**[redacted] WATER SUPPLY AND SANITATION PROJECT
IN BENI SUEF GOVERNORATE**

GROUNDWATER RESOURCES INVENTORY
FINAL REPORT

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EXECUTIVE SUMMARY

The area under monitoring is located between Beba and El Fashen markaz approximately between longitudes 30° 30' and 31° E and latitudes 28° 46' and 28° 56.' It lies approximately on the level 38.4 m above the main sea level. It covers an area of about 800 Km^2. The area is bounded by river Nile from the east and the new reclaimed land from the west, Beba markaz from the north and El Fashen markaz from the south. The location map is presented in **(fig. 1)**

A. Climate

The area is characterized by:-

i. The maximum recorded monthly average temperature is 38.4 °C in July , while the minimum average recorded monthly temperature is 5.6 °C in January.

ii. The amount of rainfall is not significant through the year. During the winter time, occasional short rainy storms may take place over the area. The main annual value of rain fall is about 6.2 mm/ year.

iii. Wind velocity varies from month to another. The maximum monthly mean value is 12.4 knot (6.4 m/s) as recorded during June and July, while the minimum value is 5.8 knot (3 m/s) as recorded during December .

iv. The mean maximum monthly value of the relatively humidity is 63.3% in December, while the minimum value is 37.6 % in May.

v. The maximum recorded evaporation is 19.2 mm / day in June and the minimum reaches 5.3 mm / day in December. It is worth mentioning that there is a high percentage of evaporation and inconsiderable value of rainfall in the area west of the Nile Valley.

vi. The total amount of area rain precipitation is about 4,960,000 m^3 /year where the catchment area is about 800 km^2.

vii. The surface water evaporation (Eo)= 61,780,000 m^3/ year where the surface water area is about 25.8 Km^2 while, the evapotranspiration by plants (Et) = 1,210,600,000 m^3 / year where land is 503.20 Km^2 (119800 feddans) and the evaporation from soil (Es) =677,900,000 m^3 / year where the area in which the Es take place is about 271.20 Km^2 (64600 feddans).

B. Stratigraphy And Structural Geology

The surface layer consists of Holocene Nile silt with average of about 12 m. These deposits become thinner towards the valley slope (west direction)

The Pleistocene deposits consists of unconsolidated sand and gravel, this formation is overlained by the Holocene sediments and underlined by Pliocene clay deposits , which rest unconformably on the Middle Eocene rocks.

A generalized stratigraphic column in the project area is presented in **(fig. 2).** The study area is structurally related to the Nile basin and affected by faulting, joints and unconformaty. A representative geological cross section along the study area is presented in(**fig. 3).**

C. Grain Size Analysis

A comprehensive grain size analysis are represented in collected data report (hydrogeological and hydrogeochemical study along Beni Suef governorate - Ashraf F. Ewiss 1992, Cairo University). These collected data were carried out on about 70 subsurface Pleistocene sand samples (water bearing formation) indicate that:

i. The majority of sandy samples are course to medium grained, and moderately to poorly sorted.

ii. The hydraulic conductivity (k) and specific yield as average are estimated of about 76m/day and 28 % respectively.

iii. Heavy minerals assemblages of the studied samples are dominated by Zircon, Hornblende, Rutile, Biotite, Tourmaline, Garnet and Monazite.

iv. The light minerals encountered in the studied samples consists mainly of Quartz and a few amount of feldspar

D. Hydrogelogy

Two types of aquifers are recorded; the first is the semi confined aquifer, which occupies the flood plain of the Nile Valley. It consists of sand and gravel intercalation with clayey lenses (Quaternary aquifer). The thickness of this aquifer ranges from more than 100 m in the north to less than 240 m in the south.

It is totally connected with surface water and partially with the deeper older aquifer .

The second aquifer is the unconfined aquifer, which occupies the fringes of the Nile valley in the reclaimed area. It consists of sand and clay intercalated with gravels (Plio-Pleistocene aquifer). The thickness of the this aquifer ranges between 20 m in the northern and central part to more than 50 m in the southern part. The hydraulic connection between these two aquifers is expected.

In the study area, the aquifer is mainly recharged from the dominated surface water, especially the infiltration from the irrigation canals and flood irrigation. The discharges of ground water from this aquifer take place by :

i. The abstraction from the aquifer to different purposes.
ii. The underlying aquifer.
iii. The river which in turn acts as an effluent stream in most of it's parts.
iv. The agricultural drains.
v. The irrigation canals during the winter closure period.
vi. The evaporation process from ground water at depth less than 1.5 m from the ground surface.

The regional direction of the groundwater movement is towards the east and northeast with a variable hydraulic gradient up to 7 m/km (from the reclaimed area to the area west of Bahr Youssef) and hydraulic gradient ranging between 0.4 to 1 m/km (between Bahr Youssef and River Nile). The water table varies from more than 40 m in the west to less than 30 m (a. m. s. l.) in the east and the north.

From 9 pumping tests, the values of transmissivity (T) and hydraulic conductivity (K) of the Quaternary aquifer are calculated by two different methods (Jacob pumping method and Theis recovery method). The calculated values are:

The average transmissivity (T) = 16441 m^2 / day.
The average hydraulic conductivity (K) = 96.7 m/day.

E. Groundwater Chemistry

The total salinity of the studied aquifer is widely varying from 339 beside the River Nile to 4910 ppm in the reclaimed area.

Also there is an increase of total hardness in the west direction.

The relation between EC (electric conductivity) and TDS (total salinity) of the aquifer displays a highly positively significant correlation and best linear regression.

The ground water in area between River Nile and El Ibrahemiya and the northern part of western bank of Bahr Youssef represents the best area from quality point of view while the groundwater in central area needs for mixing with surface water to improve some properties like TDS and total hardness especially around Sumusta area, but the groundwater of the reclaimed area represents the worst quality and it is not suitable for domestic use.

The dominant ions in the investigated groundwater samples of the Quaternary aquifer can be classified into three main orders:

i. Order I : $HCO_3^- > Cl^- > SO_4^{--}$ and $Na^+ > Ca^{++} > Mg^{++}$
This order Characterizes the water of the drilled wells in the area between the River Nile and west El Ibrahemiya.

ii. Order II : Cl^{-} > SO_4^{--} > HCO_3^{-} and Na+ > Ca++ > Mg++
This order Characterizes the water of the drilled wells in the central area of the aquifer.

iii. Order II: HCO_3^{-} > Cl^{-} > SO_4^{--} and Na++ > Mg++> Ca++
This order Characterizes the water of the drilled wells in the area beside the western bank of Bahr Youssef

iv. Order III: SO_4^{--} > Cl^{-} > HCO_3^{-} and Ca++ > Mg++ > Na+
This order Characterizes the water of the drilled wells in the reclaimed area.
This order Characterizes the water of the drilled wells in the reclaimed area.

The dominant ions are hypothetically combined together to form salts in systematic manner depending upon the activity of ions. From the pie diagrams which represent the equivalent % of the major cations and anions along the different sectors of the study area, four salt assemblages are reported :

* ***Assemblage 1:*** (Eastern sector of the aquifer)
($NaHCO3$, $Mg(HCO_3)_2$, $MgCl_2$, $CaCl_2$, $CaSO_4$)

* ***Assemblage 2:*** (Central sector of the Aquifer)
($NaHCO_3$, $NaCl$, $MgCl_2$, $CaCl_2$, $CaSo_4$)

* ***Assemblage 3:*** (Beside western bank of Bahr Youssef)
($NaCHO_3$, $NaCl$, $MgCl_2$, $MgSO_4$, $CaSO_4$)

* ***Assemblage***:(Reclaimed area)
($NaHCO_3$, $Mg(HCO_3)_2$, $MgCl_2$, $MgSO_4$, $CaSO_4$)

F. Groundwater Quality Changes

The TDS and the concentration of cations and anions of the groundwater vary widely from east to west where they increase in the western and central sectors due to the effect of the reclamation in the western sector and due the presence of dense drains system and deep drain wells in the central part.

It was found that there is no considerable worse of pumping period on the groundwater quality along the study area. The relations between groundwater quality, locations and pumping period are presented in figures 42, 43, 44, 45, 46, 47, 48, and 49.

F. Utilization Of Groundwater

The groundwater along the study area is generally of suitable quality for domestic, irrigation and industrial purposes (except in the western sector) RIGW. 1990

In Beni Suef area the groundwater abstraction was estimated, based on the inventory of 1984 for all purposes with 68 x 10^3 m^3/day, while the total abstracted groundwater from the aquifer 1990 is 196x10^3 m^3/day for irrigation, industrial and domestic uses.

1. INTRODUCTION

1.1 GENERAL OUT LINE

The surface water is generally easy to harness, but its availability varies with the season. Especially the draught and the flood seasons are problematic. Surface water is easily subjected to contamination. Groundwater on the other hand is obtainable and has steady quality along the year.

The groundwater resources are represented by a relatively thick water bearing section (aquifer) covering the whole project area. There is an interrelationship between surface water and groundwater. The water bearing layer (aquifer) is recharged by leakage from the irrigation canals and by deep perculation of excess irrigation water. However, during the winter draught season, these canals receive ground water from the aquifer. The surface water and ground water are not separate i.e. what is surface water at certain point may become ground water at another and may emerge again as surface water at third point. The geological formation filtrate and eliminate most of the polluting components of the surface water.

1. 2 DESCRIPTION OF STUDY AREA

1. 2.1 Location

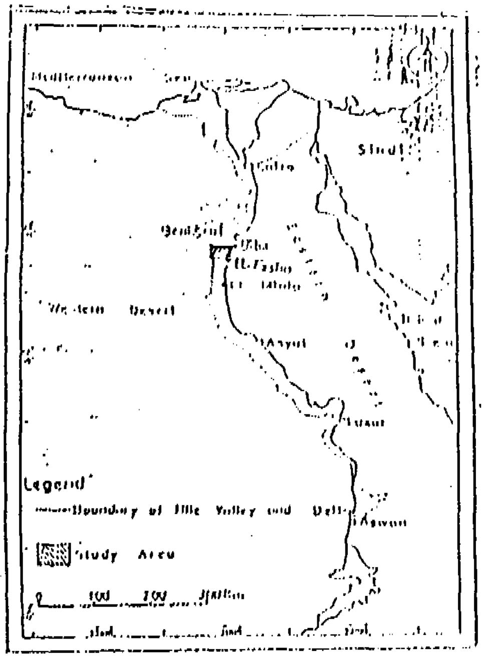
The area under investigation is located between Biba and El Fashen markazes approximately between longitudes 30° 30' and 31° 00' E and latitudes 28° 46' and 28° 56' **(fig.1)**. It lies approximately on the level 28.4 m above the sea level. It covers an area of about 800 km². The area is bounded by River Nile from east, the desert boundary of reclaimed land from the west, Beni Suef town from the north and southern boundary of El Fashen markaz from the south.

The area under study can be divided into two main areas; the old cultivated land and the new cultivated land.

The old cultivated land is situated west of the River Nile with elevation from 30 m to 34 m above the sea level. It is covered with silty clay deposits which become thinner towards the valley edges.
The reclaimed area is situated on the sandy and gravely west slope of the Nile Valley **(fig. 2)**.

1.2.2. Geomorphology

The area of the study lies along the alluvial plains which were developed into a flood plain of the River Nile.



Fig(1)Location Map

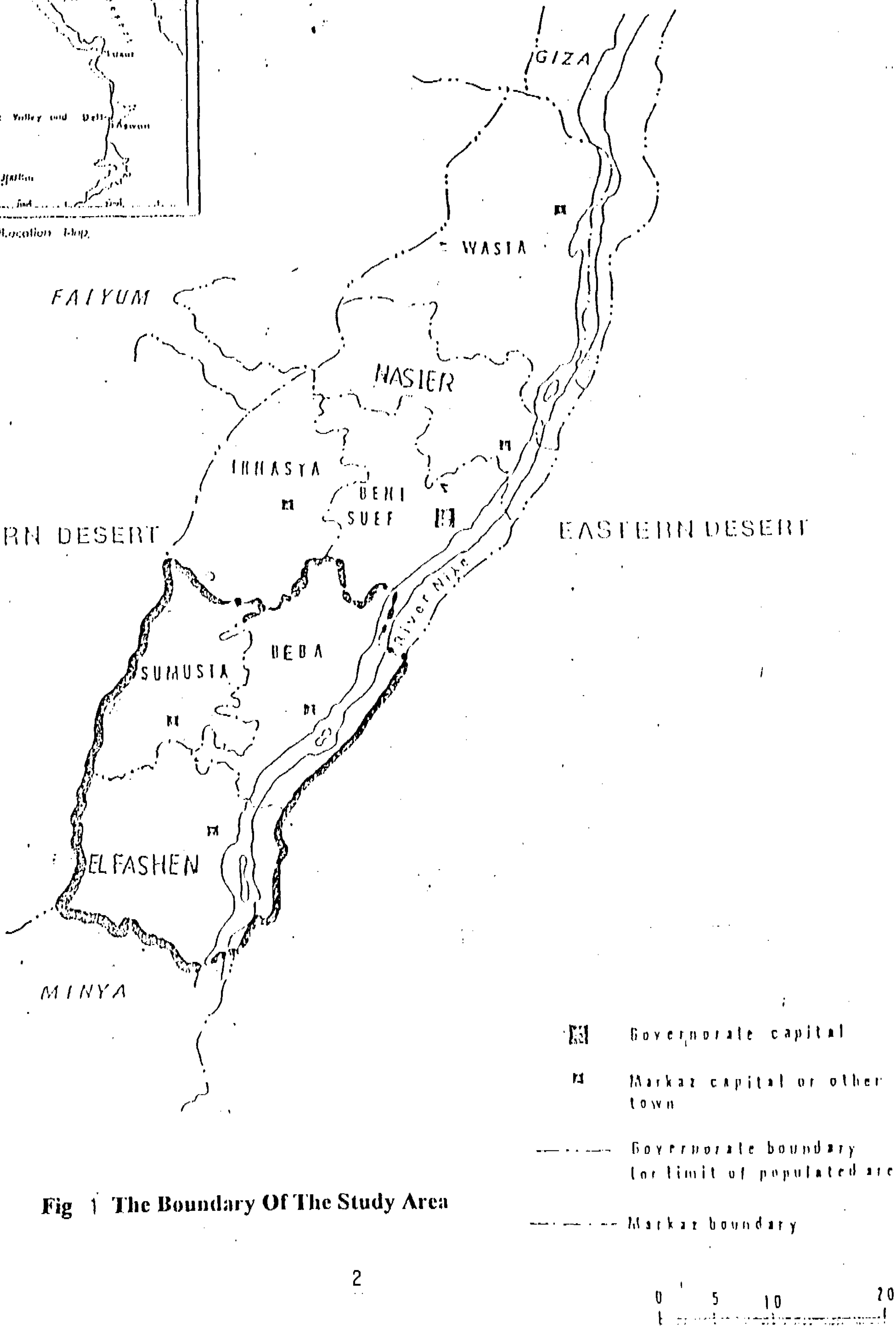


Fig 1 The Boundary Of The Study Area

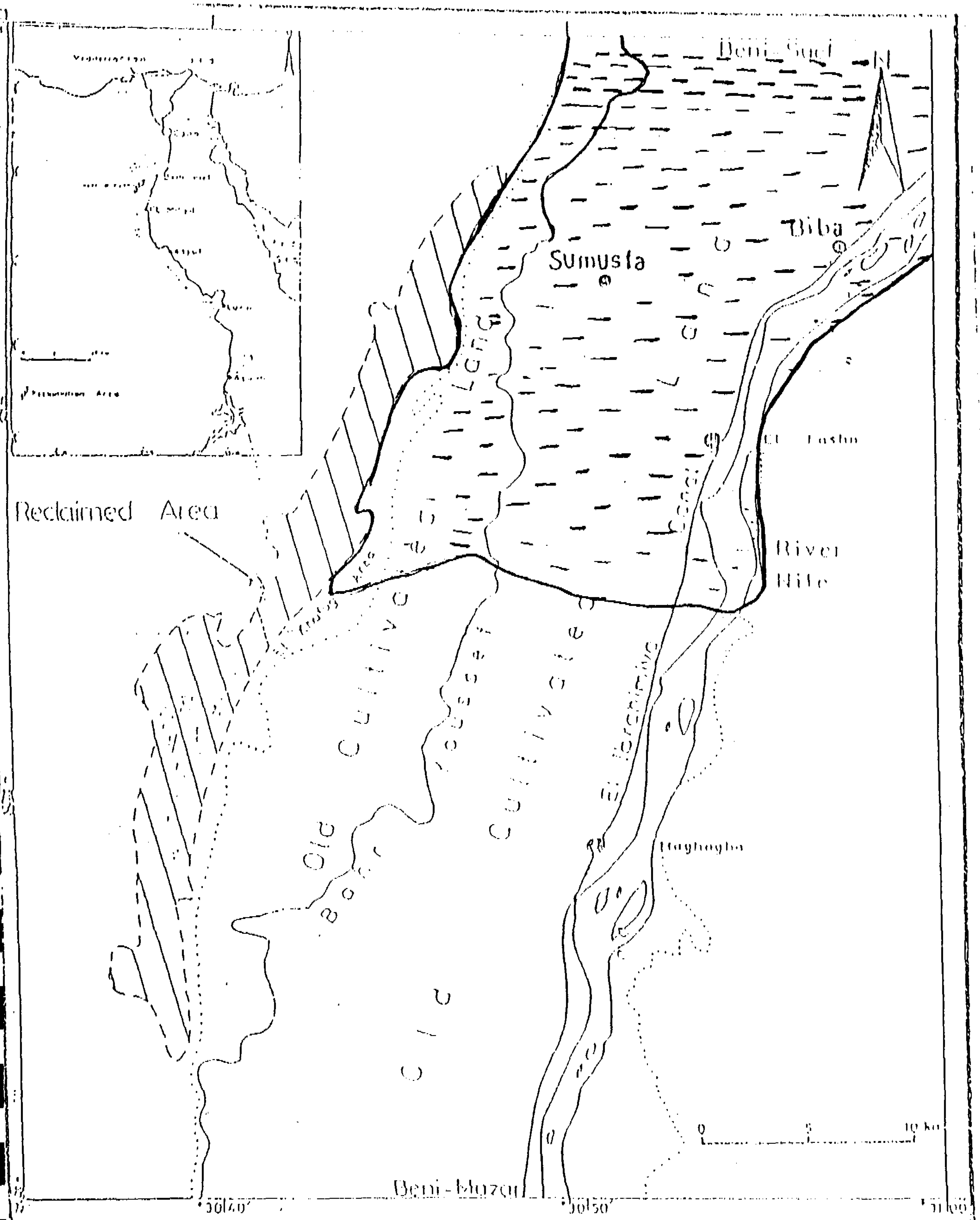


Fig. 2 - Location Of The Project Area & Reclaimed Land

It passes through a high eastern and western calcareous plateau, with a general slope from south to north of about 0.1 m/km. The Nile tends to occupy the eastern portion of its valley, so that the cultivable lands on the west of the river are generally much wider than those of the east. The cliffs of the east side of the valley are closer and much higher than those on the west side.

The River Nile in the area of the study favors the eastern portion of the flood plain, where many island are exposed within the river channel which have been developed by braiding processes.

The following morphological features (land forms) can recognized in the study area and its vicinities **(fig. 3)**:

i. The young alluvial plains of the Nile (Holocene silty clay).
ii. Sand dune accumulations.
ii. The old alluvial plains of the Nile (Quaternary sand and gravel).
iv. The calcareous structural plateau and their sloping boundaries (Middle Eocene limestone).

1.2.3 Climate

Beni Suef area is generally characterized by arid climate. it is marked by hot summer and cold winter. During the spring season, hot winds and dust storms occur during the period of about 50 days and is locally known as " El Khamaseen Period".

The arid climate plays an effective role on the present hydrologic response in Beni Suef area. It represents one of the active parameters in the manner of hydrogeologic evaluation of ground water and surface water resources in the study area.

The study of different climatic features in concerned area requires the analysis of meteorological data represented in **(table 1).**
From this table the following are noticeable:

i. The maximum recorded monthly average temperature is 38.4 C in July, while the minimum average recorded temperature is 5.6 C in January.

ii. The amount of rainfall is not significant through the year .during the winter time, occasional short rainy storms may take place over the area. The main annual value rain fall is about 6.2 mm / year.

iii. Wind velocity varies from month to another. The maximum monthly mean value is 12.4 knot (6.4 m/s) as recorded during June and July, while, the minimum value is 5.8 knot (3 m/s) as recorded during December.

iv. The mean maximum monthly value of the relatively humidity is 63.3% in December, while the minimum value is 37.6 % in May.

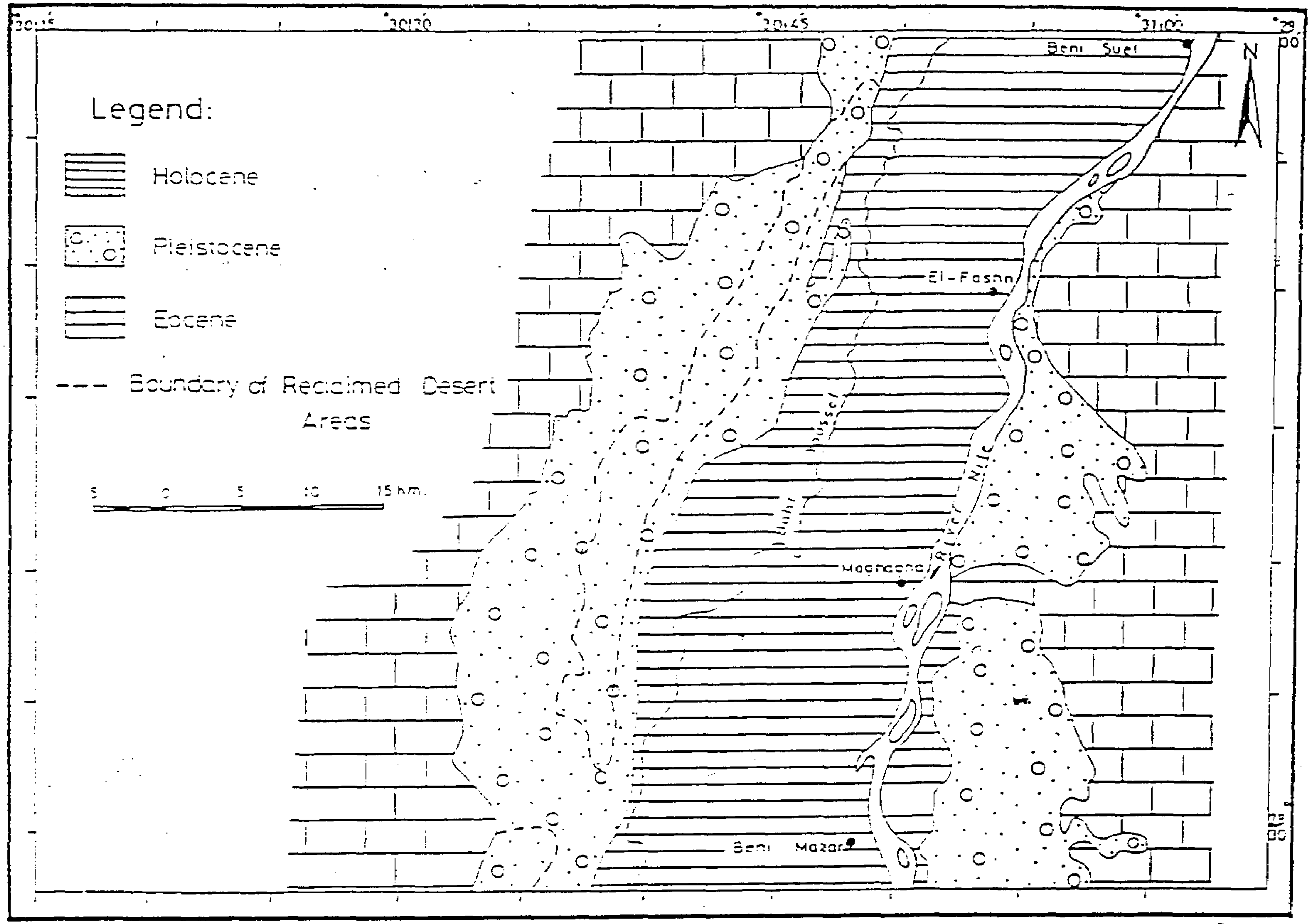


Fig.(3)Geomorphological Map of the Area Between Beni-Suef and Beni-Mazar

(After Said , 1981)

Table (1) : Meteorological records for the average long-term of Bèni- Seuf (Period 1952-1994)

Month	Temp. °C			Relative Humidity (in %)	Evaporation (mm/day)	Mean scalar wind speed (Knots)	Rainfall (mm)
	Max.	Min.	Average				
January	20.3	5.6	13.0	60.2	6.0	6.0	1.5
February	22.2	6.9	15.1	53.2	7.6	7.7	0.90
March	25.2	9.7	18.3	45.9	10.5	9.4	1.1
April	31.2	13.5	23.1	40.6	15.2	10.6	0.0
May	35.4	17.6	27.2	37.6	17.5	11.5	0.1
June	38.0	20.5	30.3	39.5	19.2	12.4	0.0
July	38.4	21.4	30.8	45.8	17.0	12.4	0.0
August	37.9	21.9	30.5	49.9	15.1	11.3	0.0
September	35.9	20.2	28.6	52.1	14.4	11.8	0.0
October	32.0	17.1	24.9	53.4	11.3	9.7	0.0
November	27.1	12.5	20.4	59.2	7.4	8.4	1.4
December	21.3	7.8	15.0	63.3	5.3	5.8	1.0
Annual mean	30.6	14.6	23.1	50.1	12.2	9.7	-

v. The maximum recorded evaporation is 19.2 mm/ day in June and the minimum reaches 5.3 mm / day in December. It is worth mentioning that there is a high percentage of evaporation and inconsiderable value of rainfall in the area west of the Nile Valley. Graphical presentation of the average climatic data for the study area, in the period 1952 to 1994 are shown in **(fig. 4).**

vi. The total amount of area rain precipitation is about 4,960,000 m^3 /year where the catchment area is about 800 km^2.

vii. The surface water evaporation (Eo) = 61,780,000 m^3 / year, where the surface water area is about 25.8 Km^2, while the evapotranspiration by plants(Et) = 1,210,600,000 m^3 / year, where the cultivated land area is about 503.16 Km^2 (119800 feddans) and the evaporation from soil (Es) =677,900,000 m^3 / year, where the area in which the Es take place is about 271.16 Km^2 (64600 feddans).

1.3 SCOPE OF THE STUDY

The present study deals with the hydrogeological properties of the Quaternary aquifer and the water quality of this aquifer from the potable points of view along the study area of RWS&SP (Sumusta, Beba and El Fashen). This was done through three steps of monitoring and sampling programs beside the collected data about the study area.

i. Random sampling program.

ii. Preliminary monitoring.

iii. Regular monitoring program.

Also the impact of the reclamation effect on the groundwater conditions becomes evident through the chemical analysis of the surface water in the western part and pumping test data belong to many wells in the study area.

The estimation of the change in water storage in the aquifer by using the water budget in the study has to be performed.

These study comprises the interpretation of the mechanical analysis, heavy and light minerals separation which have been carried out on many bore hole samples of represented water bearing formation in the study area.

All these tools have been used to clarify the hydrogeology, water quality and sources of aquifer contamination in the study area.

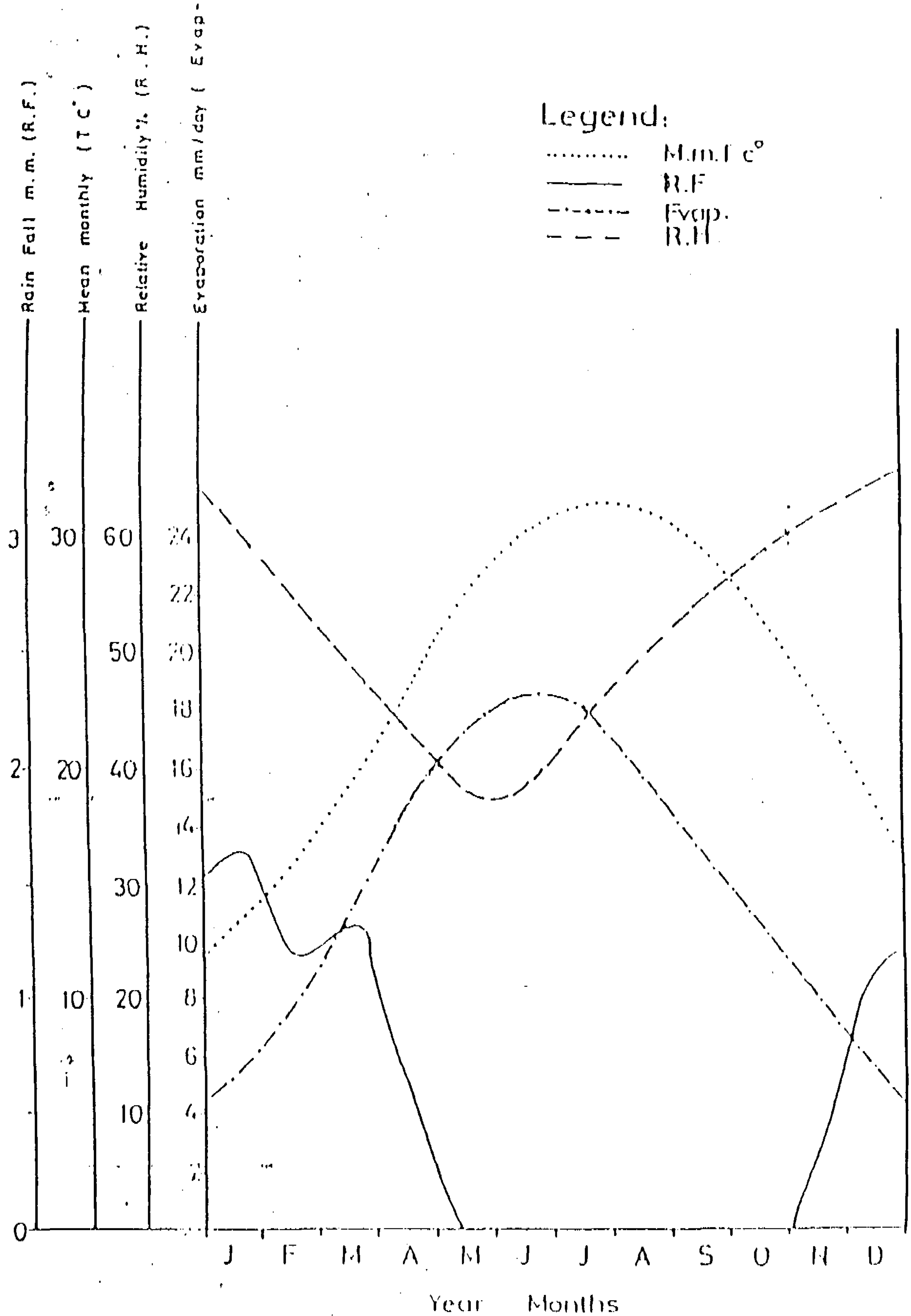


Fig 4 Graphical Representation Of The Average Climatic Data For The Studied Area (In The Period 1952-1994)

1.4. MATERIALS AND METHODS

The present work is based mainly on the following data that are collected from several sources :

i. The periodical records of climatic data during the period 1952 to 1994 in the study area (The Egyptian Meteorological Authority-Cairo)

ii. The periodical records of the surface water levels (River Nile, irrigation canals and drains) discharge of the main canals and water duties for different groups, and purpose of drinking and industry (Directorate of irrigation in Beni Suef) .

iii. The periodical records of the ground water levels and chemical analysis data of the observation and some production wells (Research Institute For Groundwater).

iv. The periodical records of the groundwater levels, lithology and pumping test data of the production wells, West El Fashen project - High Dam Co. for Civil Works (Ministry of Irrigation - Cairo)

v. Geophysical survey along the study area for groundwater and oil exploration, Arabian Western Geophysics, 1993 (Cairo - London).

vi. The hydrogeological and hydrogeochemical study along Sumusta, Biba and El Fashen markaz - Ashraf F. Ewiss - Cairo University 1992.

vii. Chemical analysis results of random, preliminary and regular monitoring program - RWS&SP - Beni Suef.

viii. The hydrogeochemical and hydrogeological data and representation study along the study area, Desert Researches Institute (El Mataria -Cairo)

2. GEOLOGICAL SETTING

The area between north Biba and south El Fashen Markaz in the Nile Valley is considered to be low area in the Eocene plateau . This valley is filled with Pliocene and Quaternary deposits. Generally, the lithostratigraphic units of the Nile Valley comprise the rock units exposed on both sides of the valley, the plateau range in age from Precambrian to Eocene age, while those filling the valley are of Pliocene to Quaternary age.

2.1. STRATIGRAPHIC SEQUENCE

The stratigraphic sequence along the study area as described in the surface outcrops and the subsurface ranges from Pre Eocene to Quaternary in age.

The generalized stratigraphic sequence in the study area is presented in **(fig.5)**, it consists essentially of the following rock units from base to top:

i. Pre-Eocene rocks

In the study area, these rocks are not exposed on the surface , and no drilled wells reached them. Nubian sandstone is encountered in a number of wells drilled at wade El. Rayan and exposed on the depression surface of the Baharyia oasis. (El.Sayed. 1987)

ii. Eocene rocks

Eocene rocks at the study area have a wide distribution and are represented mainly by the Middle Eocene rocks. The lower and the upper Eocene rocks are not exposed in the area of study, but they are detected in several other localities along the Nile Valley (Hume, 1911). Eocene rocks are the oldest unit cropping in the study area. This unit (EL Mokattam) formation consists of limestone with thin shale and clay intercalations. Limestone is white, hard and fine grained.

iii. Pliocene deposits

Pliocene unit was recorded in the different deep boreholes scattered over the several parts of the Nile valley (Tamer et al., 1974). These deposits represent a thick impermeable to semi permeable zone. It underlies the Quaternary sediments in the central area **(fig. 5)**. Pliocene deposits are represented by dark colored clays. The unexposed clay is unconformably overlaying the Eocene limestone.

iv. Plio Pleistocene deposits

The Plio Pleistocene deposits were reported by Tamer et al., (1974) in a number of deep water wells, in the area between Beni Suef and El Faiyum, in the northwest of the study area **(fig.6)**.

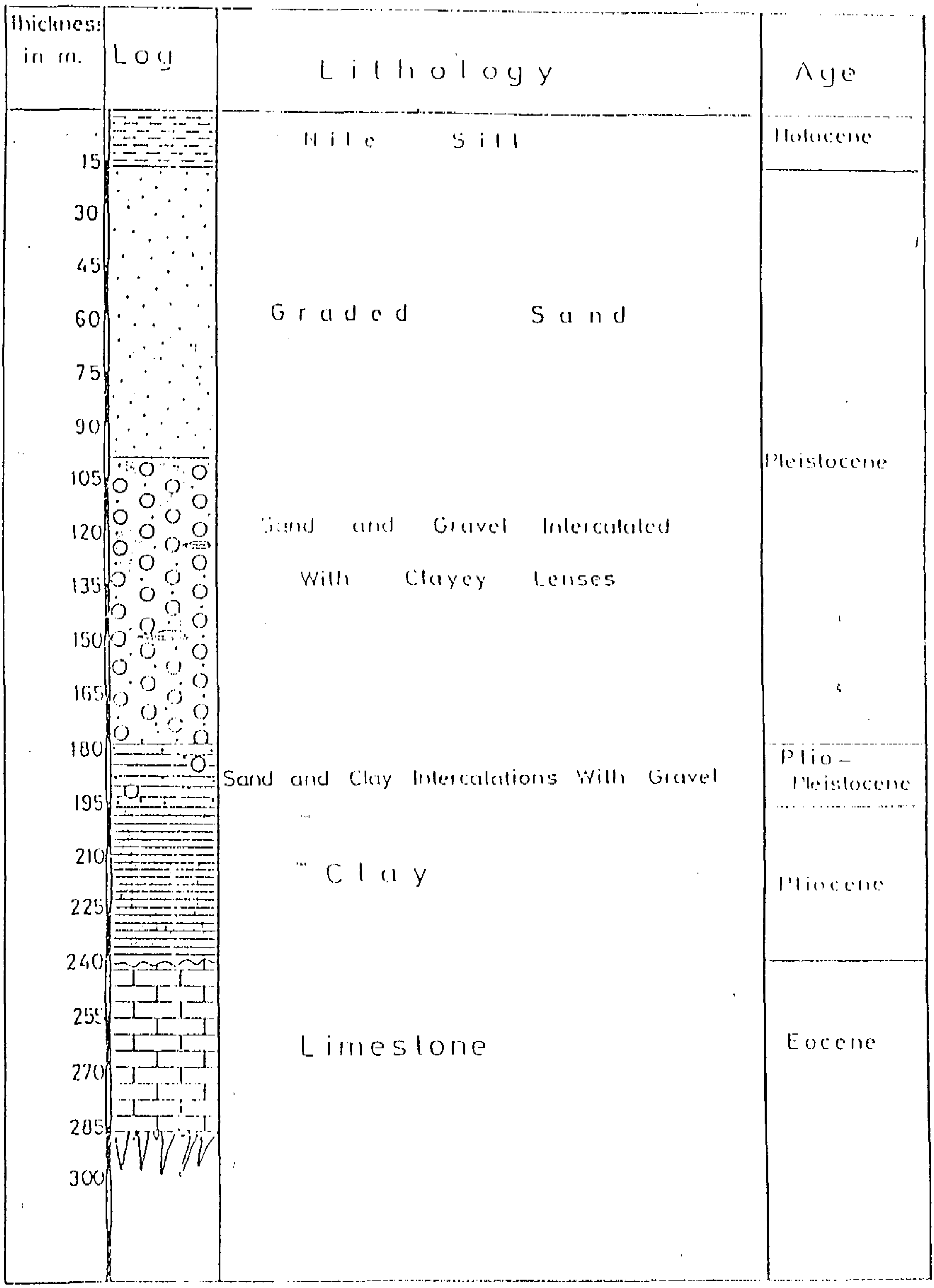


Fig (5) Generalize Stratigraphic Column along the study Area

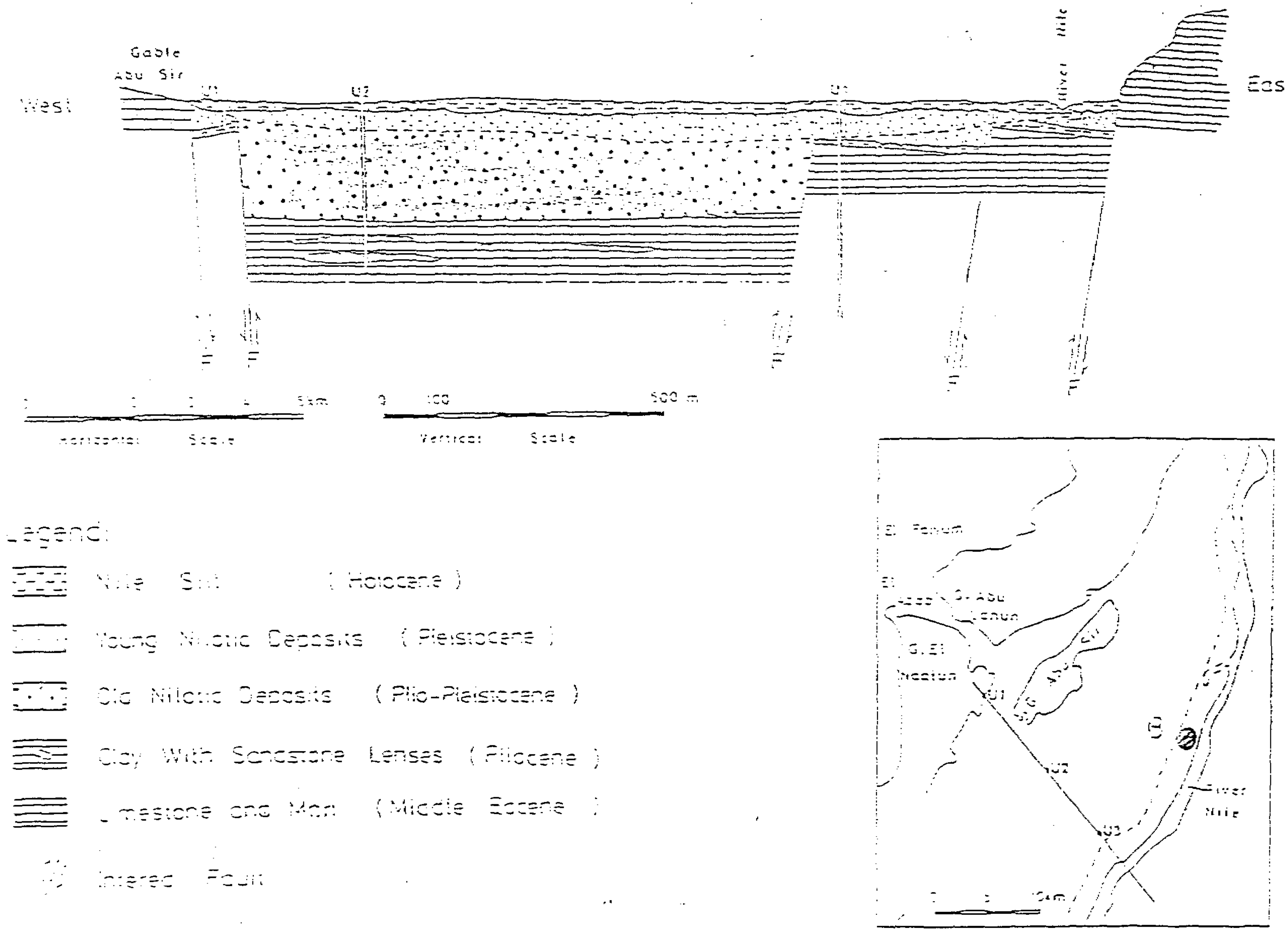


Fig.(3)Geological Cross Section Between Beni-Suef and El Faiyum.

After Tamer, 1974

However, the Plio Pleistocene deposits are overlained by quaternary deposits and underlined by clay Pliocene deposits in the Nile Valley. These deposits are formed of sand and clay intercalated with gravels **(fig. 5)**. Moreover these deposits expose as strip between the flood plain and the valley slopes.

v. Quaternary units

These units cover the major part of the Nile Valley especially in the study area, where the valley width varies between 10 km and 23 km. These Quaternary deposits can classify (El. Sayed, 1987) from top to bottom as:

a. Holocene deposits:

These deposits comprise all series unconsloidated sediments, accumulated under different environmental conditions such as:

- Nile silt :

The Nile Silt has a wide distribution along the study area, it forms a cultivated layer which caps the mean Quaternary aquifer in the central part of the area. These deposits are the product of the seasonal flood of the Nile over the entire Nile basin.

The thickness of these silt deposits demonstrates a great variation from place to another, with the main value of about 12 m. Such deposits are composed of silts and clay. It have a semi permeable character and play an

important role in recharging the Quaternary aquifer in the Nile Valley through the infiltration of the surface water from irrigation system.

- Sand dunes :

The sand dunes wide tracks of marginal areas of cultivated land. These dunes are essentially composed of well sorted loose sand and gravel, mixed with some heavy minerals and interbedded with the silts of Holocene.

b. Pleistocene deposits:

These deposits consist of sands and gravels with clay intercalations. It is directly overlained by the Nile silt. These deposits represent the water bearing sediments of the Nile Valley.

2.2. Structural Features

Several structural parameters were effect on the study area

i. Faults:

The surface is effected by a number of step faults which have two trends NW.SE and NE.SW directions. These step faults cause between them a big graben that is filled with Pliocene and Quaternary Sediments. The large numbers of faults give rise to other structural features such as horsts and graben.

All these faults are responsible for the creation of the Nile Valley and especially the irregularity of the bottom of the Nile basin in the study area, where they control the Eocene plateau. The representative geological cross section show the structural elements along the study area **(fig. 10)**.

ii. Unconformities:

The main unconformities detected in the concerned and surrounding areas either on the surface or subsurface are:

- Between Pliocene clays and the Middle Eocene rocks.
- In the north of the study area , Pleistocene and Middle Eocene
- In the south of the study area between Quaternary and Middle Eocene.

iii. Joints:

Joints have been recorded in the study area, they are trending approximately parallel to the existed fault system.

3. GRAIN SIZE ANALYSIS

The grain size analysis and mineralogical study took place through the master study of the consultant (Hydrogelogical and hydrgcochemical study along Sumusta, Biba and El Fashen- Cairo University 1992) and are summarized here as following :

The collected samples for mechanical analysis and grain description **(fig.7)** in this study represent most of the varieties encountered in sand aquifer of the wells lie in between north Biba and south El Fashen markaz.

Sixty seven friable samples were selected, quartered and desegregated either by hand or by using pestle and pieces of rubber. Some were soaked in water to ease desegregation. It should note that the degree of desegregation was controlled under the binocular microscope prior to sieving 100 grams for each sample screened through a set of Tyler standard sieves (2, 1, 0.5, 0/125, 0.125, 0.0625 mm diameter).

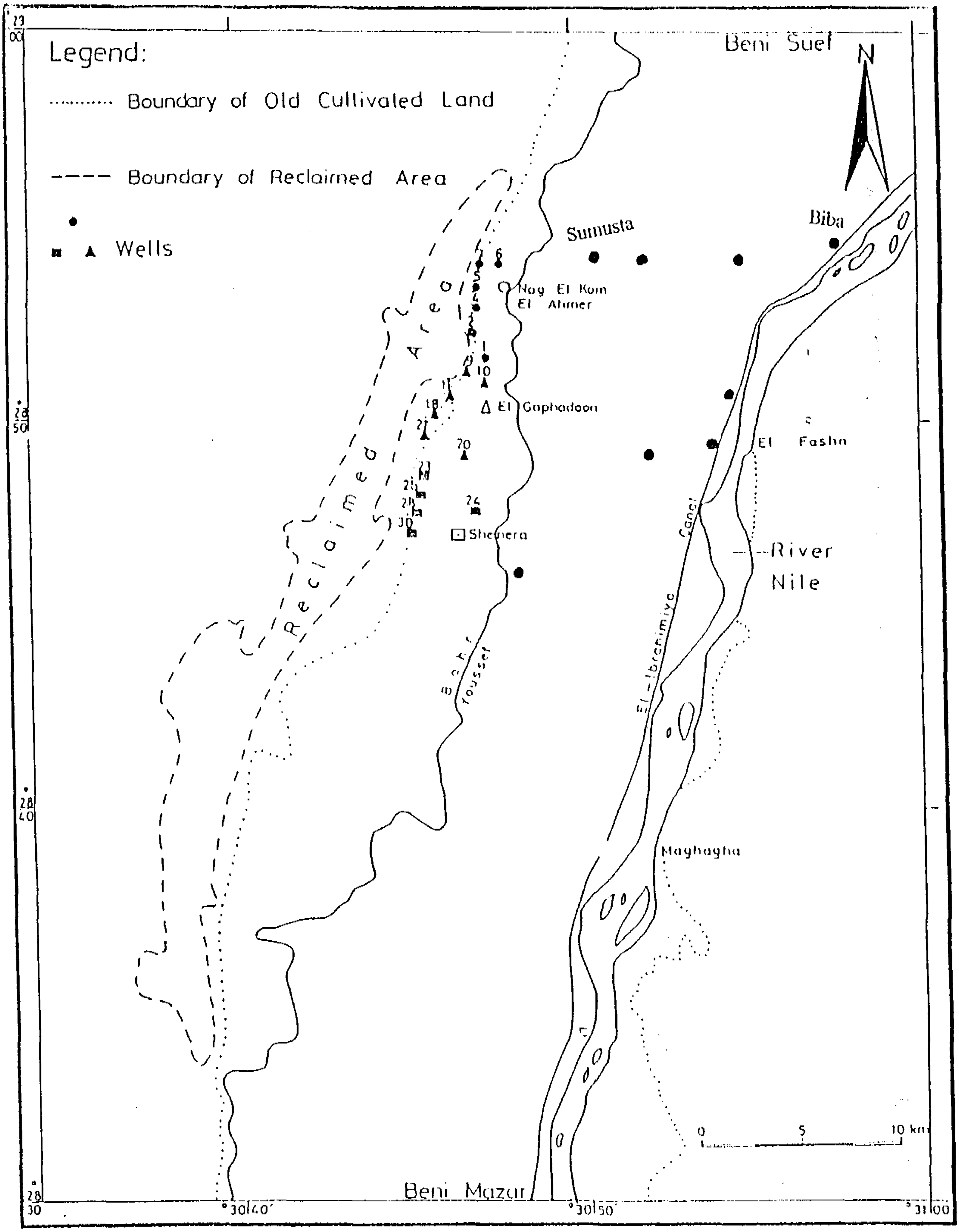
3.1. MEASUREMENTS OF THE AVERAGE GRAIN SIZE

i. Main grain size in sector 1
Sand range from coarse to fine sand.

ii. Main grain size in sector 2
From coarse sand to fine gravels.

iii. Main grain size in sector 3
Coarse sand to fine pebbles.

iv. Main grain size in sector 4
Medium to fine sand.



Fig(7)Location Map of Selected Samples

3.2. GRAIN SORTING (Uniformity of the grains size)

90 % of the collected samples along the study area shoe moderately sorting grains while 5% show poorly sorting grains.

3.3. PALEOENVIRONMENTAL INTERPRETATIONS

Most of the studied samples along the study area (85.6 %) are of river environment while, 14.6 % are of swampy environment.

3.4. HYDRAULIC CONDUCTIVITY

The hydraulic conductivity of the aquifer (k) along the study area are varying between 64.3 and 91.8 m/day with average value 76 m/day as represented in **(fig. 8)**.

3.5. SPECIFIC YIELD

According to Prill and Johnson, the relation between specific yield and particle size can be shown if the data which obtained from the grain size analysis were plotted on the trilinear graph **(fig. 9)**. In the studied area, the observed specific yield values vary between 25 % and 35 % with a mean value 30 %.

3.6. MINERALOGY OF HEAVY AND LIGHT MINERALS

The fine sand fractions (separated by mechanical analysis technique) were taken for bromoform separation, where heavy minerals tend to concentrate in fine sand size.

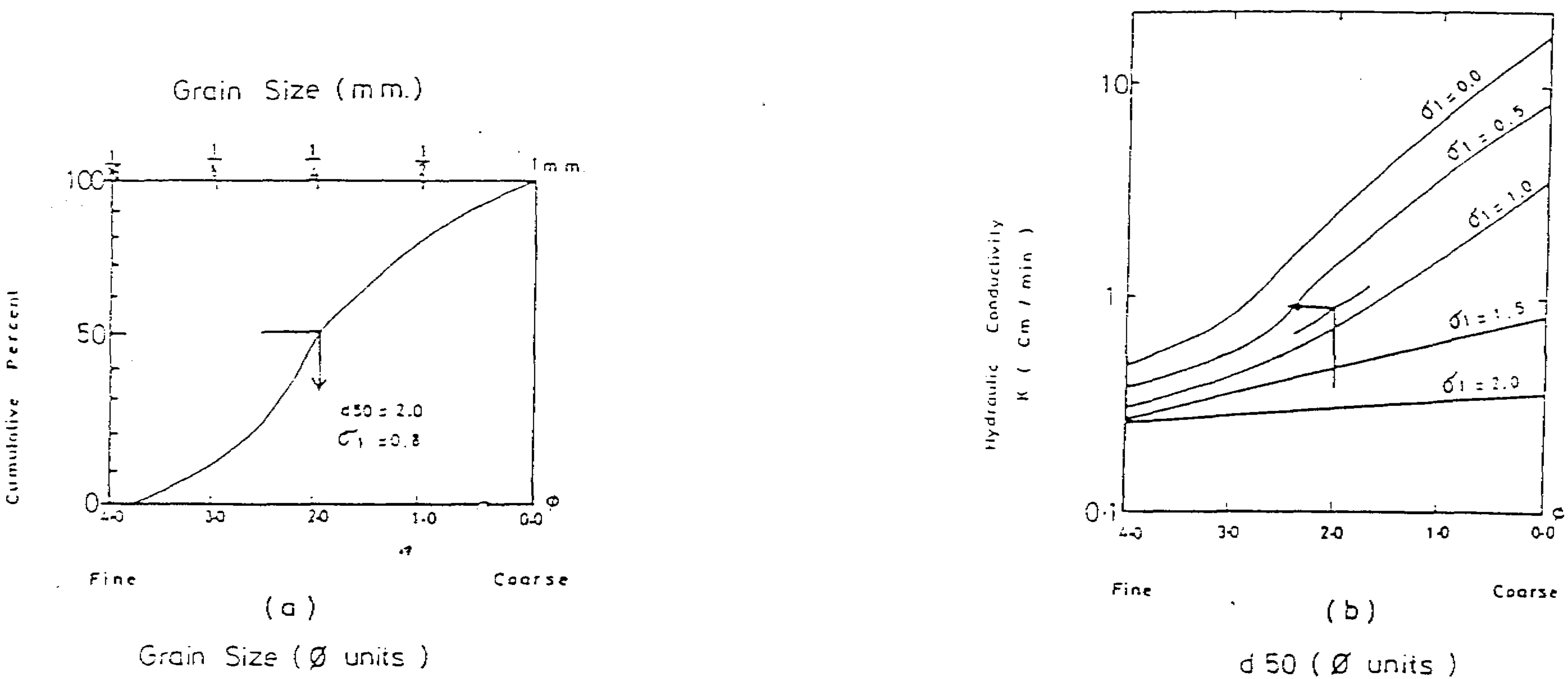
i. Heavy Minerals

The main heavy minerals in the aquifer grains are iron oxides (Hematite, Magnetite and Sedrite) 64.02 to 83.66 % in the studied samples, while Zircon, Gluconite, Biotite and Tourmaline represent 35 to 16 %.

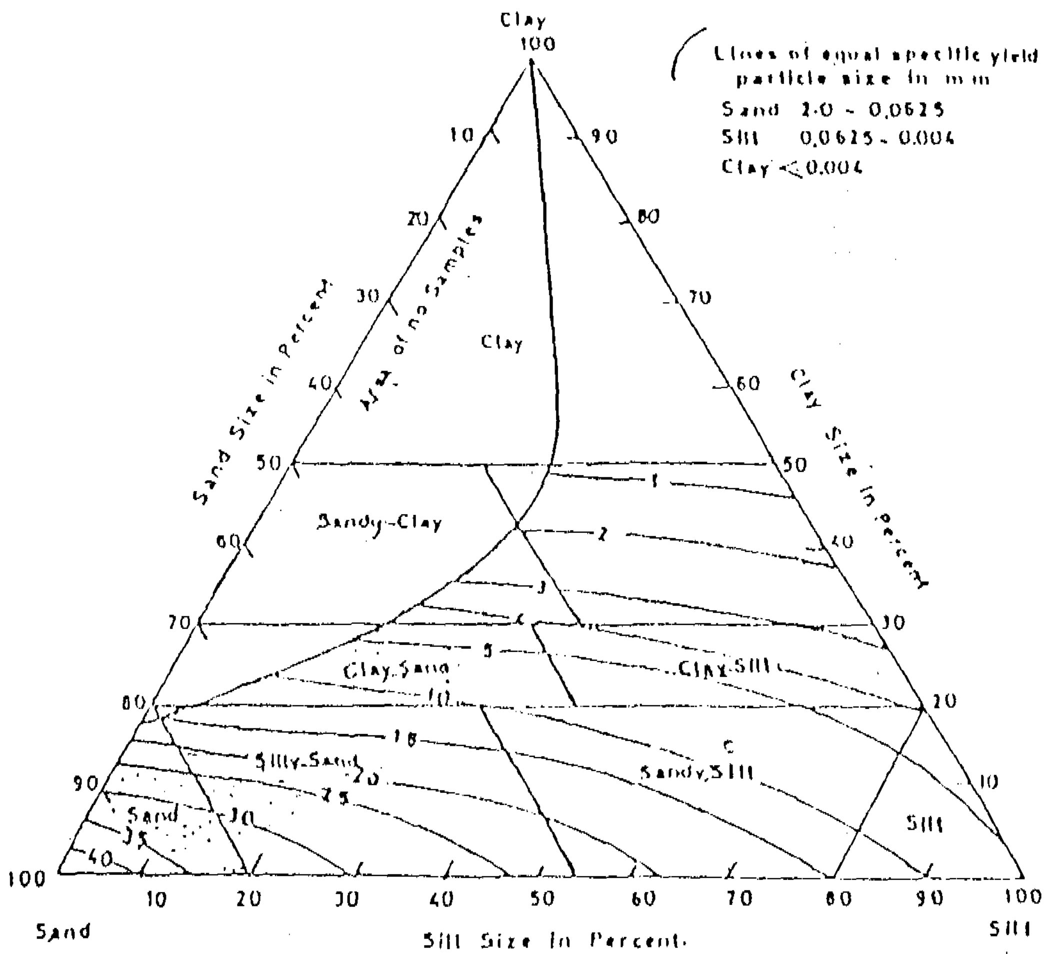
ii. Light Minerals

The light minerals encountered in the studied samples consist mainly of Quartz, few amounts of Muscovite and calcite (frequency less than 10 %). The Quartz forms constituents 86.2 % to 93.4 % of the light minerals.

So, it can be concluded that the Nile sediments which had been examined in the present study resulted from the disintegration of the metamorphic and igneous rocks.



Fig(8)Determination of Saturated Hydraulic Conductivity from Grain Size Gradation Curves for Unconsolidated Sands (After Masch and Denny , 1966).



Fig(9)TRIANGLE SHOWING RELATION BETWEEN PARTICLE SIZE AND SPECIFIC YIELD

(After Prill and Johnson , 1967)

4. HYDROGEOLOGY

The hydrogeological studies along the study area are based on the following foundation:

i. Correlation and evaluation of the available old data.

ii. The data collected within the present study (data collection and preliminary monitoring program.

iii. Surface and groundwater measurements, during the present work.

iv. Chemical analysis of water samples collected from some wells along the study area .

Consequently the following main points will be discussed :

4.1. AQUIFER BOUNDARIES

The study area covers an area of about 800 km^2, the representative geological cross section in (**fig. 10)** illustrate the no flow boundary and the structural elements which effect on the aquifer.

The western bank of The River Nile represent the eastern boundary of the study area. The river Nile cuts completely through the top semi pervious layer into the aquifer. The water levels in the Nile varies slowly during a year. Further more, the average difference between the highest and lowest water levels does not exceed 1.1 m in the study area. Consequently, the eastern boundary is represented constant heads (water levels of the Nile).

The northern and the southern boundaries are also represented by constant piezometric heads.

Bahr Youssef runs through the study area from north south and is assigned to the model as a third type boundary condition. This mean that, the parameters governing the flow from the canal into the aquifer are the level of the water in canal, the wetted parameter of the canal, the hydraulic resistance of the seepage surface.

4.2. AQUIFER TYPES AND EXTENSION

Many transversal geological sections along the study area were investigated and accordingly a fairly clear idea about the lithology and extensions of water bearing sediments along the study area have been obtained. The aquifers in the study area can summarized as follows:

4.2.1. The Eocene fissured carbonate water bearing formation

This aquifer is of very limited hydraulic conductivity due to low permeability and porosity specially along the study area but south the study area the permeability increase to considerable degree (Beni Mazar area)

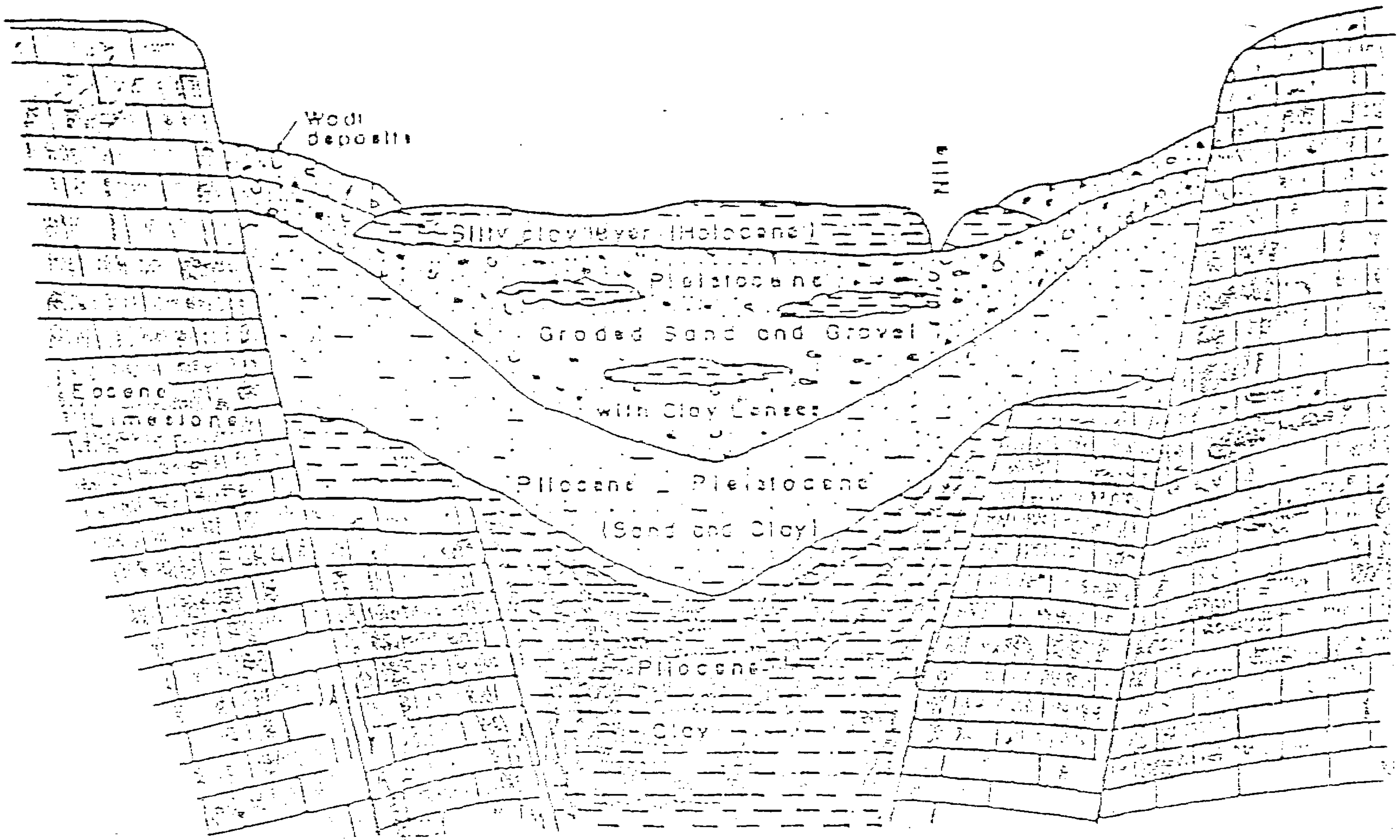


Fig 10 Representative geological cross section of the study area

4.2.2. Post Eocene water bearing sediments

These water bearing sediments have wide geographical distribution along the study area . They composed mainly of sandstones, sands, graverls and clay, which are related to the Pliocene, Pleistocene and Holocene ages. There is hydraulic connection between this aquifer and the surface water of the River Nile, irrigation canals and the occasional water runoff of the desert wades .

The quantity and quality of the water in this aquifer are largely affected by the rate of both infiltration and evaporation, which in turn depend on the variations of thickness and facies of aeration zone.

In the study area, two types of aquifer with the same age are recorded; the semi confined aquifer type which occupy the flood plain of the Nile Valley and it covered by semi permeable layer of mud and underlain by a virtually impermeable Pliocene clay, which is considered the lower boundary of the aquifer.

While outside the flood plain, where the Nile mud is absent (Including the reclaimed areas), the aquifer is generally unconfined. A strip of fine grain sediments separates the flood plain and the valley slopes (El.Kufug formation).

Towards the valley slopes (west direction) the aquifer becomes gradually thinner and bounded by faults.(RIGW, 1993)

The maximum thickness of the aquifer (240 m) attains in the central part of the valley (latitude 28° 30') and decreases towards the north reaching 100 (latitude 29°00') (**Arabian Western Geophysics & La Champagne General De Geophysics.1992**). But the maximum thickness along the study area at the central part is 180 m. (**RIGW,1989,fig.11).**

The geophysical survey as well as the boreholes data indicate a rather shape of the aquifer in the reclaimed desert areas. In average, the thickness of the aquifer in these areas ranges from locally 20 m in the northern part and central part, to more than 50 m in the southern part. However, locally rather large deviations from these average values may occur (**RIGW.1989).** Generally, the geometry of the aquifer is characterized by steep inclination near the valley slopes with infinite extension in north-south direction, while it is limited from the east and west by the edge of the plateau Eocene limestone. The relation between the different unit of the aquifer is presented in **(Fig. 12 , 13 and 14).**

4.3. GROUNDWATER RECHARGE AND DISCHARGE

In the reclaimed desert areas the aquifer is recharge by leakage from the irrigation canals and by deep percolation of excess irrigation water.

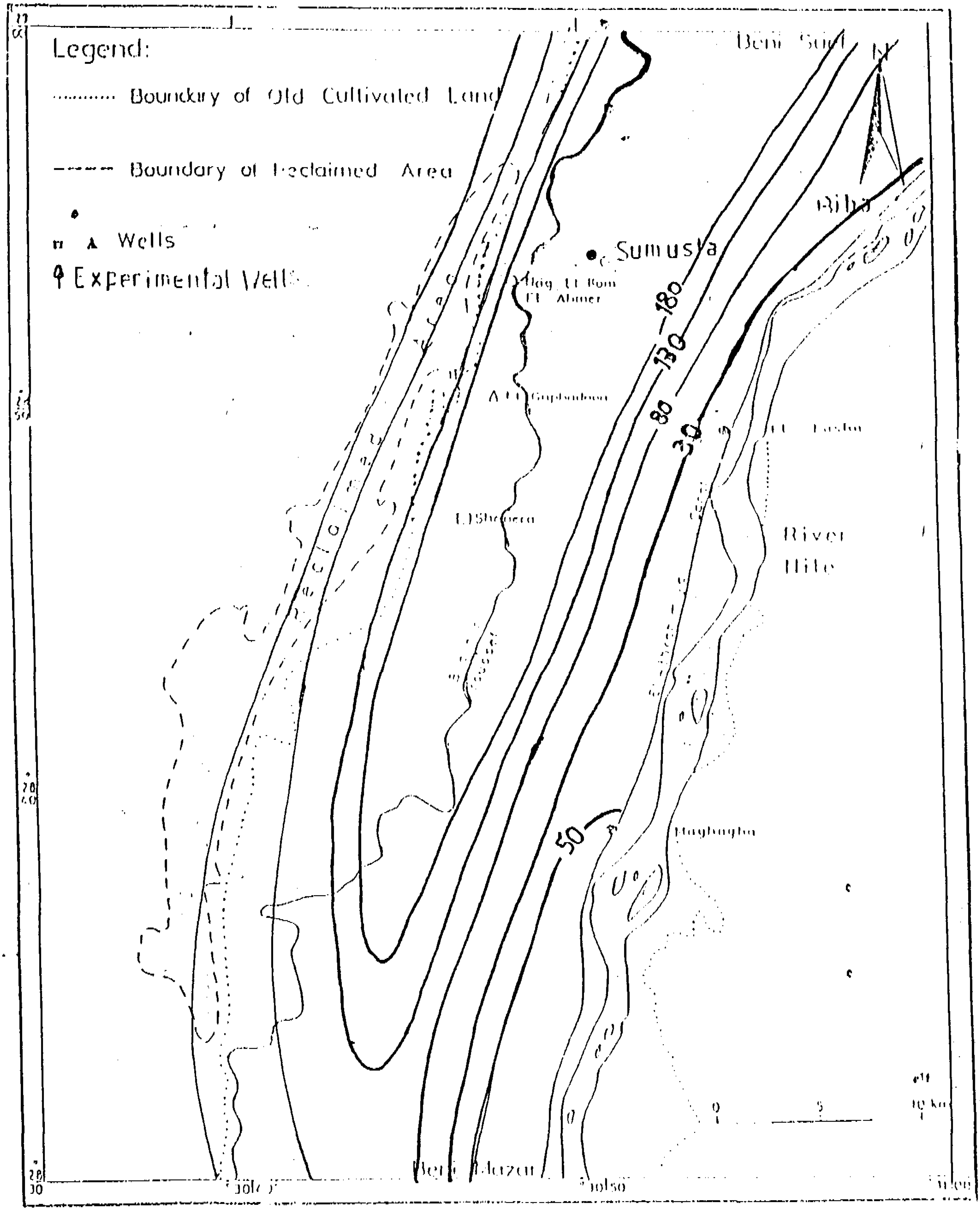


Fig. (11) Thickness Contour Map Of The Water Bearing Formation Along The Study Area.

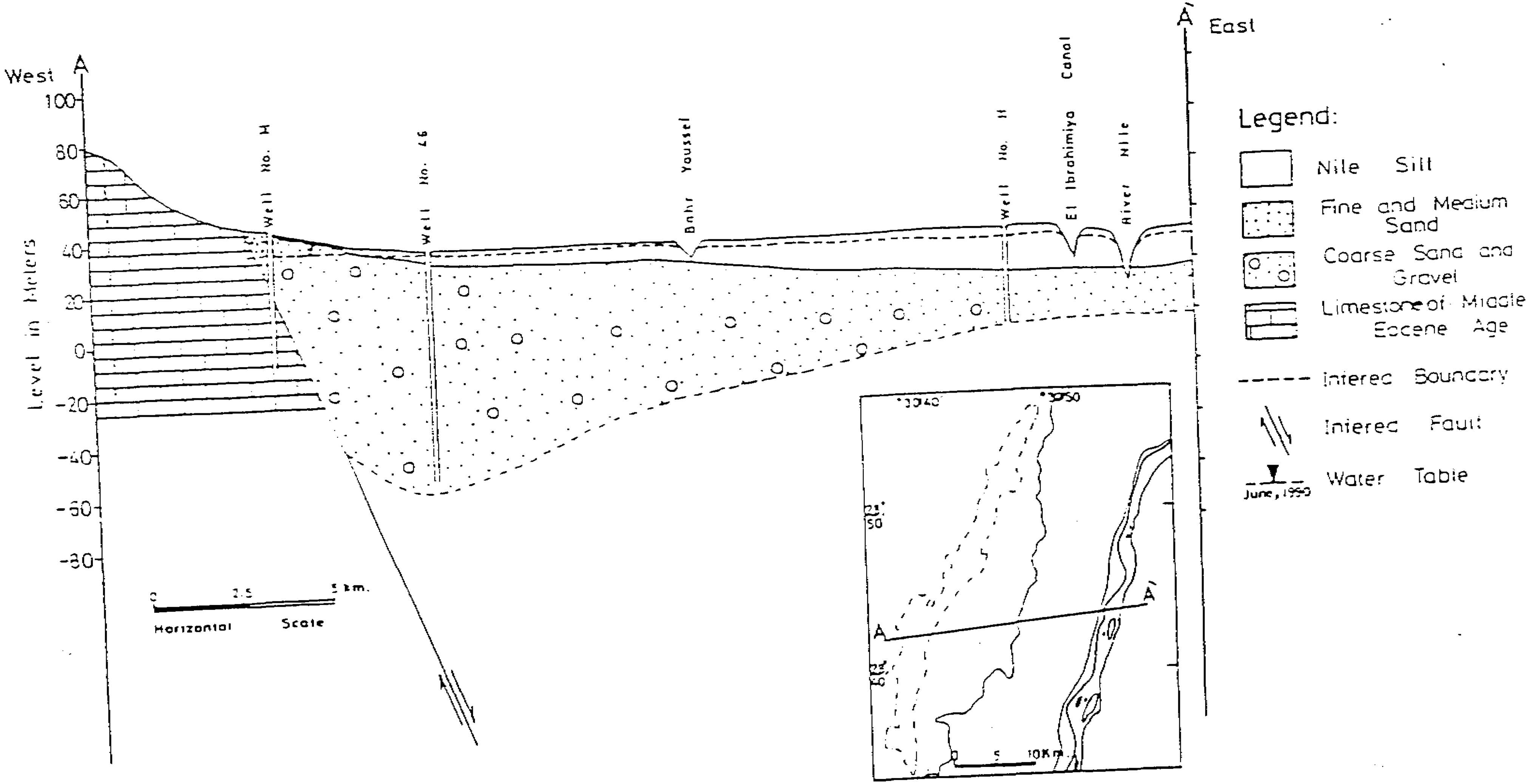


Fig.(12)Hydrogeological Cross Section A - A`

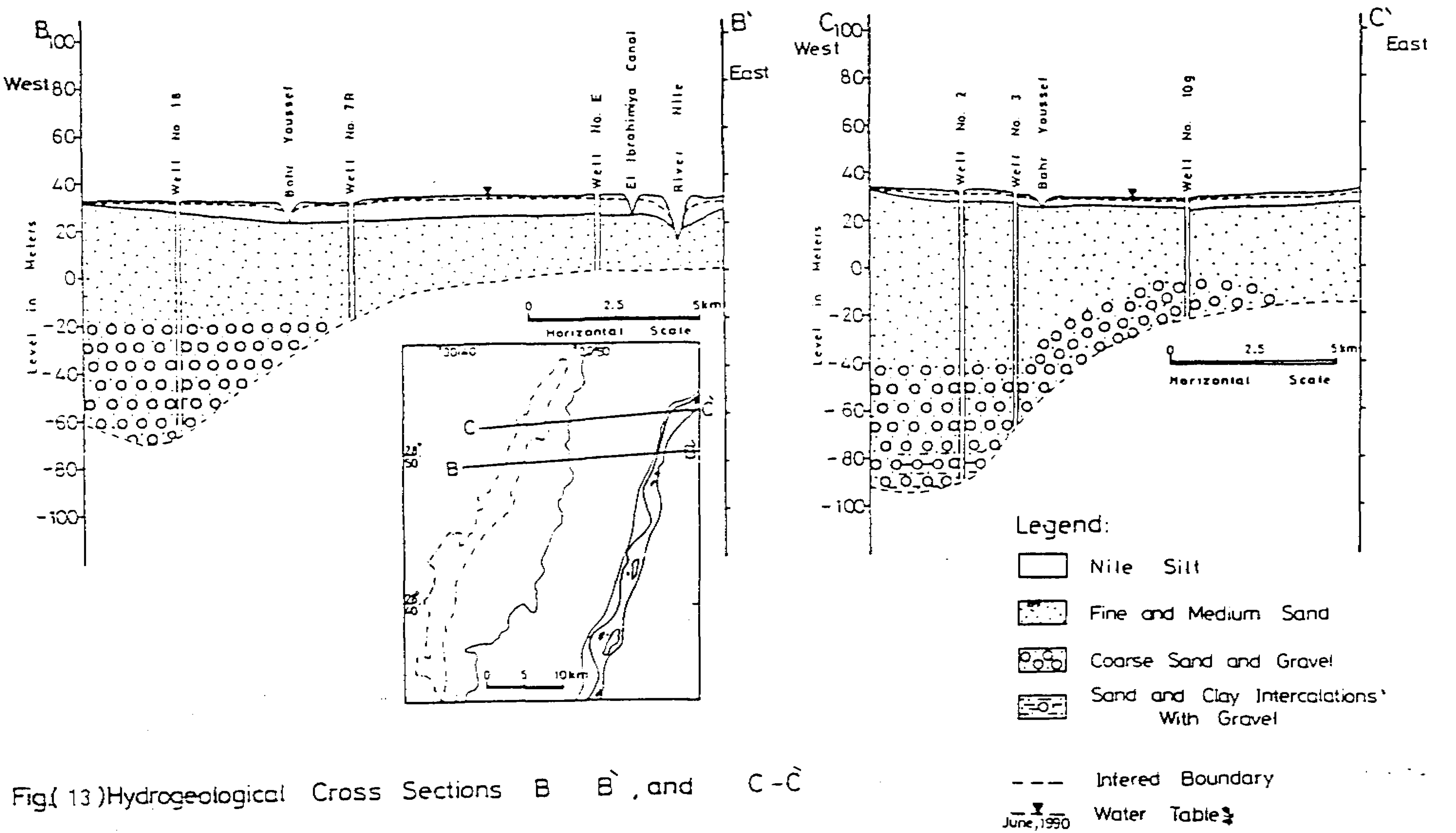


Fig.(13)Hydrogeological Cross Sections B B`, and C-C`

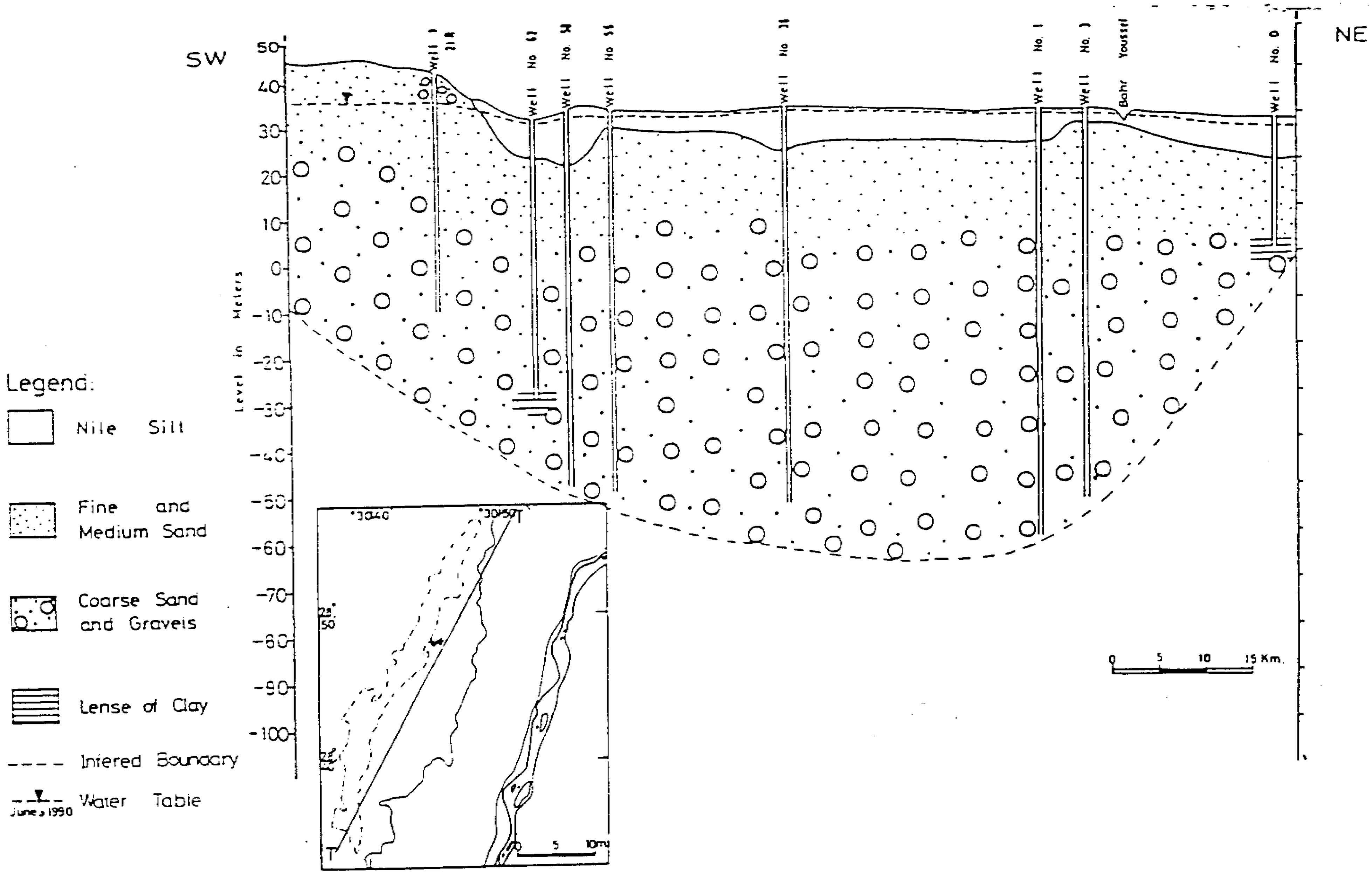


Fig.(14) Hydrogeological Cross Section T - T` (Beni Suef - Beni Mazar Area)

A man made drainage system does not exist in most of this area. Almost all subsurface drainage water percolates to the groundwater table. Also, as the irrigation water in the lifting canals runs continuously through sandy deposits, large quantities of water are percolating to the aquifer. The amount
of water contributing the aquifer is estimated as 30% of the total surface water inflow. This quantity corresponds to 4.9 mm/day for the reclaimed area. **(RIWG.1993)**

The total recharge of the aquifer amounts to about 11.1 mm/day for the reclaimed area . As consequence the amount of excess irrigation water (subsurface drainage water from field application) equals 6.2 mm/day **(RIGW. 1993).**

The area west Bahr Youssef which adjacent to the reclaimed area has not been provided with drains. The subsurface drainage water in this area is discharged by open drains which are not functioning properly, only the seepage water is intercepted (estimated as 20% of the total seepage). The major part of the seepage is laterally recharging the aquifer . Accordingly, upward groundwater rising from aquifer to the zone occurs in extensive areas, thus cause waterlogging and saliniztion.

The major part of the area east of Bahr Youssef has been supplied with some drains which are used to discharge the subsurface drainage water. Meanwhile the levees along the River Nile are provided with a system of open collector drains. In this area the groundwater table is relatively deep. The major part of the subsurface drainage water in this area percolates to the aquifer (natural drainage).

4.4. GROUNDWATER MOVEMENT

The infiltration of the water from the sides of canals and excess rising in the water table. This great difference in the groundwater levels between the reclaimed area in the west and old cultivated lands in the east causes a high hydraulic gradient, and therefore a lateral flow of the groundwater eastward direction, but this movement represents about 10-20% from the general flow of the aquifer . This flow is limited by the Eocene limestone located along the western boundary of the aquifer, which act as an impervious barrier for groundwater flow.

Also, the groundwater flows from south to north according to the naturally existed hydraulic gradient. The groundwater movement is well illustrated in three water table maps 1987, 1989 and 1994 (**Fig. 15, 16 and 17)**

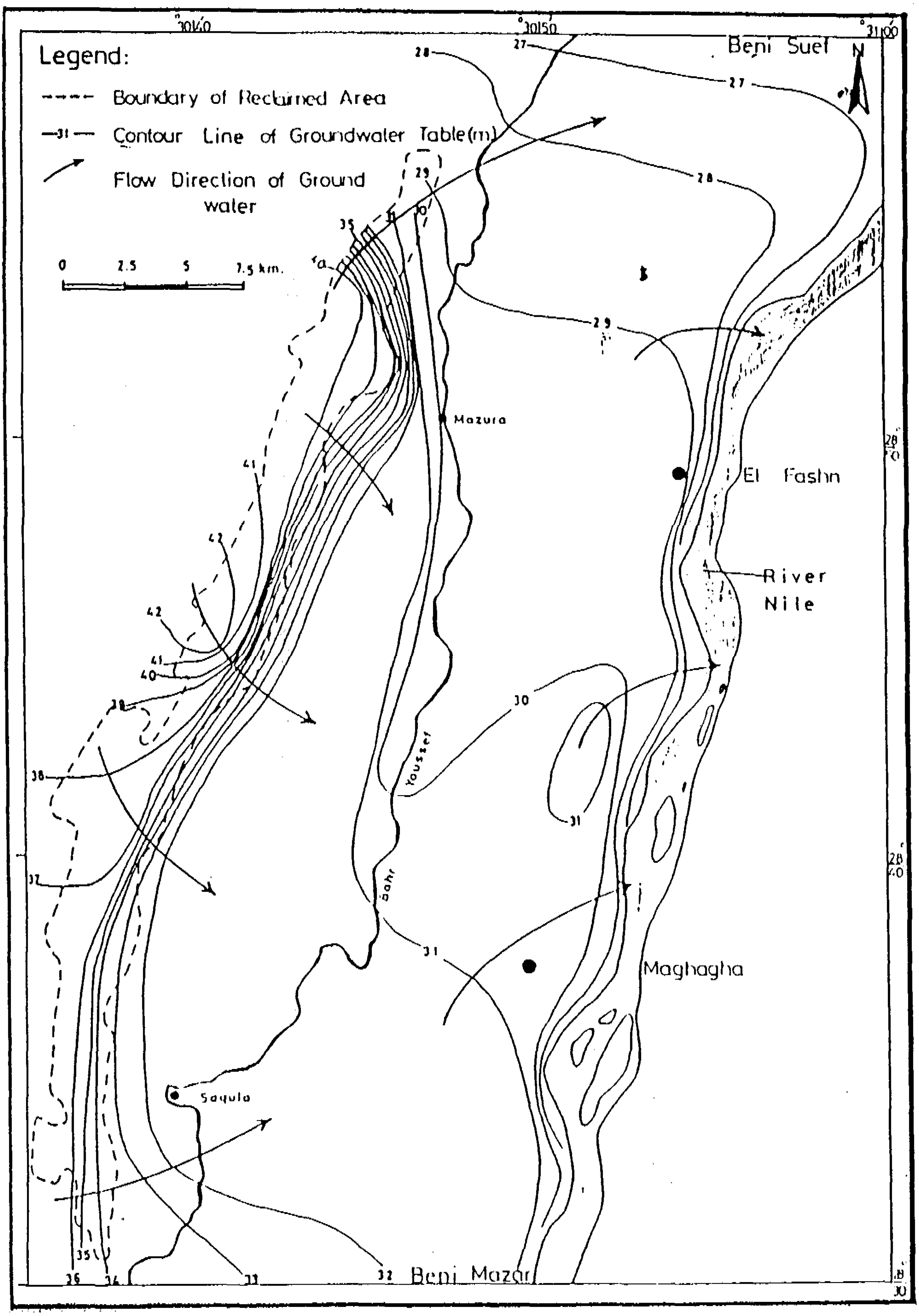


Fig 15 Water Table Contour Map Along The Study Area.
(After RIWG, 1987)

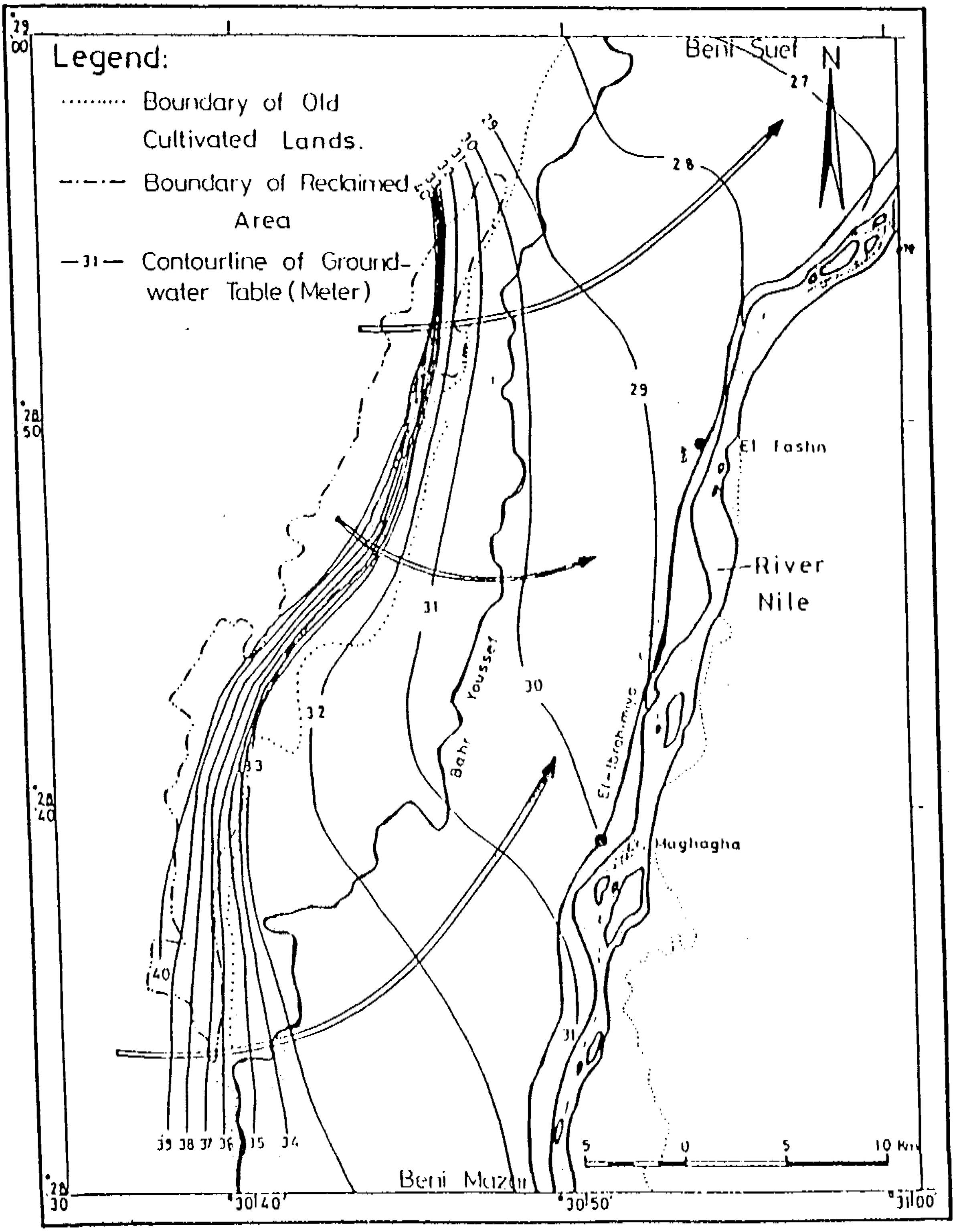


Fig (16) Water Table Contour Map Along The Study Area .
(After RIGW, 1989)

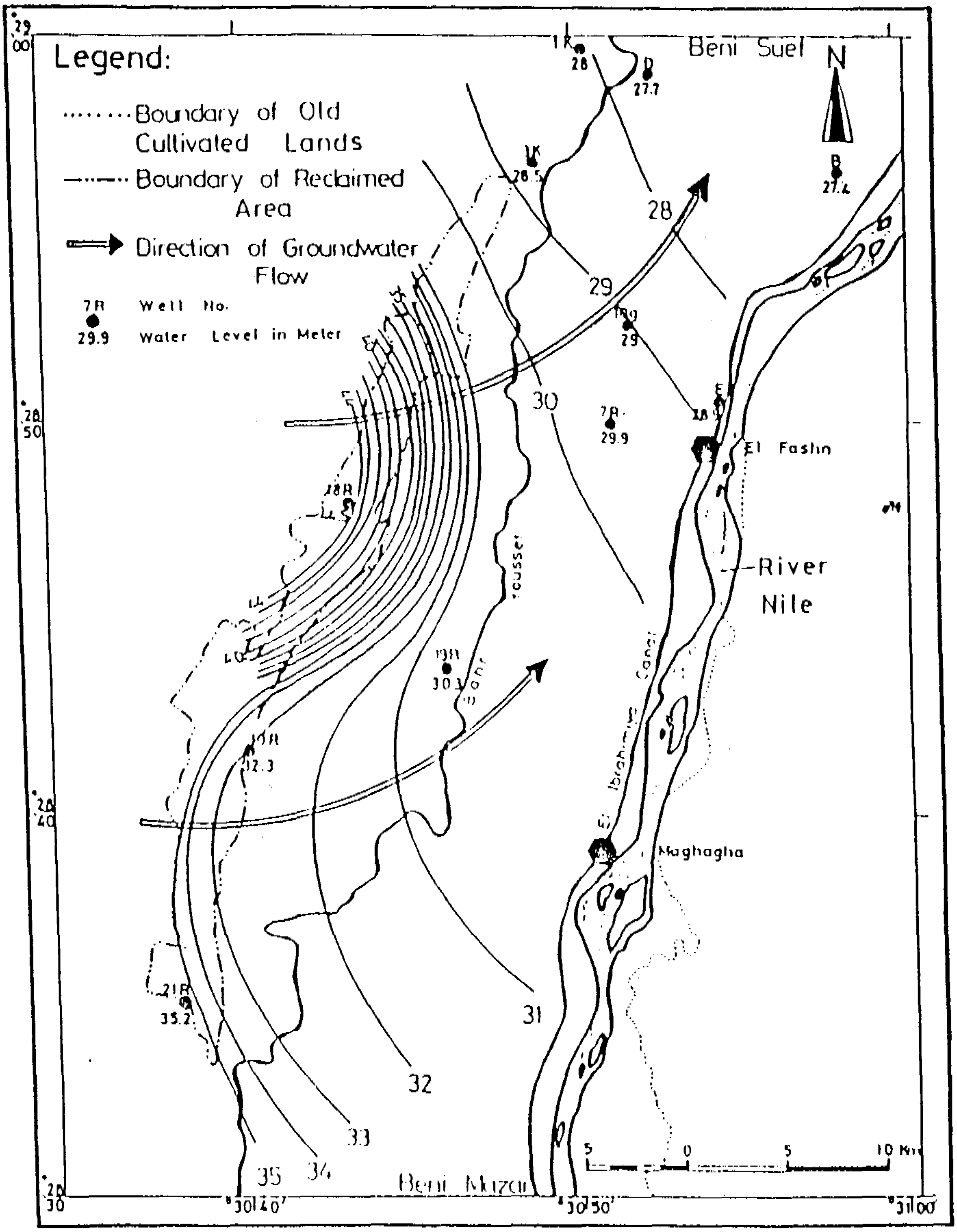


Fig (17) Water Table Contour Map Along The Study Area.

(After RIWG,1994)

4.5. RELATIONSHIP BETWEEN SURFACE WATER AND GROUNDWATER

The interrelationship between the surface water and ground water will be concerned with the River Nile , the irrigation canals and surface drains.

Referring to the River Nile before the construction of the High Dam the groundwater flow used to take place laterally from the Nile to the aquifer (effluent seepage). The flow from the aquifer to the Nile (influent seepage), however, has occurred only during the draught seasons. After the construction of the High Dam (1966), the water level of the River Nile becomes fully controlled all over the year, and so it acts as a drain for groundwater in many parts of the basin **(fig. 18&19).**

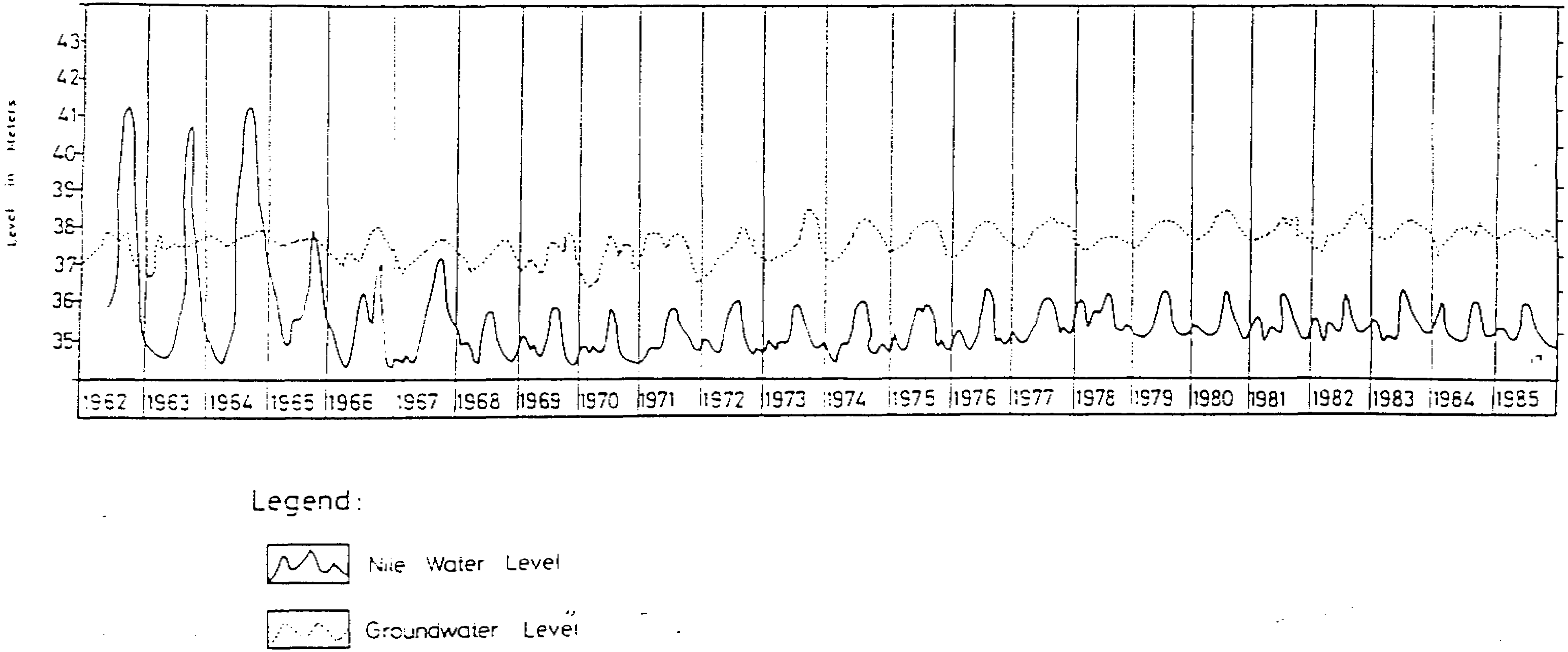
The rising in the water level of the Nile during June, July and August, and the dropping in December, January and February is represented in **(fig. 19)**.

In some observation wells H, E and C **(fig. 20)** which are located very close to the River Nile, The ground water level is obviously controlled by the fluctuation of the water level in the River Nile, while in the far wells no relation between the water level in the river and that of the ground water could be detected.

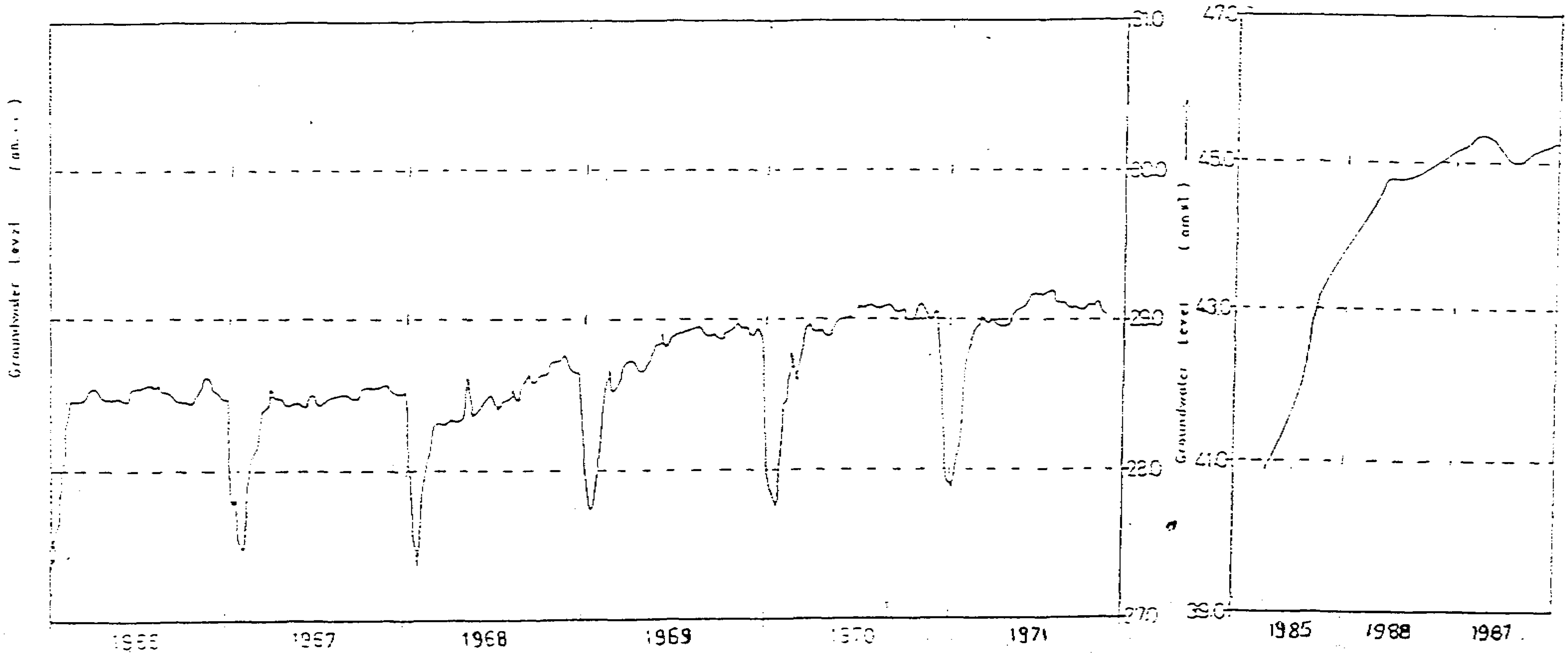
Referring to the above discussion it can be announced that the River Nile as well as the system of irrigation canals play the most important role in recharging the aquifer. This is obvious from the water table maps, also from local fluctuation of both surface water and groundwater **(fig. 19)** . During the winter close period , these canals act as drains for the groundwater . On the other hand, the small irrigation canals become dry during this period and accordingly they have a negligible effect on the ground water fluctuations.

Consequently a marked lowering in the groundwater level was recorded in the cultivated old lands as shown in **(fig. 20)** and the irrigation canals play an observable role in discharging the ground water from shallow aquifer. At the end of this period, water level begins to rise rapidly to its original position.

With respect to the irrigation water, after completion of the High Dam, all the lands that were practically flood irrigated, have been transferred into perennial irrigation. This situation leads to continuous usage of additional amounts of irrigation water which have generated new problem, mostly related to rising the water table, waterlogging, and increasing salinity in various cultivated areas. Moreover, the additional increase in the irrigation water plays obviously the



Fig(18)Fluctuation in Groundwater and Surface Water Levels Before and after the Construction of the High Dam



(a) Observation Well No. F (G.L. - 30.0m)

(b) Observation Well No. 18 R (G.L. - 47.19m)

Fig(19)Hydrographs of Observation Wells 18 R and F

(After RIGW, 1989)

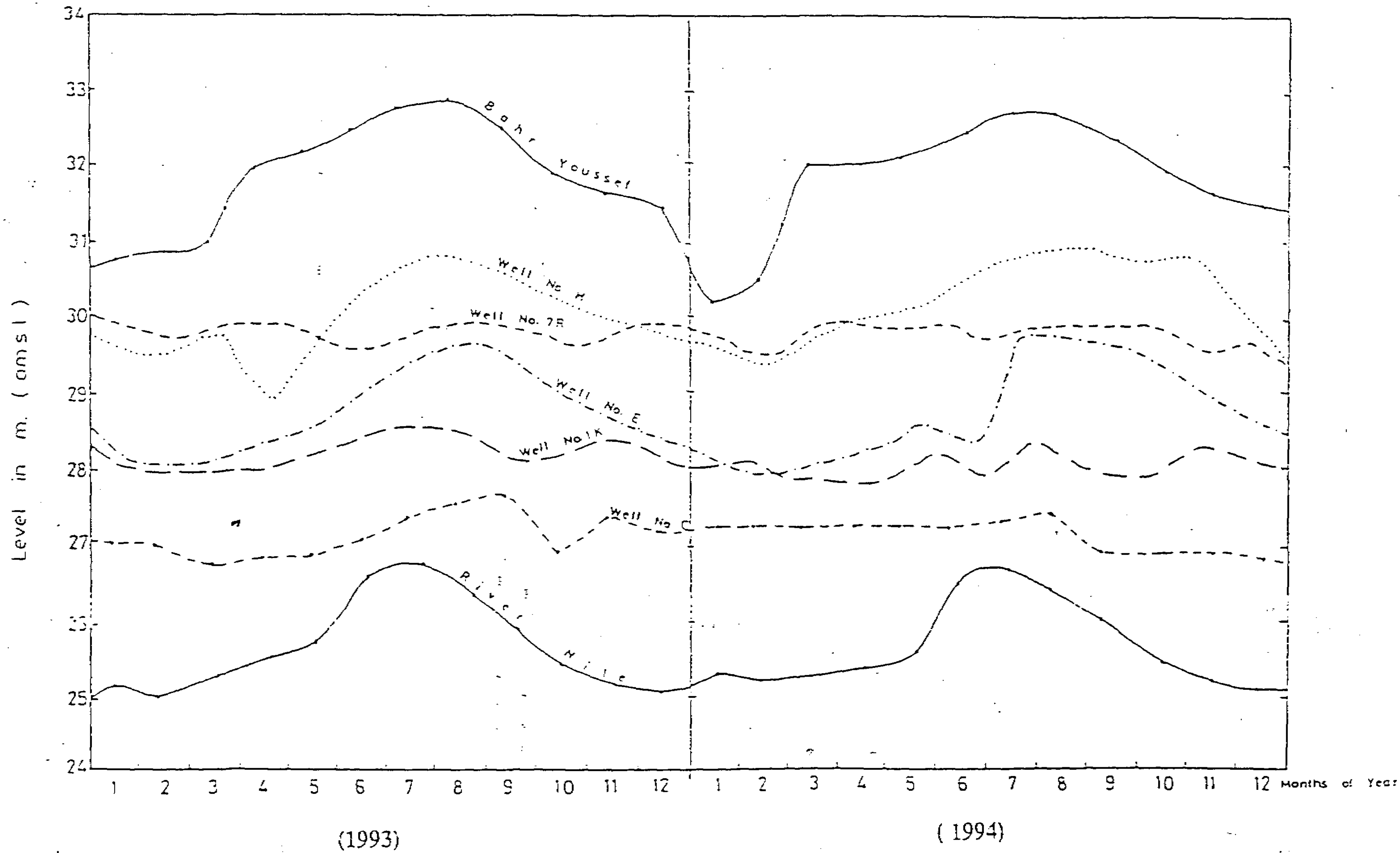


Fig 20 Digram Showing Fluctuation In Ground water And Surface water
In The Area Between Su sta and El Fashn

important role in the irregularities which have been noticed in local fluctuations of the water in the groundwater.

With regard to the surface drains, the need for drainage system was limited before the construction of the High Dam. At that time, the groundwater heads allowed the area were low for enough for vertical downward seepage during the Nile draught seasons. After the completion of the High Dam, however and due to the lack in developing an efficient drainage network, the water tables have continuously rise as a result of excessive surface water seepage. Thus, the waterlogging problems have been observed in some areas of old cultivated and reclaimed lands.

4.6. DEPTH TO THE GROUNDWATER

The static depth to the groundwater level influences both the cost of pumping (installation and cost of energy) and the impact of pumping on the environment. On the other hand, the dynamic depth depends on the aquifer characteristics, the rate of pumping, and the recharge.

From many measurements of the static water levels of the observations, experimental and production wells it was found that :

i. The depth of the groundwater levels varies from one locality to another. It is affected by the general relief of the ground surface and the levels of the surface water in channels of both irrigation and drainage system.

ii. The groundwater table in the west is higher than the east as shown in **(fig. 21).**

4.7. HYDRAULIC PARAMETERS

The determination of the numerical values of the hydraulic parameters enables us to evaluate the aquifer behavior during its development for water supply. So, attention will be given to determine some of the hydraulic parameters such as conductivity **(K)**, transmissivity **(T)**, and storage coefficient (S) through the analysis of the data collected from some pumping and recovery tests which were carried out representing all possible conditions of the aquifer in the study area. In order to analyze the obtained pumping test and recovery data of the aquifer, the following remarks were taken into consideration:

i. The aquifer is semiconfined (Leaky aquifer), and piezometeric surface decline in the eastward direction.

ii. All the pumped wells are partially penetrated the aquifer.

iii. In all cases the pumped wells are without piezometers.

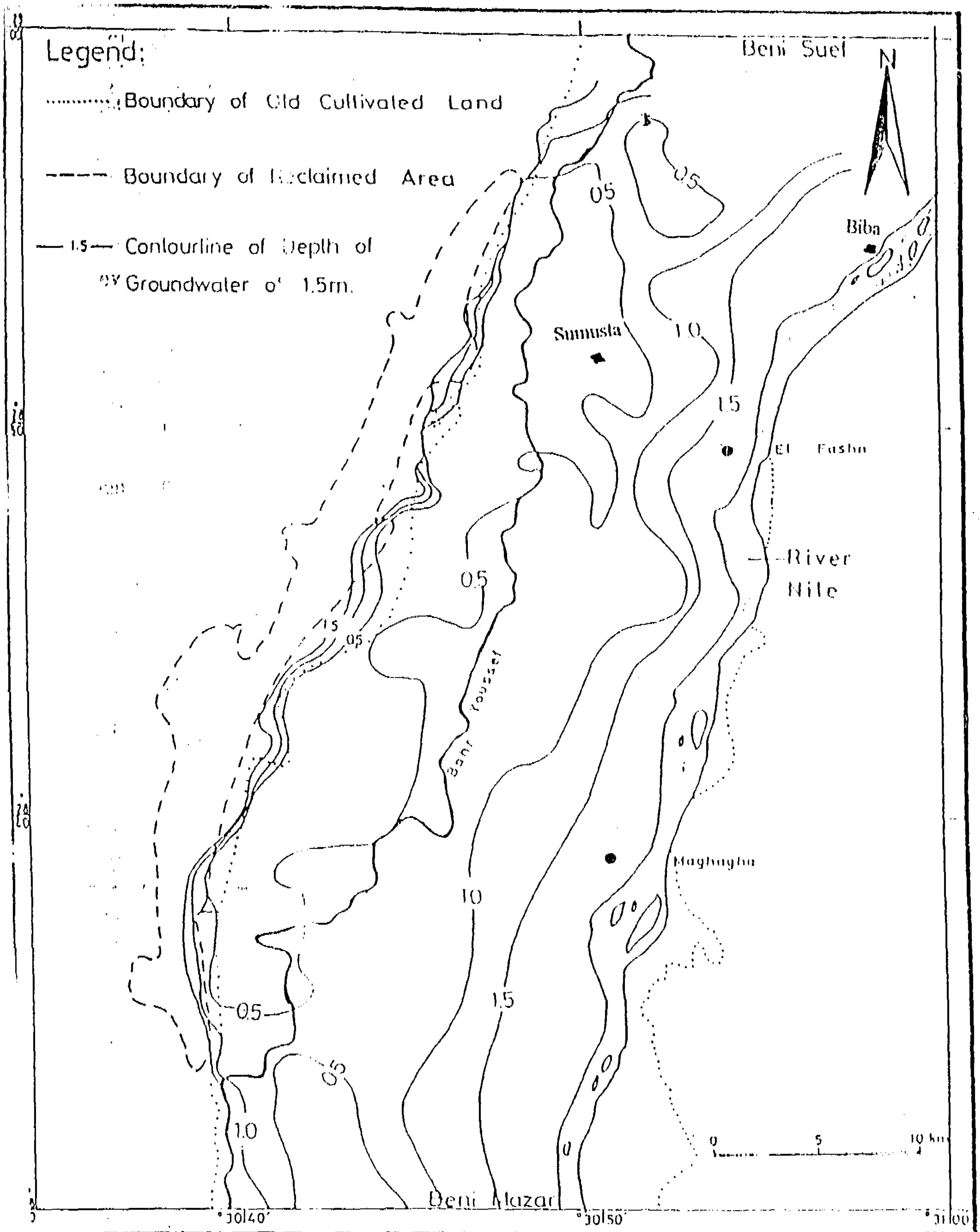


Fig (21) Depth To Water Contour Map, 1994

(After Research Institute for Ground Water, 1995)

4.7.1. Adjustment of Partial Penetration

The present form (DE Glee) for such adjustment is as follows:

$$\frac{Qp}{Qf} = \frac{\ln \dfrac{ro}{rw}}{\dfrac{(ho)}{hs} \ln \dfrac{(hs)}{2rw} + 0.1 + \left(\ln \dfrac{ro}{2ho}\right)}$$

Where :

Qp = actual field discharge of the penetrating well, (m^3 \ hour)
Qf = discharge of similar fully penetration with the same total draw down (m^3 \ hour).
ro = radius of influence assumed to be **2 ho** (meters).
rw = radius of the well (meters).
ho = aquifer thickness of saturated zone .
hs = portion of saturated thickness of aquifer tapped the well.

The calculation of the adjusted discharge due to partial penetration (**Qf**) and portion of saturated thickness tapped by the well (**hs**) is given in the (**table 2**). In order to fulfill such conditions, two methods of data analysis are followed; namely:

i. Jacob's pumping test method.

ii. Theis recovery method.

Table 2 : values of the adjusted discharge due to the partial penetration of the aquifer and corresponding specific capacity

No.	hs (m)	pumping time (hr)	Qp m^3/hr	Qf m^3/hr	(S) Total drawdon (m)	Sp. capacity Qp/S (m^3/hr/m)
1	95	12	294	470.4	16.7	28.2
2	95	12	291	466.6	4.4	101.2
3	100	12	233	357.5	23.5	15.2
4	100	6	174	266.9	25.2	10.6
5	100	12	298.8	458.4	6.0	76.4
6	100	12	287	432.7	13.1	33.0
7	100	12	211	323.7	25.7	12.6
8	100	12	368	564.6	7.5	75.3
9	90	10	140	236.3	25.8	9.2
10	90	6	166	280.2	21.6	13.0
12	95	12	303	484.8	5.5	88.1
13	95	12	311	497.6	4.7	105.9
14	95	12	317	507.2	6.8	74.6
15	100	12	283	434.2	11.7	37.1
16	100	12	274	420.1	15.9	26.4
17	100	12	294	451.1	11.9	37.9
18	95	12	176	281.6	22.5	12.5
19	55	12	364	925.3	11.5	80.5
20	60	12	368.5	860.2	5.1	168.7

4.7.2. Transmissivity, Hydraulic Conductivity and Storage Coefficient

Transmissivity (T) can be calculated by Jacob's method and Theis recovery method through this equation :

$$T = \frac{2.3\,Q}{4\,\Pi\,\Delta S}$$

Where :

Q = is the pumping rate
ΔS = is the slope of the time - draw down graph expressed as the change in draw down between any two values of time for one log cycle.

So, the hydraulic conductivity **(K)** can be calculated as follows :

$$K = T / D$$

Where:

D = is the average thickness of the aquifer (180 m).

Also, the data obtained during data collection phase permit the calculation of (transmissivity **(T)** by using Theis recovery method through the equation:

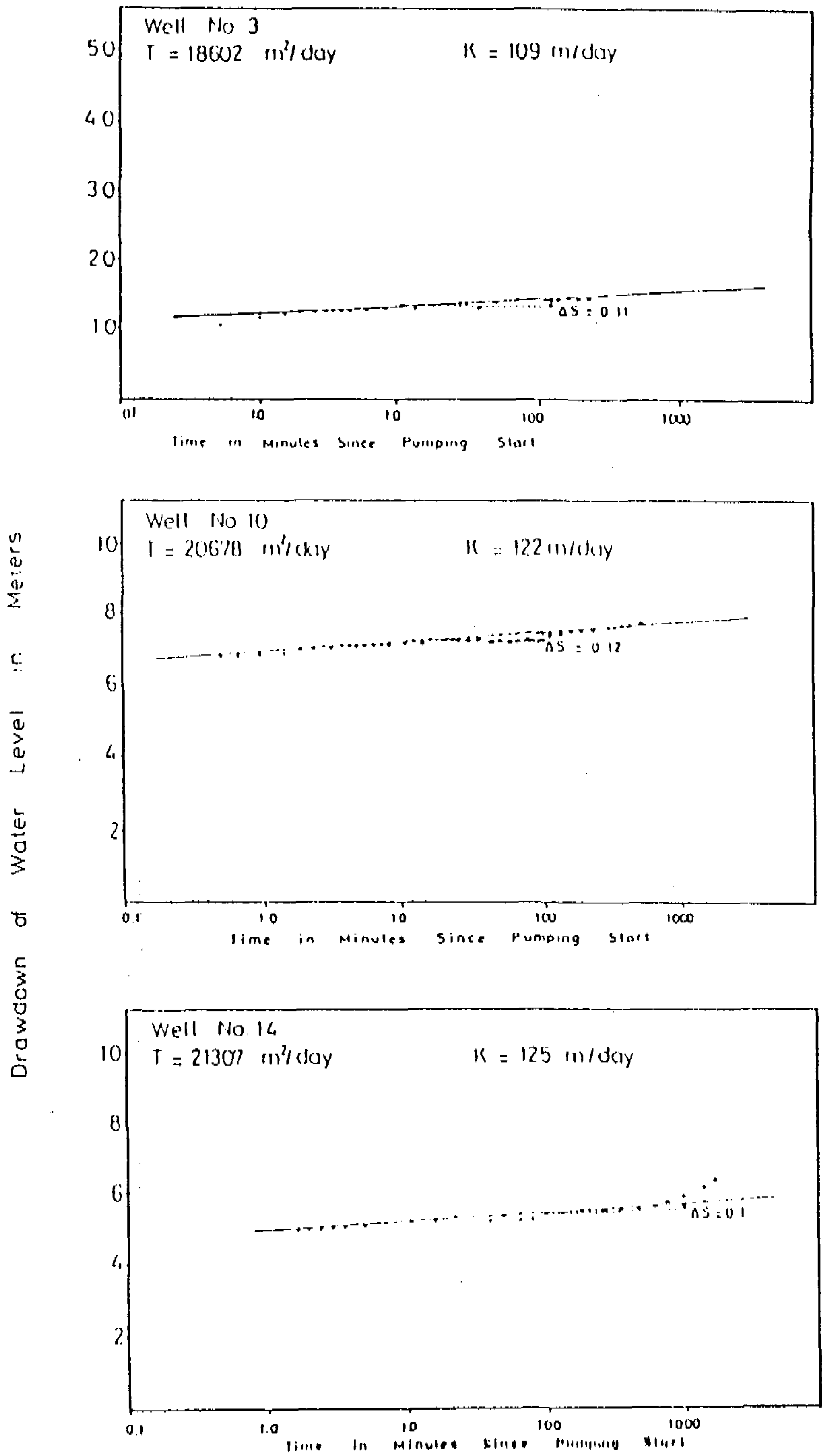
$$T = \frac{2.3\,Q}{4\,\Pi\,\Delta S}$$

Where **ΔS** here; is the recovery per log cycle. Also, Hydraulic conductivity can be calculated from equation :

$$K = T / D$$

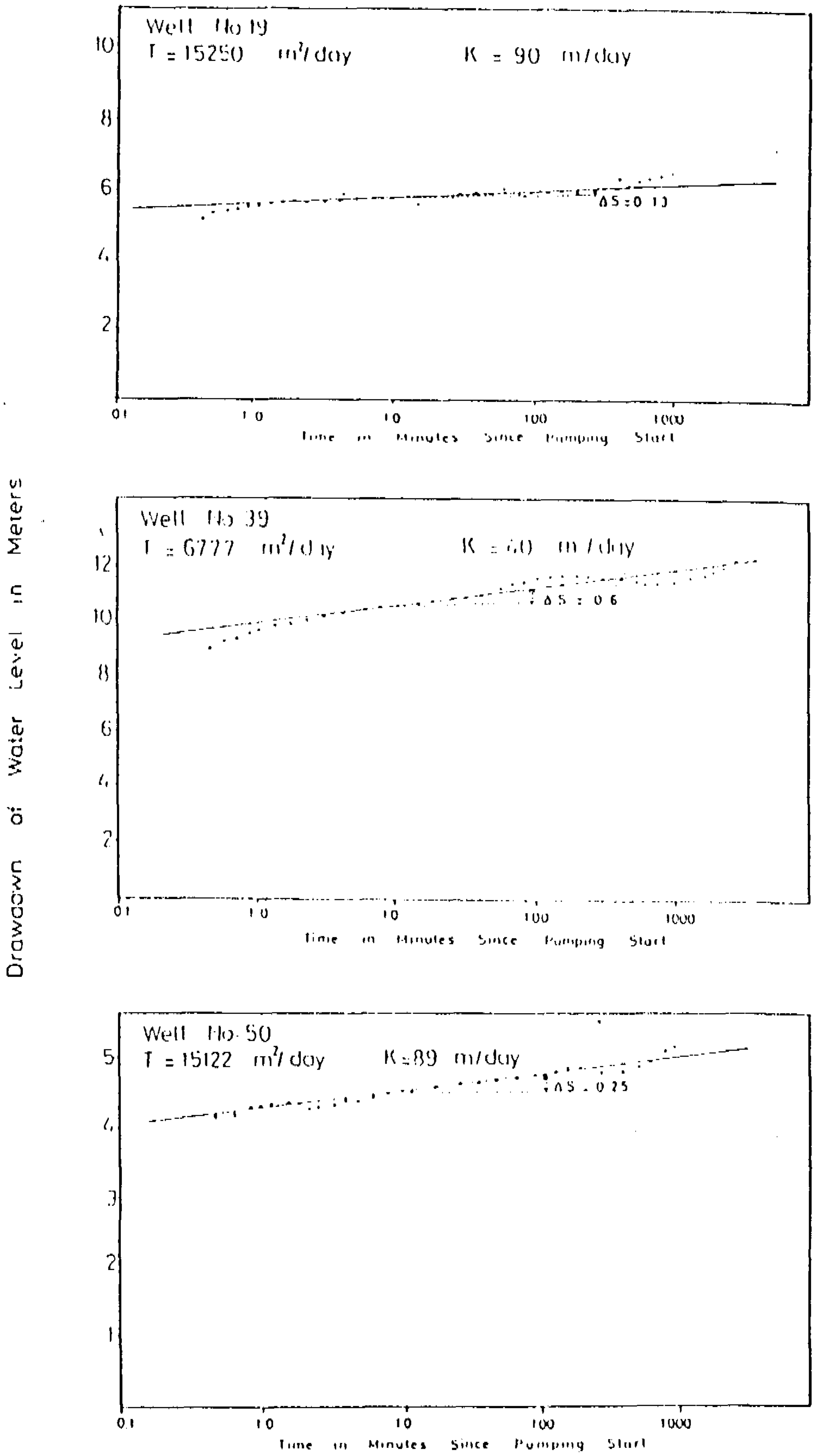
From the values **T & K** which obtained by using Jacob and Theis method, the average can be calculated.

The plotting pumping test and recovery data on semilogarithmic papers are illustrated in (**figures 22, 23, 24, 25).** The calculated values of **T & K** are obtained in (**Table 3**). However, it was found that some of the obtained values of **T & K** are hardly correlated with that given in the literature. Therefore, the analysis of the tests in well 3, 10, 14, 19, 39 and 50 are more reliable in the evaluation of the aquifer potentiality in the study area.



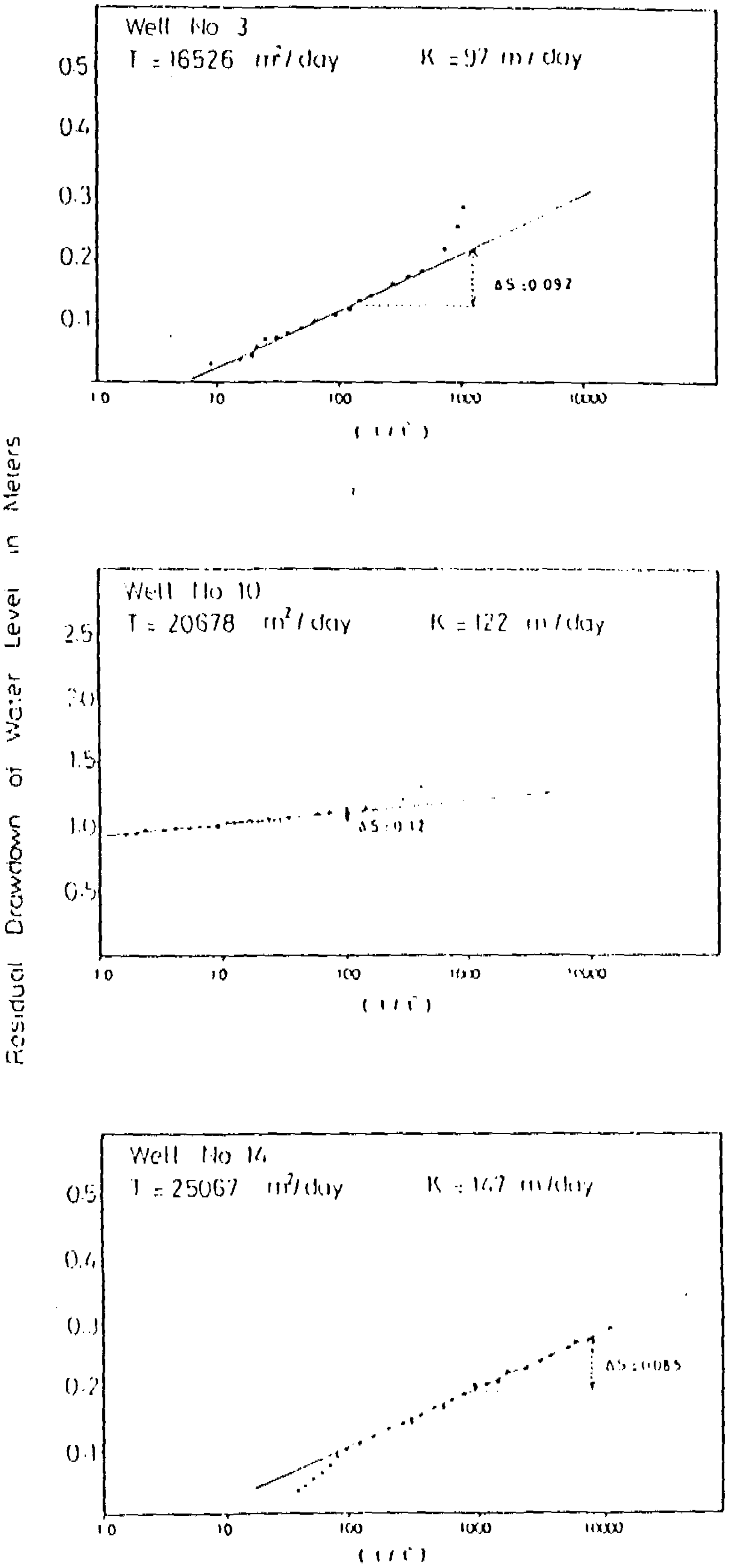
Fig(.22)Time - Drawdown Curves for Selected Aquifer Tests

(Jacob Pumping method)



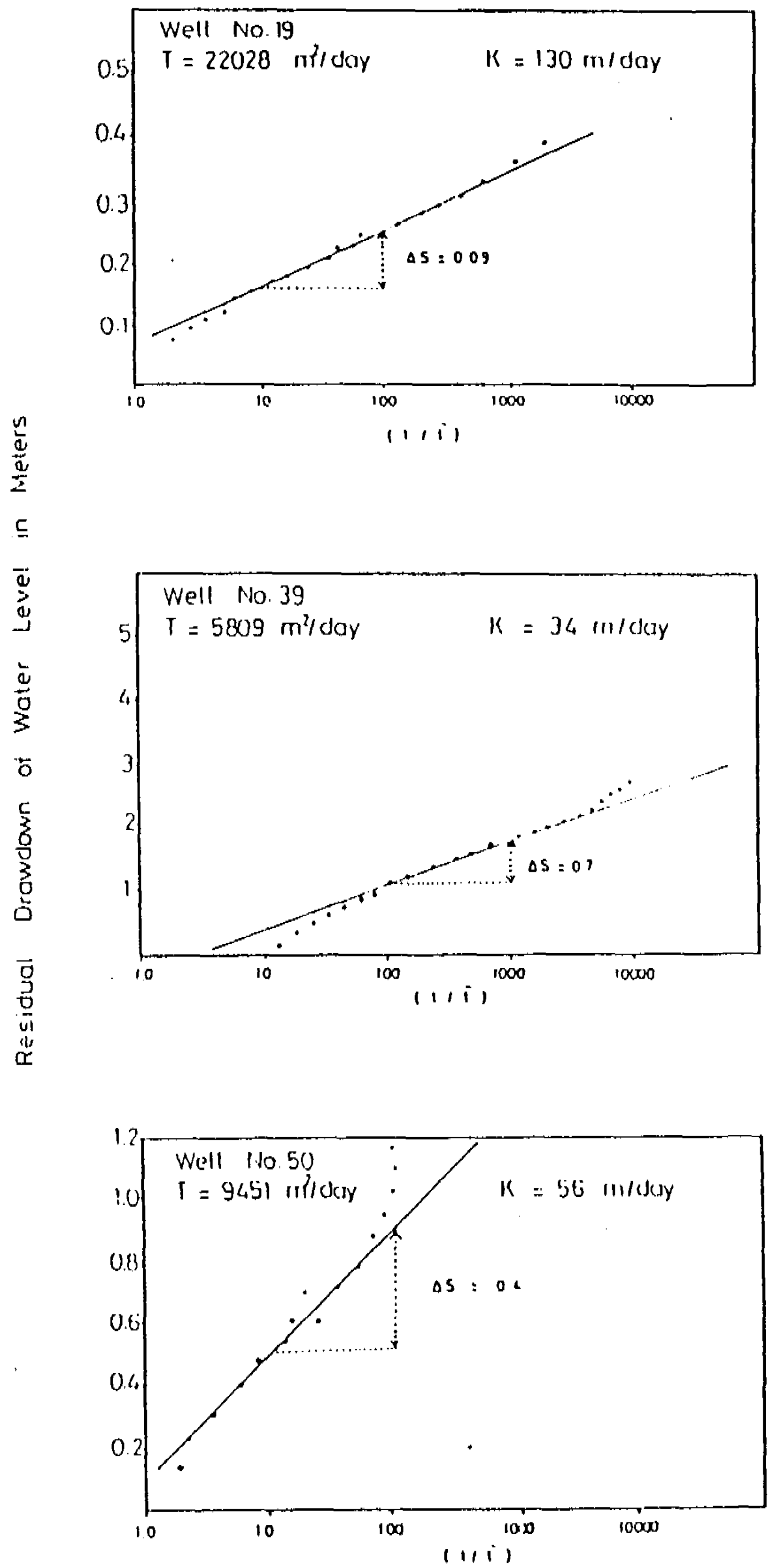
Fig(47)Time-Drawdown Curves for Selected Aquifer Tests

(Jacob Pumping method)



Fig(24)Residual Drawdown-Time Curves for Selected Aquifer Tests

(Theis Recovery method)



Fig(25)Residual Drawdown - Time Curves for Selected Aquifer Tests.
(Theis Recovery method)

The average of (T) of the aquifer along the study area is about 16441 m^2 /day and it differs locally from one place to another depending on both thickness and hydraulic conductivity of the aquifer in this location. The transmissivity coefficient of the aquifer decrease in the south direction where, it was estimated to be 11000 m^2 /day at El Minia governorate border.

The hydraulic conductivity of the aquifer could be calculated using the following equation:

$$K = T/D$$

So, the average hydraulic conductivity of water bearing formation (170 m) is 96.7 m/day. While the hydraulic conductivity of the alluvium deposits which represent the semipervious cap of the aquifer along the study area is range from 0.576 to 0.696 m/day.

Table 3: values of transmissivity (T) and hydraulic conductivity (K) by using Jacob and Theis methods.

Well No.	Jacob		Theis		Average	
	T m^2/day	K m/day	T m^2/day	K m/day	T m^2/day	K m/day
1	4399	26	19689	116	12044	71
* 3	18602	109	16526	97	17564	103
4	2619	15	22445	132	12532	73.5
5	3087	18	22558	133	12822.5	75.5
6	20146	119	34735	204	27440.5	161.5
7	12675	75	23765	140	18220	107.5
8	7113	42	28453	167	17783	104.5
*10	20678	122	20678	122	20678	122
11	2807	17	11539	68	7173	42.5
12	4398	26	12315	72	8356.5	49
*14	21307	125	25067	147	23187	136
15	21869	129	27336	161	24602.5	145
16	17147	101	29721	175	23434	138
17	10602	62	23853	140	17227.5	101
18	10265	60	13686	81	11975.5	70.5
*19	15250	90	22028	130	18639	110
22	5626	33	16073	95	10849.5	64
*39	6777	40	5809	34	6293	37
*50	15122	89	9451	56	12286.5	72.5

The average values of the storage coefficient is equivalent to 6 % in the upper alluvium layer, whereas it increase up 12% in the lower bearing sediments.

The specific capacity as shown in (**table 3**) is equal **Q/S** (m^3 /hr/m) range in wells from 37.9 to 168.7 m^3 /hr/m after 12 hours of pumping test 19 and 50 respectively.

4.7.3. Elements Controlling Water Balance

In the present study, an attempt is made to calculate the elements controlling the water budget along the project area, which is based on the following principles:

i. The catchment area for which the elements are calculated is about 800 km^2.
ii. The water bearing formation along the study area is sand and gravel with average saturated thickness of about 170 m.
iii. From the elevation point of view the area dissected by two parallel; sectors; the old cultivated sector and the new reclaimed land, varying in elevations between 30 m to 65 m (a.m.s.l.) from east to west respectively.
iv. There are two directions of groundwater flow, one from south to north (represent 10 to 20 % from the groundwater movement along the aquifer) while, the second is north east direction (represent the main flow direction i.e. toward the River Nile).
v. The main irrigation canals are; El Ibrahemiya and Bahr Youssef, many channels exist in the study area and branching from those main canals.
vi. The climatic data have been obtained from Beni Suef mateorogical station for a period of 42 years (1952 - 1994).
vii. The surface water measurements for the Nile, irrigation canals and drains have been obtained from the irrigation directorate of Beni Suef and Sediments & Hydraulics institute in Cairo.

Water Balance analysis is based on the fact that a balance should exist between the quantity of water entering the area of the study, changes in the amount of water stored in the study area and the water leaving the area.

This balance is expressed by the following equation in the simplest form:

$$I = O \pm \Delta S$$

Where:

I = total inflow
O = total outflow
Δ S = change in storage

Each element of this equation includes several components, but not all of these components are necessarily present in each basin. In the case of study area, the following components may be considered in a general water budget:

$$P + S1 + G1 + R_{(i+c)} = E + S2 + F \pm \Delta S$$

Inflow components (water gains) = Outflow components (water losses)$\pm\Delta S$

P = total amount of area precipitation
S1 = surface water inflow
G1 = Groundwater inflow
$R_{(i+c)}$ = The flow return from irrigation excess (**i**) and infiltration from irrigation canals (**c**). (**fig. 26a**)
E = Total evaporation.
S2 = Surface water out flow
G2 = Groundwater outflow
F = Artificial discharge through pumping including both surface and groundwater for different purposes (irrigation, domestic, industrial,.. etc.).
ΔS = Change in water storage ($\Delta S1 + \Delta S2 + \Delta S3$)
$\Delta S1$ = Change in groundwater storage
$\Delta S2$ = Change in the surface water storage.
$\Delta S3$ = Change in soil moisture (zone of aeration)

The inflow and the outflow components in the study area is represented in (**fig. 26b and 26c**)

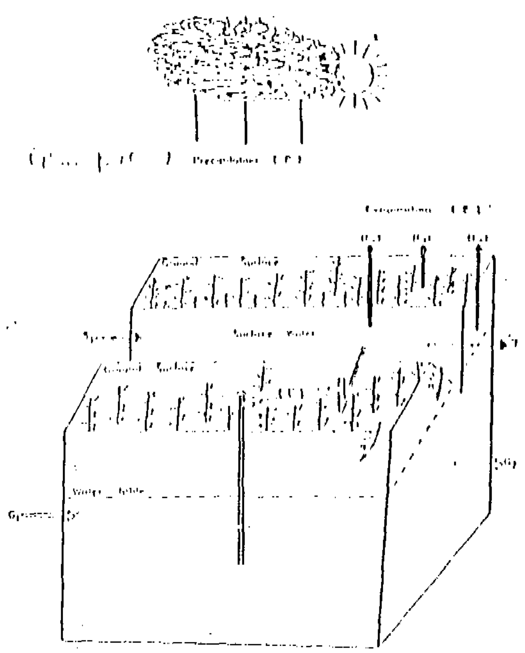


Fig. 26b Water system along the study area

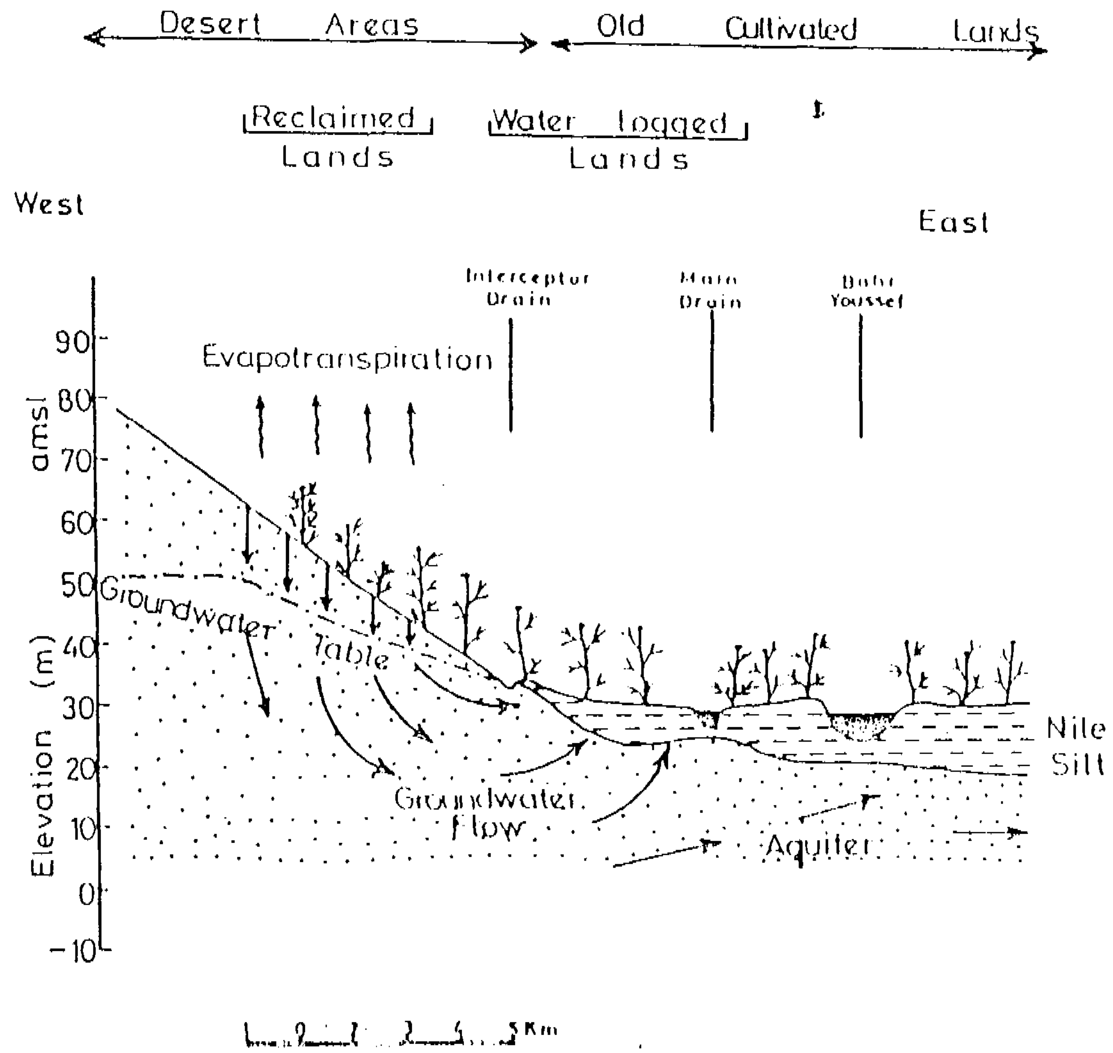


Fig (26c) Schematization Groundwater flow

(After RIGW, 1989)

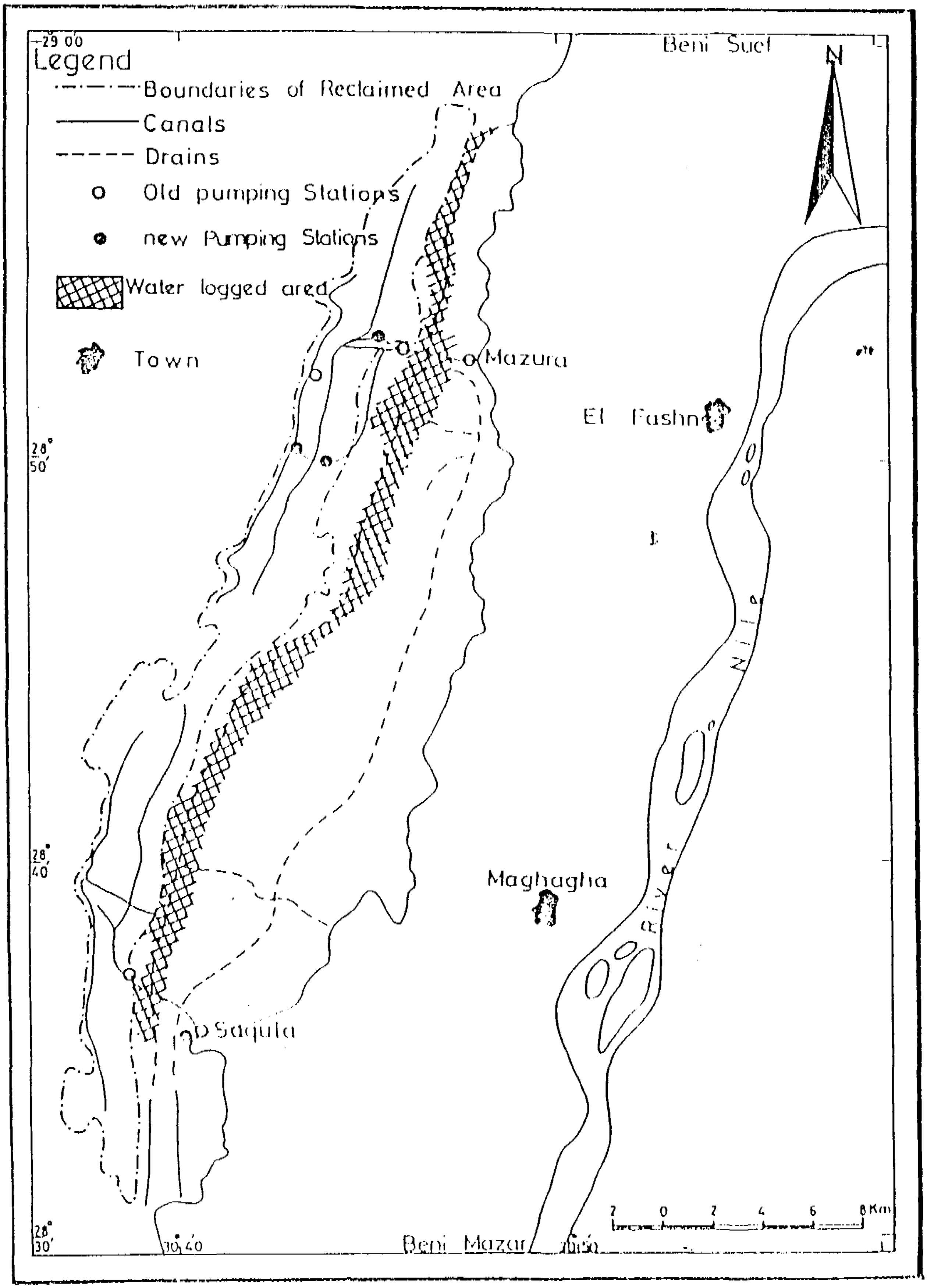


Fig.(26a)Waterlogged Area and Location of Pumping Stations.

(After RIGW , 1989)

Consequently, from the calculation of the above budget elements, the average of the change in the water storage (Δ S) during 1995 has been estimated. It has a decremental value of about (- 116.1 MCM) as shown in (**table 4**).

Table 4 : water budget of the study area in million m^3 /year

Inflow Components					Outflow components					Storage Components
P	S1	G1	(R(i+C)	Total	E	S2	G2	F	Total	Δ S
5	42522.9	55.7	653.6	43237.2	1950.3	35014	31	6358	43353.3	- 116.1

The above mentioned calculations reveal that the inflow and outflow are almost balanced where, $I = O \pm \Delta S$
But Δ S is not equal zero, it is equal (- 116.1 MCM) . this difference due to he return water from irrigation canals (Rc) in the old cultivated area, which is neglected from the equation.

4.8. EXISTING USE OF GROUND WATER

In Beni Suef area the ground water abstraction was estimated, based on the inventory of 1984 for all purposes with $68x10^3$ m^3/day, while the total abstracted ground water from the aquifer during 1990 is $196x10^3$ m^3/day (72,000,000 m^3/ year) for irrigation, industrial and domestic purposes.

In Beni Suef governorate about 600, 000 citizen depend on ground water for their domestic uses, the ground water extraction for this use is about $41x10^3$ m^3/day (15,006,000 m^3/year).

The groundwater balance along the project area has been studied and calculated during the data collection phase as a part of this study. From the calculation of water balance it can be concluded that only insignificant percentage of the available groundwater potential is used along the study area. Evident benefits as cost savings and environmental improvement will be gained by increasing the abstraction and use of ground water in large quantities for different purposes where the ground water quality is acceptable.

5. GROUND WATER QUALITY

The study of the ground water quality and its relation to the under investigation is the main target of that study.

Group of samples (95 sample) of ground water representing the study area were collected and analyzed through different stages of preliminary monitoring program which was designed and implemented by RWSSP from 1/1994 to 18/8 /1996. A a first phase of permanent water quality monitoring program were the results of May 1997. The study area was divided to four sectors each of which have a different ground water quality (Hydrogeologic map of the study area.**RIGW.1992- fig.27**)

Where, the phase of 18/8/1996 represents the flood time period of the Nile (August i.e. the high level season) and the phase of May 1997 represents the intermediate level of water in the Nile to study water quality and to shows the effect of the change in the surface water quantity and quality on the ground water quality and quantity along the year.

The locations, method and technique of sampling as well as the dates of sampling are presented in (**Fig. 28, Appendix 1 and analysis results are illustrated in Appendix 2-5**) .

During the design of this preliminary monitoring program many vital points are taken in consideration like :

- **i.** Type, design and depth of the well.
- **ii.** The presence of deep drainage wells near the sampling locations.
- **iii.** The density of population
- **iv.** The relative locations of industrial areas..
- **v.** The distance between sampling points not exceed 20 km.

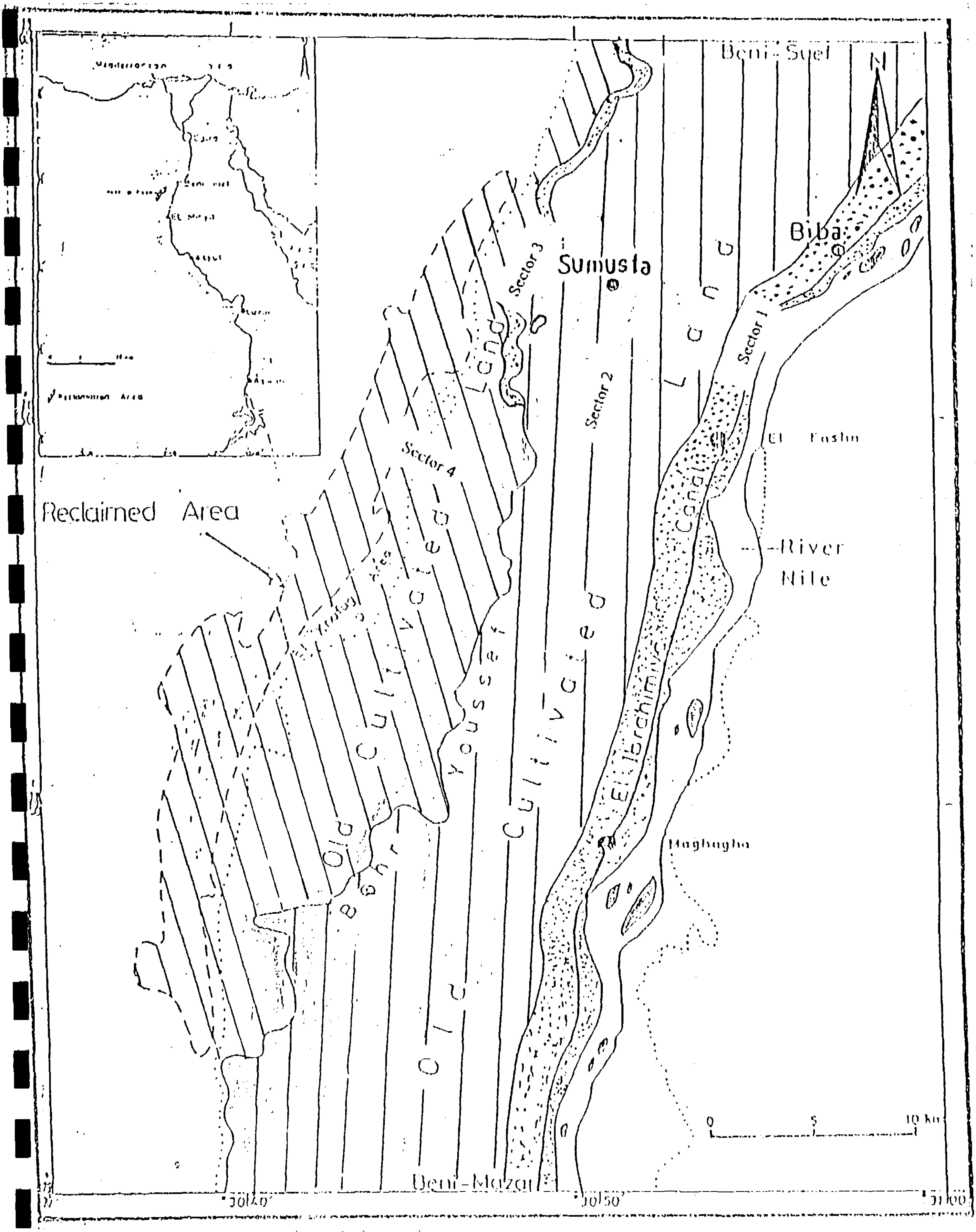
5.1. THE PROGRAM PARAMETERS

Parameters measured by water quality preliminary monitoring program are highly dependent upon the objectives, basic characteristics and the budget required.

A group of basic parameters measured in all samples in addition to some parameters were measured in the field (Temp., odor and electric conductivity)

5.1.1. Insitu chemical analysis program (Sumusta laboratory)

- Temperature (in the field)
- Turbidity
- Color
- Odor (in the field)



Fig(27) **STUDY AREA SECTORS**

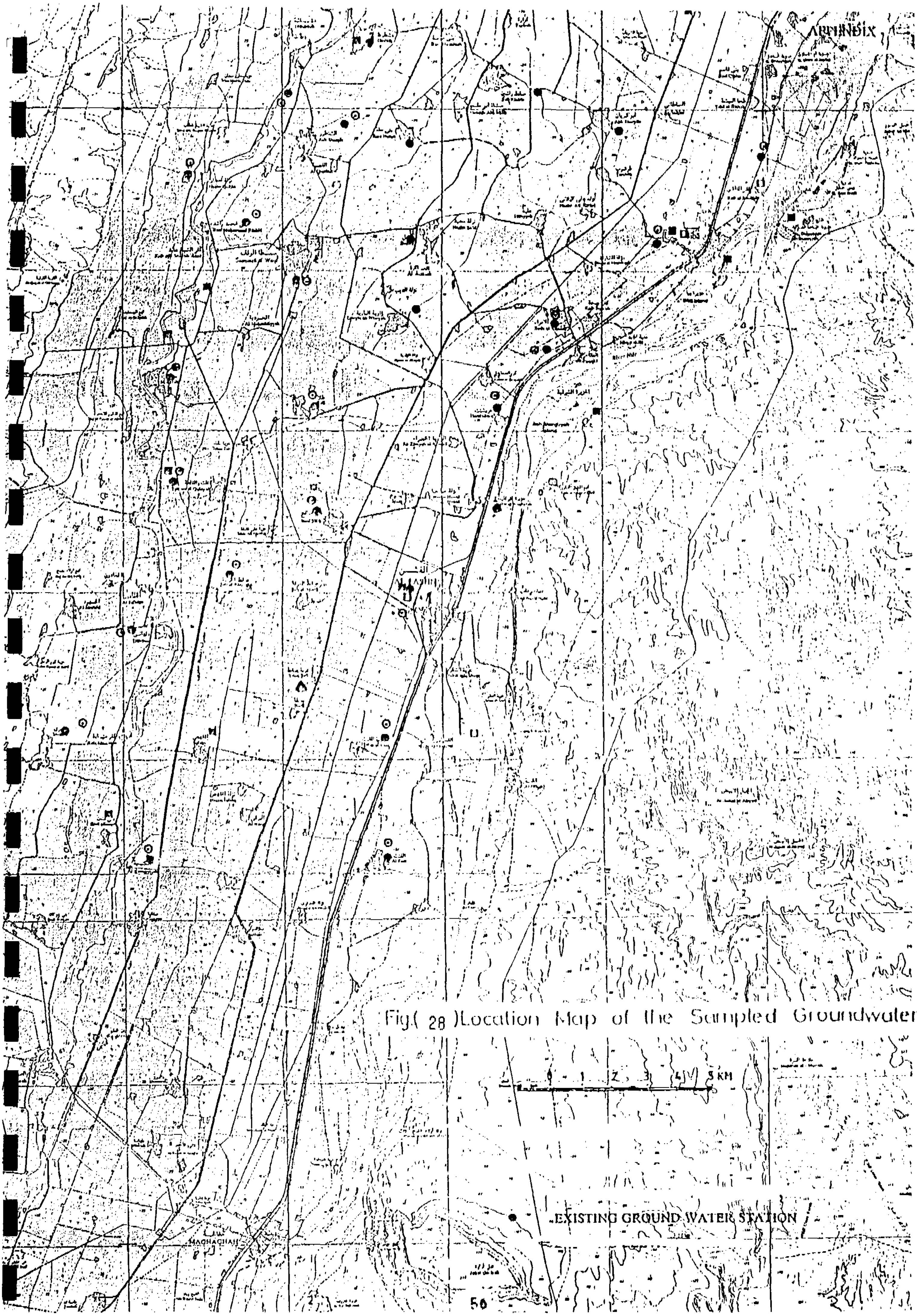


Fig.(28)Location Map of the Sampled Groundwater

- Electric conductivity (in the field)
- pH
- Hardness
- Alkalinity
- Carbonate
- Ca^{++}
- Mg^{++}
- Chloride
- Bicarbonate
- Nitrate
- Nitrite
- Fe^{++}
- Mn^{++}
- Ammonia
- Total coliforms

5.1.2 Laboratory chemical analysis program (EL Fustat Laboratory - Cairo)

i. Physical analysis

- Temperature
- Turbidity
- Color
- Taste
- Odor

ii. Chemical analysis

- Electric Conductivity
- T.D.S.
- pH.
- Total alkalinity
- Total Hardness
- K^+, Na^+, Mg^{++}, Ca^{++}-
- HCO_3^-, CO_3^{--}, SO_4^{-}
- Nitrate
- Nitrite
- Total Chlorides
- Copper
- Lead
- Fe^{++}
- Mn^{++}
- Ammonia.

iii. Bacteriological analysis

- Total and Shape of coliform col / 100 ml

5.2. PROGRAM RESULTS

The results of chemical analysis of the samples which have been collected through the preliminary surface water monitoring program are given in (**Appendix 2 - 5**) and have been compared with WHO recommendations and Egyptian standards.

Based on these analysis the following topics will be discussed:

5.2.1. Physical Characters

The physical quality all collected ground water samples from all locations follow the requirements of the Egyptian standards and WHO recommendations except H_2S odor which characterize some locations (Suds well, Sumusta wells, Bedahl well, El Fashen, and El Sheik Abed experimental well). This odor is due the effect of reducing sedimentary environment of the water bearing formation and thin interbed layer of iron sulfide (Pyrite) which are intercalated with the aquifer layer.

5.2.2. Chemical Characters

i. TDS

The TDS of the aquifer under investigation is widely varying from 339 ppm in the area adjacent to River Nile to 4900 ppm in reclaimed area. This increase in the TDS is due to:

a. The effect of leaching processes of the reclaimed soil during irrigation practices.

b. The thickness of the aquifer small (20-50 m) along reclaimed area and there is no abstraction from this part of aquifer except few wells, i.e. the water is relatively stagnant.

c. The depth of water west Bahr Youssef and some areas around the reclaimed area is which less than 1.5 m, this phenomenon causes evaporation, in turn causes concentration of the salts in soil and groundwater.

d. The effect of drain water of brackish type on the ground water by seepage. However, the hydraulic connection between aquifer and surface water leads to a salt transportation through whole system.

e. Fig. 29a reveals that the groundwater salinity increase gradually towards the west, i.e. from the old cultivated lands to the reclaimed area.

f. The relation between the electric conductivity EC and the total salinity TDS is shown in (**fig. 29 b**)

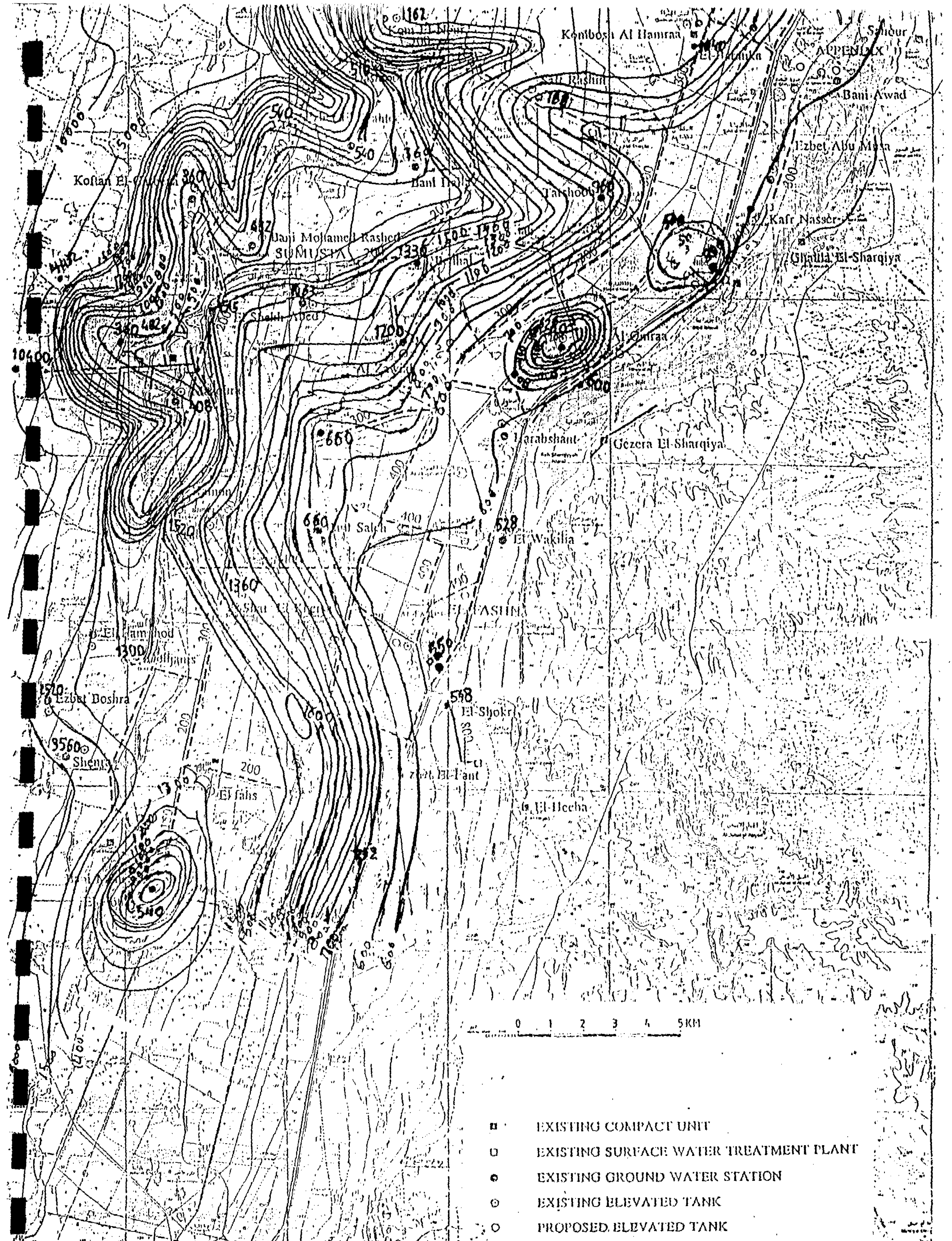
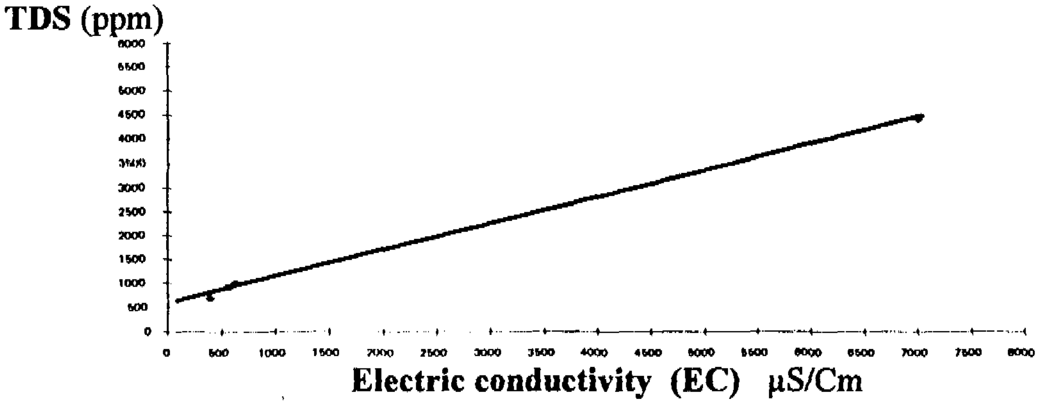


Fig. 29 Total Salinity Contour Map Along The Study Area



(fig. 29a - The Relation Between TDS & EC)

ii. Total Hardness

The total hardness of the ground water vary from 176 ppm beside the Nile at Biba water stations to reach 1504 ppm at the new cultivated land (**fig. 30** show the hardness distribution along the study area).

iii. Ion Dominance($K^+, Na^+, Mg^{++}, Ca^{++}$ & $HCO_3^-, CO_3^{--}, Cl^-, SO_4^{--}$)

The dominant ions in the investigated groundwater samples of the Quaternary aquifer can be classified into three main orders:

a. Order I :

$HCO_3^- > Cl^- > SO_4^{--}$ and $Na^+ > Ca^{++} > Mg^{++}$

This order characterizes the water of the drilled wells in the area between the River Nile and the western part of El Ibrahemia.

b. Order II:

$Cl^- > SO_4^{--} > HCO_3^-$ and $Na^+ > Ca^{++} > Mg^{++}$

This order characterizes the water of the drilled wells in the central sector specially Sumusta markaz.

c. Order III:

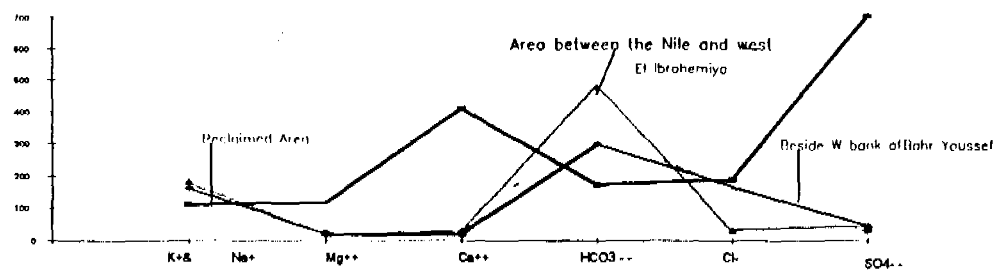
$HCO_3^- > Cl^- > SO_4^{--}$ and $Na^+ > Mg^{++} > Ca^{++}$

This order characterizes the water of the drilled wells in the area beside the western bank of Bahr Youssef

d. Order VI:

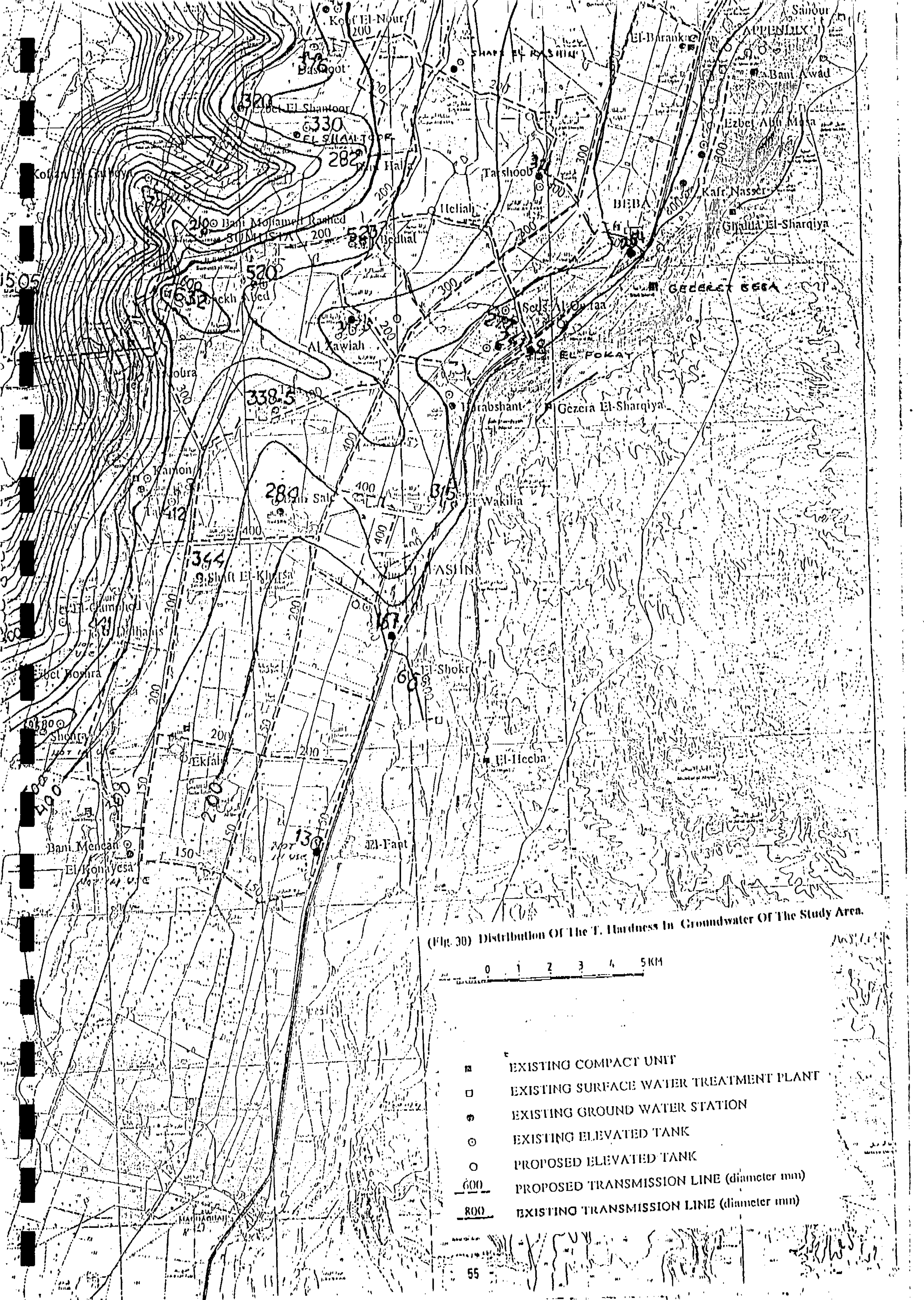
$SO_4^{--} > Cl^- > HCO_3^-$ and $Ca^{++} > Mg^{++} > Na^+$

This order characterizes the water of the drilled wells in the reclaimed area. (**fig. 31**) show the ground water analysis of the main components along the study area.

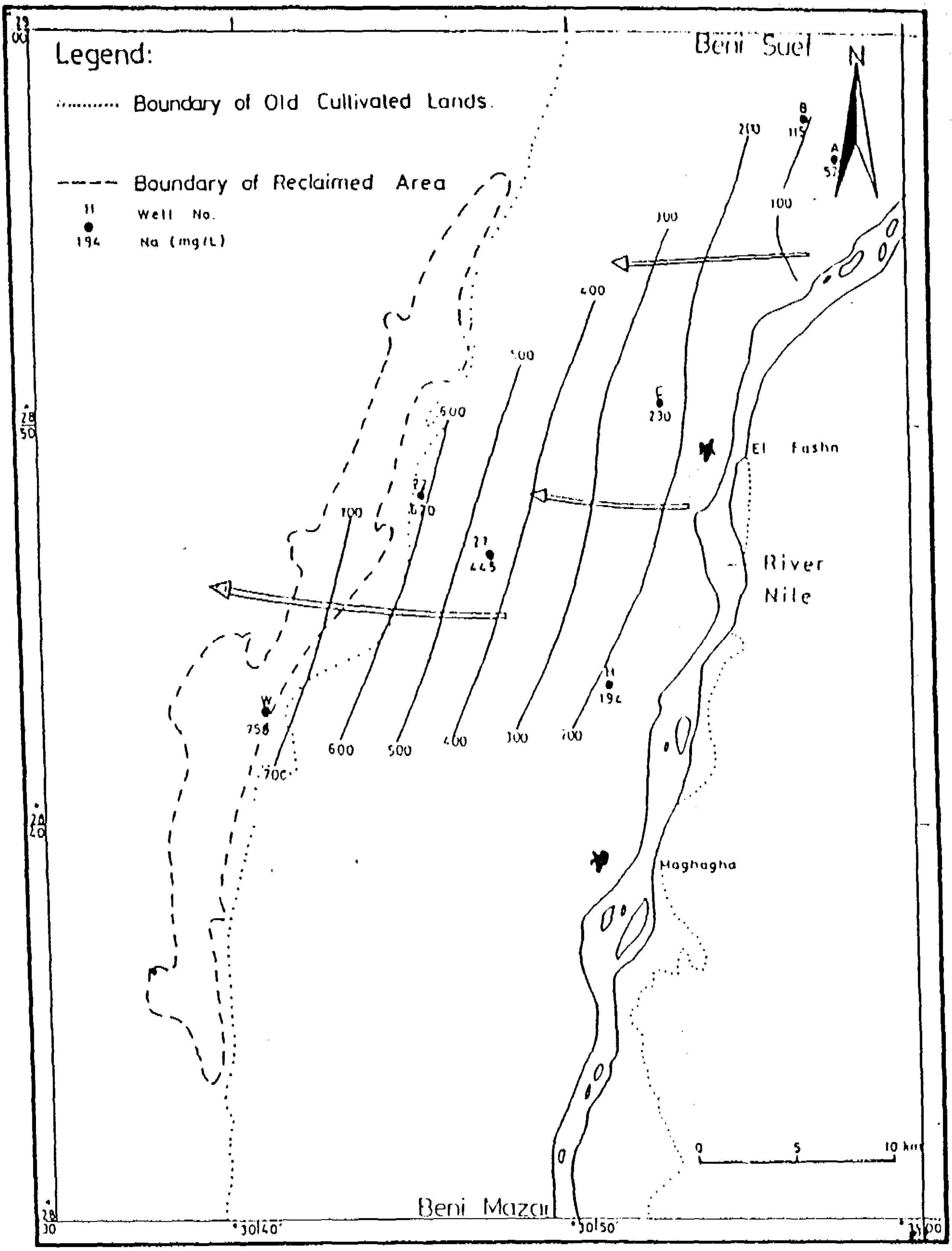


PPM Major Cations and anions

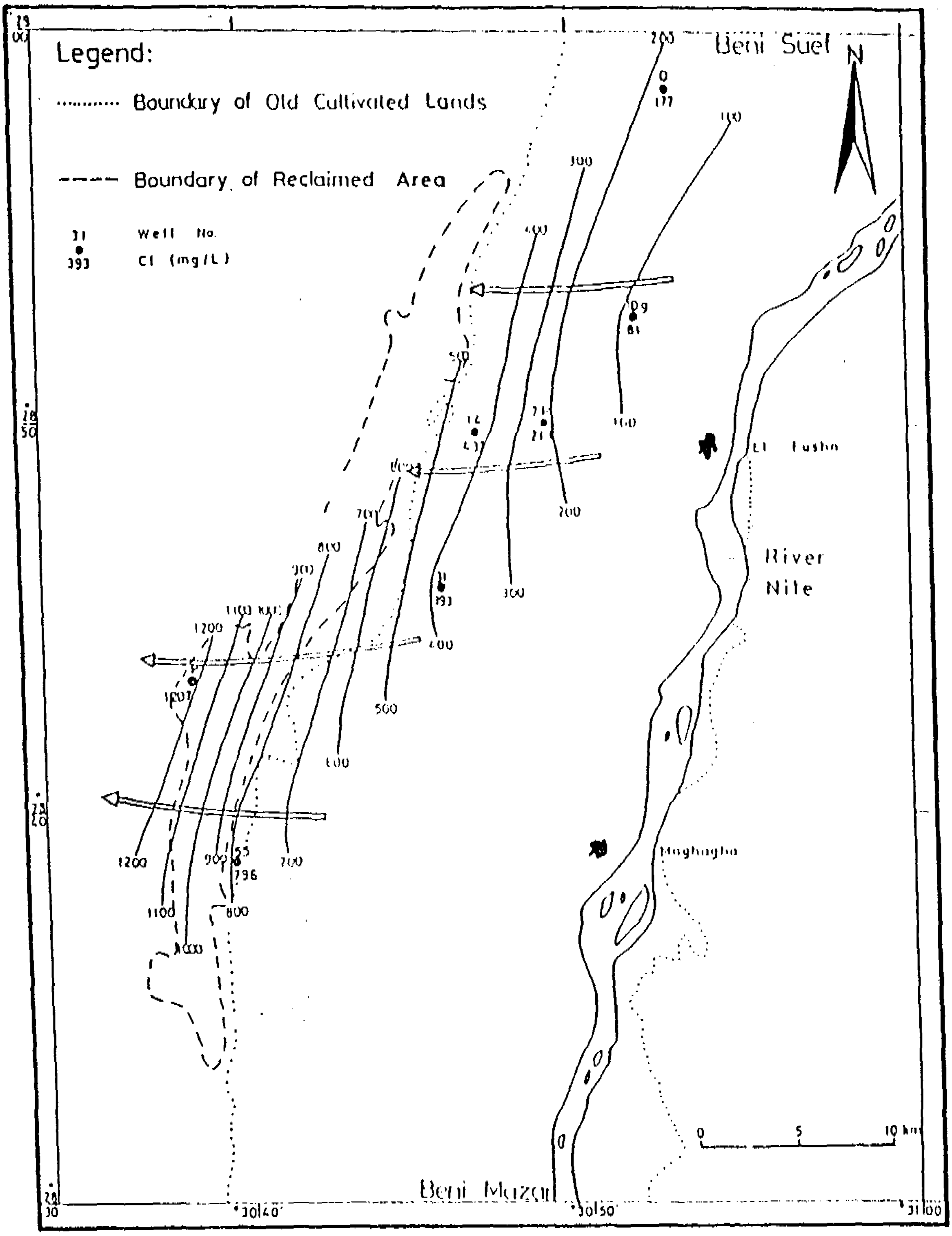
Fig. 31 Distribution Of Cations And Anions Along The Study Area



(Fig. 30) Distribution Of The T. Hardness In Groundwater Of The Study Area.



Fig(32) Sodium Distribution Contour Map



Fig(33) Chloride Distribution Contour Map Along The Study Area

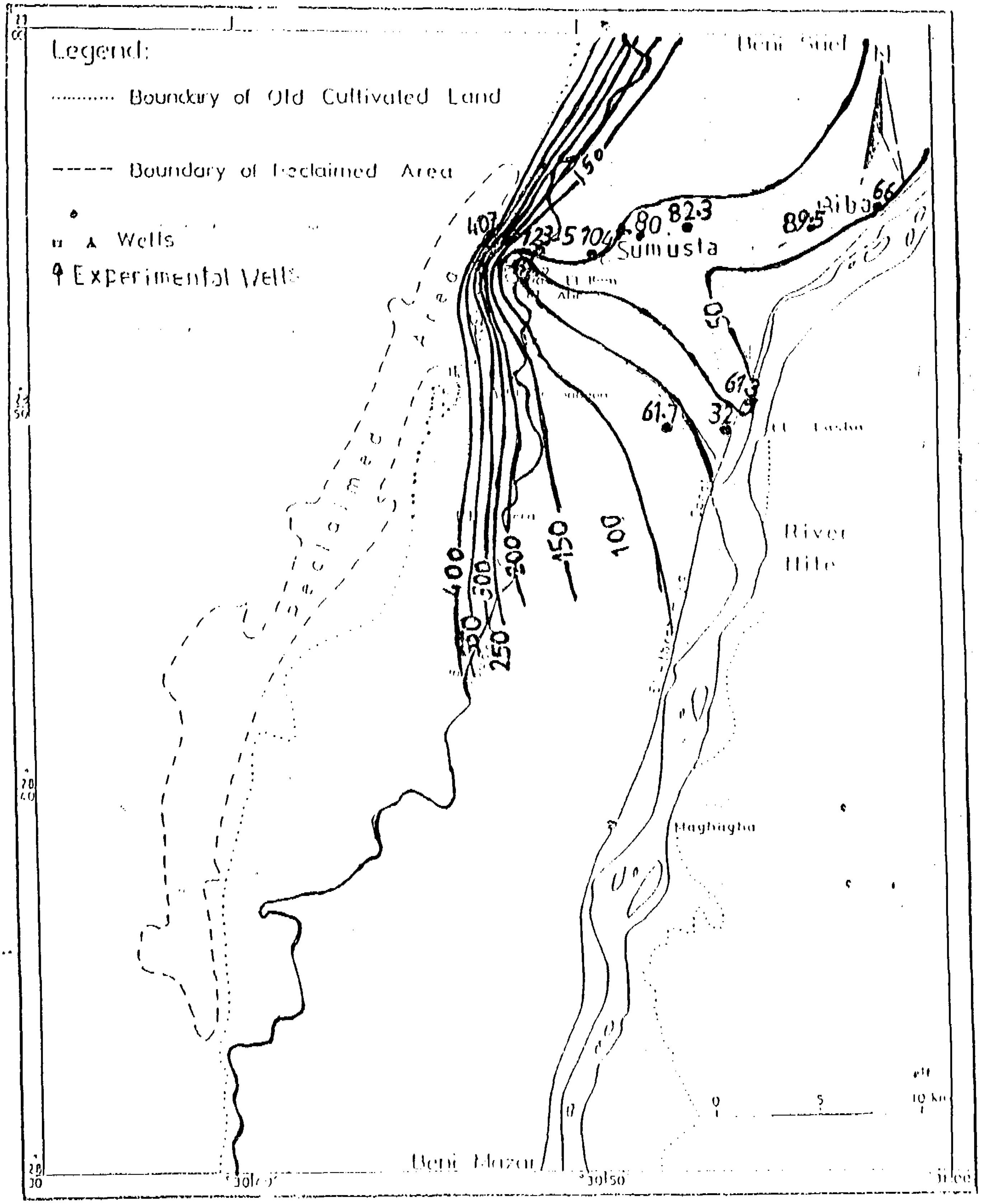


Fig. 34 Ca++ Disribution Contour Map Aong The Study Area.

The areal distribution of the Na+, Ca++ and Cl^- is illustrated in **(fig. 32, 33 & 34)**.

From those figures the following can be concluded :

- The Sodium concentration ranges widely from 66.32 ppm at Biba to more than 700 ppm at the reclaimed area. This show a quite regular manner of distribution which contemporaneously reveals a considerable harmony with the salinity distribution This mean that the increase of Na+ concentration in the west direction, is in agreement with the salinity distribution.
- Nearly, the distribution of Cl^- ion concentration follows more or less, that of Na+ ion regardless the magnitude and the direction of increase is the same as sodium.
- Also, the distribution of the Ca++ ion concentration is widely vary from 32 ppm beside the Nile at El Fashn to 407.4 ppm at the reclaimed area.

iv. Hypothetical Salt Combinations

The hypothetical salt combinations can be deduced from the hydrochemical formula of the selected following wells:

a. Biba old water plant (Eastern sector Of The Study Area)

			$HCO3^-$	Cl^-	$SO4^{--}$		
			52.48	41.96	5.5		
Mn++,	Cu++	TDS	————	————	————	pH=7.75	22.2 °C
0.01	0.01	0.39 g/l	Na+	Mg++	Ca++		
			38 .35	36.13	25.517		

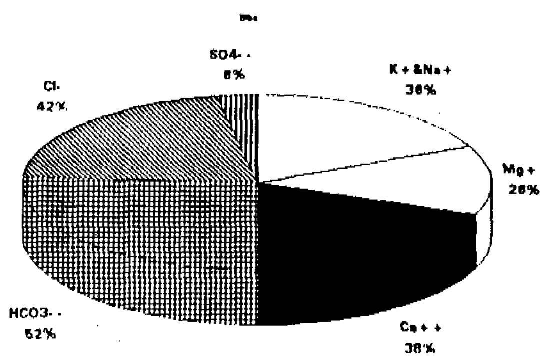


fig. 35 Show the Equivalent % of the Major Elements in Biba

b. El Fashen old Plant (Eastern sector of The Study Area)

				$HCO3^-$	$SO4^{--}$	Cl^-		
				80.9	9.8	9.34		
Fe++,	Mn++,	Cu++	TDS	————	————	————	pH=7.078	24 °C
0.2	0.25	0.01	0 .55g/l	Na+	Mg++	Ca++		
				68.7	17.09	14.23		

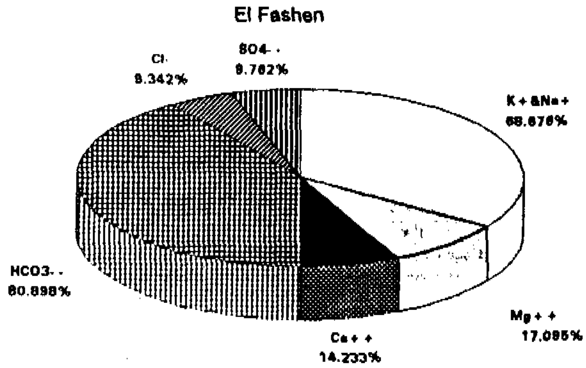


fig. 36 Show the Equivalent % of the Major Elements Eastern Sector

c. High Reservoir Well-Sumusta (Central Sector Of the Study Area)

			Cl^-	SO_4^{--}	HCO_3^-		
			13.818	5.191	5.415		
Fe^{++}, Mn^{++}		TDS				pH= 7.4	19 °C
0.57	1.3	1.463 g/l	Na^+	Ca^{++}	Mg^{++}		
			11.826	5.189	5.131		

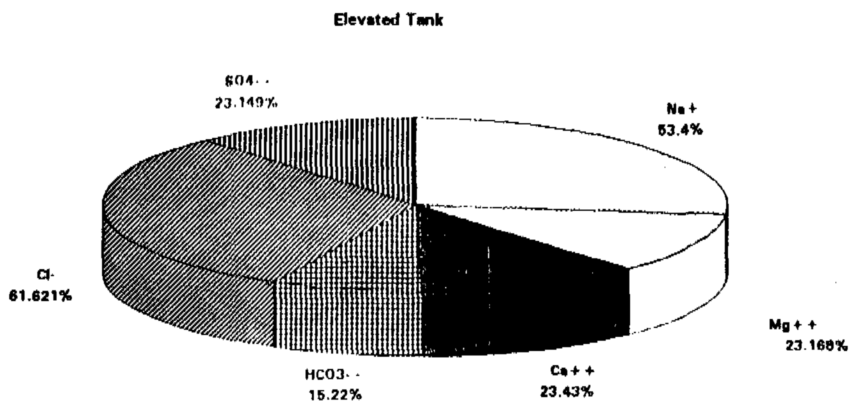


fig. 37 Show the Equivalent % of the Major Elements along central Sector

d. El Gendi exp. well (Beside Western Bank Of Bahr Youssef)

			HCO_3^-	Cl^-	SO_4^{--}		
			46.68	44.6	8.72		
Mn,	Cu,	TDS				Ph=8.001	24 °C
0.3	0.01	.482 g/l	Na^+	Mg^{++}	Ca^{++}		
			74.46	16.40	9.20		

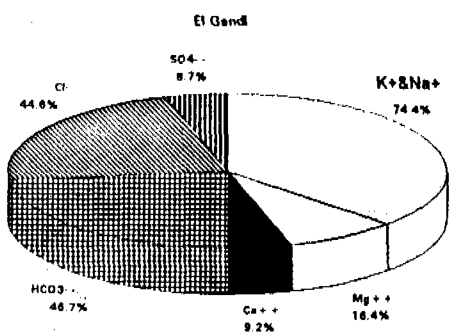


fig.38 Equivalent % Representation of the Major Elements along west Bahr Youssef

e. Reclaimed Area (Western Sector of the study area)

SO4-- Cl- HCO3-
64.13 23.537 12.537
Fe++ Mn++ TDS ——————— Ph 7.185 20.3°C
0.1 0.5 4.43g /l Ca++ Mg++ Na+
59.38 28.349 12. 2

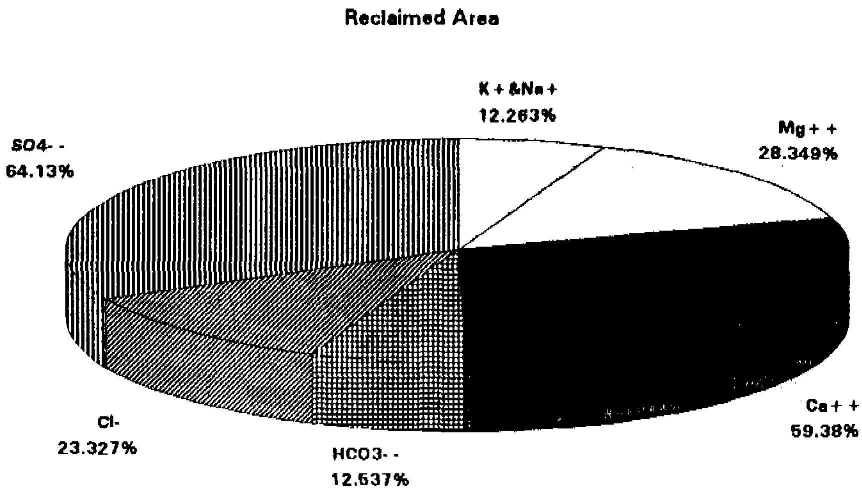


fig. 38 Show the Equivalent % of the Major Elements along Reclaimed area

The dominant ions are hypothetically combined together to form salts in systematic manner depending upon the activity of ions. From the pie diagrams which represent the equivalent % of the major cations and anions along the different sectors of the study area, four salt assemblages are reported :

- **Assemblage 1:** (Eastern sector of the aquifer) (Na HCO_3, Mg $(HCO_3)_2$, Mg Cl_2, Ca Cl_2, $CaSO_4$)
- **Assemblage 2**: (Central sector of the Aquifer) (Na HCO_3, NaCl, $MgCl_2$, $CaCl_2$, $CaSo_4$)
- **Assemblage 3:** (Beside western bank of Bahr Youssef) ($NaCHO_3$, NaCl, $MgCl_2$, $MgSO_4$, $CaSO_4$)
- **Assemblage**:(Reclaimed area) ($NaHCO_3$, $Mg(HCO_3)_2$, $MgCl_2$, $MgSO_4$, $CaSO_4$)

v. Minor Elements (Fe++ & Mn++)

Practically all water supplies contain some iron and manganese . the iron and manganese of water is of considerable concern because small amounts seriously affect the water's usefulness for some domestic purposes.

The Egyptian standards of the ground water suggests that the iron content of drinking water is 1.0 for groundwater mg \l and that for manganese is 0.5 for groundwater (26/2/1995) while, the W.H.O 1970 suggested 0.3 mg\l for iron and 0.1 mg\l for manganese . This limit is fixed for other than physiological considerations.

In fact the human body appears to require from 5 to 6 mg\l of iron which would be the amount in 5 to 6 liter of water at the concentration of 1 mg\l.

a. Distribution Of Iron And Manganese In The Ground Water Along The Study Area

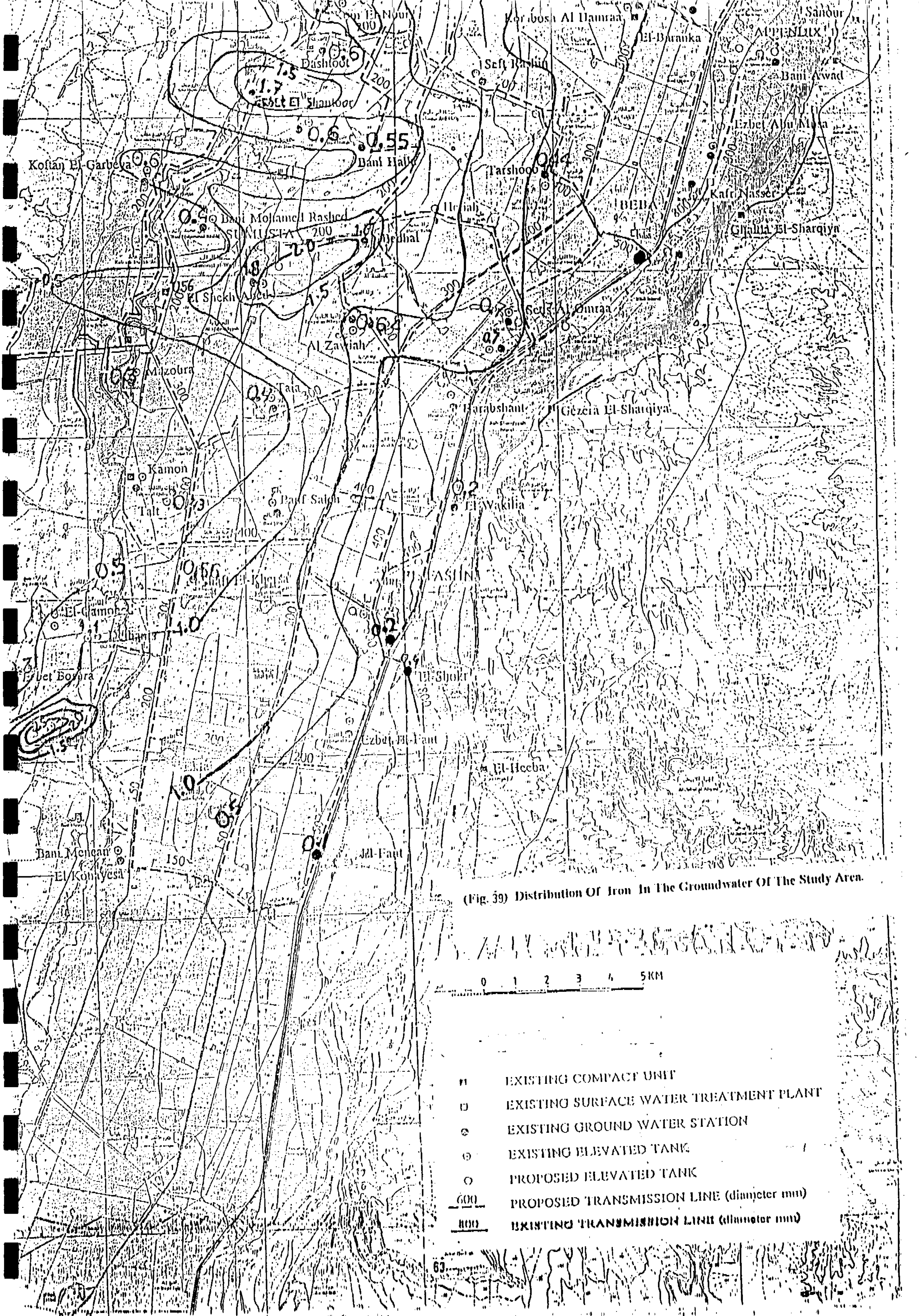
The distribution of iron and manganese of ground water along the study area varying horizontally and vertically, where the most highly concentrated area in Fe++ and Mn++ is central sector i.e. that located West El-Ibrahimia and the eastern bank of Bahr Youssef where this zone is close to the dense drains net (Fe++ from 1.6 to 1.94 mg\l and Mn++ from 0.7 to 1.3 mg\l), specially Sumusta markaz while, the eastern sector between River Nile and Ibrahemiya canal(Fe++ 0-0.2 ppm&Mn++ 0.25-0.5ppm) and the area beside western bank of Bahr Youssef represent lowest concentration sector in Iron and manganese(Fe++ 0-0.5 ppm& Mn++ 0.2-0.3 ppm). The Reclaimed area also represents a low iron and manganese sector i.e. there is an increase of iron and manganese from El Ibrahemiya to the eastern bank of Bahr Youssef where, maximum concentration is reached at central sector specially at Sumusta markaze(**fig.39&40)** and then decrease in concentration takes place specially at beside the western bank of Bahr Youssef. The area of study also shows a vertical variation in the concentration of ground water iron and manganese along the same aquifer. Where the upper level of the aquifer is effected by the drains net and widely distributed deep drainage wells in which jetting of waste water takes place through the upper part of the aquifer (till the depth 30 m), (Fe++1.3 - 2.5 mg\l &Mn++ 0.3 - 1.3 mg\l).

The 2 <u>nd</u> level along the aquifer is of concentration vary from (0.4 to 0.65 mg\l for Fe++ and 0.13 to 1 mg\l and the depth of this level is rang from 50-55m.

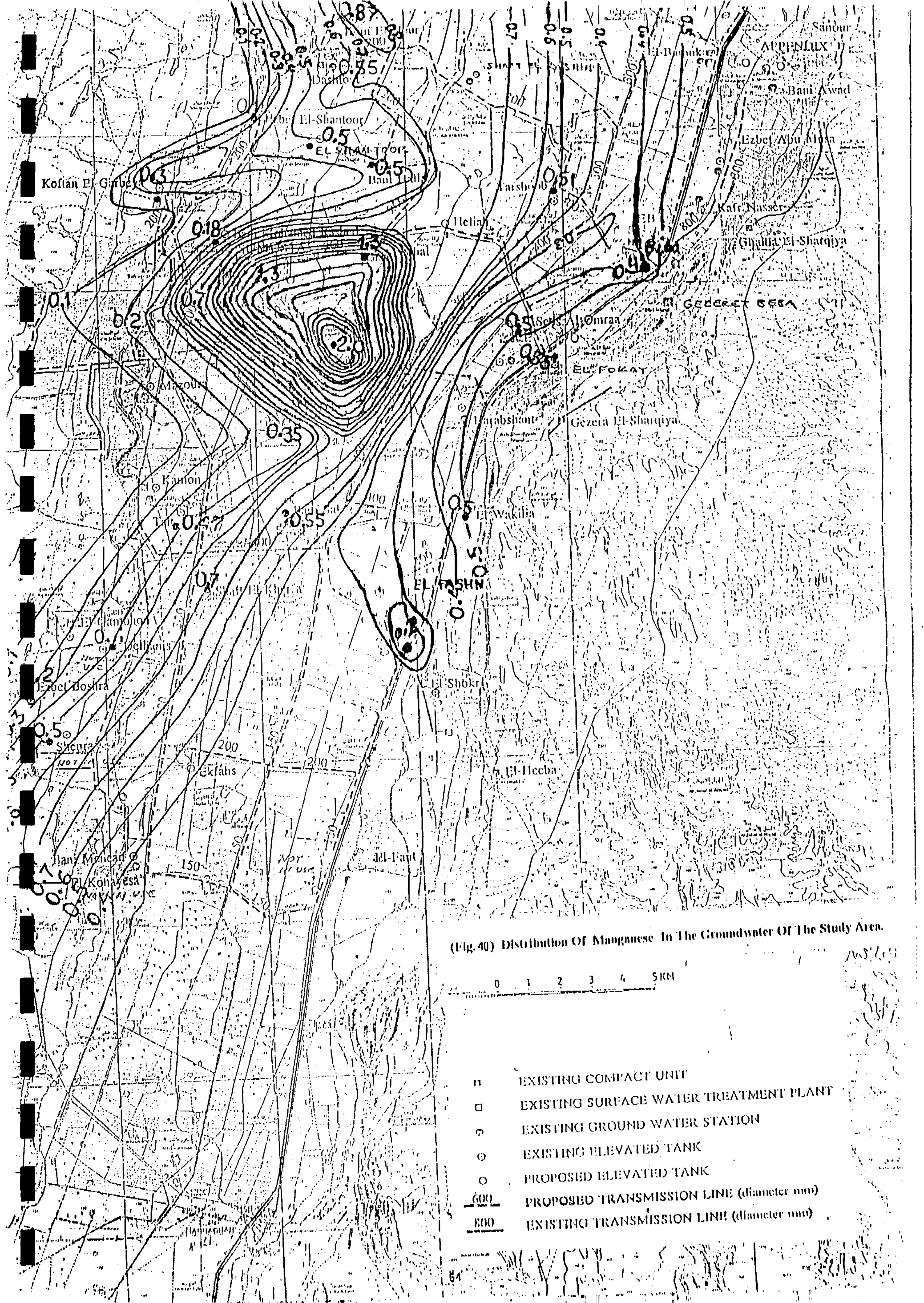
The 3 rd level along that aquifer is characterized by high conc. in Fe++ and relatively low Mn++ where conc. of Fe++ rang from 1.2 mg\l to 1.9 mg\l , while Mn++ rang from 0.2 to 0.4 mg\l and the depth of this level is rang from 60 to 70 m.

b. Sources Of Iron And Manganese In The Under Ground Water Along Study Area

- The effect of the reducing environment of this aquifer beds, where the water is of high CO2 and low in dissolved oxygen this lead to convert the insoluble iron and manganese to ferrous and manganese bicarbonates (where the grayish color of sand grains, H2S odor, and presence of Gluconite mineral indicate this reducing environment of deposition)



(Fig. 39) Distribution Of Iron In The Groundwater Of The Study Area.



(Fig. 40) Distribution Of Manganese In The Groundwater Of The Study Area.

- Presence of pyrite (Iron Sulfide) and manganese ore as disseminated form in thin layers of compacted sand stone which need experience to observed it by necked eye during soil samples collection.

- Ionic exchange between ground water and the clay lenses of Pleistocene which distributed along the upper part of the aquifer and also the clay of the Pliocene which represent the bottom of the aquifer.

- The effect of jetting waste water to the aquifer through cess pools.

vi. Pesticides

All collected samples through premonitoring program are acceptable and meet the Egyptian standards and WHO recommendations.

5.2.3. Bacteriology

All the collected samples through preliminary monitoring program are meet the Egyptian standards and WHO recommendation except three locations, (El Sheik Abed Exp. well 700 col/100 ml, El Gendi Exp. well 600 col/100 ml and Abed El Moniem well 700 col/ml) but, these wells not pumped for long time and flushing duration before sampling is short and this lead to pollution by bacteria.

5.3. GROUNDWATER CONTAMINATION AND NATURAL MIXING

The expression of the ionic relationship in the terms of mathematical ratios, is quite helpful for establishing chemical similarities among waters representing a single geologic terrain or single aquifer. Ion ratios are also used as tool for correlations of water analysis as well as for the detection of any groundwater contamination or mixing. The examination of such values led to the following observations:

i. rNa / rCl: the value of this ratio in the majority of samples (66%) is more than unity, it is meant that there is no contamination with old or drains water (this case is represented by groundwater of sector 1 and 3). On the other hand, the rest of the samples (34 %) have chloride ion in excess of the sodium ion content; i.e. rNa / rCl is less than unit, which means that there is contamination from old water and drains (this case is represented by groundwater in sector 2 and 4).

ii. rCa / rMg: all collected samples from sector 1 and 3 show that this ratio is less than unity, while the samples which were collected from sector 2 and 4 show this ratio higher than the unit, that is due to the effect of contamination by old groundwater of Eocene aquaclude (aquifer with very low potential).

The existence of **(K+Na) Cl, Mg Cl_2, Ca Cl_2, $MgSO_4$ and $CaSO_4$** salts in the groundwater of the Quaternary aquifer along sector 2 and sector 4 (central and west Bahr Youssef sector) is due to the following:

i. The permanent leaching and dissolution of the irrigation water to the soil of the reclaimed area (due to wrong method of irrigation) which consists of calcium carbonate (10-20 %); gypsum (8-15 %) and organic matter (0.3%).

ii. The base exchange process of the clay minerals of Pliocene age which forms the bottom of the Quaternary aquifer and groundwater.

iii. The leakage either from the Plio- Pleistocene aquifer which is composed sand and clay intercalations with gravel or from the underlying fissured water carbonate of Eocene age along the fault planes of this limestone plateau.

iv. Leaching and dissolution of the west dolomitic limestone plateau by rainfall.

v. The prevailing drains having brackish salt water specially in the western sector.

iv. Bad sanitary drainage system in villages (vaults) and presence of many deep drainage wells distributed along the study area.

5.4. CHANGES OF GROUNDWATER QUALITY

Many changes in the groundwater chemistry such as leaching and solution process by distance, pumping rate and depth of water bearing zone. These reasons, will be concisely discussed as follows:

5.4.1. Changes Of Groundwater quality by distance

In this part of groundwater evaluation report for domestic use, an attempt is made to answer the question of groundwater in the study area acquired its present quality through its down gradient movement, and what changes may occur in it.

As previously described, groundwater is flowing from the west to the east, i.e. from the fringes of the reclaimed area, near the Eocene plateau to the flood plain. this means that groundwater starts movement from the sandy soil which contains high calcium and sulfate to the Pleistocene deposits (sand and gravel). Also The reclaimed area considers a recharge area to the aquifer, yet it continents a considerable amount of salts.

The main changes in the groundwater chemistry during its movement from west to east are well illustrated by three hydrochemical profile A-A', B-B' and C-C' (**fig. 41, 42, 43**).

Generally there are an increase in the T.D.S. and main parameters in the SW direction but, the highest concentration of iron and manganese is in the central part.

5.4.2. The Effect Of Pumping On The Groundwater Quality

The pumping period may effect on the water quality, so may relationships between water quality and pumping period & discharge should study during the implementation of the pumping test as following :

i. Effect of pumping on total salinity

The possibility changes in water salinity with pumping period are investigated in some wells of the study area. The relation between the electric conductivity (EC) and the pumping period is illustrated in (**fig.44, 45**). The relations between iron and manganese content & pumping period are presented in (**fig. 46,47 and 48**). Two experiments of pumping (production wells 10" diameter) were select from fifteen experiments in well 12 with pumping rate of 166 m³ / hour and well 17 with pumping rate of 283 m³ / hour to illustrate the relation between the EC and pumping period.

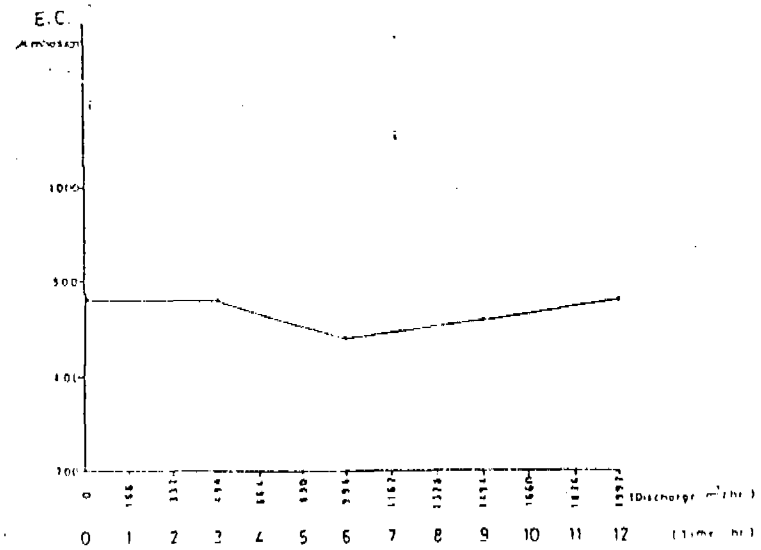


Fig. 44 The relation between EC and pumping period (well 12)

In well 12 there is no considerable change in the total salinity with pumping period. The total salinity in the first three hours is equal the total salinity after twelve hours from the pumping start time, except slight fluctuations.

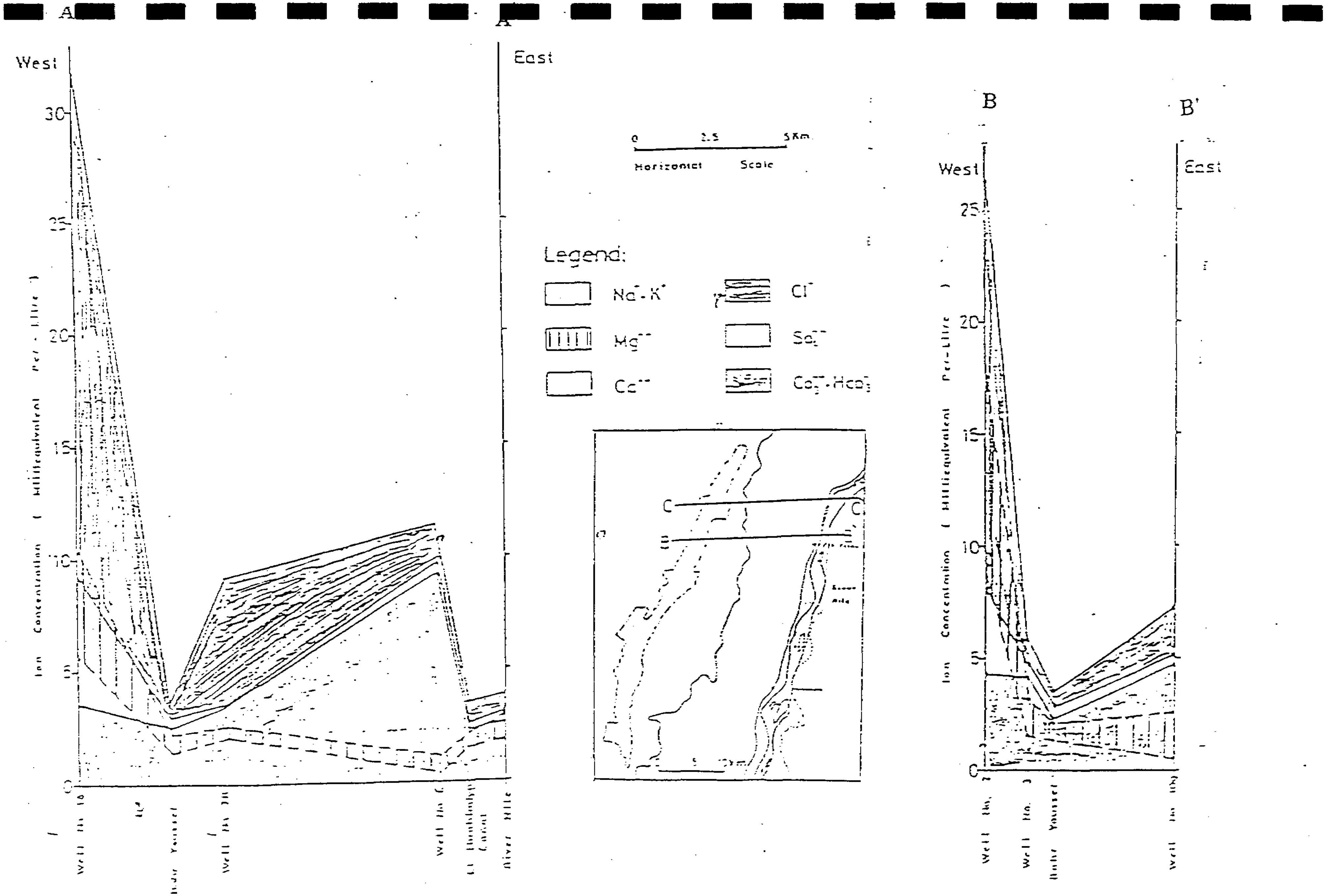


Fig. (41 and 42) Hydrochemical profile In The direction E-W Along A-A' And B-B' cross sections.

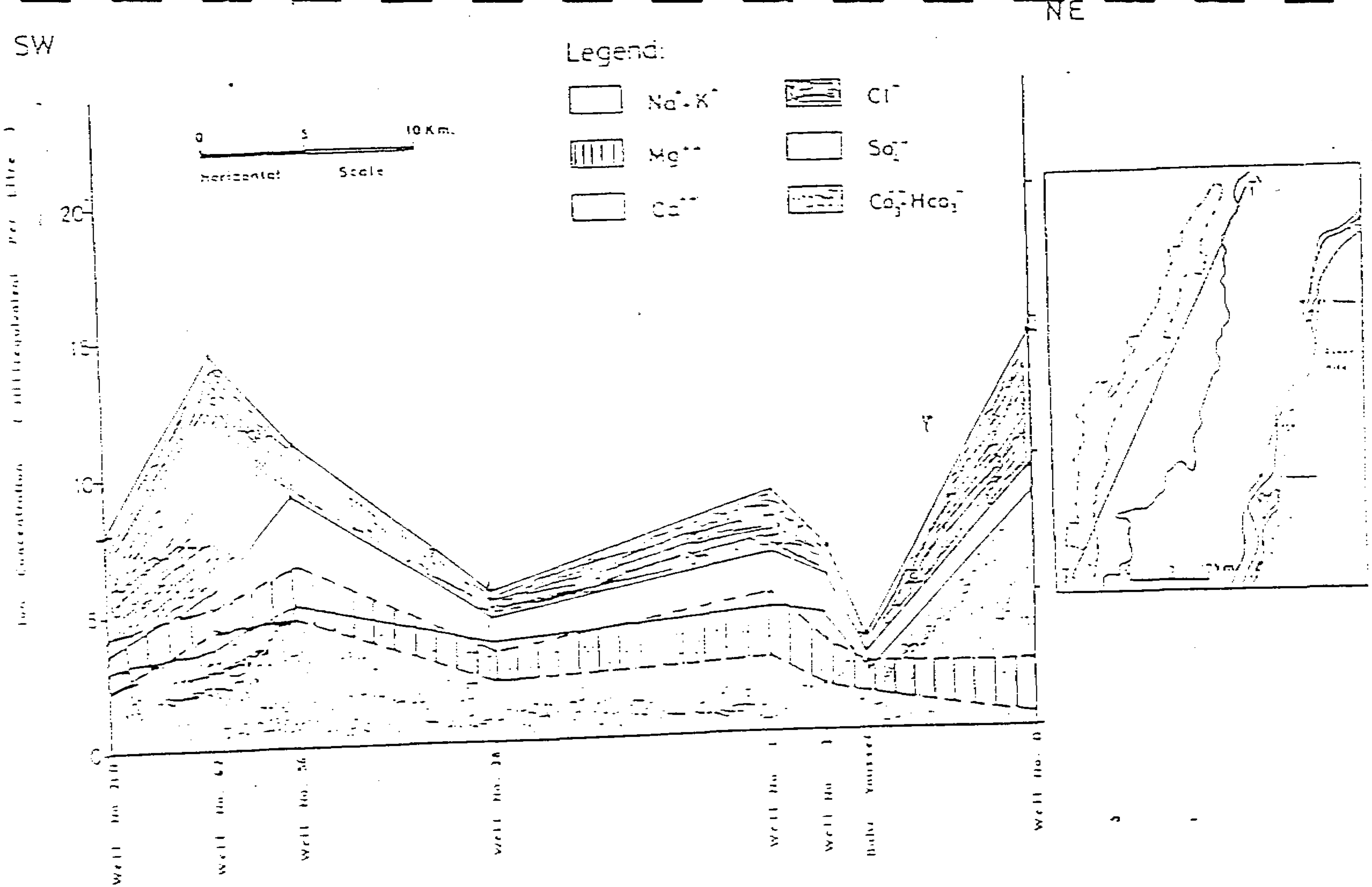


Fig.(43)Hydrochemical Profile in Southwest - Northeast Direction Along the Cross Section C — C'

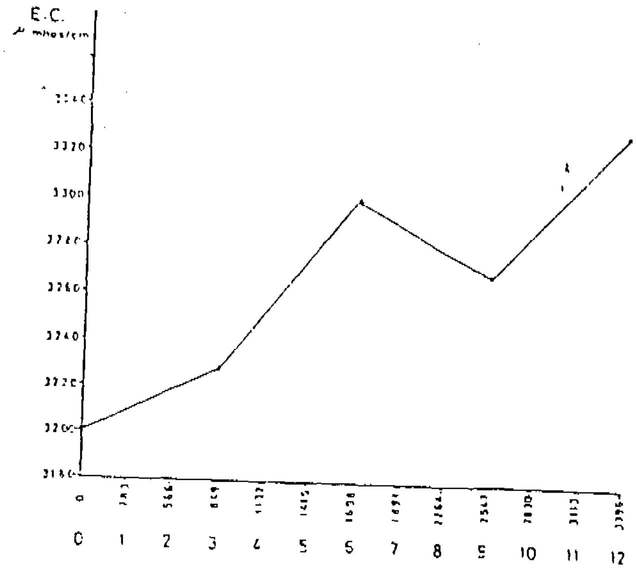


Fig. 45 The relation between EC and pumping period (well 17)

In the well 17 the total salinity increase gradually from about 3200 µS/cm with pumping to about 3330 µS/cm after twelve hours from pumping start time.

It was find that 80 % of the pumping tests in the Quaternary aquifer along the study area reveal no considerable changes in the water salinity as the result of pumping it self.

ii. The effect of pumping period on iron and manganese content

The relationship between pumping period (72 hours) and iron & manganese contents through three experimental wells along Sumusta city are illustrated in (**fig. 46a, 46b, 47a, 47b, 48a and 48b**)

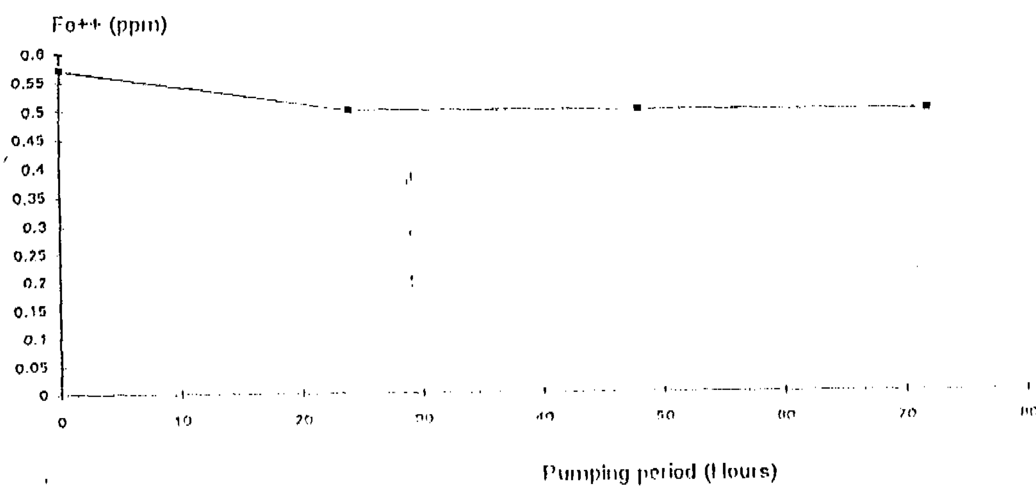


Fig. (46a) The relation between Iron content and pumping period.
(High Reservoir - Sumusta)

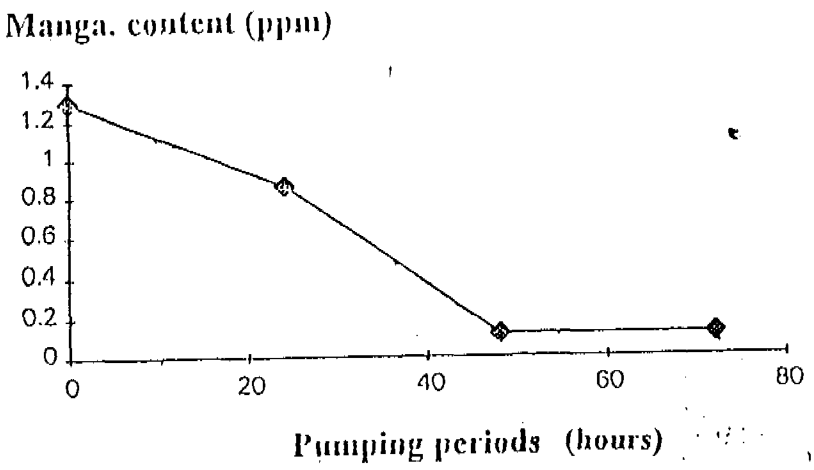


Fig. (46b) Manganese content & Pumping Period.

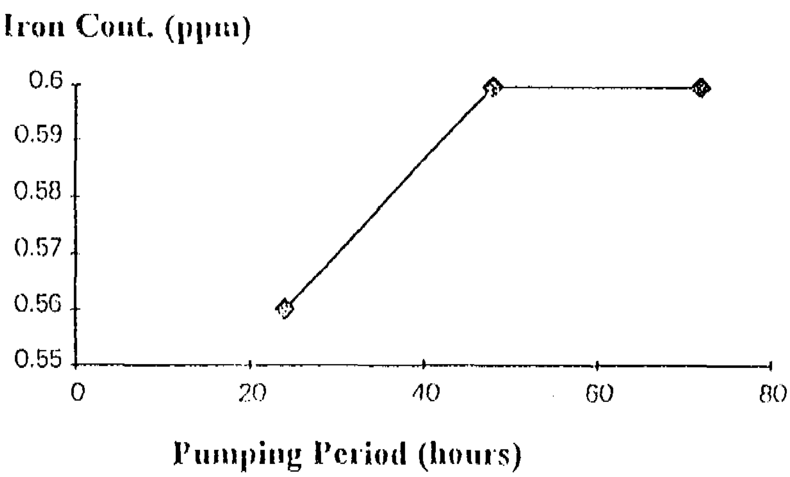


Fig. (47a) Iron content & Pumping period. (Sumusta Garden)

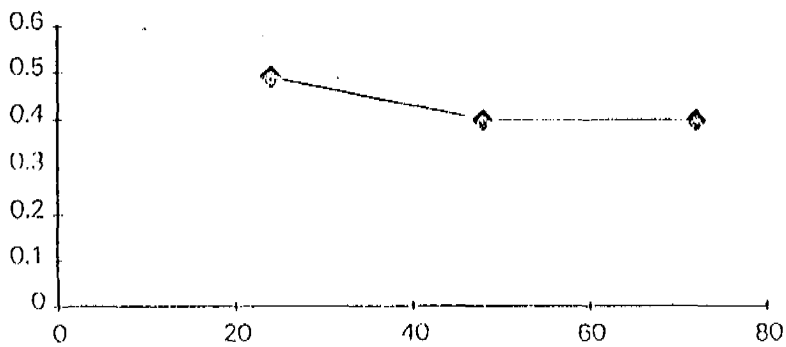
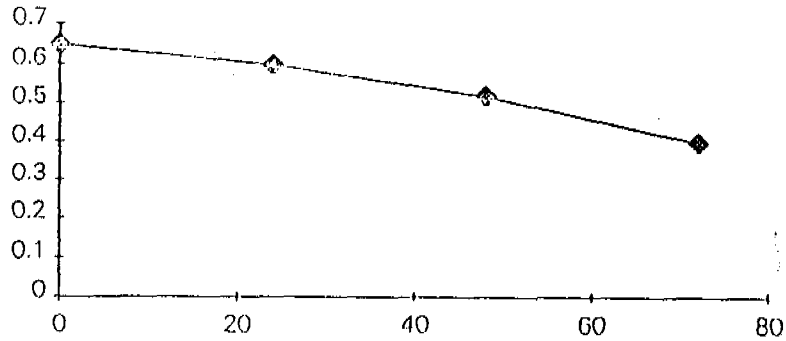


Fig. (47 b) Manganese content & Pumping period (Sumusta Garden).

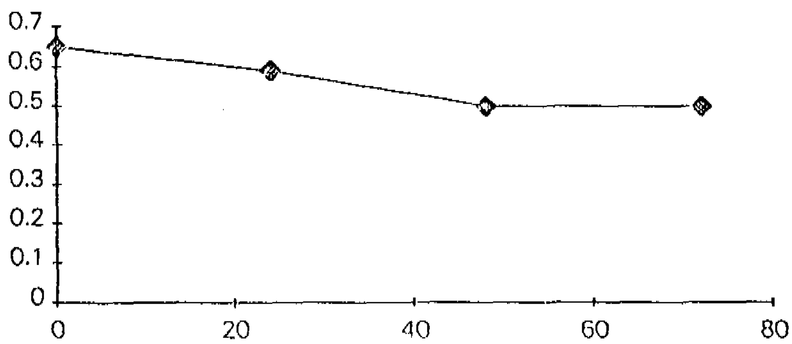
Iron content (ppm)



Pumping period (hours)

Fig. (48a) Iron content & Pumping period (El Slakanh - Sumusta)

Mang. Cont. (ppm)



Pumping period (hours)

Fig.(49 b) Manganese cont & Pumping period (El Slakanh - Sumusta).

From all those pumping experiments, the following can be concluded:

i. The groundwater is in hydraulic connection with surface water along the study area.

ii. The Quaternary aquifer in the study area is of high potentiality.

iii. No considerable change in water salinity with pumping can be detected.

5.5. EVALUATION OF THE GROUNDWATER IN THE PROJECT AREA

The ground water along the study area is generally of suitable quality for domestic and irrigation purposes (except in the western sector, the central sector requires further studies and special arrangements) (RIGW. 1990).

Based on results of ground water sampling program, data representation and analysis, the study area was divided to four sectors which have different ground water quality. The ground water suitability for domestic use along the study area are represented in (fig.49). The ground water quality in the four sectors is summarized in table 5.

Table 5. Summary of ground water quality in different sectors.

Prop. / Sector	Sector 1	Sector 2	Sector 3	Sector 4
Location	- Between the Nile and w. El Ibrahemiya Canal.	- Between w. bank of Ibrahemiya canal and Bahr Youssef.	- Adjacent to the north part of the western bank of Bahr Youssef.	- Occupy the western part of the study area.
T.D.S. (ppm)	300 - 600	800 - 1600	480 - 500	1600 - 5000
T. Hardness (ppm)	75-350	400-600	120 -220	400 - 1800
Fe^{++} (ppm)	0.0-0.1	0.5 - 2	0.0 - 0.4	0.5 - 2.6
Ion Dominance	$Na^{+} > Ca^{++} > Mg^{++}$ $HCO_3^{-} > Cl^{-} > So_4^{--}$	$Na^{+} > Ca^{++} > Mg^{++}$ $Cl^{-} > SO_4^{--} > HCO_3^{-}$	$Na^{+} > Mg^{++} > Ca^{++}$ $HCO_3^{-} > Cl^{-} > SO_4^{--}$	$Na^{+} > Ca^{++} > Mg^{++}$ $SO_4^{--} > Cl^{-} > HCO_3^{-}$
Salt Combination	$(Na+K)Cl$, $NaSO_4$, $NaHCO_3$, $Ca(HCO_3)_2$	$Na+K\ Cl$, $MgCl_2$, $MgSO_4$, $CaSO_4$, $Ca(HCO_3)_2$.	$Na+KCl$, Na_2SO_4, $Mg(HCO_3)_2$, $Ca(HCO_3)_2$,	$Na+K\ Cl$, $MgCl_2$, $CaCl_2$ $MgSO_4$, $CaSO_4$, $Ca(HCO_3)_2$
Mn^{++} (ppm)	0.2-0.4	0.3 - 1.3	0.16 - 0.3	0.1 - 0.4
Bacteriology	Nill	1-20 col / 100 ml	>1 col / 100 ml	700 col/ 100 ml
Suitability For Domestic Use	Suitable	Needs mixing with surface water or simple treatment	Suitable	Not suitable

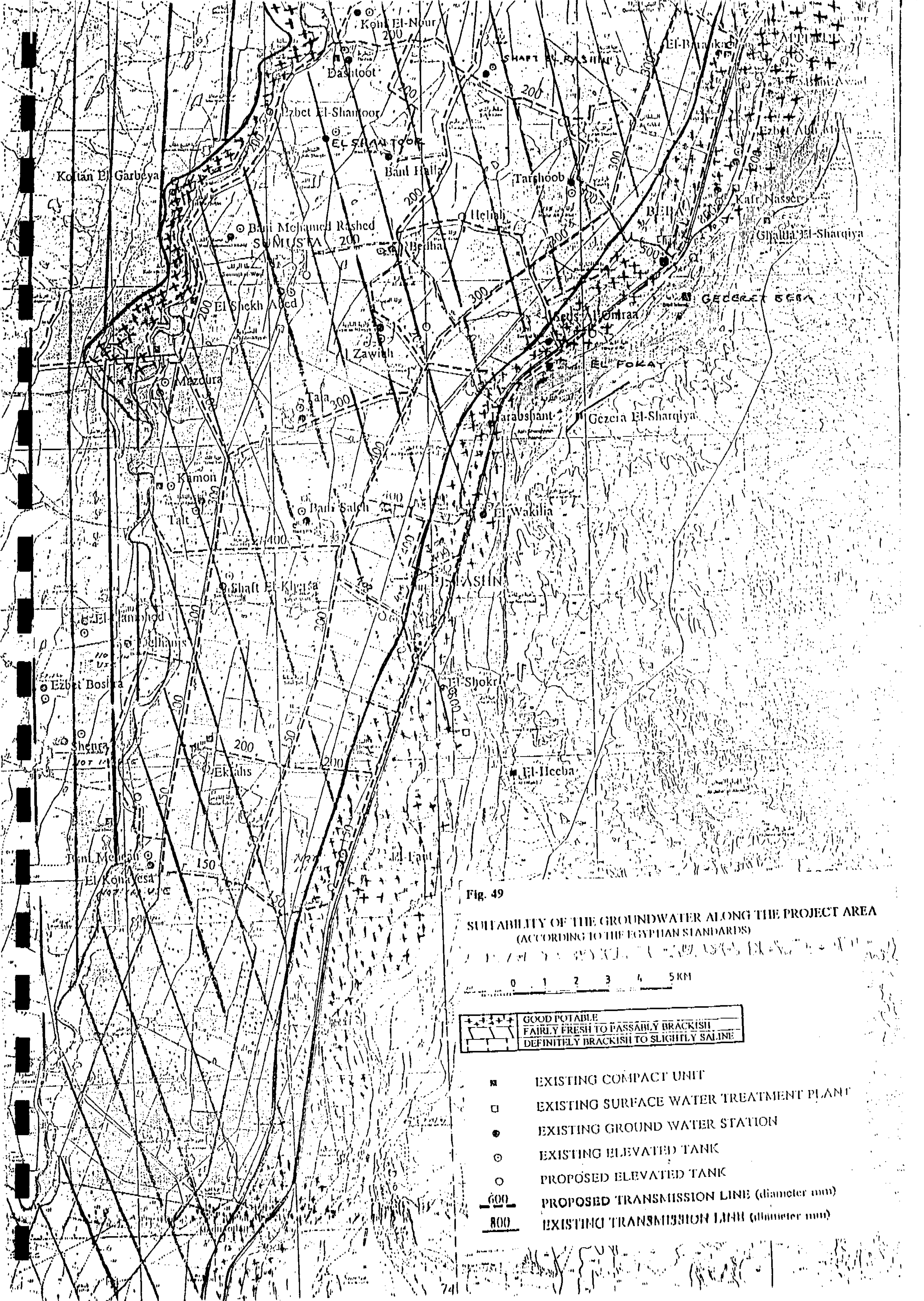


Fig. 49

SUITABILITY OF THE GROUNDWATER ALONG THE PROJECT AREA
(ACCORDING TO THE EGYPTIAN STANDARDS)

6. RECOMMENDATIONS

Based on this study, the consultant suggests the following recommendations :

- The groundwater potential of the area offer possibilities for further utilization of ground water. There is enough groundwater in the area for pumping in large quantities. The water quality sets limitations to the use of ground water for domestic purposes. The water quality sectors 1 and 3 defined in (**fig.49**) have very good groundwater quality. Groundwater in sector 2 can be utilize to a limited extend but it needs for mixing with surface water or simple treatment to be suitable for domestic uses and the groundwater in sector 4 can not be used.

- The aquifer in the study area specially in sector 2 and in whole governorate needs more test drillings and water quality monitoring to determine the locations and depths of good groundwater quality, suitable for domestic use. The use of suitable drilling techniques and proper borehole designs are needed to abstract the water from the horizons that have better quality.

- It is recommendable to increase abstraction of the groundwater form the aquifer to improve the ground water quality and to keep the subsoil water at deeper level. Careful and detailed hydrogeological & quality studies should be done during planned pumping from the 63 wells in area west Bahr Youssef (FAO project). The irrigation drainage system in the new reclaimed area should be improved to reduce the soil salinization.

- The test of mixing of ground water with surface water to improve its quality and to make it suitable for domestic uses has given promising results. This alternative needs to be further studied.

- The measures should be done for protection of ground resources . It is highly recommendable to change the technique of irrigation from flood irrigation to sprinkler or drip irrigation well decrease soil salinity and the aquifer contamination.

- Further education of the population regarding the waste and wastewater handling.

- It is vital to monitor continuously both the surface ground water quality and levels in the study area and in the governorate according to regular monitoring program. This will enable to detect in advance any undesirable conditions.

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Subject: The time schedule of sampling program
GROUND WATER SAMPLES

Sampling order (No.)	Sampling date	Sampling site	Sampling locations	Transportation and driver	Sampling staff	Sampling preparation	Analyses of samples	Comments
1	29.7.1996	Beba old water station	Pump No. 7	Priv. car + Pick up	SST,CHE, Ashraf	Official letter	Sumusta + Cairo lab.	Plus oil analyses
2	29.7.1996	Seds water station	Electric one	Pick up + Priv. car	SST,CHE, Ashraf	Official letter	Sumusta lab.	
3	29.7.1996	El Sheik Abed water station	Exp. well	Pick up + Priv. car	SST,CHE, Ashraf	Official letter + pump unit	Sumusta lab.	
4	30.7.1996	El Gendi village	Exp. well	Pick up + Priv. car	SST,CHE, Ashraf	Official letter + pump unit	Sumusta + Cairo lab.	
5	30.7.1996	Bedahl water station	Well No. 4	Pick up + Priv. car	SST,CHE, Ashraf	Official letter	Sumusta lab.	
6	30.7.1996	El gabal way mazoura	Abd El Monem	Pick up + Priv. car	SST,CHE, Ashraf	Official letter, Mr Ashraf arr.	Sumusta + Cairo lab.	
7	1.8.1996	El Konesa water station	Well No. 1	Pick up + Priv. car	SST,CHE, Ashraf	Official letter	Sumusta lab.	
8	1.8.1996	Saft El Orfaa water station	Well No. 1	Pick up + Priv. car	SST,CHE, Ashraf	Official letter	Sumusta lab.	
9	1.8.1996	El fashen old water station	Well No. 4	Pick up + Priv. car	SST,CHE, Ashraf	Official letter	Sumusta + Cairo lab.	
10	1.8.1996	El Waquliaa water station	Well No. 1	Pick up + Priv. car	SST,CHE, Ashraf	Official letter	Sumusta lab.	Pump need mainten.

Regional water supply & sanitation project
in Beni Seuf Governorate

Laboratory : Sumusta central lab.
Supervisor : Dina Omar
Site : Ground water sites....
Locations :1)BEBA old water plant-pump No:7
2)SEE3 water station(electric one)
3)ABD EL MONEM well(EL gabaal way-private well)
Sampling date :29/7/96
Analyzing date :29/7/96

Parameter No. Lab.No.	1/1)Cairo	2	3/2)Cairo	
Color 00 TCU	<5	<5	<5	Sumusta lab.
Taste (descrip.)		----------		ElFUSTAT lab.
Odor(discr ip.)	Odorless	H2S	odorless	Sumusta lab.
pH 00.0	7.75	7.899	7.185	Sumusta lab.
Temperatur e 00.0 °C	22.2	25.0	20.3	in the field
Turbidity NTU 0-10 0.0 10-40 00	0.15	2.5	0.5	Sumusta lab.
TDS 0000 mg/l		----------		ElFUSTAT lab.
Conduct. uS/cm 0000	700	1500	2500	Sumusta lab.
Hardness CaCO3 000 mg/l	264	277	1504	Sumusta lab.
Alkalinity 000 mg/l	338	667	172.5	Sumusta lab.
Ammonia NH 00.0 mg/l	0.27	0.2	nil	Sumusta lab.

Carbonate 00.0 mg/l				Sumusta lab.
Calcium 00.0 mg/l	66.04	89.5	407.4	Sumusta lab.
Chloride 000 mg/l	158	112	188	Sumusta lab.
Bicarb. 00.0 mg/l				Sumusta lab.
Iron <1 0.00 >1 00.0 mg/l	nil	1.94	0.50	Sumusta lab.
Manganese <1 0.00 >1 00.0 mg/l	0.40	0.30	0.10	Sumusta lab.
Sulphate 000 mg/l				ElFUSTAT lab.
Nitrate NO3 00.0 mg/l	0.61	0.75	8.0	Sumusta lab.
Nitrite NO2 0-1 0.00 >1 00.0 mg/l	0.00	0.00	0.00	Sumusta lab.
Oils ppm		----------	----------	ElFUSTAT lab.
Magnesium 00.0 mg/l	24.00	13.1	118.0	Sumusta lab.
Pesticides ppm		----------		ELFUSTAT lab.
Sodium 00.0 mg/l		-----------		ELFUSTAT lab.
Potassium 00.0 mg/l		-----------		ELFUSTAT lab.
Copper ppm		-----------		ELFUSTAT lab.
Lead ppm		----------		ELFUSTAT lab.

T.Phosph. 00.0 mg/1		----------		ELFUSTAT lab.
Herbicides ppm	-----------	---------	----------	ElFUSTAT lab.
Algae count	--------	----------	---------	Sumusta lab.
Total coliform col/100 ml	<1	<1	700	Sumusta lab.

------- not tested

APPENDIX 3

Regional water supply & sanitation project
in Beni Seuf Governorate

Laboratory : Sumusta central lab.
Supervisor : Dina Omar
Site : Ground water sites....
Locations :1) ELFASHEN old water plant-well No.4
2) ELWAQULIA water station
3) ELSHEIK ABED EX.well
Sampling date :30/7/96
Analyzing date :30/7/96

Parameter No. Lab.No.	1/3) Cairo	2	3	
Color 00 TCU	<5	5	5	Sumusta lab.
Taste (description)	acceptable	----------	----------	ElFUSTAT lab.
Odor (discribtion)	H2S	odorless	H2S	Sumusta lab.
pH 00.0	7.078	7.96	7.8	Sumusta lab.
Temperature 00.0 °C	24.0	24.0	24.0	in the field
Turbidity NTU 0-10 0.0 10-40 00	0.6	0.5	6.0	Sumusta lab.
TDS 0000 mg/l	550.0	----------	----------	ElFUSTAT lab.
Conductivity uS/cm 0000	900	700	1800	Sumusta lab.
Hardness CaCO3 000 mg/l	176.0	315.0	632.0	Sumusta lab.
Alkalinity 000 mg/l	473.0	322.0	253.0	Sumusta lab.

Ammonia NH 00.0 mg/l	nil	nil	nil	Sumusta lab.
Carbonate 00.0 mg/l				Sumusta lab.
Calcium 00.0 mg/l	32.0	61.5	123.5	Sumusta lab.
Chloride 000 mg/l	31.8	59.0	490.0	Sumusta lab.
Bicarb. 00.0 mg/l				Sumusta lab.
Iron <1 0.00 >1 00.0 mg/l	0.2	nil	0.56	Sumusta lab.
Manganese <1 0.00 >1 00.0 mg/l	0.25	0.50	0.7	Sumusta lab.
Sulphate 000 mg/l	45.00	----------	----------	ElFUSTAT lab.
Nitrate NO3 00.0 mg/l	0.55	0.65	nil	Sumusta lab.
Nitrite NO2 0-1 0.00 >1 00.0 mg/l	0.00	0.00	nil	Sumusta lab.
Oils ppm	----------	----------	----------	ElFUSTAT lab.
Magnesium 00.0 mg/l	23.31	39.12	78.7	Sumusta lab.
Pesticides ppm	ND	----------	----------	ELFUSTAT lab.
Sodium 00.0 mg/l	167.7	----------	----------	ELFUSTAT lab.
Potassium 00.0 mg/l	16.00	----------	----------	ELFUSTAT lab.
Copper ppm	<0.01	----------	----------	ELFUSTAT lab.

Lead ppb	8.5	----------	---------	ELFUSTAT lab.
T.Phosph. 00.0 mg/l	0.5429	----------	----------	ELFUSTAT lab.
Herbicides ppm	----------	---------	----------	ElFUSTAT lab.
Algae count	--------	----------	---------	Sumusta lab.
Total coliform col/100 ml	<1	<1	700	Sumusta lab.

------- not tested
ND not detected at or above the method reporting limit

REGIONAL WATER SUPPLY & SANITATION PROJECT IN BENI SEUF GOVERNORATE

RESULTS OF WATER QUALITY ANALYSES for SECTOR PLAN

Laboratory :SUMUSTA lab.

Supervisor :Dina Omar

Site :Ground water sites

Sampling locations :1)ELGENDI EX. well
2) BEDAHL water station-well NO.4
3)SAFT EL ORAFAA water station

Sampling date :31/7/96

Samples analyses :31/7/96

Parameter NO. Lab. NO.	1/4 cairo	2	3 1/8/96	LAB.
Color 00 TCU	<5	5	5	sumusta lab
Taste (descrip.)	acceptable	---------	--------	ELFUSTAT lab.
Odor (descrip.)	odorless	H2S	odorless	Sumusta lab.
pH 00.0	8.001	7.681	8.075	Sumusta lab.
Temprature 00.0	24	21.5	22.2	in the field
Turbidity NTU 0-10 0.0 10-40 00	0.4	6.5	5.1	Sumusta lab.
TDS mg/1 0000	482.3	---------	----------	ELFUSTAT lab.
Conduct. uS/cm 0000	700	1500	1200	in the field
Hardness CaCO3 mg/1 000	120	529.0	344.0	Sumusta lab.

Alkalinity CaCO3 mg/l 000	299	264.5	338.1	Sumusta lab.
Ammonia NH4 mg/l 00.0	0.08	0.2	0.06	Sumusta lab.
Carbonate CaCO3 mg/l 00.0	2.8167	1.1927	3.7766	Sumusta lab.
Calcium mg/l 00.0	17.28	62.3	61.72	Sumusta lab.
Chloride mg/l 000	166.3	274	177.7	Sumusta lab.
Bicarbonate CaCO3 mg/l 00.0	298.95	264.476	338.04	Sumusta lab.
Iron mg/l <1 0.00 >1 00.0	nil	1.6	nil	Sumusta lab.
Mang. mg/l <1 0.00 >1 00.0	0.3	1.3	0.35	Sumusta lab.
Sulphate SO4 mg/l 000	44.0	---------	---------	ELFUSTAT lab.
Nitrate NO3 mg/l 00.0	nil	nil	nil	Sumusta lab.
Nitrite NO2 mg/l 0-1 0.00 >1 00.0	nil	nil	nil	Sumusta lab.
Magnesium mg/l 00.0	18.68	90.0	46.17	Sumusta alb.
Sodium mg/l 00.0	156.00	---------	---------	Sumusta lab.
Potassium mg/l 00.0	7.5	---------	---------	ELFUSTAT lab.
Copper ppm 00.0	<0.01	---------	---------	ELFUSTAT lab.
Lead ppb 00.0	2.00	---------	---------	ELFUSTAT lab.

Phosphates mg/l 00.0	0.144	---------	---------	ELFOUSTAT lab.
Oils ug/l 00.0	0.02	---------	---------	ELFUSTAT lab.
Pesticides ug/l 00.0	ND	--------	--------,--	ELFUSTAT lab.
Herbicides mg/l 00.0	-------	--------	--------	ELFUSTAT lab.
Total coliform col/100 ml	600	<1	<1	Sumusta lab.

------ not tested
ND not detected at or above the method reporting limit.

Summary of ground water quality analysis 1994-1996

location/depth	date	color hazen units	pH	N.T.U.	T.D.S mg/l	cond. S/cm	hard. mg/l	alk. mg/l	amonia mg/l	calcium mg/l	chloride mg/l	iron mg/l	mang mg/l	sulph. mg/l	nitrate mg/l	nitrite mg/l	sodium mg/l	comments
Elgendi EX.well-Summsta/43 m	25/08/94	<5	7.55	0.5	420	700	164	266	0	not tested	44	0.05	nil	113	0.03	0	not tested	S/C/B
Nosaier EX.well-Summsta/42 m	31/08/94	<5	7.55	7.34	896	1400	434	275	0	not tested	250	0.5	0.2	200	0.15	0	not tested	S/C/B
Bani Khalil EX.well-Beba/35 m	6/9/94	<5	7.5	11	1760	2200	1110	285	0	not tested	1600	1	1.4	575	1	0	not tested	S/C/B
Elgezera Elshark. EX. well/16.7 m	12/09/94	<5	7.33	2.6	768	1200	282	423	0	not tested	52	0.3	nil	386	15.8	0	not tested	S/C/B
Summsta C.U. EX. well/38 m	1/12/94	<5	not tested	1.7	896	1400	616	not tested	not tested	not tested	450	0.77	0.45	151.43	not tested	not tested	not tested	S/C/B
Summsta C.U. EX.well/48 m	2/12/94	<5	not tested	0.2	not tested	not tested	576	not tested	not tested	not tested	550	0.73	0.44	153.9	not tested	not tested	not tested	S/C/B
Summsta C.U. EX. well/26 m	3/12/94	<5	not tested	2.3	480	800	390	not tested	not tested	not tested	225	2.3	0.33	72.42	not tested	not tested	not tested	S/C/B
Summsta high reserivoir EX. well/38 m	5/12/94	<5	7.6	0.22	1760	2200	812	not tested	not tested	not tested	400	1.48	1.1	249.37	not tested	not tested	not tested	S/C/B
Summsta high reserivoir Ex. well/51 m	6/12/94	<5	7.8	0.27	600	1000	372	not tested	not tested	not tested	150	0.57	1.3	82.3	not tested	not tested	not tested	S/C/B
Hadiket el Sultani EX. well 28 m	8/12/94	<5	7.38	2	600	1000	590	not tested	not tested	not tested	350	0.55	0.58	57.61	0.24	not tested	not tested	S/C/B
Hadiket el Sultani EX. well/ 50 m	9/12/94	<5	7.39	1.5	600	1000	380	not tested	not tested	not tested	600	0.65	0.13	100.41	0.39	not tested	not tested	S/C/B
Hadiket el Sultani EX. well/ 70 m	10/12/94	<5	7.09	9.3	2640	3300	750	not tested	not tested	not tested	1150	1.27	0.2	258.42	0.16	not tested	not tested	S/C/B
Elsheik Ali Ex. well-Summsta/ 29 m	12/12/94	<5	7.3	2.9	1200	1500	1000	not tested	not tested	not tested	400	0.58	1.13	178.5	0.108	not tested	not tested	S/C/B
Elsheik Ali EX. well-Summsta/ 66 m	13/12/94	<5	7.06	15	600	1000	816	not tested	not tested	not tested	1200	1.24	0.27	319.4	0.194	not tested	not tested	S/C/B
El Estad Ex. well-Summsta/ 30 m	19/12/94	<5	7.39	5.7	1600	2000	648	not tested	not tested	not tested	380	0.77	0.6	225.5	0.14	not tested	not tested	S/C/B
El Estad EX. well-Summsta/ 63 m	22/12/94	<5	7.04	9	1840	2300	988	not tested	not tested	not tested	950	1.8	0.37	227.9	0.146	not tested	not tested	S/C/B
Al Salakana EX. well-Summsta/ 26 m	25/12/94	<5	7.24	3.2	1200	1580	676	not tested	not tested	not tested	340	0.65	0.65	139.91	0.16	not tested	not tested	S/C/B
Al Salakana Ex. well-Summsta/ 63 m	27/12/94	<5	7.29	0.8	600	1000	472	not tested	not tested	not tested	180	0.32	0.44	180	0.16	not tested	not tested	S/C/B
Summsta high reserivoir EX. well/51 m	25/03/95	<5	7.2	2	540	900	380	not tested	not tested	not tested	118	0.5	0.12	93.8	NIL	NIL	not tested	S/C
Hadiket el Sultani EX. well/ 50 m	6/04/95	<5	7.41	2	768	1200	414	not tested	NIL	not tested	194	0.6	0.19	106.1	NIL	NIL	not tested	S/C

APPENDIX 5

Summary of ground water quality analysis 1994–1996

location/depth	date	hazen	pH	N.T.U.	T.D.S mg/l	cond. S/cm	hard. mg/l	alk. mg/l	amonia mg/l	calcium mg/l	chloride mg/l	iron mg/l	mang mg/l	sulph. mg/l	nitrate mg/l	nitrite mg/l	sodium mg/l	comments
Bedahl w.s.-Sumusta/45 m	6/04/95	<5	7.36	4.7	660	1100	394	not tested	0.54	not tested	208	1	1.28	58.2	NIL	NUL	not tested	S/C
ElSantor WS.-Sumusta/40 m	11/04/95	<5	7.14	8	540	980	330	not tested	0.93	not tested	78	1.7	0.41	58.4	NIL	NIL	not tested	S/C
ElSalakana EX. well-Sumusta/ 63 m	11/04/95	<5	6.97	2.4	1120	1400	720	not tested	NIL	not tested	310	0.9	0.43	140.7	NIL	NIL	not tested	S/C
Mazora 1 WS.-Sumusta/40 m	15/04/95	<5	7.47	0.9	330	550	110	not tested	0.4	not tested	38	0.5	0.07	46.9	NIL	NIL	not tested	S/C
Mazora 2 WS.-Sumusta/40 m	15/04/95	<5	7.39	0.39	300	500	110	not tested	0.3	not tested	36	0.1	<0.05	14	NIL	NIL	not tested	S/C
Bani Mohamed R WS.-Sumusta/ 40 m	16/04/95	<5	7.2	1.8	432	720	210	not tested	0.33	not tested	118	0.4	0.18	55.14	NIL	NIL	not tested	S/C
Bani Hala WS.-Sumusta/40 m	17/04/95	<5	7.52	1.3	360	600	234	not tested	0.66	not tested	42	0.4	0.41	30.45	NIL	NIL	not tested	S/C
Kom el Nor WS.-Sumusta/40 m	17/04/95	<5	7.15	8.8	768	1200	464	not tested	1.3	not tested	120	1.4	0.87	92.17	NIL	NIL	not tested	S/C
Dasmot 1 WS.-Sumusta/40 m	18/04/95	<5	7.34	1.8	not tested	not tested	376	not tested	0.76	not tested	94	0.6	0.88	51.8	NIL	NIL	not tested	S/C
ElSantor ezzba WS.-Sumusta/ 40 m	19/04/95	<5	6.97	0.3	540	980	320	not tested	0.31	not tested	86	0.2	<0.05	42.8	NIL	NIL	not tested	S/C
Dasmot 2 WS.-Sumusta/40 m*	20/04/95	<5	7.23	2.1	510	850	376	not tested	0.71	not tested	68	0.4	0.41	59.3	NIL	NIL	not tested	S/C
Koftan WS.-Sumusta/40 m	20/04/95	<5	7.11	2	360	600	206	not tested	0.37	not tested	55	0.4	0.16	41.97	NIL	NIL	not tested	S/C
Sumusta P. W. 62 m*	8/05/96	5	7.48	3.2	1176	1200	520	300	not tested	96	425	0.6	0.17	120	0.012	not tested	265	S/C
Beba O.W.P.-well no.7*	29/07/96	<5	7.75	0.15	390	700	264	338	0.27	66.04	158	NIL	0.4	28	0.61	0	60.6	S/C
Seds WS.-elect.-Beba	29/07/96	<5	7.89	2.5	1200	1500	277	667	0.2	89.5	112	1.94	0.3	not tested	0.75	0	not tested	S/C
Abd el Monem well(privet)-Sumusta*	29/07/96	<5	7.185	0.5	4426	7000	1504	172.5	NIL	407.4	188	0.5	0.1	700	8	0	95.6	S/C
ElFashen O.W.P.-well no.4	30/07/96	<5	7.078	0.6	550	900	176	473	NIL	32	31.8	0.2	0.25	45	0.55	0	167.7	S/C
ElSheik Abd EX. well-Sumusta/ 48 m	30/07/96	5	7.8	6	1440	1800	632	253	NIL	123.5	490	0.56	0.7	not tested	NIL	NIL	not tested	S/C
Elwaqila WS.-ElFashen/38 m	30/07/96	5	7.96	0.5	420	700	315	322	NIL	61.5	59	NIL	0.5	not tested	0.65	0	not tested	S/C
ElGenai EX. well-Sumusta/43 m*	31/07/96	<5	8.001	0.4	482.3	780	120	299	0.08	17.28	166.3	NIL	0.3	44	NIL	NIL	156	S/C

Summary of ground water quality analysis 1994-1996

location/depth	date	hazen	pH	N.T.U.	T.D.S mg/l	cond. S/cm	hard. mg/l	alk. mg/l	amonia mg/l	calcium mg/l	chloride mg/l	iron mg/l	mang mg/l	sulph. mg/l	nitrate mg/l	nitrite mg/l	sodium mg/l	comments
Bedahel WS.-well no.4-Sumusta/40 m	31/07/96	5	7.681	6.5	1200	1500	529	264.5	0.2	62.3	274	1.6	1.3	not tested	NIL	NIL	not tested	S/C
Saft el Oraiaa WS.-ElFashen/40 m	31/07/96	5	8.075	5.1	768	1200	334	338.1	0.06	61.72	177.7	NIL	0.35	not tested	NIL	NIL	not tested	S/C
Sumusta P.W./62 m*	13/08/96	not tested	not tested	not tested	1463	2100	520	not tested	NIL	104	490	not tested	not tested	not tested	NIL	NIL	272	S/C
Sumusta P.W./62 m	16/09/96	<5	7.376	not tested	not tested	not tested	577.6	310.5	not tested	112.95	523.1	not tested	not tested	210	not tested	not tested	287.73	S/C
Sumusta P.W./62 m	29/09/96	<5	7.53	[illegible]	1920	2400	585	303.6	not tested	112.34	526.08	not tested	not tested	not tested	not tested	not tested	not tested	S

S/Sumusta lab.

C/Cairo lab.

B/BeniSeuf lab.

WS/Water Station

P.W./Production Well

EX/Expermental Well

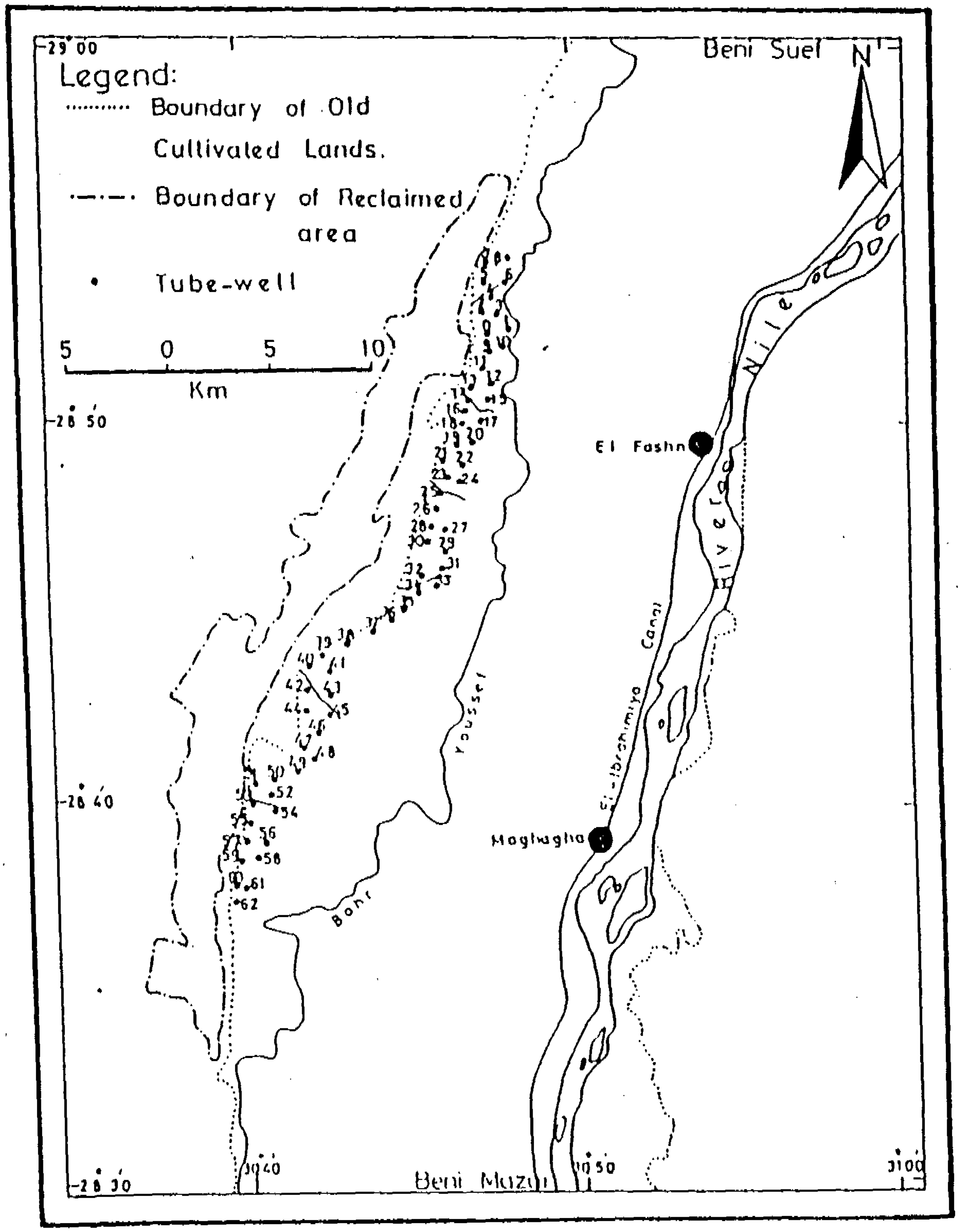
*/TDS analysed in C.lab

TDS calculated from the conductivity as:

0-1100 * 0.6

1200 *0.64

>1200 * 0.8



Locations of Production Wells

Chemical Analysis Of Groundwater - Summary cycle 1992 (RIGW)

Well No.	pH	E.C. u mons/cm	T.D.S. ppm	Units	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Total Cations epm	Co_3^{--}	HCo_3^{-}	So_4^{--}	Cl^{-}	Total Anions epm	Hydrochemical Formula	Water type
2K	8.02	730	650	ppm	46.2	31.5	96.6	19.5		0.0	252.3	62.4	142.		HCO3 44.79 Cl 41.67 So4 13.54	
				epm	2.31	2.59	4.2	0.5	9.6	0.0	4.3	1.2	4.0	9.6	S 0.7	Sodium Bicarbonate
				e%	24.06	26.98	43.75	5.21		0.0	44.79	13.54	41.67		Na 48.96 Mg 25.98 Ca 24.06	
10g	8.2	600	508	ppm	10.2	26.63	98.9	9.4		18.0	262.3	1.92	81.7		HCO3 67.68 Cl 31.77 So4 0.55	
				epm	0.51	2.19	4.3	0.24	7.24	0.6	4.3	0.04	2.30	7.24	S 0.51	Sodium Bicarbonate
				e%	7.04	30.25	59.39	3.31		8.29	59.39	0.55	31.77		Na 62.7 Mg 30.25 Ca 7.04	
B	8.2	770	605	ppm	18.2	35.1	115	14.4		30	3.05	3.4	106.5		HCO3 66.16 Cl 33.05 So4 0.77	
				epm	1.31	2.89	5	0.47	9.07	1.0	5.0	0.07	3.0	9.07	S 0.63	Sodium Bicarbonate
				e%	8.93	31.86	55.13	4.08		11.02	55.13	0.77	33.05		Na 59.21 Mg 31.86 Ca 8.93	
C	8.2	670	734	ppm	28.2	41.2	102.4	10.3		0.0	500.2	15.8	35.5		HCO3 86.04 Cl 10.49 So4 3.46	
				epm	1.41	3.39	4.45	0.28	9.53	0.0	8.2	0.33	1.0	9.53	S 0.73	Sodium Bicarbonate
				e%	14.80	35.57	46.69	2.94		0.0	86.04	3.46	10.49		Na 49.63 Mg 35.57 Ca 14.8	
D	8.2	1200	1022	ppm	10.2	24.2	270.3	17.6		54.0	420.9	48.0	177.5		HCO3 59.18 Cl 34.01 So4 6.8	
				epm	0.51	2.0	11.75	0.45	14.71	1.8	6.9	1.0	5.0	14.70	S 1.0	Sodium Bicarbonate
				e%	3.47	13.60	79.88	3.06		12.24	46.94	6.80	34.01		Na 82.94 Mg 13.6 Ca 3.47	
E	8.3	920	857	ppm	8.0	8.5	230	11.7		42	481.9	4.8	71		HCO3 81.58 Cl 17.54 So4 0.88	
				epm	0.4	0.7	10	0.3	11.14	1.4	7.9	0.1	2	11.4	S 0.9	Sodium Bicarbonate
				e%	3.51	6.14	87.72	2.63		12.28	69.30	0.88	17.54		Na 90.35 Mg 6.14 Ca 3.51	
F	7.8	960	883	ppm	4.0	13.4	215.2	12.9		0.0	530.7	15.8	71		HCO3 78.66 Cl 15.13 So4 2.99	
				epm	0.2	1.10	9.4	0.33	11.03	0.0	8.7	0.33	2	11.03	S 0.9	Sodium Bicarbonate
				e%	1.81	9.97	85.22	2.99		0.0	78.88	2.99	18.13		Na 28.21 Mg 9.97 Ca 1.81	
H	8.2	800	774	ppm	12.3	10.8	194.4	23.4		30	390.4	7.2	106.5		HCO3 70.14 Cl 28.44 So4 1.42	
				epm	0.61	0.89	8.45	0.6	10.58	1.0	6.4	0.15	3.0	10.58	S 0.8	Sodium Bicarbonate
				e%	5.78	8.44	80.1	5.69		9.46	60.66	1.42	28.44		Na 85.79 Mg 8.44 Ca 5.78	

Hydrochemical Parameters of the Investigated Water Samples

WELL NO.	Ion Ratios							Hypothetical Salt Combinations in %									
	rCa/rCl	rMg/rCl	rNa/rCl	rK/rCl	rSO4/rCl	r(Cl-r(Na+K))/rMg	r((Na+K)-Cl)/rSO4	KCl	NaCl	Na_2SO_4	$NaHCO_3$	$MgCl_2$	$CaCl_2$	$MgSO_4$	$CaSO_4$	$Mg(HCO_3)_2$	$Ca(HCO_3)_2$
2K	0.53	0.65	1.05	0.13	0.33	—	0.54	6	36	7	-	-	-	6	-	21	34
10g	0.22	0.35	1.87	0.10	0.02	—	56.0	3	23	1	31	-	-	-	-	30	7
B	0.27	0.36	1.67	0.12	0.02	—	33.56	4	29	1	25	-	-	-	-	32	9
C	1.41	3.29	4.45	0.23	0.33	—	11.30	3	7	4	36	-	-	-	-	35	15
D	0.1	0.4	2.35	0.09	0.2	—	7.2	3	31	6	43	-	-	-	-	13	4
E	0.2	0.35	5.0	0.15	0.05	—	3.2	2	5	1	72	-	-	-	-	6	4
F	0.1	0.35	4.7	0.17	0.17	—	23.42	3	15	3	67	-	-	-	-	10	2
H	0.20	0.22	2.82	0.2	0.05	—	40.33	6	22	2	56	-	-	-	-	8	6

Chemical Analysis Of Groundwater - Summary cycle 1993 (RIGW)

Well No.	pH	E.C. u mhos/cm	T.D.S. ppm	Units	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Total Cations epm	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{-}	Total Anions epm	Hydrochemical Formula	Water type
33R	8.3	5400	3238	ppm	135	119	811	1		36	116	1186	831		SO_4 48.24 Cl 45.70 HCO_3 6.05	
				epm	6.8	9.78	35.25	0.03	51.36	1.2	1.9	24.71	23.41	51.22	S------------------------	Sodium
				e%	13.11	18.86	67.97	0.05		2.34	3.71	48.24	45.70		3.24 Na 66.03 Mg 18.86 Ca 13.11	Sulphate
34R	8.2	2100	1360	ppm	56	44	345	21		12	116	379	387		Cl 52.15 SO_4 37.5 HCO_3 10.06	
				epm	2.8	3.6	15	0.54	21.34	0.2	1.9	7.8	10.9	20.90	S------------------------	Sodium
				e%	12.76	16.41	68.37	2.46		0.96	9.1	37.50	52.15		1.4 Na 70.83 Mg 16.41 Ca 12.75	Chloride
J	8.1	3300	2174	ppm	92	73	529	11		0.0	92	1005	369		SO_4 63.81 Cl 31.6 HCO_3 4.59	
				epm	4.6	6	23	0.28	33.88	0.0	1.51	21	10.4	32.91	S------------------------	Sodium
				e%	13.58	17.71	67.89	0.83		0.0	4.59	63.81	31.60		2.2 Na 66.72 Mg 17.71 Ca 13.58	Sulphate
D	7.4	8080	4907	ppm	848	112	759	19		0.0	31	1008	2130		Cl 73.61 SO_4 25.76 HCO_3 0.63	
				epm	42.4	9.2	33	0.49	85.09	0.0	0.51	21	60	81.51	S------------------------	Calcium
				e%	49.83	10.81	38.78	0.58		0.0	0.63	25.76	73.61		4.91 Ca 49.83 Na 39.36 Mg 10.81	Chloride
W	7.8	4300	2583	ppm	360	72	437	13		0.0	49	384	1207		Cl 79.44 SO_4 18.69 HCO_3 1.87	
				epm	18	6	19	0.33	43.33	0.0	0.8	8	34	42.8	S------------------------	Sodium
				e%	41.54	13.85	43.85	0.76		0.0	1.87	18.69	79.44		2.52 Na 44.61 Ca 41.54 Mg 13.85	Chloride
L	8.0	720	972	ppm	141.4	66	82.8	10.1		0.0	176.9	125.2	369.2		Cl 65.29 HCO_3 18.20 SO_4 16.51	
				epm	7.07	5.4	3.6	0.26	16.33	0.0	2.9	2.63	10.4	15.93	S------------------------	Calcium
				e%	43.29	33.07	22.05	1.59		0.0	18.20	16.51	65.29		0.97 Ca 43.29 Mg 33.07 Na 23.64	Chloride

	Hydrochemical Parameters of the Investigated Water Samples																
	Ion Ratios							Hypothetical Salt Combinations in %									
WELL NO.	rCa/rCl	rMg/rCl	rNa/rCl	rK/rCl	rSO_4/rCl	$rCl-r(Na+K)/rMg$	$r(Na+K)-rCl/rSO_4$	KCl	$NaCl$	Na_2SO_4	$NaHCO_3$	$MgCl_2$	$CaCl_2$	$MgSO_4$	$CaSO_4$	$Mg(HCO_3)_2$	$Ca(HCO_3)_2$
33R	0.23	0.42	1.51	0.001	1.06	—	0.48	1	45	22	-	-	-	19	7	-	6
34R	0.26	0.33	1.38	0.05	0.72	—	0.59	2	50	15	-	-	-	17	3	-	10
a	0.44	0.33	2.21	0.03	2.02	—	0.61	1	31	26	-	-	-	18	10	-	4
P	0.71	0.15	0.55	0.01	0.35	2.38	—	1	38	-	-	11	23	-	26	-	1
W	0.53	0.18	0.56	0.01	0.24	2.45	—	1	43	-	-	14	21	-	19	-	2
L	0.68	0.32	0.35	0.03	0.25	1.21	—	2	21	-	-	33	9	-	17	-	18

Chemical Analysis Of Groundwater - Summary cycle 1994 (RIGW)

Well No.	pH	E.C. µ mohs/cm	T.D.S. ppm	Units	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Total Cations epm	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{-}	Total Anions epm	Hydrochemical Formula	Water type
36	8.25	970	1222	ppm epm e%	129.3 5.54 34.11	57.6 4.06 25	173.6 6.46 39.78	8.19 0.18 1.11	15.24	12 0.4 2.46	274.5 4.5 27.72	310.5 6.47 39.86	172.7 4.86 29.94	15.23	SO4 39.86 HCO3 30.19 Cl 29.94 S ---------- 1.32 Na 40.89 Ca 34.11 Mg 25	Sodium Sulphate
37	7.74	880	935	ppm epm e%	64.2 3.02 19.20	42.9 3.31 21.04	226.1 9.21 58.55	7.9 0.19 1.21	15.72	24 0.8 5.09	561.2 9.2 58.49	2.26 0.05 0.32	201.5 5.66 36.11	15.72	HCO3 63.58 Cl 36.11 SO4 0.32 S ---------- 0.93 Na 58.76 Mg 21.04 Ca 19.2	Sodium Bicarbonate
38	8.10	[illegible]	324	ppm epm e%	53.6 2.21 39.96	17.3 1.21 21.88	55.56 2.0 36.17	5.22 0.11 1.99	5.53	24 0.8 14.18	176.9 2.9 51.42	41.2 0.86 15.25	38.33 1.08 19.15	5.64	HCO3 65.6 Cl 19.15 SO4 15.25 S ---------- 0.32 Ca 39.96 Na 38.16 Mg 21.88	Sodium Bicarbonate
53	8.34	1870	2262	ppm epm e%	160.1 7.27 24.18	91.8 6.86 22.81	397.3 15.71 52.24	9.66 0.22 0.75	30.07	24 0.8 2.66	233.5 3.5 11.64	873.7 18.20 60.53	266.7 7.57 25.17	30.07	SO4 60.53 Cl 25.17 HCO3 14.3 S ---------- 2.4 Na 53 Ca 24.18 Mg 22.81	Sodium Sulphate
54	8.35	380	430	ppm epm e%	32.3 1.44 19.81	16.8 1.23 16.32	114.7 4.44 61.07	5.96 0.15 2.20	7.27	30 1 13.76	256.2 4.2 57.77	47.7 0.99 13.62	38.35 1.09 14.86	7.27	HCO3 71.53 Cl 14.86 SO4 13.62 S ---------- 0.43 Na 63.27 Ca 19.81 Mg 16.32	Sodium Bicarbonate
55	8.62	2520	3074	ppm epm e%	139.9 6.39 13.46	70.96 5.33 11.24	390.6 35.35 74.61	12.7 0.32 0.67	47.42	30 1 2.11	183 3 6.33	1007.3 21 44.28	796.4 22.43 47.29	47.43	Cl 47.29 SO4 44.22 HCO3 8.44 S ---------- 3.4 Na 75.28 Ca 13.46 Mg 11.24	Sodium Chloride

APPENDIX 9

WELL NO.	Hydrochemical Parameters of the Investigated Water Samples: Ion Ratios							Hypothetical Salt Combinations in %									
	rCa/rCl	rMg/rCl	rNa/rCl	rK/rCl	rSO_4/rCl	$rCl-r(Na+K)/rMg$	$r(Na+K)-rCl/rSO_4$	KCl	$NaCl$	Na_2SO_4	$NaHCO_3$	$MgCl_2$	$CaCl_2$	$MgSO_4$	$CaSO_4$	$Mg(HCO_3)_2$	$Ca(HCO_3)_2$
36	1.24	0.84	1.33	0.04	1.33	—	0.28	1	29	11	-	-	-	25	3	-	31
37	0.53	0.58	1.62	0.03	0.01	1.12	—	1	34	1	24	-	-	-	-	21	19
38	2.05	1.12	1.35	0.102	0.30	—	1.20	2	[illegible]	15	-	-	-	-	-	22	40
53	0.54	0.91	2.08	0.03	2.40	—	0.46	1	24	28	-	-	-	23	10	-	14
54	1.22	1.14	4.31	0.15	0.52	—	3.56	2	13	13	35	-	-	-	-	17	20
55	0.23	0.24	1.58	0.01	0.94	—	0.53	1	46	28	-	-	-	11	5	-	9

Chemical Analysis Of Groundwater - Summary cycle 1994 (RIGW)

Well No.	pH	E.C. µ mohs/cm	T.D.S. ppm	Units	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Total Cations epm	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{-}	Total Anions epm	Hydrochemical Formula	Water type
14	8.13	1980	1456	ppm epm e%	135.65 6.83 35.63	60.34 4.96 25.87	165 7.17 37.40	8.25 0.21 1.1	19.17	12 0.4 2.05	256.2 4.2 21.57	121.92 2.54 13.05	437.70 12.33 63.33	19.47	Cl 63.33 HCO3 23.62 So4 13.05 S---------------- 1.5 Na 38.5 Ca 35.63 Mg 25.87	Sodium Chloride
7R	8.8	830	563	ppm epm e%	42 2.1 21.99	7.2 0.6 6.28	157.5 6.8 71.20	1.9 0.05 0.52	9.55	54 1.8 18.85	97.5 1.6 16.75	21.6 0.45 4.71	203 5.7 59.69	9.55	Cl 59.69 HCO3 25.6 So4 4.71 S---------------- 0.6 Na 71.72 Ca 21.99 Mg 6.28	Sodium Chloride
18R	10.2	800	519	ppm epm e%	34 1.7 20.45	40 3.28 39.52	68 2.94 35.42	15 0.38 4.58	8.30	66 2.2 28.03	177 2.9 36.94	82 1.71 21.78	37 1.04 13.25	7.85	HCO3 64.97 So4 21.78 Cl 13.25 S---------------- 0.52 Na 40 Mg 39.52 Ca 20.48	Sodium Bicarbonate
[illegible]	8.4	780	490	ppm epm e%	61 3.03 36.95	12 0.97 11.83	91 3.95 48.17	10 0.25 3.05	8.2	36 1.2 15.48	104 1.7 21.94	16 0.34 4.39	160 4.51 58.19	7.75	Cl 58.19 HCO3 37.42 So4 4.39 S---------------- 0.5 Na 51.22 Ca 36.95 Mg 11.83	Sodium Chloride
31R	11	1120	658	ppm epm e%	8 0.4 3.34	79 6.5 54.30	115 5 41.77	2 0.07 0.55	11.97	132 4.4 38.39	109 1.8 15.70	99 2.08 18.15	113 3.18 27.75	11.46	HCO3 54.1 Cl 27.75 So4 18.15 S---------------- 0.7 Mg 54.3 Na 42.35 Ca 3.34	Magnesium Bicarbonate

	Hydrochemical Parameters of the Investigated Water Samples																
	Ion Ratios							Hypothetical Salt Combinations in %									
WELL NO.	rCa/rCl	rMg/rCl	rNa/rCl	rK/rCl	rSO4/rCl	rCl-r(Na+K)/rMg	r(Na+K)-rCl/rSO4	KCl	NaCl	Na2SO4	NaHCO3	MgCl2	CaCl2	MgSO4	CaSO4	Mg(HCO3)2	Ca(HCO3)2
14	0.55	0.40	0.58	0.02	1.09	1.0	—	[illegible]	27	-	-	25	-	2	11	-	24
7R	0.37	[illegible]	1.19	[illegible]	0.08	—	[illegible]	[illegible]	—	—	[illegible]	-	-	-	-	7	22
18R	1.63	[illegible]	2.33	0.37	1.64	—	1.33	4	[illegible]	22	[illegible]	-	-	-	-	39	21
21R	0.67	0.22	0.38	0.06	0.08	0.32	—	2	44	-	-	7	-	5	-	1	37
31R	0.13	2.09	1.57	0.02	0.55	—	0.91	1	25	15	-	-	-	4	-	51	3

PROPOSAL FOR GROUNDWATER REGULAR MONITORING PROGRAM IN BENI SEUF GOVERNORATE.

1. BACKGROUND

In a step to study the underground water potentialities along Biba, Sumusta and El Fashen Markaz, a preliminary monitoring program was planned and implemented by RWS&SP in Beni Suef as a step towards the determination of groundwater quality and its degree of pollution.

Twenty under groundwater samples were raised in August 1996(9 samples) and the rest during January ,Feb., and March 1995 from the Exp. and production wells drilled in the study area especially Sumusta district and which locations are shown in Fig. . Water samples raised vary in depth between 36 m to 71 m.

So, it is very important to detect the groundwater quality continuously (3 times every year). For this object this regular monitoring program was designed not only for the project area but also for the whole governorate.

2. PROGRAM OBJECTIVES

The main objectives of monitoring program are:

i. Monitoring of the quality of water resources and follow up of changes and the important indications of these changes.
ii. Identify and follow up of the pollution sources, quantitative and qualitative detection of pollutants.
iii. Analytical follow up of the different water bearing levels of the Quaternary aquifer to choose the best depths for abstraction water of good quality and to prevent contamination from the other unfavorable levels.
iv. Analytical follow up of the water quality in the River Nile and irrigation canals in the governorate in the areas that are subjected to pollution.
v. Determine seasonal variations of the water quality in the Nile and the main canals.

2. SAMPLING LOCATIONS

The preliminary monitoring program include 15 locations for ground water sampling and 20 locations for surface water sampling, **(fig. 1, 2)** show the sampling locations.

For the Selection of these locations the following factors were taken into consideration :

i. Type, design and depth of the well.
ii. The presence of cess pools near the sampling locations.
iii. The density of population
iv. The relative locations of industrial areas..
v. The distance between sampling points not exceed 20 km.

4. PROGRAM PARAMETERS

The main parameters that shall be measured by the regular monitoring program are highly dependent upon the objectives, basic characteristics and budget required.
Table 1 show the main required chemical parameters that must measure at all samples.

Laboratory chemical analysis program

i. Physical analysis

-Temperature
-Turbidity
-Color
-Taste
-Odor

ii. Chemical analysis

- Electric Conductivity
-T.D.S.
- pH.
-Total alkalinity
- Total Hardness
-K^+, Na^+, Mg^{++}, Ca^{++}-
-HCO_3^-, CO_3^{--}, SO_4^{--}-
- Nitrate
-Nitrite
-Total Chlorides
-Copper-
-Lead-
-Fe^{++}
-Mn^{++}
-Ammonia.

iii. Bacteriological analysis

-Total and Shape of coliform col / 100 ml

3. SAMPLING FREQUENCY

The collection of samples is planned to take place three times per year as follows:
i. In January : during low level (draught season) of water in the River Nile.

ii. In May : this period represent the medium stage between high and low water level in the Nile.
iii. In August : during the high water level in the Nile or flood time.

6. SAMPLING TOOLS

A number of factors can lead to changes in the composition of the ground water samples. These include the ex solution of dissolved gases, contamination from the atmosphere (e.g. by gas adsorption, aerosols or bacteria), cooling or heating through contact with pump motor, disturbance or destruction of biota, and so on.
Also the pumping period may change the ground water quality.

In selecting the sampling device it is important to pick the one that will not alter the chemistry of the sample as it is brought to the surface. This could occur if the material of the sampling tool would leach compounds into sample or adsorb compounds from the samples. The most suitable tools for sampling in the area under monitoring are:

i. Discrete interval sampler : discrete interval sampling can be used to profile an open bore hole or screen well, or to regularly trap samples from distant levels or points of inflow. Where the stainless steel sampler is pressurized with a foot or hand pump before entering the well . This prevents water flowing through the sampler on the way down the well, before the sample zone is reached . Once the desired depth is reached, the pressure is released and hydrostatic pressure allows the sampler to fill directly with water directly from the sampling zone.
ii. Environmental submersible pump : this type of pumps is characterize by stainless steel or p.v.c. impellers, small outer diameter (1.5-2 inch), low discharge (5-10 m^3/h) and high head **(Fig. 1)**

Generally the best sampling devices that will not put the sample in contact with air or non inert gases as it brought to the surface and well maintain the sample under positive pressure (these considerations limit the usefulness of several samplers such as suction pumps, peristaltic pumps and coating pumps.

7. SAMPLING TECHNIQUE

Many technical and environmental factors play an important role during ground water sampling like the pumping program and suggested contamination. We are dealing with two types of wells from the pumping point of view along the study area.

i. Pumped wells

Where extraction of water take place from one well or group of wells connected with each other (the maximum distance between every two wells is 20 m)and only one pump is use for these group of wells, where these wells are pumped along 24 hour alone or every 12 hour and an other adjacent group the work the other 12 hour.

This state of pumping represent the main type along the groundwater stations in the study area. The main representative sample can be obtained if we use a secondary sampling pump beside the main well pump but one of the most problems which shall meet the sample catcher is the connection of the suction open of the pump with the permanent casing flange directly i.e. the suction line is the main casing and this case is the most popular through

water stations along the study area and Beni-Seuf gavernorate where the main used pumps are centrifugal, horizontal and one stage type.

Therefor; we are dealing with a sealed well and the best method for sampling is to connect the sample container with a hose to the sampling tab or discharge valve head (**fig no. 2 and 3**). If we want to study the effect of pumping period on water quality the 1 st samples must be taken before pumping. The static water level needs to be recorded simultaneously if possible. The 2nd sample will be taken after steady state of dynamic level and the 3rd sample will be taken at the end of pumping of this well or group of connected wells.

ii. Unpumped wells :

This type of wells is represented by a group of experimental drilled by the RWSSP from 3 years ago and some old pizometers wells which were drilled by Irrigation Directorate of Beni Seuf. The sampling of this group of wells can be done by using 37.5 mm bailer for surface sampling or 1.5" diameter environmental pump for downhole sampling.

8. IMPLEMENTATION TEAM

To achieve a successful results from the analysis of the groundwater samples a qualified sampling team will be required to implement this program.

ITEM	STUFF
i. Sampling	Water stations Technicians and Sanitarium
ii. Insitue and laboratory analysis	Health, Governorate Chemists and station laboratories Chemists
iii. Results analysis and representations	Governorate staff
iv. Supervision and revision	The Governorate & Drinking and Sanitation Authority in Beni Seuf

9. SHORTAGE IN INSTRUMENTS AND TOOL

During the implementation of the preliminary surface water program, it was found that there are no any tools for sampling groundwater in all water stations along the study area and also there is a big shortage in the lab. instruments (Except Sumusta lab.) specially those for biological and bacteriological analysis.

10. TRAINING

To implement this regular program successfully certain training courses must be taken into consideration for the implementation (table 1)

Table 1 Essential Required Training Courses

COURSE NAME	TARGET GROUP	COURSE ITEMS
1. Sampling tools and techniques	.Sampling team (water stations and health technicians).	i. Identifications of different types of sampling tools. ii. Different types of water samples. iii. Different methods of sampling. iv. Preparation of the sampling tools and containers for field analysis.
2. Bacteriological and biological sampling.	.Water stations lab. chemists along the governorate.	i. Preparation the sampling tools for bacteriological and bio. analysis ii. Chemicals and instruments required for bio.sample description in the lab. iii. Preparation of the bact. and bio. sample in the lab. ii. detection and microscopic description of the bact.& bio. sample. iv. Bacteriology analysis reporting.
3. Analysis, representation and . interpretation of the monitoring program results.	. Chemists and governorate staff.	i. Points taken into consideration during monitoring program. ii. Sources of surface water contamination along the study area. iii. Factors effect on the analysis iv. Models of hydrochemical representation. v. Expected Effects of seasonal quantitative changes of Nile water on the water quality .

10. FIELD PROCEDURES

In order to get representative sampling sites, some general recommendations should be followed:

* At all sites depth integrates samples will (form three to five samples) will be taken. Composite samples will be formed from all the integrated samples taking into consideration the depth adjustment for the volume being contributed to the composite for each point in the cross-section. The number of cross-sectional sampling points can expanded beyond five if there is a considerable number of point source inflows upstream of the sampling sites.

* Field, biological, and bacteriological measurements will be determined in all vertically integrated samples for all sites. The best of the measurements will be conducted on the composite samples for all samples in the laboratory.

* The data collection **(table 2)** about the sampling point shall help in interpretation and analysis of the results.

WELL DETAILS TABLE

WELL NAME: LOCATION:

ITEM	DESCRIPTION
1-Well type.	a-production b-experimental
2-The total depth of the well.	m
3-Type of drilling.	a-cable drilling b-rotary drilling
4-Static water level.	m
5- Casing and screen materials.	a-p.v.c. b-black iron c- galvanized iron d-Stainless steel
6- No. of screen levels .	1 2 3 ....
7- Depth of each level.	m
8- Diameter of casing.	inch
9- Diameter of screen.	inch
10-Type of screen opening	a-perforated b-horizontal slotted c-vertical slotted d-wire mish
11- Filter pack	a-present b-absent its length m - its depth m - its thickness inch
12- Contamination protecation	a-present b- absent a-cement b- bentonite c - casing d- other a - no of stage b-depth m c-length m d-thickness m
13- Pumping state	a-pumped well b-unpumped well a-continuous pumping b-discontinuous pumping
14- Pump specification	a-horizontal b-vertical a-mono stage b-multi stage a-electric motor b-disel motor a-cast iron impellers b-stainless impellers c- other a-Q m3/h b-head m
15- Detecation tools	a-flow meter b- pressure meter c- depth meter.

Table No2

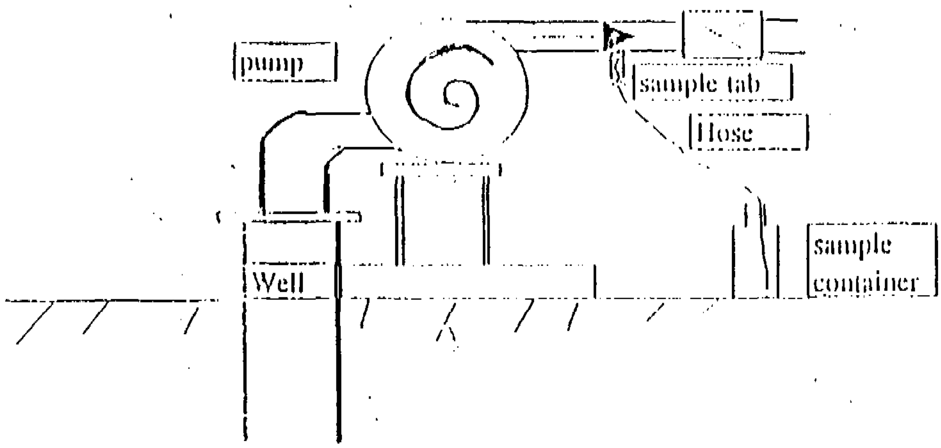


Fig No 2

Groundwater sampling

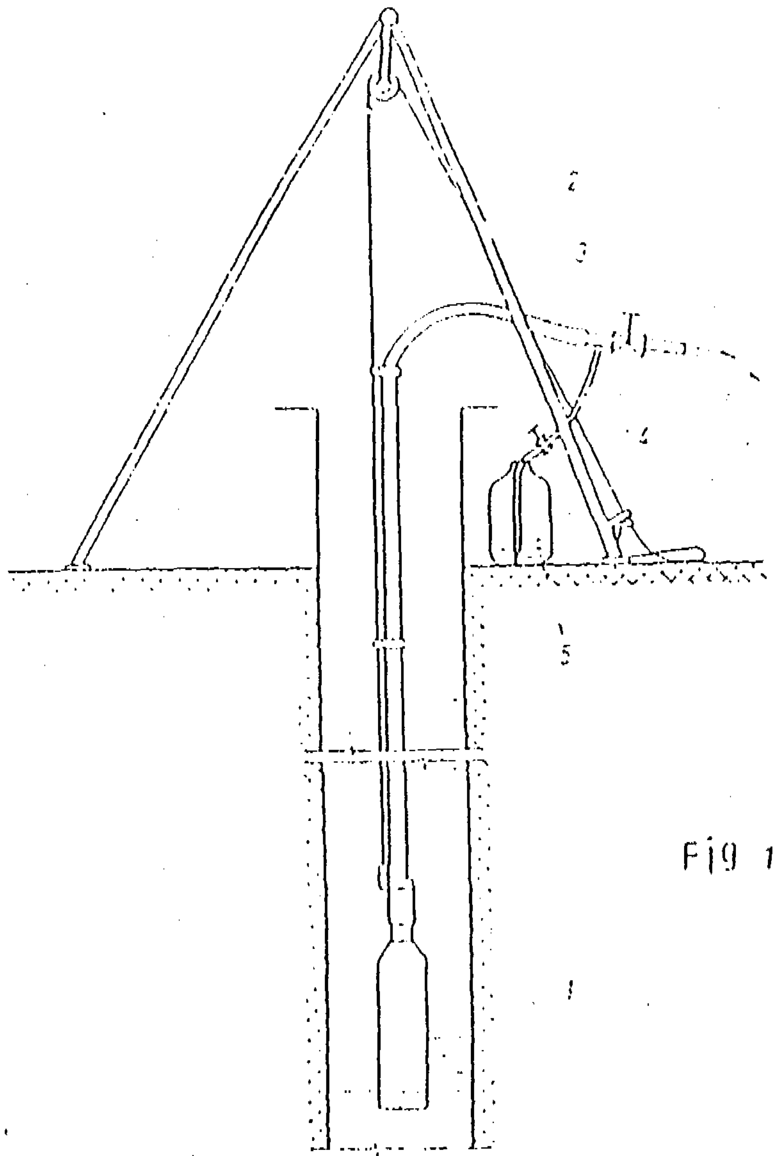
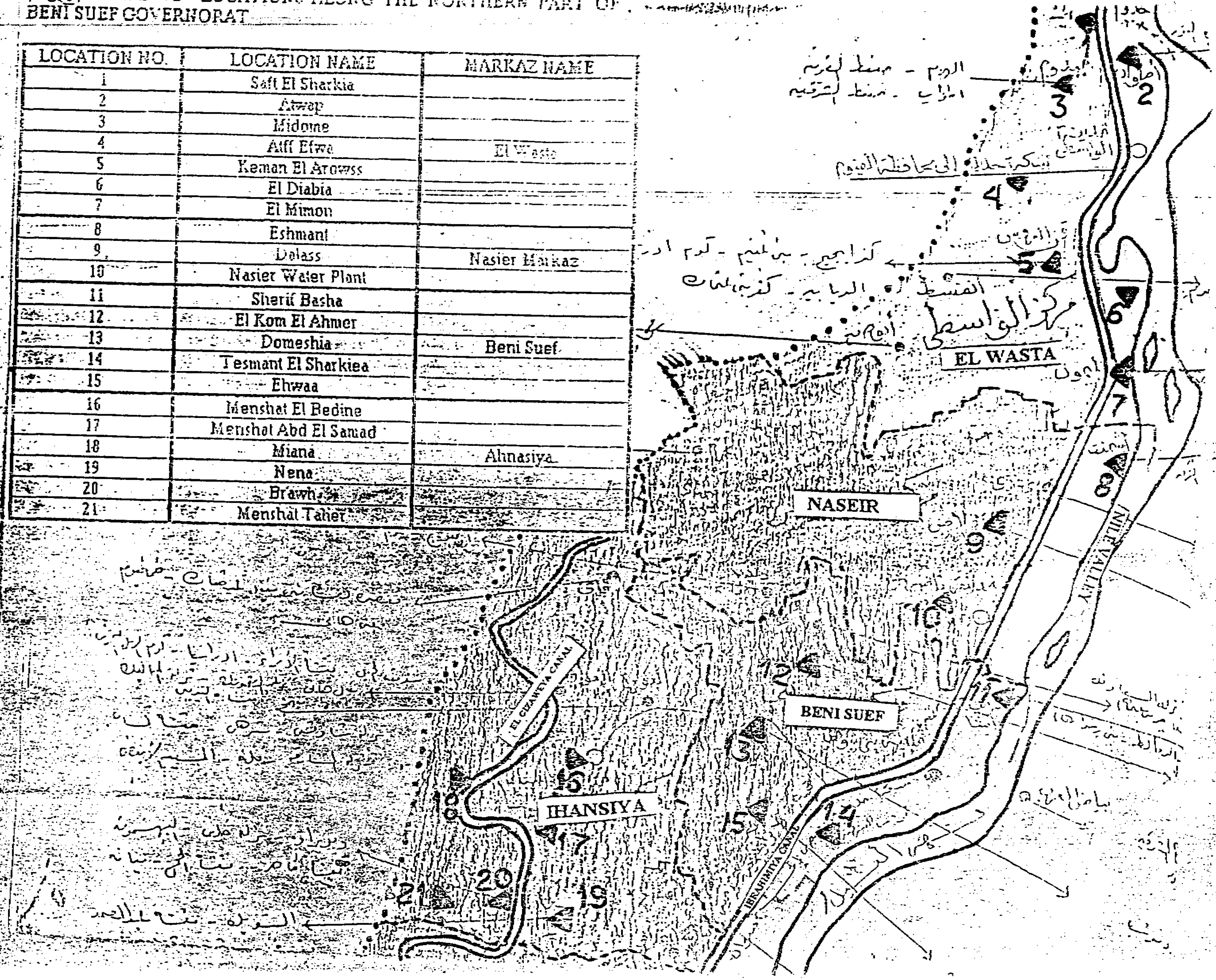


Fig 1.

— Surface sampling from a borehole using a portable submersible pump. 1, submersible pump; 2, support tripod; 3, delivery tube from temporary rising main; 4, sample delivery tube; 5, sample container.

(Fig 3) SAMPLING LOCATIONS ALONG THE NORTHERN PART OF BENI SUEF GOVERNORAT

LOCATION NO.	LOCATION NAME	MARKAZ NAME
1	Saft El Sharkia	
2	Atwap	
3	Midome	
4	Afif Efwa	El Waste
5	Keman El Arowss	
6	El Diabia	
7	El Mimon	
8	Eshmant	
9	Delass	Nasier Markaz
10	Nasier Water Plant	
11	Sherif Basha	
12	El Kom El Ahmer	
13	Domeshia	Beni Suef
14	Tesmant El Sharkiea	
15	Ehwaa	
16	Menshat El Bedine	
17	Menshat Abd El Samad	
18	Miana	Ahnasiya
19	Nena	
20	Brawh	
21	Menshat Taher	



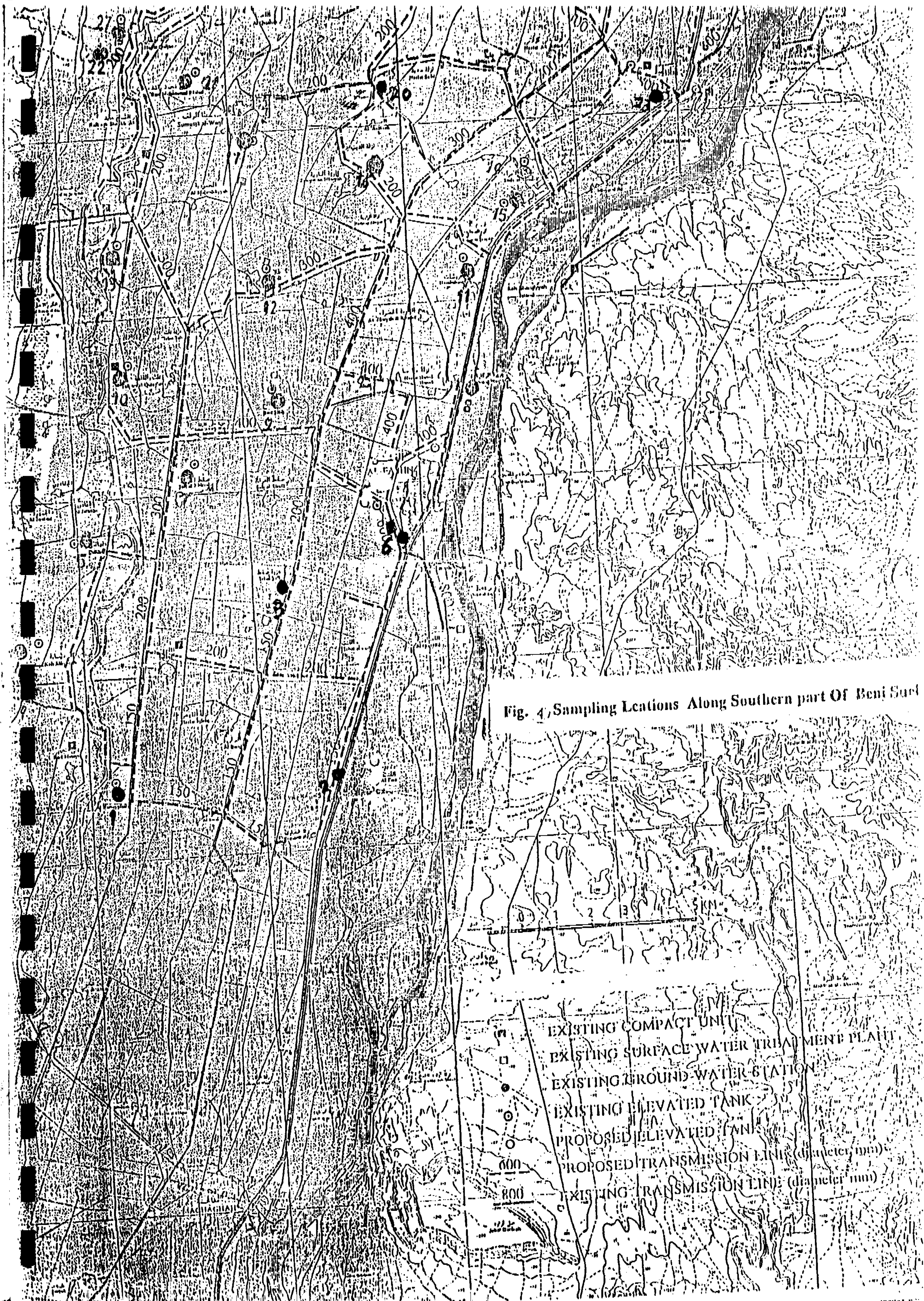


Fig. 4 Sampling Lcations Along Southern part Of Beni Suef