

EXPLORATION OF GROUND WATER USING ELECTRICAL RESISTIVITY METHOD



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NAVEEN KUMAR

Roll No. 10601037

Under the guidance of

PROF. A.K PRADHAN

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA, ORISSA -769 008

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**DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY,
ROURKELA -769 008, INDIA**

CERTIFICATE

This is to certify that the thesis entitled “Exploration of ground water using electrical resistivity method”, submitted by Naveen Kumar for the requirements of bachelor’s degree in Civil Engineering Department of National Institute of Technology, Rourkela is an original work done under my supervision and guidance.

Date-12/05/10

**Prof A.K Pradhan
Department of Civil Engineering
National Institute of Technology,
Rourkela- 769008**



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In the pursuit of this academic endeavour, I feel I have been singularly fortunate. I should fail in my duty if I do not record my profound sense of indebtedness and heartfelt gratitude to my supervisor Prof A.K Pradhan who inspired and guided me in the pursuance of this work.

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I am thankful to with whose permission I was able to carry out the survey and witness the drilling work in progress.

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Abstract

The project report underlines the survey work carried in Feb 2010 in order to tap ground water in order to cater to need the increasing demand of water for domestic and other uses by the NIT Rourkela. Based on the survey results drilling operations were carried out at proposed point incorporating Rotary percussion method and measurement of discharge was done. The survey work was carried out with the help of Ashida electrical resistivity method and the results obtained through the survey work were coherent with the actual findings obtained through drilling operations.



Chapter 1

Report on ground water development plan November 2009

Prepared and submitted by

Orissa Space Application Center
Bhubneswar



National Institute of Technology ,Rourkela Orissa is facing water scarcity problems in meeting its requirements of water for various purposes. There is a huge demand for the potable water for domestic and other uses. it was concluded that present supply of water from koel river and few bore wells is inadequate.

ORSAC was given the job to propose suitable points for drilling work to be carried out to cater to the increasing demand of water.

Study area: the study area was bounded by 22 14 19 and 22 15 30 N-latitude and 84 53 31 and 84 56 5 E longitude. This area covers the Nit campus and its surroundings keeping in view the future expansion of the nit campus by acquiring more land.

A survey was carried out in Nit Rourkela in November 2009 by ORSAC. It was based on remote sensing and GIS for ground water prospects and identification of suitable sites for bore wells in the campus.

Satellite images of IRS-P6 LISS -3 and Cartosat -1 was used for the preparation of the maps and at the end of the survey 14 suitable points were selected for bore wells by integration of all the information in a GIS environment.

Advantages:

- 1) Larger area coverage enabling regional surveys
- 2) Repetitive coverage allowing regular monitoring
- 3) Data acquisition over inaccessible areas
- 4) Data availability at different scales
- 5) Advantages of higher resolution data for proper identification
- 6) Accurate, quicker and cost effective method.

Based on landforms, lithography ,lineaments ,ground water prospects sites were selected and these sites were shown on the map categorized as priority -1,priority-2,priority-3.

Priority 1 sites were considered the best sites to be targeted first and then followed by priority 2 and priority 3.

So my job was to prepare a case study on a suitable site by which I can make a confirmation by resistivity studies for one of the points given by



ORSAC involving subsequent measurement of discharge and deciding the horsepower of the pump for supply of water from the well point to the suitable sump.

The site was selected far behind hall 2 , Near Pushpa lake.



Chapter 2

Electrical Resistivity Method



Electrical resistivity method

Principle

- Groundwater contains various dissolved salts and is ironically conductive and enables electric currents to flow into the ground. Consequently, measuring the ground resistivity gives the possibility to identify the presence of water, taking in consideration the following properties:
- A hard rock without pores or fracture and a dry sand without water or clay are very resistive: several tens thousands ohm.m
- A porous or fractured rock bearing free water has a resistivity which depends on the resistivity of the water and on the porosity of the rock , several tens to several thousands ohm.m
- An impermeable clay layer, which has bound water, has a low resistivity: several units to several tens ohm.m
- Mineral ore bodies (iron, sulphides, ...) have very low resistivity's due to their electric conduction: usually lower or much lower than 1 ohm.m



Know your Instrument:

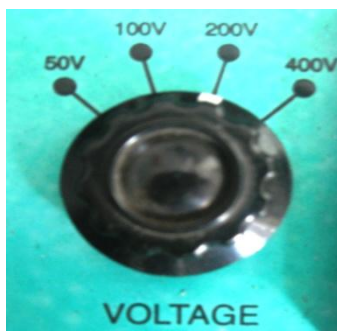
1. The main instrument: The main instrument is opened with the lid hinged out at the left side , we can see the following controls.



Current indicator: At the left hand corner is the Red push button marked as “CURRENT”. While operating the instrument when this button is pressed the meter indicates the current that is being penetrated in the ground (between P1 and P4 circuit).if the meter indicates say 20 that means the actual current flowing is 50 milliamps (2.5 times of the meter reading)



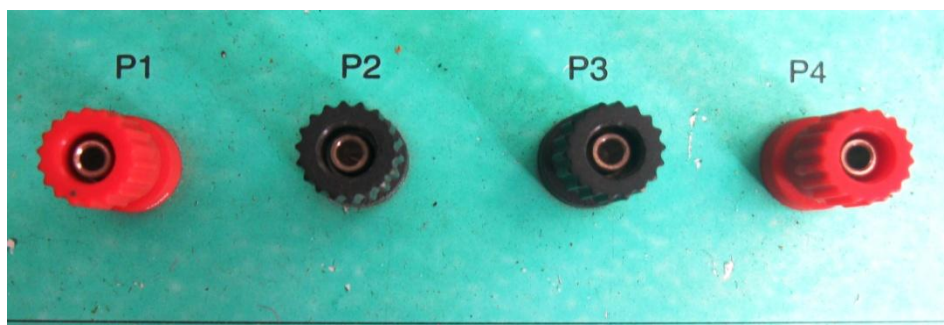
Voltage selector : This switch is located below the current push button .the output AC voltage (50 /100/200/400 VAC) is to be selected with this selector switch ,at different stages.



Range selector: The range selector switch is located below the voltage selector switch. There are 5 different ranges that can be selected viz X1,X10, X100,X1000, X10000. in the first range ie. X1 the resistance upto 1 ohm can be measured . In the second range (X10) ,resistance upto 10 ohm can be measured .thus for X100 –upto 100 ohm and for X1000- upto 1000 ohm and for X10000-upto 10000 ohm .



Terminals : At the lower end there are 4 terminals marked as P1,P2 ,P3 and P4 .terminals P1 and P4 are of red colour whereas P2 and P3 are of black colour .P1 and P4 are connected to the extreme 2 probes (current probes) through which the current is injected in the ground. P2 and P3 are connected to the middle 2 probes that are called as potential probes and measure the potential created by injecting the current through the current probes.



ON/OFF switches: With this toggle switch the main battery supply to the instrument is disconnected. This switch is to be kept OFF when the instrument is not in use.



“CAL” knob : The calibration of the instrument is done with this knob .once the instrument is calibrated for a particular range this knob should not be disturbed. Till the required set of the reading is obtained for that range

Meter : The meter is used for three different functions

1. **Current indication :** when the probes are connected to the instrument and the instrument is switched ON and now when the CURRENT push button is pressed ,the meter indicates the milli –Amp (mA) current that is flowing through the ground. The full scale deflection (100) indicates the 250 mA

2. **Battery indication** : when the push button marked “BATTERY” is pressed ,the meter shows the battery input voltage ,along with the proper connection (polarity) .when the pointer is in the green region (7 A) of the meter scale (4.5 to 7 V DC) that means the battery voltage is sufficient to operate the instrument correctly. If the indication is less then the battery need charging if the pointer moves in the other direction (below 0) that means the battery is connected in the wrong polarity interchange the connections.
3. **NULL BALANCING**:this is the principle use of the meter. The actual readings of the ground survey are taken when there is a NULL balance i.e. The pointer deflection is towards the maximum left side towards zero .



Neon indicator : when the instrument is switched ON the neon red lamp on the top of the meter glows ,which indicates that the ac voltage is developed.

Battery check push buttons: at the right hand corner there is a push button marked battery .when this button is pressed ,the pointer deflection indicates the battery status(voltage)..for proper results ,the battery voltage should always be within the green zone (7 A)of the meter .the battery voltage indication may vary when the instrument is OFF or ON

condition . But in either case the battery voltage should never drop below 4.5 V DC.this is the minimum voltage required to operate the instrument satisfactorily .



Sensitivity : The black knob is situated at the right hand side ,below the battery push button ,when this knob is rotated in the clockwise direction ,the sensitivity increases ie. The deflection is more and the null balancing can be done precisely



Ten turn potentiometer knob : the “R” knob is situated right below the sensitivity knob .it measures the resistance accurately .the least count of this knob is 0.0001 ohm and when the full ten turns are completed it measures 1.0000 ohm .

thus it will measure

0 ohm to 1 ohm on X1 range ,

0 ohm to 10 ohm on X10 range

0 ohm to 100 ohm on X100 range

0 to 10000 ohm on X1000 range

0 to 10000 ohm on X10000 range





In short the reading obtained on the ten turn pot is to be multiplied with the selected range ,to get the actual reading.

The adaptor : the adaptor is to be attached with the main instrument .the P1,P2,P3 and the P4 pins are to be inserted into the respective terminals of the main instrument .there is a band switch (or a series of 5 push buttons) below the terminals of the adaptor .each push button is pressed to select a particular range .each press button when pressed individually connects a standard resistor of a known value across the instrument. the value of the standard resistor is indicated below the push button .



Winches: there are four winches(reels).each winch has a wire winded on it which has a distinguished colour. The open end of the wires has a crocodile pin connected to it which in turn is to be connected to the respective probes. The other end of the wires is terminated on the banana socket located on the opposite side of the handle of the winch .



Probes: 4 stainless steel probes of the appropriate size are supplied along with of each probe has a sharp pointed end. This facilitates to hammer the probe in the ground. The probes are hammered in the ground in such a manner that firm electrical contact is established.



Battery: the battery supplied with the instrument is a maintenance free battery of 6 V 10 AH rating. It has to be charged only with the matching charger provided along with it. When connected to the instrument with power switch in OFF position and the battery switch pressed the meter shows the battery 's charge position .even after continuous charging for 10 to 12 hours the meter's pointer doesn't go above 4.5 volt then that means that the battery has gone weak and needs replacement. Caution : do not connect the battery and the instrument at the same time .neither connect the charger to the instrument directly .

Remember to disconnect the battery from the instrument, whenever the instrument is not to be used for more than one hour. Ensure that the instrument is OFF before disconnecting the battery

Battery charger: The input to the charger is our normal household supply of 230 V AC ,50 Hz .the charger has 2 indicating bulbs .the AC ON bulb indicates healthiness of the AC input circuit. The DC ON bulb indicates the healthiness of the DC output circuit. If either of the bulb doesn't glow first check the respective fuse with mains OFF.

Never short the DC output terminals, even momentarily .this will permanently damage the charger the charger is for indoor use only .





Chapter 3

Survey Method



Survey method:

1. First place the instrument horizontally on the ground. Open the cover and rest it on the stopper on the left hand side.
2. Take the pair of battery connecting wires, which have a banana pin at one end and a small crocodile pin on the other end. Locate the battery connection banana sockets (red +black) on the left hand side of the instrument .insert the appropriate wires in the sockets .connect the other side of the wires to the terminals of a fully charged battery.
3. Without putting the instrument on press the battery push button on the instrument and confirm the battery voltage .the pointer on the meter must be within the green zone (7A) only, not more or not less.
4. Hook the adaptor to the edge of the instrument box .make one to one connections from the adaptor side P1, P2,P3 and P4 to the instrument side .Ensure that the wires are not cross connected.
5. Press the “X 10” button on the adaptor .note the resistance value given below this button (say 6.66 ohm)
6. Adjust the value on the “R” knob .turn it clockwise till the digit 6 appears in the main scale window .then turn this knob further so that sixty sixth divisions of the circular(vernier scale)coincides with the marking .
7. Set the range selector switch on the instrument to “X10” position.
8. Set the voltage selector switch to 50 V AC position.
9. Set the sensitivity knob to maximum position (clockwise)
10. Similarly .rotate the “CAL” knob clockwise to its maximum position .
11. Now after the ensuring all the above settings, switch ON the instrument. The red neon indicator just above the meter will glow indicating the developing AC voltage
12. The pointer of the meter will gradually move towards right hand side and at times may also move beyond 100. Rotate the sensitivity knob in the anticlockwise direction to keep the pointer between 60 to 100 of the meter.
13. Now slowly rotate the “CAL” knob in the anticlockwise direction .with this the side ie. From 100 towards 0.at a certain place ,the pointer will stop moving towards 0and



will start moving back .the maximum deflection towards the left (0) is the point of null balance and this method is called as NULL BALANCING METHOD

14. At this particular point ,from where the pointer starts moving back ,stop rotating the cal knob .now this instrument is said to be calibrated for that particular range in this case for X10 range.



15. Counter check the calibration by rotating the “R” knob .the pointer moves in the opposite direction for the “R” knob rotating direction
16. Thus when the instrument is properly calibrated for a particular range, ie. The position of the “CAL” knob is set properly, then the instrument will precisely measure the soil resistance within that particular range, this is how the instrument is calibrated on site and the possibility of taking wrong reading is eliminated.
17. Once calibrated for a particular range, the “CAL” knob is not to b disturbed until all the readings in that range are properly taken. The “R” knob is once again brought to its full 0 position and the Range switch is kept at X10 position the X10 calibration holds good for X1.X10,X100 ranges also
18. Unpressing the adaptor button disconnects the adaptor from the main instrument and the instrument can now actually measure the soil resistance

Wenner's Configuration:



Wenner's configuration in 4 pin method

Distance between P1 ,P2,P3 , P3 P4 has to be kept same every time

Chapter 4

Ground water exploration



Ground water exploration

The ASHIDA SOIL RESISTIVITY meter can solve all the problems of ground water exploration because of its 2 pin and 4 pin techniques

The three questions mainly arising in ground water exploration are

- How to locate a best spot in a given area
- At what depth the water would make it's appearance
- What would be the nature of the strata

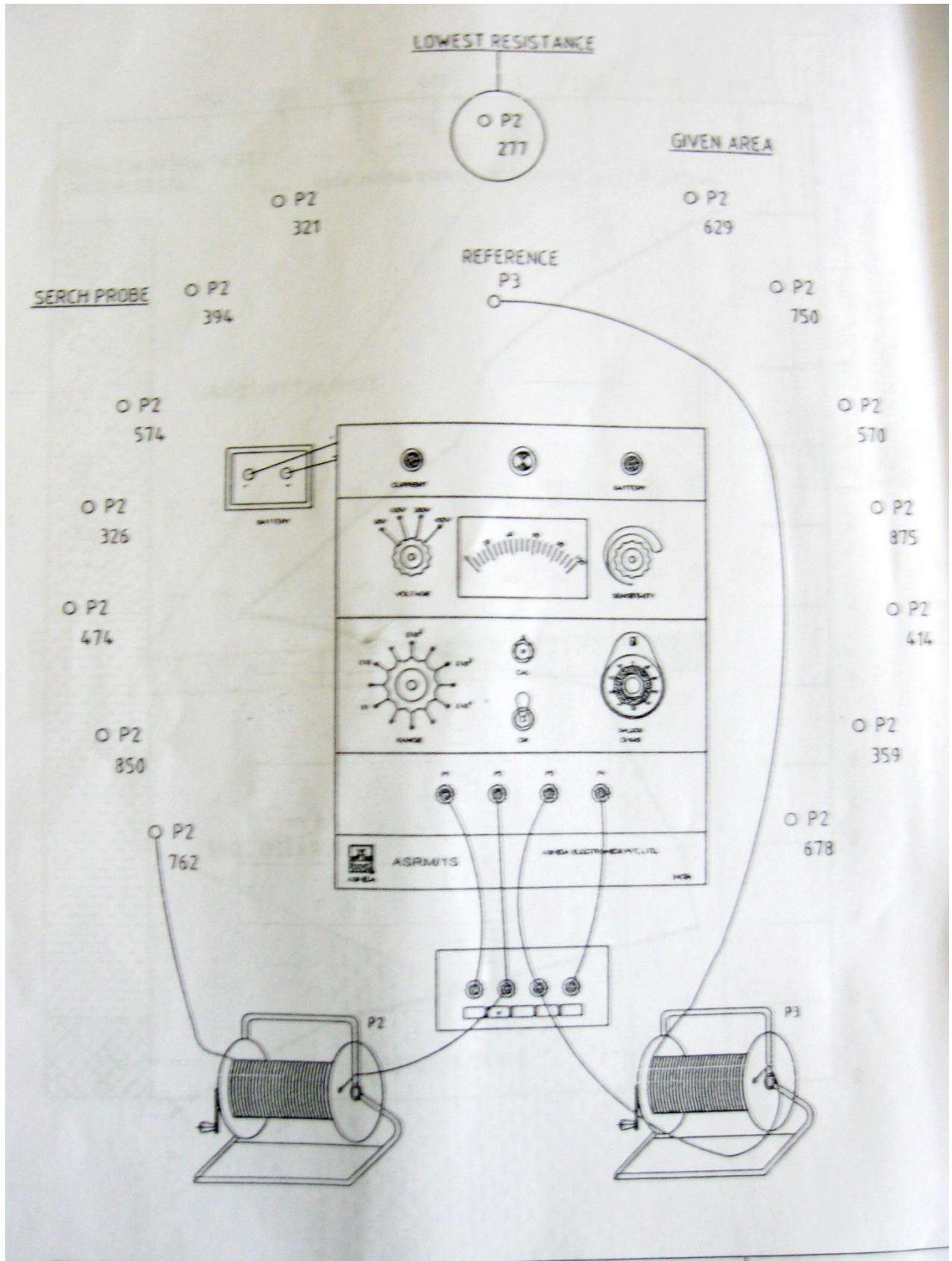
How to locate a best spot in a given area

For location of the best spot for maximum availability of water in a given area, the following experiment was carried out in the South West of PUSHPA Lake far behind hall 2.

The ASRM 2 pin method was first used as follows:

- 1) First of all the centre of the given area was approximately marked and the P3 probe the reference probe was hammered there. This reference was an arbitrary one, chosen at random
- 2) The instrument was set for ASRM 2 pin method ie. X1000 range was selected. The calibration of the instrument was checked and after finding it correct the adaptor press button marked as "ASRM 2 PIN" was pressed down. Now as the search probe the p2 probe was moved along the periphery of the area in a radius of 20 m approximately. After getting a reading for a said distance (5 meter) the search probe was moved with equal intervals of 5 meters. The spot where low resistance was recorded were marked and finally the lowest resistance spot was marked.





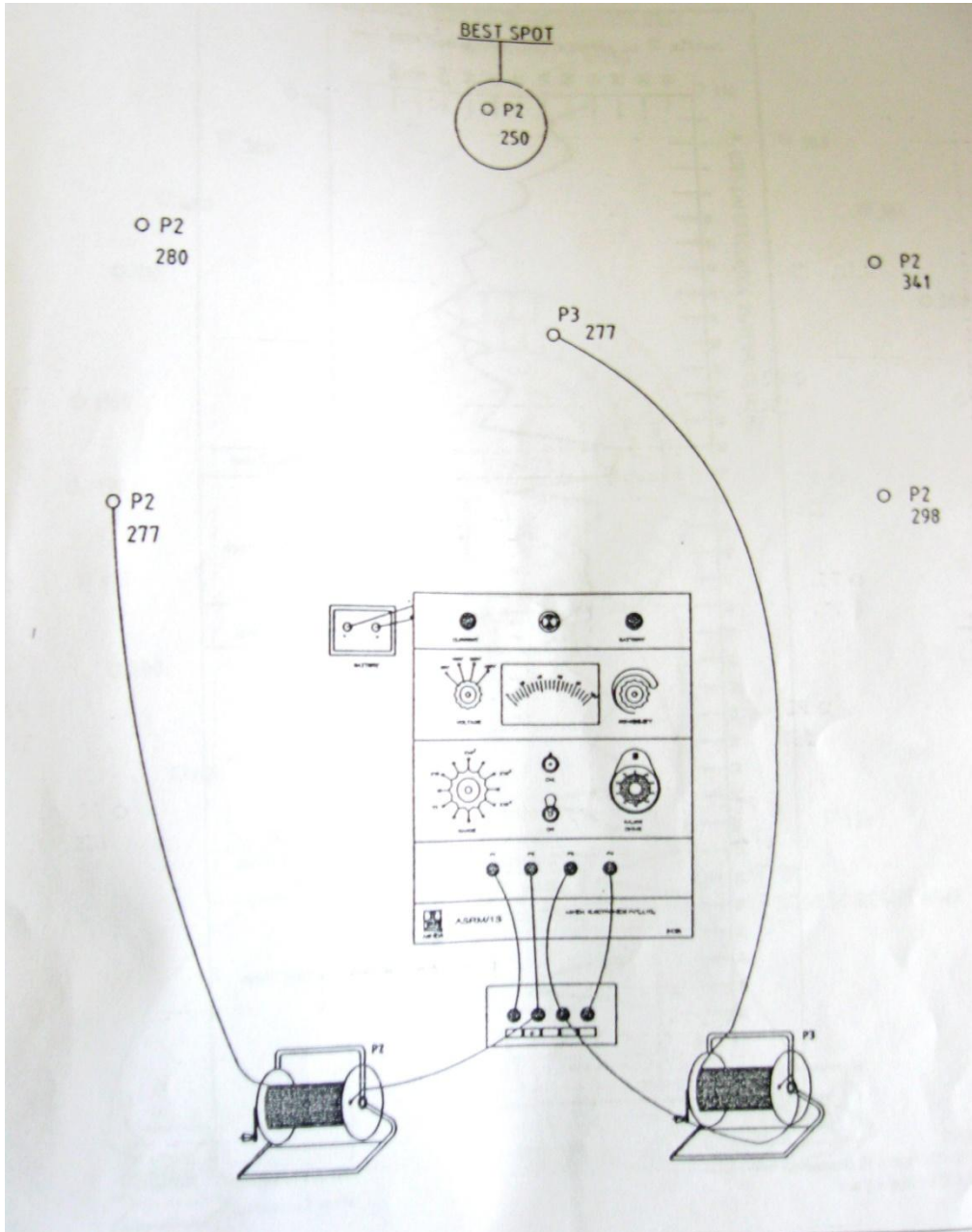
The readings taken by 2 pin method are the following:

Sl. No.	Range of instrument	Readings	R ohms
1	X 1000	.018	18
2	X 1000	.020	20
3	X 1000	.023	23
4	X 1000	.023	23
5	X 1000	.010	10
6	X 1000	.020	20
7	X 1000	.011	11
8	X 1000	.016	16
9	X 1000	.005	05
10	X 1000	.013	13
11	X 1000	.032	32
12	X 1000	.024	24
13	X 1000	.008	08
14	X 1000	.013	13
15	X 1000	.016	16
16	X 1000	.009	09
17	X 1000	.031	31
18	X 1000	.020	20
19	X 1000	.032	32
20	X 1000	.035	35
21	X 1000	.026	26
22	X 1000	.030	30
23	X 1000	.039	39
24	X 1000	.036	36
25	X 1000	.046	46
26	X 1000	.044	44
27	X 1000	.036	36
28	X 1000	.025	25



It was observed that the 9th reading was the lowest and hence it was chosen the next spot. Now at that spot 6 more readings were taken to check out the best spot at the lowest resistance spot taken out earlier.





Sl. No.	Range of Instrument	Readings	R ohms
1	X 1000	.002	2
2	X 1000	.009	9
3	X 1000	.006	6
4	X 1000	.002	2
5	X 1000	.004	4
6	X 1000	.002	2

In this way the best spot is marked which is expected to yield maximum ground water in the area.

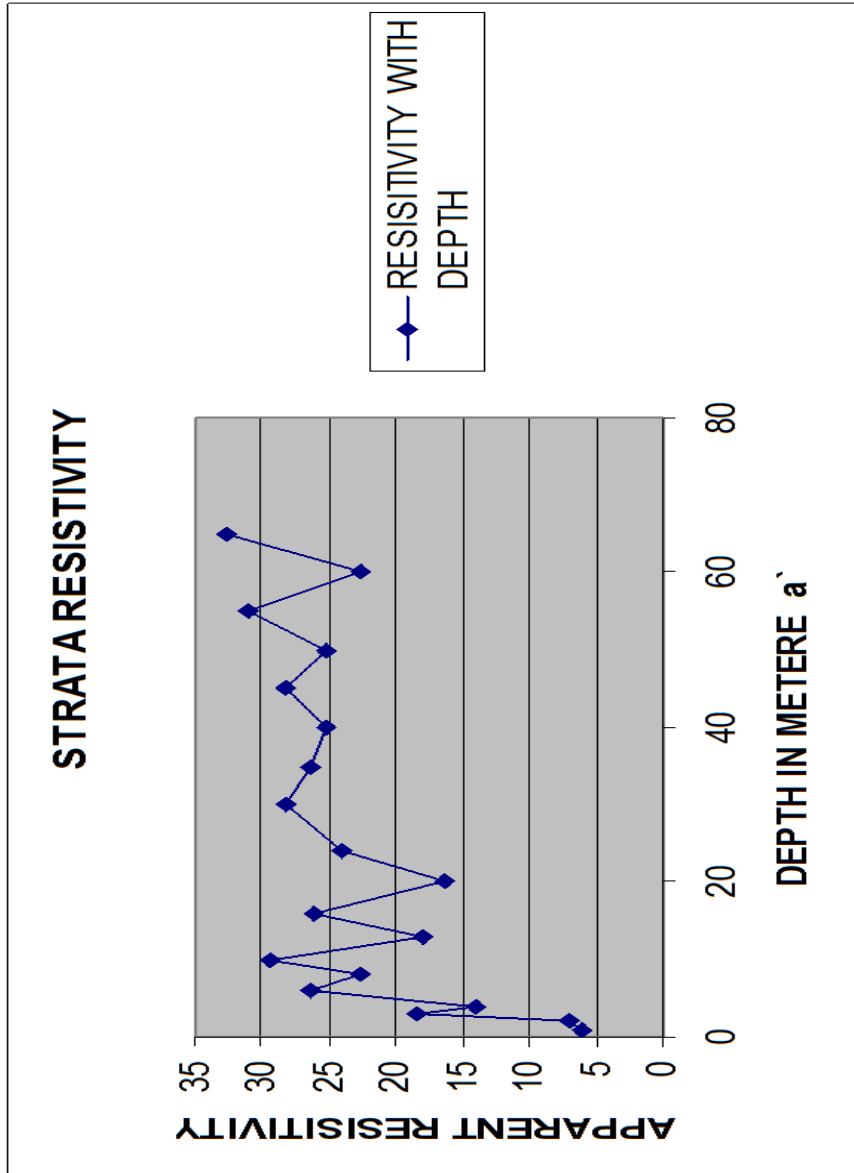


The finalised spot is considered as a centre for the 4 pin readings.

The readings were taken upto 65 meters and a graph is plotted between apparent resistivity and depth at that spot.

4 pin method readings:

Sl. No.	“a” Depth in meters	Range of instrument	Readings	R ohms	“P” Ohm meters $2*3.14*a*R$
1	1	X10	.095	.95	5.966
2	2	X10	.055	.55	6.908
3	3	X10	.098	.98	18.463
4	4	X10	.056	.56	14.067
5	6	X10	.070	.70	26.376
6	8	X10	.045	.45	22.608
7	10	X10	.047	.47	29.516
8	13	X10	.022	.22	17.960
9	16	X10	.026	.26	26.125
10	20	X10	.013	.13	16.328
11	24	X10	.016	.16	24.15
12	30	X10	.015	.15	28.26
13	35	X10	.012	.12	26.376
14	40	X10	.010	.10	25.12
15	45	X10	.010	.10	28.26
16	50	X10	.008	.08	25.12
17	55	X10	.009	.19	31.086
18	60	X10	.006	.06	22.608
19	65	X10	.008	.08	32.656



Looking at the graph it can be clearly stated that the probability of finding ground water is high in this region giving more stress at depths 15 m and 20m. But this belongs to unconfined aquifers what we are looking for is the confined aquifers which from the graph can be predicted to be at 60 m .

Chapter 5

Drilling work



Drilling work:

Rotary percussion method

A recently developed rotary percussion procedure using air as the drilling fluid provides the fastest method for drilling in hard rock formations. In this a rotating bit with the action of pneumatic hammer delivers 10 to 18 impacts per second to the bottom of the hole.

Penetration rates of as much as 0.3 m/min have been achieved.





Chapter 6

Features of the bore well



Some features of the bore well

- Depth of boring =466 ft
- Depth of casing pipe=213 ft
- Diameter of the bore well =8 inches
- V notch head=17 cm
- Vertex angle of V notch=60 degrees
- Length of the drilling shaft=18.5 ft
- Length of the casing=10 ft

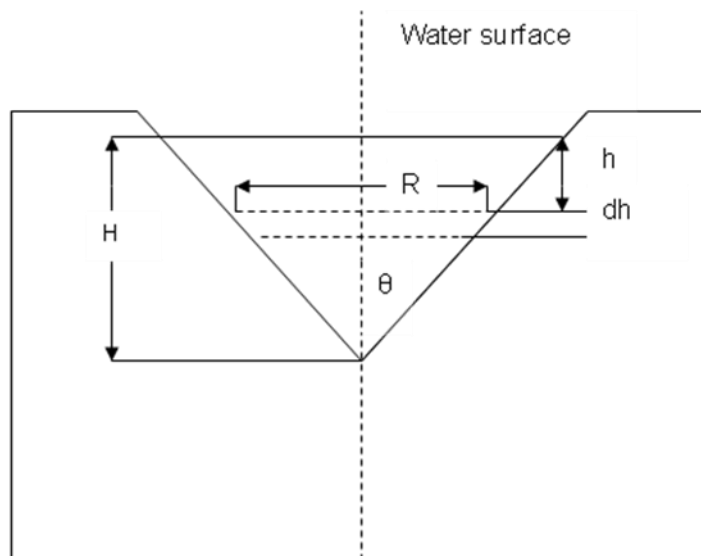


Chapter 7

Calculation of discharge



Measurement of discharge



$$Q = \frac{8}{15} C_d (2g)^{1/2} \tan(\theta/2) H^{5/2}$$

C_d = coefficient of discharge = .62

θ = vertex angle = 60°

H = head above the crest of weir = 0.17m

$$Q = 0.845 H^{5/2} = 0.01007 \text{ m}^3/\text{sec} = 36.27 \text{ m}^3/\text{hour}$$

Submersible pump(8 stages) of 7.5 HP was used.

$$HP = \gamma_w * Q * H / 75$$

$$7.5 = (1000 * 0.01007 * H) / 75$$

$$H = (7.5 * 75) / 1000 * 0.01007$$

$$H = 55.86 \text{ m}$$



Chapter 8

Conclusions



Conclusions:

- The NIT Rourkela terrain and its surrounding receive an average rainfall of approximately 130 cm and hence there is a high potential of recharge of ground water.
- But due to different types of deposits or formations the quality of ground water is not always satisfactory.
- Also due to urbanization and growth of industry, there is always a possibility of waste water pollution into the ground water basin.
- Hence it becomes important to properly investigate the quality of ground water before making them for use.
- In view of the discharge obtained from the surveyed point it is found that the point is highly potential for use of ground water. If all the points will be collectively taken into consideration for exploitation the water requirement of the campus and the halls including academic areas can be met adequately.
- Ground water can also be exploited through large diameter water table dug wells in the valley from the unconfined aquifers. However water from these wells need to be treated before making them for domestic and other uses.



Chapter 9

Recommendations



Recommendations:

- Groundwater is limited so a judicious use of groundwater need to be done with a proper planning.
- The ground water basins needs to be replenished with some recharge measures in the area.
- Recharge structures such as nala bunds and water harvesting system should be constructed at suitable points.
- Plantations may be taken up on the waste lands to enhance ground water recharge.
- Concentration of trace metals needs to b determined by analysing samples of ground water from various sites with the help of atomic absorption spectrophotometer and other modern methods.



References

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- ✓ Hydraulics and Fluid mechanics by P.N MODI
And S.M. SETH
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