GROUND WATER SIMULATION OF VARUNA BASIN BY RESISTANCE-CAPACITANCE NETWORK (ANALOG MODEL)

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the requirements for the award of the Degree
of
MASTER OF ENGINEERING
in
HYDROLOGY

By

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CERTIFICATE

This is to certify that the dissertation entitled "GROUND WATER SIMULATION OF VARUNA BASIN BY RESISTANCE CAPACITANCE NETWORK (ANALOG MODEL) " being submitted by Mr. Delwar Husain in partial fulfilment of the requirements for award of the degree of Master of Engineering in Hydrology of the University of Roorkee, is a record of the candidate's own work carried out by him under our supervision and guidance. The material embodied in this dissertation has not been submitted for the award of any other degree or diploma.

This is further to certify that Mr. Husain has worked for a period of six and half months at the University since October 1975 to April 15, 1976 in the preparation of this dissertation under our guidance.

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SYNOPSIS

Electric analog model is a valuable tool for the management of ground water basins. Analog models can play an important role in the forecast of the consequences of developing nonhomogeneous aquifers having irregular boundaries and a variety of head and discharge controls. Analog models are simple, versatile and of moderate cost. The use of analog model enables ground water development schemes to be tested rapidly and accurately thus permitting the apparaisal of the relative merits of alternative choices of development.

The electric analog model system consists of an analog model and wave form functional Generator assembly and oscilloscope. The analog model is based on the similarity of laws governing flow of current in an electrical network and flow of water in an aquifer. The electric network is commonly used is Resistance-Capacitance network. Resistors are inversely proportional to the hydraulic conductivity of the aquifer and capacitors store electric energy in a manner analogous to the storage of water in an aquifer.

The behaviour of the electric network is described by the equation that has the same form as the finite difference equation for nonsteady state, two or three dimensional flow of ground water. Electrical units (Voltages, Coloulumb, amphares and seconds) and corresponding hydraulic units (cubic metre, cubic metre per day and months) are connected by 4 scale factors.

In the present study the analogy has been established for the Varuna basin - a basin in the State of Uttar Pradesh, India. The available pump test data have been analysed to evaluate the formation constants of the aquifer and thus the scale factors for the analog model have been derived using formation constants uniform over the basin. The area of

the basin has been divided into polygonal subareas with respect to rain-gauge stations. The weighted monthly rainfall recharges (30 percent & 35 percent of total monthly rainfalls in each node) and withdrawls from the aquifer has been calculated monthly considering with respect to gross water requirements by the different crops both in tubewell and canal commands. The seepage losses in the canal command has been taken as recharge monthly into the aquifer. Thus the monthly net recharges and withdrawls have been worked out for each nodes. The available water level elevation records have been simulated in the form of direct current voltage on the model by stabilized power supply. The net recharge and withdrawls have been given as input to each nodes in wave form and the response of the aquifer for each node has been obtained.

The waveform functional generator forces equal electrical energy in proper time phase into the analog model and energy levels within the Resistor-Capacitor network at each nodes has been measured. Oscilloscope traces i.e. Time-Voltage graph are analogous to water level change in time with the change in discharge or head. A catalog of Time-Voltage graphs provide data for the construction of a series of water level change maps.

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CHAPTER - I

INTRODUCTION

1.1 SCOPE AND ITS OBJECTIVE

With the increasing demand for water coupled with limited supplies, the planned development and optimum utilization of water resource has become absolutely necessary. In the past much attention has been paid towards the development of surface water. A systematic study of groundwater, its development and its influence on surface water, is important. A necessary aspect of ground water development however, is to assess the potential of a basin. The indiscriminate exploitation of ground water may creat new problems. This calls upon thorough investigations and estimation of groundwater potential by the hydrologist as they are concerned chiefly with the quantitive description of aquifers and their physical parameters and with the response of aquifers to the development. It is the responsibility of the hydrologists to evaluate ground water resource and to forecast the consequences of the utilization of the aquifers. Proper planning of groundwater development requires testing of all possible schemes and appraising of the relative merits of various alternatives. The hydrologist must consider the many choices of alternative development and describe their effects. Questions relating to the use of ground-water resource require that pumping in related to water level charges with reference to time and space. The two factors to be considered are the cause and effect i.e. pumpage and recharge and corresponding fluctuation in water level.

The hydralogic characteristics to be considered in calculating aquifer response are the transmissibility and storage coefficient of the aquifer. The response of the aquifer can be related to the cause of changes in in water levels provided the hydrologic maps are available. The information essentials required is coefficient of transmissibility of aquifer storage coefficient of the aquifer, area of the aquifer, location, extent and nature of aquifers and the confining bed boundaries. Saturated thickness of aquifer, Area under canal command, Area under Tubewell Command, Area under different crops, Location of Raingauge stations, Water level data for longer period and location of observation wells, Pump Test data for longer period etc. However the task of defining the hydrologic condition of aquifer is difficult, because of available basic data are seldom sufficient to permit rigorous description of aquifer and budgetary constraints often prohibit the collection of such an extensive and detailed data of the aquifer.

In this study, ground water simulation of Varuna basin has been done by direct electric analog computors and model has been built for the whole of basin. The analog model consists of Resistance-Capacitance network and excitation response apparatus. The theory and construction features are described here in, and the accuracy and reliability of the model are assessed by comparing the results with the observed data. The analog solution for the aquifer situation of Varuna basin and the pervious observed values and analytical results are compared.

Considerable work has been done recently on direct electric analog simulation. Walton and Pricket (1963) give a lucid and comprehensive reports on the analog simulation of the aquifer system in Illinois, and aquifer-stream system, Venice, Ohio; U.S.A. Tyson & Weber (1964) report the use of a general purpose analog and digital computer for the coastal plain of Los Angels, U.S.A. Schicht (1965) reports electric analog studies for the East St. Luis area. White and Hardt (1965) carried out electric analog analysis of San Simon Basin, Cochine and Graham countries, Arizona, U.S.A. The San Simon model was constructed as a two layer model. Moore and Leonard (1967) report the data requirement and preliminary results of an analog model evaluation of the Arkansas River Valley in Eastern Colorado. This electric analogy model consist of 100,000 resiston and 10,000 capaciton. Anderson (1966) carried out analog analysis of the hydrologic system in Tueson basin of Arizona, U.S.A. Pricket and Lonnquist (1968) give a detail comparison of analog and digital simulation techniques applied to different aquifer situations. Lakshmanarayana (1971) gives a review of electric analog models for management of aquifers. Rushton and Bannister (1970) report on slow time (several seconds on the model). Resistance capacitance analog as an alternative to the usual fast time (a few microseconds on the model) analog.

CHAPTER - II

HYDROLOGY OF VARUNA BASIN

2.1 DETAILS OF THE BASIN AREAS

The An irrigation project to plan conjunctive use of surface and ground water resources for optimising agricultural production is planned for the Varuna basin. The basin is situated between latitude 250^{0} 18' and 250^{0} 42' and Longitude 81^{0} 58' and 83^{0}-02' East in the Eastern part of the province of Uttar Pradesh of India. The Basin covers the portions of the districts Allahabad, Jaunpur, Varanasi and Pratapgarh. The basin is somewhat oblong in shape and the maximum length and width are 125 and 45 kilometres respectively. The river Varuna with its three tributories flows through the Basin and outfalls in the River Ganges which flows along the Southern boundary of the Basin.

The total geographical area of the Basin is 2,58,250 Hactares. Out of which, total cultivable command area is 1,98,000 Hectares and 27,400 Hectares area is commanded by canal system, 96,236 Hectares area is commanded by State tubewells and the remaining 76,364 Hectare area by Private work i.e. Shallow tubewells, pumping sets and dugwells. The area at present is under intensity of irrigation of 43.5%. The total nos. of private tubewells and pumping sets in the Basin are 4587 and also there are 20,486 numbers of dugwells. In addition to these private works there are 491 state tubewells in Varuna Basin at present.

The Basin lies in the Indogangetic plains and is generally flat. It comprises chiefly of sand of various grades, clay, Kankar and their admixtures. The first aquifer is encountered at a depth of 100 ft below ground level. At places, this aquifer is confined to semi-confined in nature, and at places it comes upto 50 ft below ground level. Sand grades of the aquifer is medium to course sand, but pebbles are also formed. This aquifer is fairly extensive in the area, and supplied to the most of the private and state tubewell, clay lenses are also present within the aquifer. Depth of state tubewells are generally ranging between 350 ft. and 450 feet.

The area receives an average annual rainfall of 794 mm which is not sufficient to meet water requirement of crops grown in the basin. In the existing system the canal supplies are augmented to ground water through private work. The state tubewells command is separated from the canal command . Therefore no state tube wells is located in canal command area of the Basin.

2.2 DETERMINATION OF FORMATION CONSTANTS FOR THE AQUIFER OF THE BASIN

Increasing need for water, to bring additional area under cultivation and intensive cropping of the present canal irrigation system, require greater utilization of ground water. This requires an estimation of hydraulic properties of aquifers in the basin.

The properties of the aquifer that influences the well performances are depth and areal extent of the aquifer. The properties of the aquifer may be expressed in terms of its permeability, transmissibility and storage coefficient. In other words the abilityof the formation to store water is governed by the coefficient of storage 'S' and the ability to transmit the water is governed by the coefficient of transmissibility denoted by 'T'. So 'S' and 'T' are the formation constants.

The coefficient of storage, 'S' can be defined as the quantity of water that an aquifer releases or takes into per unit surface area of a vertical column of an aquifer per unit change in component head normal to the surface. In case of an unconfined aquifer the storage coefficient corresponds to specific yield.

The coefficient of Transmissibility 'T' may be defined as the rate of flow of water expressed in the formation expressed in discharge units either in gpd or cusecs or cumec, through a vertical strip of the aquifer for unit width extending the fall saturated thickness of the aquifer under hydraulic gradient of 100 percent.

For determination of the formation constants 'S' & 'T', the available pump test data for two tubewells, unlocated at Raghupur and at Banwaripur, has been used depending upon the aquifer types. The following methods of pump test Analysis have been used.

Type of Aquifer	State	Methods of Analysis
Confined	Steady	(a) Thein's method
	Unsteady	(a) Theis method
		(b) Jacob's method
		(c) Chow's method
		(d) Theis Recovery method
Unconfined	Steady	(a) Thein's method
	Unsteady	(a) Theis' method
		(b) Jacob's method
		(c) Theis Recovery method
		(d) Chow's method

Leaky confined	(a) Walton's method
	(b) Hantash method
Leaky Unconfined	(a) Boulton's method

Analysis of the Pump Test Data:

According to the given project data the aquifer is confined to the semi-confined at places so it is decided to analyze the pump test for the well located at Raghupur to considering as confined aquifer and thus the Thie's method is applied.

(a) Theis' Method:

Theis method involves the following steps :

(i) Firstly a plot on logarithmic paper of W(u) versus u is prepared. This plot is known as 'Type Curve' and is given at Plate No.1.

(ii) Secondly, using the given pump test data, a plot between draw-down v/s r^2/t is drawn (as given at the Plate No.2) on a logarithmic paper of the same size of that of type curve.

(iii) Thirdly, the field data curve is then superimposed on the "Type Curve" keeping in view the y axis parallel and found that the field curve does not match with the line segment of the "Type curve" and most of the points fall below it. So the acquifer cannot be taken as confined one. Hence the aquifer is lacking analysed for leaky aquifer.

The various terms used above method can be defined as follows:

W(u) = Well function

$$W(u) = (-0.5772 - \log_e u + u - \frac{u^2}{2L^2} + \frac{u^3}{3\,L^3})$$

$u = r^2 s/4 T t$, where

r = distance between observed well and pumped well.

s = storage coefficient

T = Transmissibility coefficient

t = time in days of pumping.

(b) Hantosh Method for Leaky Confined Aquifer[5]

The method describes the following procedures for analysing pump test data :

(i) Plotting on a single logerithmic paper the drawdown v/s the corresponding time t (t on logerithmic scale) and drawing the curve that best fits through the plotted points to get time drawdown curve (Plate 4).

(ii) Determination of the value of maximum drawdown 'sm' by extrapolation. It will be possible if the period of pump test is long enough.

(iii) Calculation of 'sp' by using sp = 1/2 sm. This value of sp on the curve locates the value of inflection point P. Thus sp is the drawdown at the point of inflection.

(iv) Then the value of tp at the inflection point from the time axis is observed.

(v) To determine the slope sp of the curve at the inflection point. This can be closely approximated by reading the drawdown difference per log cycle of time over the straight portion of the curve on which the inflection point lies or over the tangent to the curve at inflection point.

(vi) Substituting the value of sp and sp in the equation.

$$2.3\ \delta p / \Delta \delta p = K_0(r/\lambda) e^{+r/\lambda} \qquad \text{..... (ii)}$$

Where r = distance between observation well and the pumped well.

λ^2 = KBC, K = coeff. of permeability

B = Thickness of aquifer

C = Resistance of the combining layer in days or years.

(vii) To find r/λ by interpolating from the table of the function $e^x K_0(x)$ and also $e^{-r/\lambda}$ is found out.

(viii) Knowing r/λ and r(given); can be computed.

(ix) Knowing Q, δp, $\Delta \delta p$ and r/λ, KB which gives the coefficient of transmissibility (T) is calculated applying the equation

$$sp = \frac{2.3\ Q}{4\ \pi\ K\ B}\ e^{-r/\lambda} \qquad \text{..... (iii)}$$

(x) Knowing KB, tp, r and r/λ. To calculate S(Storage coefficient) by using the equation,

$$U_p = \frac{r^2\ s}{4\ K\ B\ t_p} = r/\lambda \qquad \text{..... (iv)}$$

(xi) Knowing KB & , C can be calculated by the relation $\lambda^2 = K\ B\ C$ ....(v)

Thus all the parameters of the leaks confined aquifer is known.

A. Application of the above method to the Well No.81 Located at Raghupur:

From the given data:

(i) Discharge of the well = 45,000 gph = Q

(ii) r = Distance between observed well & pumped well = 150 ft.

From the plotting of the data, in fig. 2.2.7 Extrapolated value of δm = 2.56 ft.

$\therefore$ $sp = 1/2\ sm = 1.28$ ft.

$\therefore$ The value of tp at inflection point $= 4.7 \times 10^{-3}$ days.

sp at inflection point $= 1.11$ ft per log cycle.

Now from the equation (ii)

$$K_0 (r/\lambda)\ e^{+r/\lambda} = \frac{2.3\ sp}{\Delta sp} = \frac{2.3 \times 1.28}{1.11} = 2.65$$

Using the table[5] Annexure No.III, page 192 of Bulletin No.11, "Analysis & Evaluation of Pumping Test Data", we have

$r/\lambda = 0.104$, $e^{-r/\lambda} = 0.901$

Since $r = 150$ ft, $150/\lambda = 0.104$.

$\therefore$ $\lambda = 1495$ ft.

$\therefore$ Using the equation (iii), and substituting the value of r, λ, sp & Q
Q

$$sp = \frac{2.3\ Q}{4 \pi\ K B} \times e^{-r/\lambda},$$ K B can be found out to be

found out to be 2.58×10^4 ft^3/day ft.

$\therefore$ Resistance of the layer $C = \lambda^2/K B = \dfrac{1495^2}{2.58 \times 10^4}$

$\therefore$ $C = 86.5$ days

Applying the equation (iv)

$$up = \frac{r^2\ s}{4\ K\ B\ tp} = \frac{r}{2\lambda} \quad \therefore\ S = \frac{4 \times 2.58 \times 10^4 \times 4.7 \times 10^{-3}}{2 \times 1495 \times 150}$$

$$= 1.07 \times 10^{-3}$$

Now to check the extrapolated value of sr whether it is correct or not, the following procedures are applied :

(i) Using the value of S & T, To compute the Up at point where $t_p = 0.02$ days

$$U_p = \frac{r^2 s}{4 T t_p} = \frac{150 \times 150 \times 1.07 \times 10^{-3}}{4 \times 2.58 \times 10^4 \times 0.02} = 1.16 \times 10^{-2}$$

For the value of u, To find the value of $W(u, r/\lambda)$ from the table,

$\therefore W(u, r/\lambda) = 3.588$

$$\therefore s_p\,(0.02) = \frac{173 \times 3.588 \times 10^3}{4 \times 2.58 \times 10^4 \times 3.14} = 1.92$$

On curve for $t_p = 0.02$ days, the value of drawdown $st_p = 1.96$. Thus it is found that the computed value of st_p and the value on the curve are not close proximity. So the value of sm is taken not justifiably. This shows that the pump test should be carried out for longer period.

(ii) Application of the Hantosh method for the Well No.25 located at Banwaripur.

From the given data,

(a) Q, discharge of Well = 45000 gph = 173×10^3 ft^3/day

(b) r = Distance between observation Well & pumped well=147 ft.

From Figure No.2.2.9 Extrapolated value of sm has been assumed as=0.51 m.

$\therefore$ The value of s_p at inflection point = 1/2 s_m

$$= \frac{0.51 \times 3.281}{2} = 0.836 \text{ ft.}$$

The value of tp at inflection point = 104.2×10^{-3} days. Then the value of $\Delta\, s_p$ at inflection point per log cycle = 0.64 m = 2.1 ft.

Using the equation (ii),

$$\frac{2.3\ sp}{\Delta\, sp} = K_0(r/\lambda)\ e^{r/\lambda} = \frac{2.3 \times 0.836}{2.1} = 0.915$$

Using the table, r/λ = 1.664 for $K_0(r/\lambda)\ e^{r/\lambda} = 0.915$

$$\therefore \quad e^{-r/\lambda} = 0.19 \text{ and } = r/1.664 = \frac{147}{1.664} = 87.3.$$

Now using $sp = \frac{2.3\ Q\ e^{-r/}}{4\ \pi\ T}$, T can be found out to be

$$T = \frac{2.3 \times 173 \times 10^{3} \times 0.19}{4 \times \quad \times 2.1} = 0.286 \times 10^{4}\ ft^{2}/day$$

$$\therefore \quad C = \frac{2}{T} = \frac{87.3 \times 87.3}{0.286 \times 10^{4}} = 2.6 \text{ days.}$$

S (storage coefficient) can be computed by using the equation

$$\frac{r^2\ s}{4\ T\ tp} = \frac{r}{2}$$

$$\therefore \quad S = \frac{4 \times 0.286 \times 10^{4} \times 104.2 \times 10^{-3}}{2 \times 83.7 \times 1.47} = 0.0485$$

From the above results, it is observed that the resistance of layer in both the case is very small which shows doubtful to consider the delayed yield as a leaky confined aquifer. The idea has been further supported by the statement from the project report that there are clay lenses present in the aquifers which are tapped. So it can be decided to treat aquifer as a semi-unconfined and to analyse accordingly.

* Please Refer Page 13 in the next page

B = Saturated thickness of aquifer.

$W(U_{AY}, r/\lambda B)$ = Well function by Boulton for the Ist segment, the equation (i) reduces to

$$\therefore \quad s \; \frac{Q}{4 \; K B} \; W(U_A, \; r/\lambda B) \qquad \text{.....(ii)}$$

Where $u_A = \dfrac{r^2 \, s_A}{4 \, K \, B \, t}$

s_A = Effective early time coefficient of storage for the 3rd segment of d-d curve, the equation (i) reduces to

$$s = \frac{Q}{4 \; K B} \; w\,(u_y, \; r/\lambda B) \qquad \text{.....(iii)}$$

Where $u_y = \dfrac{r^2 \, s_y}{4 \, K \, B \, t}$

s_y = Total volume of delayed yield per unit drawdown per unit horizontal area or specific yield.

Another relation given by Boulton is

$s = S_A + S_y = \quad S_A$

Where S = effective coefficient of storage

$\gamma >$ 100 , Boulton method will give good result and if $\gamma >$ 10 & $\gamma <$ 100, the second segment of the curve is no longer horizontal when the tends to infinity, the second segment can be described by

$$s = \frac{Q}{2 \pi K B} \; K_0 \,(r/\lambda B) \qquad \text{.....(iv)}$$

Where

$K_0(r/\lambda B)$ = Modified Bessel function of second kind & zero order.

B = Drainage factor = $\sqrt{\dfrac{KB}{\alpha \cdot S_y}}$

$1/\alpha$ = delay index.

Please refer Page 14 in Previous page

C. Boulton's Method for Semi-Confined Aquifer:

According to Boulton the method can be applied to the aquifer as follows:

(i) The aquifer is unconfined but showing phenomena of delayed yield or the aquifer is semi-confined.

(ii) The flow of well is an unsteady state.

(iii) Well diameter is small and storage in the well may be neglected.

Theory of the Method:

The time drawdown curve of a piezometer in a pumped unconfined aquif aquifer with delayed yield can be divided into three distinct segments as in Fig.2.a.

The first segment, covering a short period after pumping has started indicates that in unconfined aquifer reacts in the same manner as that of confined aquifer. The water is released instantaneously from storage by the compaction of the aquifer and by the expansion of the water itself. Gravity drainage has not yet started. Then the Thie's method can be applied approximately to determine transmissibility but the storage coefficient computed from the segment cannot be used to predict long term drawdown of water table. The second segment of drawdown-time curve indicates decrease in slope because of replenishment by gravity drainage. During this period Thei's curve will differ appreciably from the deserve data curve. The third segment conforms closely to the Thei's curve as there is equilibrium between gravity drainage and fall of water table.

According to Boulton, the flow equation is given by the relation

$$s = \frac{Q}{4\pi K B} \; w\left(U_{AY}, \, r/\lambda B\right) \qquad \text{..... (i)}$$

Where Q = discharge of well

K = Coeff. of permeability

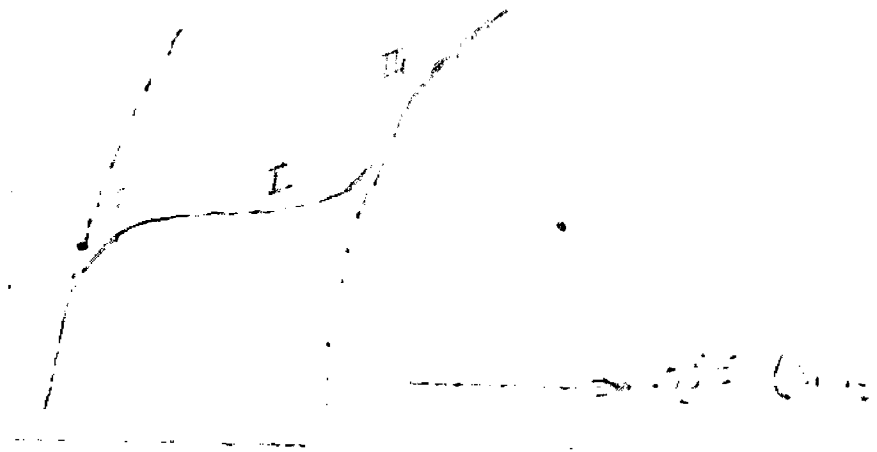


FIG 2a

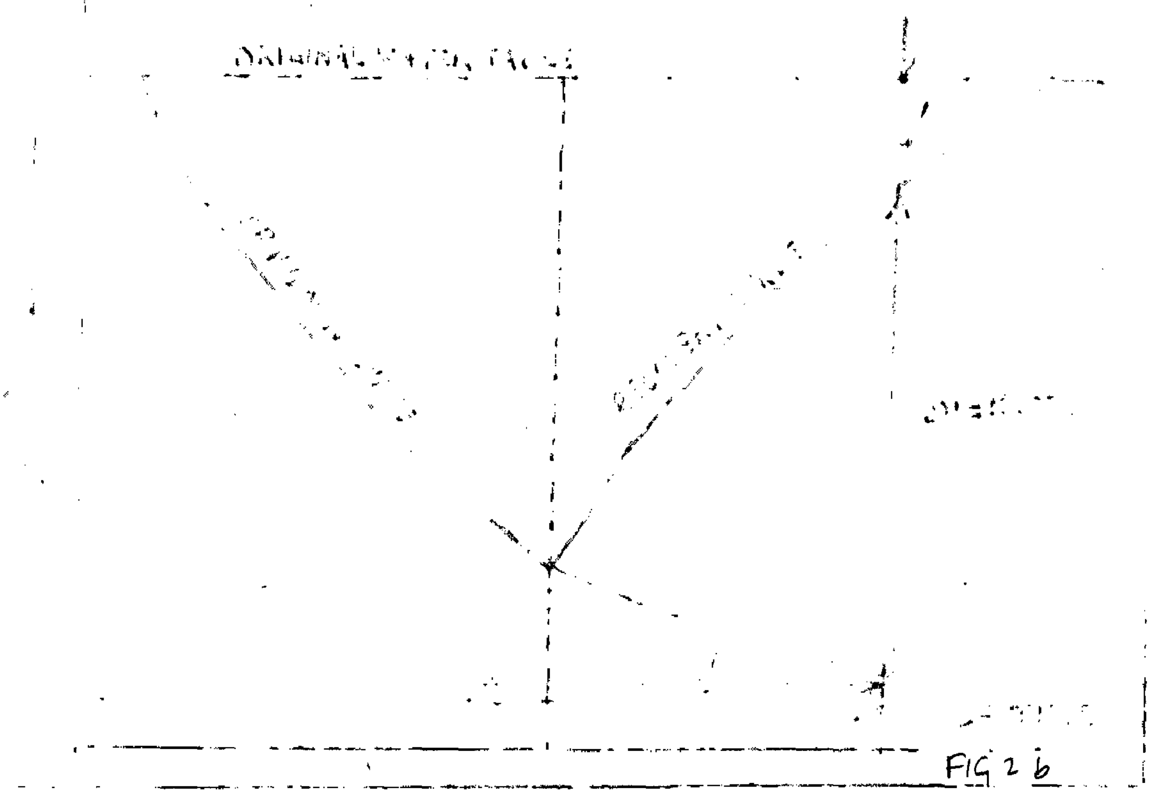


FIG 2b

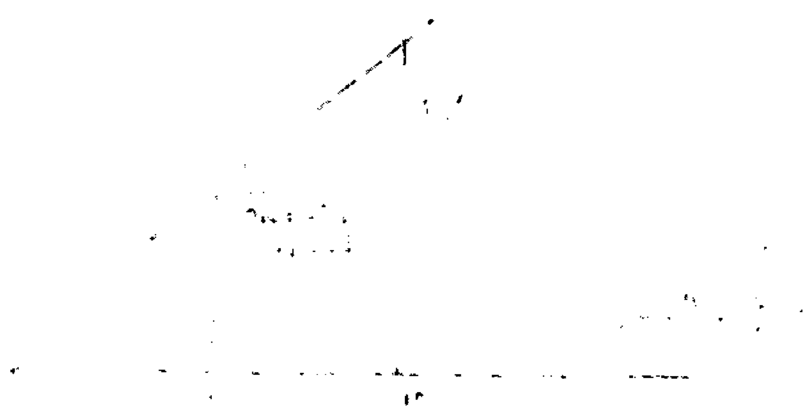


FIG 2C

Procedure of the Method

(i) Firstly 'Boulton Type Curves' is to be plotted by plotting $W(u_{AY}, r/\lambda B)$ versus $1/u_A$ and $1/u_Y$ for a practical range of values of $r/\lambda B$ on a Double logerithmic paper Plate No.9. Left hand side (Type A) of curves show $W(u_A, r/\lambda B)$ versus $1/u_A$ and Right hand side (Type Y) shows $W(u_{AY}, r/\ B)$ v/s . $1/u_Y$ in the graph.

(ii) To prepare the observed data on a double logerithmic paper of the scale as that of type curves Drawdown s against time plate no.8.

(iii) The observed data curve is then superimposed on type 'A' curve keeping ordinate scale parallel to each other. Now a point on the overlapping portion of the two sheets of graphs and the values of s, t, $1/u_A$ and $W(u_A, r/\lambda B)$ are noted and values are substituted in the equation valid for Ist segment of curve to find S_A & T.

(iv) Then the later portion of Time-drawdown curve is matched with Type Y curve with same $r/\lambda B$ value as that of type A curve and the values of S, t, $1/u_Y$ and $W(u_Y, r/\ B)$ are noted for the match point. Then the values are substituted in equation of the 3rd segment which will give S_Y and T. In both the positions T should have the same value.

(v) Thus the value of S_A & S_Y are used to compute $r = 1 + S_Y/S_A$.

Application of this Method for Tubewell No.25 located at Banwaripur:

The plotted Time drawdown curve (Plate No.2.2.3) conforms with "Boulton Curves" so the aquifer as semi-unconfined is justified. From early match point, $W(u_A, r/\lambda B) = 0.043$

for $r/\lambda B = 2$, $\therefore$ $1/u_A = 0.7$

$\therefore$ $s = 0.048$ ft, $t = 0.00104$ days.

Now using equation (ii)

$$\cancel{s} = \frac{Q}{4\pi K B} W(u_A, r/\lambda B) \ \& \ u_A = \frac{r^2 S_A}{4 K B t}$$

Where $Q = 45000$ gph $= 173 \times 10^3$ ft^3/day.

r = Distance between the pumped well & observation well = 147 ft.

$\therefore \quad KB = T = \frac{173 \times 10^3 \times 0.043}{12.56 \times 0.048} = 12200$ ft^3/day/ft.

$\therefore \quad S_A = 4 \times \frac{1}{0.7} \times \frac{12200 \times 0.00104}{147 \times 147} = \frac{50.8}{15.12} \times 10^{-3}$

$= 0.00335$

When the later portion is matched, using the equation (iii), we hav get

$$s = \frac{Q}{4 \quad K B} W(u_Y, r/\lambda B), \quad u_Y = \frac{r^2 S_Y}{4 KB t}$$

$\therefore \quad W(u_Y, r/\lambda B) = 1.2$, $1/u_Y = 4.2$ from the same plate.

$\therefore \quad s = 1.3$ ft, $t = 250$ minute $= 0.173$ day

$\therefore \quad T = \frac{173 \times 10^3 \times 1.2}{4 \times 3.2 \times 1.3} = 12800$ ft^3/day/ft.

and $\quad S_Y = 4 \ \frac{1}{4.2} \times \frac{12800 \times 0.173}{147 \times 147} = 0.093$

$\therefore \quad S = 0.093 + 0.0033 = 0.0963$

$= 0.096$ (approximately).

The value of 'T' can be taken as average of the two positions,

$T = \frac{12200 \times 12800}{2} = 12500$ ft^3/day/ft.

$= 0.124$ hectare/day.

$\therefore \quad = \quad 1 + S_Y/S_A = 1 + 0.093/0.00336 = 1 + 27.6 = 28.6$

$\therefore \ \gamma > 10$ and $\gamma < 100$ $\therefore$ This shows that horizontal portion should be small which is confirmed from the plotting of data.

The drawdown-time curve for the well No.81 on a double logarithmic paper for the observed pump test data (Plate No.6) does not reveal anything, which shows that period of Pump test was insufficient. If pump test could be carried out for longer period, better result could be obtained. So the aquifer will be taken as semi-unconfined as found out from the analysis of Pump Test data of Well No.25.

Thei's Recovery Method

Thie modified the formula for drawdown which are as follows:

$$s = \frac{Q}{4\pi KB} W(u) = \frac{Q}{4\pi T} \log_e \frac{1}{u}$$

Where $T = KB$, $u = r^2 s/4\,T\,t$

$W(u) = -\log u$ (neglecting all other terms in sizes).

$$\therefore \quad s = Q/4\pi T.\ \log_e.\ \frac{4\,T\,t}{r^2\,s} \qquad \text{.....(i)}$$

When the pumping is stopped, the time t' is measured and the recovery drawdown

$$sr = \frac{Q}{4\pi T} \log_e \frac{4\,T\,t'}{r^2\,s} \qquad \text{.....(ii)}$$

But in the field it is difficult to measure the Recovery and therefore the residual drawdown is measured and is given by s' = s-sr.

$$\therefore \quad s' = s - sr = \frac{Q}{4\pi T} \left(\log_e \frac{4\,T\,t}{r^2\,s} - \log_e \frac{4\,T\,t'}{r^2\,s}\right)$$

or, $$s' = \frac{2.3\,Q}{4\ T} (\log_{10} (t/t'))$$

$$\therefore \quad T = \frac{2.3\,Q}{4\pi s'} \log_{10} (t/t') \qquad \text{.....(iii)}$$

Which is modified formula as given by Theis. Thus T can be found out knowing the value of t', $\Delta s'$ and t from the observed field data as in Fig.2.b.

Procedure:

From the available data, the residual drawdown s' in normal scale v/s t/t' on log scale are plotted and thus t per log cycle of t/t' can be computed as in Fig.2-c.

$$T = 2.3\ Q/4\pi\ \Delta s'$$

Calculations

I. From the plotting of data for well No.81 in Fig.2.2.8, the $\Delta s'$ value is equal to 0.93 for one cycle of $\log_{10}$ t/t'.

$$\therefore \quad T = \frac{2.3 \times 173 \times 10^3}{4 \quad \times 0.93} = 3.4 \times 10^4\ ft^2/day$$

II. From the plotting of Well No.25 data in Fig.No.2.2.6, the $\Delta s'$ value is equal to 0.51 m per log cycle of t/t'.

$$\therefore \quad s' = 1.67\ ft.$$

$$\therefore \quad T = \frac{2.3 \times 173 \times 10^3}{4 \times 3.14 \times 1.67} = 1.89 \times 10^4\ ft^2/day.$$

Thus it is observed that the Recovery Method given by Theis indicates higher value of T than that of Boulton method. For all calculation purposes, the value of Transmissibility is taken as

$T = 1.25 \times 10^4\ ft^2/day$ as obtained by Boulton method.

S = Coefficient of storage = 0.096.

Hence the values obtained by Boulton Method have been taken as the formation constants for the aquifer.

2.3 CALCULATION OF NET RECHARGE AND WITHDRAWLS IN THE BASIN:

The computation net recharges and drafts has been done in the following steps :-

(i) 25 polygons have been constructed according to the Thiessen Method (Fig.2.3.(b)). These polygons have been chosen in a manner such that the water levels at these nodes are known for some period and they form well conditioned triangles.

(ii) The six raingauge stations in the area are shown in the figure and have been designated as P, H, MS, MM, MI and G. Thiessen polygons have been drawn also for those stations.

(iii) The area of each polygon has been measured.

(iv) The recharges to various nodes are in the form of precipitation and canal seepage losses. The precipitation at each raingauge station being known for different months, the average weighted value for each polygon associated with any node has been worked out on the basis of the proportion of the area of this node under the influence of a given raingauge station with the help of Thiessen Polygon method for rainfall.

Rainfall Recharges were assumed both 30 percent and 35 percent of Total monthly rainfall.

(v) The canal seepage losses are assumed zero for all polygons other than those falling in the canal command (i.e. node Nos, 13, 17 & 18). The canal seepage have been computed applying the emperical formula:

$$\text{Seepage loss} = C/8\ (B + D)^{2/3} \quad \text{cusec/mile.}$$

Where C = length of channel in mile

B = Width of channel in ft^2

D = Depth of flow in ft.

(vi) The withdrawls in the form of tube well draft has been assumed distributed uniformly over the area of all the polygons except those falling in canal command.

(vii) The water requirements of different crops in the canal command (existing) has been calculated. The monthly canal (releases and the tubewell release were being considered during the calculations.

(viii) The water Requirement of crops in tube well command have also been calculated monthly at each polygon and the net weighted average withdrawls have been computed with respect to gross irrigation requirement from the available tubewell releases data.

(ix) Then the net recharge in positive volume and withdrawls in negative volume have been computed by substracting the net weighted tube well withdrawls from the net weighted recharges data.

(x) These net volumes both positive and negative, monthly data are then used to determine the current in milliamphere by using appropriate scale factors to use as input for the analog model at each node under consideration.

The computed tables are given in Tables sequentially.

CHAPTER - III

ANALOG SIMULATION

3.1 DESCRIPTION

Analog model for simulating ground water of Varuna Basin are patterned after models developed by W.C.Walton and consists of regular arrays of resistor and capacitors. The model is said to be direct analog model since the two systems are one to one correspondence between each element in the systems as well as between the excitation and response function of element and the system as a whole. In R-C network, resistors are inversely proportional to hydraulic conductivity of aquifer and capacitor store electrostatic energy, in a manner analogous to the water within the aquifer. Thus electrical network is a scaled down version of aquifer.

A R-C network is characterised by "Junctions" and discrete branches. Four resistors and a capacitor are connected to each terminal. The capacitor is also secured to ground connection of the electrical system. The boundary of the network is adjusted in a step function to approximate the actual boundary of the aquifer. To do this, boundary terminals are connected to two or three resistors and a capacitor depending upon the Geometry of the boundary. In this model the network of the resistors and capacitors in the proximity of the boundary are connected to take into consideration of the irregular shaped boundary and Resistors and capacitors are selected such that there is correspondence between network parameters and aquifer parameters.

3.2 MATHEMATICAL BASIS FOR THE SIMULATION

The approximate nonlinear partial differential equation which describes ground water flow in two dimensions in an unconfined aquifer

* Please refer Page 23 in the next page

Thus, it can be written similar expressions for nodes (1),(4),(2) and substituting these expressions in equation (4), which gives

$$\sum_{i=1}^{4}\left[h_i^{t+\Delta t} - h_o^{t+\Delta t}\right] T_{i,o} = \frac{A_o S_o}{\Delta t}\left[h_o^{t+\Delta t} - h_o^{t}\right] + Q_o^{t+\Delta t} \quad \ldots (6)$$

($T_{i,0} = T_{0,i}$ assumed)

For finite difference approximation of equation (2), the acquifer is subdivided into squares of equal area, $\partial x . \partial y$. The sides of the squares ∂x and ∂y, are equal and are of finite length, Δx and Δy respectively. The square grid is shown in Fig.(30). The intersections of grid lines are called nodes. The finitesimal $\Delta x \Delta y$ is approximated by ag^2 in which ag is the width of grid interval. The area ag^2, is small compared with the aquifer.

Examination of node '0' and equation (2) shows that the record differentials of head can be approximated by Stallman (1956).

$$\frac{\partial^2 h}{\partial x^2} = \frac{h_1 + h_3 - 2h_0}{ag^2} \qquad (7)$$

$$\frac{\partial^2 h}{\partial y^2} = \frac{h_2 + h_4 - 2\,h_0}{ag^2} \qquad (8)$$

Substituting the equations (7) and (8) in equation (2) results in

$$\frac{h_1 + h_2 + h_3 + h_4 - 4\,h_0}{ag^2} = \frac{S}{T}\,\frac{\partial h}{\partial t} \qquad (9)$$

which is the finite difference form of partial differential equation governing the nonsteady state, two dimensional flow of ground water in an infinite aquifer. Equation (9) can be written as

$$T\left(\sum_{1}^{4} h_i - 4h_o\right) = ag^2 S \frac{\partial h}{\partial t} \quad \ldots \quad (10)$$

* Please refer Page 24 in Previous page

is given by the equation (i).

$$\frac{\partial}{\partial X}\left(P_X \frac{\partial h}{\partial X}\right) + \frac{\;}{Y}\left(P_Y \frac{\partial h}{\partial Y}\right) = S \frac{\partial h}{\partial t} \qquad \text{..... (i)}$$

If drawdowns are small relative to the initial saturated thickness of the aquifer the product P_X & P_Y coefficient of permeabilities along X & Y directions can be replaced by T_X & T_Y, transmissibilities and then taking by the aquifer homogeneous, equation (i) becomes

$$\frac{\partial^2 h}{\partial X^2} + \frac{\partial^2 h}{\partial Y^2} = \frac{S}{T}\frac{\partial h}{\partial t} \qquad \text{.....(ii)}$$

Equation of the same form occur in the theories of nonsteady-state flow of heat and electricity. When the ground water flow is considered, the unsteady flow equation for aquifer is

$$\frac{\partial}{\partial x}\left(T_x \frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(T_y \frac{\partial h}{\partial y}\right) = S \frac{\partial h}{\partial t} + Q \qquad \text{.....(iii)}$$

The above equation (iii) has to be solved for appropriate boundary conditions.

3.3. FINITE DIFFERENCE APPROXIMATION

In the direct electric analog simulation and digital methods, equation (iii) is written in a finite difference form. Figure of Finite grid patterns is shown in below in Fig. 3(a).

Fig.3 (a)

For a square grid pattern, the continuity equation for the node O can be written as

$$Q_{3,0}^{t+\Delta t} + Q_{2,0}^{t+\Delta t} = Q_{0,1}^{t+\Delta t} + Q_{0,4}^{t+\Delta t} + Q_0^{t+\Delta t} + A_0 S_0 \frac{h_0^{t+\Delta t} - h_0^t}{\Delta t} \qquad \text{-(IV)}$$

By Darcy's law, we get,

$$Q_{3,0}^{t+\Delta t} = \frac{\left(h_3^{t+\Delta t} - h_0^{t+\Delta t}\right)}{\Delta x} \times \Delta x, T_{3,0} \qquad \text{(V)}$$

where h_0 is the head at node '0' h_i ($i = 1,2,3$ and 4) represents head at nodes 1-4; ag denotes the width of grid interval; T stands for coefficient of transmissibility, S equal the storage coefficient and t stands for time in days.

3.4. ELECTRICAL NETWORK

A resistor capacitor network with square grid pattern of fig.3(a) is shown in Fig.3(b). At junction '0' four resistors and a capacitor are connected. The capacitor is earthed. Using Kirchoff's current law at point 'o', we get

$$I_{3,0}^{t+\Delta t} + I_{2,0}^{t+\Delta t} = I_{0,1}^{t+\Delta t} + I_{0,4}^{t+\Delta t} + I_s + I_0 \quad \ldots \quad (11)$$

where

$$I_{1,0}^{t+\Delta t} = \frac{V_1^{t+\Delta t} - V_0^{t+\Delta t}}{R_{1,0}} \quad \ldots \quad (12)$$

Similar expressions can be written for the nodes 2,3 and 4 and

$$I_s = C_0 \frac{V_0^{t+\Delta t} - V_0^t}{t}$$, where C_0 is the capacitance of capacitor at node '0'. Substituting the value of I_s and I_1, 0, in equation (11). We get

$$\sum \left[V_i^{t+\Delta t} - V_0^{t+\Delta t} \right] \frac{1}{R_{i,0}} = \frac{C_0}{\Delta t} \left[V_0^{t+\Delta t} - V_0^t \right] + I_0 \quad \ldots (13)$$

A resistor capacitor network with a square grid pattern is shown in Fig.3(c) and network junctions at nodes as defined in Fig.3(d) is set up.

The junctions consists of 4 resistors and one capacitor connected to a common terminal; the capacitor is also connected to the ground. The relation of electrical potential in the vicinity of the junction according to Kirchoff's current law, can be expressed as

$$\left[V_2 - V_0\right]\frac{1}{R_2} + \left[V_1 - V_0\right]\frac{1}{R_1} + \left[V_4 - V_0\right]\frac{1}{R_4} + \left[\frac{V_3 - V_0}{R_3}\right] = C_0 \frac{\partial V}{\partial t} \qquad (14)$$

where V_{0-4} is the electric potential at the ends of resistor, R_{1-4} denotes the resistance 1. If the resistances are equal, equation (14) may be as follows :

$$(V_1 + V_2 + V_3 + V_4 - 4\,V_0)\;1/R = C_0 \frac{\partial V}{\partial t} \qquad (15)$$

which may be written as

$$\frac{1}{R}\left[\sum_{1}^{4} V_i - 4V_0\right] = C_0 \frac{\partial V}{\partial t} \qquad (16)$$

where V_i (i = 1, 2,3 and 4) is the electrical potential at the ends of resistors 1-4.

3.5. DIRECT ELECTRICAL ANALOGY:

The analogy between the electrical systems and aquifer systems is apparent. The hydraulic heads h in meters are analogous to electrical potentials V in volts.The co-efficient of transmissibility 'T' in m^2 per day is analogous to the reciprocal of the electrical resistance, 1/R in 1/ohms. The product of the storage coefficient 'S' and ag^2 is analogous to the electrical capacitance, Co in Tarads.

Continuing the comparison, water moves in an aquifer just as charges more in an electrical circuit. The quantity of water is calculated in volume 'V' in m^3 or gallons, while the charge is calculated Z in coulombs. The rate of flow of water through a given cross-section of the aquifer 'Q' is expressed in m^3 per day or gallons per day, while the flow of electricity 'I' is expressed in coulomb per second or ampheres. The time 't' in days in the aquifer analysis is analogous to the time 'ta' in seconds in the electrical analog model.

Thus, there are four units are analogus. There is necessarily a scale factor connecting each unit in one system to the analogous unit in the other system. Knowing the four scale factors, the hydrologist is able to relate electrical units associated with the analog model to hydraulic units associated with the aquifer. The four scale factors K_1, K_2, K_3 and K_4 are defined as follows :

(1) $K_1 = V/Z = m^3/\text{ coulomb}$ (17)

(2) $K_2 = H/v = \text{metre/volt}$ (18)

(3) $K_3 = Q/I = m^3/\text{ day amphere}$ (19)

(4) $K_4 = t/ta = \text{days/second}$ (20)

The relation between scale factors K_1, K_3 and K_4 is expressed by

$$K_3 = \frac{m^3}{\text{day-amp.}} = \frac{m^3/\text{day}}{\text{coulomb/sec.}} = \frac{m^3/\text{coulomb}}{\text{days/second}}$$

$$= K_1/K_4 \qquad K_3 K_4/K_1 = 1 \qquad (21)$$

The values of resistors and capacitors required to model of a given aquifer may be determined from equation (17) and eq.(21). To minimise the cost of model, scale factors are choosen that allow the use of standard tolerance, low wattage, fixed carbon resistors with values from 10^2 to 10^7 ohms and capacitors of low voltage rating with values from 10 microfard. to 100 microfarad. Substituting of ohm's law and Darcy's law in equation (19) yields.

$$R_R = K_3 / K_2 T \qquad (22)$$

where R_R is the resistance in ohms and T refers to coeff. of transmissibility in m^2/day. The equation (22) may be used to determine the value of resistor of interior parts of analog model.

$$Co = ag^2 \; S. \; K_2/K_1 \qquad (23)$$

where Co = capacitance, ag = grid spacing. The equation (23) may be used to determine the value of capacitor of interior parts of analog model, is derived by taking into consideration of storage coefficients 'S' and the analogy between ag^2S and Co. Network spacings are selected to minimize the errors due to finite difference approximation and are selected by trial and error method to adjust the available number and values of resistor and capacitor in the prevailing market condition.

$$\therefore \; R_R \times Co = \frac{ag^2 \, SK_2}{K_1} = \frac{K_3}{K_2 T} = \frac{ag^2 \cdot S.K_3}{K_1 \, T}$$

$$= ag^2 \, S/ K_4 T \qquad (K_3/K_1 = 1/K_4)$$

$$\therefore \; ag^2 = \frac{R_R \times Co \times T \times K_4}{S} \qquad (24)$$

For regional studies on a gross basis, the network spacing can be 10,000 ft. for local studies involving details, a network spacing of 100 feet is adequate as suggested by Walton (15) 1963.

3.6. DIFFERENT METHODS OF SIMULATION OF AQUIFER ELEMENTS:

Leaky artisian conditions exist where aquifers are overlain by aquitard through which leakage occurs. Leakage through the aquitard into the aquifer is vertical, and proportional to drawdown, the hydraulic head in the deposits supplying leakage remains more or less uniform. Under these conditions leakage can be simulated in an analog model by the addition of the resistors connected to ground and to each node of the network.

Substitution of ohms law and darcey's law in equation (19) results in

$$RG = K_3/ K_2 \; (P'/m') \; ag^2 \qquad (27)$$

where p'/m' is the coefficient of leakage in gallons per day per cu.ft. or m^3/day/cft. and the value of resistor G is determined by the equation (27). as proposed by Walton (63).

Barrier boundaries (lines across where there is no flow) can be simulated by an open circuit. Resistors connected to the nodes along the edge of the analog model and to the ground simulate horizontal leakage through boundary of the aquifer.

Leakage of water through a stream leed can be simulated with a resistor connected to appropriate nodes and to the ground. The magnitude of resistors (RS) simulating the streambed are inversely proportional to the areas of the portions of streambed they represent.

By substituting ohm's law and Darcy's laws into equation (12) the following equation can be derived, which may be used to compute the values of resistors simulating the stream bed (Walton, 1966).

$$Rs = K_3/ K_2 \; (I_h) \; As \qquad (28)$$

Where As is the area of the stream bed represented by the resistor, in square metre, and I_h is the infiltration rate of the stream bed in $m^3/day/m^2$. The values of resistor of capacitors adjacent to the boundaries can be computed based on the " vector volume " technique described by Karplus (1958).

$$Rx = R_b \frac{\Delta x}{\Delta y} \quad (29)$$

$$Ry = R_b \frac{\Delta y}{\Delta x} \quad (30)$$

$$Cb = A * S * K_2/K_1 \quad (31)$$

The above equations may be used to compute the resistor value (Rx & Ry) in x and y directions respectively and R_b is the interior resistor, y are the grid spacing in f. and y directions. The value of capacitor adjacent stream boundary proportional to area Ao in m^2 and S is the coefficient of storage.

The stream bed elements were designed by Walton. at St.Luis Illinois (1963) so that leakage through stream bed reaches a maxim rate when the water level decline is 4 feet and thereafter remains constant. Therefore analog simulation under this condition has been developed by connecting a vertical stream bed resistor (RG) at stream bed node, which is in line connected to ground and a diode connected to a negative 4 volts. As the voltage in the aquifer elements decreases to - 4 volts the current through the stream bed resistor increases in direct proportion to voltage drop. The low forward impedance of diode prevents the voltage in the aquifer element from going further negative. Sometimes diode was formed insufficient to control the decreasing characteristic of current. Since the current is non linear, an active device (Transistor have nonlinear characteristics) must be used.For output voltage greater than 4 volts, the transistor comes out of saturation and Resistors become a current source.

3.7. RIVER SIMULATION IN THE BASIN BY R-L-C NETWORK

If the velocity changes with time, the nonsteady flow equations, for a length of Δx of river or channel will be

$$\frac{\Delta x}{\rho g A} \frac{\partial m}{\partial t} + \left[32 \mu / g \rho^2 A D^2 \right] \Delta x \; m = -\Delta x \quad (32)$$

where m = mass flow rate, D = diameter of channel section,

A = area, t = time of propagation u = coeff.of viscosity,

p = density in F.P.S. units.

In electrical flow equation is

$$L \frac{\partial I}{\partial t} + RI = V \qquad (33)$$

Where I = current, L = inductance, R = Resistance

The voltage is the representation of hydraulic head stage H , the current is the analogous to mass flow rate, 'm' , resistance is analgous to frictional loss and inductance is analogy to $\Delta x / \rho g A$. The following scale factors can be used for the river simulation.

(a) $VF = V/H$ (34) (b) $I_f = I / m$ (35)

(c) $RF = R / 32 \mu \Delta x / g \rho^2 A D^2$ (36)

(D) $L_f = L / \Delta x . \rho \, Ag$ (37)

(e) $Tf = LF/RF = te/tf$ (38)

The local storage can be done to the rise in a free water surface. Let M be total mass in length ox of a channel and thus the rate of mass changing with time along the channel flow, equation is

$$\frac{\partial M}{\partial t} = \frac{\partial m}{\partial x} * x \qquad (39)$$

The corresponding electrical equation is that governing the accumulation of charges in a capacitor in the figure 4.3.

$$\frac{\partial Q}{\partial t} = C\frac{\partial V}{\partial t} \qquad (40)$$

The equation (39) relates the time rateof accumulation of mass to the rate at which mass flow rate changes with time and it is related to time rate of head increases and storage factor 'S' as

$$\frac{\partial M}{\partial t} = S\frac{\partial H}{\partial t} = M \qquad (41)$$

Since S is proportional to C in equation (40) $C_f = C/S = (I/m)(\ te/tf)/)V/H)$

$$Cf = I_f \times If / V_f = T_f / R_f \qquad (42)$$

$\therefore$ Propagation time = $\Delta t_e = (LC)^{1/2}$ (43)

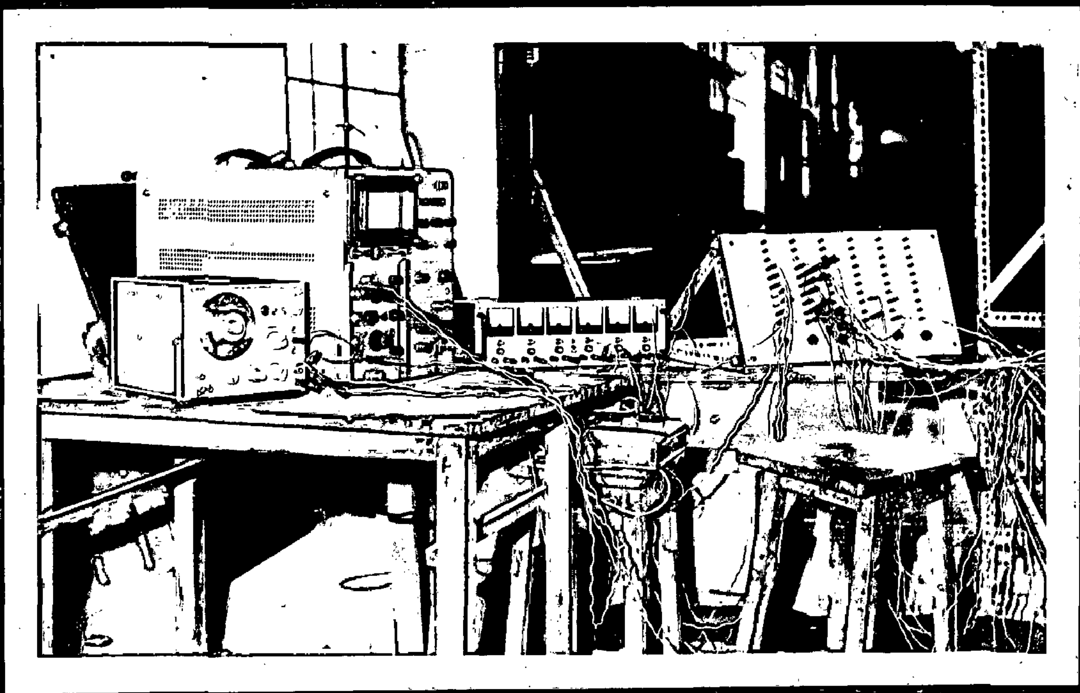
in water system $t_f = \Delta te / Tf$ (44)

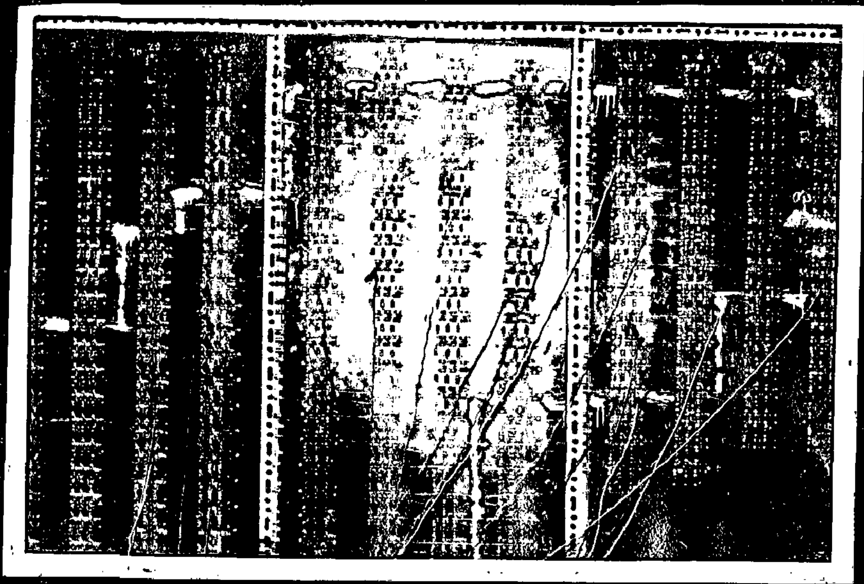
$\therefore$ Velocity of water = $\frac{\text{Length of channel}}{t_f}$

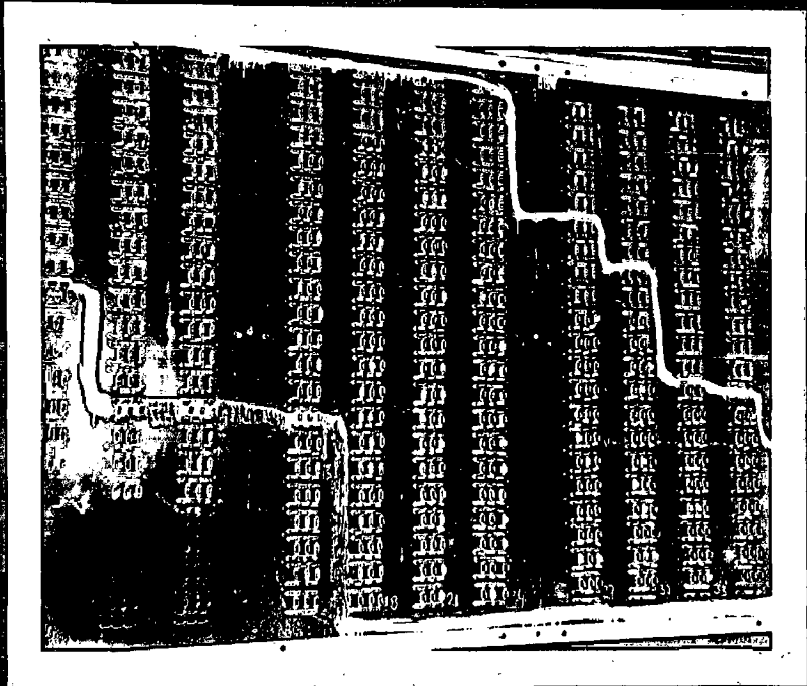
Thus river simulation can be done by using resistance inductance and capacitance network. Depending upon the channel reaches, the number of network (R-L-C) sets will be used in the aquifer model simulating stream aquifer system also.

3.8. EXCITATION RESPONSE APPARATUS:

Excitation-response apparatus forces electrical energy in the proper time phase into the analog model and measures energy levels within the energy dissipative, Resistance capacitance network. The excitation response apparatus consists of four major parts, a stabilized power supply, a functioned generator combined with pulse generator, distribution Board and oscilloscope.







3.8.1. Functional Generator:

The functional generator, which produces a particular wave similarto well hydrograph, is connected with pulse generator and oscilloscope, thereby controlling the rate of computation and synchronizing the oscilloscope's sweep and output of pulse generator. The pulse generator which produces hydrograph shaped pulses of various amplitude and of fixed duration on command from the functional generator, is coupled to the junction of the analog model representing the production well.

3.8.2. C-R-D :

The oscilloscope is connected to the junction of simulation model in which it is desired to determine the response of the analog model to excitation. An electron beam is swift across the cathode ray tube of oscilloscope.

3.8.3. [illegible] APPARATUS

The function generator sends a pulse to oscilloscope as input to start a horizontal sweep, at the same time, it sends a hydrograph shaped pulse consisting both positive and negative portion according to the amplitude and duration with respect to net field recharge (positive part) and net withdrawls (negative part). This pulse is sensed by the oscilloscope as a function of analog model components, boundary conditions, nodal position of the junction connected to the oscilloscope. Thus the oscillo. scope trace is analogous to the water level fluctuation that would result after a wave function type both recharge and pumpage change of known duration and amplitude.

A method of computing the pumpage rate is incorporated in the circuit between the pulse generator analog model by the small resistor Ri in series.

$$Q = [illegible] \quad V_{Ri} \times K_3 / Ri \qquad (26)$$

where Q denotes the pumping rate in m^3 per month, V_{Ri} denotes the voltage drop across Ri in volts and Ri is the known resistance (1 kilo ohms).
This equation may be used to compute rate of recharge rate and can be measured on the oscilloscope itself.

The switch is then returned to the original position (i.e. off-position). The oscilloscope is then connected to other junctions of the analog model representing observation well and then switch is connected at on position and thus the time voltage curves for junctions can be recorded by reading from the traces. The screen of the oscilloscope is accurately calbirated so that voltage and time may be read on the vertical and horizontal axes respectively. The time in the 1/10th of a second is the value of each horizontal division on the screen, is determined by noting the duration of pulses and the number of divisions covered by the time voltage traces for junction of pumped well. The time voltage graph obtained from the oscilloscope can be converted into water level fluctuations versus time graph or time duration graph by means of scale factor K_2 and K_4 respectively.

The performance of specification of function generator, oscilloscope are compatible with the following criteria desired for analog models.

(1) Low power requirements

(2) Fast computing speeds.

Special apparatus may also be coupled to the excitation apparatus such as Distribution board with relay circuit and a capacitor for rejecting unwanted noise pick up, integral circuit for amplifying the input voltage level, thus permiting the measurement of smaller voltage. To record the time-voltage graph accurately the storage type oscilloscope has been used. In general, the accuracy of analog simulation model is a matter of the quality of the resistors and capacitors of the effects of finite difference approximation and the signal noise ratio.

CHAPTER - IV

CONSTRUCTION OF RESISTANCE AND CAPACITANCE NETWORK

4.1 CALCULATION OF RESISTANCE AND CAPACITANCE VALUE FOR THE NETWORK

For Varuna Basin study, the two dimensional flow through homogeneous and isotropic aquifer has been considered. The area of the Basin is 258.23 x 10^7 m^2 and the Geographical Index map is showing the scale 1" = 4 miles = 212200 ft. Therefore 1 cm = 8300 ft = 2530 metres. Thus the whole basin is divided into equal square grid of 1 cm x 1 cm so that the grid size is 2530 metres. The scale factors has been calculated for the available voltage supply in the Laboratory, and whereas capacitors and resistors have been used in numbers and values in with their availability.

(1) K_2 = Head Scale = 12 metre/12 volt = 1 metre/1 volt

(2) $R_a = 10^5$ ohms, $C_o = 10^{-5}$ x farad = 10 μf

$T = 1.16 \times 10^3$ m^2/day, $S = 0.096$

ag = grid size = 2530 metres

$$K_4 = \text{time scale} = \frac{ag^2 * S}{C * T * R} = \frac{(2530)^2 * 0.096}{10^{-5} * 1.16 * 10^3 \times 10^5}$$

$\therefore$ $K_4 = 5.3 \times 10^2$ = 530 day/second

Since $K_4 = t/t_a$ = 1 year/t_a $\therefore$ t_a = 365/530 = 0.69 second.

From the adopted time scale factor, one year in prototype will be represented by 0.69 second in analog model. Thus one month is prototype will be represented by 0.69/12 = 0.0575 second = 57.5 milliseconds.

(3) $K_3 = K_2 * T * R$ = Discharge scale

$\therefore$ $K_3 = 1 * 1.16 * 10^3 * 10^5 = 1.16 * 10^8$ m^3/amp-day

$$\therefore \quad I = \frac{Q}{K^3} = \frac{\text{Pumping rate or monthly recharge in } m^3/\text{month}}{1.16 * 10^8 \ m^3/\text{amp-day} * 30}$$

$$= \frac{Q}{3.480} \times 10^{-9} \ \text{amphere} \quad .....(25)\text{-A}$$

Where Q is expressed in m^3/month.

Similarly,

When K_2 = Head scale = 2 metre/volt

$$\therefore \quad K_3 = K_2 * T * R = 2 \times 1.16 \times 10^{+3} * 10^5$$

$$= 3.32 \times 10^8 \ m^3/\text{amp-day.}$$

$$\therefore \quad I = \frac{Q}{K_3} = \frac{Q}{2.32 * 10^8} \ \text{amphere}$$

$$I = \frac{Q}{30 \ K_3} = \frac{Q}{6.96} \times 10^{-9} \ \text{amphere} \quad .....(25\text{-} B)$$

When Q is expressed in M^3/month.

4.1.2. Grid Size

From the above considerations the grid size is 2530 metres which is sufficient for Regional studies(15) and all the scale factors have been calculated depending upon this grid size.

4.2 CONSTRUCTION OF SIMULATION MODEL FOR VARUNA BASIN STUDY

Ground water Basin of the Varuna Basin has been approximated by the surface basin area and covers 258.25×10^7 square metres. It is assumed that the semi-unconfined aquifer is homogeneous with respect to transmissibility computed from the available Pump Test data. The study area is divided into a network of square grids of size equal to 2530 metre x 2530 metres. This resulted into 464 node points. But the entire basin has also been divided into polygons. To this end 25 nodes have been chosen in the area in a manner such that the water levels at these nodes are known for some period and they form well conditioned triangles. Polygons have been constructed according to Theissen method Figure 2.3. The six rain gauge stations in the area also shown in that figure. They have been designated as P, H, MS, MM, MI and G. Theissen polygons have been drawn for these stations also. The canal command has also been delineated. The inputs to various nodes are in the form of precipitation and canal input.

The canal input is assumed zero for all polygons other than those falling in the canal command. The output in the form of tubewell draft has also been assumed distributed uniformly over the area of all polygons except those falling in canal command. The conveyance losses have also been computed. For the analog model, the input have been fed in the form of current in milliamperes and all recharges are assumed positive value and the tubewell drafts are assumed as negative values. The inputs for each node under study have been expressed in the form of graph current in milliampheres versus time in second. All the computation have been done depending upon the scale factors under consideration for the construction of simulation model.

In the following tables 4(a) & 4(b) the input data have been shown that are calculated on the basis of volume of recharge and drafts that on the basis of volume of recharge and drafts that were computed in the Tables 2.3(a) & 2.3(b).

In the present work boundaries are approximated by using full square grids. Hence no special calculations are needed for boundary resistances. Using the computed value of resistors and capacitors an R-C model is build. The model size is roughly 3 m x 1.5 m. The complete assembly of the model took about two months. The cost of each resistor was 25 n.p. and capacitor cost was about 40 np. (1974 prices).

4.3. FEEDING OF D.C. VOLTAGES FOR INITIALIZATION AND STEADY CONDITIONS IN THE BASIN

From the computed scale factor K_2 (metre/volt) i.e. head scale, the initial steady voltage level in the analog model has been maintained by supplying D.C.voltages according to nodal spring level. To do this a stabilized power supply is used from which Distribution board with relay circuit has been used to give supply to the different nodes. In the first set up the different voltage level is fed following K_1 = 1 metre/volt and again in the second setup K_2 = 2 metre/volt has been used. The initial voltage level in the model is the initial potential spring level of the observation wells of the basin in the beginning of the hydrologic year i.e. June.

4.4. FEEDING OF VARIABLE INPUTS

In the present study there are twenty five nodal points under consideration. The input data is variable from node to node, both in magnitude and time. All the input data are in the shape of hydrograph having positive part and negative part also. In the positive part, the shape of the wave of input is similar to the positive part of Sinsudal wave approximately. But the negative part is with long tail. The figure is shown in the input data (Fig.5.4.1.) in the units of milliamphere versus time in millisecond.

To feed the variable shaped wave from Functional generator having Sinusoidal wave and triangular wave attached with frequency control and shape control can give a type of curve which may be similar. But to get proper shape of input data with proper amplitude in comparison to nodal initial level, a set of integral circuits has been connected with variable resistance potentiometre. Thus the voltage level in the supply and in the models can be matched. The supply of A.C. input wave to the different nodes at a time has been done through Distribution Board connected with Relay circuit. The current amplitude has been changed by changing the Resistance in the Potentiometers. The time span of the input hydrograph has been done by changing the frequency level on the Functional generator.

4.5. MEASURING DEVICE

In this analog model study, the measuring device of the potential is the oscilloscope. The voltage level in the network is measured on the oscilloscope directly just comparing with the ground potential level. The current as input has been measured by measuring the voltage drop across a known resistor in series with the functional generator supply using oscilloscope.

Since the oscilloscope is of storage type, the reading of the potential level can easily be done as there are scales in horizontal and vertical scale. The smaller response can also read just by amplifying the response on the oscilloscope. Before the measuring the potentials on the oscilloscope, the ground level potential must be checked.

CHAPTER-V

EXPERIMENTAL PROCEDURES AND RESULTS

5.1. EXPERIMENTAL PROCEDURE FOR THE APPLICATIONS OF FIELD DATA:

From the available data of rainfalls and tubewell withdrawls both in tubewell command and canal command in Varuna basin, the net recharges and withdrawls were calculated and thereby converted into the amount of currents in milliampheres. The computed monthly net recharges and withdrawls in current units are drawn on graph in current (milli-amphere) versus time in second as shown in input data graph for each nodes.

Working procedures are as follows :-

1) In the experimental set up, the circuit elements, analog model, excitation response apparatus are properly grounded.

2) The initial voltage level with reference to spring level of observation wells in the month of June is supplied to the different nodes from the direct current stabilized Power supply source so as to maintain the spring level throughout the polygonal nodal points under consideration as far as possible. The voltage level in the model is checked by oscilloscope by comparing with ground potential level.

3) A known value of resistor R_i in series from the functional generator to the input node is connected. The operational switch for A.C. supply is switched off and subsequently it is switched on, to charge the model. The voltage drop across the resistor Ri is measured.

Thus the amount of current flowing into the input node is known. During switches, the D.C. supply is disconnected to get superimposition. The measurement is also done on oscilloscope so that the graph shape can be compared with the graph for current in milliamphere versus time in second for the hydrologic year under consideration.

4) The single sweep switch is operated to record the response of input node by supplying the current for the limited time from the pulse generator. The wave shape of the voltages both positive and negative values gives the response (of water level fluctuation).

5) For each shot at the input nodes, the response in voltage level in all surrounding nodes have been measured as per previous methods.

6) The different input nodal polygons are then considered for recording the responses by supplying individual wave shaped current proportional to the net monthly recharges (+ ve) and for the withdrawl (-ve).

7) The computed net recharges and withdrawls are fed to the analog model for the study of response by using both 30 percent and 35 percent of total rainfall recharge data.

8) The recorded responses of the model at different nodes are compared with the water levelobserved data of elevations of the basin are then compared.

From this study, the necessary monthly water level fluctuation maps can be prepared for the basin in detail with respect to space variations.

For the second set up, the input data in the shape of current wave is supplied at twenty five nodes simultaneously for complex pumping and recharger study.During switching the D.C. supply is being disconnected. Then the response of to get better superimposition. The aquifer model is recorded at different surrounding nodes. In this set up, the scale factor was considered K_2 = 2 metres/volt. Thus the steady initial voltage level will be the half of the actual level. This facilitates a better of the initial voltage level in the model and of A.C. supply from the functional generator. In this study the Sin nodes at a time were fed from the functional generator assembly in the form of current wave through relay sum switching bound. Then the superimposed response at the different nodes are studied.

5.2. POTENTIALS

The spring levels in the different observation wells , at the nodal points have been shown in Table-21. and also indicated in the Table. The monthly change in water levels for the year 1972-73, from which the initial potential level in the beginning of the hydrologic year(June) is adopted. The potentials in the model is measured generally on the oscilloscope. The response of the model is recorded in voltage change with respect to time.

5.3. INPUTS

The input data has been computed from the given monthly rainfall data and cropwise tubewell withdrawl data of the Varuna Basin. The net of recharge and withdrawls, in a year is the input and represented as current versus time graph as shown in Fig.5.4.1. During the input calculation, the recharge from rainfall is taken as (a) 30. Percent (b) 35 percent of total rainfall. The net withdrawl has been computedalso and considered as negative part.

5.3.1. The table-4 shows the rainfall recharge computation considering both 30 percent and 35 percent. Then from the monthly rainfall recharges the withdrawl from tubewell has been substracted to get net recharge(+ve) and net withdrawl (-ve). The table 17 and 20 show the input data to different nodes considering 30 and 35 percent rainfall recharges respectively.

5.4. RESULTS

The results in the form of graphs Fig.5.4.1. at each node have been shown foom which voltage versus time i.e. water level fluctuation in metre per month with the variation of space can be calculated as in Table(22).

5.5. COMPARISON

The response of the aquifer at the node itself i.e. input node at which current is fed representing net recharges and withdrawls for the whole year, the voltage level change shows, with the change of time that the increase of water level is limited for thetime during the recharge takes place but the level is going slightly down during withdrawls.

In the case of the voltage level change with time for 35 percent rainfall recharge is slightly more than the level change in the case of 30 percent rainfall recharge. The variation of voltage level change is found from the response of the aquifer that the change of potential level is less from the original level (both rise and fall of water table) when the response of the model is measured at the surrounding nodea away from the input node as in Fig.5.4.1.

In comparison with the field observed spring level for the year 1972-73, the water level change is very closed with the voltage-time. change values as found in the case of 30 percent recharge from rainfall considered.

5.6. DISCUSSION

In the first setup, K_2 = 1 metre/volt there is a discharge in the network since then an higher voltage level than the level in input supply source. But in the case of lower potential level, the response is quite satisfactory. In this case the input is fed at individual node and the response is measured on oscilloscope, but these responses may be affected when the input current is fed at the nearest two nodes at same time. So to avoid the self discharge in the network, K_2 = 2 metre/volt has been considered for the 2nd set up and the voltage level (D.C.) became lower about half as well as current input also. The input voltage level in the functional generator has been raised to match the voltage level in the model network by amplifying the voltage level with the addition of integral circuit. In the second set up the complex recharge and withdrauls have been considered so the input is fed at time to the six nodes and all nodes (observation) fed simultaneously and switching is done to get superimposed effect of A.C. on D.C. level, so that complex effect on the potential level were studied. The responses show that the change is gradually loss with the space away from the input nodes.

CHAPTER-VI

CONCLUSIONS

In this work an electric analog model is used for simulating two dimensional subsurface flow of water. The pumping pattern and the recharge over a year is fed into the model in the form of a wave plot of current versus time. The response from the model is available in the form of a graphical relationship between voltage and time which is reinterpreted for the water level fluctuations in the aquifer.

For the year 1972-73, the recharge from rainfall was considered at 30 and 35 percent. For these recharges the responses from the model simulated for the Varuna Basin were compared with the digital computer results using the water balance technique and the two are found to be in close aggrements (8). The recharge from rainfall by Analog model is found to be 30% from the comparison of field observation data.

The study reveals that :

1) The accuracy and reliability of analog model is a matter of quality of the resistor and capacitors. The effects of finite difference approximation and the signal noise ratio. For a more comprehensive study of the aquifer of Varuna Basin, the grid size should be smaller.

2) The accuracy of the response depend upon the value of transmissibility and storage coefficient of aquifer. In this study the value of storage and transmissibility are assumed to be uniform for the simplification of the model construction. The values obtained from the short period pump test data given ~~an~~ approximate idea, of S and T data of a long durational pump are model. It is suggested that the value of S and T should be computed from long durational pump test data and the values of S and T at least for the district should be considered for

future study so that better accuracy will be possible.

3) The steady voltage level representing initial water level at observation wells points should be maintained by supplying D.C. stabilized power supply ~~power~~ source.

4) During A.C. supply for feeding input data, it is found that the voltage level in the functional generator as well as in the nodel points of the model should be same otherwise the self discharge from the model will be expected.

5) During the switching of the ~~switching~~ board, the D.C. supply is switc hing disconnected so that the superimposition of A.C. input has been attained properly.

6) In this model, 25 nodes havebeen fed simultaneously from the 4 sets of functional generator assembly. It is proposed that individual set of functional generator assembly is preferred to control individual wave shaped, amplitutudes and simultaneous switchin-gwork.

7) The response due to single shot is recorded at the surrounding nodal points of each input node. The study is conducted for one year only.The model can be used for different input data for different years.

8) It is suggested that continuous operation of the input should be conducted for the study of response of aquifer after continuous recharge and withdrauls for some years. Proper arrangement of recording devices will be necessary to study such response of the model.

9) The advantage of the model is that it can be used for other basin just by replacing proper resistors and capacitors.

10) The model construction based on finite difference approximation is a self approximate method which can be improved in the model by considering the all boundary conditions like curved boundary of the aquifer of closer grid size etc.

11) Curved boundary of the aquiferhas been considered by assining approximate square grids in stepwise which gives approximate value. Inflow from other adjascent aquifer hasnot been considered in this model during boundary approximation.

12) Recharge from stream bed of the river Varuna and River Ganges has not been considered. These are to be considered for further study to get better approximation considering stream stage relationship.

13) From the aquifer response graph obtained from the model indicates that the water level declining from October to May as rainfall recharge was not sufficient to meet. It is proposed that the quantity of recharge by other means other than rainfall is to be studied by feeding more positive current in the model.

However, further works are necessary on this electric analog model considering data for longer periods. Detail study is necessary using smaller grids on the model. Also simulation study should be conducted to evaluate performance of this approach.

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PUMP TEST DATA

Tube Well No.81 Raghupur Discharge = 45,000 gph

Spring Level = 29' - $5\frac{1}{2}$"

Distance of observation well= 150 ft.

TABLE - A

Time in minute since pumping started	Time in days since pumping started x 10^{-3}	r^2/t ft^2/m x 10^2	Water level in ft.		Drawdown in inches	Drawdown in ft.
1	2	3	4		5	6
			ft.	inch		
1	0.695	225	29	9.5	4	0.333
2	1.39	112.5	30	1	7.5	0.625
3	2.085	75.0	30	4	10.5	0.875
4	2.78	56.25	30	5.5	12	1.0
5	3.475	45.0	30	6.75	13.25	1.104
6	4.16	37.5	30	8	14.5	1.2104
7	4.865	32.14	30	9	15.5	1.291
8	5.360	28.12	30	9.75	16.25	1.355
9	6.255	25.0	30	10.25	16.75	1.396
10	6.950	22.5	30	11	17.50	1.458
12	8.340	18.76	31	0	18.50	1.542
14	9.37	16.08	31	1.25	19.75	1.646
16	11.11	14.07	31	2	20.50	1.709
18	12.51	12.5	31	2.5	21.0	1.25
20	13.9	11.25	31.	3.25	21.75	1.812
25	17.375	9.0	31	4.25	22.75	1.895
30	20.85	7.5	31	5.25	23.75	2.092
35	24.325	6.43	31	6	24.50	2.082

1	2	3	4	5	6
40	27.80	5.62	31 6.5	25.0	2.142
50	34.75	4.5	31 7	25.50	2.208
60	41.7	3.74	31 8	26.50	2.25
70	48.65	3.21	31 8.5	27.0	2.29
80	55.6	2.81	31 9	27.50	2.335
100	69.5	2.25	31 9.5	28.00	2.42
120	83.4	1.87	31 10.5	29.0	2.92
140	97.3	1.60	31 10.5	29.0	2.52
180	125.1	1.25	31 11.75	30.35	2.54
220	152.9	1.02	32 0	30.50	2.56
260	180.7	0.865	32 0.25	30.75	2.56
320	222.4	0.705	32 0.75	30.75	2.56
425	295.375	0.528	32 0.25	30.75	2.56

WELL NO.81 RAGHUPUR

By Thies Recovery Method

Spring Level = 29' - 5.5"

TABLE B

Time in (t) min. since Pumping started	(t')time in minute since pumping started	t/t'	Water level in ft.	inch	Residual Drawdown in inches	Residual drawdown in feet
426	1	426.0	31	9	27.5	2.29
427	2	213.5	31	6	24.5	2.04
428	3	142.66	31	3	21.5	1.79
429	4	107.25	30	4	16.5	1.375
431	6	71.83	30	8	14.5	1.208
432	7	61.74	30	7	13.5	1.125
433	8	54.12	30	6	12.5	1.041
435	10	43.5	30	5	11.5	0.958
437	12	36.41	30	4.5	11.0	0.917
441	16	27.56	30	3.5	10.0	0.833
445	20	22.25	30	2	8.5	0.708
455	30	15.16	30	0	6.5	0.541
465	40	11.62	28	11	5.5	0.458
475	50	9.5	29	10	4.5	0.375
485	60	8.08	29	9.5	4.0	0.333
505	80	6.31	29	8	2.5	0.208
525	100	5.25	29	7.5	2.0	0.166
555	130	4.27	29	6.75	1.25	0.104
585	160	3.65	29	6.5	1.0	0.083
645	220	2.93	29	6.75	0.75	0.062
685	260	2.63	29	6.0	0.50	0.041

PUMP TEST NO.2

Tube Well No.25 (Banwaripur-Varanasi) SPRING LEVEL BELOW G.L. = 12.22 Metre

Discharge = 45,000 gph

Distance between observation well & Pumped well = 147 ft.

TABLE C

Time in minute since pumping started	Time in days $\times 10^{-3}$	Water level in Metres(M)	Drawdown in Metres	Drawdown in feet
1.0	0.695	12.23	0.01	0.03281
2.5	1.739	12.24	0.02	0.06562
8.0	5.56	12.245	0.025	0.0821
21.0	14.60	12.255	0.035	0.115
32	22.24	12.270	0.05	0.1641
40	27.8	12.285	0.065	0.2138
50	34.78	12.295	0.075	0.2464
60	41.7	12.31	0.09	0.2958
80	55.60	12.345	0.135	0.41
100	69.55	12.385	0.165	0.541
120	83.4	12.425	0.205	0.674
150	104.20	12.475	0.255	0.837
180	125.0	12.53	0.31	1.018
210	146.0	12.58	0.36	1.182
245	170.0	12.610	0.39	1.201
300	208.4	12.675	0.455	1.495
320	222.0	12.69	0.47	1.544
346	240.2	12.71	0.49	1.61

RECUPATION TEST DATA

Tubewell No.25 Spring Level = 12.22 m

r = 147 ft (Distance of observation well)

TABLE D

Time in minute since pumping started(t)	Time in minutes since pumping started t'	t/t'	Water level in metres	Residual draw-down in metres
347	1	347.00	12.71	0.49
371	25	14.85	12.70	0.48
375	29	12.92	12.69	0.47
377	31	12.17	12.68	0.46
380	34	11.18	12.67	0.45
387	41	9.44	12.65	0.43
390	44	8.87	12.64	0.42
395	49	8.06	12.62	0.393
398	52	7.65	12.613	0.383
402	56	7.17	12.59	0.37
407	61	6.67	12.54	0.32
416	70	5.95	12.51	0.29
440	94	4.68	12.49	0.27
455	109	4.17	12.47	0.25
480	134	3.91	12.45	0.23
505	159	3.18	12.425	0.205
580	234	2.41	12.355	0.135
640	294	2.18	12.32	0.10

TABLE - 1

PLANIMETER READING WITH RESPECT TO RAINGAUGE STATION POLYGON OF VARUNA BASIN

Sl.No.	Name of Station	Planimeter Area	Proportions of Area	Actual Area	Nodal Area in 10^7 m^2
1	2	3	4	5	6
1	H	0.6	0.1200	31×10^7	
2	P	0.9	0.1800	45.0×10^7	
3	MS	1.04	0.2070	54.0×10^7	
4	MM	1.08	0.2160	55.8×10^7	
5	G	1.07	0.2145	55.5×10^7	
6.	M	0.307	0.0625	16.95×10^7	
	GRAND TOTAL			(258.25×10^7)	
7.	1(P)	0.410	0.0705	18.2×10^7	
8.	2(P)	0.340	0.0582	15×10^7	16.5
9.	2(MS)	0.035	0.006	1.55×10^7	
10.	3(MS)	0.140	0.024	6.2×10^7	6.38
11.	3(P)	0.041	0.0070	0.18×10^7	
12.	4(H)	0.081	0.0139	3.6×10^7	
13.	4(P)	0.025	0.0041	0.106×10^7	3.7
14.	5(H)	0.22	0.0377	9.75×10^7	
15.	5(MS)	0.073	0.0125	3.34×10^7	13.4
16.	5(P)	0.010	0.0017	0.44×10^7	
17.	6(MS)	0.29	0.0477	12.8×10^7	16.1
18.	6(P)	0.075	0.0128	3.3×10^7	
19.	7(MS)	0.36	0.0616	15.8×10^7	12.85
20.	8(MS)	0.14	0.024	6.2×10^7	

Table 1 contd...

1	2	3	4	5	6
21.	8(MM)	0.015	0.0257	6.65×10^7	4.47
22.	9(MM)	0.014	0.0024	0.62×10^7	
23.	9(M)	0.056	0.0097	0.25×10^7	4.47
24.	9(H)	0.081	0.0134	3.6×10^7	
25.	10(H)	0.24	0.041	8.8×10^7	8.9
26.	10(MM)	0.02	0.0034	0.106×10^7	
27.	11(H)	0.05	0.0085	0.22×10^7	17.92
28.	11(MS)	0.404	0.0685	17.7×10^7	
29.	12(MM)	0.30	0.0514	13.3×10^7	13.76
30.	12(MS)	0.011	0.0018	0.465×10^7	
31.	13(MM)	0.36	0.061	15.8×10^7	
32.	14(M)	0.12	0.0205	5.3×10^7	5.92
33.	14(MM)	0.014	0.0024	0.62×10^7	
34.	15(M)	0.109	0.0187	4.83×10^7	
35.	16(M)	0.014	0.0024	0.62×10^7	
36	16(G)	0.031	0.0053	0.137×10^7	7.45
37.	16(MM)	0.Ø151	0.026	6.7×10^7	
38.	17(MM)	0.36	0.061	15.8×10^7	
39.	18(MM)	0.09	0.0154	3.98×10^7	9.28
40.	18(G)	0.12	0.0205	5.3×10^7	
41.	19(G)	0.156	0.0266	6.9×10^7	
42.	20(G)	0.082	0.0145	3.76×10^7	3.91
43.	20(M)	0.034	0.0058	0.15×10^7	
44.	21(G)	0.146	0.025	6.46×10^7	
45.	22(G)	0.28	0.048	12.4×10^7	
46.	23(G)	0.031	0.053	13.7×10^7	
47.	24(G)	0.21	0.035	9.05×10^7	
48.	25(G)	0.103	0.0176	4.55×10^7	

TABLE - 2

PLANIMETER READING OF NODAL POLYGONS(DISTRICT WISE)

S.No.	Name of Station	Planimeter Reading	Proportions of Area	Actual area m2	Nodal Area
1	2	3	4	5	6
1	5 ALLAH	0.213	0.2610	11.60	13.4
2	5 VARA	0.099	0.0380	2.80	
3.	10 ALLA	0.037	0.0454	2.01	8.9
4.	10 VARA	0.17	0.0655	0.99	
5.	11 VARA	0.15	0.0578	5.90	17.92
6.	11 JAUN	0.11	0.0418	12.02	
7.	13 JAUN	0.240	0.0912	11.2	15.7
8.	13 VARA	0.11	0.0425	4.6	
9.	16 VARA	0.12	0.0464	4.67	7.45
10.	16 JAUN	0.056	0.213	2.88	
11.	18 VARA	0.11	0.0635	6.40	8.48
12.	18 JAUN	0.045	0.0168	1.88	
13.	6 ALLAH	0.05	0.0612	3.3	16.1
14.	6 JAUN	0.3	0.114	12.8	
15.	3 JAUN	0.181	0.0686	0.380	6.38
16.	7 JAUN	0.36	0.137	15.8	15.8
17.	8 JAUN	0.155	0.056	12.85	12.85
18.	2 JAUN	0.375	0.1426	16.9	16.9
19.	1 ALLAH	0.41	0.502	18.2	18.2
20.	4 ALLAH	0.106	0.138	3.7	3.7
21.	12 JAUN	0.311	0.118	13.76	13.76
22.	14 VARA	0.134	0.0517	5.92	5.92

Table 2 Contd..

1	2	3	4	5	6
23.	15 VARA	0.109	0.042	4.83	4.83
24.	9 VARA	0.07	0.027	4.47	4.47
25.	17 VARA	0.36	0.139	15.80	15.80
26.	19 VARA	0.156	0.0602	6.9	6.9
27.	20 VARA	0.034	0.0131	3.91	3.91
28.	21 VARA	0.146	0.0562	6.46	6.46
29.	22 VARA	0.28	0.108	12.40	12.40
30.	23 VARA	0.031	0.01198	13.7	13.7
31.	24 VARA	0.21	0.081	9.05	9.05
32.	25 VARA	0.103	0.0393	4.55	4.55

TABLE - 3

MONTHLY RAINFALL DISTRIBUTION OF THE BASIN

IN METRES

S.No.	Raingaage Station	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
1.	Phool Pur (P)	-	0.1364	0.1837	0.1137	0.0059	0.0137	-	0.0046	-	-	-	-
2.	Machali Sahar(MS)	0.002	0.1374	0.1661	0.271	0.0032	0.048	-	0.0182	0.0364	-	-	-
3.	Mariahun (MM)	-	0.1577	0.2412	0.2048	0.0132	-	-	0.007	-	-	-	-
4.	Mirzapur (M)	0.0109	0.27	0.244	0.1186	0.0556	0.0711	-	0.005	0.0258	-	-	-
5.	Gangpur (G)	-	0.1688	0.372	0.0841	0.0054	0.068	-	-	-	-	-	-
6.	Handia (H)	0.004	0.217	0.2883	0.073	0.0165	0.0584	-	0.009	-	-	-	-

TABLE - 4

MONTHLY WEIGHTED NODAL DISTRIBUTION OF RAINFALL IN METRES

Nodal Sl.No.	Nodal Points	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
1	0 - 9A	-	0.1364	0.1837	0.1137	0.0069	0.0137	-	0.0046	-	-	-	-
	30%	-	0.041	0.055	0.0341	0.00177	0.0041	-	0.00138	-	-	-	-
	25%	-	0.0342	0.046	0.0284	0.001475	0.00342	-	0.00115	-	-	-	-
	35%	-	0.0479	0.0644	0.0398	0.00207	0.0048	-	0.00161	-	-	-	-
2	0 - 7	-	0.1363	0.181	0.1294	0.0059	0.017	-	0.0059	0.0035	-	-	-
	30%	-	0.041	0.0543	0.0388	0.00177	0.0051	-	0.00177	0.00105	-	-	-
	25%	-	0.0341	0.0452	0.0324	0.00147	0.00425	-	0.00147	0.000875	-	-	-
	35%	-	0.0478	0.0634	0.0452	0.00207	0.00525	-	0.00207	0.001225	-	-	-
3	0 - 5	-	0.137	0.166	0.271	0.0032	0.048	-	0.0182	0.0364	-	-	-
	30%	-	0.041	0.0497	0.0812	0.00076	0.0014	-	0.00945	0.0109	-	-	-
	25%	-	0.0342	0.0415	0.0677	0.0008	0.0012	-	0.00455	0.0091	-	-	-
	35%	-	0.048	0.058	0.095	0.00112	0.00168	-	0.00636	0.01275	-	-	-
4	OP - 7	0.004	0.217	0.288	0.073	0.0165	0.0584	-	0.009	-	-	-	-
	30%	0.0012	0.065	0.0865	0.0219	0.00495	0.0175	-	0.0027	-	-	-	-
	25%	0.001	0.0542	0.072	0.0182	0.00412	0.0146	-	0.00225	-	-	-	-
	35%	0.0014	0.076	0.102	0.0256	0.00578	0.0204	-	0.00315	-	-	-	-

5	OP - 6	0.0033	0.194	0.255	0.122	0.0124	0.057	-	0.0119	0.009	-	-	-
	30%	0.00099	0.0592	0.0765	0.0366	0.0037	0.0171	-	0.00357	0.0027	-	-	-
	25%	0.000825	0.0485	0.0638	0.0305	0.0031	0.01425	-	0.00298	0.00225	-	-	-
	35%	0.001155	0.0679	0.0894	0.0427	0.00434	0.020	-	0.00417	0.00315	-	-	-
6	OP - 5	-	0.137	0.17	0.238	0.003	0.04	-	0.026	0.028	-	-	-
	30%	-	0.041	0.051	0.0715	0.0009	0.012	-	0.0078	0.0084	-	-	-
	25%	-	0.0342	0.0425	0.0595	0.00075	0.010	-	0.0065	0.007	-	-	-
	35%	-	0.048	0.0595	0.0832	0.00105	0.014	-	0.0091	0.0098	-	-	-*
7.	OP - 3	0.002	0.137	0.166	0.271	0.003	0.048	-	0.0182	0.036	-	-	-
	30%	-	0.041	0.0477	0.0512	0.00096	0.014	-	0.00545	0.0104	-	-	-
	25%	-	0.0342	0.0415	0.0677	0.0008	0.0012	-	0.00455	0.0091	-	-	-
	35%	-	0.048	0.058	0.095	0.00112	0.00168	-	0.00636	0.0127	-	-	-*
8	OP - 2A	-	0.147	0.204	0.239	0.0084	0.0232	-	0.0126	0.0189	-	-	-
	30%	-	0.044	0.0612	0.0717	0.0025	0.0725	-	0.00378	0.00556	-	-	-
	25%	-	0.0368	0.051	0.0597	0.0021	0.0605	-	0.00318	0.00472	-	-	-
	35%	-	0.0515	0.0715	0.0836	0.00294	0.0846	-	0.0044	0.0066	-	-	-

*Canal Seepage to be added to node 3, 7 & 8

Jun	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
0.0115	0.0119	0.0119	0.00995	0.0111	0.00822	0.0085	0.00852	0.00772	0.0107	0.0082	0.0085

9	VA - 2	0.005	0.22	0.288	0.148	0.023	0.0316	-	0.007	0.005	-	-	-
	30%	0.0015	0.066	0.0865	0.0443	0.0069	0.0095	-	0.0021	0.0015	-	-	-
	25%	0.00125	0.055	0.072	0.037	0.00579	0.0079	-	0.00175	0.00125	-	-	-
	35%	0.00175	0.077	0.101	0.0519	0.00806	0.01105	-	0.00245	0.00175	-	-	-
10	VA - 4	0.004	0.217	0.288	0.073	0.016	0.058	-	0.009	-	-	-	-
	30%	0.0012	0.065	0.0865	0.0219	0.0048	0.0174	-	0.0027	-	-	-	-
	25%	0.001	0.054	0.072	0.0182	0.004	0.0145	-	0.0022	-	-	-	-
	35%	0.0017	0.076	0.101	0.0255	0.0056	0.0863	-	0.0031	-	-	-	-
11	VA - 5	0.002	0.137	0.166	0.271	0.003	0.048	-	0.018	0.036	-	-	-
	30%	-	0.041	0.0497	0.0812	0.0009	0.0014	-	0.0054	0.0109	-	-	-
	25%	-	0.034	0.0415	0.0677	0.0008	0.0012	-	0.0045	0.0091	-	-	-
	35%	-	-0.048	0.058	0.095	0.00112	0.00168	-	0.00636	0.012	-	-	-
12	P - 3	-	0.157	0.241	0.2048	0.013	-	-	0.007	-	-	-	-
	30%	-	0.0472	0.0722	0.0615	0.0039	-	-	0.0021	-	-	-	-
	25%	-	0.0392	0.0602	0.0512	0.00325	-	-	0.00175	-	-	-	-
	35%	0.055	0.0845	0.0718	0.00455	0.00455	-	-	0.0024	-	-	-	-
13	P - 6A	-	0.157	0.241	0.2048	0.013	-	-	0.007	-	-	-	-
	30%	0.0472	0.0472	0.0722	0.0615	0.0039	-	-	0.0021	-	-	-	-
	25%	-	0.0392	0.0602	0.0512	0.00325	-	-	0.00175	-	-	-	-
	35%	-	0.055	0.0845	0.0718	0.00455	-	-	0.0024	-	-	-	-

Table 4 Contd...

14	P – 7	0.0109	0.27	0.244	0.118	0.055	0.0711	–	0.005	0.0238	–	–	–
	30%	0.0032	0.081	0.0732	0.0354	0.0165	0.0213	–	0.0015	0.00715	–	–	–
	25%	0.0027	0.0675	0.061	0.0295	0.0137	0.0177	–	0.00125	0.00595	–	–	–
	35%	0.0038	0.0945	0.0855	0.0412	0.0193	0.0245	–	0.00175	0.00832	–	–	–
15	VB – 3	0.0109	0.27	0.244	0.1185	0.0556	0.0071	–	0.005	0.0238	–	–	–
	30%	0.0032	0.081	0.0732	0.0354	0.0165	0.0513	–	0.0015	0.00715	–	–	–
	25%	0.0027	0.067	0.064	0.0295	0.0137	0.0122	–	0.00125	0.00595	–	–	–
	35%	0.0038	0.0945	0.0855	0.0412	0.0193	0.0245	–	0.00175	0.00832	–	–	–
16	V B – 5	–	0.158	0.245	0.204	0.09	0.01	–	0.006	–	–	–	–
	30%	–	0.0473	0.0735	0.0512	0.027	0.003	–	0.0018	–	–	–	–
	25%	–	0.0395	0.0612	0.0512	0.0225	0.0025	+	0.0015	–	–	–	–
	35%	–	0.0552	0.0858	0.0715	0.0315	0.0035	–	0.00210	–	–	–	–
17	VC – 10	–	[illegible]	0.241	0.2048	0.0132	–	–	0.007	–	–	–	–
	30%	–	0.0472	0.0722	0.0615	0.0039	–	–	0.0021	–	–	–	–
	25%	–	0.0392	0.0602	0.0512	0.00325	–	–	0.00175	–	–	–	–
	35%	–	0.055	0.0845	0.0718	0.00455	–	–	0.00245	–	–	–	–

Table 4 Contd...

18	VC - 8	-	0.164	0.33	0.12	0.06	0.04	-	0.002	-	-	-	-
	30%	-	0.0492	0.099	0.036	0.018	0.012	-	-	-	-	-	-
	25%	-	0.041	0.0825	0.030	0.015	0.01	-	-	-	-	-	-
	35%	-	0.0573	0.115	0.039	0.021	0.014	-	-	-	-	-	-
19	VC - 6	-	0.168	0.372	0.084	0.0054	0.068	-	-	-	-	-	-
	30%	-	0.0505	0.1115	0.0252	0.0016	0.0204	-	-	-	-	-	-
	25%	-	0.042	0.093	0.021	0.00135	0.017	-	-	-	-	-	-
	35%	-	0.059	0.13	0.0294	0.0189	0.0239	-	-	-	-	-	-
~~20~~	~~VC - 4~~	~~0.21~~	~~0.33~~	~~0.12~~	~~0.06~~	~~0.069~~							
20	VC - 4	-	0.21	0.33	0.12	0.06	0.069	-	-	-	-	-	-
	30%	-	0.063	0.099	0.036	0.018	0.0206	-	-	-	-	-	-
	25%	-	0.0525	0.0825	0.03	0.015	0.0172	-	-	-	-	-	-
	35%	-	0.0735	0.115	0.039	0.0215	0.0241	-	-	-	-	-	-
21	VD - 5	-	0.168	0.372	0.0841	0.0054	0.068	-	-	-	-	-	-
	30%	-	0.0505	0.1115	0.0252	0.0016	0.0204	-	-	-	-	-	-
	25%	-	0.042	0.093	0.021	0.00135	0.017	-	-	-	-	-	-
	35%	-	0.059	0.13	0.0294	0.00189	0.0239	-	-	-	-	-	-

Table 4 Contd...

22	VD - 7	-	0.1688	0.372	0.0841	0.0054	0.068	-	-	-	-	-
	30%	0.05[illegible]	0.0505	0.1115	0.0252	0.0016	0.0204	-	-	-	-	-
	25%	0.042	0.042	0.093	0.021	0.00135	0.017	-	-	-	-	-
	35%	-	0.059	0.13	0.0294	0.00189	0.068	-	-	-	-	-
23	VD - 9	-	0.168	0.372	0.0841	0.0054	0.068	-	-	-	-	-
	30%	-	0.0505	0.1115	0.0252	0.0016	0.0204	-	-	-	-	-
	25%	-	0.042	0.093	0.021	0.00135	0.017	-	-	-	-	-
	35%	-	0.059	0.13	0.0294	0.00169	0.0239	-	-	-	-	-
24	PQ - 3	-	0.168	0.372	0.0841	0.0054	0.068	-	-	-	-	-
	30%	-	0.0505	0.1115	0.0252	0.0016	0.0204	-	-	-	-	-
	25%	-	0.042	0.093	0.021	0.00135	0.017	-	-	-	-	-
	35%	-	0.059	0.13	0.0294	0.00189	0.0239	-	-	-	-	-
25	PQ - 4	-	0.168	0.372	0.084	0.0054	0.068	-	-	-	-	-
	30%	-	0.0505	0.1115	0.0252	0.0016	0.0204	-	-	-	-	-
	25%	-	0.042	0.093	0.021	0.00135	0.017	-	-	-	-	-
	35%	-	0.059	0.13	0.0294	0.00189	0.0239	-	-	-	-	-

TABLE - 5

CROPS DISTRIBUTION DATA OVER THE BASIN (DISTRICT-WISE)

Sl. No.	Name of Station	Geog. area	IRRIGATED AREA UNDER DIFFIERENT CROPS								
			Paddy	Sugar Cane	Wheat	Barley	Gram	Potato	Pea	Total	Proportion
1.	Allahabad	44.45	1.003	0.3580	3.645	3.28	0.53	0.445	0.44	9.7083	0.1127
2.	Jaunpur	112.0	2.515	3.794	14.15	19.84	0.6144	2.350	1.885	45.1484	0.5240
3.	Varanasi	101.8	9.85	2.84	8.85	7.44	1.068	0.162	1.068	31.2780	0.3633
	TOTAL	258.25	13.368	7.002	26.645	30.56	2.2124	2.957	3.393	86.1347	

TABLE - 6

NODAL DISTRIBUTION OF CROPS DATA

S.No.	Name of Station	Geog. Area in 10^7 m^2		Node No.	Paddy	S.Cane	Wheat	Barley	Gram	Potato	Pea
1	2	3	4	5	6	7	8	9	10	11	12
1.	JAUN 3	6.38	CANAL COMMAND	3	0.173	0.26	0.97	1.365	0.0423	0.162	0.1299
2.	JAUN 7	15.8	CANAL COMMAND	7	0.344	0.52	1.94	2.72	0.084	0.322	0.2580
3.	JAUN 8	12.85	CANAL COMMAND	8	0.11	0.163	0.609	0.855	0.0264	0.101	0.081
4.	2	16.5	TUBE COMMAND	2	0.358	0.54	2.02	2.83	0.0875	0.3360	0.268
5.	1	18.2	TUBE COMMAND	1	0.502	0.179	1.83	1.64	0.266	0.222	0.220
6.	4	3.7	T.C.	4	0.1385	0.048	1.93	2.73	0.0845	0.324	0.260
7.	5	13.4	T.C.	5	0.358	0.2382	1.49	1.61	1.61	0.197	0.186
8.	6	16.1	T.C.	6	0.35	0.49	1.82	2.45	0.102	0.293	0.241
9.	12	13.76	T.C.	12	0.299	0.448	1.67	2.345	0.0725	0.278	0.222
10.	17	15.8	T.C.	17	1.365	0.394	1.23	1.032	0.148	0.0224	0.148
11.	10	8.9	T.C.	10	0.69	0.35	0.75	0.656	0.093	0.0307	0.0697
12.	11	17.92	T.C.	11	0.67	0.31	1.09	1.24	0.086	0.105	0.138
13.	13	15.8	T.C.	13	0.644	0.464	1.56	2.12	0.101	0.22	0.236
14.	14	5.92	T.C.	14	0.5	0.144	0.45	0.379	0.054	0.0082	0.054

Table 6 Contd...

1	2	3	4	5	6	7	8	9	10	11	12
15	15	4.83	T.C.	15	0.412	0.119	0.272	0.312	0.044	0.00677	0.044
16	16	7.45	T.C.	16	0.995	0.967	3.34	4.40	0.273	0.041	0.273
17	18	9.28	T.C.	18	0.665	0.236	0.77	0.804	0.077	0.04	0.098
18	/19	4.47	T.C.	9	0.265	0.0765	0.238	0.20	0.0287	0.00435	0.0287
19.	19	6.9	T.C.	19	0.592	0.121	0.532	0.459	0.0644	0.00975	0.0644
20.	20	3.91	T.C.	20	0.129	0.0372	0.116	0.09775	0.014	0.00212	0.014
21.	21	6.46	T.C.	21	0.552	0.159	0.498	0.417	0.06	0.009	0.06
22.	22	12.4	T.C.	22	1.065	0.306	0.495	0.805	0.115	0.0175	0.115
23.	23	13.7	T.C.	23	0.1125	0.0338	0.1055	0.089	0.01225	0.00193	0.01275
24.	24	9.05	T.C.	24	0.795	0.23	0.715	0.602	0.0815	0.013	0.0865
25.	25	4.55	T.C.	25	0.392	0.1125	0.352	0.236	0.0425	0.00645	0.0425

TABLE - 7

WATER REQUIREMENT OF CROPS AT TUBEWELL COMMAND

in 10^7 m^3

Sl. No.	Name of Crop	Area on State T.W.	Area on Pri-Wells	June	July	August	September	October	November	December	Jan.	Feb.	March	April	May
1	Paddy	1.057×10^7	10.979×10^3	1.88	2.58	2.19	2.51	-	-	-	-	-	-	-	-
2	S.Cane	3.22×10^7	2.315×10^3	1.975	0.338	0.079	0.179	0.954	0.605	-	-	-	0.579	0.97	2.54
3	Wheat	7.11×10^7	12.04×10^3	-	-	-	-	-	1.63	0.586	1.28	2.78	2.7	-	-
4	Barley	7.9×10^7	14.0×10^3	-	-	-	-	-	0.169	0.944	1.8	3.358	-	-	-
5.	Gram	0.5×10^7	1.04×10^3	-	-	-	-	-	-	0.168	-	0.253	-	-	-
6.	Potato	0.76×10^7	1.35×10^3	-	-	-	-	-	0.165	0.238	0.163	-	-	-	-
7.	Pea	0.87×10^7	1.547×10^3	-	-	-	-	0.024	0.254	0.285	0.265	0.178	-	-	-
	Total G.I.R. in $\times10^7$ m^3			3.855	2.918	2.369	2.68	0.970	2.823	2.22	3.52	6.569	3.27	0.976	2.54
	Total Release from T.Wells			2.34	2.42	2.42	2.34	2.42	3.193	3.303	3.303	2.98	3.303	3.193	3.303

TABLE - 8

DISTRIBUTION OF TUBEWELLS & OTHER WORKS IN TUBEWELL COMMAND

Sl. No.	Name of Distt.	No.of Pumping sets	No.of Pumping Tube-walls	No.of State Tube-Wells	Area under Tube-wells	Proportion	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
1.	Allahabad	195	372	995	9.0783×10^7	0.1127	.263	.280	.28	.263	.28	.360	.373	.373	.336	.373	.36	.373
2.	Jaunpur	857	815	2506	45.1484×10^7	0.5240	1.25	1.28	1.28	1.25	1.28	1.673	1.741	1.741	1.56	1.741	1.673	1.74
3.	Varanasi	1356	992	1774	31.278×10^7	0.3633	.787	.760	0.76	0.787	0.76	1.160	1.171	1.172	1.08	1.172	1.16	1.17

TABLE - 9

WATER REQUIREMENTS OF CROPS IN CANAL COMMAND (EXISTING)

Month	Fortnight	Wheat	Gram	Barley	Pea	Potatos	Sugar Cane $\times 10^7\ m^3$	Paddy	GIR	Released from canal	Release from Tube Well (Private)
1	2	3	4	5	6	7	8	9	10	11	12
June	I						0.334	-	0.324	0.287	-
	II						0.334	0.292	0.626	0.287	-
July	I						0.066	0.245	0.311	0.287	-
	II						0.66	0.245	0.311	0.306	-
Aug.	I						0.015	0.198	0.213	0.287	-
	II						0.015	0.198	0.213	0.306	-
Sept.	I						0.03	0.198	0.228	0.248	-
	II						0.03	0.198	0.228	0.248	-
Oct.	I						0.149	0.225	0.374	0.248	-
	II		0.006		0.008	0.044	0.149	-	0.207	0.306	-
Nov.	I	0.755	0.016	0.092	0.922	0.045	0.085	-	1.871	0.220	0.57
	II	0.004	0.016	0.061	0.042	0.045	0.093	-	0.261	0.220	0.041
Dec.	I	0.145	0.019	0.32	0.047	0.064	0.051	-	0.646	0.220	-
	II	0.145	0.019	0.32	0.047	0.064	0.024	-	0.619	0.234	-

Table 9 Contd...

1	2	3	4	5	6	7	8	9	10	11	12
Jan.	I	0.299	0.024	0.328	0.046	0.043	-	-	0.74	0.220	0.033
	II	00.299	0.024	0.328	0.046	0.043	-	-	0.74	0.235	0.043
Feb.	I	0.65	0.028	0.582	0.029	0 -	0.30	-	1.319	0.206	0.542
	II	0.65	0.028	0.582	0.029	-	0.30	-	1.319	0.206	0.542
March	I	1.27	0.045	0.89	-	-	0.093	-	2.298	0.337	0.541
	II	0.95	0.045	-	-	-	0.093	-	1.088	0.235	0.541
April	I	-	-	-	-	-	0.152	-	0.152	0.220	-
	II	-	-	-	-	-	0.152	-	0.152	0.220	-
May	I	-	-	-	-	-	0.415	-	0.415	0.220	-
	II	-	-	-	-	-	0.415	-	0.415	0.234	-

TABLE - 10

ESTIMATION OF SEEPAGE LOSSES IN CANAL COMMAND

Loss = $c/8\ (B + D)^{2/3}$ Cusec/m

Sl.No.	Br/Dy./Mr.	Length of Channel	Width B in ft.	Depth of flow		Rabi Running days	Kharif Running days	Seepage in Kharif	Seepagein Raib
1.	Mariahun Br.	47.5 m	25	4	$1/8(29)^{2/3}\times 47.5 = 55$	102	96	$1.310\times10^{7}m^{3}$	$1.390\times10^{7}m^{3}$
2.	Machali Sahar Br.	14	5	1.33	$1/8(6.33)^{2/3}\times 14 = 6.02$	51	51	$.732\times10^{7}m^{3}$	$0.732\times10^{7}m^{3}$

TABLE - 11

DISTRIBUTION OF WITHDRAWALS IN CANAL COMMAND

Nodes	Area of each node in $10^7 m^3$	Under District	June	July	August	September	October	November	December	January	February	March	April	May
3 Proportion	6.38×10^7 (0.182)	Jaunpur	-	-	-	-	-	0.1112	-	0.0138	0.1972	1.97	-	-
7	15.8×10^7	Jaunpur	-	-	-	-	-	0.276	-	0.0343	0.49	0.489	-	-
Proportion (0.451)														
8	12.85×10^7	Jaunpur	-	-	-	-	-	0.2245	-	0.0279	0.398	0.396	-	-
Proportion (0.367)														

TABLE - 12

MONTHLY DISTRIBUTION OF CANAL SEEPAG IN CANAL COMMAND)

Nodes			June	July	August	September	October	November	December	January	Feb.	March	April	May
	Canal Releases		0.574	0.593	0.593	0.496	0.554	0.440	0.454	0.455	0.412	0.572	0.440	0.454
	Canal Seepage			2.042				2.122						
	Proportions	Area	0.197	0.204	0.204	0.171	0.19	0.136	0.14	0.1405	0.1275	0.177	0.136	0.14
3	0.182	6.38×10^7	0.0734	0.076	0.076	0.0635	0.0707	0.0525	0.05415	0.0544	0.0493	0.0684	0.052	0.0541
7	0.451	15.8×10^7	0.1815	0.1885	0.1885	0.1580	0.1755	0.1305	0.1345	0.1350	0.1225	0.1695	0.13	0.1345
8	0.367	12.85×10^7	10.1471	0.1535	0.1535	0.1285	0.1425	0.1060	0.10945	0.1095	0.0995	0.1380	0.106	0.1094

TABLE - 13

WATER AVAILABLE DATA FROM TUBE WELL AND OTHER WOR

S.No.	Name of Crops	Area in 10^7 m^2	June	July	August	September	October	November	D
1.	Paddy	13.363	1.14	2.14	2.34	2.195	-	-	
2.	Sugar Cane	7.002	1.2	0.28	0.08	0.145	2.36	0.685	
3.	Wheat	26.645						1.835	0.[illegible]
4.	Barley	30.56						0.190	1.4
5.	Gram	2.2124						-	0.2
6.	Potato	2.952						0.186	0.[illegible]
7.	Pea	3.393					0.06	0.287	0.[illegible]
	TOTAL		2.34	2.42	2.42	2.34	2.42	3.193	3.[illegible]

TABLE - 12

MONTHLY DISTRIBUTION OF CANAL SEEPAGE (IN CANAL COMMAND)

Nodes			June	July	August	September	October	November	December	January	Feb.	March	April	May
	Canal Releases		0.574	0.593	0.593	0.496	0.554	0.440	0.454	0.455	0.412	0.572	0.440	0.454
	Canal Seepage			2.042				2.122						
	Proportions	Area	0.197	0.204	0.204	0.171	0.19	0.136	0.14	0.1405	0.1275	0.177	0.136	0.14
3	0.182	6.38×10^7	0.0734	0.076	0.076	0.0635	0.0707	0.0525	0.05415	0.0544	0.0493	0.0684	0.052	0.054
7	0.451	15.8×10^7	0.1815	0.1885	0.1885	0.1580	0.1755	0.1305	0.1345	0.1350	0.1225	0.1695	0.13	0.134
8	0.367	22.85×10^7	10.1471	0.1535	0.1535	0.1285	0.1425	0.1060	0.10945	0.1095	0.0995	0.1380	0.106	0.109

TABLE - 13

WATER AVAILABLE DATA FROM TUBE WELL AND OTHER WORKS (CROP-WISE)

S.No.	Name of Crops	Area in 10^7 m^2	June	July	August	September	October	November	Dec.	January	February	March	April	May
1.	Paddy	13.363	1.14	2.14	2.34	2.195	-	-	-	-	-	-	-	-
2.	Sugar Cane	7.002	1.2	0.28	0.08	0.145	2.36	0.685	-	-	-	0.589	3.193	3.303
3.	Wheat	26.645						1.835	0.88	1.193	1.262	2.725	-	-
4.	Barley	30.56						0.190	1.42	1.685	1.525	-	-	-
5.	Gram	2.2124						-	0.252	-	0.115	-	-	-
6.	Potato	2.952						0.186	0.357	0.152	-	-	-	-
7.	Pea	3.393					0.06	0.287	0.426	0.248	0.0805	-	-	-
	TOTAL		2.34	2.42	2.42	2.34	2.42	3.193	3.303	3.303	2.98	3.303	3.193	3.303

TABLE - 14

WATER AVAILABILITY OF CROPS AT EACH NODES (1 to 25)

Sl. No.	Name of Crops	Area	Total Area	June	July	August	September	October	November	December	January	February	March	April	May
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.	PA	0.358	13.363	0.0306	0.0575	0.0627	0.0588	-	-	-	-	-	-	-	-
2.	SC	0.54	7.002	0.0925	0.0216	0.006	0.0112	0.1825	0.053	-	-	-	0.0453	0.246	0.255
3.	WA	2.02	26.645	-	-	-	-	-	0.138	0.0660	0.0996	0.0946	0.2045	-	9-
4.	BA	2.83	30.56	-	-	-	-	-	0.0176	0.1315	0.156	0.1415	-	-	-
5.	GR	0.0875	2.212	-	-	-	-	-	-	0.010	-	0.00455	-	-	-
6.	PO	0.336	2.95	-	-	-	-	-	0.0212	0.0406	0.01730	-	-	-	-
7.	PE	0.268	3.393	-	-	-	-	0.00474	0.0226	0.0336	0.0196	0.00635	-	-	-
			TOTAL	0.1231	0.0791	0.1745	0.060	0.0872	0.2524	0.2817	0.2825	0.2470	0.2428	0.246	0.255

NODE 1

Sl. No.	Name of Crops	Area	Total Area	June	July	August	September	October	November	December	January	February	March	April	May
	PA	0.502	13.363	0.0429	0.0805	0.088	0.8985	-	-	-	-	-	-	-	-
	SC	0.179	7.000	0.03065	0.00716	.002	0.0037	0.0605	0.0175	-	-	-	0.01495	0.0817	0.0845
	WH	1.83	26.645	-	-	-	-	-	0.126	0.0604	0.0817	0.0866	0.187	-	-
	BA	1.64	30.56	-	-	-	-	-	0.01022	0.0762	0.0905	0.082	-	-	-
	GR	0.266	2.212	-	-	-	-	-	-	0.0316	-	0	-	-	-
	PO	0.222	2.95	-	-	-	-	-	0.014	0.02682	0.01145	-	-	-	-

1	2	3	4	5	6	7	8	9						
							NODE 6							
PA	0.35	13.363	0.0298	0.056	0.0613	0.0574	-	-	-	-	-	-	-	-
SC	0.45	7.002	0.0772	0.018	0.00514	0.0093	0.1515	0.044	-	-	-	0.0376	0.205	0.212
WH	1.82	26.645	-	-	-	-	-	0.1255	0.060	0.0815	0.086	0.189	-	-
BA	2.45	30.56	-	-	-	-	-	0.0152	0.1140	0.1355	0.1225	-	-	-
GR	0.102	2.2124	-	-	-	-	-	-	0.00116	-	0.00531	-	-	-
PO	0.293	2.952	-	-	-	-	-	0.0184	0.0364	0.01505	-	-	-	-
PE	0.241	3.393	-	-	-	-	0.00425	.0204	0.0302	0.0176	0.0057	-	-	-
			0.107	0.074	0.664	0.667	0.15570	0.2235	0.2417	0.2496	0.2195	0.226	0.205	0.212
							NODE 12							
PA	0.299	13.363	0.0255	0.048	0.0525	0.0992	-	-	-	-	-	-	-	-
SC	0.448	7.002	0.768	0.0179	0.0051	0.00926	.1510	0.0938	-	-	-	0.0274	0.204	0.211
WH	1.67	26.645	-	-	-	-	-	0.1155	0.0553	0.075	0.0790	0.171	-	-
BA	2.345	30.56	-	-	-	-	-	0.0146	0.1093	0.130	0.1175	-	-	-
GR	0.0725	2.2129	-	-	-	-	-	-	0.00825	-	0.00375	-	-	-
PO	0.278	2.952	-	-	-	-	-	0.0175	0.0347	0.0143	-	-	-	-
PE	0.222	3.393	-	-	-	-	0.00392	0.0188	0.0279	0.01625	0.005275	-	-	-
			0.1023	0.0659	0.0576	0.00926	.1549	0.1664	0.2360	0.2355	0.2054	0.148	0.204	0.211

PE	0.22	3.393	-	-	-	-	0.00389	0.0186	0.02765	0.01610	0.00522	-	-	-
		TOTAL	0.0735	0.0876	0.09045	.0862	0.0643	0.1863	0.2226	0.1997	0.1881	0.2019	0.0817	0.0845

NODE 4

PA	0.1385	13.363	0.0118	0.0222	0.0243	0.0227	-	-	-	-	-	-	-	-
SC	0.048	7.002	0.00825	0.00192	0.00055	0.001	0.01625	.0048	-	-	-	0.00402	0.0219	0.0227
WH	1.94	26.645	-	-	-	-	-	0.1335	0.064	0.0869	0.0915	0.1980	-	-
BA	2.73	30.56	-	-	-	-	-	0.0170	0.127	0.1505	0.1365	-	-	-
GR	0.0845	2.2124	-	-	-	-	-	-	0.00965	-	0.0044	-	-	-
PO	0.324	2.952	-	-	-	-	-	-	0.0276	0.0392	0.0167	-	-	-
PE	0.260	3.393	-	-	-	-	0.0046	0.0220	0.0327	0.0190	0.00616	-	-	-
PA	0.358	13.363	0.0306	0.0573	0.0626	0.0588	-	-	-	-	-	-	-	-
SC	0.2382	7.002	0.0408	0.00952	0.0272	0.00493	0.0804	0.0233	-	-	-	0.0199	0.1085	0.1125
WH	1.49	26.645	-	-	-	-	-	0.103	0.0495	0.059	0.0832	0.153	-	-
BA	1.61	30.56	-	-	-	-	-	0.01	0.075	0.0889	0.0804	-	-	-
GR	1.61	2.2124	-	-	-	-	-	-	0.0183	-	0.00838	-	-	-
PO	0.199	2.952	-	-	-	-	-	0.0124	0.0238	0.01055	-	-	-	-
PE	0.186	3.393	-	-	-	-	0.0032	0.0157	0.02335	0.0138	0.0044	-	-	-
		TOTAL	0.0714	0.0668	0.0898	0.0637	0.083	0.1411	0.1899	0.1718	0.1757	0.1729	0.1085	0.1125

1	2	3	4	5	6	7	8	9						
						NODE 6								
PA	0.35	13.363	0.0298	0.056	0.0613	0.0574	-	-	-	-	-	-	-	-
SC	0.45	7.002	0.0772	0.018	0.00514	0.0093	0.1515	0.044	-	-	-	0.0376	0.205	0.212
WH	1.82	26.645	-	-	-	-	-	0.1255	0.060	0.0815	0.086	0.189	-	-
BA	2.45	30.56	-	-	-	-	-	0.0152	0.1140	0.1355	0.1225	-	-	-
GR	0.102	2.2124	-	-	-	-	-	-	0.00116	-	0.00531	-	-	-
PO	0.293	2.952	-	-	-	-	-	0.0184	0.0364	0.01505	-	-	-	-
PE	0.241	3.393	-	-	-	-	0.00425	.0204	0.0302	0.0176	0.0057	-	-	-
			0.107	0.074	0.664	0.667	0.15570	0.2235	0.2417	0.2496	0.2195	0.226	0.205	0.212
						NODE 12								
PA	0.299	13.363	0.0255	0.048	0.0525	0.0992	-	-	-	-	-	-	-	-
SC	0.448	7.002	0.768	0.0179	0.0051	0.00926	.1510	0.0938	-	-	-	0.0274	0.204	0.211
WH	1.67	26.645	-	-	-	-	-	0.1155	0.0553	0.075	0.0790	0.171	-	-
EN	2.345	30.56	-	-	-	-	-	0.0146	0.1093	0.130	0.1175	-	-	-
GR	0.0725	2.2129	-	-	-	-	-	-	0.00825	-	0.00375	-	-	-
PO	0.278	2.952	-	-	-	-	-	0.0175	0.0347	0.0143	-	-	-	-
PE	0.222	3.393	-	-	-	-	0.00392	0.0188	0.0279	0.01625	0.005275	-	-	-
			0.1023	0.0659	0.0576	0.00926	.1549	0.1664	0.2360	0.2355	0.2054	0.148	0.204	0.211

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
						NODE 9								
PA	0.265	13.363	0.0226	0.0214	0.0465	0.0436	-	-	-	-	-	-	-	-
SC	0.0765	7.002	0.0131	0.0030	.000875	0.00158	.0258	0.0075	-	-	-	0.0064	0.035	0.036
WH	0.238	26.645	-	-	-	-	-	0.1635	0.0875	0.1065	0.1124	0.242	-	-
BA	0.20	30.56	-	-	-	-	-	0.0124	0.0925	0.1105	0.1	-	-	-
GR	0.0287	2.2124	-	-	-	-	-	-	.008284	.0	0.00149	-	-	-
PO	0.00435	2.952	-9	-	-	-	-	.000274	0.00052	.000224	-	-	-	-
PE	0.0287	3.393	-	-	-	-	0.00051	.00244	0.00362	0.00211	0.00685	-	-	-
			0.035	0.024	0.0473	0.0451	0.0253	0.184	0.176	0.218	0.2144	0.248	0.035	0.036
						NODE 19								
PA	0.592	13.363	0.0505	0.0947	0.1035	0.097	-	-	-	-	-	-	-	-
SC	0.171	7,002	0.0294	0.00685	0.00195	0.00354	0.0576	0.0167	-	-	-	0.0143	0.078	0.0806
WH	0.532	26.645	-	-	-	-	-	0.038	0.0182	0.0248	0.026	0.0565	-	-
BA	0.459	30.56	-	-	-	-	-	0.00285	0.0213	0.0253	0.0228	-	-	-
BR	0.0644	2.2124	-	-	-	-	-	-	0.00735	-	0.00375	-	-	-
PD	0.00975	2.952	-	-	-	-	-	0.00065	0.001178	.000502	-	-	-	-
PE	0.0644	3.393	-	-	-	-	.000114	.00545	0.00806	.0047	.000152	-	-	-
			0.0799	0.1015	0.1055	0.105	0.0577	0.0634	0.055	0.053	0.051	0.0708	0.078	0.0804

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
							NODE 14							
PA	0.50	13.363	0.0426	0.08	0.0876	0.08	-	-	-	-	-	-	-	-
SC	0.144	7.002	0.0247	.00575	.00164	.00298	.0485	.0141	-	-	-	0.012	0.0658	0.068
WH	0.45	26.645	-	-	-	-	-	.0312	0.0150	0.0203	0.0214	0.0463	-	-
BA	0.379	30.56	-	-	-	-	-	.00236	0.0176	0.0209	.01895	-	-	-
GR	0.054	2.2124	-	-	-	-	-	-	.00615	-	.00281	-	-	-
BO	0.0082	2.952	-	-	-	-	.00516	.00516	.00099	.000422	-	-	-	-
PE	0.054	3.393	-	-	-	-	.000955	.00457	.0068	.00395	.001285	-	-	-
			0.0673	,08575	0.0892	.08298	0.0494	0.0526	0.0464	0.0455	0.0436	0.0583	0.0658	0.068
							NODE 15							
PA	0.412	13.363	0.0352	0.066	0.072	0.0676	-	-	-	-	-	-	-	-
SC	0.119	7.002	0.0204	0.00476	.00136	.00246	0.140	.00162	-	-	-	.00995	0.0542	0.0562
WH	0.272	26.645	-	-	-	-	-	0.0187	.00895	0.0122	0.0128	0.0278	-	-
BR	0.312	30.56	-	-	-	-	-	.00194	0.0145	0.0172	0.0155	-	-	-
BA	0.044	2.2124	-	-	-	-	-	-	0.00501	-	.00229	-	-	-
PO	0.00677	2.952	-	-	-	-	-	.000426	0.00082	.000349	-	-	-	-
PE	0.044	3.393	-	-	-	-	.0001145	.00545	0.0081	.0047	.000152	-	-	-
			0.0556	0.07076	.07336	0.07	0.0401	0.0275	0.0373	0.0844	0.0306	0.0377	0.0542	0.0562

NODE 16

PA	0.995	13.363	0.085	0.1594	0.174	0.164	-	-	-	-	-	-	-
SC	0.967	7.002	0.161	0.0387	0.011	0.02	0.326	0.0945	-	-	-	0.0609	0.442	0.456
WH	3.34	26.645	-	-	-	-	-	0.230	0.11	0.1495	0.1575	0.351	-	-
BA	4.4	30.56	-	-	-	-	-	0.0274	0.205	0.243	0.22	-	-	-
GR	0.273	2.2124	-	-	-	-	-	-	0.0312	-	0.0142	-	-	-
PO	0.041	2.952	-	-	-	-	-	.00258	.00496	.00211	-	-	-	-
PE	0.273	3.393	-	-	-	-	.00484	0.0231	0.0344	0.002	0.0065	-	-	-
			0.0246	0.1981	0.185	0.186	0.330	0.3775	0.3855	0.396	0.397	0.431	0.442	0.456

NODE 18

PA	0.665	13.363	0.0555	0.1040	0.1140	0.1065	-	-	-	-	-	-	-	-
SC	0.236	7.002	0.0405	.00945	.00269	0.0049	0.0795	0.023	-	-	-	.01970	0.1075	0.111
WH	0.77	26.645	-	-	-	-	-	0.053	0.0253	0.0344	0.0364	0.0786	-	-
BA	0.804	30.56	-	-	-	-	-	0.005	0.0374	0.0443	0.0401	-	-	-
GR	0.077	2.2124	-	-	-	-	-	.00878	-	0.004	-	-	-	-
PO	0.04	2.952	-	-	-	-	-	.00252	.00482	.00206	-	-	-	-
PE	0.098	3.393	-	-	-	-	.001735	.008	.01235	.0072	.00233	-	-	-
			0.096	0.1134	0.1166	0.1119	0.0812	0.091	0.0895	.087	0.082	0.0983	0.1075	0.111

NODE 17

1	2	3												
PA	1.365	13.365	0.1165	0.2185	0.239	0.2245	-	-	-	-	-	-	-	-
SC	0.394	7.002	0.0676	0.0152	0.0045	0.00818	0.0132	0.0386	-	-	-	0.033	0.18	0.186
WH	1.23	26.645	-	-	-	-	-	0.0845	0.0406	0.055	0.0585	0.126	-	-
BA	1.032	30.56	-	-	-	-	-	0.00632	0.0472	0.056	0.0506	-	-	-
GR	0.148	2.2124	-	-	-	-	-	-	.0176	-	0.00802	-	-	-
PO	0.0224	2.952	-	-	-	-	-	0.00148	0.00272	0.001159	-	-	-	-
PE	0.148	3.393	-	-	-	-	.00262	.001255	.0186	.01085	.00352	-	-	-
			0.183	0.233	0.243	0.232	0.015	0.141	0.124	0.122	0.119	0.159	0.18	0.186

NODE 10

PA	0.69	13.363	0.059	0.111	0.122	0.1139	-	-	-	-	-	-	-	-
SC	0.35	7.002	0.06	0.014	0.009	0.00725	0.131	0.0343	-	-	-	0.0293	0.1595	0.165
WH	0.75	26.649	-	-	-	-	-	0.0514	0.0247	0.0336	0.0354	0.0765	-	-
BA	0.656	30.56	-	-	-	-	-	.00407	.0305	.0361	0.0326	-	-	-
GR	0.093	2.2124	-	-	-	-	-	-	0.0106	-	0.00485	-	-	-
PO	0.0307	2.952	-	-	-	-	-	0.00193	.00376	.00158	-	-	-	-
PE	0.0697	3.393	-	-	-	-	0.00123	0.00587	0.00875	.00509	.00164	-	-	-
			0.11	0.125	0.126	0.185	0.132	0.095	0.075	0.075	0.072	0.105	0.159	0.165

NODE 11

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PA	0.67	13.363	0.0572	0.1072	0.1175	0.11	-	-	-	-	-	-	-	-
SC	0.31	7.002	0.0531	0.0124	.00354	.0064	0.1038	0.303	-	-	-	0.0259	0.142	0.146
WH	1.09	26.649	-	-	-	-	-	0.0755	0.036	0.471	0.05	0.0122	-	-
BA	1.24	30.56	-	-	-	-	-	0.00772	0.0576	0.0685	0.062	-	-	-
GR	0.086	2.2124	-	-	-	-	-	-	0.103	-	0.0469	-	-	-
PO	0.105	2.952	-	-	-	-	-	0.0066	.01275	.00539	-	-	-	-
PE	0.138	3.393	-	-	-	-	.00244	.01165	.0173	.0101	.00327	-	-	-
			0.110	0.119	0.121	0.116	0.113	0.123	0.225	0.574	0.163	0.137	0.142	0.146

NODE 13

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PA	0.646	13.363	0.0553	0.101	0.1135	0.1065	-	-	-	-	-	-	-	-
SC	0.464	7.002	0.0775	0.0181	.00518	.00935	.1529	0.454	-	-	-	0.0378	0.2065	0.214
WH	1.56	26.645	-	-	-	-	-	0.1075	.0517	0.07	0.0742	0.16	-	-
BA	2.12	30.56	-	-	-	-	-	0.00132	.0985	0.117	.1055	-	-	-
GR	0.101	2.2124	-	-	-	-	-	-	0.012	-	.00545	-	-	-
PO	0.22	2.952	-	-	-	-	-	0.0139	0.0266	.01135	-	-	-	-
PE	0.236	3.392	-	-	-	-	0.00417	.020	.0297	.0172	0.0056	-	-	-
			0.1328	0.119	0.1186	0.118	0.156	0.186	0.216	0.217	0.189	0.197	0.2065	0.214

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
							NODE 20							
PA	0.129	13.363	0.0108	0.0202	0.0221	0.02075	-	-	-	-	-	-	-	-
SC	0.0372	7.002	0.00636	0.00149	0.00042	0.00077	0.01255	0.00364	-	-	-	0.00311	0.01695	0.0175
WH&	0.0116	26.645	-	-	-	-	-	0.00796	0.00384	0.0052	0.0056	0.1185	-	-
BA	0.09775	30.56	-	-	-	-	-	0.000483	.00302	.00428	.003865	-	-	-
GR	0.014	2.2124	-	-	-	-	-	-	0.0016	-	0.00073	-	-	-
PO	0.00213	2.952	-	-	-	-	-	0.000013	.000025	.00010	-	-	-	-
PE	0.014	3.393	-	-	-	-	.000249	.00119	.00177	.00103	.000334	-	-	-
			0.0171	0.0216	0.0225	0.0214	0.0127	0.0011	0.0009	0.104	0.0104	0.0149	0.0169	0.0175
							NODE 21							
PA	0.552	13.363	0.046	0.0865	0.0945	0.0885	-	-	-	-	-	-	-	-
SC	0.159	7.002	0.0272	0.00634	.001855	.00329	0.0536	.01555	-	-	-	0.0133	0.0725	0.075
WH	0.498	26.645	-	-	-	-	-	0.0342	-	0.0223	.0234	0.0507	-	-
BA	0.412	30.56	-	-	-	-	-	0.0026	0.0194	0.0234	0.0208	-	-	-
GR	0.06	2.2124	-	-	-	-	-	-	.00685	-	.00312	-	-	-
PO	0.009	2.952	-	-	-	-	-	0.00556	.001085	.000755	-	-	-	-
PE	0.06	3.393	-	-	-	.00107	.00567	.00755	.10439	.00143	-	-	-	-
			0.073	0.0928	0.0963	0.0927	0.0986	0.0598	0.032	0.046	0.046	0.046	0.0725	0.075

			4	5	6	7	8	9	10	11	12	13	14	15
							NODE 22							
PA	1.065	13.363	0.0872	0.167	0.183	0.1715	-	-	-	-	-	-	-	-
SC	0.306	7.002	0.0524	0.01225	0.0035	0.00632	0.103	0.03	-	-	-	0.0256	0.14	0.1445
WH	0.495	26.645	-	-	-	-	-	0.0341	0.01635	0.022	0.0234	0.0506	-	-
BA	0.805	30.54	-	-	-	-	-	0.005	0.0375	0.044	0.040	-	-	-
GR	0.45	2.212	-	-	-	-	-	-	0.0514	-	0.0234	-	-	-
BO	0.0175	2.952	-	-	-	-	-	0.001102	.00212	.0009	-	-	-	-
PE	0.115	3.393	-	-	-	-	.00204	0.0097	0.0144	.00853	0.00273	-	-	-
			0.19	0.179	0.186	0.1778	0.109	0.079	0.120	0.074	0.108	0.0761	0.14	0.1445
							NODE 23							
PA	0.1175	13.363	0.1002	0.188	0.206	0.193	-	-	-	-	-	-	-	-
SC	0.0338	7.002	0.00576	.001345	0.00038	.0007	0.0113	0.00329	-	-	-	.00281	0.01535	0.01585
WH	0.1055	26.645	-	-	-	-	-	0.0072	.00345	.00469	.00495	0.0107	-	-
BA	0.089	30.54	-	-	-	-	-	.000555	.00414	.00492	.00445	-	-	-
GR	0.01275	2.2123	-	-	-	-	-	-	.00145	-	.000666	-	-	-
PO	0.00193	2.952	-	-	-	-	-	.000122	.000234	.0001	-	-	-	-
PE	0.01275	3.393	-	-	-	-	0.195	.00932	.01365	.000805	.000261	-	-	-
			0.1054	0.189	0.206	0.1937	0.0114	0.0119	0.0104	0.0104	0.0101	0.01288	0.1535	0.01585

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
							NODE 24							
PA	0.795	13.363	0.0699	0.1275	0.1395	0.13	-	-	-	-	-	-	-	-
SC	0.23	7.002	0.0395	0.0092	0.00263	0.0776	0.0225	0.00478	-	-	-	0.0192	0.105	0.109
WH	0.715	26.645	-	-	-	-	-	0.0492	0.02375	0.0319	0.0334	0.0756	-	-
BA	0.602	30.56	-	-	-	-	-	0.00375	0.028	0.33	.0302	-	-	-
GR	0.0865	2.2124	-	-	-	-	-	0.00103	-	.0045	-	-	-	-
PO	0.013	2.952	-	-	-	-	-	0.00156	.00816	.000616	-	-	-	-
PE	0.0865	3.393	-	-	-	-	.00155	0.00735	.0109	.00635	.000206	-	-	-
			0.1074	0.1367	0.1658	0.207	0.029	0.065	0.059	0.418	0.0638	0.0948	0.105	0.109
							NODE 25							
PA	0.392	13.363	0.0335	0.0627	0.0685	0.0644	-	-	-	-	-	-	-	-
SC	0.1125	7.002	0.0193	0.0045	0.001285	.00252	0.0399	0.011	-	-	-	0.0095	0.0514	0.053
WH	0.352	26.645	-	-	-	-	-	0.0242	0.0116	0.01575	0.0166	0.036	-	-
BA	0.296	30.56	-	-	-	-	-	0.0184	0.138	0.1635	0.148	-	-	-
GR	0.0425	2.2124	-	-	-	-	-	-	0.00484	-	0.0022	-	-	-
PO	0.00645	2.952	-	-	-	-	-	.000406	.00078	.000332	-	-	-	-
PE	0.0425	3.393	-	-	-	-	.00075	.0036	.00834	.00252	0.00125	-	-	-
			0.0528	0.0674	0.0697	0.0669	0.0386	0.056	0.158	0.180	0.167	0.0455	0.0514	0.053

TABLE - 15

WEIGHTED DISTRIBUTION OF WITHDRAWALS AT EACH NODES (MONTHLY)

Nodal Area No.	Area in 10^7 m^2	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Remarks
1	18.2	.00404	.00482	.00496	.00473	.00353	.0005	.0122	.01094	.0103	.0111	.0045	.00464	Tubewell Command
2	16.5	.00741	.00479	.00755	.00304	.0113	.0153	.0171	.01715	.0154	.0151	.0149	.0155	Tubewell Command
3	6.38	-	-	-	-	-	.0174	-	.00217	.0309	.03085	-	-	Canal Command
4	3.7	.0054	.00647	.0067	.0062	.00449	.00484	.00618	.00797	.0069	.00545	.00592	.00613	Tubewell Command
5	13.4	.00532	.005	.0067	.00475	.0062	.01051	.0415	.0143	.0131	.0129	.0081	.0084	Tubewell Command
6	16.1	.00665	.0046	.00415	.00965	.01382	.0115	.01454	.01365	.01402	.0126	.01315	.01315	" "
7.	15.8	-	-	-	-	-	.0175	-	.00217	.031	.03097	-	-	Canal Command
8.	12.85	-	-	-	-	-	.0175	-	.00218	.0311	.0309	-	-	Canal Command
9.	4.47	.00782	.00542	.01068	.0102	.0057	.0416	.0397	.0492	.0485	.056	.00782	.0079	Tubewell Command
10.	8.9	.01235	.014	.01417	.0208	.01485	.0107	.00482	.0482	.0081	.0118	.0179	.0167	" "
11.	17.9	.00615	.00665	.00675	.0065	.0063	.00688	.0126	.032	.0091	.00765	.00792	.00815	" "
12.	13.76	.00745	.00478	.0042	.00067	.01125	.0121	.0172	.0171	.0149	.0144	.0148	.01535	" "
13.	15.8	.0084	.00752	.0075	.00727	.0987	.0118	.01365	.0137	.01195	.01245	.01305	.0155	" "
14.	5.92	.0113	.01445	.0151	.014	.01834	.00888	.00782	.00768	.0074	.0985	.0772	.0115	" "
15.	4.83	.0115	.01465	.0152	.0145	.00828	.00569	.0077	.00712	.00633	.0078	.01125	.01165	" "

16.	7.45	.0033	.0266	.0248	.0247	.0443	.0505	.0517	.0532	.0533	.0577	.0592	.0614	Tubewell	Command
17.	15.8	.0116	.01475	.0154	.0147	.00095	.00892	.00785	.0077	.00752	.01005	.0114	.01175	"	"
18.	9.28	.01035	.0130	.01258	.012	.00875	.0098	.00965	.00936	.00882	.0006	.0116	.01195	"	"
19.	6.9	.01145	.0147	.0153	.0153	.00837	.0092	.008	.0074	.0109	.01025	.01135	.0117	"	"
20.	3.91	.00437	.0055	.00575	.0545	.00325	.000281	.00279	.0266	.00267	.00381	.00433	.00447	"	"
21.	6.46	.0113	.0143	.0149	.0143	.00906	.00925	.00994	.0071	.0071	.0099	.0112	.0116	"	"
22.	12.4	.01129	.0144	.015	.01435	.00845	.00636	.00966	.00596	.0087	.00614	.00113	.0116	"	"
23.	13.7	.00774	.0138	.015	.014	.00832	.00868	.0076	.0076	.0074	.0094	.0112	.00115	"	"
24.	9.05	.0119	.0151	.0183	.0228	.0265	.0719	.00652	.045	.00716	.01032	.0116	.01205	"	"
25.	4.55	.0116	.01475	.0153	.0146	.0085	.0123	.0347	.0396	.0367	.01	.0113	.0116	"	"

TABLE - 16

NET RECHARGE & WITHDRAWLS AT EACH NODE (35% RAINFALL RECHARGES)

Nodal Area no.	Observed Point	Nodal points on model	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Initial Level	Remarks
1	O-9A	6-L	-.0040	+.0431	+.0594	+.0351	-.00142	-.0054	-.01225	-.0098	-.01034	-.011	-.0045	-.00465	27.1	T
2	O-7	8-O	-.00745	+.043	+.0558	+.0416	-.0092	-.0101	-.01705	-.015	-.0136	-.0151	+.0149	-.0155	23.4	
3	O-5	11¾B	+.0115	+.0595	+.069	+.1054	+.0173	-.00750	+.0085	+.0127	-.0028	-.0198	+.0082	+.0082	25.65	
4	OP-7	8-G	-.004	+.0685	+.0980	+0.0194	+.00129	+.0155	-.00618	-.0048	-.0069	-.0054	-.0059	-.00613	18.99	
5	OP-6	14¾H	-.0042	+.0629	+.0827	+.038	-.0053	+.0095	-.0145	-.0102	-.010	-.0129	-.0081	-.0084	18.44	
6	OP-5	13-K	-.0066	+.044	+.055	+.079	-.0086	-	-.015	-.0145	-.0038	-.014	-.0126	-.01315	23.94	
7	OP-3	16-Q	+.0115	+.0599	+.0699	+.10495	+.122	-.0077	+.0085	+.0102	-.017	-.0202	+.0082	+.0085	19.95	
8.	OP-2A	21-R	+.0115	+.0634	+.0824	+.0935	+.014	+.0753	+.0085	+.0102	-.017	-.0202	+.0082	+.0085	9.13	
9.	VA-2	19-B	-.0061	+.0716	+.091	+.0509	+.0236	-.031	-.0397	-.0468	-.0468	-.056	-.078	-.0079	6.24	
10.	VA-4	16-E	-.0109	+.062	+.086	+.0043	-.0092	+.0093	-.00842	-.0809	-.0081	-.0118	-.0179	-.0167	9.0	
11.	VA-5	17-G	-.00895	+.0414	+.0513	+.0885	-.0051	-.0052	-.0126	-.0257		-.00765	+.00762	-.00815	8.74	
12.	P-3	23-M	-.00745	+.0502	+.08	+.0712	-.0067	-.0076	-.0172	-.0146	-.0149	-.0144	-.0148	-.01535	13.69	
13.	P-6A	23-G	-.0084	+.0475	+.077	+.0645	-.00532	-.0118	-.01365	-.0113	-.0119	-.01285	-.01305	-.0135	12.74	
14.	P-7	23-B	-.0075	+.080	+.0704	+.0272	+.011	+.016	-.00782	-.00585	+.0007	-.0985	-.077	-.0119	15.27	

15	VB-3	26B	-0.0077	+.0798	+.0703	+.0267	+.01042	+.0192	-.0077	-.00545	+.002	-.0978	-.012	-.01165	10.27
16	VB-5	26E	-.0116	+.00286	+.061	+0.0468	-0.013	-0.047	-.0511	-.0532	-.0533	-0577	-0592	.0614	2.01
17	VC-10	28K	-.016	+.0403	+.069	+.0533	+.0036	-.00872	-.00775	-.0053	-.00752	-.01005	-.0114	-.01175	10.1
18	VC-8	30H	-.01035	+.045	+.1025	+.027	+.0123	+.0042	-.00965	-00936	-.0088	-0106	-.00116	-.0119	11.07
19	VC-6	29C	-.0014	+.044	+.114	+.141	-00644	+.0137	-.008	-.0077	-.0109	-01025	-01135	-0117	5.0
20	VC-4	28A	-.0043	+.068	+.0994	-.015	+0183	+0.238	-0075	-.0266	-.00266	-.00381	-0.0048	-.0044	2 .07
21	5VD	35A	-.113	+.0347	+.098	+.0157	-.0071	+.014	-00494	-0071	-0071	-0.0099	-.0112	-.0116	1.64
22	7VD	34E	-.0112	+.0347	+.099	+.0158	-.0071	+0.14	-.00966	-00546	-.0087	-.0054	-.0113	-.0116	2,37
23	VD9	35G	-.0077	+.0347	+.098	+.0151	-.0071	+.014	-.0076	-.0076	-.0074	-0094	.0112	-0011	1.40
24	PQ3	39C	-.0119	+.0347	+.098	+.0151	-.0071	+0.014	-.0065	-.045	-.00716	- .01032	-.0116	-.01205	9.0
25	PQ4	39G	-.0116	+.0347	+.098	+.0151	-.0077	+014	-.0347	-.0396	-.0367	-.010	-.0113	-.0116	2.0

TABLE - 17

NET RECHARGES & WITHDRAWALS AT EACH NODES IN MILLI AMPHERES

Nodal Sl.No.	Nodes on Model	Area in 10^7 M^2	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Initial Level	Initial Level
1	6-L	18.2	-.209	+2.25	+3.1	+1.835	-.074	-.283	-.642	-.513	-.54	-.575	-.237	-.243	27.1	13.55
2	8-O	16.5	-.353	+2.04	+2.64	+1.97	-.436	-.48	-.81	-.715	-.647	-.718	-.709	-.736	23.4	11.7
3	11-R	6.38	+.212	+1.09	+1.26	+1.93	+.316	-.137	+.156	+232	-.51	-.362	+.15	+.15	25.65	12.825
4	8-G	3.7	-.0425	+.74	+1.01	+.206	+.137	+.165	-.0657	-.051	-.0735	-.0575	-.0626	-.065	18.99	9.495
5	14-H	13.4	-.162	+2.42	+3.19	+1.46	-.204	-.366	-.556	-.392	-.384	-.48	-.311	-.323	18.44	9.22
6	13-K	16.1	-.305	+2.09	+2.55	+3.65	-.397		-.692	-.67	-.175	-.647	-.582	-.61	23.94	11.47
7	16-Q	15.8	+.523	+2.72	+3.17	+4.75	+5.75	+.35	+.391	+.577	-.5	-.918	+.373	+.386	19.95	9.97
8	21-R	12.85	+.426	+2.35	+3.05	+3.47	+.52	+.269	+.316	+.376	-.63	-.75	+.304	+.316	9.13	4.56
9	19- B	4.47	-.0782	+.92	+1.168	+.652	+.302	-.327	-.508	-.6	-.6	-.718	-1.0	-1.01	6.24	3.12
10.	16-E	8.9	-.278	+1.585	+2.2	+.11	-.235	-.2375	-.215	-.206	-.207	-.3	-.456	-.426	9.0	4.5
11.	17-G	17.9	-.316	+2.13	+2.63	+4.55	-.262	-.647	-1.325	-0		-.391	-.41	-.42	-8.74	4.37
12	23-M	13.76	-.294	+1.98	+3.16	+2.82	-.265	-.3	-.679	-.775	-.588	-.568	-.584	-.606	13.69	6.84
13	23-G	15.8	-.38	+2.15	+3.49	+2.92	-.241	-.535	-.619	-.512	-.54	-.565	-.591	-.612	12.7	6.35
14.	23-B	5.72	-.127	+1.355	+1.19	+.46	+.186	+.27	-.1395	-.099	-.016	-.167	-.1305	-.202	15.7	7.85
15.	26-B	4.83	-.107	+1.11	+.976	+.372	+.145	+.267	-.107	-.078	-.027	-.1085	-.167	-.162	10.2	5.13

16.	26-E	7.45	-.248	+.614	+1.31	+1.005	-.278	-1.005	-1.09	-1.14	-1.145	-1.255	-1.27	-1.315	2.01	1.005
17.	28-K	15.8	-.527	+1.835	+3.14	+2.43	+.164	-.406	-.356	-.241	-.342	-.457	-.52	-.335	10.1	5.05
18.	30-H	9.28	-.276	+1.2	+2.74	+.72	+.328	+.112	-.257	-.25	-.234	-.282	-.308	-.317	11.7	5.5
19.	29-C	6.9	-.226	+.874	+2.26	+.28	-.1275	+.272	-.159	-.1525	-.2165	-.203	-.2245	-.232	5.0	2.5
20.	28-A	3.91	-.0487	+.765	+1.11	-.168	+.205	+.267	-.0313	-.298	-.0298	-.0427	-.0482	-.0495	2.0	1
21.	35-A	6.46	-.21	+.645	+1.85	+.28	-.132	+.26	-.0916	-.132	-.132	-.184	-.209	-.216	1.64	0.82
22.	34-E	12.4	-.399	+1.235	+3.48	+.336	-.252	+.498	-.344	-.212	-.309	-.228	-.402	-.412	2.77	1.18
23.	35-G	13.7	-.302	+1.37	+3.86	+.594	-.279	+.55	-.299	- .299	-.291	-.37	-.472	-.432	1.4	0.7
24.	39-C	9.85	-.31	+.902	+2.55	+.392	-.1845	+.362	-.169	-.117	-.1865	-.268	-.302	-.312	2.0	1
25.	39-G	4.55	-.152	+.453	+1.275	+.197	-.0925	+.1825	-.452	-.515	-.478	-.1305	-.447	-.148	9.0	4.5

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NET RECHARGE & WITHDRAWALS AT EACH NODES (30% OF RAINFALL RECHARGES) IN METRES

Sl.& Nodal Area No.	Obs. Points	Nodal Points in Model	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Initial Level	Area(M
1	O-9A	6 - L	-.00404	+.03619	+0.05	+.0293	-.00176	-.00615	-.01225	-.0096	-.01034	-.0111	-.0045	-.00465	27.1	28.2x10^7
2	O-7	8-O	-.00745	+.03635	+.0467	+.03517	-.00955	-.0102	-.017	-.01523	-.01387	-.0151	-.0149	-.0155	23.4	16.5x10^7
3	O-5	4-R	+.0115	+.0525	+.0616	+.0911	+.0012	-.007	+.0085	+.0117	-.01262	-.01225	+.0082	+.0085	25.65	6.38x10^7
4	OP-7	8-G	-.0042	+.0585	+.08	+.0157	+.0004	+.01266	-.00618	-.00527	-.0069	-.00545	-.00592	-.00613	18.99	3.7x10^7
5	OP-6	14-H	-.00435	+.0532	+.07	+.03185	-.0025	+.0065	-.01415	-.01073	-.0104	-.0129	-.0081	-.0084	18.44	13.4x10^7
6	OP-5	13-K	-.00665	+.0364	+.046	+.06735	-.00875	-.00182	-.015	-.0076	-.00525	-.01402	-.0126	-.01315	23.94	16.1x10^7
7.	OP-3	16-Q	+.0115	+.0529	+.0616	+.09115	+.01206	-.0149	+.0085	-.0118	-.0203	-.0202	+.0082	+.0085	19.95	15.8x10^7
8	OP-2A	21-R	+.0115	+.0559	+.0791	+.0816	+.0135	+.0625	+.0085	+.010	-.0178	-.0202	+.0082	+.0085	9.13	12.85x10
9	VA-2	19-B	-.0063	+.0606	+.0759	+.0341	+.0012	-.0321	-.0397	-.0471	-.047	-.056	-.0078	-.0079	6.24	4.47x10^7
10.	VA-4	16-E	-.0111	+.051	+.0723	+.0011	-.0009	+.0026	-.00842	-.0815	-.0081	-.0118	-.0179	-.0167	9.0	8.9 x10^7
11.	VA-5	17-G	-.00615	+.0343	+.0429	+.0747	-.0054	-.0054	-.0126	-.0268	+.0018	-.00765	-.0079	-.00815	8.74	17.9x10^7
12.	P-3	23-M	-.00745	+.0424	+.068	+.0608	-.0083	-.0121	-.0172	-.015	-.0149	-.0144	-.0148	-.01535	13.69	13.76x10
13.	P-6A	23-G	-.0084	+.0395	+.0645	+.05421	-.005421	-.0059	-.0118	-.01365	-.0116	-.01195	-.01245	-.01305	12.71	15.8x10
14.	P-7	23-B	-.0081	+.066	+.0581	+.0214	+.00816	+.0124	-.0078	-.00618	-.0003	-.0988	-.0772	-.0115	15.77	5.92x10^7
15.	VB-3	26-B	-.0083	+.0663	+.0581	+.021	+.0082	+.0156	-.0077	-.0056	-.0008	-.0078	-.01125	-.01165	10.27	4.83x10^7
16.	VB-5	26-E	-.003	+.0207	+.0487	+.0365	-0.0173	-.0502	-.0517	-.0514	-.0533	-.0577	-.0592	-.0614	2.01	7.45x10^7

17.	VC-10	28-K	-.0116	+.0324	+.0568	+.0468	+.003	-.0089	-.00785	-.0007	-.0075	-.01005	-.0114	-.01175	10.1	15.8×10^7
18.	VC-8	30-H	-.01035	-.0369	+.0864	+.024	+.0093	+.0022	-.00965	-.0093	-.0088	-.0106	-.0116	-.01195	11.07	9.28×10^7
19.	VC-6	29-C	-.01195	+.0358	+.0962	+.0199	-.0067	+.0112	-.008	-.0074	-.0109	-.0225	-.01135	-.0117	5.0	6.9×10^7
20.	VC-4	28-A	-.00437	+.0575	+.093	-.0176	+.0148	+.02032	-.00279	-.0266	-.00266	-.0038	-.0043	-.00447	2.0	3.91×10^7
21.	VD-5	35-A	-.0113	+.0361	+.1066	+.0109	-.0074	+.0112	-.00494	-.0071	-.0071	-.0092	-.0112	-.0116	1.64	6.46×10^7
22.	7 VD	34-E	-.01129	+.036	+.1065	+.01085	-.0078	+.0141	-.0096	-.00596	-.0087	-.00614	-.0113	-.0116	2.37	12.4×10^7
23.	VD - 9	35-G	-.0077	+.0367	+.1065	+.0112	-.0067	+.0117	-.0076	-.0076	-.0074	-.0094	-.0112	-.0115	1.4	13.7×10^7
24.	PQ-3	39-C	-.0119	+.0354	+.0932	+.0024	-.00105	+.01321	-.0065	-.04500	-.0071	-.0103	-.0116	-.01205	9.0	9.05×10^7
25.	PQ-4	39-G	-.0116	+.03575	+.0962	+.0105	-.0069	+.0081	-.0347	-.0396	-.0367	-.01	-.0113	-.0116	2.0	4.55×10^7

Net Recharge & Withdrawals in Cubic Metres

Nodal Area No.	Obs. Points	Nodal Points in Model	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Initial Level
1	O-9A	6-L	-.0735	+.659	+.91	+.535	-.0321	-.112	-.223	-.175	-.1895	-.2	-.0818	-.0845	27.1
2	O-7	8-O	-.123	+.583	+.77	+.58	-.1575	-.1685	-.28	-.252	-.228	-.249	-.246	-.256	23.4
3	O-5	11-R	+.0734	+.335	+.393	+.58	+.00765	-.0445	+.0542	+.0745	.805	-.076	-.0525	-.0541	25.65
4	OP-7	8-G	-.0155	+.216	+.296	+.058	+.0014	+.0466	-.0728	-.0195	-.0254	-.0201	-.0218	-.0226	18.99
5	OP-6	14-H	-.058	+.715	+.94	+.0126	-.0335	+.087	-.1895	-.144	-.1392	-.173	-.1085	-.1125	18.44
6	OP-5	13-K	-.107	+.585	+.74	+1.082	-.589	-.0292	-.273	+.1275	-.845	-.0226	-.203	-.211	23.94
7	OP-3	16-Q	+.182	+.835	+.975	+1.438	+.19	-.2365	-.134	-.1865	-.32	-.319	-.129	-.134	19.95
8	OP-2A	21-R	+.1475	+.714	+1.018	+1.04	+.1725	+.8	+.109	+.128	-.228	-.259	+.105	+.109	9.13
9	VA-2	19-B	-.0276	+.265	+.332	+.149	+.00525	-.141	-.173	-.206	-.206	-.244	-.0342	-.0341	6.24
10.	VA-4	16-E	-.0987	+.455	+.645	+.0098	-.00802	+.0232	-.075	-.0725	-.072	-.105	-.159	-.1485	9.0
11	VA-5	17-G	-.11	+.615	+.764	+1.35	-.096	-.0966	-.226	.48	+.0322	-.137	-.1415	-.1467	8.74
12.	P-3	23-M	-.1025	+.584	+.935	+.837	-.114	-.1665	-.236	-.206	-.205	-.198	-.2035	-.211	13.59
13.	P-6A	23-G	-.133	+.825	+1.02	+.854	-.0856	-.094	-.1865	-.215	-.294	-.186	-.197	-.206	12.71
14.	P-7	23-B	-.048	+.391	+.344	+.127	+.0485	-.0735	-.0462	-.0366	-.0017	-.585	-.457	-.068	15.77

16.	VB-5	26-E	-.0246	+.154	+.364	+.272	-.129	-.374	-.385	-.382	-.396	-.43	-.445	-.457	2.01
17.	VE-10	28-V	-.183	+.562	+.9	+.74	-.0474	-.141	-.124	+.111	-.1185	-.159	-.18	-.186	10.1
18.	VC-8	30-H	-.0962	+.342	+.8	+.22	+.086	+.0204	-.0895	-.086	-.0815	-.0982	-.1075	-.1105	11.07
19.	VC-6	29-C	-.079	+.247	+.665	+.1325	-.044	+.0772	-.0552	-.051	-.0752	-.0706	-.0782	-.0806	5.0
20.	VC-4	28-A	-.0171	+.225	+.364	+.0762	+.0579	+.0792	-.0109	-.104	-.0104	-.01485	-.0168	-.0177	2.0
21.	5-VD	35-A	-.073	+.237	+.688	+.0705	-.0478	-.0724	-.0319	-.046	-.046	-.064	-.0723	-.075	1.64
22.	7-VD	34-E	-.139	+.446	+1.32	+.1345	-.0967	+.175	-.119	-.074	-.108	-.076	-.14	-.164	2.37
23.	VD-9	35-G	-.1055	+.502	+1.45	+.153	-.0916	+.16	-.104	-.212	-.109	-.128	-.153	-.157	1.4
24.	PQ-3	39-C	-.108	+.32	+.845	+.0218	-.0095	+.12	- .059	-.406	-.868	-.093	-.105	-.115	9.0
25.	PQ-4	39-G	-.0529	+.1625	+.437	+.0477	-.0324	+.0369	-.168	-.18	-.167	-.0455	-.0512	-.0528	2.0

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NET RECHARGES AND WITHDRAWALS IN MILLI AMPHERES

Nodal Area No.	Obs. pts. in field	Nodal point in Model	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Initial Level in Metre/Volt in June	K_2=2Metre/Volt Initial Level
1	O-9A	6-L	-0.21	+1.86	+2.62	+1.54	+.092	-.322	-.64	-.502	-.54	-.575	-.232	-.242	27.1	13.55
2	O-7	8-O	-.352	+1.67	+2.21	+1.66	-.45	-.485	-.805	-.722	-.655	-.765	-.706	-.735	23.4	11.7
3	O-5	11-R	+.21	+.965	+1.13	+1.66	+.0219	-.128	-.155	-.214	-.231	-.219	-.151	-.155	25.65	12.8
4	OP-7	8-G	-.0445	+.62	+.85	+.1665	+.0042	+.134	-.065	-.056	-.073	-.0576	-.625	-.065	18.99	9.49
5	OP-6	14-H	-.166	+2.06	+2.7	+1.22	-.096	+.25	-.545	-.414	-.4	-.496	-.312	-.323	18.44	9.22
6	OP-5	13-K	-.307	+1.68	+2.12	+3.12	-1.69	-.084	-.785	-.352	-.242	-.65	-.554	-.605	23.94	11.97
7	OP-3	16-Q	+.522	+2.4	+2.8	+4.12	+.545	-.68	-.387	-.535	-.92	-.915	-.37	-.385	19.95	9.97
8	OP-2A	21-R	+.422	+2.03	+2.92	+2.98	+.455	+2.3	+0.314	+.368	-.655	-.745	-.302	-.314	9.13	4.551
9	VA-2	19-B	-.0792	+.762	+.995	+.429	+.0151	-.405	-.497	-.592	-.592	-.7	-.0985	-.0981	6.24	3.12
10.	VA-4	16-E	-.283	+.1.3	+1.85	+.028	-.023	-.0665	-.216	-.208	-.30	-.45	-.422	-.42	9.0	4.5
11.	VA-5	17-G	-.316	+1.77	+2.19	+3.87	-.278	-.278	-.65	-1.38	-.092	-.39	-.405	-.42	8.74	4.37
12.	P-3	23-M	-.294	+1.67	+2.68	+2.4	-.327	-.476	-.678	-.59	-.587	-.57	-.582	-.605	13.69	6.84
13.	P-6A	23-G	-.382	+1.79	+2.9	+2.44	-.244	-.27	-.515	-.616	-.84	-.54	-.565	-.59	12.71	6.35
14.	P-7	23-B	-.138	+1.12	+.985	+.365	+.139	-.21	-.132	-.105	-.005	-1.67	-1.33	-.195	15.77	7.88
15.	VB-3	26-B	-.115	+.92	+.815	+.292	+.082	+.216	-.107	-.0775	-.0111	-.0108	-.156	-.162	10.27	5.13

16.	VB-5	26-E	-.0708	+.44	+1.04	+.78	-.37	-1.07	-1.1	-1.095	-1.135	-1.23	-1.27	-1.31	2.01	1.005
17.	VC-10	28-K	-.524	+1.47	+2.58	+2.13	-.135	-.405	-.356	-.0316	-.34	-.437	-.517	-.53	10.1	5.05
18.	VC-8	30-H	-.276	+.982	+2.3	+.632	+.247	+.0585	-.259	-.247	-.234	-.282	-.308	-.318	11.07	5.8
19.	VC-6	29-C	-.227	+.68	+1.91	+.395	-.132	+.222	-.158	-.147	-.215	-.202	-.224	-.231	5.0	2.5
20.	VC-4	28-A	-.0492	+.645	+1.045	+.219	+.166	+.228	-.0315	-.308	-.0308	-.0427	-.0483	-.049	2.4	1.2
21.	5-VD	35-A	-.21	+.68	+1.95	+.202	-.137	-.208	-.0916	-.132	-.132	-.184	-.207	-.215	1.64	0.82
22.	7-VD	34-E	-0.4	+1.28	+3.8	+.388	-.273	+.502	-.342	-.212	-.31	-.218	-.412	-.328	2.37	1.19
23.	VD-9	35-G	-.303	+1.44	+4.16	+.44	-.263	+.46	-.299	-.29	-.293	-.368	-.44	-.45	1.4	0.7
24.	PQ-3	39-C	-0.31	+.92	+2.43	+.0626	-.0273	+.345	-.1692	-1.167	-.195	-.867	-.302	-.33	9.0	4.5
25.	PQ-4	39-G	-.152	+.465	1.26	.137	-.093	+.106	-.454	-.517	-.48	-.13	-.147	-.151	2.0	1

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SPRING LEVEL OBSERVED AT EACH NODE IN THE BASIN IN METRES (MONTHLY)

Nodal Area No.	Obs. Points	Spring Level / Final Level After RL & Datum	R.L.	Datum	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Initial level in volt/metre
1	O-9A	S.L.	96.90		4.5	4.4	4.5	3.7	-	4.1	4.15	4.35	4.4	4.43	4.56	4.82	2.71
x2		F.L.		65	27.4	27.5	27.4	28.2	-	27.8	27.7	27.55	27.5	27.4	27.3	27.08	
2	O-7	S.L.	95.93		7.5	7.3	5.75	4.5	-	5.55	5.62	6.28	6.14	6.7	7.07	7.2	23.4
		F.L.		65	23.4	23.6	25.18	26.4	-	24.3	25.35	24.55	24.79	24.79	23.8	23.73	
3	O-5	S.L.	92.75		-	-	2.1	5.0	-	6.2	1.9	1.83	2.0	3.1	2.63	-	25.65
		F.L.		65	25.65	25.65	25.65	22.75	-	21.55	25.85	25.92	25.75	24.65	25.12	-	
4	OP-7	S.L.	90.48		~~9.56~~ 6.49	~~8.35~~ 5.93	~~8.82~~ 5.6	~~7.64~~ 2.3	2.2	2.4	3.0	3.1	3.2	3.4	3.65	3.96	18.99
		F.L.		65	18.99	19.55	19.88	23.15	23.28	23.0	22.48	22.38	22.28	22.08	21.83	21.42	
5.	OP-6	S.L.	92.99		9.55	8.35	8.02	7.64	7.82	8.11	8.15	8.20	8.32	8.46	8.67	8.78	18.44
		F.L.		65	18.44	19.64	19.97	20.35	20.17	19.88	19.84	19.79	19.67	19.53	19.32	19.12	
6.	OP-5	S.L.	95.295		6.35	6.1	5.78	4.39	4.61	5.4	5.5	5.58	5.72	6.1	6.91	7.08	23.94
		F.L.		65	23.94	24.19	24.51	25.9	25.68	24.89	24.79	24.71	24.37	23.49	23.38	23.4	
7.	OP-3	S.L.	89.609		4.65	4.4	4.05	2.0	1.85	2.11	2.45	2.53	2.64	3.4	3.56	3.72	19.95
		F.L.		65	19.95	20.2	20.55	22.6	22.75	21.49	22.15	22.07	21.96	21.2	21.04	20.88	

8.	OP-2A	S.L.	87.48		13,35	14.07	13.85	13.03	12.1	12.8	13.2	13.26	13.4	13.9	14.05	14.15	9.13
		F.L.		65	9.13	8.41	8.67	9.95	10.38	9.68	9.28	9.22	9.08	8.55	8.47	8.33	
9.	VA-2	S.L.	82.86		11.62	11.72	9.0	9.74	9.71	9.94	9.96	9.67	9.81	11.05	11.26	11.41	6.24
		F.L.		65	6.24	6.14	8.86	8.12	8.15	8.02	7.9	8.21	8.05	6.81	6.60	6.45	
10	VA-4	S.L.	85.21		11.22	11.0	8.8	7.75	7.82	7.99	8.11	9.46	9.55	10.65	10.83	11.02	9.0
		F.L.		65	9.0	9.0	11.41	12.46	12.19	12.22	12.10	10.8	10.66	9.56	9.37	9.2	
11	VA-5	S.L.	86.14		12.4	12.48	10.35	8.32	8.29	8.26	8.38	10.33	10.45	10.95	11.95	12.32	8.74
		F.L.		65	8.74	8.66	10.79	12.82	12.85	12.88	12.76	10.81	10.69	10.19	9.19	8.82	
12	P-3	S.L.	84.37		5.68	6.08	5.82	4.75	4.86	5.6	5.7	5.76	5.91	6.65	6.82	7.08	13.69
		F.L.		65	13.69	13.3	13.55	14.6	14.51	13.77	13.67	13.61	13.46	12.55	12.29	12.2	
13.	P-6A	S.L.	84.94		7.17	6.95	6.85	6.21	6.31	6.7	6.6	6.69	6.8	7.0	7.15	7.34	12.71
		F.L.		65	12.71	20.0	20.1	20.73	20.63	20.24	20.34	20.25	20.14	19.94	19.75	19.6	
14.	P-7	S.L.	86.42		5.65	5.45	5.07	3.2	3.25	3.4	3.2	3.31	3.95	4.25	4.37	4.56	15.77
		F.L.		65	15.77	15.47	16.35	18.22	18.17	18.02	18.2	18.11	17.47	17.17	17.05	16.84	
15.	VB-3	S.L.	79.5		4.23	4.0	3.48	2.5	2.42	2.83	2.85	2.88	3.05	3.35	3.36	4.17	10.27
		F.L.		65	10.27	10.5	11.02	12.0	12.08	11.77	11.65	11.62	11.45	11.15	11.14	10.31	
16.	VB-5	S.L.	81.4		14.39	14.21	11.38	10.09	10.87	11.23	11.45	11.92	12.08	13.9	14.01	14.27	2.01
		F.L.		65	2.01	2.19	5.02	5.5	5.53	5.17	5.0	4.48	3.32	2.5	2.38	2.13	

7.	VC-10	S.L.	85.1		10.0	9.8	7.32	7.21	7.32	8.45	8.47	7.74	7.85	7.9	8.6	9.7	10.1
		F.L.		65	10.1	10.3	12.7	12.9	12.8	12.6	11.6	12.36	12.25	12.2	11.5	10.1	
8	VC-8	S.L.	87.12		11.05	11.1	8.2	8.02	8.03	9.22	8.96	8.92	9.05	9.15	9.9	11.0	11.07
		F.L.		65	11.07	11.02	13.88	14.1	14.09	12.90	13.16	13.2	12.07	13.0	12.2	11.12	
9	VC-6	S.L.	81.74		11.83	11.0	8.9	9.05	9.2	10.3	10.7	10.22	10.35	12.7	13.5	11.8	5.0
		F.L.		65	5.0	5.74	7.84	7.69	7.54	6.44	6.0	6.52	6.39	4.07	3.24	5.0	
0	VC-4	S.L.	82.42	~~15x35~~	15.35	15.2	11.72	11.5	11.43	11.89	11.7	13.63	13.8	13.15	14.05	15.2	2.0
		F.L.		65	2.0	2.2	5.7	6.0	6.0	5.53	5.7	3.79	3.6	4.27	3.37	2.2	
1.	5-VD	S.L.	81.64		15.0	14.9	13.05	11.6	11.52	12.77	13.0	13.45	13.58	13.95	14.75	15.05	1.64
		F.L.		65	1.64	1.74	3.6	5.0	5.12	3.87	5.64	3.19	3.06	2.69	2.89	1.59	
2.	7-VD	S.L.	79.82		12.45	12.4	9.35	9.48	9.52	10.52	10.85	12.25	12.39	12.9	11.50	12.23	2.37
		F.L.		65	2.37	2.42	5.47	5.34	5.3	4.3	4.0	1.57	2.43	2.0	3.32	2.6	
3.	VD-9	S.L.	79.88		13.4	13.28	10.98	10.78	10.73	11.8	11.73	12.05	12.17	12.85	12.6	13.27	1.4
		F.L.		65	1.4	1.60	4.0	4.10	4.11	3.08	3.15	2.83	2.71	2.03	2.28	1.61	
4.	PQ-3	S.L.	80.4		6.4	5.6	5.35	5.1	5.05	5.04	5.22	5.37	5.45	5.45	5.9	6.43	9.0
		F.L.		65	9.0	9.8	10.05	10.3	10.35	10.34	10.18	10.03	10.0	10.0	9.5	9.0	
5.	PQ-4	S.L.	79.34		12.34	11.6	11.6	10.55	10.88	12.25	12.48	12.57	12.69	13.0	13.5	13.92	2.0
		F.L.		65	2.0	2.7	2.7	3.99	3.46	1.09	1.86	1.77	1.65	1.34	0.84	0.42	

TABLE-22

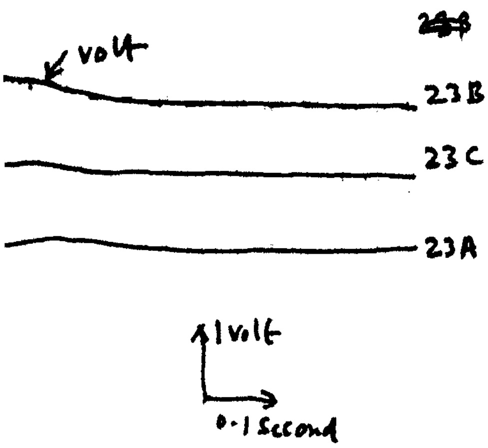
AQUIFER RESPONSE AT THE NODES IN VOLT/METER FROM ANALOG MODEL

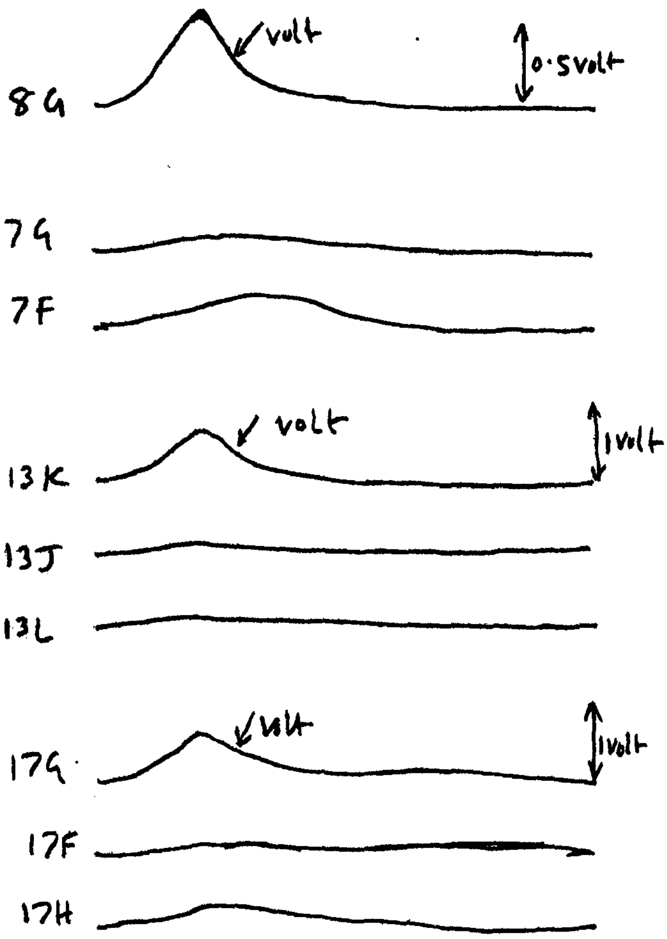
Nodal Area No.	Datum in mts.	MONTHLY READINGS IN VOLT/METRE												
		Initial level	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May

$K_2 = 2$ metre/volt

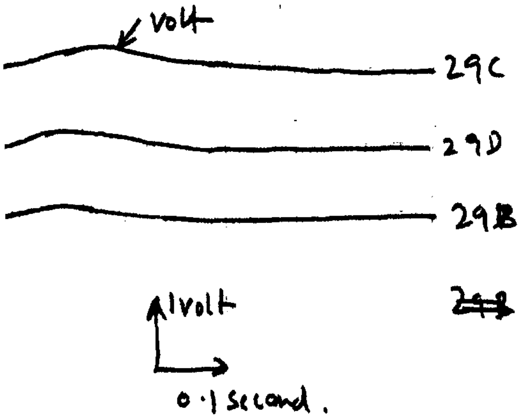
NODAL POINTS	INITIAL LEVEL VOLTS
23B	5 volts
30H	"
26B	"
16E	"
29C	"
39C	"

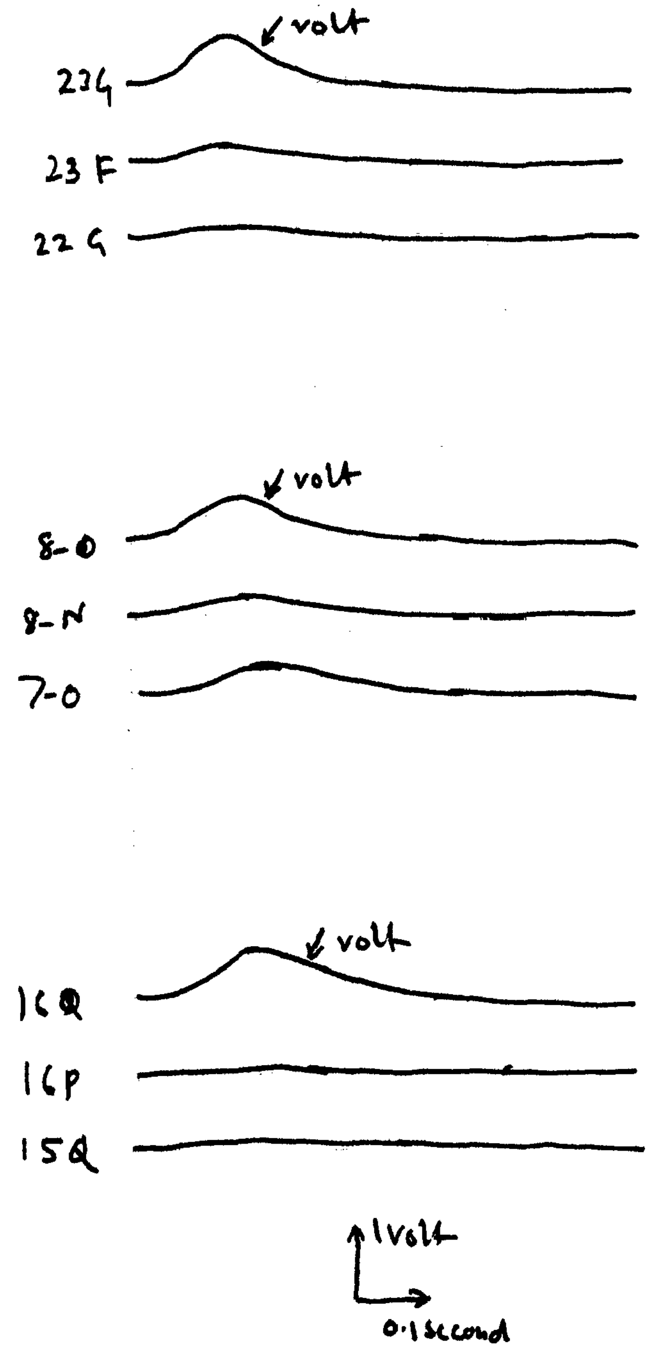
NODAL POINTS	INITIAL LEVEL VOLTS
17G	7 volts
13K	"
16Q	"
23G	"
8-0	"
8-G	"





K2=2meter/volt

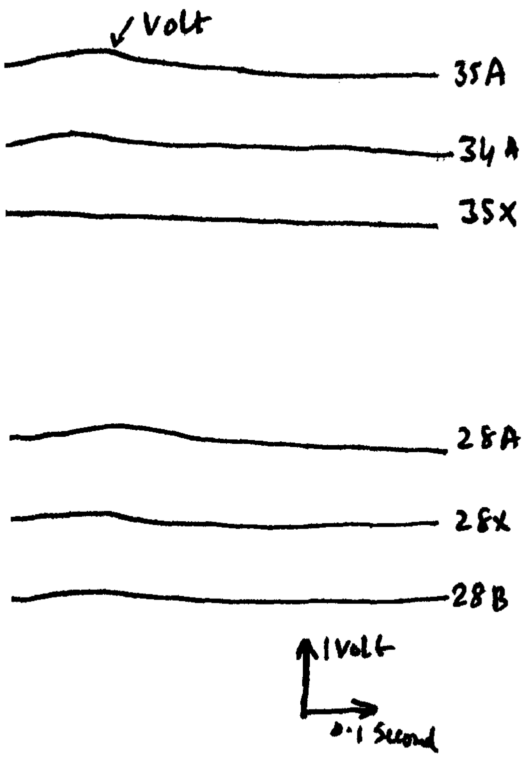


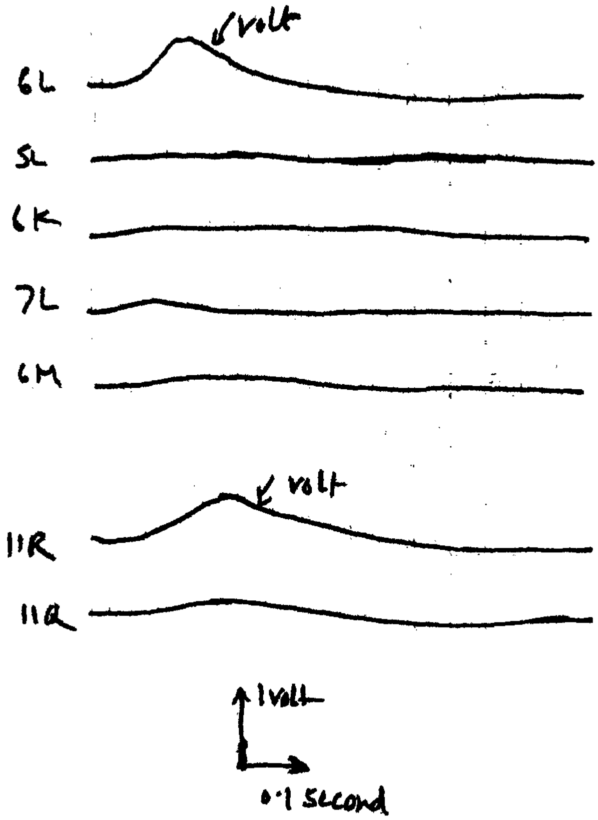


$K_2 = 2$ metre/volt

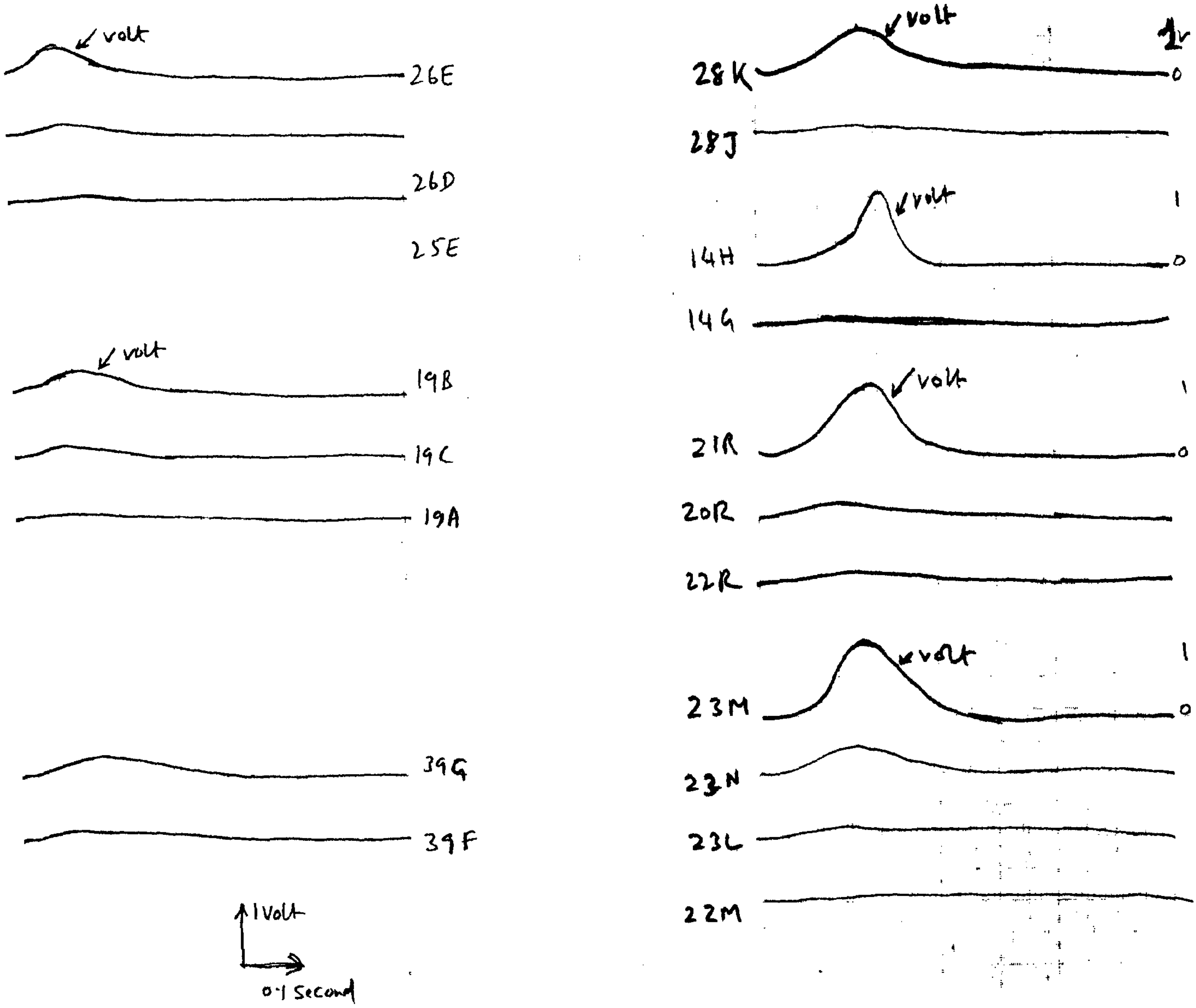
NODAL POINT	INITIAL LEVEL IN VOLT
39G	1·5 volt
28A	"
19B	"
35G	"
26E	"
35A	"
14G	"

NODAL POINT	INITIAL LEVEL IN VOLT
23M	8 volt
14H	"
21R	"
6-L	"
28-K	"
11-R	"

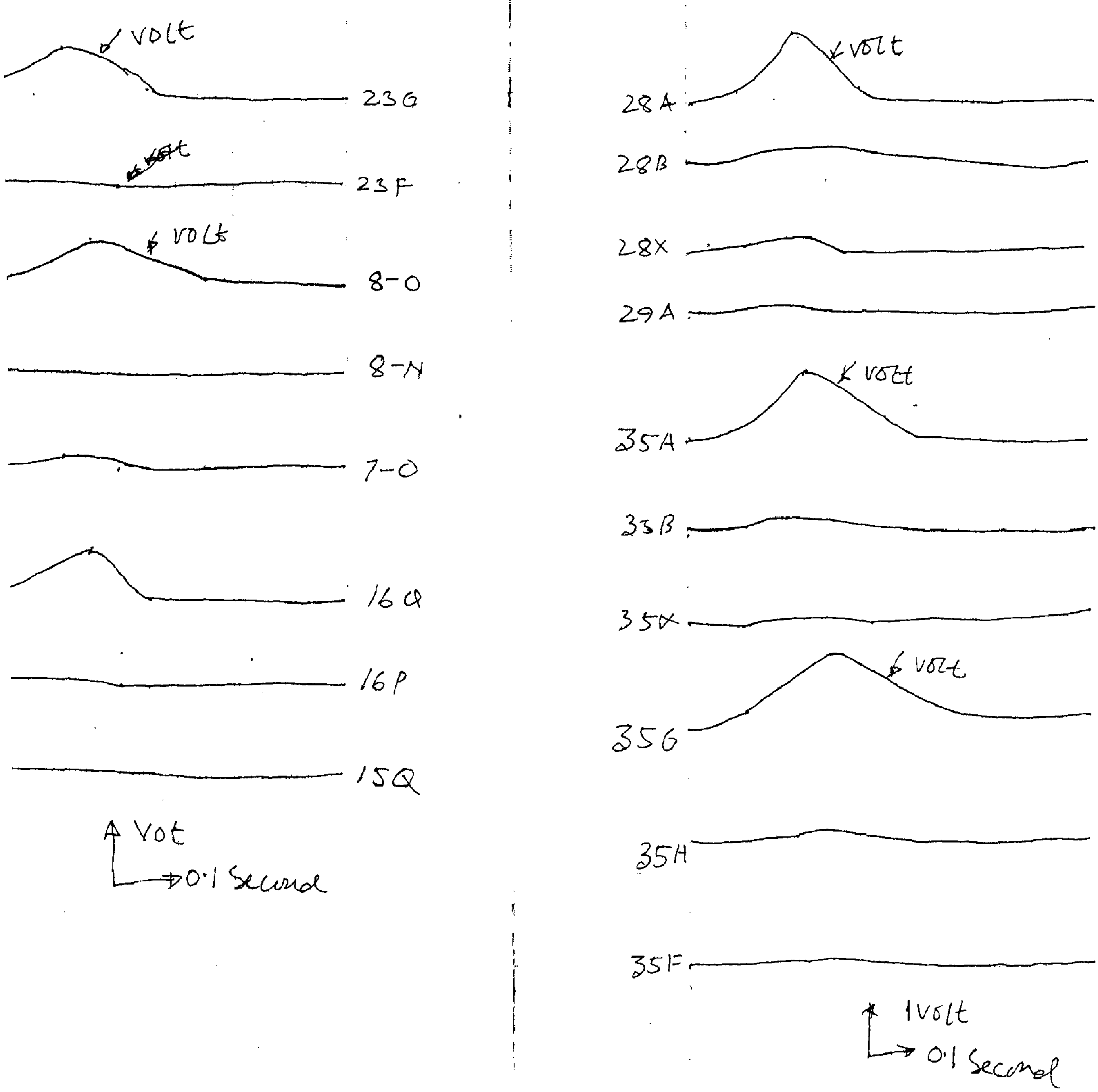




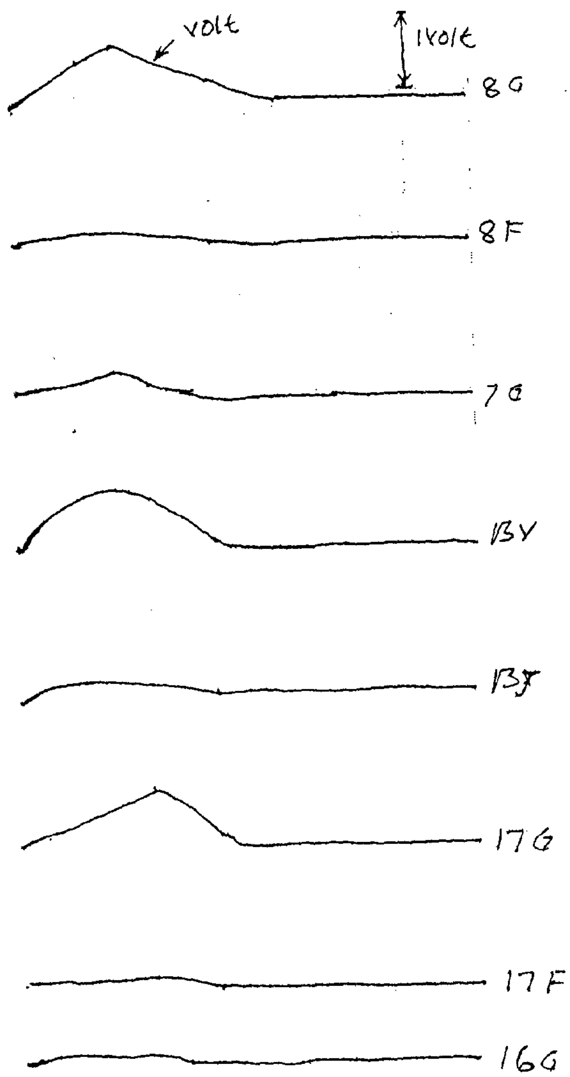
K_2 = 2 meter/volt.



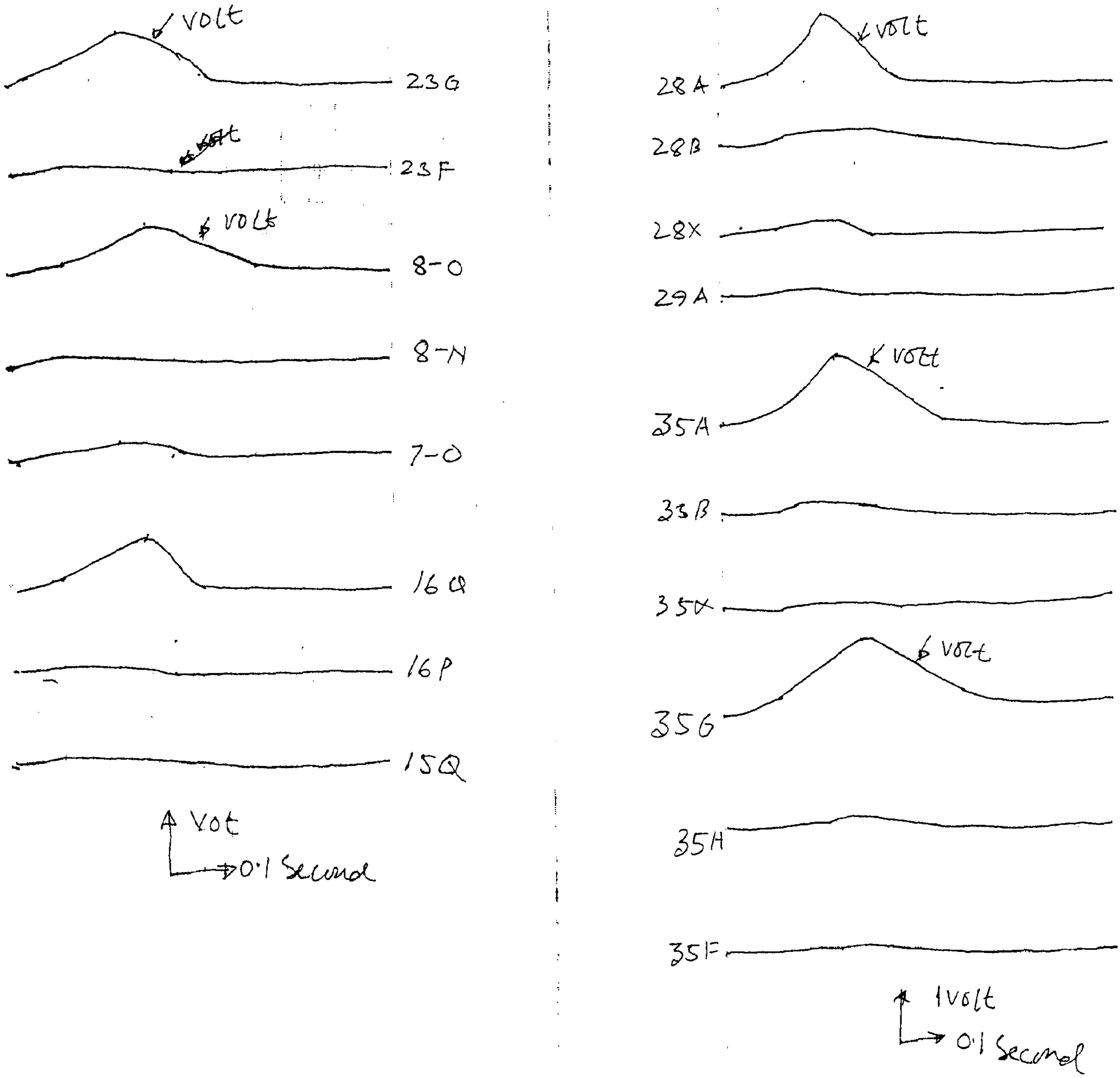
K_2 = 2 metre/volt



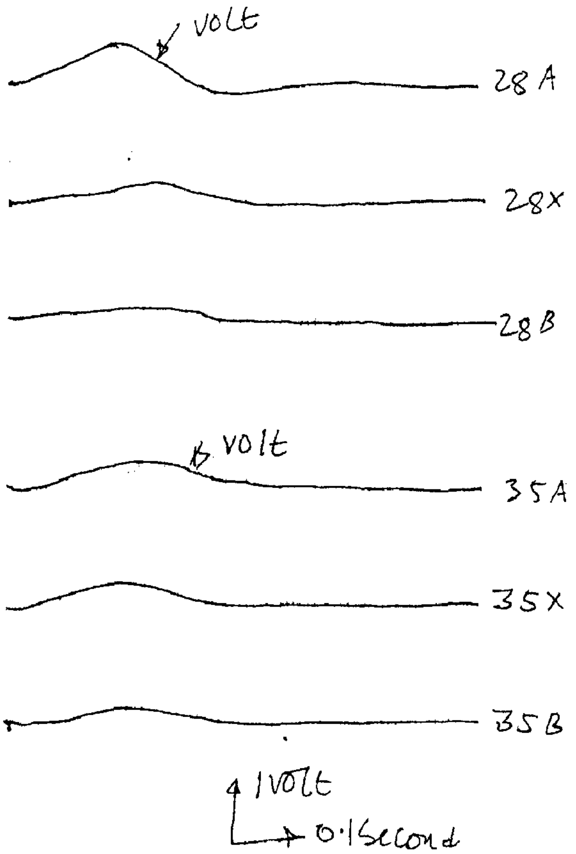
K_2 = 2 metre/volt

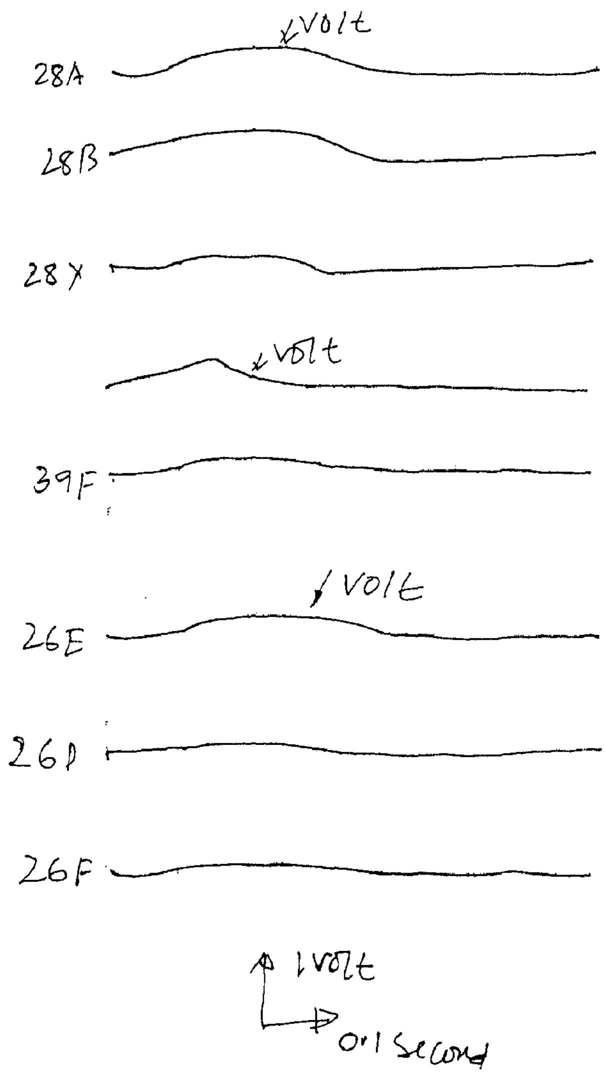


$K_2 = 2$ metre/volt

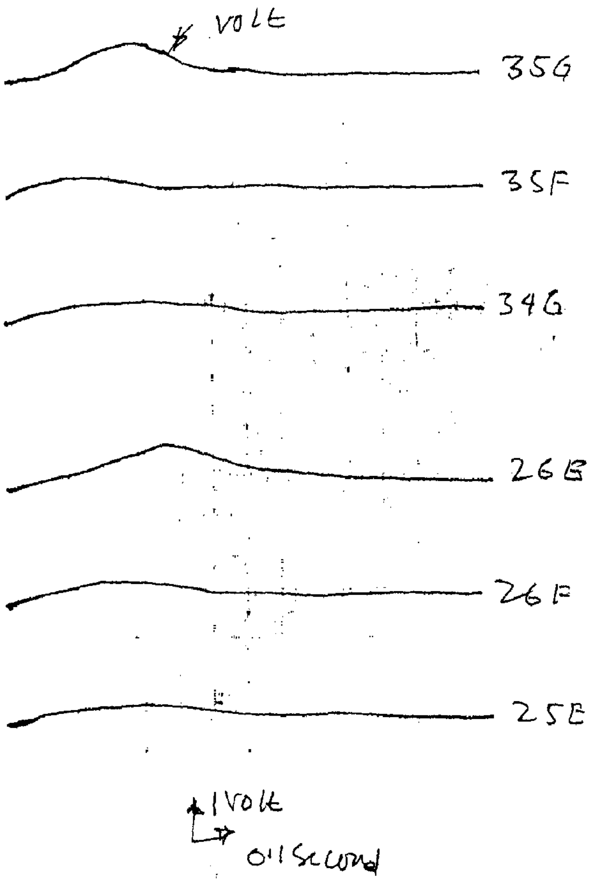


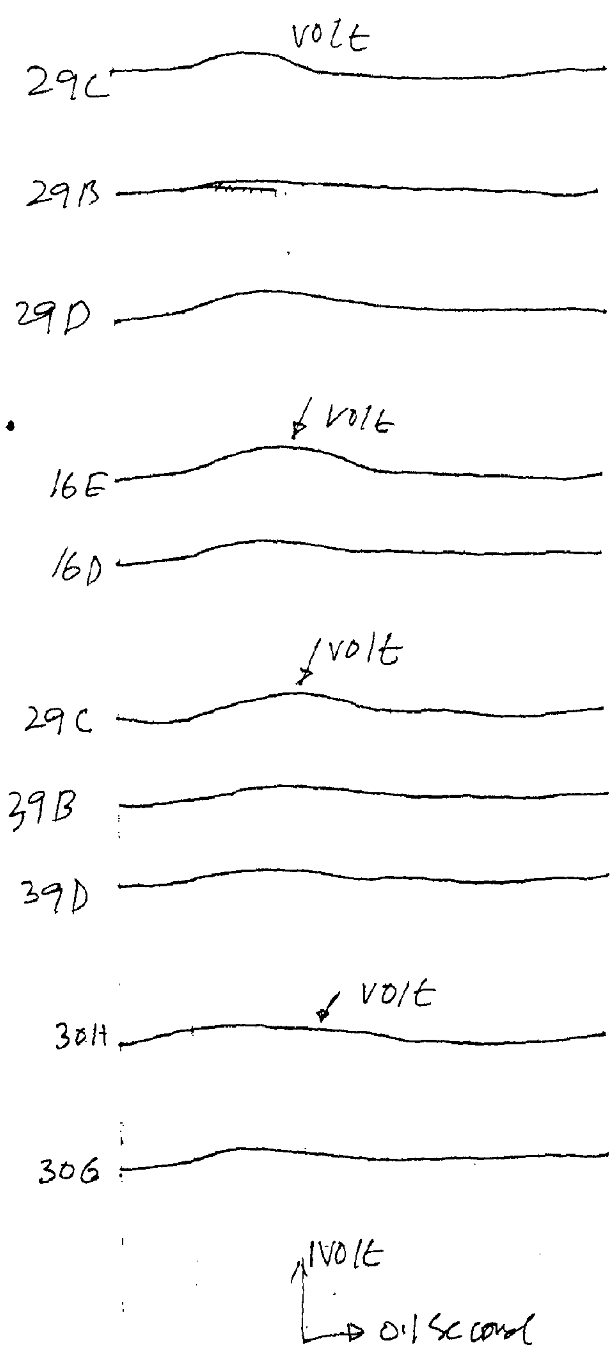
K_2 = 2 meter/volt



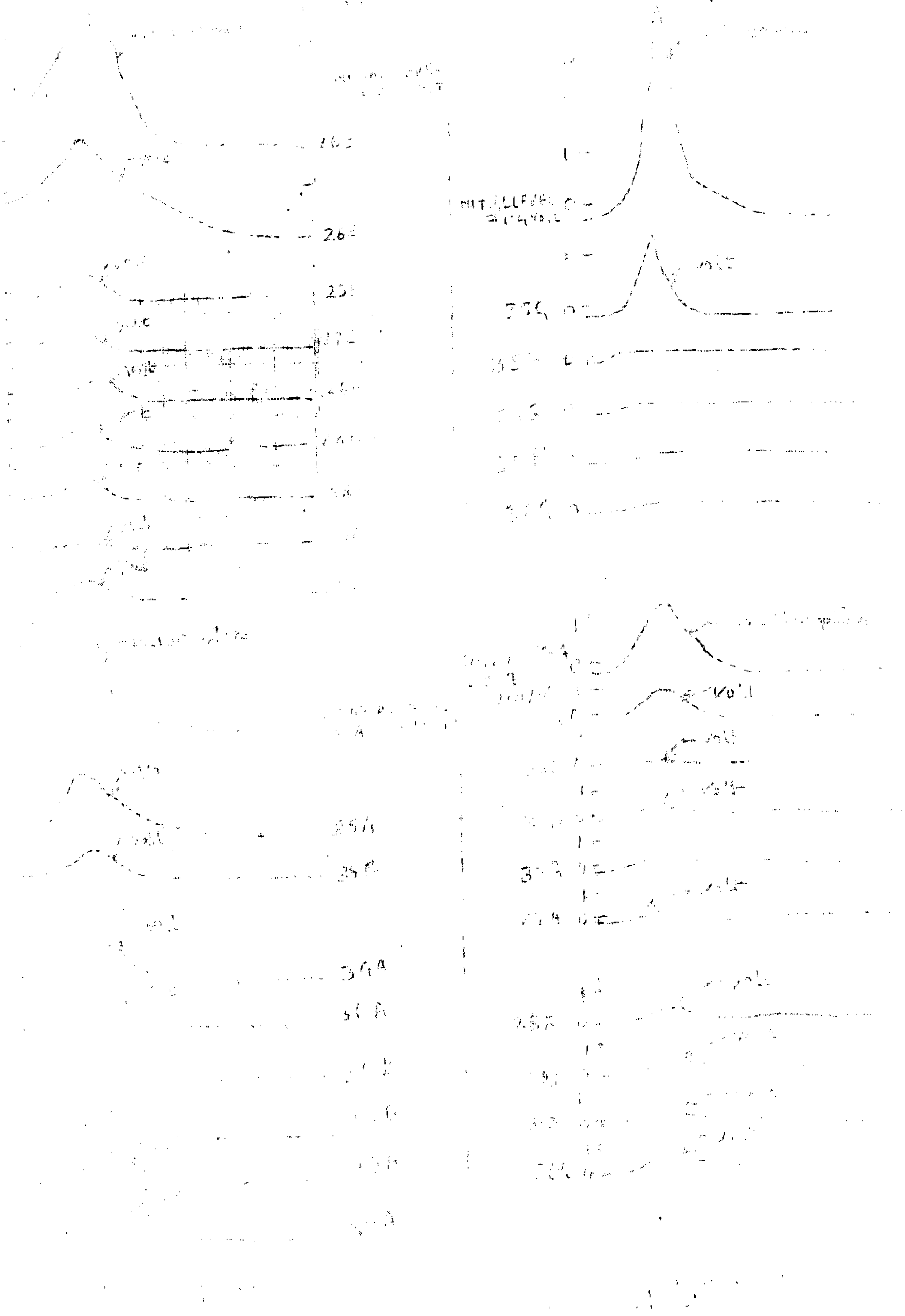


$K_2 = 2$ metre/volt

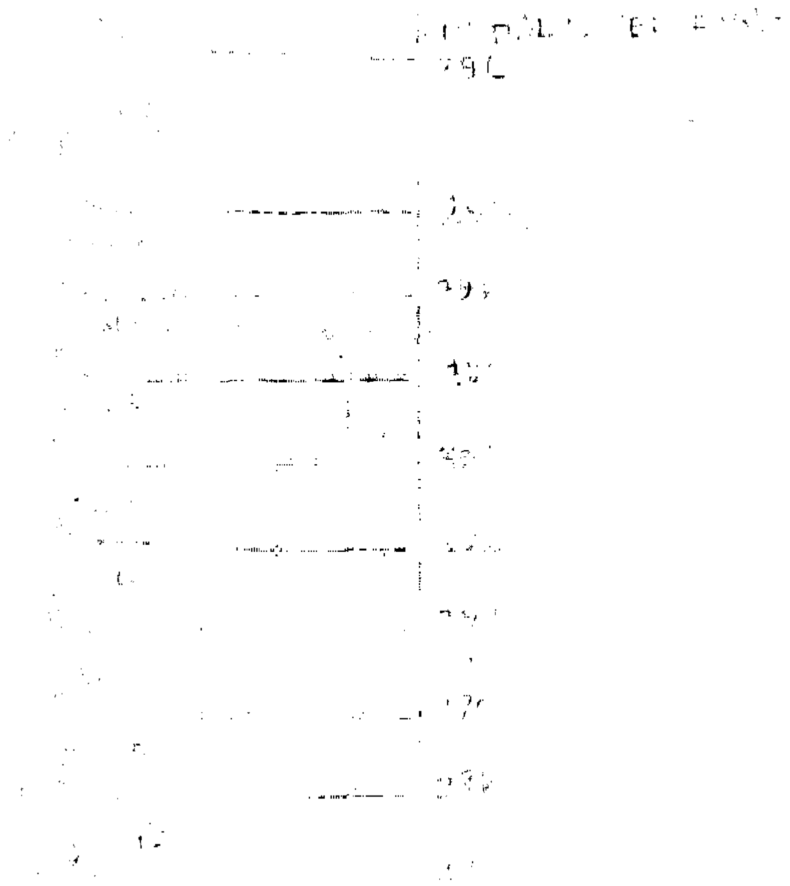




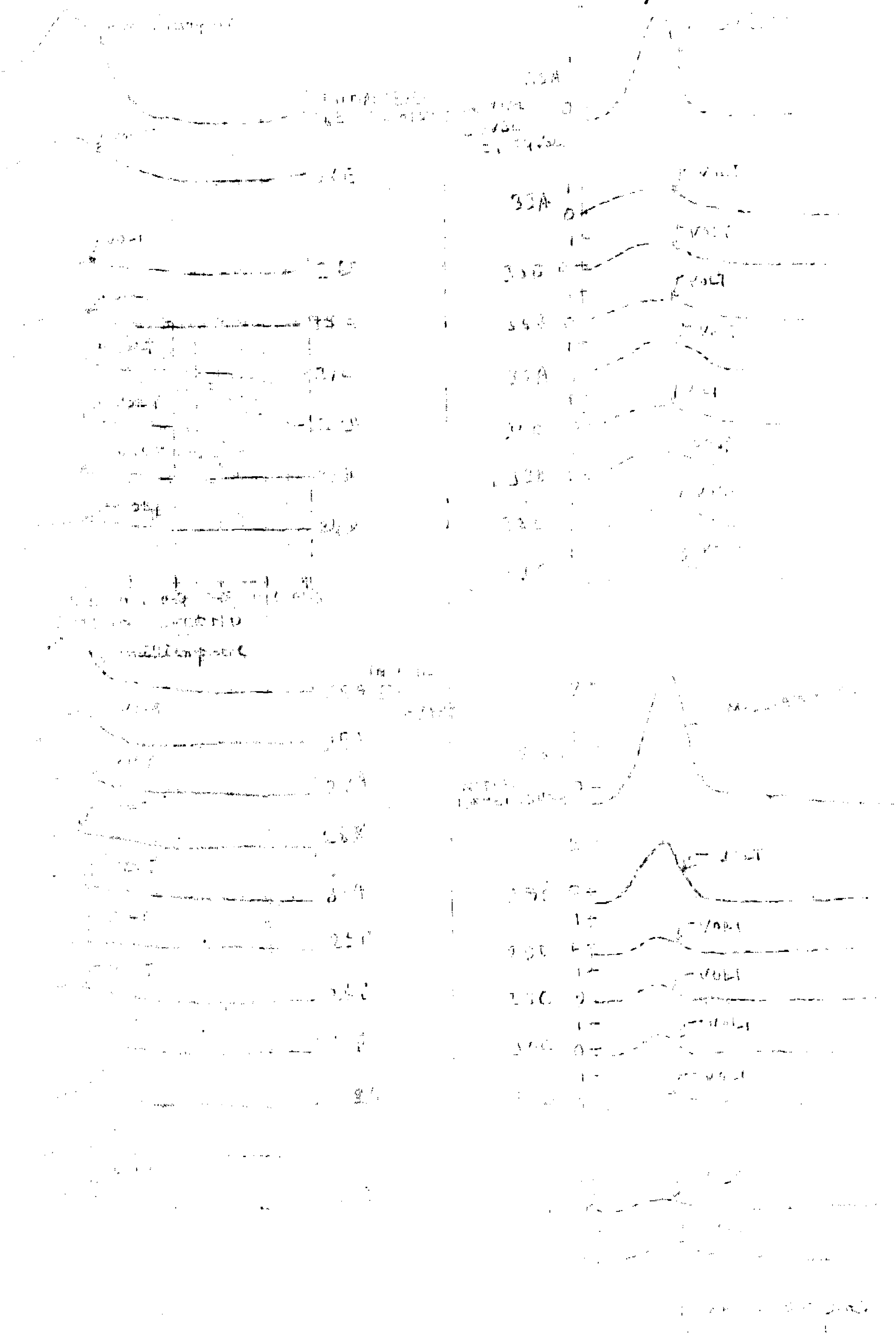
k_2 = metre/volt



K_2 = meter/volt



K2 = meter/volt



K_z = meter/volt