Groundwater Exploration by using Electrical Resistivity Meter in Granitic Terrain of Hyderabad Region, Telangana State, India

Shaik Saleemmiya[1], Prof. I. Panduranga Reddy[2], Sreenu Kunsoth[3]
[1,2,3] *Dept.of.Geology, Osmania University, Hyderabad*

***Abstract*— Hard rock occupies large parts of the earth's crust. These rocks are devoid of primary porosity and permeability. Most crystalline rock areas of Hyderabad are located in areas of high relief as a result, runoff is high and infiltration rates are very low. Most often, the occurrence of ground water in this terrain is localized and confined to weathered/fractured zones. Hence detailed pre-drilling geophysical investigations become inevitable. This present work gives a brief geological background of the hard work encountered in the study areas and explains the usefulness of the electric resistivity method.**

Electrical resistivity method is useful to investigate the nature of subsurface formations by studying the variations in their resistance to flow of electrical current and hence determine the occurrence of groundwater. The objectives of this method in the field of groundwater exploration are to locate groundwater bearing formations, estimation of depth to the water table, thickness and lateral extent of aquifers, depth to bed rock, structures and stratigraphic conditions such as fractures.

Index Terms: **Hard Rocks, porosity, Permeability, Runoff, Infiltration, weathered/fractured zones, Electrical resistivity method, groundwater.**

I.INTRODUCTION

AQUIFER:

An aquifer is a layer of relatively porous substrate that contains and transmits groundwater. When water can flow directly between the surface and the saturated zone of an aquifer, the aquifer is unconfined. The deeper parts of unconfined aquifers are usually more saturated since gravity causes water to flow downward the upper level of this saturated layer of an unconfined aquifer is called the water table or phreatic surface.

DEFINITION OFRESISTIVITY:

Resistivity is a physical property of a substance. It is an inherent property of a substance and is independent of size and shape of the substance.

The resistivity is defined as the resistance offered by a unit length of a substance of a unit area to the flow of electric current when the voltage is applied at the opposite faces. The resistivity of different soils are to be.

Resistivity of Different Materials:

Material	Resistivity (Ωm)
Alluvium	10 to 800
Sand	60 to1000
Clay	1 to 100
Groundwater (fresh)	10 to 100
Sandstone	$8 - 4 \times 10^3$
Shale	$20 - 2 \times 10^3$
Limestone	$50 - 4 \times 10^3$
Granite	5000 to 1,000,000

II. ELECTRIC RESITIVITYMETHOD

- The resistivity method is used in the study of horizontal and vertical discontinuities in the electrical properties of the ground
- It utilizes direct currents or low frequency alternating currents to investigate the electrical properties (resistivity) of the subsurface.
- A resistivity contrast between the target and the background geology must exist.
- The electrical resistivity method is highly useful to investigate the nature of subsurface formations by studying the variations in their electrical properties.

III.RESISTIVITYTHEORY

ERM (Electrical Resistivity meter) basically conducted to measure and map the resistivity of subsurface materials. It also refers as survey that carried out to present the image of electrical properties of the subsurface by passing an electrical current along many different paths and measuring the associated voltage. ERM is based on the response between the earth and the flow of electrical current. It sensitive to variations in the electrical resistivity of the subsurface measured in Ohm meters. Resistivity measurements are conducted by inducing an electric current into the earth through two current (C1 and C2) electrodes and measuring the resulting voltage at two potential electrodes (P1 and P2). The apparent resistivity (pa) value can be calculated based on the current (I) and voltage (V).

pa = k V / I

k represented the geometric factor that depends on the arrangement of four electrodes. Imaging depth of ERM method is dependent on the spacing between electrodes. Greater depth is achieved by increasing the electrode spacing. The total length of electrode array also plays role in resulting greater imaging depth. The overall subsurface resistivity also affects the imaging depth with highly resistive ground tending to decrease the depth after inversion. In accordance to the resistivity values of groundwater vary in range from 10 to 100 ohm- m depending on the concentration of dissolved salts contain as refer in the overlap value resistivity of different classes of waters was depending on several factors such as porosity, degree of water saturation and concentration of dissolved salts.

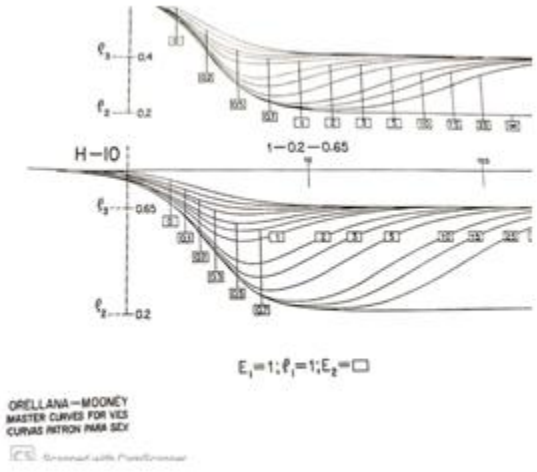
IV. DATA COLLECTION

Data collection is another important factor for the success of resistivity method.

The data should be adequate and accurate with sufficient resolution.

IV.(a). Analysis of three – layer curve:

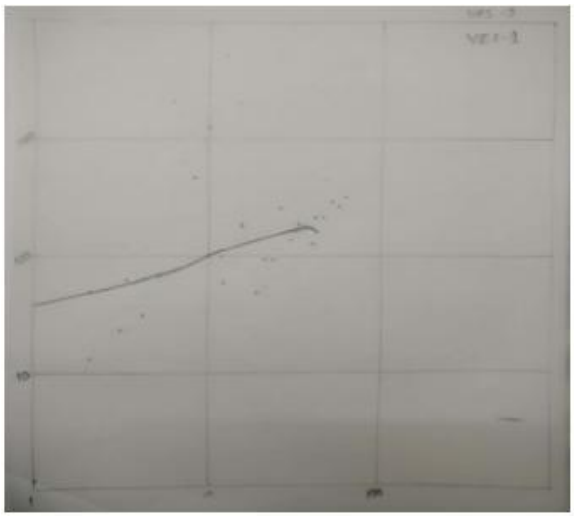
- Select the three layers master curve sheet which exhibit the similar general shape as field curve (A,K,H, or Q).
- The master curves of each type are grouped into families having different resistivity ratio combinations. The family curves contain one curve for each h/2 ratio.
- The thickness of the first layer will be equal to the abscissa value of the cross on the field curve.
- The thickness of the second layer will be equal to the thickness ratio number multiplies by the thickness of the first layer.
- Depth to the third layer will be equal to the sum of the thickness first and second layer and cannot match perfect thickness.



V. VES RESULTS (VERTICAL ELECTRICAL SOUNDING)

Ves Location.1

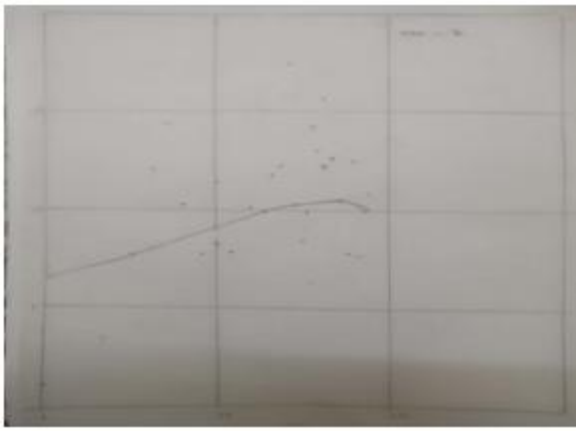
S NO.	AB/2	MN/2	VOLTAGE(V)	CURRENT(I)	CONSTANT (K)	RESISTIVITY (RO a)
1	1	0.5	48	100	2.3562	1.1309
2	2	0.5	111	100	11.781	13.08579
3	3	0.5	83	98	27.489	23.2815
4	4	0.5	60	97	49.48	30.6061
5	5	0.5	48	55	77.754	67.85803
6	6	0.5	98	04	112.31	2751.595
7	8	0.5	40	18	200.28	445.6666
8	10	0.5	99	25	313.37	1240.9452
9	10	2	88	64	75.398	103.67225
10	12	2	52	100	109.96	57.1792
11	15	2	40	39	173.57	178.0205
12	18	2	19	100	251.33	47.7529
13	20	2	29	100	311.02	90.1958
14	22	2	26	110	376.99	89.10672
15	25	2	24	49	483.73	238.881
16	28	2	22	100	612.67	134.7874
17	30	2	21	93	703.72	158.9045
18	32	2	20	90	801.11	178.02
19	35	2	18	97	958.97	177.9531
20	38	2	11	99	1131	125.666
21	40	2	17	100	1253	231.01
22	0	5	30	95	494.8	156.252
23	45	5	32	100	628.32	201.0624
24	50	5	30	79	777.54	295.268
25	55	5	29	99	942.48	276.08
26	60	5	28	100	1123	314.44



Result: About 8 meters of weathered zone is observed. Beyond this depth, a layer whose resistivity is 475-ohm meter is present, which is not a hard layer to represent a massive granite.
Hence a shallow bore well up to a depth of 180-200 feet can be recommended. Expected yield: 1-1.5" inch.

VesLocation.2

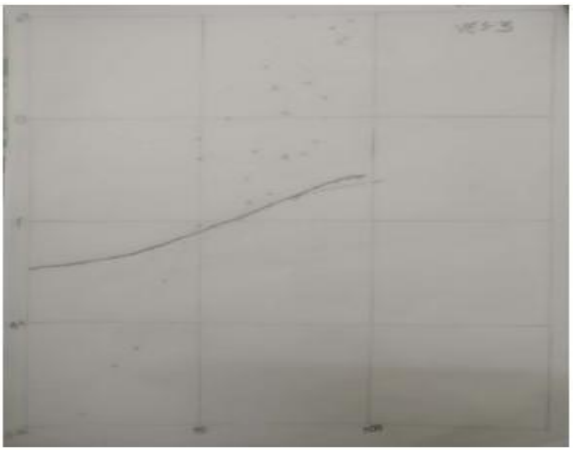
S NO.	AB/2	MN/2	VOLTAGE (V)	CURRENT(I)	CONSTANT (K)	RESISTIVITY(RO a)
1	1	0.5	19	275	2.3562	0.16
2	2	0.5	10	259	11.781	0.45
3	3	0.5	10	83	27.489	3.31
4	4	0.5	48	97	49.48	24.5
5	5	0.5	61	65	77.754	72.9
6	6	0.5	10	102	112.31	11
7	8	0.5	5	278	200.28	3.6
8	10	0.5	17	293	313.37	18.2
9	10	2	9	152	75.398	4.5
10	12	2	4	124	109.96	3.5
11	15	2	11	183	173.57	10.4
12	18	2	29	229	251.33	9.9
13	20	2	38	429	311.02	21.3
14	22	2	20	280	376.99	26.9
15	25	2	7	12	487.73	284.5
16	28	2	6	322	612.67	11.4
17	30	2	2	301	703.72	4.7
18	32	2	2	162	801.11	9.76
19	35	2	12	168	958.97	68.5
20	38	2	11	328	1131	37.9
21	40	2	16	149	1253	134.5
22	0	5	10	182	494.8	27.2
23	45	5	17	332	628.32	32.2
24	50	5	9	551	777.54	12.7
25	55	5	2	527	942.48	3.6
26	60	5	6	215	1123	31.4
27	65	5	1	404	1319	3.3
28	70	5	2	327	1532	9.4
29	75	5	3	368	1759	14.4



Result: About 7 meters of weathered zone is observed. Beyond this depth, a layer whose resistivity is 495-ohm meter is present, which is not a hard layer to represent a massive granite.
Hence a shallow bore well up to a depth of 150-200 feet can be recommended. Expected yield: 1- 2 inch.

VesLocation.3

S NO.	AB/2	MN/2	VOLTAGE(V)	CURRENT (I)	CONSTANT (K)	RESISTIVITY (RO a)
1	1	0.5	3	706	2.3562	0.01
2	2	0.5	1	937	11.781	0.01
3	3	0.5	1	767	27.489	0.03
4	4	0.5	1	941	49.48	0.05
5	5	0.5	4	631	77.754	0.49
6	6	0.5	1	449	112.31	0.25
7	8	0.5	1	341	200.28	0.58
8	10	0.5	12	632	313.37	5.95
9	10	2	29	569	75.398	3.84
10	12	2	4	508	109.96	0.86
11	15	2	30	529	173.57	9.84
12	18	2	2	215	251.33	2.34
13	20	2	2	137	311.02	4.54
14	22	2	16	203	376.99	29.7
15	25	2	18	465	487.73	18.9
16	28	2	4	226	612.67	10.8
17	30	2	4	712	703.72	3.9
18	32	2	39	337	801.11	92.7
19	35	2	1	594	958.97	1.6
20	38	2	3	828	1131	4.1
21	40	2	5	314	1253	20
22	0	5	32	102	494.8	155.2
23	45	5	7	779	628.32	5.6
24	50	5	7	378	777.54	14.4
25	55	5	18	239	942.48	70.9
26	60	5	02	45	1123	49.9
27	65	5	14	334	1319	55.3
28	70	5	4	73	1532	83.9
29	75	5	15	130	1759	203
30	80	5	1	795	2003	2.5
31	85	5	11	83	2262	299.7
32	90	5	34	378	2537	228.1



Result: About 7 meters of weathered zone is observed. Beyond this depth, a layer whose resistivity is 525ohm meter is present, which is not a hard layer to represent a massive granite.
Hence a shallow bore well up to a depth of 120-200 feet can be recommended. Expected yield: 1-1.5 inch.

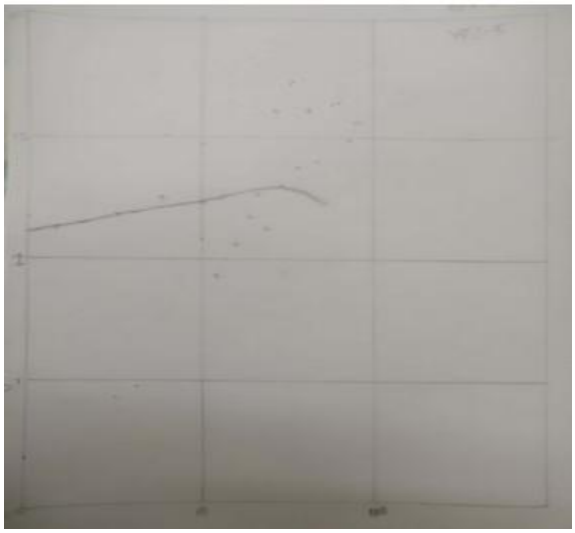
VesLocation.4

S NO.	AB/2	MN/2	VOLTAGE(V)	CURRENT(I)	CONSTANT(K)	RESISTIVITY(RO a)
1	1	0.5	8	831	2.3562	0.227
2	5	0.5	9	941	11.781	0.1127
3	10	0.5	13	315	27.489	1.1345
4	10	2	-7	287	49.48	-1.2068
5	15	2	-6	442	77.754	-1.0554
6	20	2	2	558	112.31	0.4025

Result: About 7 meters of weathered zone is observed. Beyond this depth, a layer whose resistivity is 475-ohm meter is present, which is not a hard layer to represent a massive granite.
Hence a shallow bore well up to a depth of 200-300 feet can be recommended. Expected yield 1-2’’inch.

VesLocation.5

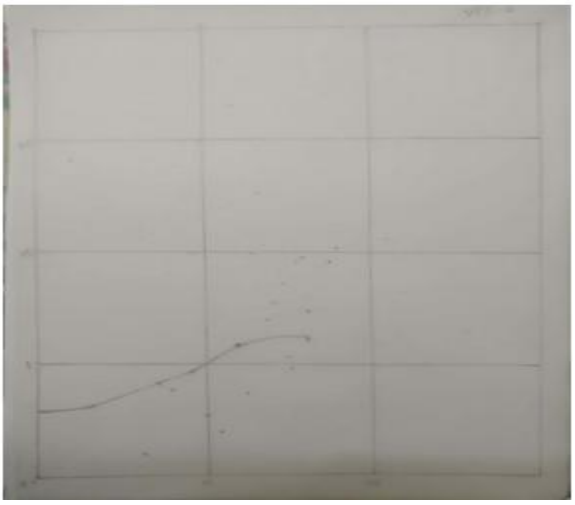
S NO.	AB/2	MN/2	VOLTAGE(V)	CURRENT (I)	CONSTANT (K)	RESISTIVITY O a)
1	1	0.5	03	286	2.35	0.02
2	2	0.5	14	85	11.78	1.94
3	3	0.5	01	386	27.4	0.07
4	4	0.5	08	446	49.48	0.88
5	5	0.5	12	28	77.75	33.32
6	6	0.5	14	156	122.31	10.07
7	8	0.5	13	20	200.28	130.18
8	10	0.5	16	540	313.37	9.28
9	10	2	04	104	75.398	2.89
10	12	2	03	464	109.96	0.71
11	15	2	03	367	173.57	1.41
12	18	2	04	486	251.33	2.06
13	20	2	07	676	311.02	3.22
14	22	2	04	864	376.99	1.74
15	25	2	09	264	487.73	16.62
16	28	2	03	469	612.67	3.91
17	30	2	28	28	703.72	201.06
18	32	2	19	552	801.11	27.57
19	35	2	03	792	958.97	3.63
20	38	2	036	607	1131	5.58
21	40	2	07	62	1253	141.46
22	0	5	08	247	494.8	16.02
23	45	5	09	931	628.32	6.07
24	50	5	03	860	777.54	2.71
25	55	5	12	643	942.48	17.58
26	60	5	16	965	1123	18.61
27	65	5	07	927	1319	9.96
28	70	5	04	463	1532	13.23



Result: About 12 meters of weathered zone is observed. Beyond this depth, a layer whose resistivity is 475-ohm meter is present, which is not a hard layer to represent a massive granite.
Hence a shallow bore well up to a depth of 150-200 feet can be recommended. Expected yield: 1-1.5’’.

VesLocation.6

S NO.	AB/2	MN/2	VOLTAGE(V)	CURREN T(I)	CONSTANT (K)	RESISTIVITY(R O a)
1	1	0.5	09	965	2.35	0.02
2	2	0.5	26	754	11.78	0.40
3	3	0.5	01	549	27.48	0.05
4	4	0.5	03	975	49.48	0.15
5	5	0.5	03	359	77.75	0.64
6	6	0.5	05	967	112.31	0.58
7	8	0.5	04	914	200.28	0.87
8	10	0.5	01	969	313.37	0.32
9	10	2	01	973	75.398	0.07
10	12	2	02	976	109.96	0.22
11	15	2	08	967	173.57	1.43
12	18	2	02	969	251.33	0.51
13	20	2	01	225	731.02	32.4
14	22	2	06	978	376.99	2.31
15	25	2	07	972	487.73	3.51
16	28	2	08	954	612.67	5.13
17	30	2	01	630	703.72	1.11
18	32	2	01	975	801.11	0.82
19	35	2	08	969	958.97	7.91
20	38	2	03	378	1131	8.97
21	40	2	01	435	1253	2.88
22	0	5	03	973	494.8	1.52
23	45	5	35	165	628.32	133.28
24	50	5	35	438	777.54	62.13
25	55	5	05	584	942.48	8.06
26	60	5	10	975	1123	11.51

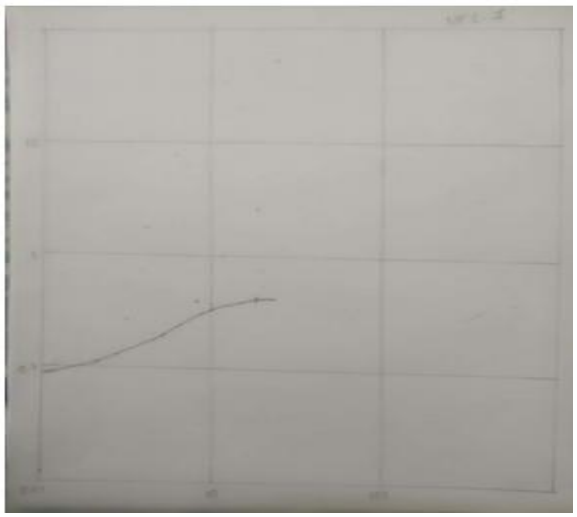


Result: About 7 meters of weathered zone is observed. Beyond this depth, a layer whose resistivity is 475-ohm meter is present, which is not a hard layer to represent a massive granite.

Hence a shallow bore well up to a depth of 100-150 feet can be recommended. Expected yield: 2-3 inch

VesLocation.7

S NO.	AB/2	MN/2	VOLTAGE(V)	CURRENT (I)	CONSTANT(K)	RESISTIVITY (RO a)
1	1	0.5	2	952	2.35	0.0049
2	2	0.5	0	967	11.78	0
3	3	0.5	1	289	27.48	0.0951
4	4	0.5	0	54	49.48	0
5	5	0.5	0	946	77.75	0
6	6	0.5	4	887	112.31	0.5064
7	8	0.5	1	883	200.28	0.2268
8	10	0.5	-3	968	313.37	-0.9711
9	10	2	0	964	75.39	0
10	12	2	7	843	109.96	0.4130
11	15	2	6	544	173.57	1.9143
12	18	2	37	403	251.33	23.0749
13	20	2	17	110	311.02	118.0667
14	22	2	12	52	376.99	86.9976



Result: At this site a moderately weathered zone, up to a depth of 5m is underlined by a semi weathered layer whose resistivity is 129ohm-mtrs & thickness is5m. beyond this depth a moderately hard granite whose resistivity is 445 ohms is expected. As this is not a very hard layer and the curve shown is gradually rising trend, it is expected that the massive granite is at a depth of by 150 feet.

Hence, a borewell up to a depth of 300-400ft is recommended. Expected yield: 1-1.5 inch.

VesLocation.8

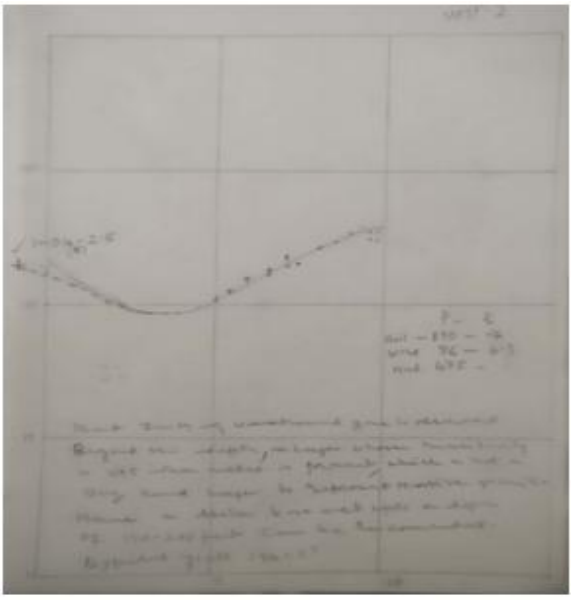
s.no	AB/2	MN/2	VOLTAGE	CURRENT	K VALUES	RESISTIVITY VALUES
1	1	1	1419	54	2.352	61.92
2	2	1	336	55	11.781	71.98
3	3	1	109	38	27.489	78.85
4	4	1	84	41	49.48	89.3
5	5	1	36	30	77.54	93.05
6	6	1	38	38	112.31	96.99
7	8	2	20	45	200.28	105.41
8	10	2	15	49	313.57	104.46
9	10/2	2	72	43	75.398	110.79
10	8/2	2	98	34	47.124	107.4
11	12	2	36	40	109.96	116.43
12	15	3	28	34	173.57	121.5
13	18	3	17	31	251.33	125.6
14	20	2	12	26	311.02	120.4
15	25	5	7	30	487.43	131.12
16	20/5	5	22	44	188.5	138.23
17	30	10	49	23	117.81	161.35
18	40	10	13.5	24	274.89	185.55
19	50	10	9	46	494.8	202.84
20	60	10	12	66	777.54	204.20
21	70	10	15	109	1123.12	210.76
22	80	10	13	126	1532	206.64

Result: At this site a moderately weathered zone, up to a depth of 5m is underlined by a semi weathered layer whose resistivity is 129ohm-mtrs & thickness is5m. beyond this depth a moderately hard granite whose resistivity is 445 ohms is expected. As this is not a very hard layer and the curve shown is gradually rising trend, it is expected that the massive granite is at a depth of by 150 feet.

Hence, a borewell up to a depth of 150-200ft is recommended. Expected yield is 1.5 - 2 inch.

VesLocation.9

s.no	AB/2	MN/2	VOLTAGE	CURRENT	K VALUES	RESISTIVITY VALUES
1	1	1	405	5	2.352	192.74
2	2	1	316	27	11.781	137.88
3	3	1	118	36	27.489	90.1
4	4	1	55	32	49.48	85.04
5	5	1	21	19	77.54	85.7
6	6	1	22	29	112.31	85.2
7	8	2	14	27	200.28	96.89
8	10	2	15	40	313.57	117.50
9	10/2	2	90	62	75.398	108.5
10	8/2	2	37	40	313.57	96.89
11	12	2	37	32	109.96	127.14
12	15	3	15	17	173.57	153.15
13	18	3	13	23	311.02	175.8
14	20	2	13	29	487.43	218.64
15	25	5	38	37	188.5	183.67
16	20/5	5	37	27	117.81	161.44
17	30	10	40	56	274.89	196.35
18	40	10	50	98	494.8	252.45
19	50	10	12	35	777.54	266.58
20	60	10	23	76	1123.12	339.9
21	70	10	28	95	1531.53	370.8
22	80	10	15	100	2002.76	300.3



Result: About 7 meters of weathered zone is observed. Beyond this depth, a layer whose resistivity is 475-ohm meter is present, which is not a hard layer to represent a massive granite.

Hence a shallow bore well up to a depth of 150-200 feet can be recommended. Expected yield: 1-1.5 inch.

VI. CONCLUSION

LOCATION	DISCHARGE OF WATER PRESSURE (inch)	REMARKS
VES 1	1-1.5''	AVERAGE FLOW
VES 2	1-2"	GOOD FLOW
VES 3	1-1.5''	NORMAL FLOW
VES 4	1-2"	GOOD FLOW
VES 5	1-1.5''	AVERAGE FLOW
VES 6	2-3"	EXCELLENT FLOW
VES 7	1-1.5''	AVERAGE FLOW
VES 8	1.5-2''	MEDIUM FLOW
VES 9	1-1.5''	NORMAL FLOW

From the above table, we can conclude that, VES 6 has excellent water pressure (3'' inch). Hence a borewell can be suggested in this location of area, where test is conducted.

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