MODELING OF GROUND WATER FLUCTUATION IN A SMALL WATERSHED.
(A CASE STUDY OF EMILUGI CATCHMENT AREA OF NIGER STATE)

BY

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PGD AGRIC ENGR.

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A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF POST GRAUATE DIPLOMA IN AGRICULTURAL ENGINEERING.DEPARTMENT OF AGRICULTURAL ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE. NIGERIA.

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CERTIFICATION

This is to certify that this project work Modeling of ground water fluctuation in a small water shed. (A case study of Emilugi catchment area of Niger State) was conducted and presented by Umaru Emmanuel Ibrahim of Agricultural Engineering Department, Federal University of Technology, Minna, in partial fulfillment of the requirement for the award of Post graduate Diploma in Soil and Water Engineering.

APPROVED BY

Signature: ....
ENG'R N. A. EGHAREVBA

Date 27th Jan, 2000

Project supervisor

Signature: ....
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HEAD OF DEPARTMENT

Date..................

DEDICATION

The project work is totally dedicated to my loving Darling dear Late Mummy Mrs. Mary Galadima Egwa for she had a wrongful prefect peaceful heart, which she demonstrated until death. Mummy rest in perfect peace with the Lord.

We all missed you.

ACKNOWLEDGMENT

I wish to express my unreserved and sincere gratitude to Almighty God who made it possible to me to reach this time and do this work. All thanks and glories are totally His.

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Remain blessed for this success is as a result of your collective contributing effects.

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ABSTRACT

This project work titled modeling ground water fluctuation in a small watershed, and is a case study of Emilugi catchment Area in Niger State.

It is aimed at studying the ground water fluctuation at the same time plant growth. Maize was used on a four ridges of (50cm x 50cm) area and the planting was done on ridge top which happens to be the ridges height, while piezometers were used to read ground water fluctuation. Plant height, leaf area and groundwater fluctuations were monitored at an interval of (7) Seven days.

Four piezometer's at different ground level were monitored on this study.

Modeling expression finally arrived at will help advice any farmer, if the possibility of cropping more than ones and the period putting into consideration the ground water fluctuation in this area.

The Modeling expression is: -

$Y=A+BX+CX^2$

Where Y = the forecast' A = intercept, B = Gradient, C = constant ,$A = \Sigma Y-(\Sigma X^2)/N$

$B = \Sigma XY/ \Sigma X 2$, $C = \Sigma X 2 Y-A (\Sigma X 2) /\Sigma x4$

CHAPTER ONE

1.10 INTRODUCTION

1.11 BACKGROUND OF STUDIES

The area under study happens to fall within the middle belt region of Nigeria, with its unique character of low and higher variable rainfall, air temperature and high evaporation. This area is Emilugi a little water shed very close to Badeggi that houses the full main National Cereals Research Institute. The soils are poorly structured while rainfall is scarce and non-uniform plants grow and reproduce in response to an interaction of dynamic and ever exchanging of components in their environment. To increase productivity, the fluctuation of water within the soil profile and the proportion that remains in the root zone for the plants to utilize appears to be amore crucial limitation than the total rainfall, thus the study or modeling.

In this light modeling the water fluctuation is particular important if rational strategies are to be formulated for plant growth several times within a season or at any chosen period with or without rainfall playing the dominant role.

1.12 GROUND WATER

Any water below the soil surface could be term ground water. This water occupies voids in the soil. Capillary action of water table enables it to reach the root -zone of plants, which serve as the major sources of water for plant growth, while for water to be most effective without harm to plant growth ground water should be as near but below the depth few which the needed portion the plants water needs are extracted.

Thus this work is focused on modeling the ground water fluctuation vice-Sa-vise the growth of crop(s) maize. On or around this small water shed Emilugi – a demonstration farm own by National Cereals research Institute (NCRI) Badeggi, Niger State, Nigeria project site location art.

1.13 PROJECT SITE LOCATION

This small water (the project site) is located 8km away from Bida, along Bida – Lambata – Izom – Suleja express way. This same site is under Bida Local Government Area.

Geographical location this site is situated between latitude 90 45N and longitude 6 7" and stand at about 70.57m above sea level with its wet season spanning from May to October while the dry season runs from November to April.

This water shed is a demonstration from used by NCRI that was established by Agricultural Research Institute order of 1975 then in Ibadan and later moved to its present location at Badeggi. Crops growth here include rice, maize, cowpea, and sugar cane.(Idris 1997)

1.14 PURPOSE OF THE PROJECT.

(i) To monitor the ground water table fluctuation at the water shed (project site).

(ii) To monitor plant grown (maize) with reference to the ground water table fluctuation.

(iii) To model the ground water fluctuation in this watershed.

1.15 PROJECT JUSTIFICATION.

(i) To monitor the fluctuation of ground water in the water shed .

(ii) To inform farm of the possibilities of growing this crop (maize) within the water shed several times in a season.

(iii) To advice farmers also on the best period to do this cropping.

(iv) To advice on irrigation periods and frequency, from seasonal fluctuation of water table.

CHAPTER TWO

2.10 LITERATURE REVIEW.

2.11 SITE GEOLOGICAL FORMATION AND WATER RESOURCES.

As reported in a final report on Niger State Regional planning by Max Lock Group Nigeria Limited (1980), the geology of Niger State is divided into two distinct geological zones: - (I) the basement and (ii) the Nupe sand stone.

The border line is a straight line from North West to South East orientation from about South of Kontagora the present Local Government Area Headquarters to North of Lapai the Headquarters influential factors of the existing settlement distribution within this geological formation.

i. THE BASEMENT COMPLEX ZONE.

The greater part of the area is underlined by the basement complex is composed of banded genesis and migmatrites. The meter-sediments comprise schist, Philips, quartz and marbles. The metamorphosed representatives of ancient sediments such as days, sandstone and limestone's. The terrain of the Basement complex varies from small area of plain through large area of underrating land scope to several scarped slopes and rocks. The Basement determines crops of the farm. However, crops like cowpea, groundnut Soya beans and pigeon pea are planted to replenish the soil.

Complex terrain exhibits a fairly dense pattern of rivers. However they are of only marginal valves in that the majority area perennial while some are very seasonally. Indeed only those with very large catchment area are perennial. The Rajin, Kagara, Minna, Pandogari Kuta and Suleja area are conspicuous example of these features.

II THE NUPE SANDSTONE.

This consist of weekly cemented fine to coarse grained days, silt stones and sandstone with locally interceded thin beds of carbonaceous sheets. Lenses of conglomerate and pebbly sandstone also occur particularly near the contact with the underlying Basement rocks.

Generally the terrain of this type is much more hospitable than the Basement complex. Topography present fewer constraints. The river network in this zone is closely related to the permeability of the geographical formation which varies from high in the northwestern are to the low area in Kutigi-Bida-Agaie areas. Rivers are less common on the Nupe sandstone zone than in the Basement complex but are usually perennial.

2.12 HYDROLOGICAL CYCLE.

The circulation of water between the earth and atmosphere play the most important role in the existence of the living being.

The direct effect of the solar radiation over water bodies, (ocean, lakes, rivers) and soil cause evaporation. The release vapor is transported over the continent by moving air masses under proper and favorable conditions the vapor is cool and condensed. It condenses to visible water droplets, which form cloud or fog that finally result into precipitation.

The greater part is temporarily retained in the soil where it falls and eventually will return to the atmosphere by either evaporation or transpiration by plants action.

Some portion find its way over and through the soil to the river or stream, while other penetrate further with the soil to form part of ground water under the influence of gravity both surface and ground water move toward lower elevation and may eventually discharge into the ocean.

About two-third of the total precipitation is returned to the atmosphere by evaporation and through transpiration by plant.(See Fig 2.10)

2.13 PRECIPITATION.

This includes all water that falls from the atmosphere to the earth's surface. This occurs in a variety of forms. Liquid precipitation Rainfall or Solid Precipitation Snow.

2.14 EVAPORTRANSPIRATION.

This is a combination of two words Evaporation.

This is the process by which molecules of water on earth surface or mist soil acquires enough solar energy to change it state from liquid to gaseous and escape to the atmosphere as water vapor.

This is the process by which plant loss water into the atmosphere.

2.15 RUN-OFF.

This term is usually considered along site stream flow and is the sum of surface run-off and ground water flow that reaches the streams. Surface run-off amounts to

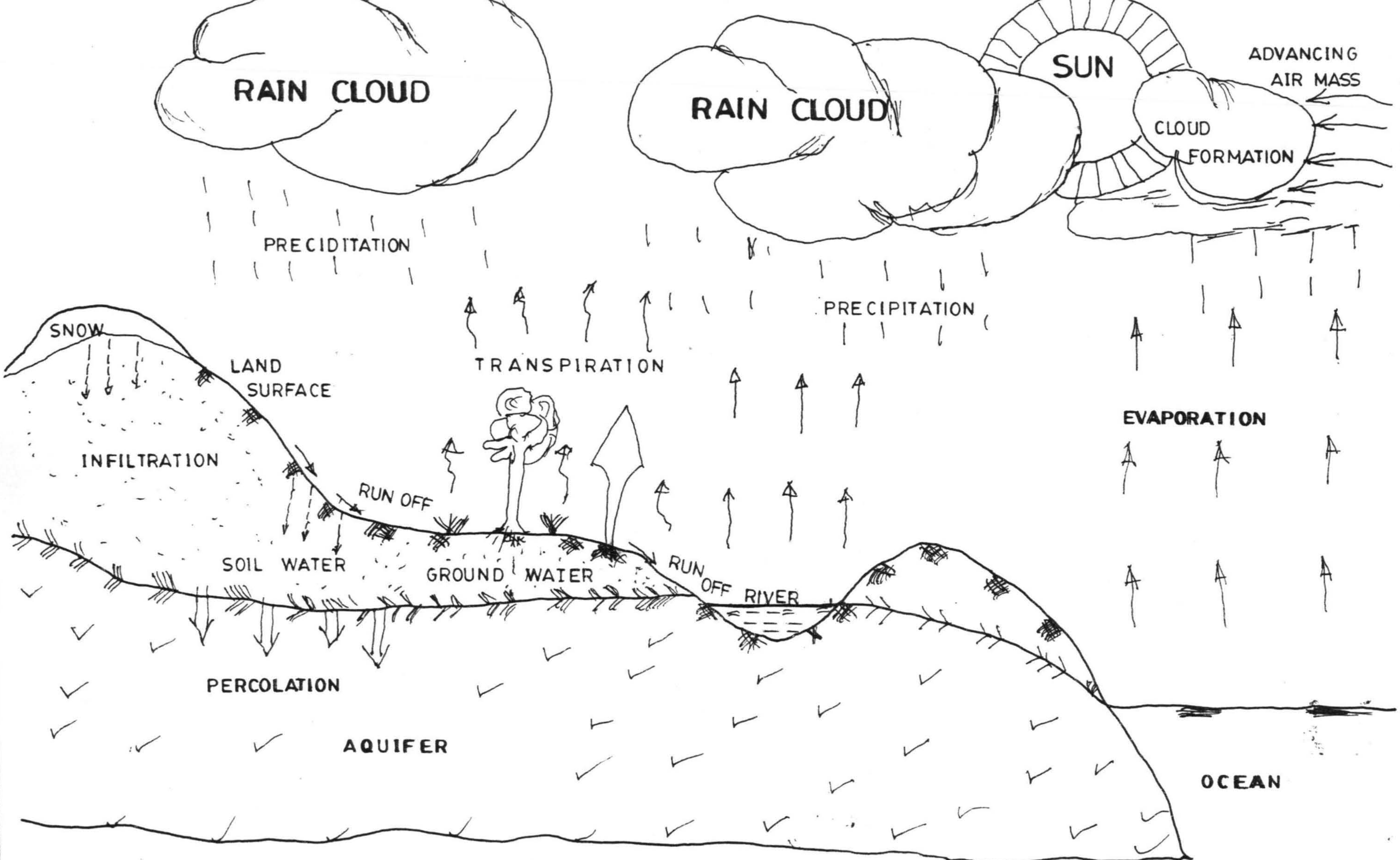

FIG 2.10 :- THE HYDROLOGIC CYCLE

precipitation less surface retention. Infiltration is the passage or down ward movement of water through the surface of the soil.

Expression of these following explains some factors that determines the amount of surface run off from a given area for a time period of chosen: -

a. Surface run-off water gains – water loses – water storage.
b. Water gain – precipitation, condensation and absorption.
c. Water losses = percolation, evaporation and transpiration.
d. Water storage = interception storage surface storage.

2.16 GROUND WATER

.This is the tension – free continuous mass of water below the soil surface. It fills all the process of the materials in which it occurs the surface or top of the groundwater becomes the ground water table. It can be found by drilling a test above hole.

Some unique ground water cases exist above each other, where extensive buyers of impervious materials occurs.

The upper ground water masses are known as perched ground water, and this level change with the season. It is usually high in the wet season and low during the dry season. The capillary fringe of ground water is held by the soil under tension and its therefore soil moisture and not ground water.

Capillary fringe explains the water in the buyer of soil or sub soil into which groundwater enters due to capillary rise.

The direct value of ground water to plants depends on whether roots can reach the capillary fringe. Whether this can be so or not is determined by the depth of the water table, the rate and extend of capillary rise, the ovation of the soil and crop nature is established alfata, corn and other deep rooting plants that benefit from ground water.

2.17 IRRIGATION.

This can be explained as the application of water to soil for the purpose of supplying the moisture essential for plant growth. But in a broader and more inclusive manner irrigation can be explain as the application of water to the soil for any number of the following points: -

i. To add water to soil to supply the moisture essential for plant growth.

ii. To provide crop insurance against short duration droughts.

iii. To cool the soil and atmosphere thereby making more favorable environment for plant growth.

iv. To reduce the hazard of frost.

v. To wash out or dilute salts in the soil.

vi. To soften tillage pans and clods.

vii. To de bud formation by evaporative cooling.

The following are irrigation types: -

1. By flooding
2. By means of furrows
3. By sub-surface irrigation
4. By sprinkler method
5. By Trickily system.

However the possible sources of irrigation water are: -

1. Precipitation
2. Atmosphere water other than precipitation
3. Floor water
4. Ground water
5. Irrigation.

Consideration should be given to all sources and the proportion of water that each supply to total plant needs may results in faulty design of an irrigation scheme. In some cases one or more sources will supply the major portion of water plant needs.

2.18 DRAINAGE.

This is the removal of excess water from the agricultural land.

Adequate drainage of crop producing lands requires a general covering of shallow water table. In some valleys the higher lands don't require drainage while drainage is needed in the low valley land.

Drainage and irrigation should be complemented practices; the necessity for changes being increased by low efficiencies in the conveyance and application of irrigation water.

2.19 BENEFITS OF DRAINAGE.

1. Aids early plowing and planting.
2. Lengthens the crop-growing season
3. Provides more available soil moisture and plant food by increasing the depth of root zone soil.
4. Aids soil in ventilation and leaches excess salts from farm soils.
5. Decreased solid erosion gulling, by increasing water infiltration into soil.
6. Assures higher soil temperature.

2.20 SOURCES OF EXCESS WATER.

Seepage losses from reservoirs or canal and deep percolation losses from irrigation land are major sources of excess water that make drainage necessary on plants from irrigation lands. Correct water application on the higher irrigation lands reduces the need for drainage of the lower lands.

Flooding of low lands due to overflow of rivers and natural drainage channels during period of maximum streams flow constitute important sources of excess water in certain low valley area. In Some area flow is largely downward through highly permeable surface soil to relatively impermeable sub-soils. In other area unconfined or free ground water may flow under small hydraulic slopes. In yet other areas the major source of excess water may be upward flow from an atestion aquifer. Ground water and subsoil investigation are needed tools to wisely design a good drainage system.

2.21 CONTROL OF WATER SOURCE AND GROUND WATER.

A very large amount of water is lost during conveyance about 40% of water conveyance lost. This seepage reaches the water table and causes it to rise. Lining canals to reduce these loses should be encourage lining of the irrigation canals to prevent seepage losses and more efficient application of irrigation water to reduce area eliminate deep percolation. Water losses may result in a satisfactory lowing of the water table in these areas, thus removing the need for drainage a good drainage. The following methods can be used to lower ground water table: -

1. Open channel drains
2. Covered clay or concrete pipe
3. Pumping ground water.

2.22 RECHARGE

Critical shortage of underground water due to limited natural recharge, small storage capacity and over use have stimulated effort to recharge ground water reservoirs with surface waters. Flood, which would otherwise have been lost, are diverted and applied to the land, thus providing water to seep into under-ground reservoir.

Full conservation and use of available water requires an integrated use of surface and subsurface waters and storage facilities. Water percolates into the ground water reservoir to be stored until needed for irrigation.

2.23 MOISTURE CONTENT

Measurement of water stored in soils and capacity of soil to store water are important. Some soils produce crops despite the lapse of many days, sometime weeks, between rainfall period, which is evidence of their ability and capability and capacity to store available water since all growing plants require water when needed.

In irrigated regions the capacity of soil to store available water for the use of crop growth is of special importance and interest for the depth of water to be applied in each irrigation, and the interval between supplying both influences the storage capacity of the soil.

A sound idea of the capacity of soil to retain available irrigation water is also essential for efficient irrigation. If the irrigation supplies more water than the root zone soil reservoir can retain at single irrigation, the excess water is wasted and when application is less the plants wilt from lack of water.

In the light, it is important to find the available water capacity for any soil plant or crop to be grown.

Methods available are:

i. Appearance and feel of soil
ii. Gravimetric determination
iii. Using electrical properties of a porous block.
iv. Tensionmeters.
v. Neutron method.

For this particular work the Gravimeter method will be used to determine the availability of moisture content. Using the expression as proposed by Black (1965) as a percentage of dry weight thus can do this: -

$$Md = \frac{Ww}{Wa} - x\ 100 \quad \ldots\ldots 1$$

Where Ww = Wet weight of soil

Wa = Dry weight of soil

Md = Moisture content expressed as percentage of dry weight of dry weight.

While

$$Mv = Md \times As \quad \ldots\ldots 2$$

Where

Mv = Available Moisture holding capacity

As = Apparent specific gravity of soil so

For $Mv = Md \times As$

$$As = \frac{Mv}{Md}$$

While

$$d = \frac{Mv}{100} \times D \quad \ldots\ldots 3$$

where

d = Available water to plants

d = depth of soil.

When expression 11 & iii are combined

$$D = \frac{Md}{100} \times As \times D \quad \ldots\ldots 4$$

2.24 BULK DENSITY.

This is defined as the ratio of the mass of dry particles to the total volume of soil (including particles and pores).

$$D1 = \frac{Ms}{Vt} = \frac{Ms}{v + va + Vw} \quad \ldots\ldots 5$$

Where D1 = Bulk density.

Ms = Mass of dried soil

Vt = Total volume

Va = Volume of air

Vw = Volume of water.

The term dry bulk density and apparent specific gravity are often used synonymously whereas the term specific gravity denotes a dimension has quantity, bulk density is expressed in grams per centimeter cubic or mass per unit volume.

The structure, texture and compatibility of the soil influence the apparent specific gravity. It is an important soil physical property and considering it influence the water holding capacity of soil and soil hydraulic conductivity.

Looking at this issue like when like when the bulk density of medium to fine texture subsoil exceeds say 1.7glcc, the hydraulic conductivity values will be so low that drainage may becomes difficult.

Total (wet) bulk density: - Wet bulk density is the mass of moist soil per unit volume

Thus: -

$$Dbt = \frac{Mt}{Vt} - \frac{Ms + Mw}{Vs + Va + Vw} \quad \ldots\ldots 6$$

Where: - Dbt = Wet Bulk density

Mt: - Total mass of soil

Vt = Total volume of soil

2.25 POROSITY

This is defined as the ratio of the proves to the total soil volume.

Thus: -

$$\gamma = \frac{Va + Vw}{Vt} = \frac{Va + Vw}{Va + Vw + Vs} \quad \ldots\ldots 7$$

Where

γ= Porosity.

Porosity is an index of the relation volume of pores. It is influenced by the textural and structural habit of the soil. Michael (1985). The porosity of sandy soils usually ranges from 35 to 50 percent, while that of clay soil 40, to 60 percent. The move finely divided the individual soil particles are the greater the porosity.

2.26 WATER HOLDING CAPACITY.

1. The moisture content of a sample of soil is usually defined as the amount of water lost when dried at 105c,

Expressed either as the weight of water per unit weight of dry soil or is the volume of water per unit volume of bulk soil.

Although using such knowledge is not a clear indication of the availability of water for plant growth. The differences is always there between because water retention characteristics may be different from one soil to the other Michael (1985).

About half of soil volume is pore space, which is occupied by varying amounts of water and air with respect to the degree of wetness.

Water is held in the pore spaces in form of films adhering to the soil particles. The smaller porous in the small are known as micropores and the larger ones the macropores do not hold water properly for the water films becomes too thick to adhere well to the surrounding soil particles. In this light drainage's takes place within macropores while water holding ability occur within micropores.

Hence:

My = Md x As as in...................... 2

2.27 HYDRAULIC CONDUCTIVITY.

Permeability and conductivity are frequently used interchangeably. The characteristics that determines how air and water moves through soils defines what permeability is. The rate of water movement through soil is determined by the least permeable horizontal how plans or natural clay plans reduces the permeability of a soil.

The permeability of soil is defined as the velocity of flow caused by a unit gradient and this is an important point of difference between permeability and infiltration.

Permeability is influenced by most physical properties. An unsaturated soil, the moisture content is one of the dominant factors influencing permeability. Vaugh (1979).

Henry Darcy (1956) describes water flow through porous medium and whose report on the infiltration of water flowing through a sand bed for an improved supply.

The work by Henri Dany showed that the flow of water through a column of saturated sand is proportion to the different in hydraulic head at the ends of the column, and inversely proportional to the length of the column.

This expression known as Darcy Law is expressed as: -

$$V = \frac{K(h_1 - h_2)}{L} \quad \ldots 8$$

Where V = Velocity of flow m/s or m/h or m/day

K = Hydraulic conductivity, with Respect to the properties of the Sand and the liquid {m/day}.

H_1-h_2 = difference in hydraulic head in meter (m).

L = distance along the flow path between The points h1 and h2 in meter (m).

Definition with the difference in hydraulic head ($h_1 - h_2$) all over distance L, along the flow path that fluid flows is the hydraulic gradient is, hence

$$V = ki \quad \ldots 9$$

Sometimes the quantity of flow may be of greater interest than the velocity.

Hence in term of quantity of flow Henri Darcy Law can be expressed as: -

$$Q = av = ki\, a \quad \ldots 10$$

Where

Q = Volume of water discharged in saturated length of time usually expressed as m^3/day.

A = cross-sectioned area through where water passed or moved is m^2.

The value of K can be obtained from the laboratory test of my sample formation by the constant head perimeter.

- khile and Dirksan (1986).
- With a constant head maintained by either continuous inflow or frequent addition of water, steady flow through the soil is obtained.
- Darcy's Law or flow of water in soils is applied for the computation of permeability after measuring volume of flow in unit time across a sectional area-a- at right angles to flow, loss of hydraulic head hi.

So

$k = \underline{QL}$ (cm/hr) ...11

Ah1

Where

L = flow length

A = cross sectional area at right angles to flow

h_1 = loss of hydraulic head.(Idris 1997)

2.28 INFILTRATION.

This is defined as the rate water enter soil when not limited by the rate of supply when measured in the field with water either ponded on the surface or falling on it artificial or national rain at a rate sufficient to cause run off and expressed in m/s.

Three ways of estimating infiltration characteristic of a soil are: -

-I. Water entry rate into soil as measure in the field this intake rate"

II. Measurement of subsidence of free water in a large basin.

-III Estimation of accumulated infiltration from the water from advance data.

CULTIVATION AND MANAGEMENT

2.29 PLANTING PATTERN

Planting patterns have direct effect on yield solar energy capture and evaporation and thus has an indirect effect on water use efficiency.

Two important planting pattern practices are: -

i. Plant density.

ii. Row spacing.

For maize production the agronomic density and spacing 75cm x 75 or 90cm x 20cm at a rate of 55000 plant per hectare. Widely spaced crop rows are avoided. Harrowing of rows generally means a uniform distribution of plants over a given area; thus making the plant canopy more effective in intercepting of solar radiation energy while shading weeds. An added advantage is the reduction in raindrop impact on soil structure in the surface layer. In general dwarf varieties of this crop – maize benefit more from narrow rows than tall, late maturity varieties.

2.30 WEED CONTROL

One of the main management means of obtaining more efficient water use is the elimination of weeds in crops. Weeds complete with crops for soil nutrient, water and light. But in high rainfall areas the primary concern is the water factor because the water requirement of weed compared to nutrient requirement is greater than that of crop plant.

When the weed is taller than the crop then will be completion for light while completion for water begins when the root systems of the weed and crop overlap. Suitable techniques for efficient weed control, both mechanical and chemical have been developed which should be awaited in increasing water use efficiency of maize – Michael (1980).

2.31 TILLAGE

Tillage influence crop yield and water use efficiency. The principal effects of tillage are the preparation of seed bed conducive to the germination of seed and growth of seedling conservation of soil moisture in irrigated areas by its influence on infiltration characteristics of the soil and providing adequate soil depth for optimum root growth, proper placement of seeds and fertilizer in the soil and intercultivation of weed control.

2.32 FERTILIZER APPLICATION.

This is applied to increase yield; it increases water use efficiency. An increase in crop yield produced by increasing soil fertility does not produce a corresponding increase in evaportranspiration some of the practices essential for the efficient use of fertilizers.

i. Soil test of evaluate the nutrient deficiency in the soil and use of the proper quantity.

ii. Placement of fertilizers in the soil properly

iii. Split close application of the fertilizer at suitable time intervals rather than bulk application at one time,

iv. Controlled application of water to avoid leaching of fertilizers in deep percolation below crop root 30w.

2.33 WATER REQUIREMENT.

The estimation of water requirements (wr) of crop is one of the basic needs for crop planning on the farm and for planning of water budget. Water requirement may be defined as the quantity of water, regardless of its source, required by crops for their normal growth under field condition at a place. Water requirement includes contribution from any of the sources of water.

The major sources being irrigation water IR, effective rainfall PE, and ground water contribution GW. This is expressed as: -

WR = 1R + PE + GW0

2.34 FIELD WATER BALANCE.

The water balance of a field is an itemized statement or algebraic summation of all gains losses and changes of storage of water occurring in a given field within specified boundaries during specified period up time.

The task of monitoring and controlling the field water balance is vital to the efficiency management of water and soil. A knowledge of the water balance is necessary to evaluate the possible method to minimize losses and maximize gain and utilization of water which so often the limiting factor in crop production.

This is expressed as: -

(Gains)-(Closes)= [change in storage] field water balance,

Rathone (1990).

Those: -

NWR=(P-Ro)+1+Ds=ET + Pc.................................12

Where: -

NWR = Nut water requirement

P = Prevention

Ro = Surface run off.

DS = Change in ground water contribution or soil water content.

ET = Evapotranspiration

Pc = Percolation.

Note that change in soil water content (Ds) can be obtained from the expression:

(P+1)-(ET+Pc+Ro)= +Ds 13

The positive sign indicates a down ward direction of ground water flow. While the negative sign of Ds indicates an upward movement of ground water flow and its amount refers to the ground waterfluctuation.

$$Ds = P - NWR$$ Michael (1985).

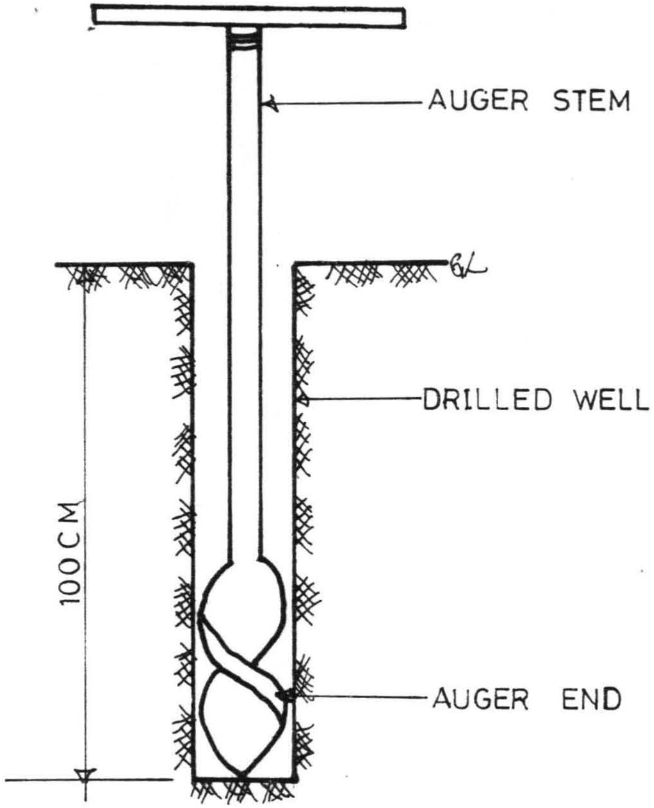

FIG 3:06 :- HAND DRIVEN AUGER

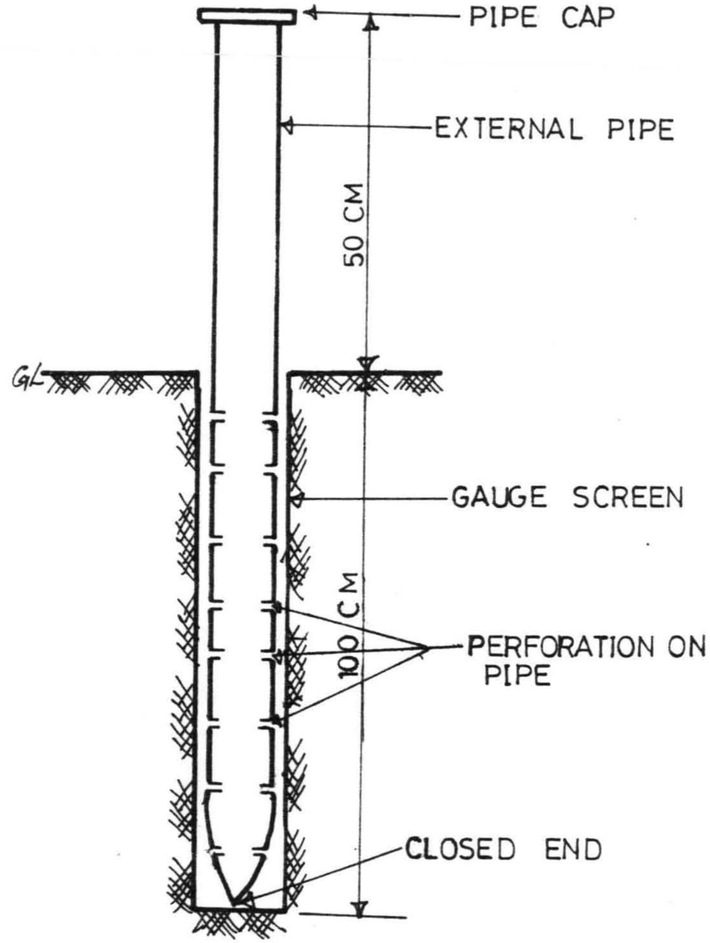

FIG 3:07: CROSS SECTION OF CONSTRUCTED PIEZOMETER PIPE

CHAPTER THREE

3.10 RESEARCH METHOD

For this project work – modeling of ground water fluctuation in this watershed, the methods used ranged from site layout and field experiments, making of ridges, planting and installation of peizometer and plant measurements to survey work were carried out.

3.11 SURVEY WORK.

The materials used in making out squares and peizometer position was done using pegs cutlass, dumping level range pole and staff, also measuring tape was used to position twelve peizometers pipes.

3.12 INSTALLATION OF PIPES.

Cutlass was used to clear the points of installing pipes and a hand driven auger of length 1.5m and screw diameter of 5cm was used to drill the hole to a meter depth.
The pipes are conduct pipes of with diameter 4.5cm and cut out length of 1.5m and 1m is allowed to be below the ground level. Radial perforation of about 2cm apart across the length of the pipe to allow sufficient and effective inflow of ground water into the pipe. (See Plate B)

3.13 EXPERIMENTAL SITE LAYOUT.

The project site is located along Bida Lambata-Izom-Suleja Express Road at about 8km from Bida, with an area spreading across a valley formation of about 160m in width (breadth).
The first row of peizometric pipes installed were 7 in number at distances 30m from each other. The second row housed 3 pipes installed at distance 6cm apart while the third row housed 2 pipe installed at distances 40m apart.(See Contour Map of Water shed)

3.14 METHODS OF INVESTIGATION.

The first set of pipes were installed on the 3rd May 1996 and the second a year after while the third now were installed in 1998 by Mr Friday and Ndagi Baba who equally worked on this water shed.
Reading were taken at 7 days interval.
A straight long wooden plank (Dip Stick) ruled on the edge along the length with chalk was inserted in the installed piezometer pipe ensuring that the stick touches the bottom of the pipes and allowed to stay for few moments, so as the water in the pipe dissolve the chalk ruling to its level. This point is now held against the standard meter rule and read of as height of water in that well. This is then subtracted from 100cm to give the actual reading, given the level of water beneath ground surface.(See Fig 3.07)

CHAPTER FOUR

RESULTS AND DISCUSSION OF RESULTS.

4.10
4.11 PLANT HEIGTH & LEAF AREA ANALYSIS

After the date (6/3/99) of the crop (maize) the weekly plant measurement started after a week. Measurements of both plant height and leaf area were carried out.
The plants showed a steady plant growth pattern between the second to the fourth week
This also continued to the12 Th week when the growth pattern becomes uniform.
This extended to the day of harvest. The plant height was 165 cm while the leaf area was72 cm(See Table4.42), while Table4.41 illustrated the plants pattern.
The mean of each plot (plants were growth on plots of six (6) plants per plot, all showed uniform growth pattern with weeks 1 to 4 as been the slowest while the increase in growth was noticed between weeks 5 to 12 till the harvest week or day.

4.12 GROUND WATER FLUCTUATION

Ground water was at its lowest during this planting period (Experimental period) recorded water level was about 50cm below the ground level.
Few weeks after planting irrigation was applied on weekly basis-about 4 liters of water was applied to each plant stand directly to the plant base.
After three weeks this was stop and the plant used the available moisture within the water shed until the rain came in later.
Ground water level slowly increased from the April till the harvest in May'1999. (Table 4.21 and Table4.20)

4.13 MODELING GROUND WATER FLUCTUATION FORECASTING USING INDEX METHOD.

A set of data depending on the time is called time series or a collection of reading belonging to different time period – Ye Lun Chan.(1984)

Mathematically a set of observation taken at specific time usually at equal interval so that Y is the function of time.

i. This method helps in the analysis of past behaviour of a variable.
ii. It helps in forecasting
iii. It helps in evaluation of current achievement.
iv. It helps in making comparative studies

The changes in the values of a variable related to time can be as a result of a large variety of factors and the analysis is to enable us understand the dynamic conditions.

The values (Y) of a phenomenon observed at any point of time (t) is the net effect based on few

categories of components:- viz trend, seasonal variation.
Irregular variation.
Secular trend refers to the general tendency of the time series data to increase or to decrease or to remain segregated during a long period of time. It describes the long-term tendency of a phenomenon; a steady movement are long time.

If the value of the phenomenon under study when plotted on a graph paper cluster more or less around the straight line the trend is said to be a straight line. Here the values increase or decrease by a constant amount.

If the plotted parts do not fall in the pattern of a straight line, the trend is said to be non-linear or non curve – linear. The growth rate is uneven.

For linear

$Y = a + bx$

Where $a = \Sigma Y\text{-}(\Sigma X^2)/N$

$B = \Sigma xy / \Sigma x^2.$

The X – codes are such thatΣ x=0, a and b are parameter of the mode/obtained by least squares curterion which seeks to minimize the sequences.

Y denation from the centre.
Y is the observation while t is time limit.

The exponential trend come for trend value is give by

$Y = A. B^x$

And

$\text{Log } Y = \log A + X\log B$

And $\log A = \frac{\Sigma \log y}{N}$

And $\log B = \frac{\Sigma(x \log y)}{\Sigma X^2}$

Other growth curves are

Y = Kabx

Where log Y = log k + (log a) bx

The equation of logistic curve is

$$1/Yc \quad = \quad k\ y\ abx$$

The use of trend is to help product the behaviour of the variable over the time corresponding period.

Another method of forecasting such time series date later over a period of time (seasons of the Year) is the use of seasonal index which helps to measure seasonal variation.
The purpose is to isolate the effect of seasonal factors (or to find the effect of seasonal forces on the data) and also to eliminate these effects from the series.

The model is $S = \frac{\tau s c I}{\tau c I} \times 100$

One method of studying seasonal variations is the method of simple average or percentages and the relation is given by

$$I = \frac{Nt}{\mu_G} \times 100$$

Where μ_t is the mean per unit of time

μ_G is the grand mean

If $I \geq 100$ this implies a higher performance (or higher level) as the case may be (here water level above the ground).

4.14 THE PARABOLIC CURVE.

The parabolic curve is sometimes used when the linear trend cannot give a satisfactory results. If a curve of second degree whose form is given as

$$Y = a + b\,x + cx^2 \qquad \ldots\ldots 1$$

Where x is the unit of time

Y is the actual observation a b c are the parameters of the model derived by the relations shown below:-

$$A = \Sigma Y - (\Sigma\, x^2) / N \qquad \ldots\ldots 2$$
$$B = \Sigma\, x\, y / X^2 \qquad \ldots\ldots 3$$

$$C = \Sigma\, x^2 y - A(\Sigma\, x^2) / \Sigma\, X4 \qquad \ldots\ldots 4$$

4.15 DERIVATION OF *X* VALUES

1 . Observation, Y=F(t)

Y is a function of time t in months, years, season .For this work the time t is in months i.e

January Febuary .... December.

The observation value Y={y1......y12}

The valid value t =

We transform months into quantity by giving coded values.

i. Procedure of coding

If n is odd the middle month takes zero as the code value.

It increase by one step for succeeding months (time) and reduces one step for the proceeding months (time).

The origin can start at any point in time. However, preference is given to middle time as origin as it sums-up to zero and reduces the computation burden.

Say

January	-2	
February	-1	
March	0	
April	1	
May	2	For n = Odd

If n is even, there is a particular point in time to four which the code can be assigned. In the other words, the origin falls between two time points t, t+1, so that the natural origin is t + t since defined but must take it into consideration we assign odd – codes increasing or decreasing by two steps beginning with 1 or –1 from the origin as follows:

Jan,	F	M,	A	M	J	J	A	S	O	N	D
-11	-9	-7	-5	-3	-1	1	3	5	7	9	11

Note:- Months are nominal value and nominal values are not amenable to analytical computation except they are transformed.

The transformation allows the effect of months to be analysed.

4.16 THE FORECAST (Y) CURVE.

The recorded ground water fluctuation (table 4.2) showed the actual ground water fluctuation.

This work span one year i.e. one season of 12 months this covers the period between June 1998 to May 1999.

The Y forecast is done per piezometer (Pie 5, 6, 7, 8). The ground water reading are on table 4.2 and 4.2 while graph sheets 4.10, 4.11, 4.12 and 4.13, shows the forecast fluctuation based on the forecast expression used i.e.

$Y = A+BX-CX^2$

$A = \Sigma Y - (\Sigma X^2) / N$

$B = \Sigma XY / X^2$

$C = \Sigma X^2Y - A(\Sigma X2) / \Sigma X^4$

(Refer table 4.6 and table 4.61)

Graph sheets 4.20,4.21,4.22,4.23, compared the Y forecast with the actual Y of respective piezometers (piezometers 5,6,7,8.)

This is in line of showing the trend or effect of the actual water fluctuation with that of the modeled fluctuation.

TABLE 4.12					
YIELD (g/m2) OBTAINED AFTER 14 WEEKS AFTER PLANTING.					
PLOTS					
	PLOT 1	PLOT 2	PLOT 3	PLOT 4	
PT I	132.7	176.2	70.8	194.2	
PT II	161.1	181.1	58.4	128.8	
PT III	141.2	162.4	98.9	180.2	
PT IV	160	188.5	54.2	190.5	
PT V	150	0	0	0	
PT VI	40.4	0	0	0	
MEAN	130.9	118.033	47.05	115.62	
NOTE:PT=====>PLANT					

TABLE 4.2

WEEKLY GROUND WATER MEASUREMENT (CM)

Jul-98	PIE5	PIE6	PIE7	PIE8
WEEK 1	72	74	86	72
WEEK 2	72	75	86	72
WEEK 3	74	76	88	74
WEEK 4	76	76	88	76
MEAN	**73.5**	**75.25**	**87**	**73.5**
Aug-98	PIE5	PIE6	PIE7	PIE8
WEEK1	76	76	88	78
WEEK2	78	78	88	78
WEEK3	80	82	88	80
WEEK4	82	82	90	82
MEAN	**79**	**79.5**	**88.5**	**79.5**
Sep-98	PIE5	PIE6	PIE7	PIE8
WEEK 1	84	84	92	84
WEEK 2	84	86	94	86
WEEK 3	86	90	96	90
WEEK 4	90	96	100	96
MEAN	**86**	**89**	**95.5**	**89**
Oct-98	PIE5	PIE6	PIE7	PIE8
WEEK 1	100	100	100	100
WEEK 2	100	100	100	100
WEEK 3	100	100	100	100
WEEK 4	100	100	100	100
WEEK 5	100	100	100	100
MEAN	**100**	**100**	**100**	**100**
Nov-98	PIE5	PIE6	PIE7	PIE8
WEEK 6	95.8	96.5	97.8	88
WEEK 7	96.2	96.5	98.5	88.5
WEEK 8	90.5	96.5	98.6	89.5
WEEK 9	76.3	86.5	88.5	82.4
MEAN	**89.7**	**94**	**95.85**	**87.1**
Dec-98	PIE5	PIE6	PIE7	PIE8
WEEK 10	70	80	86.5	80
WEEK 11	66	76	82	76
WEEK 12	60	72	80	72
WEEK 13	58	68	78	70
MEAN	**63.5**	**74**	**81.625**	**74.5**
Jan-99	PIE5	PIE6	PIE7	PIE8
WEEK 14	52	64	70	66
WEEK 15	52	62	70	62
WEEK 16	52	60	68	60
WEEK 17	50	58	68	60
WEEK 18	50	58	68	60
MEAN	**51.2**	**60.4**	**68.8**	**61.6**

Feb-99	PIE5	PIE6	PIE7	PIE8
WEEK 19	50	54	68	58
WEEK 20	50	52	66	54
WEEK 21	50	52	66	54
WEEK 22	50	52	66	54
WEEK 23	50	52.5	66.5	55
MEAN	**50**	**52.5**	**66.5**	**55**
Mar-99	PIE5	PIE6	PIE7	PIE8
WEEK 24	58	62	70	58
WEEK 25	58	64	70	59
WEEK 26	58	67	72	60
WEEK 27	58	69	72	60
WEEK 28	58	69	74	60
MEAN	**58**	**66.2**	**71.6**	**59.4**
Apr-99	PIE5	PIE6	PIE7	PIE8
WEEK 29	60	69	76	64
WEEK 30	60	69	78	64
WEEK 31	62	69	78	65
WEEK 32	62	69	80	66
MEAN	**61**	**69**	**78**	**64.75**
May-99	PIE5	PIE6	PIE7	PIE8
WEEK 33	64	70	80	67
WEEK 34	64	71	82	68
WEEK 35	66	71	82	68
WEEK 36	68	72	84	69
MEAN	**65.5**	**71**	**82**	**68**
Jun-99	PIE5	PIE6	PIE7	PIE8
WEEK37	68	72	84	69
WEEK38	70	72	84	70
WEEK39	70	72	86	71
WEEK40	72	74	86	71
MEAN	**70**	**72.5**	**85**	**70.25**

PIE======PIEZIOMTER

TABLE 4.21

MEAN MONTHLY GROUND WATER(FLUCTUATION) MEASUREMENT

MONTHS	***PIE5***	***PIE6***	***PIE7***	***PIE8***
Jul-98	73.5	75.25	87	73.5
Aug-98	79	79.5	88.5	79.5
Sep-98	86	89	95.5	89
Oct-98	100	100	100	100
Nov-98	89.7	94	95.85	87.1
Dec-98	63.5	74	81.63	74.5
Jan-99	50	58	68	60
Feb-99	50	52.5	66.5	55
Mar-99	58	66.2	71.6	59.4
Apr-99	61	69	78	64.75
May-99	65.5	71	82	68
Jun-99	70	72.5	85	70.25

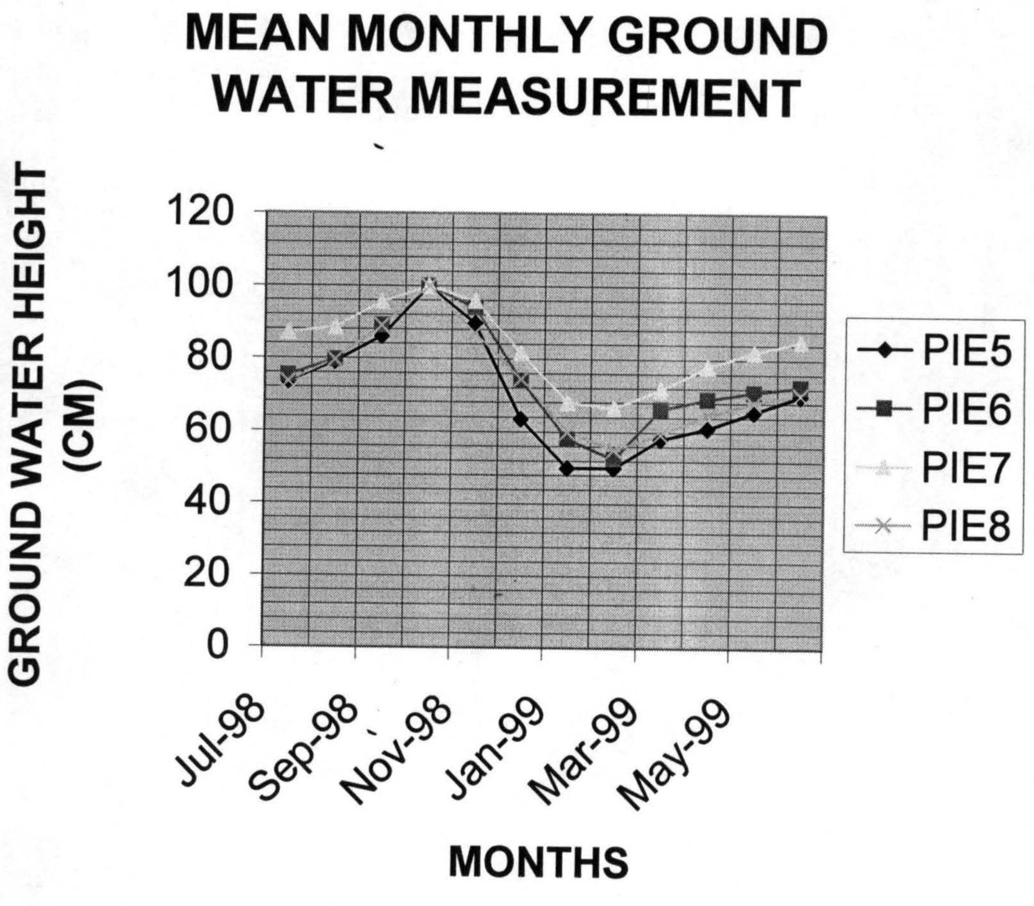

TABLE 4.41

WEEKLY MEAN PLANT HEIGHT/LEAF AREA MEASUREMENT

	PLOT 1		PLOT 2		PLOT 3		PLOT 4	
WEEKS	PH(CM)1	LA(CM2)I	PH(CM) 2	LA(CM2)II	PH(CM) 3	LA(CM2)III	PH(CM)4	LA(CM2)IV
1	5.17	6	4.5	3	7.3	8.5	7.2	8.6
2	10	13	8.25	12	11.3	12.83	10.2	13.8
3	15.5	19.35	12	15.75	15.5	19.33	14	16.8
4	23.83	32.17	18.25	32.25	25.8	39	16.4	30.2
5	36	41.83	31.25	42.5	36.2	49.4	30	34.4
6	53.83	53.83	46.75	51.5	48.2	52.2	39	47
7	71.67	65.17	62.125	60.75	64.2	60.8	47.1	50.4
8	81	66.67	93.75	66	69	62.4	51	50.6
9	91.67	67.83	117.5	71	73	65	56	53.6
10	112.83	71.33	153	77	87	69	56	54.4
11	127.5	73.5	158	77.5	115	72.25	101.6	57.4
12	138.33	75.85	158	80	135	77.5	112.5	67.5
13	138.33	75.85	158	80	135	77.5	112.5	67.5
14	138.33	75.85	158	80	135	77.5	112.5	67.5
15	138.33	75.85	158	80	135	77.5	112.5	67.5

NOTE:- PH => PLANT HEIGTH
LA=> LEAF AREA

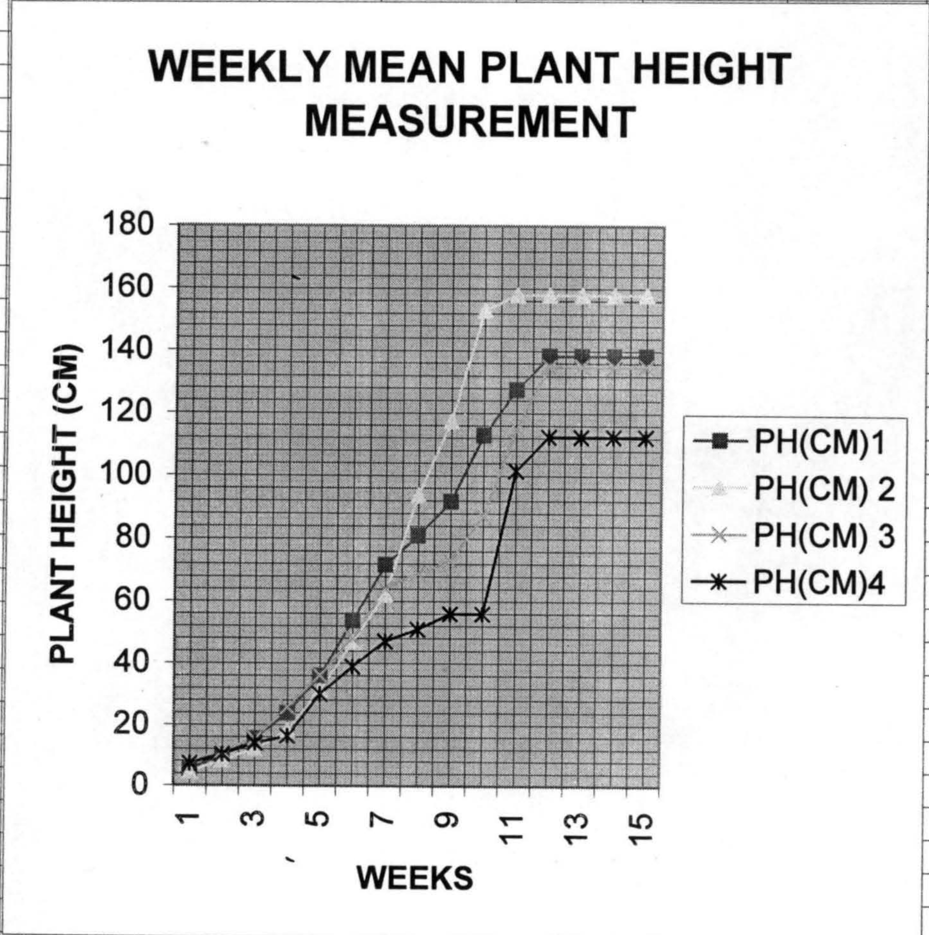

TABLE 4.42								
WEEKLY PLANT MEASUREMENT ON PLOT ONE (1)								
6/3/99	PLANTING DATE							
13/3/99	WEEK 1		20/3/99	WEEK 2		27/3/99	WEEK 3	
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	3	3	PTI	10	14	PTI	18	23
PTII	4	3	PTII	9	13	PTII	17	22
PTIII	4	5	PTIII	8	11	PTIII	13	16
PTIV	5	8	PTIV	10	14	PTIV	16	20
PTV	7	8	PTV	11	12	PTV	15	17
PTVI	8	9	PTVI	12	14	PTVI	14	18
MEAN	**5.16667**	**6**		**10**	**13**		**15.5**	**19.3333333**
3/4/99	WEEK 4		10/4/99	WEEK 5		17/4/99	WEEK6	
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	33	43	PTI	56	57	PTI	79	64
PTII	30	42	PTII	48	56	PTII	63	62
PTIII	23	33	PTIII	39	48	PTIII	59	60
PTIV	20	31	PTIV	27	33	PTIV	50	52
PTV	21	23	PTV	24	27	PTV	37	40
PTVI	16	21	PTVI	22	30	PTVI	35	45
MEAN	**23.8333**	**32.16667**		**36**	**41.83333**		**53.83333**	**53.8333333**
24/4/99	WEEK 7		1/5/99	WEEK 8		8/5/99	WEEK 9	
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	102	71	PTI	110	73	PTI	125	76
PTII	77	69	PTII	82	70	PTII	90	70
PTIII	78	71	PTIII	96	72	PTIII	115	73
PTIV	70	65	PTIV	80	71	PTIV	85	70
PTV	54	54	PTV	62	56	PTV	75	58
PTVI	49	61	PTVI	56	58	PTVI	60	60
MEAN	**71.6667**	**65.16667**		**81**	**66.66667**		**91.66667**	**67.8333333**
15/5/99	WEEK 10		22/5/99	WEEK 11		29/5/99	WEEK 12	
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	145	78	PTI	150	79	PTI	160	80
PTII	115	72	PTII	120	75	PTII	135	78
PTIII	130	75	PTIII	140	77	PTIII	145	79
PTIV	130	75	PTIV	145	78	PTIV	145	78
PTV	87	63	PTV	115	65	PTV	125	70
PTVI	70	65	PTVI	95	67	PTVI	120	70
MEAN	**112.833**	**71.33333**		**127.5**	**73.5**		**138.3333**	**75.8333333**
5/6/99	WEEK 13		12/6/99	WEEK 14		19/6/99	WEEK 15	
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	160	80	PTI	160	80	PTI	160	80
PTII	135	78	PTII	135	78	PTII	135	78
PTIII	145	79	PTIII	145	79	PTIII	145	79
PTIV	145	78	PTIV	145	78	PTIV	145	78
PTV	125	70	PTV	125	70	PTV	125	70
PTVI	120	70	PTVI	120	70	PTVI	120	70
MEAN	***138.333***	***75.8333***		***138.3333***	***75.8333***		***138.3333***	***75.8333333***

6/3/99	PLANTING DATE							
WEEKLY PLANT MEASUREMENTON PLOT TWO (2)								
13/3/99	*WEEK 1*		20/3/99	*WEEK 2*		27/3/99	WEEK 3	
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	4	3	PTI	**9**	**14**	PTI	17	23
PTII	5	3	PTII	10	12	PTII	13	15
PTIII	5	3	PTIII	7	10	PTIII	8	10
PTIV	4	3	PTIV	7	12	PTIV	10	15
PTV	0	0	PTV	0	0	PTV	0	0
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	***3***	***2***		***5.5***	***8***		***8***	***10.5***
3/4/99	*WEEK 4*		*10/4/99*	*WEEK 5*		*17/4/99*	*WEEK 6*	
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	21	32	PTI	40	46	PTI	55	60
PTII	22	40	PTII	41	50	PTII	46	52
PTIII	10	19	PTIII	11	27	PTIII	31	35
PTIV	20	38	PTIV	33	47	PTIV	55	59
PTV	0	0	PTV	0	0	PTV	0	0
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	***12.1667***	***21.5***		***20.83333***	***28.3333***		***31.16667***	***34.3333333***
24/4/99	WEEK 7		1/5/99	WEEK 8		8/5/99	WEEK 9	
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	69.5	74	PTI	82	70	PTI	95	82
PTII	52	56	PTII	86	72	PTII	120	80
PTIII	50	43	PTIII	52	52	PTIII	55	52
PTIV	77	70	PTIV	85	70	PTIV	105	70
PTV	0	0	PTV	0	0	PTV	0	0
PTVI	0	0		0	0		0	0
MEAN	***41.4167***	***40.5***		***50.83333***	***44***		***62.5***	***47.3333333***
15/5/99	WEEK 10		22/5/99	WEEK 11		29/5/99	WEEK 12	
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	110	88	PTI	175	88	PTI	175	88
PTII	130	80	PTII	160	82	PTII	160	82
PTIII	75	65	PTIII	115	65	PTIII	135	75
PTIV	155	75	PTIV	162	75	PTIV	162	75
PTV	0	0	PTV	0	0	PTV	0	0
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	***78.3333***	***51.3333***		***102***	***51.6667***		***105.3333***	***53.3333333***
WEEK 13			*WEEK 14*			*WEEK 15*		
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	175	88	PTI	175	88	PTI	175	88
PTII	160	82	PTII	160	82	PTII	160	82
PTIII	135	75	PTIII	135	75	PTIII	135	75
PTIV	162	75	PTIV	162	75	PTIV	162	75
PTV	0	0	PTV	0	0	PTV	0	0
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	***105.333***	***53.3333***		***105.3333***	***53.3333***		***105.3333***	***53.3333333***

6/3/99	PLANTING DATE							
WEEKLY PLANT MEASUREMENTON PLOT THREE (3)								
WEEK 1			*WEEK 2*			WEEK 3		
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	7	8	PTI	11	12	PTI	18	23
PTII	8	9	PTII	12	14	PTII	17	22
PTIII	7	8	PTIII	12	13	PTIII	13	16
PTIV	7	8	PTIV	11	10	PTIV	16	20
PTV	7	8	PTV	9	13	PTV	15	17
PTVI	8	10	PTVI	13	15	PTVI	14	18
MEAN	**7.33333**	**8.5**		**11.33333**	**12.83333**		**15.5**	**19.3333333**
WEEK 4			WEEK 5			WEEK 6		
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	30	47	PTI	40	56	PTI	50	53
PTII	20	40	PTII	36	50	PTII	45	52
PTIII	24	37	PTIII	34	50	PTIII	44	51
PTIV	26	30	PTIV	36	46	PTIV	50	49
PTV	29	41	PTV	35	45	PTV	52	56
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	**21.5**	**32.5**		**30.16667**	**41.16667**		**40.16667**	**43.5**
WEEK 7			WEEK 8			WEEK 9		
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	70	66	PTI	73	70	PTI	75	70
PTII	62	58	PTII	70	60	PTII	70	65
PTIII	60	54	PTIII	72	56	PTIII	80	60
PTIV	56	56	PTIV	56	58	PTIV	58	60
PTV	73	70	PTV	74	68	PTV	82	70
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	**53.5**	**50.66667**		**57.5**	**52**		**60.83333**	**54.1666667**
WEEK 10			WEEK 11			WEEK 12		
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	80	73	PTI	100	78	PTI	115	78
PTII	73	68	PTII	75	70	PTII	130	75
PTIII	80	60	PTIII	125	62	PTIII	135	78
PTIV	115	75	PTIV	160	79	PTIV	160	79
PTV	0	0	PTV	0	0	PTV	0	0
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	**58**	**46**		**76.66667**	**48.16667**		**90**	**51.6666667**
WEEK 13			WEEK 14			WEEK 15		
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PT1	115	78	PTI	115	78	PTI	115	78
PTII	130	75	PTII	130	75	PTII	130	75
PTIII	135	78	PTIII	135	78	PTIII	135	78
PTIV	160	79	PTIV	160	79	PTIV	160	79
PTV	0	0	PTV	0	0	PTV	0	0
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	**90**	**51.66667**		**90**	**51.66667**		**90**	**51.6666667**

6/3/99	PLANTING DATE							
WEEKLY PLANT MEASUREMENTON PLOT FOUR (4)								
WEEK 1			*WEEK 2*			WEEK 3		
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	7	9	PT1	12	14	PT1	18	20
PTII	8	8	PTII	9	13	PTII	10	17
PTIII	7	9	PTIII	11	14	PTIII	15	17
PTIV	6	7	PTIV	9	13	PTIV	13	14
PTV	8	10	PTV	10	15	PTV	14	16
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	**6**	**7.166667**		**8.5**	**11.5**		**11.66667**	**14**
WEEK 4			WEEK 5			WEEK 6		
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	20	36	PT1	30	35	PT1	41	51
PTII	14	22	PTII	30	32	PTII	37	40
PTIII	14	28	PTIII	36	40	PTIII	42	46
PTIV	17	32	PTIV	26	36	PTIV	39	50
PTV	17	33	PTV	28	29	PTV	36	48
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	**13.6667**	**25.16667**		**25**	**28.66667**		**32.5**	**39.1666667**
WEEK 7			WEEK 8			WEEK 9		
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	52	54	PT1	58	56	PT1	62	58
PTII	42.5	42	PTII	50	45	PTII	55	48
PTIII	48	56	PTIII	52	50	PTIII	58	58
PTIV	53	50	PTIV	51	52	PTIV	60	52
PTV	40	50	PTV	44	50	PTV	45	52
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	**39.25**	**42**		**42.5**	**42.16667**		**46.66667**	**44.6666667**
WEEK 10			WEEK 11			WEEK 12		
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PTI	70	59	PT1	85	62	PT1	100	65
PTII	40	48	PTII	100	50	PTII	120	70
PTIII	50	58	PTIII	105	60	PTIII	110	70
PTIV	55	54	PTIV	110	60	PTIV	120	65
PTV	65	53	PTV	108	55	PTV	0	0
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	**46.6667**	**45.33333**		**84.66667**	**47.83333**		**75**	**45**
WEEK 13			WEEK 14			WEEK 15		
	PH(CM)	LA(CM2)		PH(CM)	LA(CM2)		PH(CM)	LA(CM2)
PT1	100	65	PT1	100	65	PT1	100	65
PTII	120	70	PTII	120	70	PTII	120	70
PTIII	110	70	PTIII	110	70	PTIII	110	70
PTIV	120	65	PTIV	120	65	PTIV	120	65
PTV	0	0	PTV	0	0	PTV	0	0
PTVI	0	0	PTVI	0	0	PTVI	0	0
MEAN	**75**	**45**		**75**	**45**		**75**	**45**

ABLE 4.6

EAN MONTHLY GROUND WATER(FLUCTUATION) MEASUREMENT

MONTHS	PIE5	PIE6	PIE7	PIE8
Jul-98	73.5	75.25	87	73.5
Aug-98	79	79.5	88.5	79.5
Sep-98	86	89	95.5	89
Oct-98	100	100	100	100
Nov-98	89.7	94	95.85	87.1
Dec-98	63.5	74	81.63	74.5
Jan-99	50	58	68	60
Feb-99	50	52.5	66.5	55
Mar-99	58	66.2	71.6	59.4
Apr-99	61	69	78	64.75
May-99	65.5	71	82	68
Jun-99	70	72.5	85	70.25

PIE 5

MONTHS	Y	X	X*Y	X^2	X^4	X^2*Y	Y(FORECAST)
Jul-98	73.5	-11	-808.5	121	14641	8893.5	**106.86**
Aug-98	79	-9	-711	81	6561	6399	**80.98**
Sep-98	86	-7	-602	49	2401	4214	**59.86**
Oct-98	100	-5	-500	25	625	2500	**43.43**
Nov-98	89.7	-3	-269.1	9	81	807.3	**31.68**
Dec-98	63.5	-1	-63.5	1	1	63.5	**24.62**
Jan-99	50	1	50	1	1	50	**23.44**
Feb-99	50	3	150	9	81	450	**24.42**
Mar-99	58	5	290	25	625	1450	**31.58**
Apr-99	61	7	427	49	2401	2989	**43.37**
May-99	65.5	9	589.5	81	6561	5305.5	**59.66**
Jun-99	70	11	770	121	14641	8470	**80.79**
	846.2	**0**	**-677.6**	**572**	**48620**	**41591.8**	

PIE6

MONTHS	Y	X	X*Y	X^2	X^4	X^2*Y	Y(FORECAST)
Jul-98	75.25	-11	-827.75	121	14641	9105.25	**142.14**
Aug-98	79.5	-9	-715.5	81	6561	6439.5	**105.8**
Sep-98	89	-7	-623	49	2401	4361	**76.34**
Oct-98	100	-5	-500	25	625	2500	**53.76**
Nov-98	94	-3	-282	9	81	846	**38.06**
Dec-98	74	-1	-74	1	1	74	**29.24**
Jan-99	58	1	58	1	1	58	**27.27**
Feb-99	52.5	3	157.5	9	81	472.5	**32.24**
Mar-99	66.2	5	331	25	625	1655	**44.06**
Apr-99	69	7	483	49	2401	3381	**62.76**
May-99	71	9	639	81	6561	5751	**88.34**
Jun-99	72.5	11	797.5	121	14641	8772.5	**120.8**
	900.95	**0**	**-556.25**	**572**	**48620**	**43415.75**	

ABLE 4.6

PIE7	PIE 7						
MONTHS	**Y**	**X**	**X*Y**	**X^2**	**X^4**	**X^2*Y**	**Y(FORECAST)**
Jul-98	87	-11	-973.5	121	14641	10527	**182.36**
Aug-98	88.5	-9	-859.5	81	6561	7168.5	**138.86**
Sep-98	95.5	-7	-700	49	2401	4679.5	**104.48**
Oct-98	100	-5	-479.25	25	625	2500	**73.78**
Nov-98	95.85	-3	-244.89	9	81	862.65	**52.76**
Dec-98	81.63	-1	-68	1	1	81.63	**39.42**
Jan-99	68	1	66.5	1	1	68	**33.76**
Feb-99	66.5	3	214.8	9	81	598.5	**35.78**
Mar-99	71.6	5	390	25	625	1790	**45.48**
Apr-99	78	7	574	49	2401	3822	**64.86**
May-99	82	9	765	81	6561	6642	**87.92**
Jun-99	85	11	-1314.84	121	14641	10285	**120.1**
	999.58	**0**	**-2629.68**	**572**	**48620**	**49024.78**	

PIE8							
MONTHS	Y	**X**	**X*Y**	**X^2**	**X^4**	**X^2*Y**	**Y(FORECAST)**
Jul-98	73.5	-11	-808.5	121	14641	8893.5	**106.71**
Aug-98	79.5	-9	-715.5	81	6561	6439.5	**81.73**
Sep-98	89	-7	-623	49	2401	4361	**61.31**
Oct-98	100	-5	-500	25	625	2500	**45.45**
Nov-98	87.1	-3	-261.3	9	81	783.9	**34.15**
Dec-98	74.5	-1	-74.5	1	1	74.5	**27.32**
Jan-99	60	1	60	1	1	60	**26.32**
Feb-99	55	3	165	9	81	495	**27.53**
Mar-99	59.4	5	297	25	625	1485	**34.55**
Apr-99	64.75	7	453.25	49	2401	3172.75	**46.05**
May-99	68	9	612	81	6561	5508	**62.11**
Jun-99	70.25	11	772.75	121	14641	8500.25	**82.73**
	881	**0**	**-622.8**	**572**	**48620**	**42273.4**	

ABLE 4.61

(MONTHS)	**X**	Y(FORECAS	Y(FORECAS	Y(FORECAS	Y(FORECAST) 8
ULY'98	-11	**106.86**	**142.14**	**182.36**	**106.71**
UGUST'98	-9	**80.98**	**105.8**	**138.86**	**81.73**
EPTEMBER	-7	**59.86**	**76.34**	**104.48**	**61.31**
CTOBER'9	-5	**43.43**	**53.76**	**73.78**	**45.45**
OVEMBER'	-3	**31.68**	**38.06**	**52.76**	**34.15**
ECEMBER'	-1	**24.62**	**29.24**	**39.42**	**27.32**
ANUARY'99	1	**23.44**	**27.27**	**33.76**	**26.32**
EBRUARY'	3	**24.42**	**32.24**	**35.78**	**27.53**
ARCH'99	5	**31.58**	**44.06**	**45.48**	**34.55**
PRIL'99	7	**43.37**	**62.76**	**64.86**	**46.05**
AY'99	9	**59.66**	**88.34**	**87.92**	**62.11**
UNE'99	11	**80.79**	**120.8**	**120.1**	**82.73**

PLATE A: PROJECT SITE VIEW.

PLATE B: A PIEZOMETER ON THE SITE.

PLATE C: SURVEY INSRUMENT USED: TAPE, STAFF GRADUATED, AND TRIPOT STAND

CHAPTER FIVE

5.10 CONCLUSION AND RECOMMENDATION.

5.11 CONCLUSION.

From the plant height and leaf areas analysis, the plants had uniform growth pattern with increase in height from piezometer 5 to piezometer 6 to piezometer 7 and decrease on piezometer 8.

The ground water level during the months of March, which was the planting period, was low for this reason irrigation was applied for about three weeks on weekly basis. When the rains came in the water shed increase the ground water table thus increases in ground water fluctuation.

The removal of piezometers by trespassers increased the problems of taking reading.

5.12 RECOMMENDATION.

I Between the months of January and March planting of maize drop should be discouraged as this happens to be the hottest period of the year [season] with a lot of sunshine.

II Irrigation both surface and subsurface should be introduced to this field as to replace lost water during the hot dry months.

III Research work on means to cold the field either using sprinkle or other means as to aid the crop with stand the hot whether should be carried out.

IV More study on the ground water fluctuation should be carried out to increase the present data as this will give more data for a more than one cycle curve this giving a wider range or view of the forecast (trend).

V Planting on this field could be do all the season but best result is likely to be between the months of April to November of the season so there could be possibility between two (2) planting of a crop like maize.

VI Bore or tube wells can comfortably be drilled here to serve both irrigation water and domestic water in this small water shed.

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TABLE A: TOTAL MEAN MONTHLY RAINFALL (MM) 1989-1999.
AT EMILUGI (THE PROJECT LOCATION)

MONTH	YEAR 1989	YEAR 1990	YEAR 1991	YEAR 1992	YEAR 1993	YEAR 1994	YEAR 1995	YEAR 1996	YEAR 1997	YEAR 1998	YEAR 1999
JAN	0	0	0	0	0	0	0	0	0	0	0
FEB	0	4.3	0.5	0	0	0	0	18.9	0	TRACE	2.8
MAR	4.1	0	68.3	0	61.6	0	22.9	0	64.9	0	9.8
APR	104.5	81.8	50.8	141.7	8.9	38.9	43.8	12.6	53.9	67.1	112.1
MAY	102.4	287.3	205.9	136.6	154.7	171.4	92.3	199.9	129.3	213.2	135.4
JUN	129.9	117.9	331.5	133.9	241.8	151.4	128.7	190.7	279.2	78.5	196.8
JUL	287.2	266.7	237	128.6	206.9	75.8	236.7	201.8	219	239.7	456.9
AUG	280.9	180.6	244.7	148.4	308.4	425.7	307.5	326.1	227.2	145.5	
SEPT	136.7	160	149.6	216	240.4	194	152.2	170.5	145.7	153.7	
OCT	74.8	109.4	75.7	31.5	152.8	102.1	105.6	41.8	135.4	103	
NOV	0	0	0	0	0	0	12.3	0	7.2	0	
DEC	0	0	0	0	0	0	0	0	0	0	
MEAN											
TOTAL											

SOURCE :-N C R I Badeggi Meterological Department.

TABLE B: MONTHLY MEAN TEMPERATURE (^{O}C) (MAXINUM) AT EMILUGI(PROJECT SITE)1989-1999.

AT EMILUGI (PROJECT SITE)

	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR
MONTH	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
JAN	32	35	34	34	34	34	34	35	36	35	35
FEB	36	36	37	37	37	37	37	37	38	39	37
MAR	38	39	37	38	37	40	40	38	38	40	38
APR	38	36	35	35	38	37	37	39	36	39	37
MAY	33	33	32	34	37	34	34	34	34	34	34
JUN	32	33	32	32	32	32	32	32	32	33	32
JUL	31	30	31	32	31	32	32	31	32	32	
AUG	31	31	30	30	31	31	31	30	32	30	
SEPT	31	31	32	31	32	31	31	31	32	31	
OCT	32	33	32	33	33	33	33	33	33	33	
NOV	35	35	35	.	36	33	33	35	36	36	
DEC	34	35	33	35	35	34	34	36	35	35	
MEAN	**33.5833**	**33.9167**	**33.333**	**33.7273**	**34.41667**	**34**	**34**	**34.25**			
TOTAL	**403**	**407**	**400**	**371**	**413**	**408**	**408**	**411**			

SOURCE :-N C R I Badeggi Meterological Department.

TABLE C: MONTHLY MEAN TEMPERATURE (^{o}C) (MININUM) AT EMILUGI(PROJECT SITE)1989-1999.

AT EMILUGI (PROJECT SITE)

	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR
MONTH	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
JAN	14	18	17	13	14	18	15	15	22	17	17
FEB	17	19	22	14	17	18	17	21	20	21	20
MAR	22	19	22	21	21	24	24	24	23	23	25
APR	24	24	24	23	24	24	26	25	24	27	25
MAY	24	23	23	22	23	24	24	23	23	25	24
JUN	23	23	23	23	22	23	24	22	22	24	23
JUL	23	23	22	21	22	23	23	23	23	24	23
AUG	23	23	23	21	22	23	23	22	23	24	
SEPT	23	23	19	21	22	23	23	21	23	23	
OCT	22	23	20	21	23	23	23	21	23	24	
NOV	20	21	18	18	22	19	19	16	21	20	
DEC	10	20	17	12	18	15	17	16	17	17	

SOURCE :-N C R I Badeggi Meterological Department.

TABLE D : MONTHLY MEAN RELATIVE HUMIDITY (^{O}C) (1989-1999)
AT EMILUGI (THE PROJECT LOCATION)

	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR	YEAR
MONTH	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	1999
JAN	47	72	69	65	51	66	50	67	57	52	54
FEB	24	52	72	53	52	46	40	65	30	43	57
MAR	56	47	72	66	62	68	69	65	54	33	68
APR	72	72	81	82	67	69	69	65	70	68	70
MAY	81	84	85	84	75	80	75	78	77	82	79
JUN	83	86	82	86	83	81	81	83	82	82	85
JUL	86	89	91	88	87	84	84	80	84	85	
AUG	89	87	92	87	87	85	89	88	82	84	
SEPT	85	87	88	87	87	85	85	87	83	85	
OCT	84	86	88	82	83	81	81	77	82	82	
NOV	73	86	81	68	80	69	67	65	72	74	
DEC	51	81	66	69	67	53	69	68	57	59	

SOURCE :-N C R I Badeggi Meterological Department.

TABLE E:

RAINFALL RECORD DURING PERIOD OF PLANTING

DATE	Jan-99	Feb-99	Mar-99	Apr-99	May-99	Jun-99
1	0	0	0.8	0	14.6	0
2	0	0	0	0	0	11.1
3	0	0	0	0	0	0
4	0	0	0	0	0	17.7
5	0	0	0	8.2	0	0
6	0	0	0	0	0	0
7	0	0	0	0	6.2	0
8	0	0	0	0	0.5	1.6
9	0	0	0	0	0.5	0
10	0	0	9	0	10.6	2.5
11	0	0	0	0	3.5	0
12	0	0	0	0	0	0
13	0	0	0	TR	0	0
14	0	0	0	52.1	0	0
15	0	0	0	0.2	7.2	0
16	0	0	0	4.2	0	0
17	0	0	0	0	0	9.9
18	0	0	0	0	0	45.5
19	0	0	0	0	17.8	0
20	0	0	0	14.2	0	0
21	0	0	0	0	0	13
22	0	0	0	0	0	0
23	0	0	0	0.6	0	11.1
24	0	0	0	0	0	0
25	0	0	0	0	0	7.3
26	0	0	0	0	17.9	0.4
27	0	0	0	32.3	32.3	75.6
28	0	2.8	0	0	1.1	1.1
29	0	XX	0	0	0	0
30	0	XX	0	0.3	0	0
31	0	XX	0	XX	0	XX

SOURCE :-N C R I Badeggi Meterological Department.

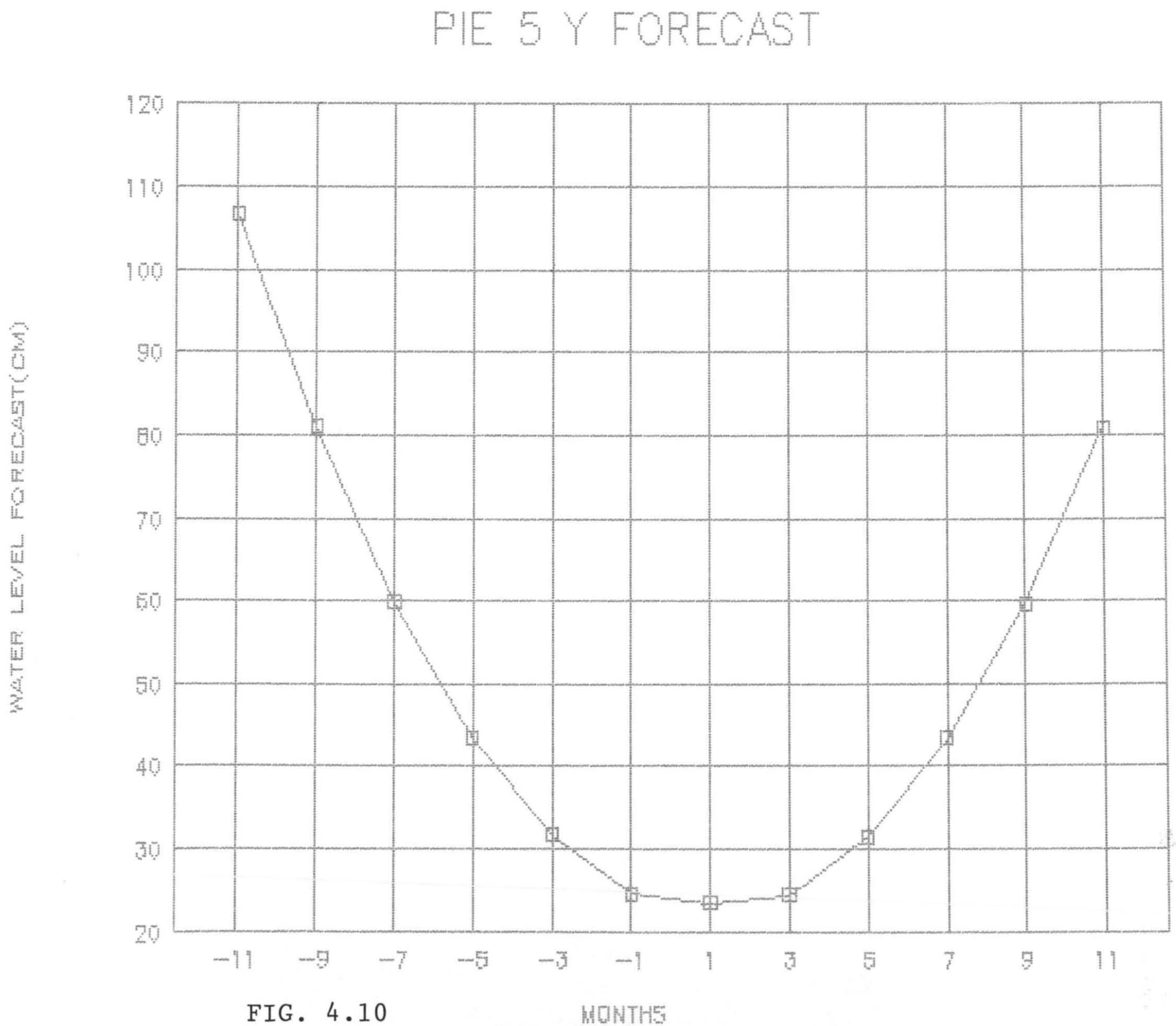

PIE 5 Y FORECAST
WATER LEVEL FORECAST(CM)
120
110
100
90
80
70
60
50
40
30
20
-11
-9
-7
-5
-3
-1
1
3
5
7
9
11
MONTHS

FIG. 4.10

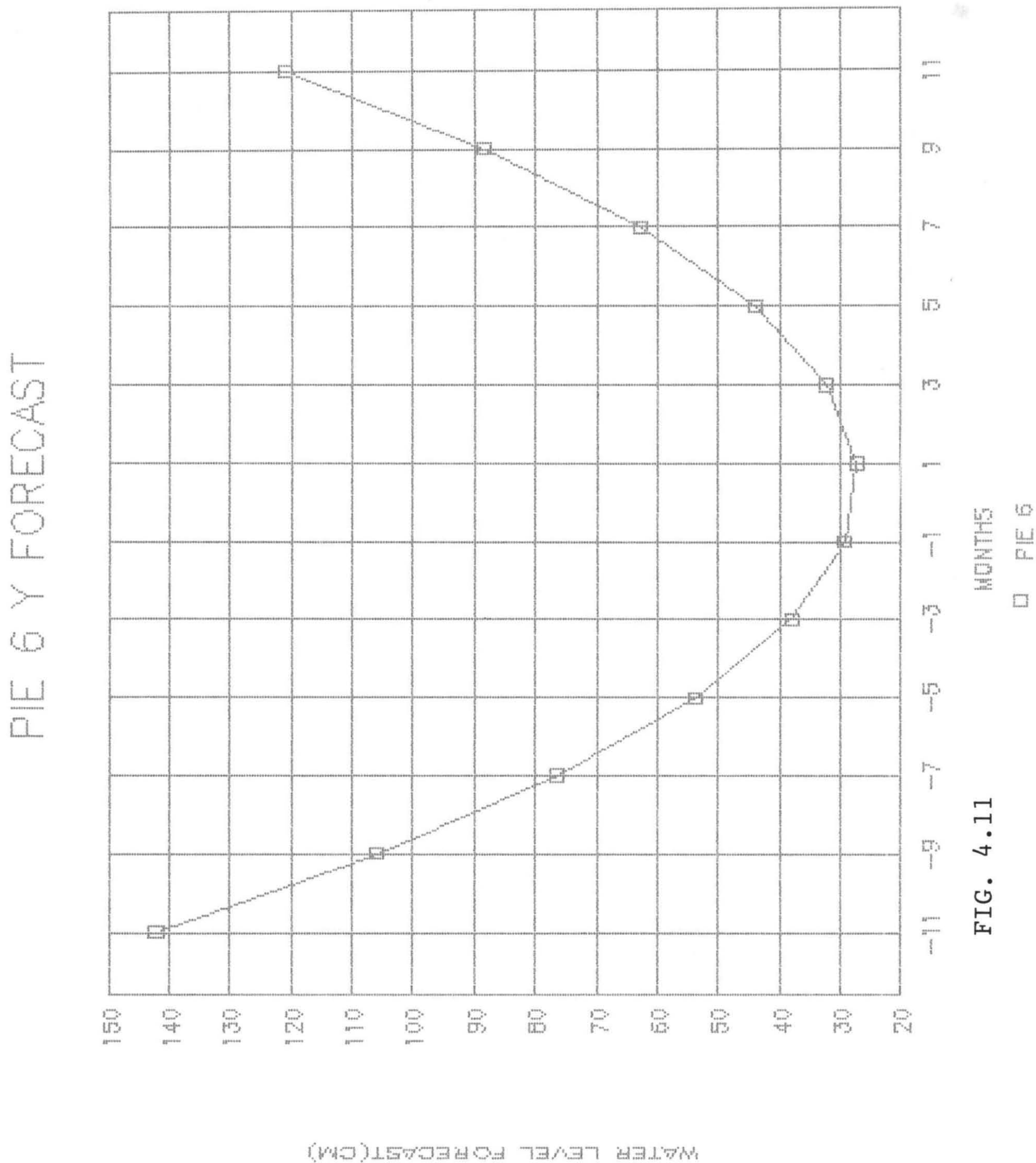

PIE 6 Y FORECAST
150
140
130
120
110
100
90
80
70
60
50
40
30
20
WATER LEVEL FORECAST(CM)
-11
-9
-7
-5
-3
-1
1
3
5
7
9
11
MONTHS
PIE 6

FIG. 4.11

PIE 7 Y FORECAST

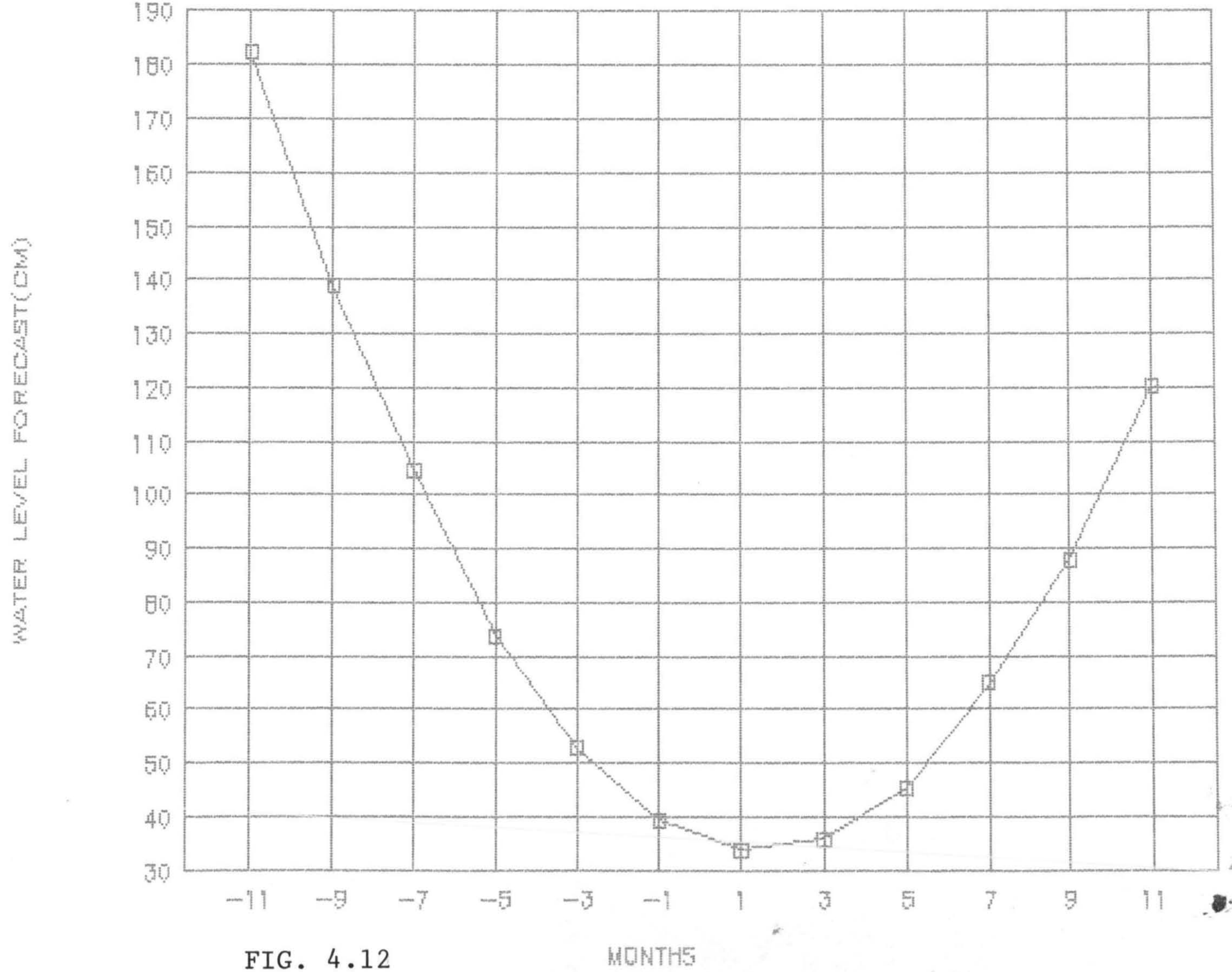


FIG. 4.12

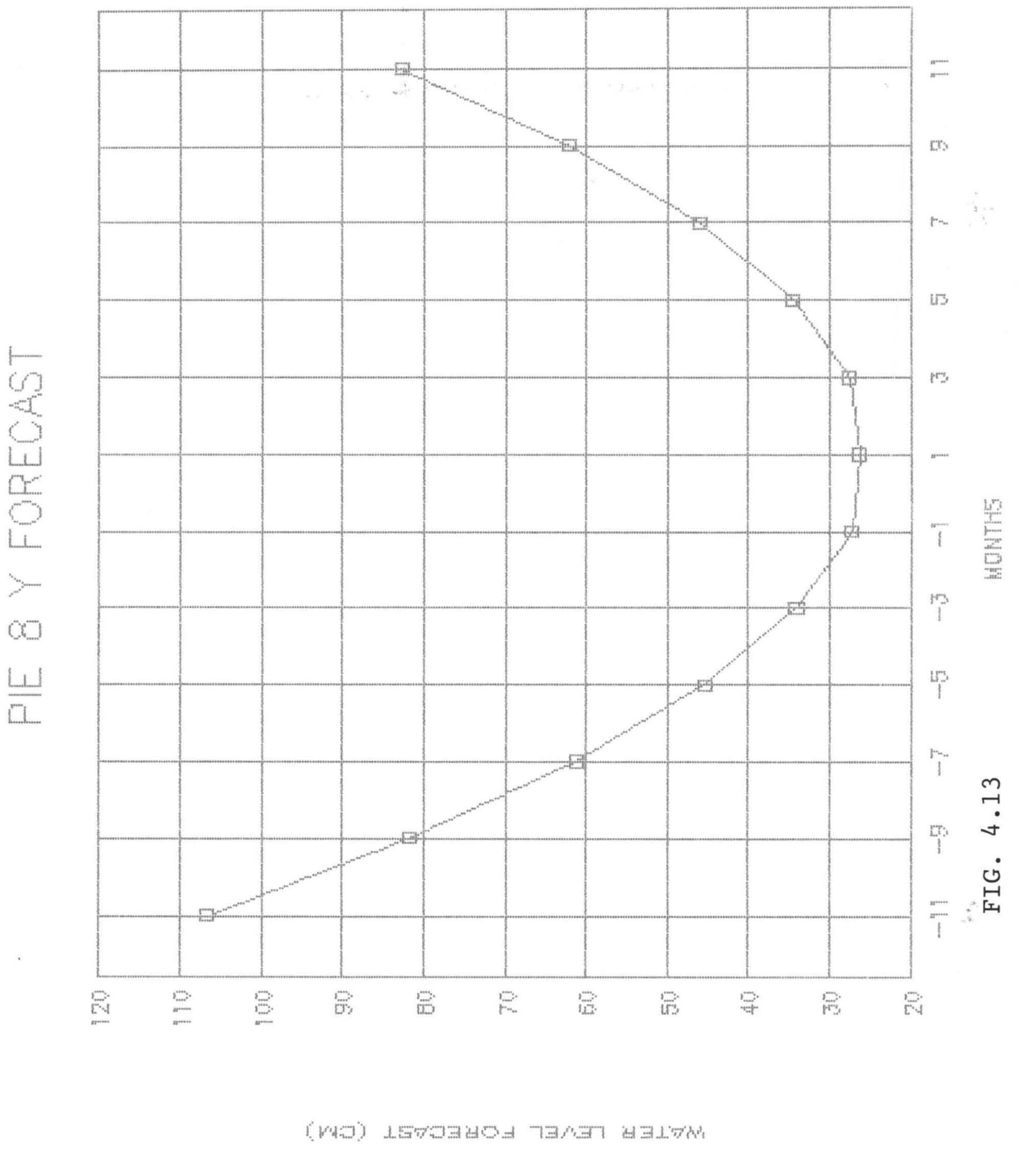

PIE 8 Y FORECAST
WATER LEVEL FORECAST (CM)
120
110
100
90
80
70
60
50
40
30
20
MONTHS
-11
-9
-7
-5
-3
-1
1
3
5
7
9
11

FIG. 4.13

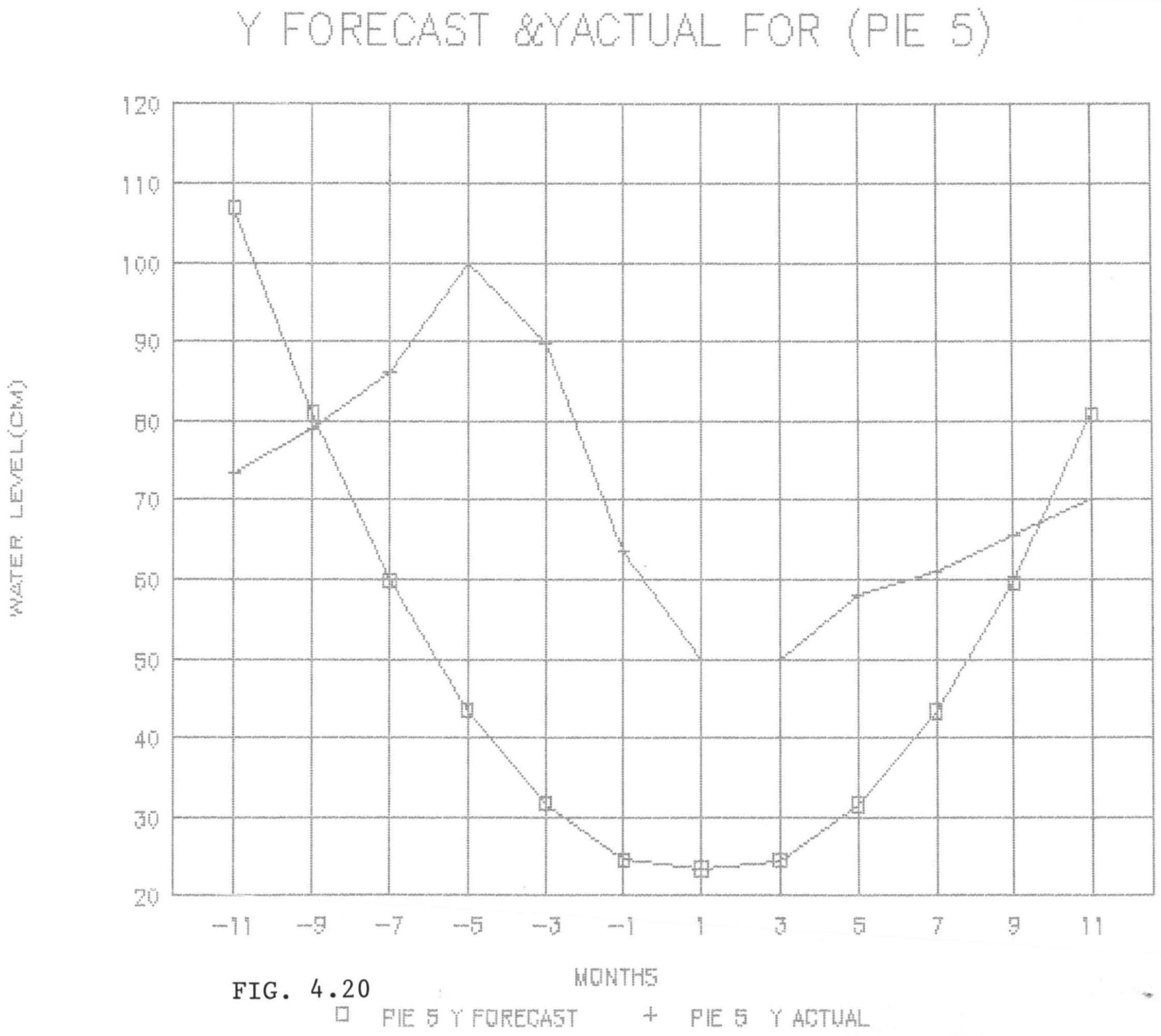

Y FORECAST &YACTUAL FOR (PIE 5)
WATER LEVEL(CM)
120
110
100
90
80
70
60
50
40
30
20
-11
-9
-7
-5
-3
-1
1
3
5
7
9
11
MONTHS
PIE 5 Y FORECAST
PIE 5 Y ACTUAL

FIG. 4.20

Y FORECAST & Y ACTUAL FOR PIE 6

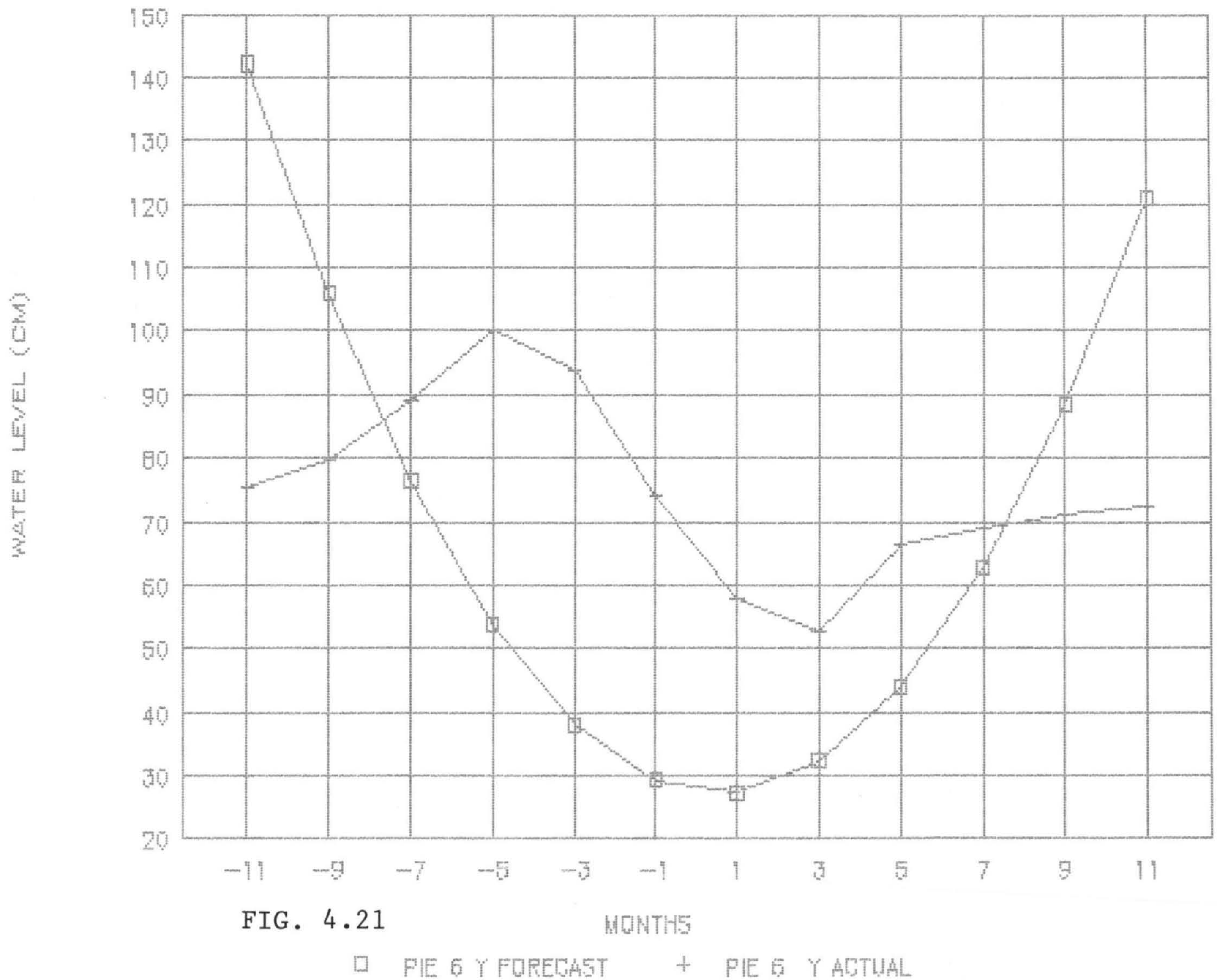
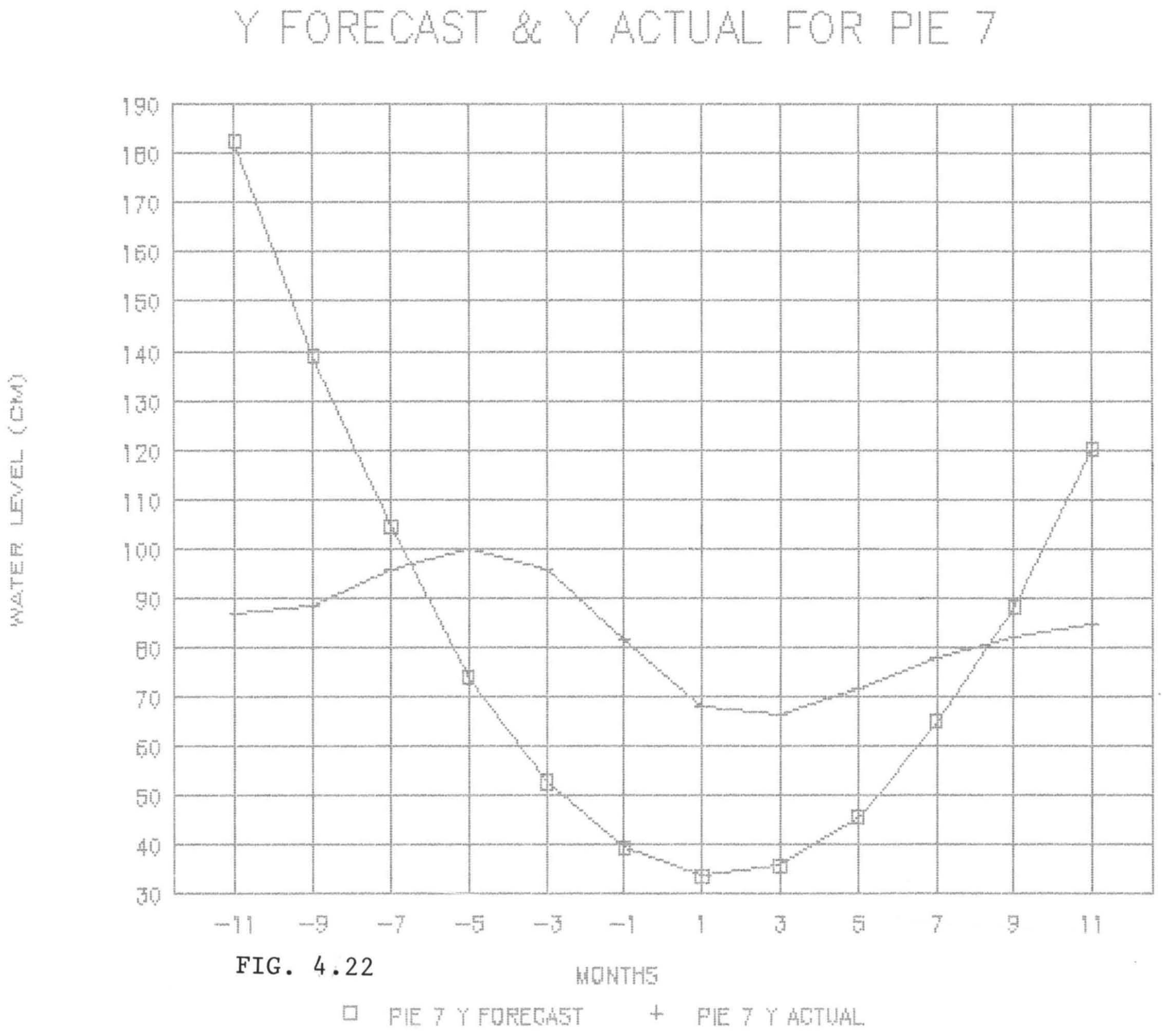


FIG. 4.21



Y FORECAST & Y ACTUAL FOR PIE 7
WATER LEVEL (CM)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
-11
-9
-7
-5
-3
-1
1
3
5
7
9
11
MONTHS
PIE 7 Y FORECAST
+ PIE 7 Y ACTUAL

FIG. 4.22

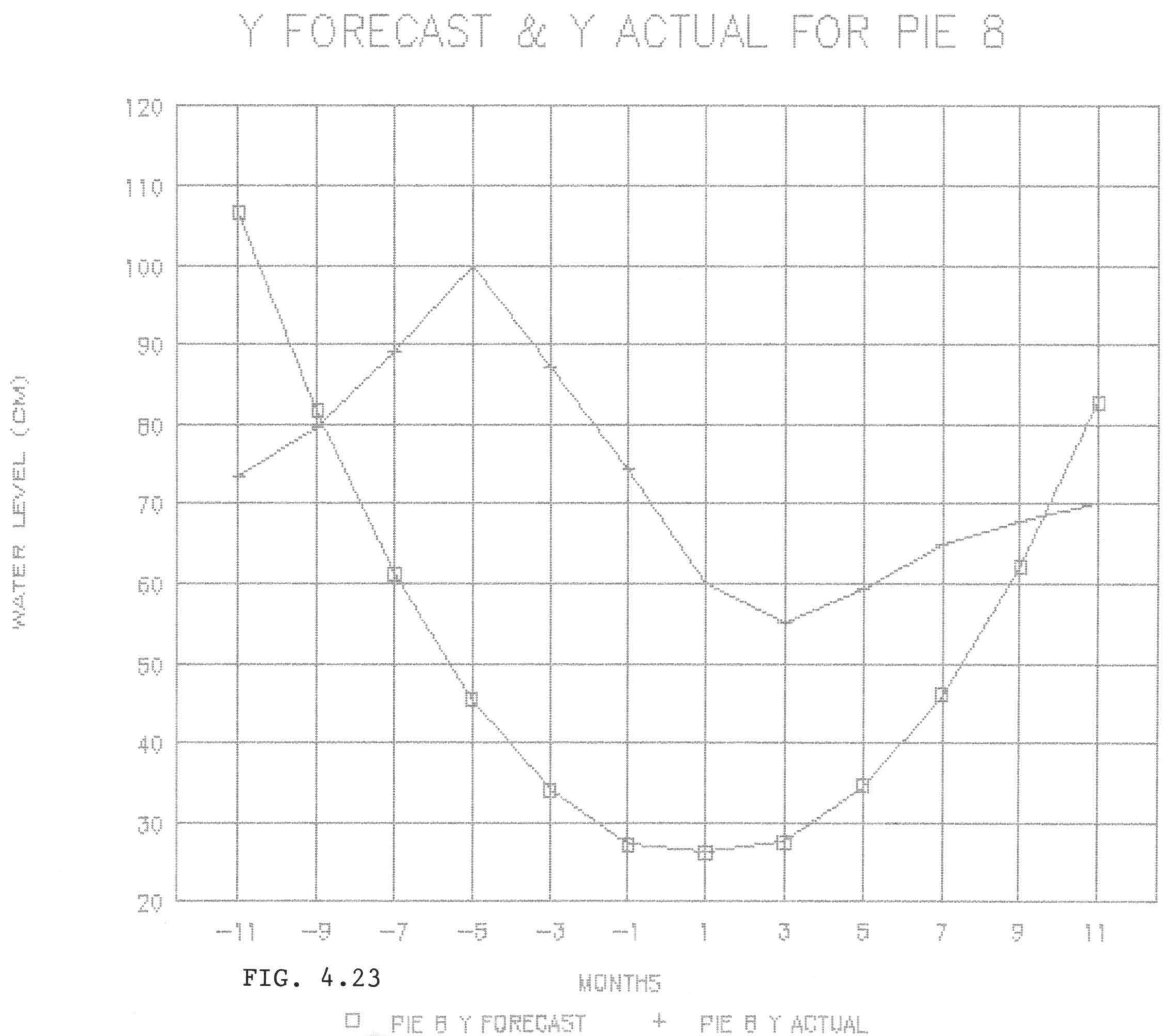
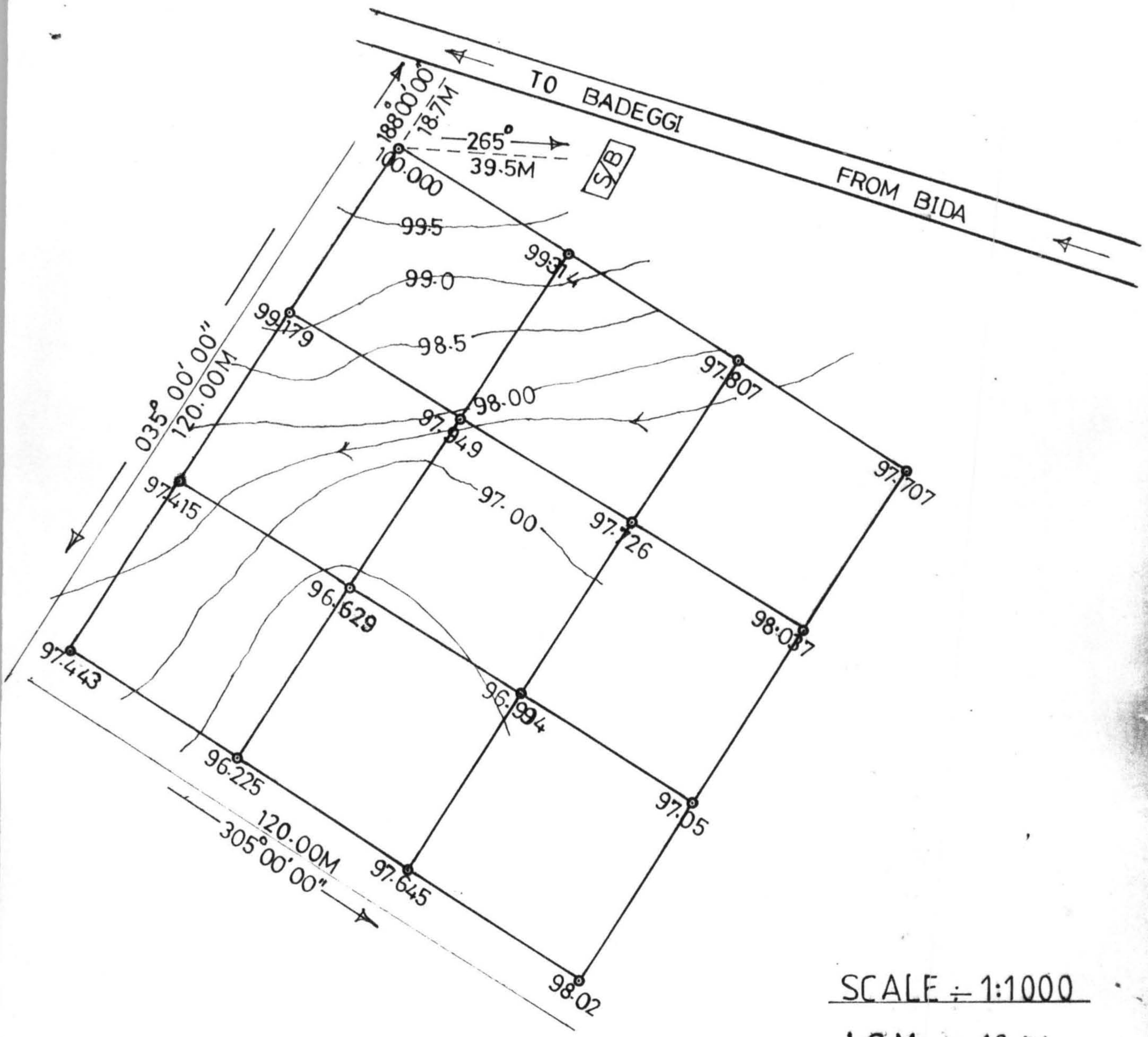

Y FORECAST & Y ACTUAL FOR PIE 8
WATER LEVEL (CM)
120
110
100
90
80
70
60
50
40
30
20
-11
-9
-7
-5
-3
-1
1
3
5
7
9
11
MONTHS
□ PIE 8 Y FORECAST
+ PIE 8 Y ACTUAL

FIG. 4.23

CONTOUR MAP OF WATER SHED A[illegible] VILLEGE, LAVUN LOCAL GOVT AREA, NIGER STATE.



⊙	PIZOMETER POINT	SURVEYED BY	UMARU E IBRAHIM
	CONTOUR PROFILE	PLOTTED BY	— DO —
	STREAM	CHECKED BY	— DO —
	MAJOR ROAD	DATE	
S/B	TIE POINT	SIGNATURE	