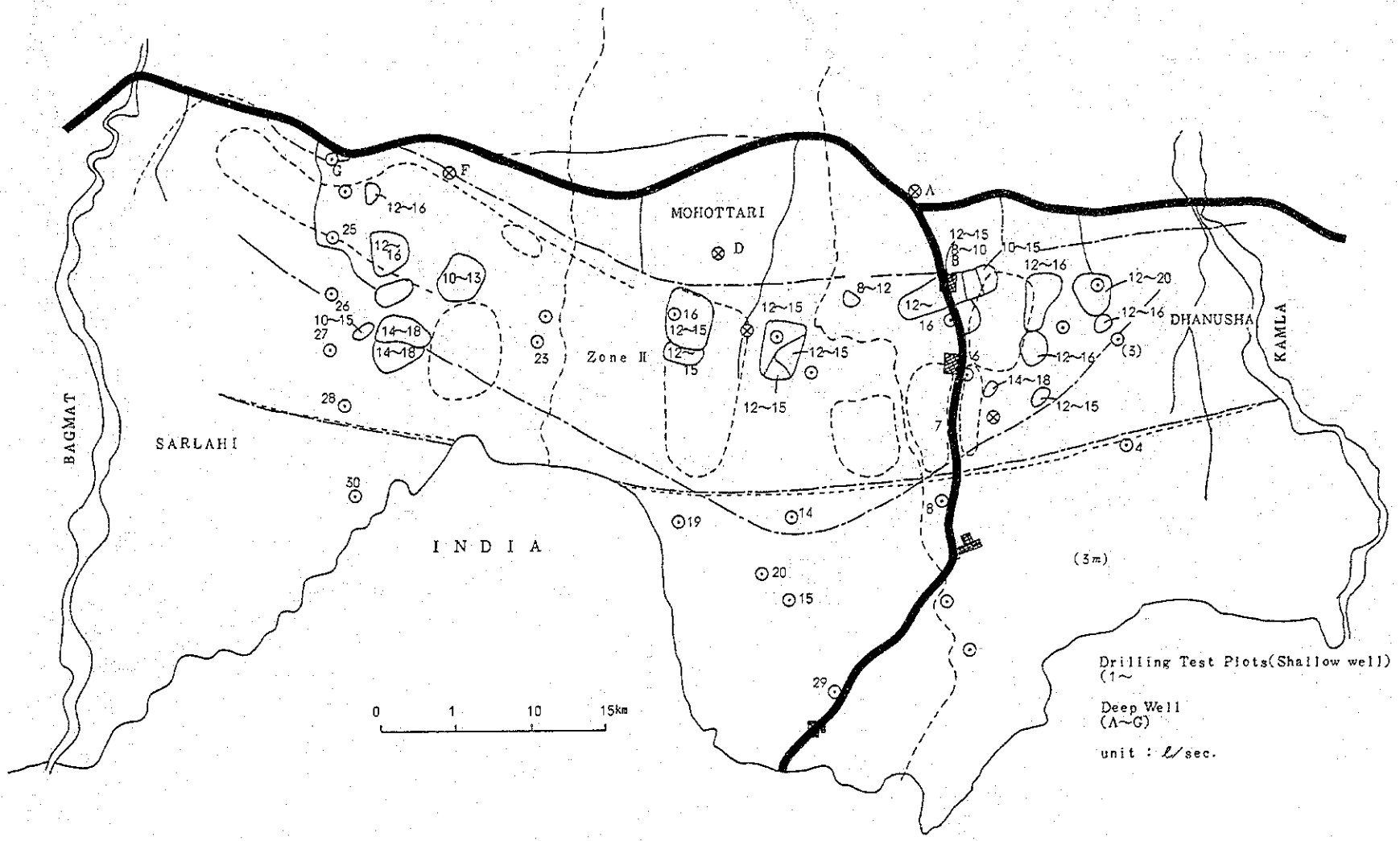


Fig 7 Distribution Map of shallow aquifer available

with maximum discharge capacity of drilling test wells

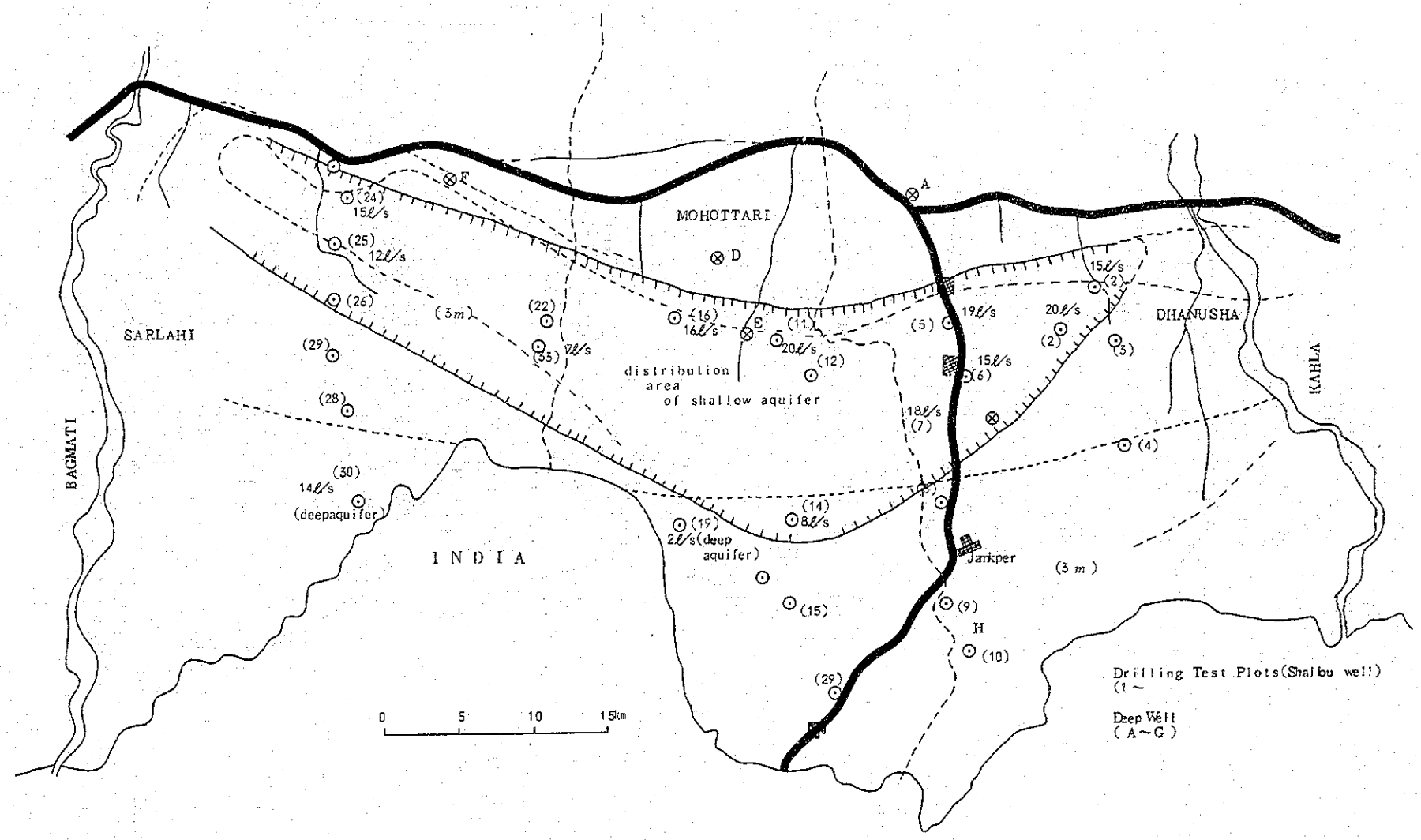


Fig. 8 Plots of setting up groundwater level Observation Well (Planned)

O.W－1 ～ O.W－8

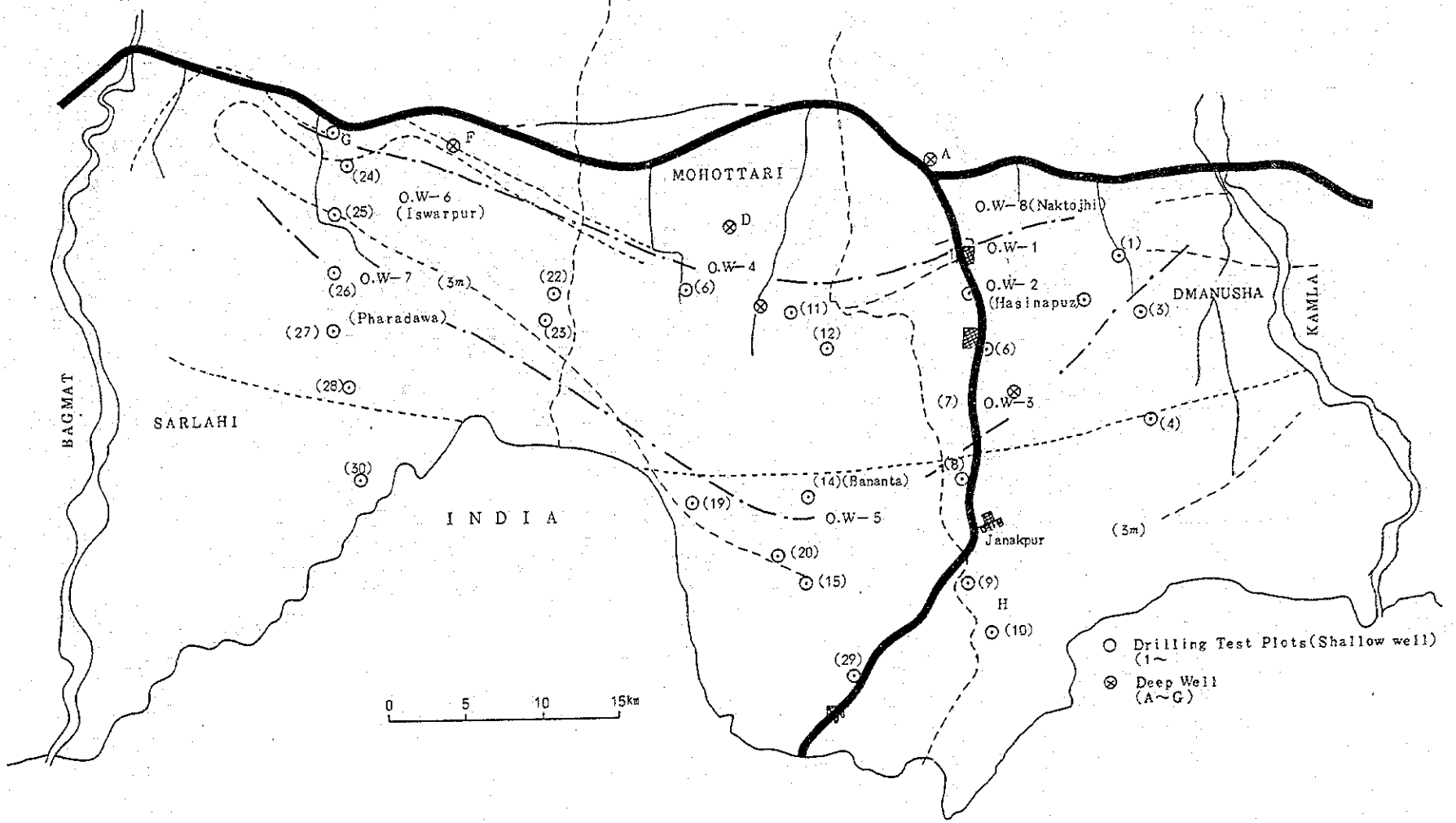


Fig9 Observation Chart of Groundwater Fluctuation

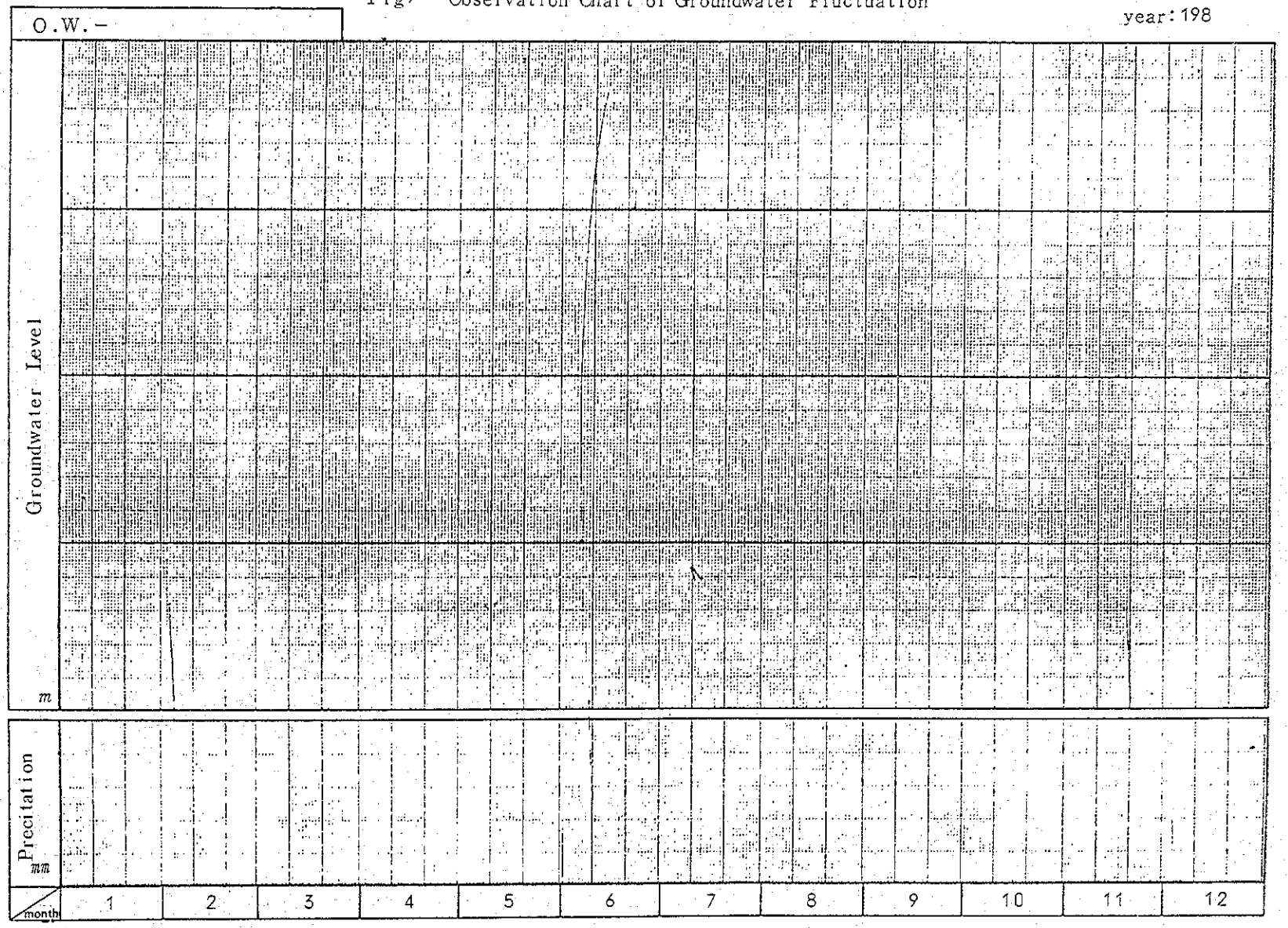


Fig 10. Investigation Plots of deeptube well (Test borings)