Chapter I

Chapter - I

INTRODUCTION

Prologue

Water is a scarce commodity and hence adequate supply of safe water is one of the pre-requisites for overall development of any country. This is particularly obvious in semi-arid to arid climatic regions. Moreover, with the growth in population, the demand for safe water increases many fold for the survival of the community. For this reason, the efforts connected with the location, development and conservation of the groundwater supplies are of fundamental economic importance for any country. An intensive activity in the exploration of groundwater has been initiated since last few decades because the groundwater like any other natural resources of the earth is becoming difficult to locate due to variations in the climatic, geomorphologic and geologic conditions. In view of this, new technique and methodology which will help to locate the potential zone for groundwater and reduce the failure rate of borewells are of a paramount importance in a developing country like India.

Due to the highly inadequate supply of safe water for domestic and irrigation purposes, the economic development of semi-arid to arid region of Rajasthan has become a challenging problem to the government. Hence formulation of strategy for speedy exploitation of groundwater resources of the region has

become an issue for the government. Generally, differentiation between saline water and clay by geophysical methods especially electrical resistivity may be difficult. The similarity in electrical conductivity of clay, saline water and brackish water in sandy aquifers limits resolution by electrical resistivity method alone. Hence, an integrated approach using hydrometeorological, satellite imagery, hydrogeological, geochemical and geophysical methods was explored to demarcate saline and fresh water zones and to develop relation between electrical resistivity parameters with hydrogeological parameters. As a result, large volume of data on groundwater applying hydrometeorological, geochemical, hydrogeological and geophysical methods have been generated over the last few years. The present thesis thus, includes all these results of integrated investigation carried out on groundwater studies in Bharatpur district of Rajasthan.

Types of Investigation

Now-a-days, with groundwater becoming scarce,the same is replenishable if it is planned in an optimal manner. For this, reliable information on quantity and quality is necessary. Consequently, the accuracy of measurements is of utmost importance with the presently available techniques. There are two main categories of measuring techniques used for determination of aquifer characteristics.

Surface Investigation : The surface investigations of groundwater do not need drilling wells and therefore they are less costly than sub- surface investigations and can broadly be divided into three groups : Geological methods, Remote sensing techniques and Geophysical methods.

Geological method depends on analysis of geological data which may be supplemented by field check. This approach is usually the first step in evaluating the hydrogeological conditions of a region.

In recent times, successful applications of satellite imagery in various fields such as, geology, oceanography, agriculture, forestry etc. have been reported by many authors viz. Martin *et al* (1973), Deutsch (1974), Moore and Deutsch (1975), Kruck (1976), Withington (1976) etc. This method, in particular, has also been used in locating suitable geological conditions favourable for groundwater occurrence, which is characterised by drainage pattern, erosion, variability of vegetation and land forms.

The main objective of geophysical methods is the search for and development of natural resources. Initially these methods developed for mineral and oil exploration have also been found very useful for groundwater investigations, supplementing the geological method. The most commonly used geophysical method for groundwater exploration is electrical resistivity method but in specific cases, other methods such as - seismic, magnetic, gravimetric etc. can also be helpful.

The electrical resistivity is the most commonly and extensively used method in groundwater exploration amongst the surface geophysical techniques because of its detectability of water bearing layers, its simplicity and its cost effectiveness. It is based on the principle that, resistivity of rock depends very much on the degree of saturation. If the geologic formation is porous and saturated, the resistivity is more dependent on water content and quality, rather than on the rock resistivity. Most popularly used configurations for electrical resistivity are Wenner and Schlumberger. Many authors, for instance, Wenner (1916), Swartz (1937), Ebert (1943), Alfano (1959), Meidev (1960), Baranov (1962), Adams *et al* (1969) etc. have successfully used this method for groundwater exploration. For interpretation of results, following theoretical work by Slichter (1933) etc, numerous tables and curves have been prepared for ready use.

Seismic method has very limited application in groundwater exploration but in special cases it has successfully been used to delineate favourable zone for groundwater occurrence. Duguid (1968), Zehner (1973), Eaton and Watkins (1980), Omorinbola (1983), Haemi (1988) and Woodward and Menges (1991) have successfully used this method for groundwater exploration.

In magnetic method, the terrestrial magnetic field is mapped for anomalies but this method also has very limited applications in groundwater investigations because magnetic anomalies are not directly related to groundwater occurrence. However, indirect

information on aquifer boundaries can be obtained by this technique, for example, the limits of basaltic flow, width and length of dyke. Adams *et al* (1969) and Bernard and Valla (1991) have successfully used this method to delineate sub-surface rock structures controlling flow of groundwater.

Gravity method, has also very limited applications in groundwater exploration but under special conditions can be used to map complex bed rock topography and drainage pattern as has been demonstrated by Ibrahim and Hinze (1972), Stewart (1980), Eaton and Watkins (1980) etc.

Sub-surface Investigation : For further information regarding hydrogeological conditions of the aquifer, sub-surface investigations are carried out. Generally, test drilling of small diameter holes are carried out to directly determine the desired quantity or quality characteristics. Rock samples thus collected are used to determine their various characteristics such as lithologs, porosity etc; water samples are also used to determine the quality parameters. Besides this direct method, there are several geophysical techniques in use for investigation in the bore hole.

Electrical resistivity log provides information of resistivities of layers which in turn can be used to evaluate the aquifer characteristics. This technique is very useful in determining the porosity of a given layer from the resistivity of the sub-surface water, correlation of lithologs, bed thickness

etc. This technique is best explained by Bush and Luckner (1974). Brown (1971), successfully used self potential (S.P.) log to determine the thickness of porous layers with greater accuracy.

Kelly (1939) used optical method to detect possible deterioration of well casing or the dimension of cavities in fractured rock aquifer that give indications of the aquifer characteristics. Recently, aquifer characteristics along bore hole have also been determined by special techniques, for instance, Induced radiation log (Pirson, 1963) and the Gamma log (Crosby and Anderson, 1971). The principle of Gamma log is based on measuring the natural Gamma radiation of the rock formation and is widely used to interpret the hydrogeological conditions. Similarly, application of Neutron log is also in vogue.

Area of Investigation

The area under present investigation forms a part of Aravalli mountain range of India which fringes the north-western margin of the Peninsular Indian shield for more than 700 km from Delhi in the north to north of Ahmedabad in the south. The Aravalli range in this part comprises flat topped monoclinal ridges of Alwar Quartzites and strike valleys curved out of soft Ajabgarh Phyllites. East of the truncated Alwar hills occurs as vast expanse of alluvial terrain which has been gradually built up by the migratory tributaries of the Yamuna, now disappeared and not connected to the master channel-the present Yamuna river. The monotony of alluvial expose is broken by a rocky flat form with low hills around Deeg ($27^{\circ}28'30"N$, $77^{\circ}19'30"E$).

The study area covers the entire part of the Bharatpur district of Rajasthan. It is located in the eastern most part of Rajasthan and can be easily approached by road connecting the cities of Jaipur and Agra. The study area is included within the Survey of India Topographic sheet Nos. 54A, 54E and 54F on 1 : 250,000 scale covering an area of about5000 sq.km. and is bounded by latitudes 26° 40'N and 27° 50'N and, longitudes 76° 53'E and 77° 45'E. The township of Bharatpur, the district headquarter is located approximately at the eastern part of the study area and can easily be approached by the National highway connecting cities of Jaipur and Agra. While the coordinates of the localities mentioned in this thesis are presented in Appendix 1, other important localities viz. Nagar, Kaman, Deeg, Kumher, Bayana, Roopwas etc. are connected with each other by metailed roads are shown in fig. 1.1. The district is bordered in its north by the state of Haryana, in its east by the state of Uttar Pradesh and in its south and west by the districts of Dholpur, Sawai Madhopur and Alwar of the state of Rajasthan. The study area covers only about 1.5% of the total area of the Rajasthan state. While the southern part of the district forms a part of the Gambhiri river basin, the central and northern parts respectively constitute the portions of the Banganga and Barah river basins.

For the development of groundwater in this region, the author has carried out hydrogeological and geophysical investigation with the following aims and objectives :

(a) Demarcation of fresh and saline water zones.

(b) Demarcation of favourable areas for potable water and water useful for irrigation and other purposes and,

(c) Establishment of relationship, if any between the geoelectrical and hydrogeological parameters.

Previous Work

It appears from literatures on electrical prospecting that R.W. Fox in 1830 was the first to discover the electrical current and potentials which were associated with certain ore deposits. Later on, P. Bachmetjiw in 1894 discovered potential which was not only due to minerals but also due to groundwater. The early decade of twentieth century saw contributions from C. and M. Schlumberger (1929), who patented this method especially its application in bore hole logging. A number of workers (Wenner, 1916; Swartz, 1937; Rust, 1938; Bays and Folk, 1944; Alfano, 1959) collected large volume of data on various aspects of electrical prospecting.

The foundation of numerical methods of calculating the apparent resistivity for various horizontal layers was laid in 1930 by S. Stefanesco's *et al* from mathematical relationship between the sub-surface resistive layers and apparent resistivities. L.B. Slichter (1933) suggested that the practical determination of the layer distribution from the measurements might be done in two steps, first determination of Kernel function and secondly, deduction of layer distribution from Kernel function. The relationship between geoelectrical

parameters and hydrogeological parameters received much attention by Archie in 1942. Later, a number of workers Croft, 1971; Bear, 1972; Griffith, 1976; Kelly, 1977; Heigold *et al.*, 1979; Koinski and Kelly, 1981 and Ponzini *et al.*, 1984 made attempt to explain the relationship between geoelectrical parameters and various hydrological parameters. Kailasam (1950) carried electrical resistivity survey in parts of Bharatpur district to locate brine zones.

The thesis consists of following six chapters :

Chapter I, under the heading "INTRODUCTION" deals with the types of investigation, previous work and brief description of the study area.

Chapter II, under the heading "NATURAL ENVIRONMENT" deals with the physiographic, geologic, hydrometeorological aspects of the area. It also describes the application of remote sensing techniques to geohydrology of the area.

Chapter III, under the heading " CHEMISTRY OF GROUNDWATER" deals with the cause behind the salinity of groundwater and the relationship between Ionic concentration with electrical conductivity.

Chapter IV, under the heading "ELECTRICAL RESISTIVITY METHOD" deals with the details of electrical resistivity theory, interpretation techniques, its usefulness and ambiguities.

Chapter V, under the heading "DATA COLLECTION AND INTERPRETATION" deals with the collection of geoelectrical data, types of resistivity curves obtained in the study area, spectrum of resistivity values and how the resistivity values depend on different type of rocks. It also deals with the apparent resistivity map with different electrode spacings, geoelectrical sections prepared on the basis of vertical electrical sounding (VES) data and discussions. In addition, it also deals with how Archie's equation for porosity gives fair picture of variation of mixed formation and how further application of Dar Zarrouk parameters helps in demarcating the areas between fresh and saline water zones.

Chapter VI, under the heading "SUMMARY AND CONCLUSIONS", deals with the precise summary of the work and important conclusions drawn from the study.

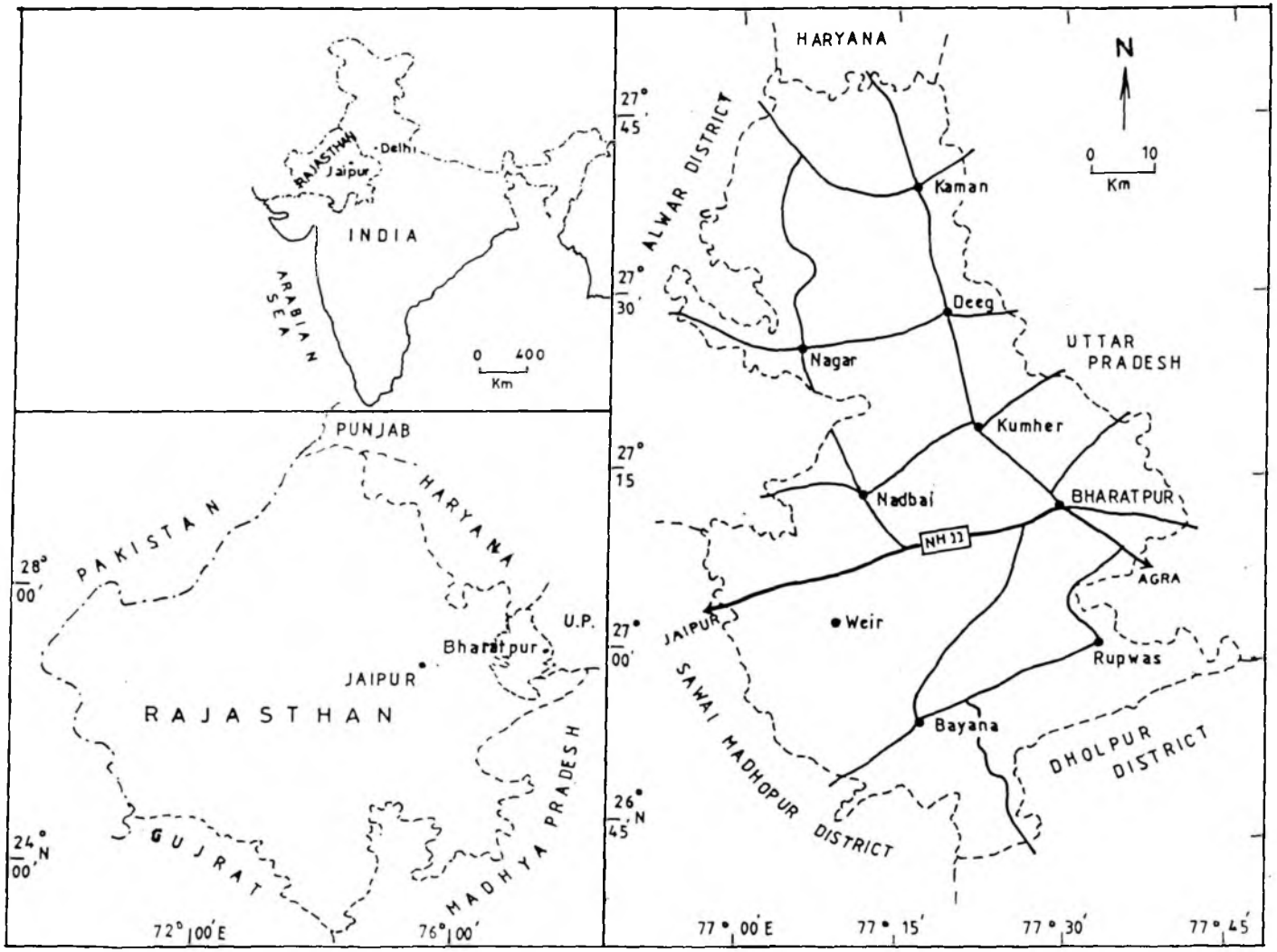

Fig 1.1 : Location map of Bharatpur District, Rajasthan.

Appendix - 1

Locality Index

S. No.	Village	Latitude	Longitude	Well No.	Vertical Electrical Sounding (VES) No.
1	Adhawali	27°28'47"N	77°13'28"E	W033	--
2	Aghapur	27°08'20"N	77°31'10"E	--	1
3	Agrawali	26°39'20"N	77°14'35"E	W054	--
4	Aikta	27°06'47"N	77°28'05"E	--	2
5	Ainchera	27°19'35"N	77°12'45"E	W079	--
6	Ajan	27°20'20"N	77°29'50"E	--	3
7	Ajau	27°14'45"N	77°20'45"E	W080	4
8	Akhegarh	27°13'40"N	77°03'30"E	W099	5
9	Alipur	27°09'40"N	76°59'40"E	W202	6
10	Arnia	27°10'08"N	77°07'52"E	--	7
11	Astawan	27°17'40"N	77°17'45"E	W081	8
12	Au	27°26'08"N	77°20'50"E	--	9
13	Awar	27°19'20"N	77°27'15"E	W082	10
14	Babekhar	27°07'40"N	76°59'00"E	W203	--
15	Bachamdi	27°12'20"N	77°33'35"E	W179	11
16	Bachrain	27°05'00"N	77°01'35"E	--	12
17	Bahaj	27°28'20"N	77°22'20"E	W035	13
18	Bahlera kalan	27°17'30"N	77°24'40"E	W083	--
19	Bahramda	27°16'40"N	77°12'45"E	--	14
20	Bahtana	27°26'30"N	77°18'28"E	W034	--
21	Baisora	26°45'10"N	77°25'50"E	W001	--
22	Bakholi	27°01'20"N	77°33'20"E	W153	15
23	Banera	27°09'30"N	77°34'00"E	--	--

S. No.	Village	Latitude	Longitude	Well No.	VES No.
24	Bansi	27°03'10"N	77°14'30"E	W204	--
25	Bansi kalan	27°09'55"N	77°21'25"E	W180	16
26	Bansi khurd	27°10'20"N	77°21'10"E	--	--
27	Bansi Paharpur	26°56'10"N	77°30'20"E	W149	17
28	Barai	27°29'30"N	77°16'50"E	W036	18
29	Baramafi	27°04'55"N	77°28'35"E	W150	19
30	Barauli chauth	26°27'40"N	77°24'40"E	--	20
31	Baretha	26°54'25"N	77°22'25"E	W002	21
32	Barkheda	27°41'30"N	77°05'00"E	W120	--
33	Barkheda sad	27°28'12"N	77°05'33"E	W121	--
34	Baroli char	27°14'05"N	77°05'40"E	W100	--
35	Baroli dhaur	27°34'55"N	77°12'55"E	W055	--
36	Barsa	27°10'43"N	77°32'45"E	--	22
37	Barwar	27°01'10"N	77°35'28"E	W151	23
38	Baseri	27°06'10"N	77°22'00"E	W152	--
39	Bayana	26°54'10"N	77°17'30"E	W003	24
40	Beru	27°30'05"N	77°04'45"E	--	25
41	Bhadira	27°17'40"N	77°11'30"E	--	26
42	Bhagori	26°58'00"N	77°15'00"E	W004	--
43	Bhagwanpura	26°56'20"N	77°23'40"E	W155	--
44	Bhandara	26°43'08"N	77°13'35"E	W056	--
45	Bhandore kalan	27°15'50"N	77°28'00"E	--	27
46	Bhanera	27°09'15"N	77°33'50"E	--	28
47	Bhanpur	27°25'28"N	77°08'15"E	W122	--
48	Bharatpur	27°13'00"N	77°30'00"E	W181	--
49	Bhaut	27°08'20"N	77°26'35"E	W154	--

S. No.	Village	Latitude	Longitude	Well No.	VES No.
50	Bhimnagar	26°55'40"N	77°17'10"E	W005	--
51	Bhosinga	27°09'40"N	77°10'50"E	W101	--
52	Bhusawar	27°02'15"N	77°03'20"E	W205	29
53	Bidyari	26°56'30"N	77°16'35"E	W006	30
54	Bilond	27°36'55"N	77°12'55"E	W057	--
55	Birampura	27°01'35"N	77°20'35"E	W007	31
56	Birharu	27°17'30"N	77°15'04"E	--	32
57	Bolkhera	27°39'10"N	77°11'28"E	W078	33
58	Borai	27°16'00"N	77°25'25"E	W084	34
59	Brahmabad	26°55'15"N	77°19'30"E	W008	35
60	Chahal	26°53'45"N	77°18'40"E	W009	36
61	Chahtauli	27°04'35"N	77°04'20"E	W206	--
62	Chandanpura	27°02'15"N	77°31'45"E	--	38
63	Chandoli	27°01'30"N	77°30'50"E	--	39
64	Chaprawas	27°43'20"N	77°02'10"E	--	40
65	Chekhora	27°00'20"N	77°38'25"E	W156	37
66	Chicksana	27°11'20"N	77°39'30"E	W182	41
67	Chirawalmali	27°26'45"N	77°05'55"E	--	42
68	Chokarwara	27°01'00"N	77°04'10"E	W207	43
69	Dabak	27°34'00"N	77°07'40"E	W123	--
70	Dahra	27°08'30"N	77°15'50"E	W102	44
71	Danduka	27°20'15"N	77°28'00"E	--	--
72	Darapur	27°07'35"N	77°33'25"E	W183	--
73	Deeg	27°28'30"N	77°19'30"E	W037	45
74	Deewli	27°03'30"N	77°01'04"E	W208	46
75	Dehwa	27°18'23"N	77°14'03"E	--	47

S. No.	Village	Latitude	Longitude	Well No.	VES No.
76	Dhadrain	26°49'30"N	77°10'55"E	W010	--
77	Dhamari	27°35'15"N	77°17'55"E	--	48
78	Dhaneta	27°10'40"N	77°20'10"E	W184	--
79	Dhanwara	27°17'08"N	77°20'50"E	W085	49
80	Dharmuin	27°17'30"N	77°32'35"E	W185	--
81	Dharsuni	27°07'25"N	77°13'00"E	W209	50
82	Dhilawati	27°41'10"N	77°19'45"E	W059	51
83	Dhimri	27°44'45"N	77°05'25"E	W058	52
84	Dholet	27°47'40"N	77°04'32"E	W060	--
85	Dhurarai	26°50'30"N	77°14'25"E	W011	--
86	Didawali	27°30'10"N	77°18'35"E	W038	53
87	Domraki	27°30'30"N	77°01'30"E	W124	--
88	Fatehpur	27°46'50"N	77°05'55"E	W061	--
89	Gadauli	27°10'45"N	77°17'15"E	W103	--
90	Gandhsora	27°44'50"N	77°02'30"E	W125	--
91	Gangroli	27°04'24"N	77°08'40"E	W211	54
92	Gangroli	27°15'20"N	77°15'10"E	W104	--
93	Garh Ajan	27°40'58"N	77°12'28"E	W062	--
94	Garwari	27°25'00"N	77°22'55"E	--	55
95	Gazipur	27°13'10"N	77°08'03"E	W105	--
96	Gazipur	27°07'32"N	77°04'15"E	W210	--
97	Ghagwari	27°36'25"N	77°08'25"E	--	56
98	Ghata	27°34'50"N	77°17'25"E	W045	122
99	Ghatoli	26°58'20"N	77°40'10"E	W157	57
100	Ghunsera	27°22'30"N	77°29'30"E	W086	58
101	Gogera	26°55'20"N	77°04'50"E	W212	--

S. No.	Village	Latitude	Longitude		Well No.	VES No.
102	Gohana	27°32'05"N	77°17'15"E	--	59	
103	Gopalgarh	27°39'15"N	77°03'45"E	W126	60	
104	Gulpara	27°32'00"N	77°07'40"E	W127	62	
105	Gundgaon	27°41'43"N	77°15'05"E	W063	--	
106	Gurera	27°44'09"N	77°14'40"E	--	63	
107	Hadoli	27°02'45"N	77°24'25"E	W158	64	
108	Halena	27°06'40"N	77°09'30"E	W213	65	
109	Hantra	27°08'10"N	77°14'15"E	W106	66	
110	Hatheni	27°16'00"N	77°33'55"E	--	67	
111	Hatori	26°59'40"N	77°06'30"E	W214	--	
112	Helak	27°13'30"N	77°22'20"E	W186	68	
113	Hingota	27°05'46"N	77°02'10"E	W215	--	
114	Hingota	27°29'08"N	77°10'44"E	W128	--	
115	Ibrahimpur	26°59'24"N	77°42'50"E	--	--	
116	Ikran	27°12'45"N	77°36'45"E	W187	--	
117	Indrauli	27°37'05"N	77°17'15"E	W064	69	
118	Induka	27°20'20"N	77°24'40"E	W087	70	
119	Jagheena	27°15'45"N	77°31'45"E	W188	71	
120	Jagjiwanpura	27°01'50"N	77°08'00"E	W216	--	
121	Jaicholi	27°07'50"N	77°24'30"E	W159	--	
122	Jaisora	26°45'08"N	77°24'55"E	W012	--	
123	Jaluki	27°27'20"N	76°57'40"E	W129	--	
124	Jangi Nagla	27°00'20"N	77°33'50"E	W160	--	
125	Januthar	27°23'00"N	77°13'50"E	W039	72	
126	Jatauli	27°16'55"N	77°35'30"E	W189	--	
127	Jatmansi	26°58'15"N	77°31'15"E	W161	73	

S. No.	Village	Latitude	Longitude	Well No.	VES No.
128	Jatwas	27°30'30"N	77°09'40"E	--	74
129	Jhalatala	27°06'00"N	77°06'40"E	W217	--
130	Jhorol	27°13'18"N	77°09'30"E	--	75
131	Jhundipur	27°40'00"N	77°05'50"E	--	76
132	Jurehra	27°46'50"N	77°12'30"E	W065	77
133	Kaithwara	27°35'40"N	77°08'00"E	W130	78
134	Kakarua	26°59'00"N	77°22'10"E	W162	--
135	Kakra	27°27'45"N	77°11'35"E	--	--
136	Kalayanpur	27°06'25"N	77°30'55"E	--	--
137	Kalluka	27°46'45"N	77°07'25"E	--	79
138	Kalsada	26°53'00"N	77°05'06"E	W013	80
139	Kalyanpur	27°06'25"N	77°30'55"E	W192	--
140	Kaman	27°39'00"N	77°16'10"E	W066	81
141	Kanjoli	27°14'15"N	77°27'00"E	W190	--
142	Kareli	27°15'20"N	77°10'30"E	W107	82
143	Karmuka	27°32'43"N	77°13'40"E	--	--
144	Kasot	27°27'15"N	77°24'45"E	W040	83
145	Kathol	27°44'25"N	77°07'35"E	W067	84
146	Kawai	27°12'15"N	77°15'35"E	W108	--
147	Keoladev park	27°09'55"N	77°31'25"E	W191	107
148	Khairora	26°58'55"N	77°09'55"E	W218	--
149	Khakhawali	27°25'15"N	77°02'25"E	W131	85
150	Khan Surajpur	26°58'40"N	77°38'10"E	W163	86
151	Khandewala	27°41'30"N	77°02'20"E	W132	--
152	Khangri	27°11'05"N	77°11'20"E	W109	87
153	Khanua	27°02'00"N	77°32'50"E	--	88

S. No.	Village	Latitude	Longitude	Well No.	VES No.
154	Kharbera	27°04'15"N	77°11'00"E	--	89
155	Kharera	27°07'00"N	77°25'25"E	--	90
156	Khareri	26°55'30"N	77°11'25"E	W014	91
157	Khatipura	27°10'20"N	77°01'00"E	W219	--
158	Khatnawali	27°00'25"N	77°16'05"E	W015	--
159	Kherli Gadasia	27°04'05"N	77°16'05"E	W016	92
160	Khoh	27°31'45"N	77°15'05"E	W041	93
161	Khori	27°26'00"N	77°17'30"E	--	95
162	Konrera	27°24'20"N	77°24'55"E	--	96
163	Kot	26°48'10"N	77°25'55"E	W017	97
164	Kuma	27°09'20"N	77°27'50"E	W193	--
165	Kumher	27°19'00"N	77°22'50"E	W088	98
166	Kunder	27°02'25"N	77°23'45"E	--	99
167	Ladlaka	27°45'35"N	77°11'34"E	W068	--
168	Lakhanka	27°19'45"N	77°24'50"E	--	100
169	Lakhanpur	27°06'40"N	77°18'30"E	--	101
170	Lakhanpur	26°58'40"N	77°10'55"E	--	--
171	Lohagarh	27°45'40"N	77°17'50"E	W069	--
172	Loharwara	27°32'50"N	76°59'50"E	W133	102
173	Lohasar	27°38'30"N	77°13'00"E	--	--
174	Ludhawai	27°10'25"N	77°24'05"E	W194	103
175	Luhasa	27°01'40"N	77°13'40"E	W220	104
176	Lulehra	27°09'40"N	77°19'00"E	W110	105
177	Mabai	27°24'08"N	77°11'40"E	W042	--
178	Madpur	26°53'10"N	77°13'05"E	W018	--
179	Mai	27°05'40"N	77°17'25"E	W111	--

S. No.	Village	Latitude	Longitude		Well No.	VES No.
180	Malahera	27°05'35"N	77°02'40"E	--	106	
181	Malipura	27°30'32"N	77°23'08"E	W043	--	
182	Maloni	27°06'15"N	77°07'25"E	--	108	
183	Manapuri	27°34'50"N	76°57'00"E	W134	--	
184	Mandhera	27°28'38"N	77°21'17"E	W044	--	
185	Mandoli	27°00'22"N	77°26'20"E	W165	109	
186	Matuki	27°37'45"N	77°10'25"E	W135	110	
187	Mazazpur	26°56'45"N	77°03'15"E	--	111	
188	Mehgaon	27°18'45"N	77°29'35"E	--	112	
189	Mehraipur	27°36'15"N	77°02'05"E	W136	113	
190	Mehrawar	27°18'35"N	77°16'30"E	--	114	
191	Mertha	26°59'40"N	77°42'50"E	W166	115	
192	Milakpur	27°01'10"N	77°22'55"E	W019	--	
193	Milswan	27°00'15"N	77°44'40"E	W167	116	
194	Mohalpur	26°56'27"N	77°28'40"E	W164	--	
195	Mohammadpur	26°54'30"N	77°21'00"E	W020	--	
196	Moondoti	27°23'28"N	77°03'38"E	W137	--	
197	Moroli dang	26°56'30"N	77°26'30"E	W168	--	
198	Moroli	27°18'30"N	77°31'05"E	W195	--	
199	Muhari	27°02'50"N	77°10'50"E	W221	117	
200	Mukhena	27°08'30"N	77°06'10"E	--	118	
201	Mundhera	27°22'15"N	77°08'35"E	--	119	
202	Nadwai	27°13'20"N	77°11'40"E	W112	120	
203	Nagar	27°25'20"N	77°06'10"E	W138	121	
204	Nagla Hota	27°05'00"N	77°10'55"E	W021	--	
205	Nagla sewa	27°02'20"N	77°21'05"E	W022	--	

S. No.	Village	Latitude	Longitude	Well No.	VES No.
206	Nagla Tulsi	26°55'40"N	77°34'40"E	W169	123
207	Nakatpur	27°37'30"N	77°03'30"E	W139	124
208	Nam	27°09'55"N	77°13'15"E	W113	--
209	Naraoli	26°57'17"N	77°21'10"E	--	125
210	Narharpur	27°02'20"N	77°06'15"E	W222	--
211	Naugaon	27°47'20"N	77°17'20"E	W070	--
212	Naugaya	27°14'55"N	77°34'50"E	W196	--
213	Nekpur	27°03'55"N	77°22'55"E	W170	126
214	Nibhera	26°59'35"N	77°26'50"E	W171	127
215	Nithar	26°57'40"N	77°02'20"E	W223	128
216	Pachora	27°17'40"N	77°13'20"E	W089	--
217	Padalwas	27°28'30"N	77°08'10"E	W140	--
218	Padla	27°28'25"N	77°10'52"E	--	130
219	Pagsari	27°33'15"N	77°02'50"E	--	132
220	Pahari	27°42'35"N	77°05'00"E	W141	--
221	Paharsar	27°09'55"N	77°17'20"E	--	131
222	Palka	27°31'00"N	77°06'45"E	W142	--
223	Paltu	27°21'55"N	77°07'50"E	--	133
224	Panhori	27°26'40"N	77°15'05"E	W046	134
225	Pansoda	27°03'20"N	77°34'30"E	W172	--
226	Paprera	27°13'10"N	77°18'30"E	W090	--
227	Parmandra	27°32'10"N	77°18'25"E	W048	--
228	Pasopa	27°34'05"N	77°13'30"E	W047	135
229	Pathena	27°07'40"N	77°01'40"E	W224	--
230	Peepla	27°15'15"N	77°36'10"E	W197	--
231	Pichumar	27°19'40"N	77°18'10"E	W091	136

S. No.	Village	Latitude	Longitude	Well No.	VES No.
232	Pichuna	27°04'05"N	77°26'15"E	W173	137
233	Pidi	27°18'28"N	77°19'25"E	--	138
234	Pilsu	27°39'10"N	77°05'20"E	--	139
235	Pingora	27°05'10"N	77°20'10"E	W114	140
236	Piprau	27°12'15"N	77°09'03"E	W115	--
237	Purbaikhera	26°57'55"N	77°20'05"E	W023	--
238	Puthka	27°31'00"N	76°55'20"E	W143	--
239	Rahimpur	27°03'40"N	77°22'55"E	--	141
240	Ramaspur	27°04'40"N	77°10'40"E	--	142
241	Ramnagar	27°06'50"N	77°11'36"E	W225	143
242	Rampura	27°11'15"N	77°28'40"E	W198	--
243	Ranota	27°26'00"N	77°01'00"E	W144	144
244	Rarah	27°19'10"N	77°33'40"E	W092	145
245	Raseri	26°49'40"N	77°12'00"E	--	146
246	Rasiya	27°26'12"N	77°10'35"E	W145	147
247	Rithoti	27°20'20"N	77°20'05"E	--	148
248	Ronija	27°18'30"N	77°09'30"E	W116	--
249	Rudawal	26°57'50"N	77°25'30"E	W174	150
250	Roopwas	26°59'30"N	77°35'30"E	W175	149
251	Sablana	27°35'35"N	77°14'55"E	--	--
252	Sabora	27°19'30"N	77°15'05"E	W093	151
253	Sahrai	27°29'05"N	77°17'00"E	W049	--
254	Sahsan	27°44'25"N	77°10'50"E	--	152
255	Saidpura	27°02'55"N	77°29'50"E	W176	153
256	Saint	27°22'10"N	77°21'30"E	W094	154
257	Sainthri	27°22'10"N	77°19'40"E	--	155

S. No.	Village	Latitude	Longitude	Well No.	VES No.
258	Salabad	26°59'00"N	77°18'50"E	W024	156
259	Salempur	26°55'30"N	77°02'15"E	W226	157
260	Samai	27°26'20"N	77°24'05"E	W050	158
261	Samogarh	26°52'00"N	77°12'55"E	W025	159
262	Samraya	26°59'10"N	77°13'10"E	W227	--
263	Sandhli	27°01'06"N	77°01'06"E	W228	--
264	Sarsena	27°08'35"N	77°08'15"E	W229	--
265	Satwari	27°40'25"N	77°07'45"E	W071	--
266	Satwas	27°42'55"N	77°16'45"E	W072	--
267	Semla khurd	27°27'35"N	77°01'35"E	W146	--
268	Semli	27°27'50"N	77°55'40"E	--	160
269	Seu	27°34'05"N	77°17'45"E	W051	--
270	Sewar	27°11'30"N	77°27'00"E	W199	161
271	Sikandra	26°52'45"N	77°15'50"E	W026	--
272	Sikripatti	27°34'35"N	77°04'35"E	W147	--
273	Singhawali	27°00'45"N	77°36'30"E	--	162
274	Sinsini	27°27'00"N	77°18'00"E	W052	163
275	Siswara	27°25'10"N	77°14'20"E	W053	--
276	Sitara	27°22'15"N	77°20'40"E	--	164
277	Sogar	27°16'40"N	77°28'55"E	W095	165
278	Sohanpur pali	27°36'20"N	77°09'45"E	--	166
279	Somka	27°42'25"N	77°10'05"E	W073	--
280	Somki	27°24'48"N	77°03'55"E	--	167
281	Sonokhar	27°44'35"N	77°14'25"E	W074	--
282	Srinagar	27°08'20"N	77°31'13"E	--	168
283	Suheri	27°01'20"N	77°04'40"E	--	169

S. No.	Village	Latitude	Longitude	Well No.	VES No.
284	Sultan ka nagla	26°54'03"N	77°08'28"E	W027	170
285	Supa	26°56'25"N	77°22'20"E	W028	171
286	Takha	27°20'30"N	77°31'40"E	W096	172
287	Taleempur	27°00'30"N	77°18'08"E	W029	--
288	Talphra	27°22'30"N	77°27'25"E	W097	173
289	Tamrer	27°22'25"N	77°22'50"E	--	174
290	Targawan	26°58'05"N	77°03'35"E	--	175
291	Tarsuman	26°51'18"N	77°23'15"E	W030	--
292	Tarwijpur	26°53'28"N	77°26'05"E	W031	--
293	Tejnagar	26°58'10"N	77°34'12"E	W177	--
294	Thanadang	26°51'30"N	77°19'35"E	W032	176
295	Therawar	27°21'55"N	77°15'40"E	W098	--
296	Thiya	27°15'30"N	77°29'35"E	--	177
297	Thoon	27°22'35"N	77°07'10"E	W148	--
298	Tilokpuri	27°39'10"N	77°08'30"E	W075	--
299	Toyla	27°07'10"N	77°19'18"E	W117	--
300	Tyohari	26°57'25"N	77°14'45"E	W230	--
301	Tyonga	27°15'10"N	77°30'05"E	W200	--
302	Uchain	27°05'25"N	77°24'40"E	W178	178
303	Udaka	27°40'28"N	77°18'15"E	W076	--
304	Uhlupura	27°04'25"N	77°00'05"E	W231	--
305	Ulanda	27°34'42"N	77°10'30"E	W077	--
306	Unapur	27°02'45"N	77°12'50"E	--	179
307	Unch	27°17'00"N	77°09'30"E	W118	--
308	Uncha nagla	27°09'10"N	77°34'50"E	W201	180
309	Unchira	27°44'20"N	77°15'45"E	--	181

S. No.	Village	Latitude	Longitude		Well No.	VES No.
310	Utarda	27°10'20"N	77°07'25"E	W119	182	
311	Vallavgarh	26°57'55"N	77°05'05"E	W232	183	
312	Weir	27°01'00"N	77°10'50"E	W233	184	