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REPRESENTATIVE BASIN STUDIES : HYDROGEOLOGICAL AND GEOCHEMICAL STUDIES OF GROUNDWATER FLOW IN SUDDAGEDDA BASIN

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Preface

As part of representative basin studies in the Suddagedda basin the Deltaic Regional Centre has conducted extensive hydrological investigations towards the water balance studies. They are monitoring monthly groundwater levels and seasonal groundwater quality at about 15 observation wells, double ring infiltrometer experiments, Guelph Permeameter tests, grain size distribution of soils etc.

Based on the field surveys and studies of the hydrogeology, it is possible to establish at least some features and to formulate the conceptual groundwater flow in a basin. In continuation of the studies and investigation in the representative basin, this study presents the data on monthly groundwater levels and seasonal groundwater quality so far observed at the 15 observation wells from July 1996 to December 1999. The same are analysed to understand the hydrogeology and geochemistry of the study area.

This study 'Hydrogeological and geochemical studies of groundwater flow in Suddagedda basin in A.P.' is part of the work plan of 1999-2000 of the Centre and is undertaken by Sri. S.V.Vijayakumar, Scientist 'C' with the assistance of Sri U.V.N.Rao, SRA under supervision of Dr K.S.Ramasastri, Scientist 'F'.

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ABSTRACT

Planning of water resources development projects makes it necessary to understand and analyse the hydrological characteristics of the region. If it is a groundwater resources development project then the hydrogeology and geochemistry of the basin need to be investigated.

The Regional Centre at Kakinada has identified the Suddagedda as representative basin along the Andhra coast and in collaboration with the State Ground Water Department has initiated investigations to undertake the water balance of the basin. In this direction so far monthly groundwater levels and seasonal groundwater quality at about 15 observation wells are monitored; double ring infiltrometer experiments, guelph permeameter tests, grain size distribution tests of soils etc., are being carried out in the basin.

In this study the water level and quality data collected in all the 15 Observation wells is analysed on the water year basis from June to May for three years 1996-97,1997-98 and 1998-99 as part of hydrogeological and geochemistry studies of the groundwater flow in the Suddagedda basin.

The study resulted in understanding the groundwater level variation in different parts of the basin and to identify places where fluctuation is very high. Also the geochemical analysis has classified the groundwater into 6 groups in the study area.

The data and analysis of the hydrogeology and geochemistry of the basin will be useful and will give a direction for undertaking groundwater balance and modelling studies of the study area in future.

INTRODUCTION:

As per suggestions of A.P. State groundwater department, Deltaic Regional Centre of National Institute of Hydrology, Kakinada has selected Suddagedda basin in Andhra Pradesh to undertake various representative basin studies as it is a typical east flowing river adjacent to a major river delta, ie. Godavari delta. Initially it was decided to undertake groundwater balance studies to understand the groundwater potential of the aquifer from quantity as well as quality aspects. The centre has conducted extensive hydrological investigations like monitoring monthly groundwater levels and seasonal groundwater quality at about 15 observation wells, double ring infiltrometer experiments, guelph permeameter tests, grain size distribution of soils etc. Based on the field surveys and studies of the hydrogeology, it is possible to establish at least some features and to formulate the conceptual groundwater flow in a basin.

In continuation of the studies and investigation in the representative basin, this study presents the data on monthly groundwater levels and seasonal groundwater quality so far observed at the 15 observation wells from July 1996 to December 1999. The same are analysed to understand the hydrogeology and geochemistry of the study area.

Since the initiation of hydrological investigations in the Suddagedda basin, which is considered for representative basin studies, a number of studies were undertaken towards establishment of monitoring network. Initially, the State Ground Water Department has compiled all the information and prepared a report on the status of network, data availability and instrumentation (DRC, 1993). The study presented the ground water level and chemistry information at Gollaprolu and Prattipadu Observation Wells and on the surface water hydrological characteristics of Suddagedda Basin along with its drainage. Also presented is a broad hyrogeological classification of the basin along with lithology at a few sites. Another study on further network upgradation and installation of equipment and monitoring was undertaken based on the standard requirements(Vijayakumar,1993). This study suggested on the setting up of raingauge network and Observation well network for proper monitoring of hydrometeorological data. Accordingly groundwater is being monitored at 15 Observation wells and a rain gauge was installed at Shantiashram.

Using double ring infiltrometers, investigations were carried at different places based on land use and the infiltration characteristics were studied (Rao,1996). Studies on geomorphology and land use mapping of the basin and hydrological soil classification are undertaken and completed.

National Gepphysical Research Institute, Hyderabad has also undertaken recharge estimation studies in some parts of the basin using nuclear technique as part of scientific studies of the geohydrology group.

2.0 STUDY AREA:

The basin lies in between latitudes 17^0 14' 00" to 17^0 36' 10"N and longitudes 82^0 08'30" to 82^0 18'15"E over a catchment area of 526 sq. km. up to Gollaprolu. But the area of monitoring of groundwater is limited to an area of 250 sq. km. in the middle and lower parts due to inaccessibility of the upper catchment and sparse habitations there. The basin relief is from 800m to 20m and slopes south to south-east. The area of monitoring is downstream of Subba Reddy Sagar reservoir up to which the catchment area is about 100 sq. Km and maximum water level (MWL) in the reservoir is +86m. The total catchment area of the basin is 658.3 sq.km up to river mouth at Uppada. The location of the basin (index map) is shown in Fig.1.

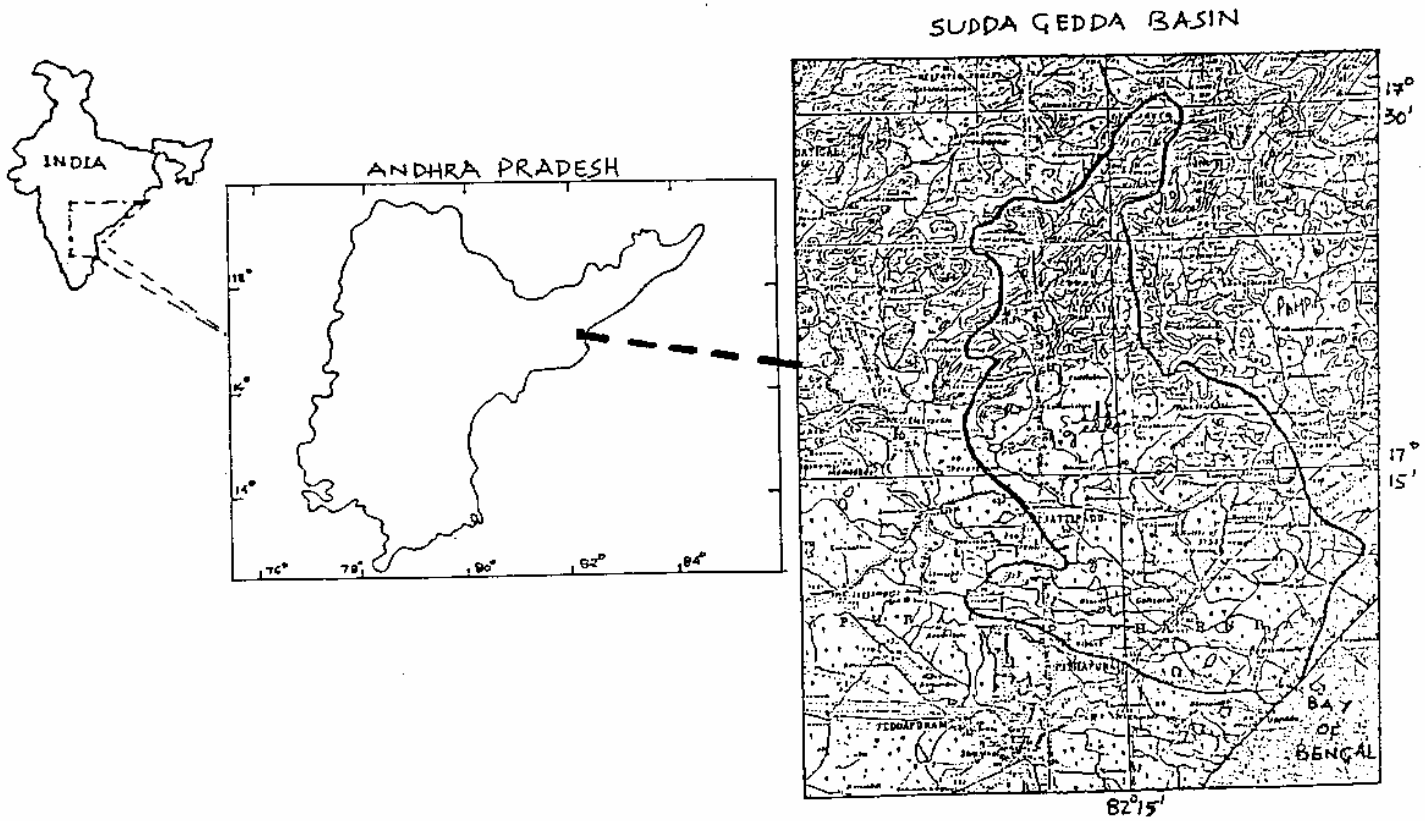
2.1 Drainage

The stream originates from Gundalamma konda in Vatangi reserved forest area in Rajavommangi mandal of East Godavari District of Andhra Pradesh at an elevation of about 813m and flows southward as Yeti kalva. It is joined by many rivulets on its way. At Gokavaram village in Prattipadu mandal, a reservoir called Subbareddy Sagar is formed. Further, travelling southwards it is joined on its left bank by Konda Kalva near Gollaprolu village and is called 'Suddagedda River'. The drainage pattern in the basin is dendritic in the upstream of the basin. However, the drainage pattern is not clear in the downstream side. Being plain terrain (coastal zone) the exact demarcation of catchment boundary is very difficult. The drainage network map of the basin along with observation well network of the basin is shown in Figure 2. Based on the observation well network for the present study the basin area covered by the 15 observation wells is demarcated as shown in Fig.2 and detailed analysis on hydrogeology and geochemistry of this area are investigated.

2.2 Hydrogeology

Khondalites, Granites and Charnokites underlie a major portion of the basin. The central and western parts of the basin is underlain by alluvium of the streams. The southern part of the basin is underlain by Khondalite suit of rocks, basaltic formation or deccan trap and Tirupati sandstones. DRC (1993) presents more detailed information on geology along with the hydrogeolgy map and rock formation in the study area. Groundwater in the crystalline rock is restricted to weathered and fractured

Fig. No.1 LOCATION MAP OF SUDDAGEDDA BASIN



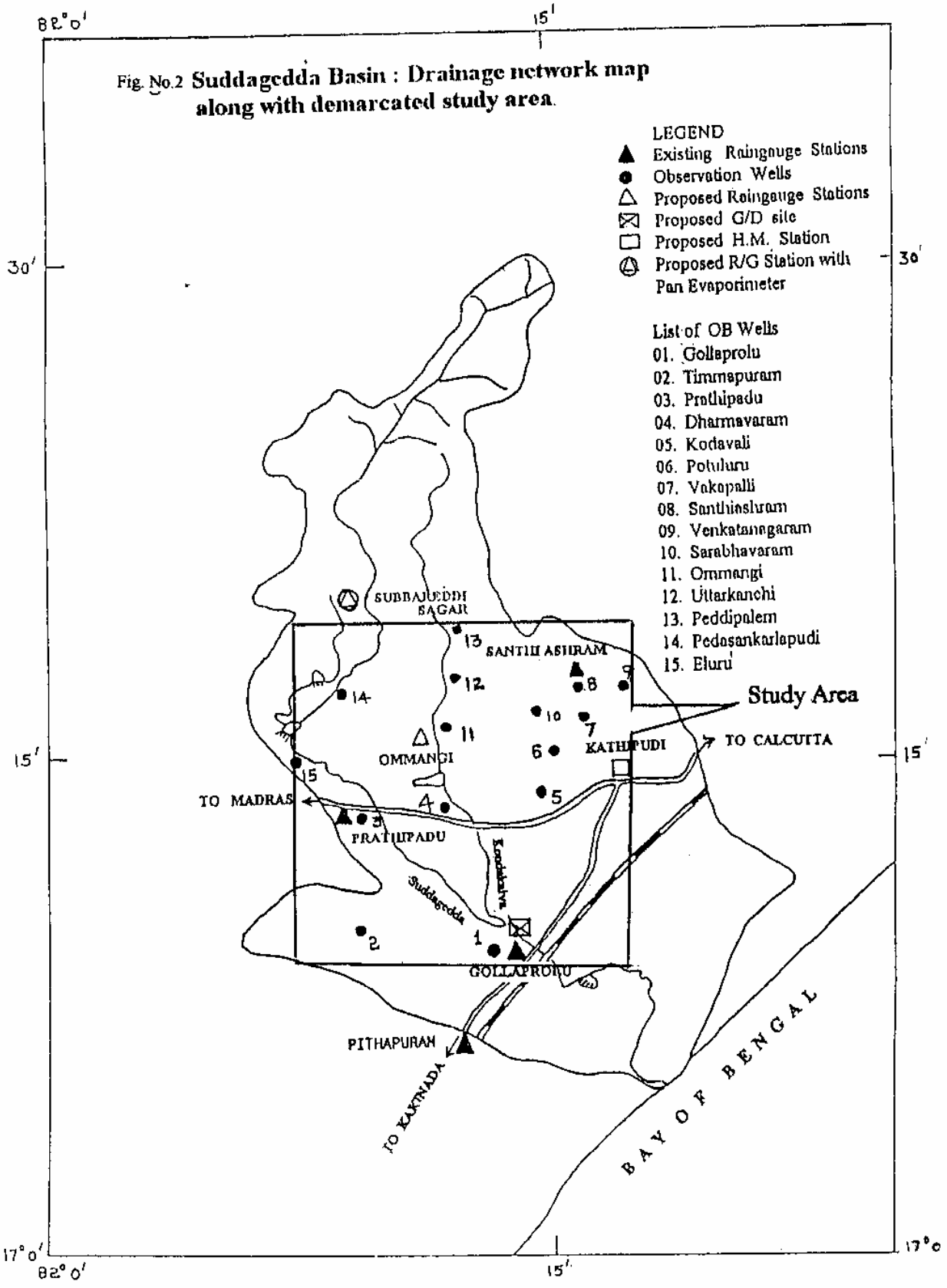


Fig. No.2 **Suddagedda Basin : Drainage network map along with demarcated study area.**

zones and is being exploited mostly by dugwells, and dug-cum bore wells (DRC,1993).

2.3 Soil and Land use

The predominant soils in the basin are black clay, red and light brown red soils. Towards the northern part of the basin, red soils are predominant in the hilly tracts and valley portions whereas the middle part of the basin has light brown soils and towards southern part black soils are predominant. The main crops are paddy, banana, sugarcane, chillies and cotton. The total area irrigated under surface water sources is 6981 hectares, out of which an extent of 1758 hectares is under minor irrigation tanks (DRC, 1993). The upstream of the basin mainly consists of forest cover.

2.4 Climate

The basin area comes under tropical climate with hot summers and light winters. The major portion, about 80%, of the rainfall is received during monsoon season (June to November). The region experiences four distinct seasons of climate viz. winter (December-February), hot weather or summer season (March-May), southwest monsoon seasons (June-September) and northeast monsoon seasons (October-November). May is the hottest month with maximum daily temperature touching about 40^0C. The minimum temperature to the tune of 15^0C is observed in the month of December.

3.0 DATA:

The complete data on groundwater levels and quality available in the study area and used in the analysis is discussed next.

3.1 Groundwater levels:

Before undertaking detailed investigation on water levels in the study area, there existed only two observation wells of State Grundwater Department at Prattipadu and Gollaprolu and the data is listed in the earlier report, DRC (1993). Since July 1996, the network of observation wells has been extended to another 12 wells initially and later one more well was added. The list of observation wells and the data available is shown in Table-1.

The water level data collected in all the 15 observation wells is analysed in this study on the water year basis i.e. June to May for three years of observation data available i.e., 1996-97,1997-98 and 1998-99. The analysis is presented in next section. The location of the 15 Observation wells is shown in Fig.2 and the monthly water level data is at Annex-.I

3.2 Ground Water Chemistry :

Along with the water level data, monitoring of ground water quality is also attempted as part of investigations. As per standard practice, water samples were collected on seasonal basis from all the observation wells listed in Table.1 and are subjected to chemical analysis in the laboratory of Ground Water Department, Rajahmundry. The water quality data is given in Annex-II .

Table 1: Groundwater Level Data availability at Observation Wells in Suddagedda Basin

Sl.No	Well Location	Interval	Available from
1	Eluru	Monthly	July'96 onwards
2	Pedasankarlapudi	--do--	--do--
3	Uttarakanchi	--do--	--do--
4	Peddipalem	--do--	--do--
5	Ommangi	--do--	--do--
6	Dharmavaram	--do--	--do--
7	Kodavali	--do--	--do--
8	Potuluru	--do--	--do--
9	P Timmapuram	--do--	--do--
10	Venkatanagaram	--do--	--do--
11	Santhi Ashram	--do--	--do--
12	Sarabhavaram	--do--	--do--
13	Vakapalli	--do--	Jan'97 onwards
14	Prattipadu	Seasonal	Nov'75 to May'88
		Monthly	Jun'88 onwards
15	Gollaprolu	Seasonal	May'74 to Nov'87
		Monthly	Feb'88 onwards

3.3 Lithology:

Understanding the lithology of the study area is very essential to properly demarcate the zone of strata where rich aquifer can be tapped, the recharge zone of such an aquifer and other boundaries of the aquifer etc. Lithologic information is essential to delineate the exact depth and extent of the aquifer; to distinguish change

of water quality at different depths; to find out thickness of materials like, clay and shale in the drill hole; to measure the flow of water in a particular aquifer etc.,. In other words it provides all the necessary information a ground water medeller requires to successfully model an aquifer system.

In the present work, as the study covers the top aquifer, the depth to which it extends and the boundary conditions are derived from the lithology data presented in an earlier report (DRC, 1993) and on the basis of drainage pattern. Accordingly, ground water in the study area occurs under water table condition. Ground water in the crystalline rock is restricted to weathered and fractured zones and is being exploited by dugwells, dug-cum-borewells in general and at some places by bore wells. The location of Observation wells in the study area and the description of wells are described at Annex-III. The depth of dug wells ranges from 6 metres in alluvium to about 16 metres in hard rock and yield 30,000 lpd to 50,000 lpd. Filter points and shallow tube wells in the middle portions of the study area are constructed down to 30 to 50 metres and yield about 15,000 to 30,000 lph. Bore wells are constructed in some zones between 40 to 60 metres depth and yield about 8,000 to 15,000 lph.

4.0 METHODOLOGY:

The present study on hydrogeology on groundwater flow of the Suddagedda basin has been undertaken to analyse the monthly water level data of groundwater in the top aquifer of the basin along with its water quality characteristics. The following methodology is used in understanding this analytical study on water year basis.

4.1 Ground water quantity:

The monthly water level data from June to May is used to get its basic statistics like maximum water level, minimum water level and average water level for each station. To understand the flow regime, the water levels thus obtained were plotted along three sections in E-W direction at top, middle and bottom sections and three sections along N-S direction at left, middle and right side of the study area. To present the spread of groundwater over the basin ground water level contours are plotted using standard computer softwares based on the Kriging technique. Such contours can be drawn for minimum, maximum and average water level and also depth to water table over the study area.

4.2 Recharge/Discharge of aquifer:

In particular water year the recharge builds during the first half and is subjected discharge as drawdown during the non-monsoon season. So the pre-monsoon's minimum water level contours (i.e., previous May) can be compared with

the maximum water level contour of November or post-monsoon season and the net volume of aquifer recharged can be found. Similarly, post-monsoon or the maximum water level contour (of November) are compared with the pre-monsoon or minimum water level contour (of next May) and the net volume of aquifer subjected to withdrawal can be evaluated. When plotted with the rainfall amount of the monsoon season for the area, these quantities will give response volumes of aquifer recharge to rainfall.

4.3 Ground water Quality:

Though ground water is considered cleaner and purer than the surface water, it may not turn out to be so seldom. The soil and rocks, through which the groundwater infiltrates, percolates and seeps, screen out the bacteria. In its movement, it reacts with a number of minerals, organic and inorganic matters and acquires different colours, odours and tastes. The geology of the area has a tremendous influence on the quality of water. Ground water carries high mineral content due to the slow circulation and longer period of contact with its surroundings. Over a period of time, problems of water quality may occur in ground water, especially when land use and cropping pattern has been changed.

As the groundwater move through the subsurface, it changes chemically as it comes in contact with different minerals and proceeds towards chemical equilibrium. Typically the cations Sodium, Calcium and magnesium and anions Bicarbonates, Sulphates and Chlorides constitute more than 90% of total dissolved solids in a sample of groundwater (Smith & Wheatcraft, 1992). According to Freeze and Cherry(1979), the chemistry of groundwater at any particular point not only depends upon the processes involved but also the order of encounter i,e which rock is in contact with penetrating water first. According Matthess(1982), minerals containing Chloride and Sulphate salts are the most soluble phase and those with Sulphide and hydroxide groups are least soluble. Minerals in the Carbonate and Silicate and the Aluminium Silicate groups have small but significant solubility.

Ground water from various rocks of acidic type is generally low in mineral content. Sodium and bicarbonate dominate and calcium and magnesium are low. Waters of basaltic rock have generally high value of Ca:Na and Mg:Ca i.e., magnesium content is high. In sedimentary rocks like sandstones, the value of Ca:Na, K:Na and Bicarbonate:Chloride will be high (Ramakrishnan, 1998). Sandstones deposited under marine environment contain sodium chloride water as connate water probably due to poor or lack of circulation and sodium and bicarbonate content is

high. In alluvial zones, the total dissolved solids is high may be due to large surface area per unit volume that is available for chemical reaction.

In the present study, the analytical chemistry data of pre-monsoon and post - monsoon samples of the observation wells is used. To understand the influence of geology on the quality, plots of bar charts for various ratios like Ca:Na, Mg:Ca, K:Na and HCO3:Cl can be plotted for all stations seasonally. Also, their time series variations are plotted station wise. Similarly, plots can be drawn to feel the changes in pH, TDS, depth to water table etc.,

To understand the geochemical classification of water in the study area and interpretation of chemical data, a latest technique suggested by Chadha (1999) can be used. The technique cited in this study as 'CGWB classification' describes how to plot a diagram which is equally useful like Piper diagram and Expanded Durov diagram to classify water based on the geochemistry.

The advantage of this new technique is the ease with which it can be drawn using MS-Excel features. In this X-Y scatter diagram the difference in milliequivalent percentage between alkaline earths (Ca+Mg) and alkali metals (Na+K) expressed as percentage reacting values (PRV) are plotted on the X-axis. The difference in milliequivalents percentage between weak acidic anions (Carbonate plus Bicarbonate) and strong acidic anions (Chloride plus Sulphate) expressed as PRV are plotted on Y-axis. The techniques discussed above are applied in the present study.

5.0 ANALYSIS & RESULTS:

The techniques applied in the study are discussed in detail in the earlier section. The analysis, thus undertaken and the results arrived at are presented in the following section.

5.1 Ground water quantity:

The ground level contour map along with the drainage network of the present study area is drawn and shown in Fig.3. The average depth to water table contours in the study area for the water year 1996-97, 1997-98 and 1998-99 are plotted using Kriging technique based on the observed monthly data on depth to groundwater table at 15 observation wells and is presented in Fig.4 to 6. The ground water level variations with respect to mean sea level across three sections in the horizontal direction are drawn and shown at Fig.7 to Fig.9. The northern section i.e., top section presents the ground water table with respect to ground level from Pedasankarlapudi-Uttarakanchi-Sarabhavaram-Santhi Ashram. The flow direction is towards the Suddagedda between PSPudi and Uttarkanchi and towards Kondakalva between

Fig. No. 3

Gound level contours in Suddagedda basin (Topo map) with drainage network

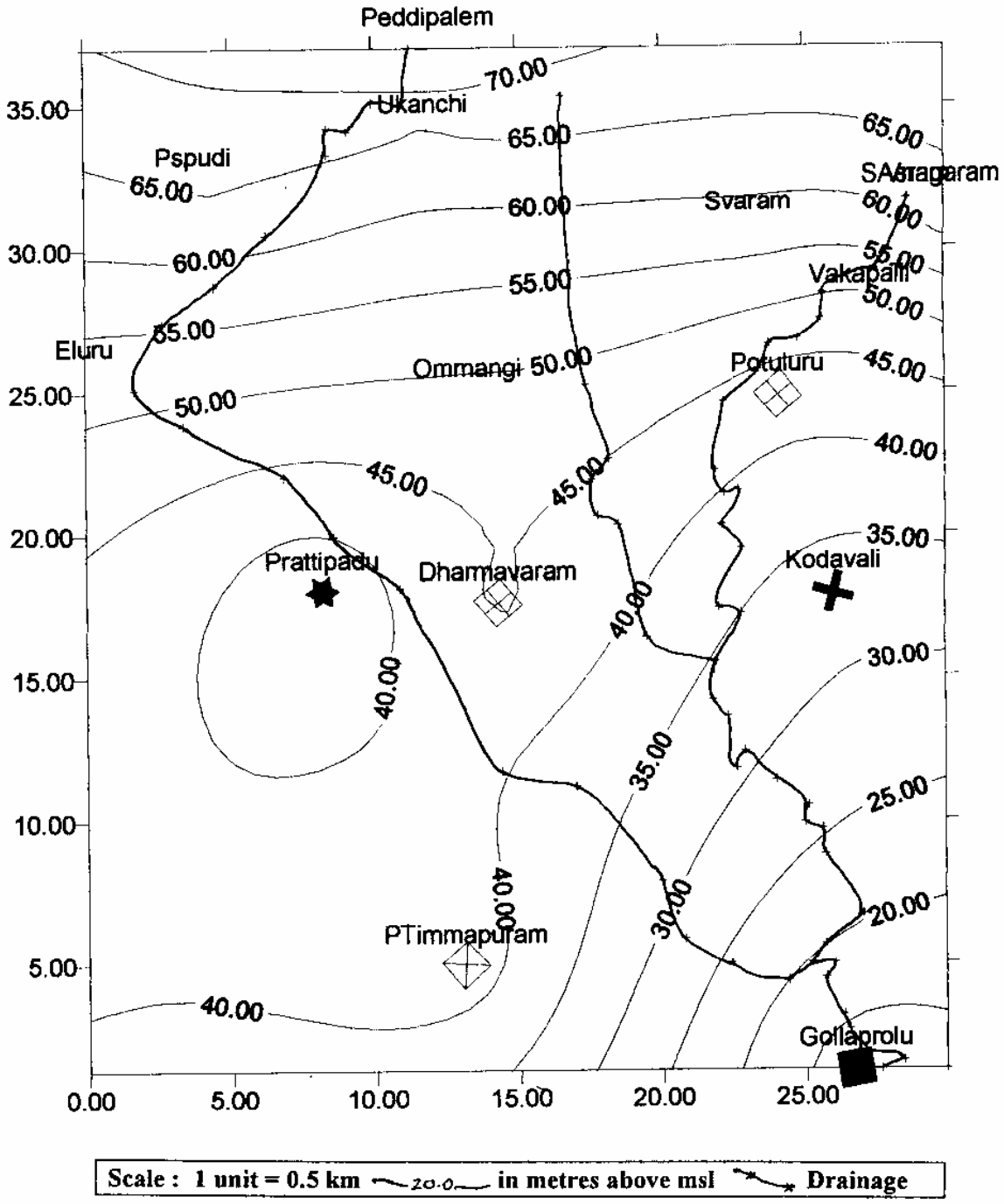


Fig. No. 4

Average depth to water table in Suddagedda basin during 1996-97

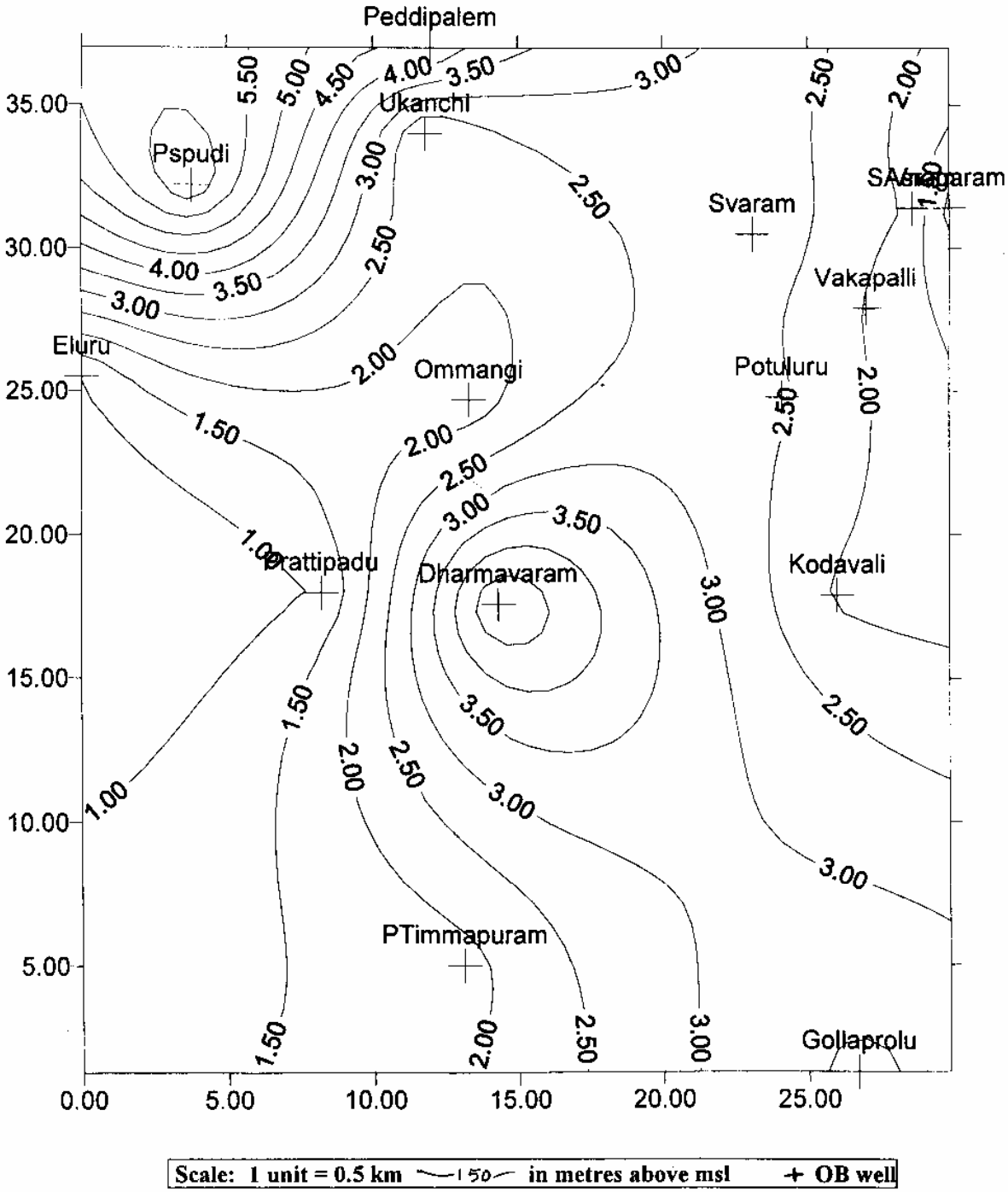


Fig. No. 5

Average depth to water table from groundlevel in 1997 in Suddagedda basin

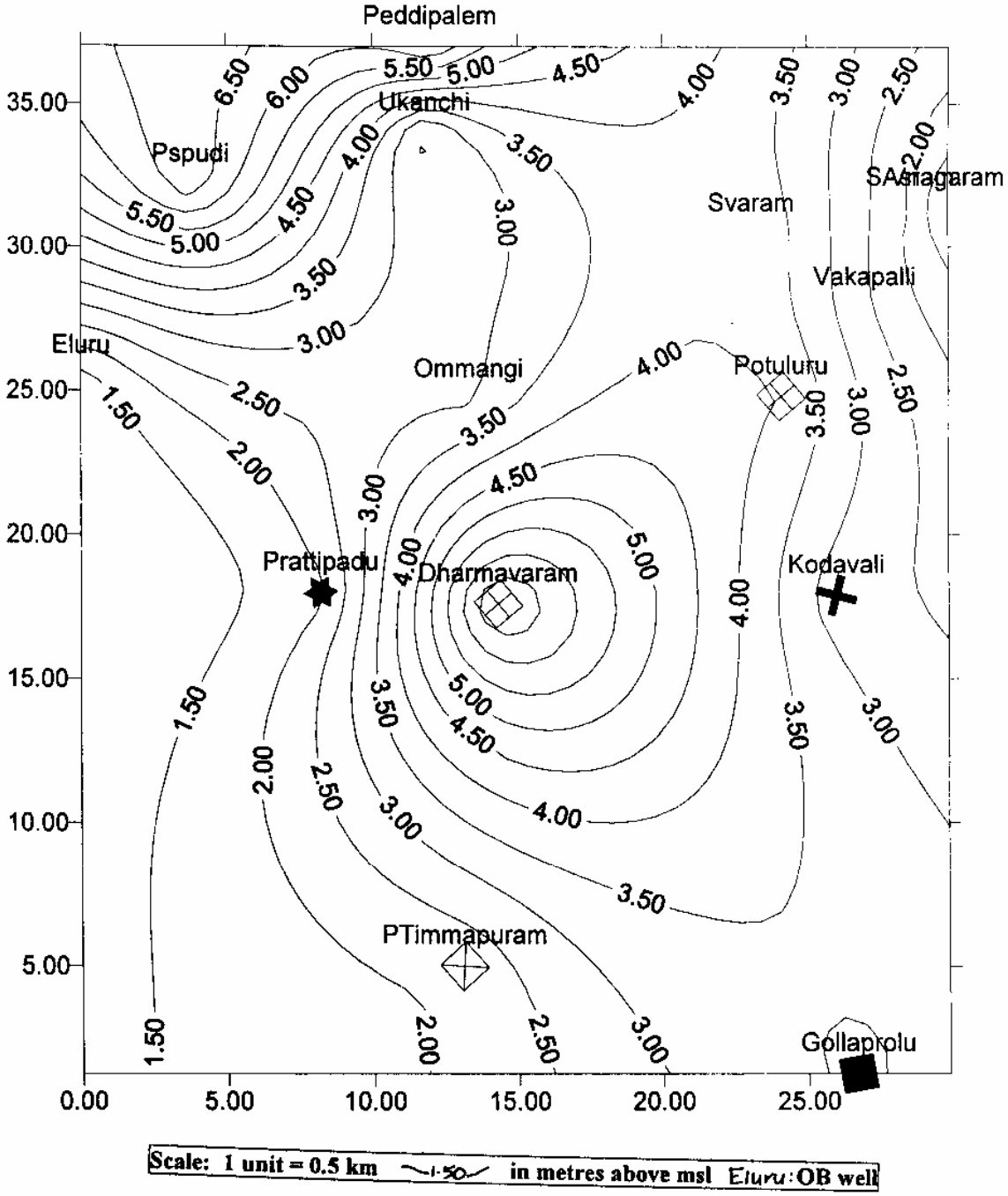
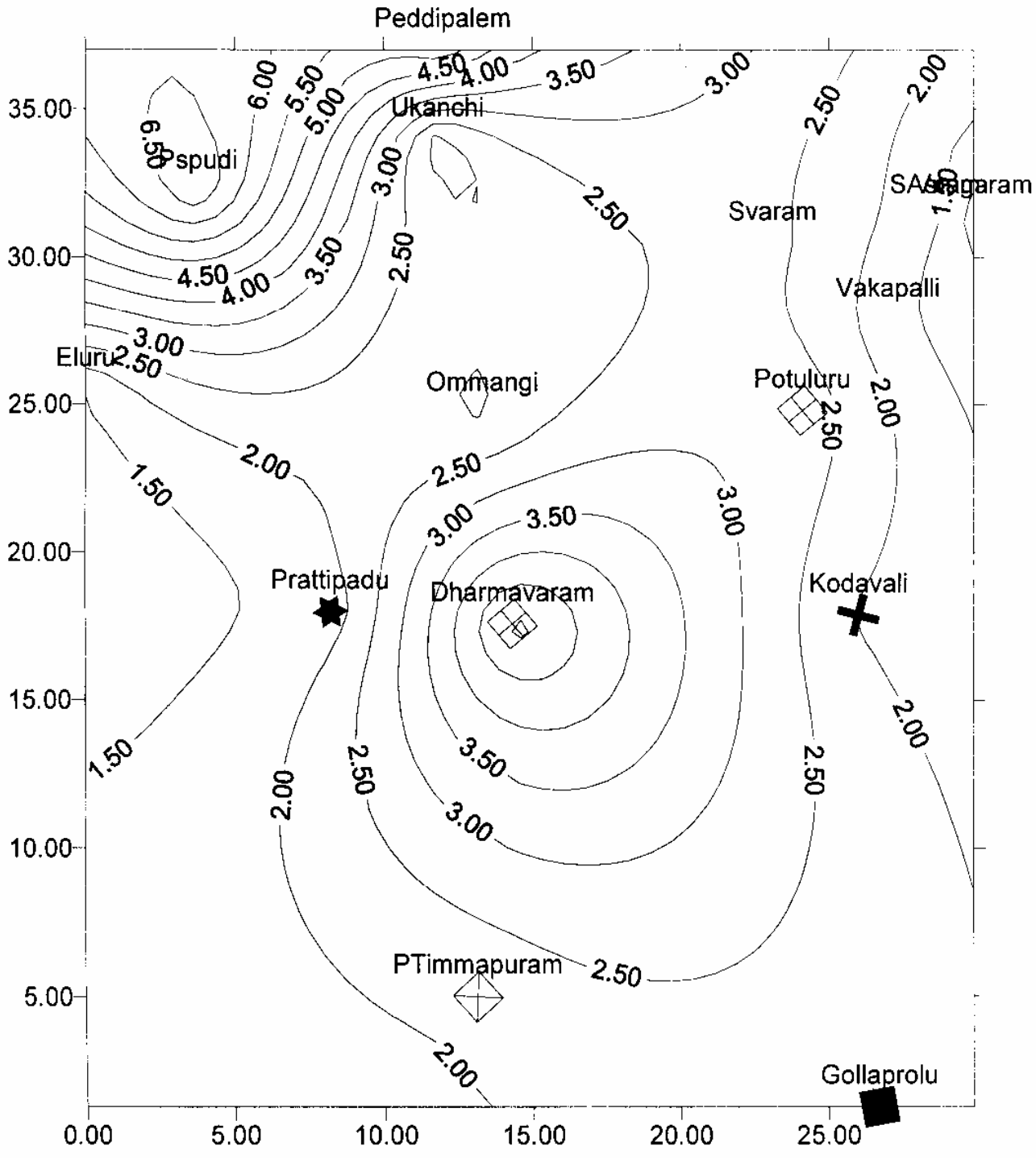


Fig. No. 6

Average depth to water table from groundlevel in 1998 in Suddagedda basin



Scale: 1 unit = 0.5 km —150— in metres above msl Eluru OB well

Fig. No. 7 Groundwater level for PSPudi-Uttarkanchi-Sarabhavaram SanthiAshram section

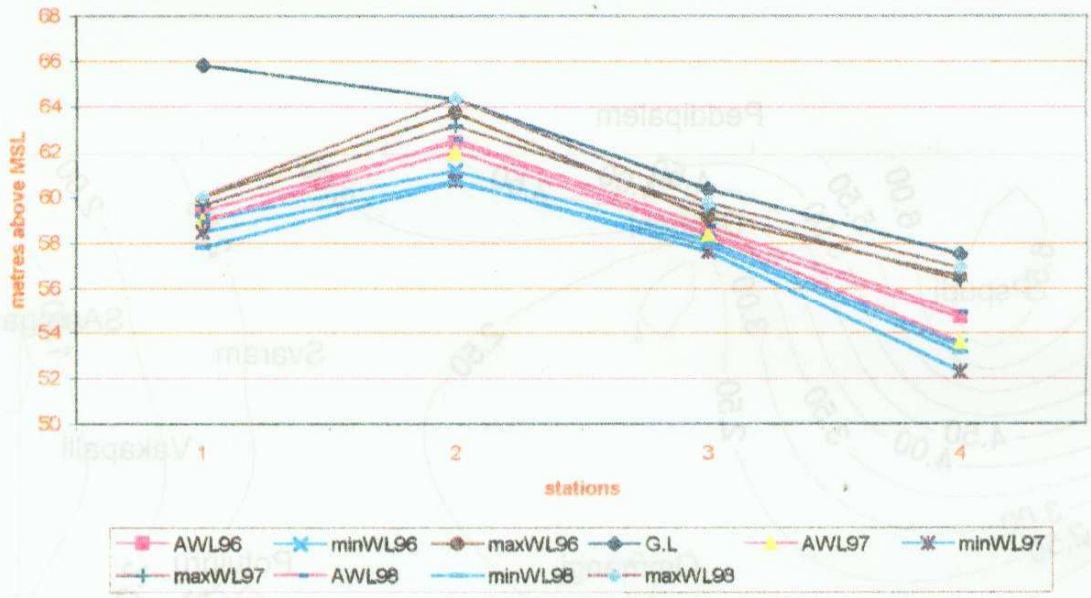


Fig. No. 8 Groundwater level to Prattipadu-Dharmavaram-Kodavali section

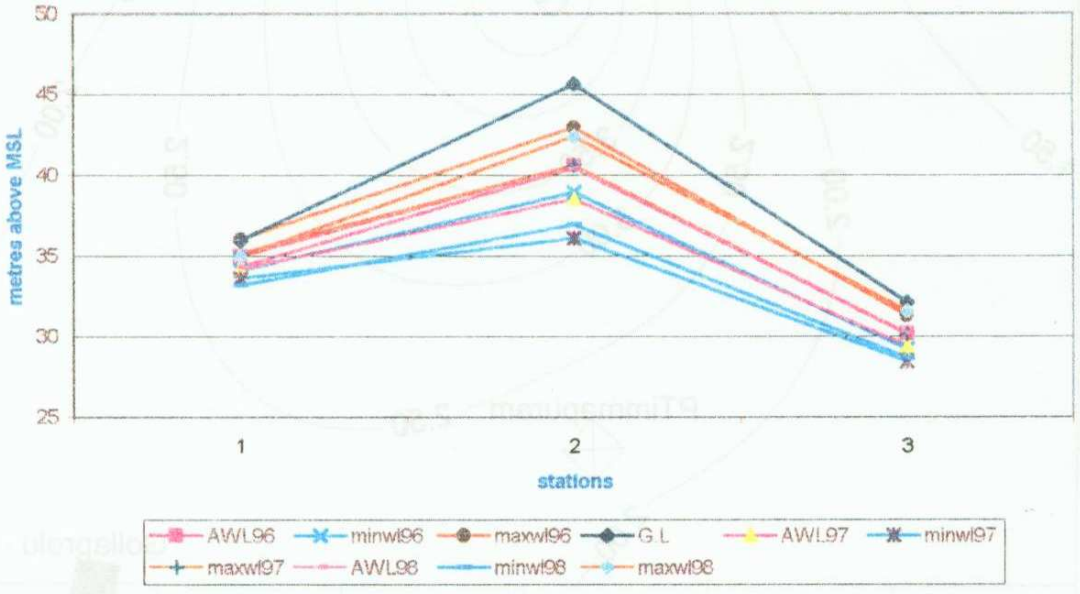


Fig. No. 9 Groundwater level for Buru-Ommangi-Potuluru section

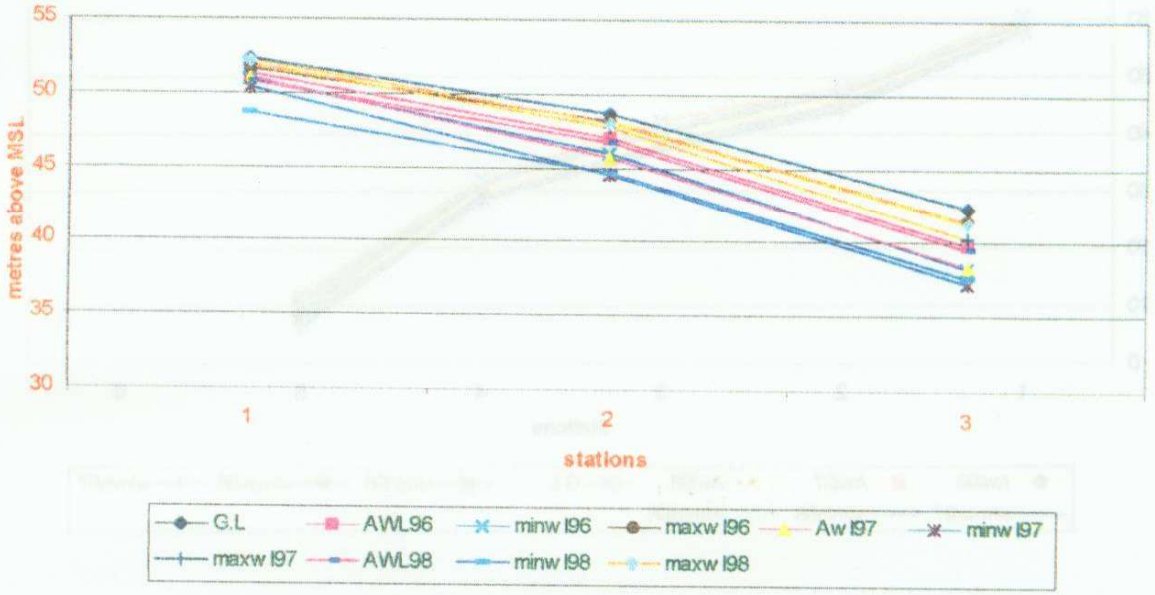


Fig. No. 10 Groundwater level for Peddipalem-Ukanchi-Ommangi-Dharmavaram section

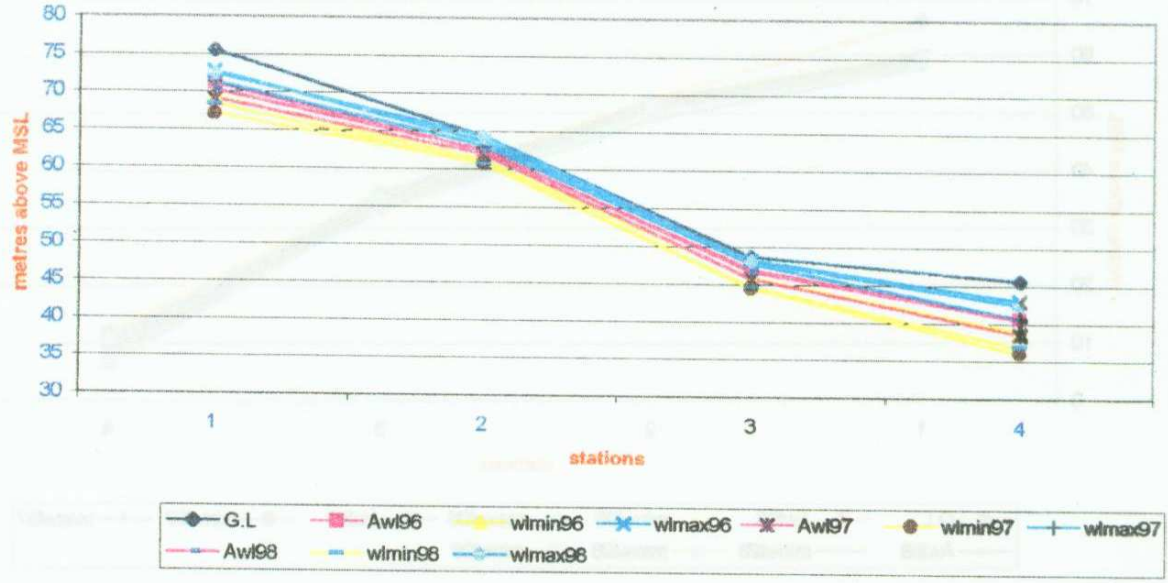


Fig. No. 11 Groundwater level for SanthiAshram-Vakapalli-Potuluru-Kodavali-Gollaprolu section

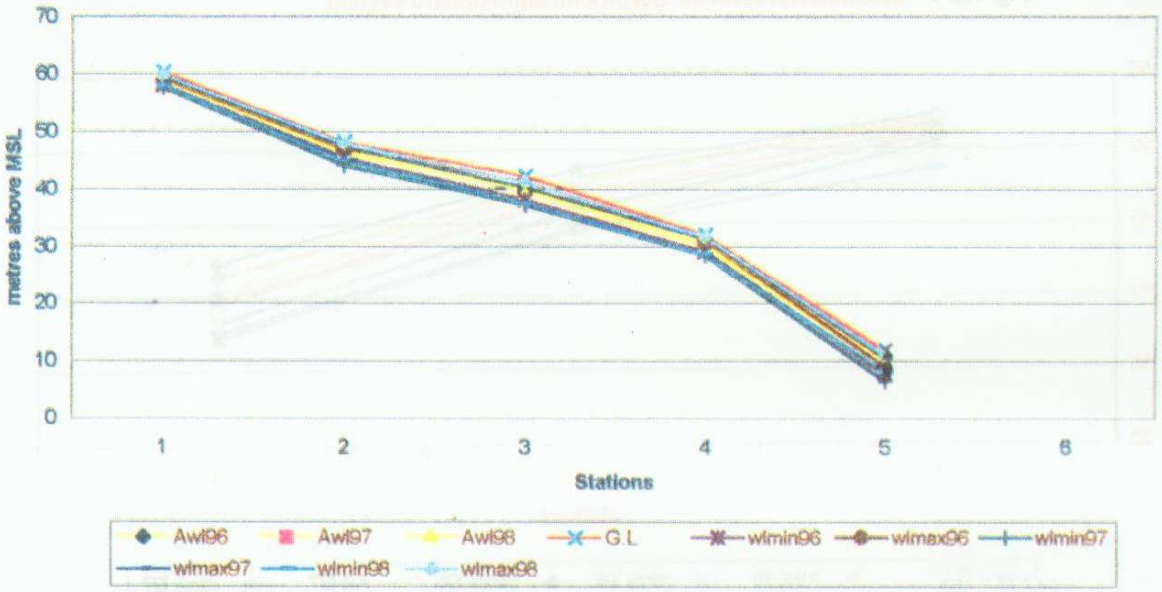
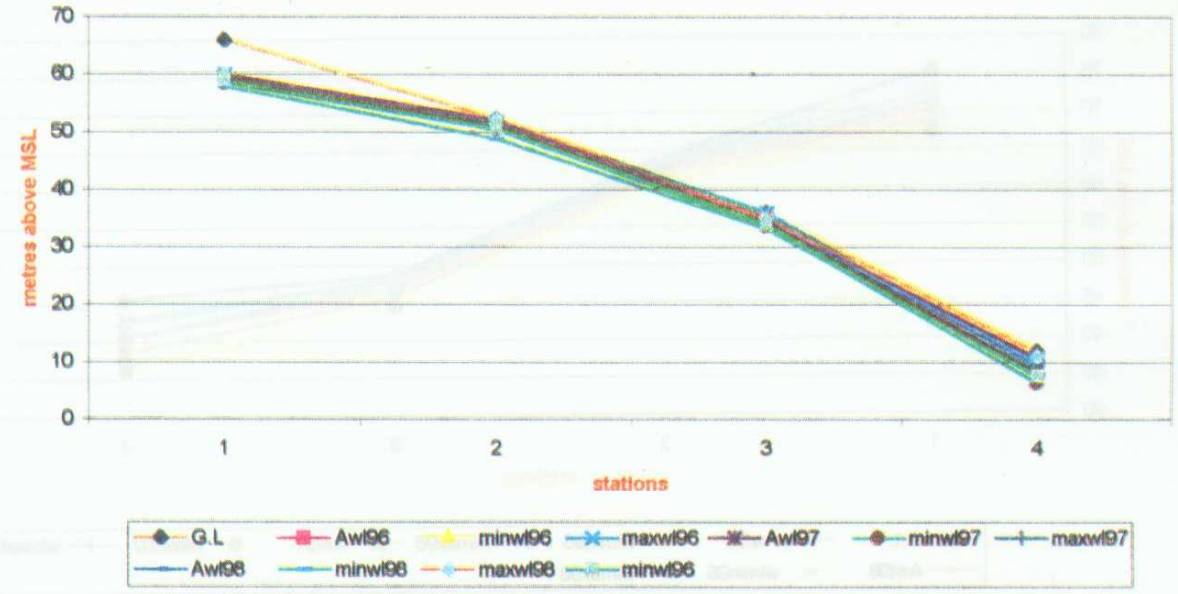


Fig. No. 12 Groundwater level for PSPudi-Eluru-Prattipadu-Gollaprolu section



Uttarkanchi and Santhi Ashram. Similar plot for Eluru-Ommangi-Potuluru in the middle and along Prattipadu-Dharmavaram- Kodavali at the bottom parallel to NH5 indicates the slope of ground water table in the study area.

In the north-south direction i.e., along the drainage pattern of the surface stream three more sections are plotted and shown at Fig.10 to Fig.12. Towards west, Pedasankarlapudi-Eluru-Prattipadu-Gollaprolu, in the middle Peddipalem-Uttarkanhci-Ommangi-Dharmavaram and in the East Santhi Ashram-Vakapalli-Potuluru-Kodavali-Gollaprolu are shown indicating the slope and flow direction of the ground water and its variation along the respective sections.

To understand the spatial occurrence of the ground water regime, the average annual depth to water table contours in the study area are plotted and shown at Fig.4 to Fig.6 for the 3 years of study. Monthly water level data over each year of the 15 observation wells is used to plot the ground water level contour for the post-monsoon season's maximum and pre-monsoon's minimum water level with respect to mean sea level. These are shown for post and pre monsoon seasons of the water year 1996-97 at Fig.13 and Fig.14, for 1997-98 at Fig.15 and Fig.16 for 1998-99 at Fig.17 and Fig.18 respectively for the maximum and minimum groundwater levels in the study area. To depict the maximum groundwater level contour for the year 1999-2000 a plot is also drawn for post monsoon ground water levels and is shown at Fig.19.

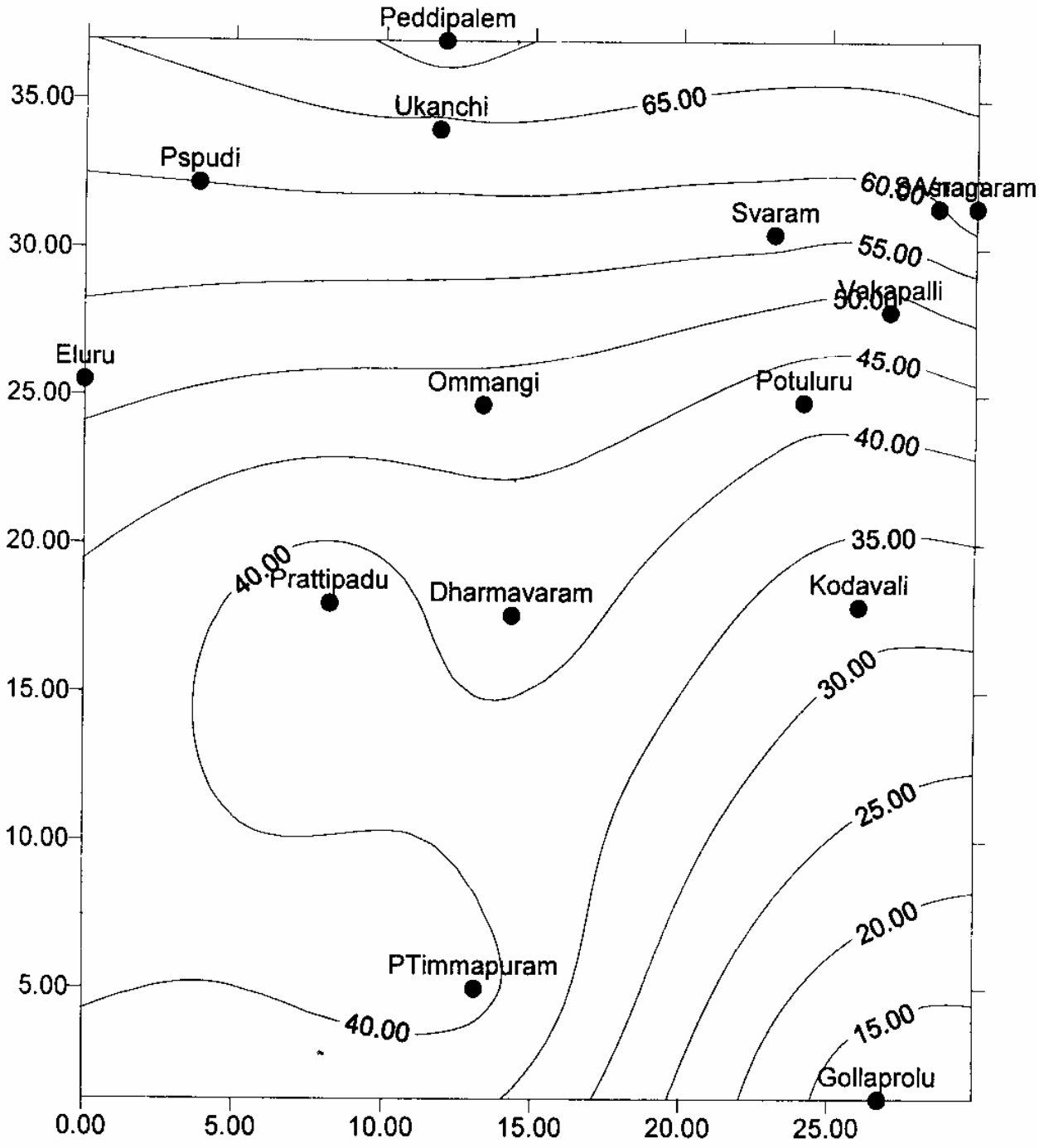
By looking at the above sectional water level plots and water table contour maps, it is observed that the water table was at maximum level during November '98 since during 1998 a copious rainfall was received. Similarly during November '97 water table was at low level as the recharge was less due to less rainfall; as far as maximum water levels are concerned. The water table fell to minimal value during May '98. On an average during 1998-99 the water table was at higher level than during the other years due to a very good rainfall of about 1550 mm.

5.2 Recharge/discharge of aquifer:

The change in storage of the aquifer at seasonal level will indicate the response of the aquifer in the study area to rainfall. Similarly the change in storage between post monsoon and pre monsoon will indicate the draft or drawdown. It is attempted to understand this aquifer response during the study period as below.

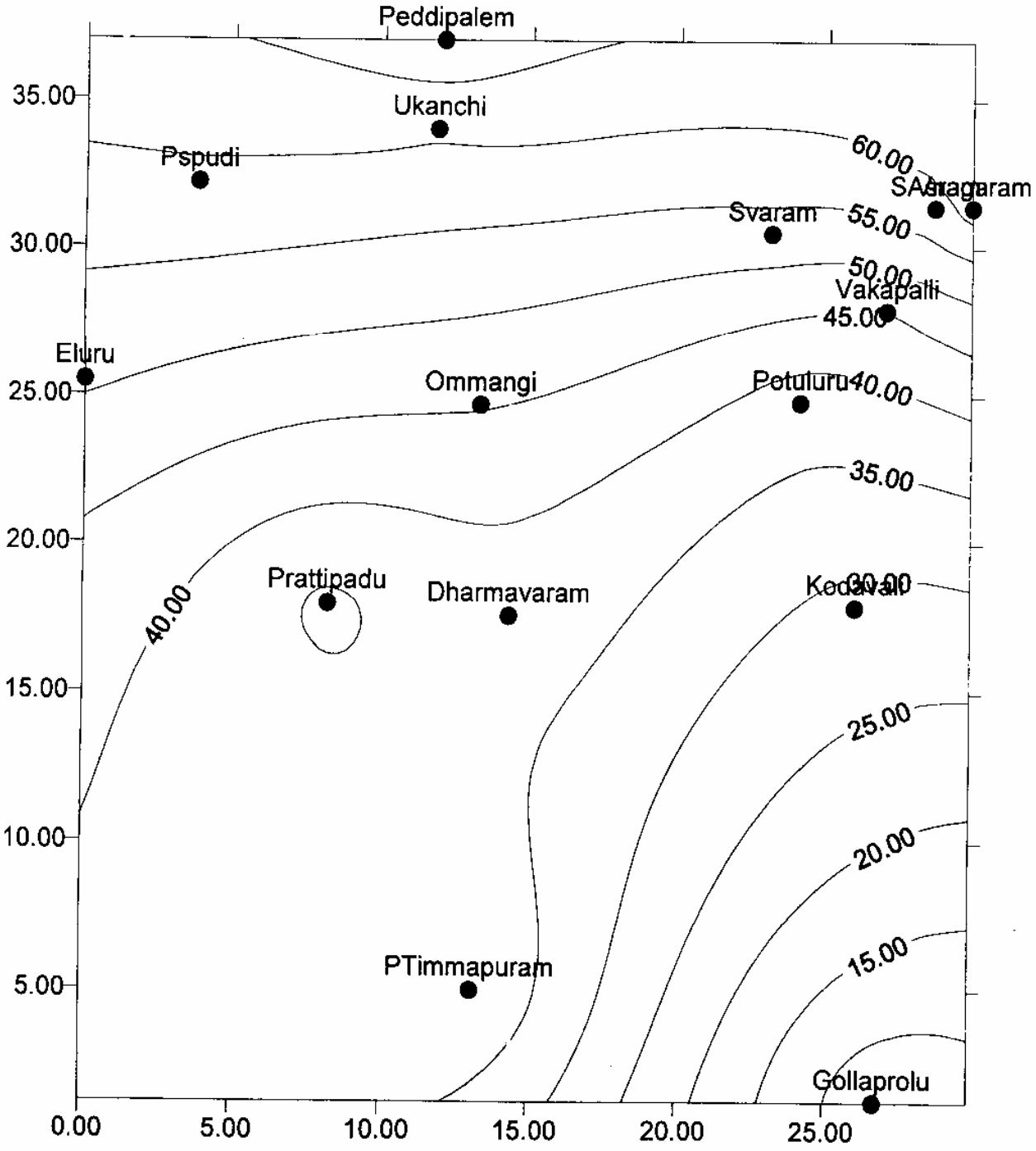
As mentioned in the earlier section, using the pre and post monsoon water levels of the study area shown as water level contour plots at Fig.13 to Fig.18, the volumes of the aquifer recharged or emptied i.e., draft are calculated based on the volume calculation between the higher and lower layers. These along with monsoon rainfall for that water year are shown in table along with the bar chart plot at Fig.20.

Fig. 13 Pre-monsoon '96 Groundwater Levels in metres above msl



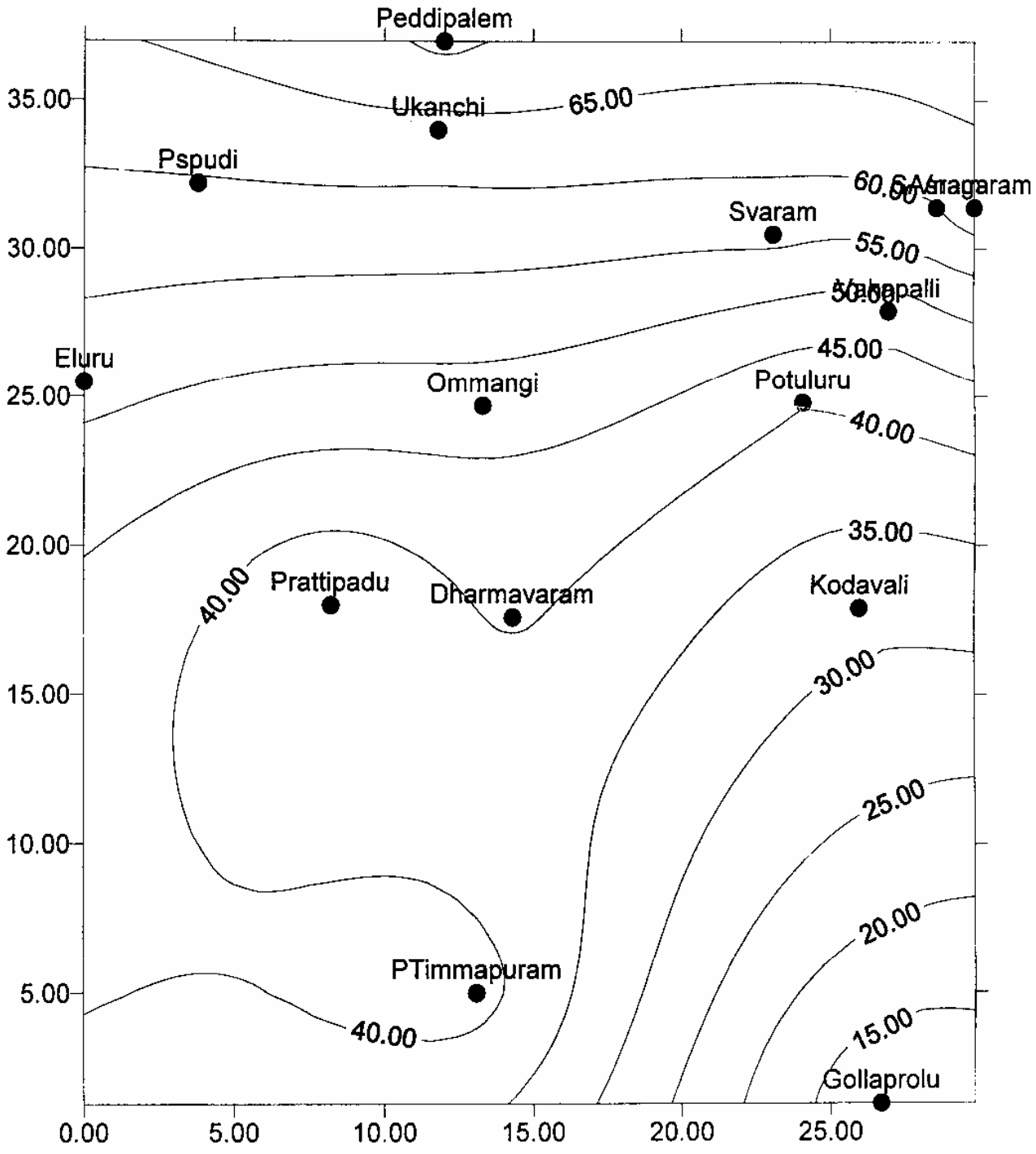
LEGEND: o : Observation well **Scale : 1 unit = 0.5 km**

Fig. 14 Pre-monsoon '97 Groundwater Levels in metres above msl



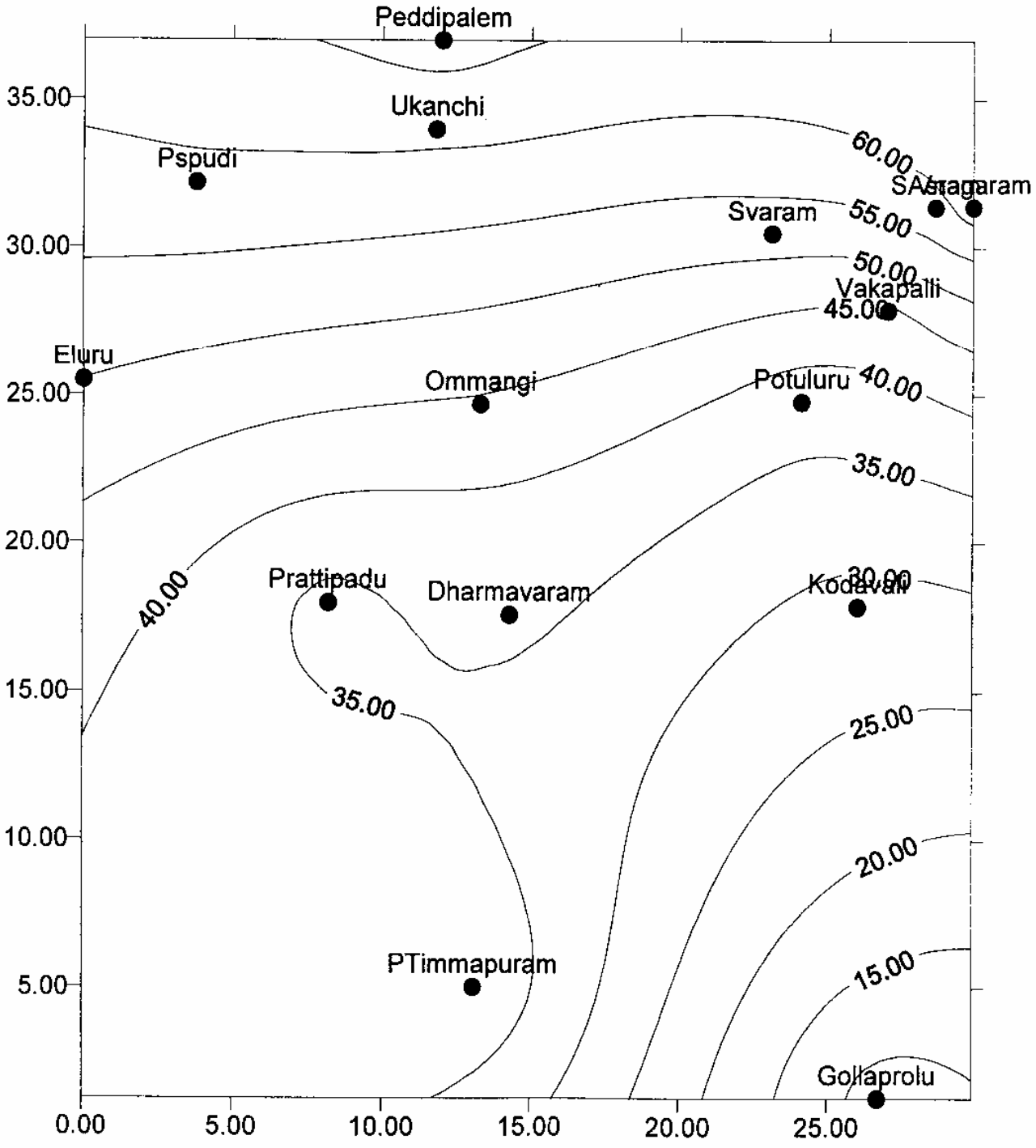
LEGEND: o : Observation well **Scale : 1 unit = 0.5 km**

Fig. 15. Post-monsoon '97 Groundwater Levels in metres above msl



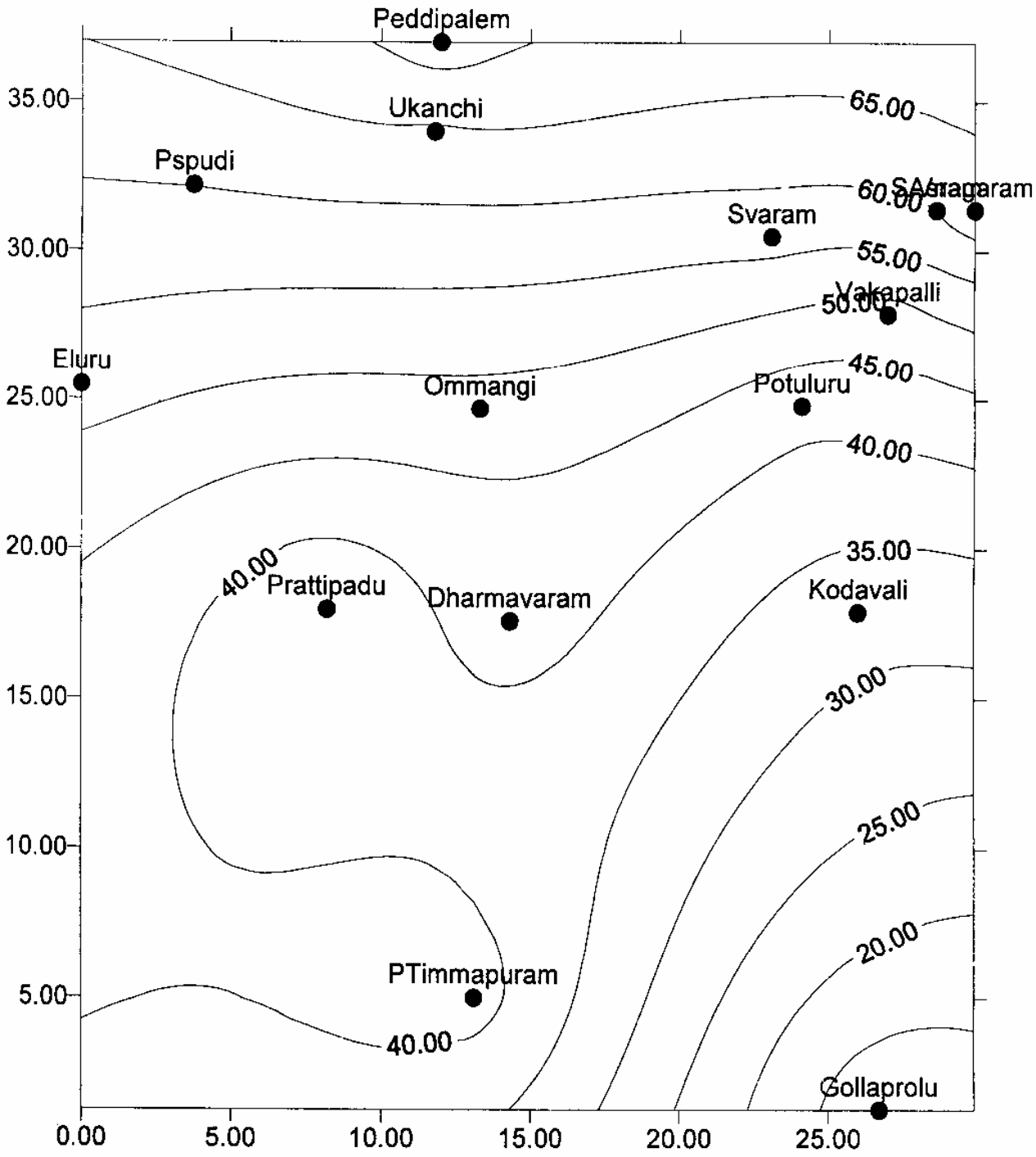
LEGEND: o : Observation well **Scale : 1 unit = 0.5 km**

Fig. 16 Pre-monsoon '98 Groundwater Levels in metres above msl



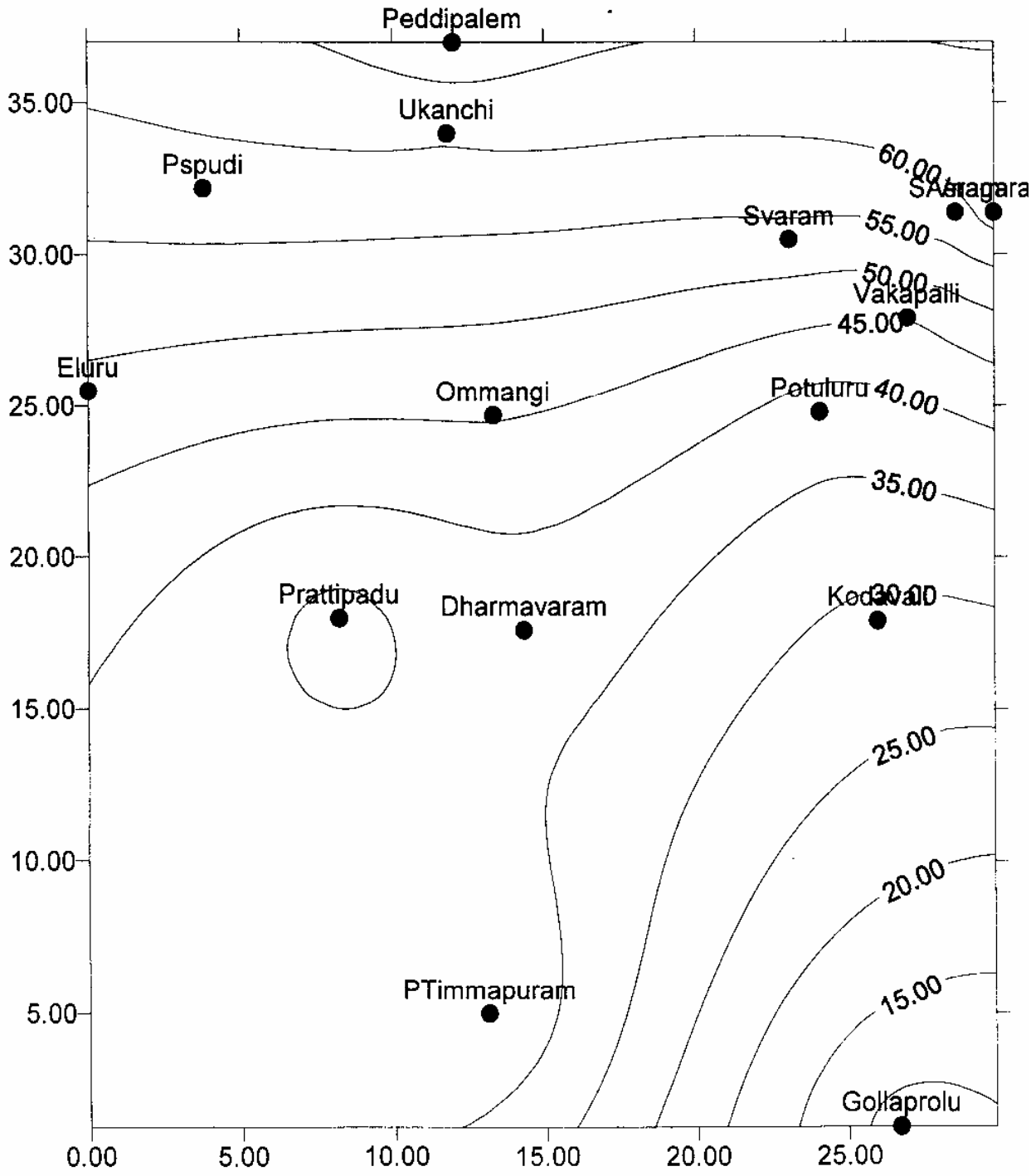
LEGEND: o : Observation well **Scale : 1 unit = 0.5 km**

Fig. 17 Post-monsoon '98 Groundwater Levels in metres above msl



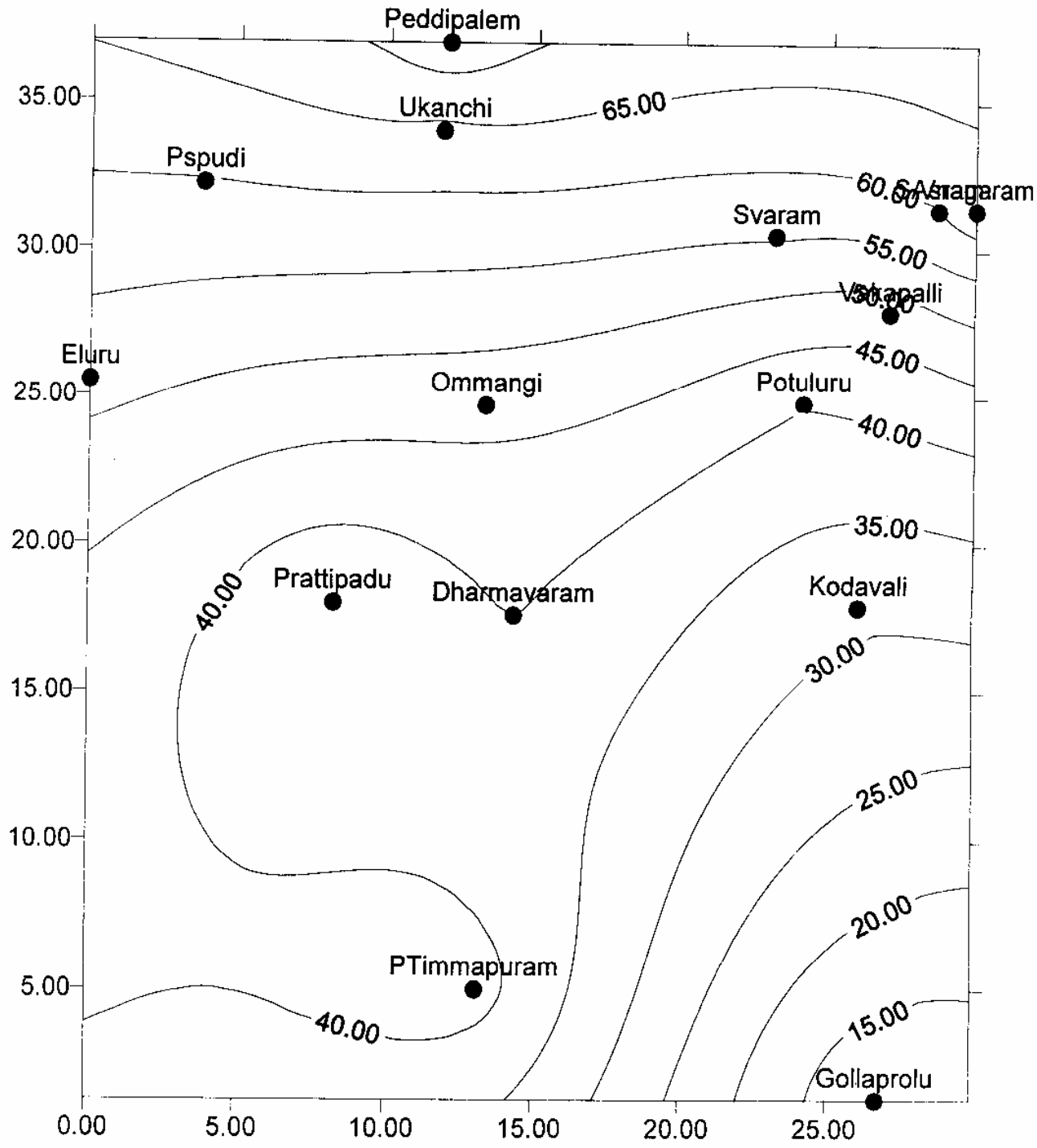
LEGEND: o : Observation well **Scale : 1 unit = 0.5 km**

Fig. 18 Pre-monsoon '99 Groundwater Levels in metres above msl



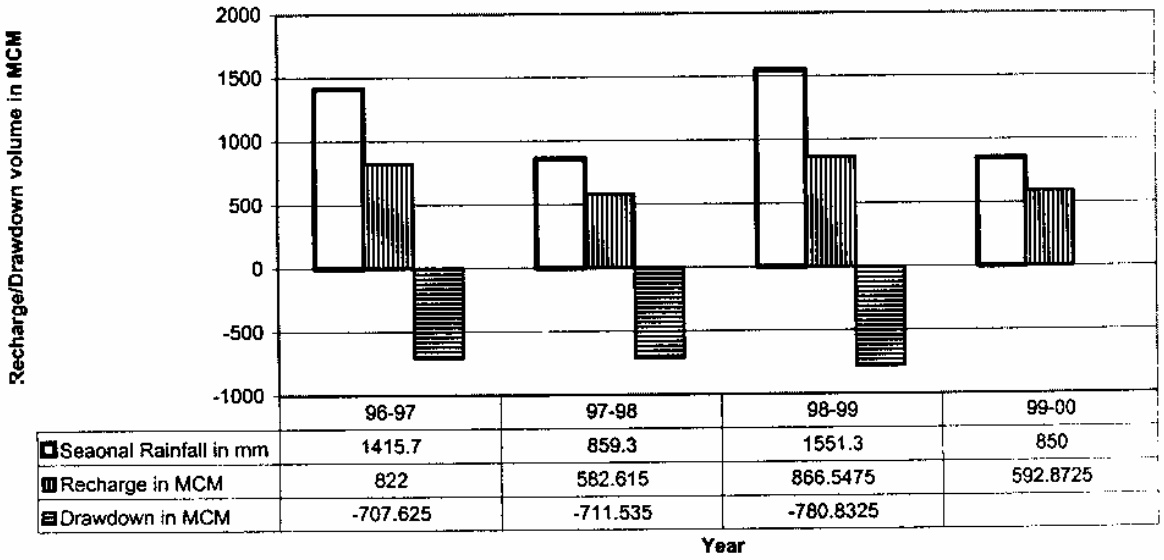
LEGEND: o : Observation well Scale : 1 unit = 0.5 km

Fig. 19. Post-monsoon '99 Groundwater Levels in metres above msl



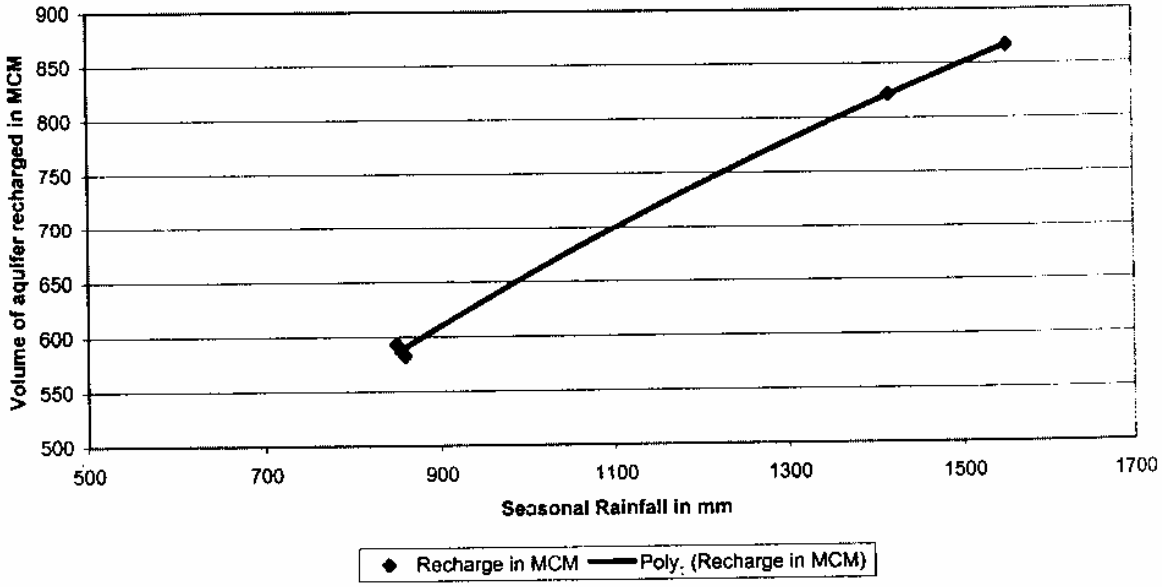
LEGEND: o : Observation well **Scale : 1 unit = 0.5 km**

Fig. 20 Volume of aquifer recharged / discharged (draft) in MCM in the study area



	96-97	97-98	98-99	99-00
Seaonal Rainfall in mm	1415.7	859.3	1551.3	850
Recharge in MCM	822	582.615	866.5475	592.8725
Drawdown in MCM	-707.625	-711.535	-780.8325	

Fig. 20a Rainfall vs Change in storage during monsoon season



The net volume of aquifer available after the 1996-97, 1997-98 and 1998-99 years is negligible i.e., by May'99 the water table is back at the level it was during May'96. In order to find how much of aquifer volume is available for extraction during non-monsoon period during 1999-2000 in the study area, the aquifer recharged during 1999-2000 is calculated in the same procedure as above. Using the water table contour plot of November '99 and May '99 and the aquifer recharged is estimated as shown at Table 2. The response of aquifer recharge to rainfall at seasonal level is shown in Fig.2 as a polynomial plot. The plot presents the relationship between seasonal rainfall and volume of aquifer recharge.

Table 2 Aquifer volume drained in the study area in M.Cu.m

Year	Recharged	Discharged	Seaonal Rainfall in mm
96-97	822	-707.625	1415.7
97-98	582.615	-711.535	859.3
98-99	866.5475	-780.8325	1551.3
Net	2271.1625	-2199.9925	------
99-00	592.8725		850

5.3 Ground water quality: __

The water samples for pre-monsoon and post-monsoon seasons of 1996-97,1997-98 & 1998-99 were subjected to chemical analysis by State Ground Water Department, Rajahmundry and the results are as reported at Annex-II. The analysis and results on the hydrochemistry of the study area are presented here.

From the analytical report as at Annex-II, Potuluru, Sarabhavarm and Peddipalem have calcium above 240 ppm. But November '99 report suggests only Sarabhavaram and Peddipalem have high calcium values of about 250 ppm whereas Potuluru has low value. Magnesium is at high level at Uttarkanchi, Kodavali and Peddipalem. Uttarkanchi, Kodavali and Dharmavaram have high sodium values ranging from 300 to 900 ppm. Potassium is present at a very high level from 450 to 1100 ppm at Dharmavaram. Total Dissolved Solids are very high at Uttarkanchi, Dharmavaram, Kodavali, Sarabhavaram and Peddipalem in decreasing order ranging from 5500 to 2000 ppm except for post-monsoon samples collected in November '99 where they show a range of 2500 to 1500 ppm. The analytical results for Dharmavaram for the post-monsoon season of November '98 show a peculiar low chemical composition for all the parameters. Whereas values for all other wells are in general trend. This may be due to a wrong sample result reported for Dharmavaram

or at a depth to water table of 4.15 metres the chemical composition may be different. The later reason may be wrong, since results of post-monsoon sample analysis of November '96 at depth to water table of 3.59 metres in the same well show high values for all the parameters.

The variation of pH, TDS i.e., total dissolved solids and DTW i.e., depth to water table from measuring point are shown as bar charts and as time series variations plots for individual stations are shown at Fig.21 to Fig.26. From the plots it can be observed that Uttarkanchi and Dharmavaram wells have high TDS values than other wells. pH is in similar range at all the wells. At Dharmavaram water table variation is high between pre and post monsoon seasons. At Pedasankarlapudi, which is on the recharge zone on a hill slope the range of DTW variation is minimum.

Seasonal chloride ion concentration is shown as bar chart at Fig.27 for each well. Time series plot well wise is plotted as at Fig.28 to observe any trend in the variation of chloride ion concentration. Uttarakanchi has the presence of large chloride ion concentration followed by Dharmavaram. The trend is similar for Peddipalem-Dhrmavaram-Uttarakanchi in increasing order. Kodavali and Potuluru have similar trend. Santhiashram has low concentration of chlorides.

To understand the geochemistry of groundwater system of the study area, standard ratio plots as bar charts seasonally and as time series well wise for different combination of ions is plotted as discussed in the earlier section. Plots for ratios, like calcium : sodium, magnesium : calcium, potassium : sodium, sodium: bicarbonate and bicarbonate : chloride are plotted as shown from Fig.29 to Fig.38. From the plots it can be observed that the trend of the parameters at all the wells is similar.

Also, as discussed earlier, to classify the waters of different OB wells, a scatter plot is drawn (Chadha, 1999) on X-Y coordinates as at Fig.39 using various cation and anion concentrations of waters at 15 OB wells. As the analytical results are not available for sulphate ion concentration, it is estimated from ion balancing technique of epm values. The difference in epm values of all major cations namely sodium, potassium, calcium, magnesium and anions namely corbonate, bicorbonate and chlorides is approximated as sulphate ion concentration. Difference of percentage reaction values (PRV) of alkaline earths and alkali metal cations on X-axis and difference of PRV of weak acidic anions and strong acidic anions on Y-axis. The location of points on the plots can be interpreted to know the geochemistry of the well waters.

From Fig.39 it can be classified that around Potuluru, Sarabhavaram, Peddipalem, P. Timmapuram areas ground water is calcium-magnesium-chloride type

Fig. No. 21 **Depth to water table from M.P at different wells**

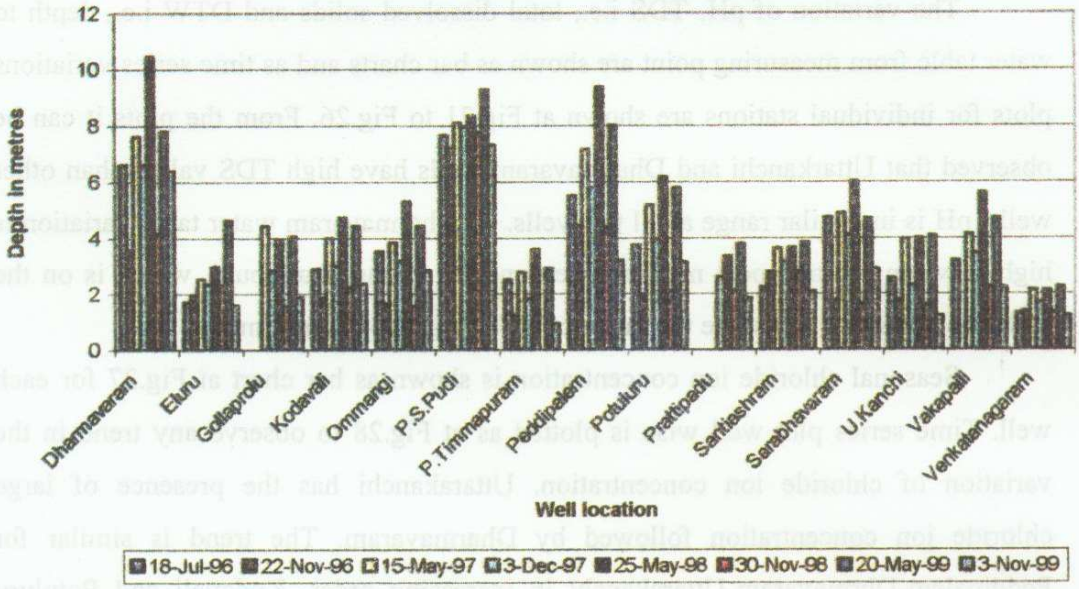


Fig. No. 22 **DTW Series at different wells**

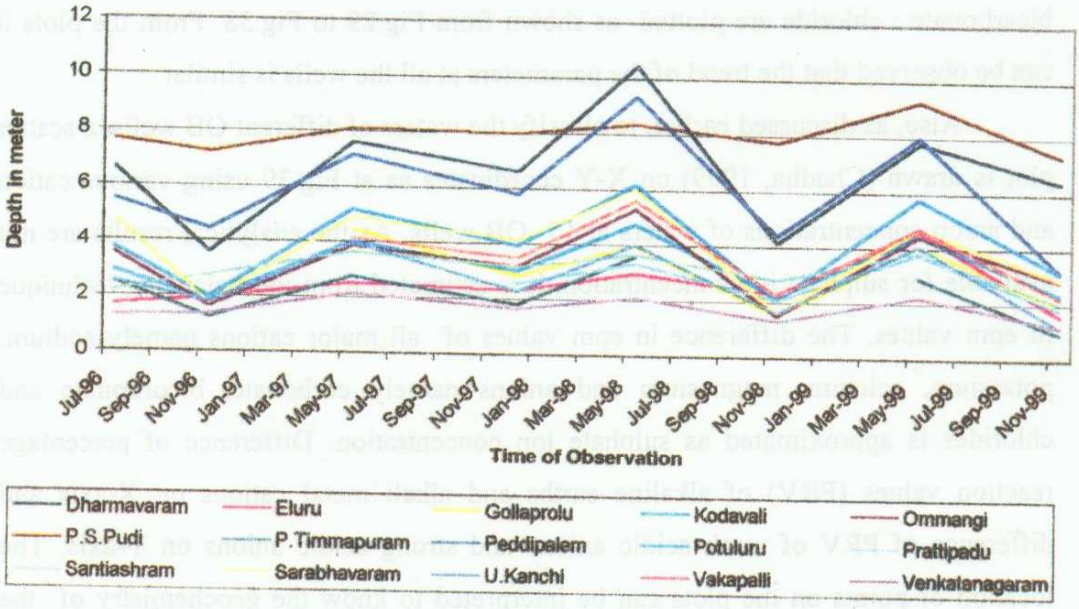


Fig. No. 23 **Ph of groundwater at different O B Wells**

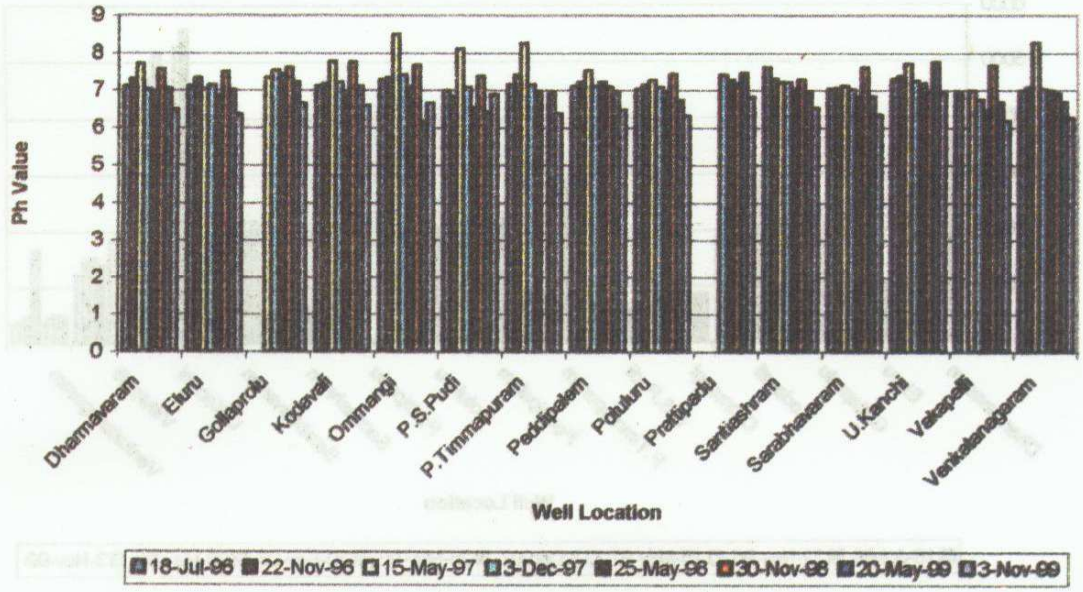


Fig. No. 24 **Ph series of Groundwater of OB Wells**

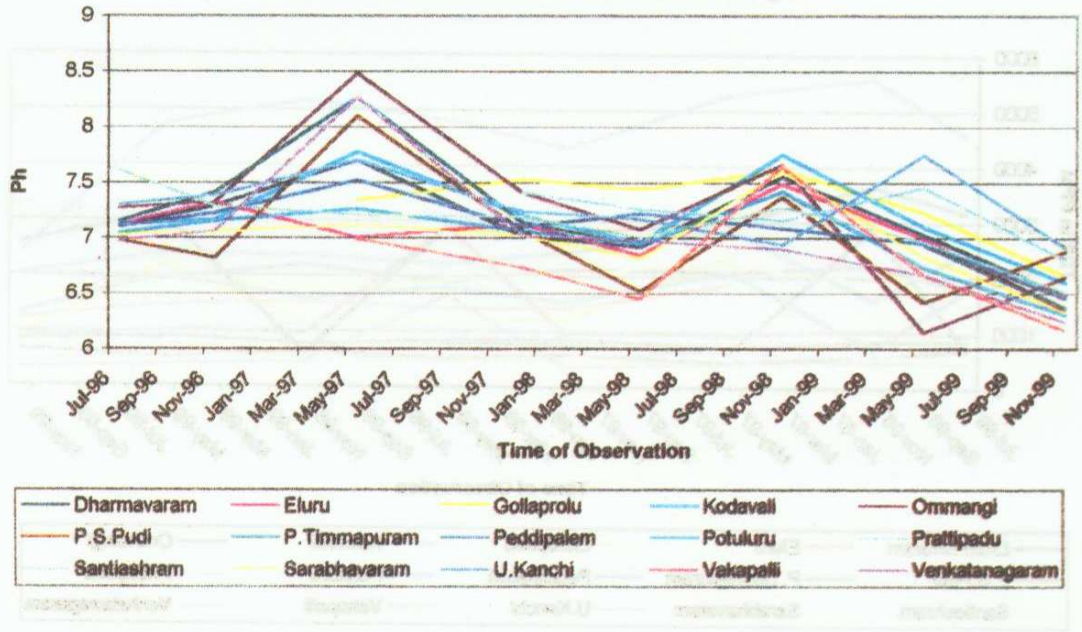


Fig. No. 25 **TDS values of Groundwater at different OB Wells**

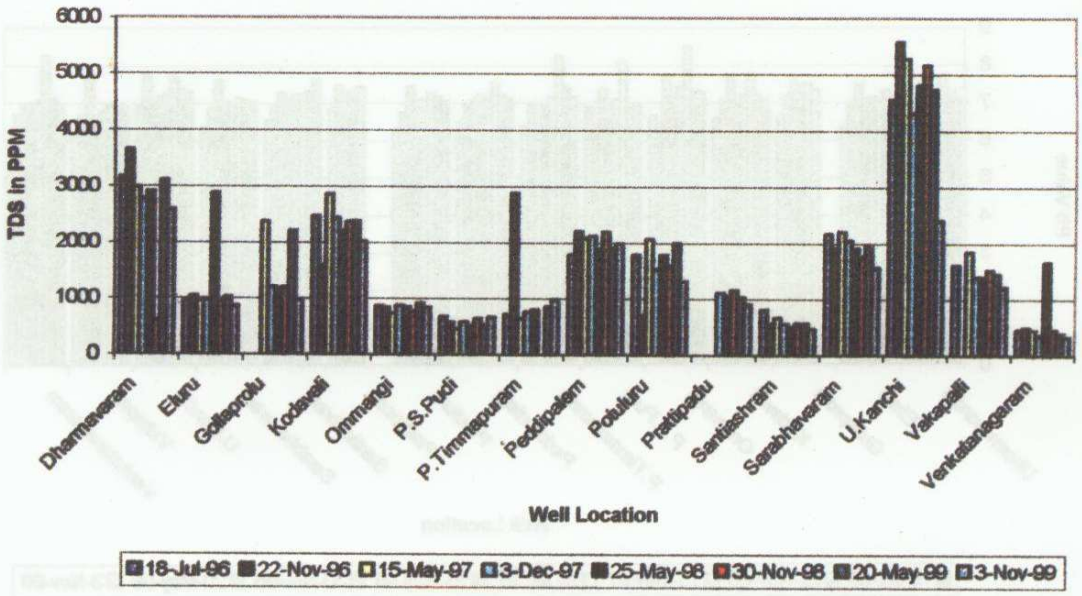


Fig. No. 26 **TDS Series of O B Wells**

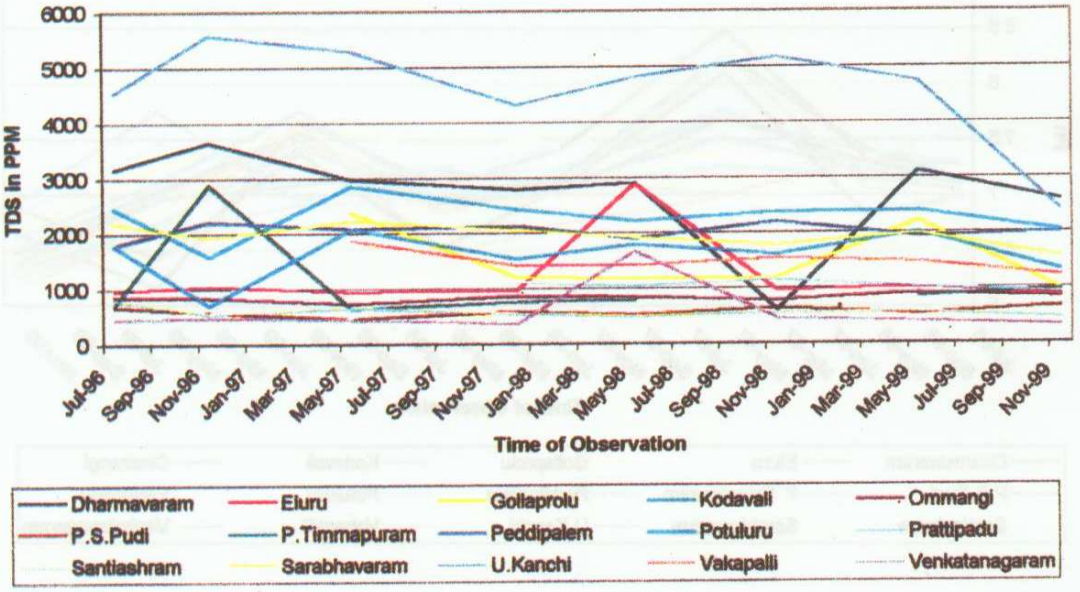


Fig. No. 27 **Chloride ion in groundwater at different OB Wells**

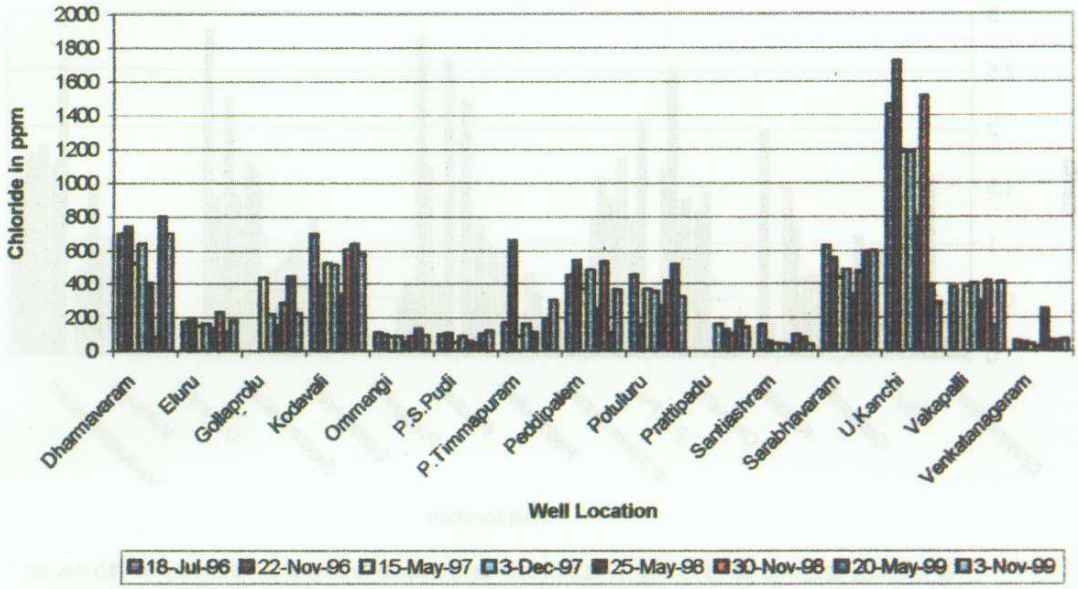


Fig. No. 28 **Chloride series of Groundwater in Suddagedda basin**

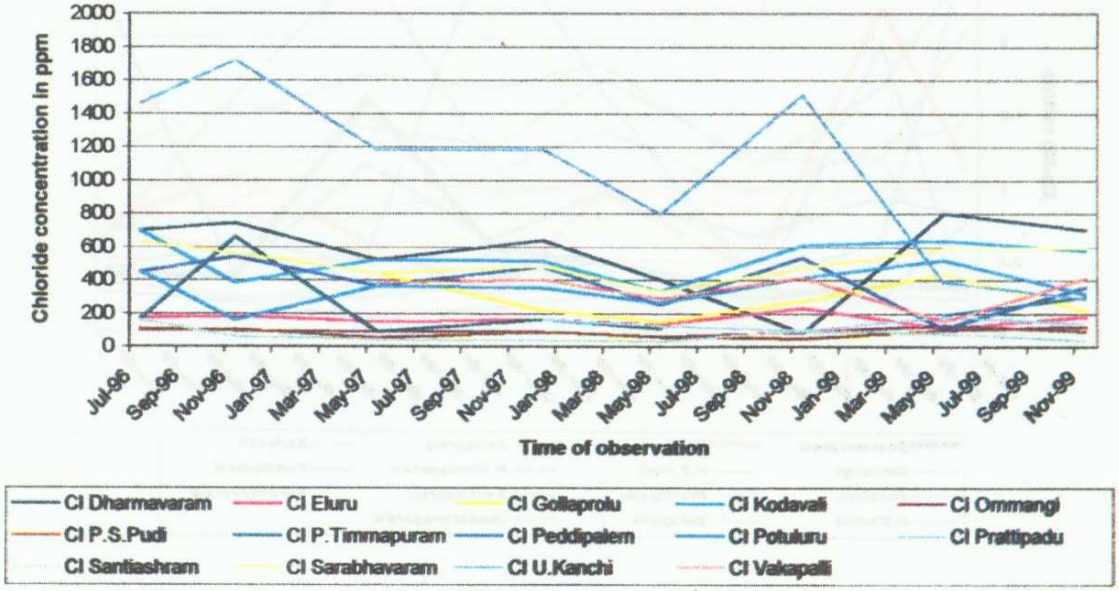


Fig. No. 29 **Ca:Na values of groundwaters at different O.B. wells**

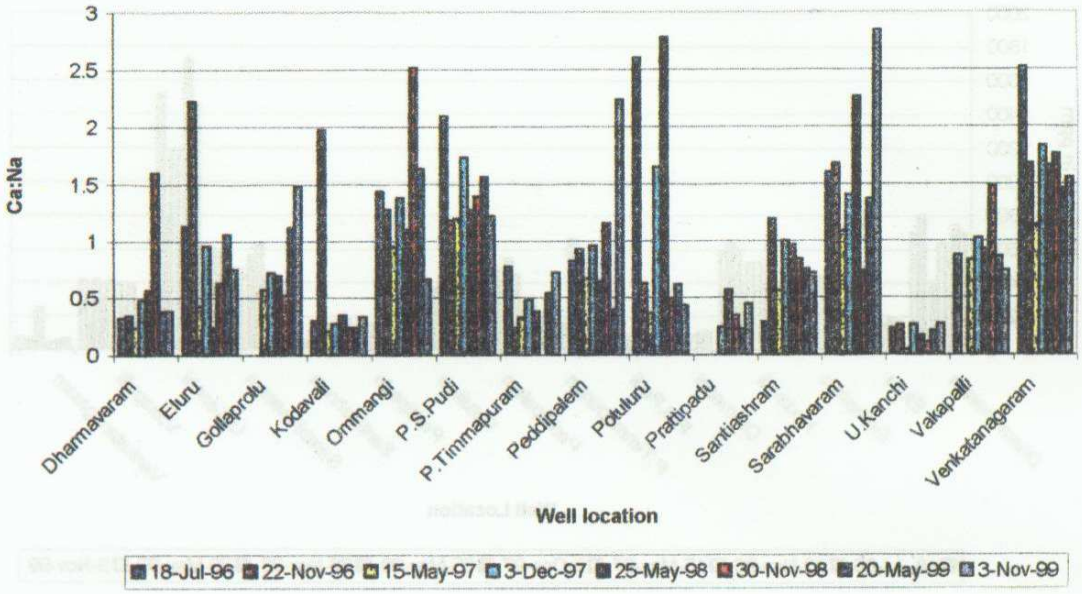


Fig. No. 30 **Ca:Na value series of groundwater in suddagedda basin**

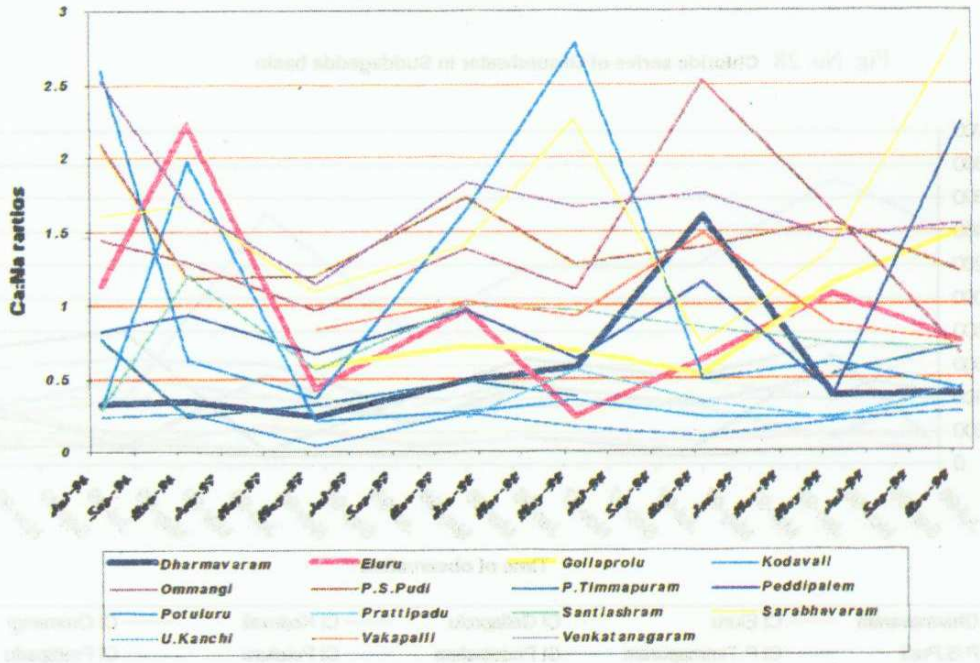


Fig. No. 31 **Mg:Ca values of groundwater at different O B Wells**

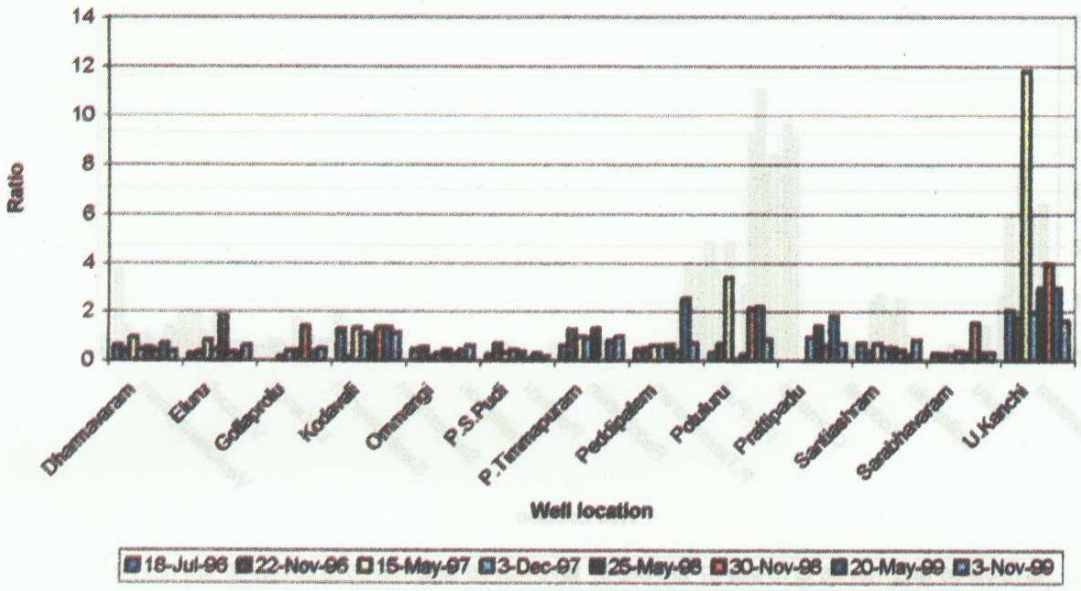


Fig. No. 32 **Mg : Ca series**

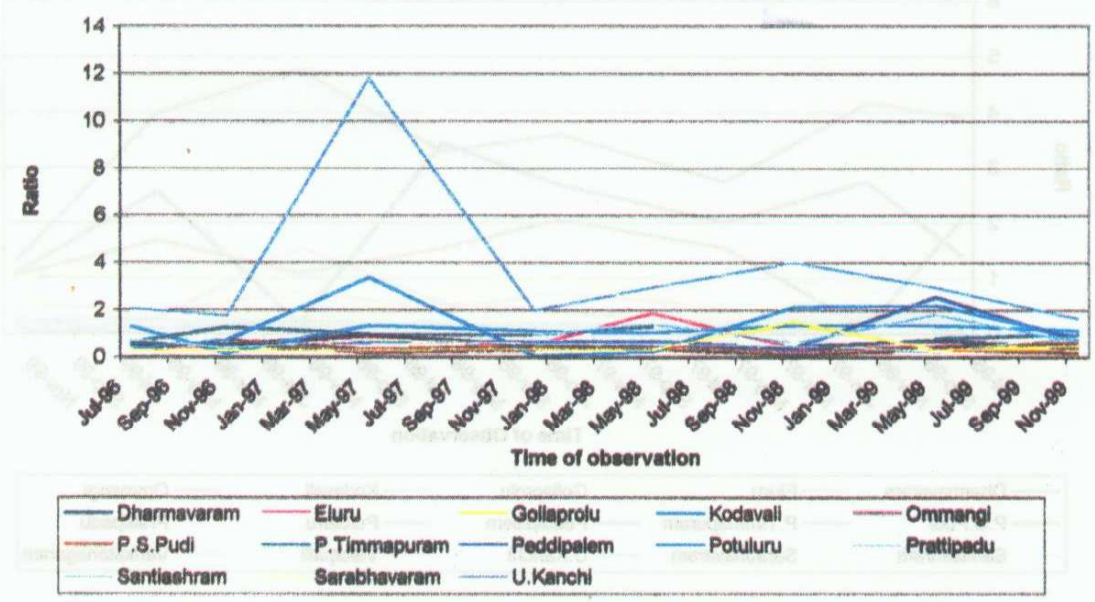


Fig. No. 33 **K:Na of Groundwater at dufferent O B Wells**

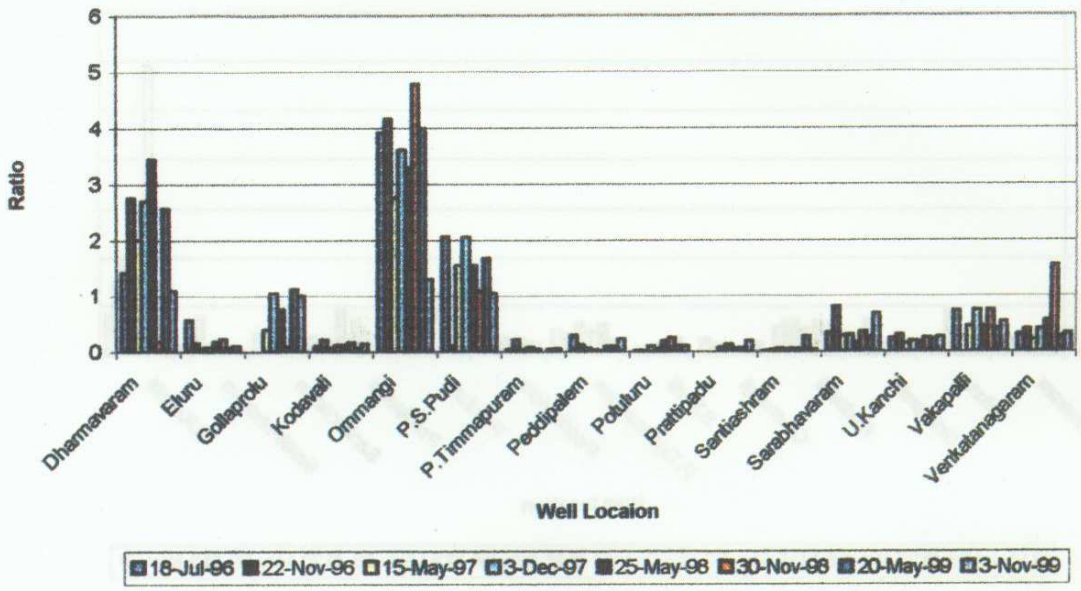


Fig. No. 34 **K:Na Series of OB Wells**

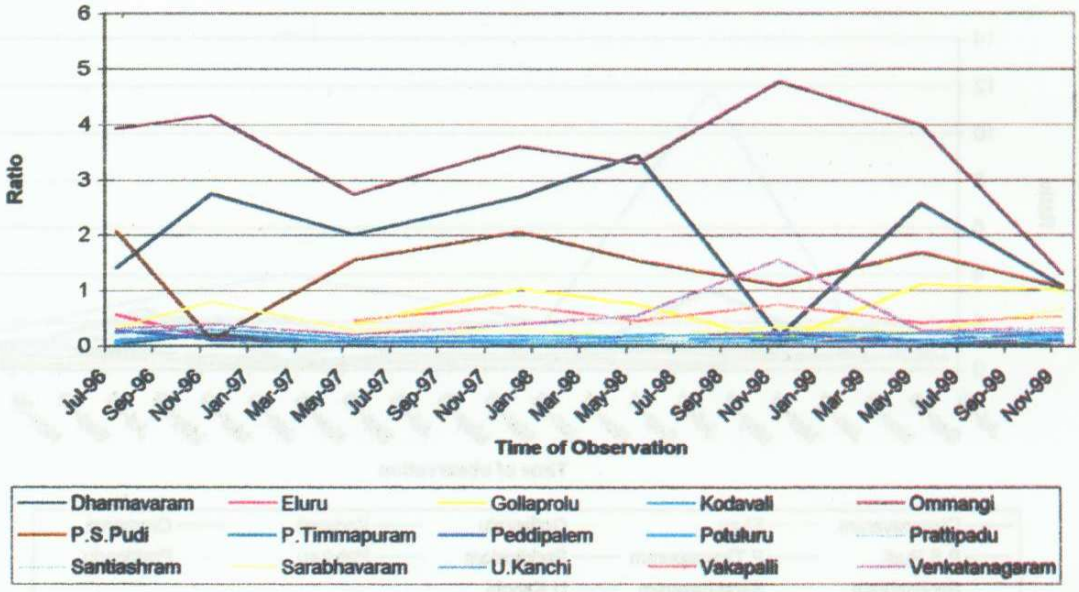


Fig. No. 35 **Na:HCO3 of groundwater at different O B Wells**

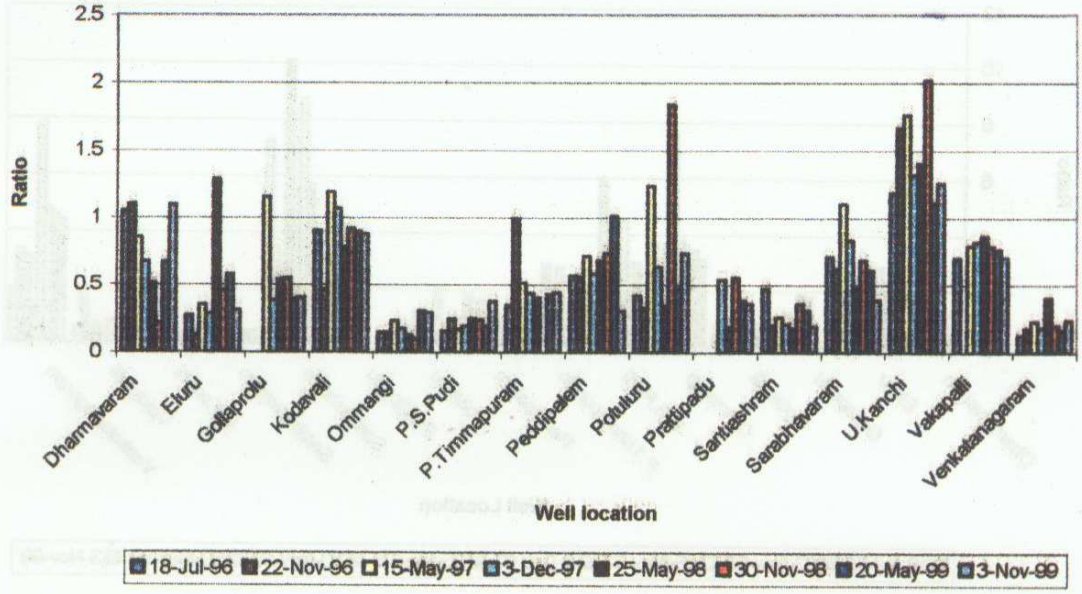


Fig. No. 36 **NaHco3 Series of groundwater at different OB Wells**

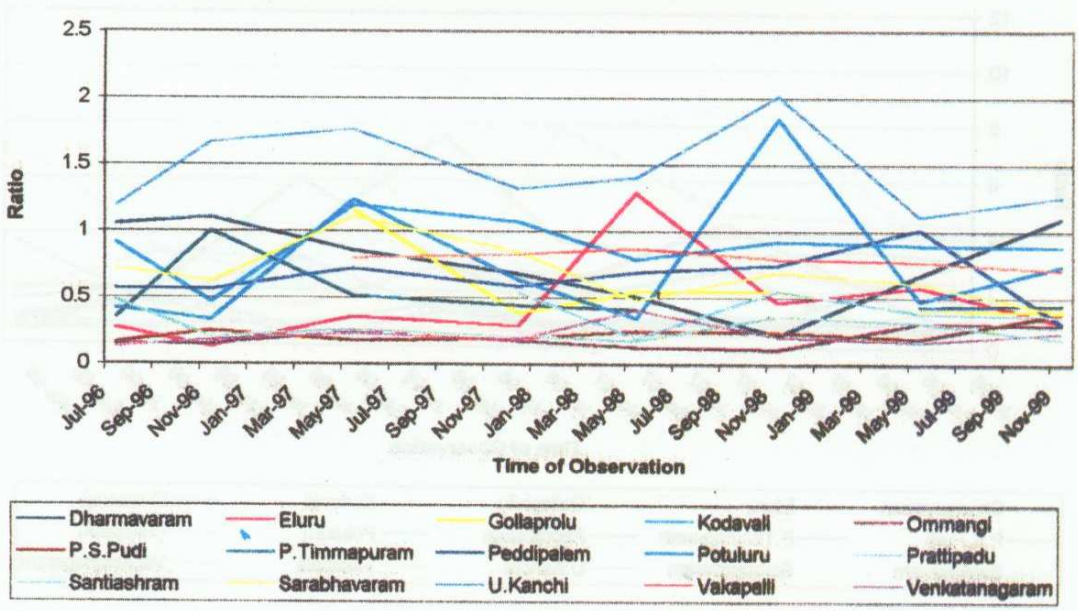


Fig. No. 37 **HCO3:Cl of groundwter at different OB Wells**

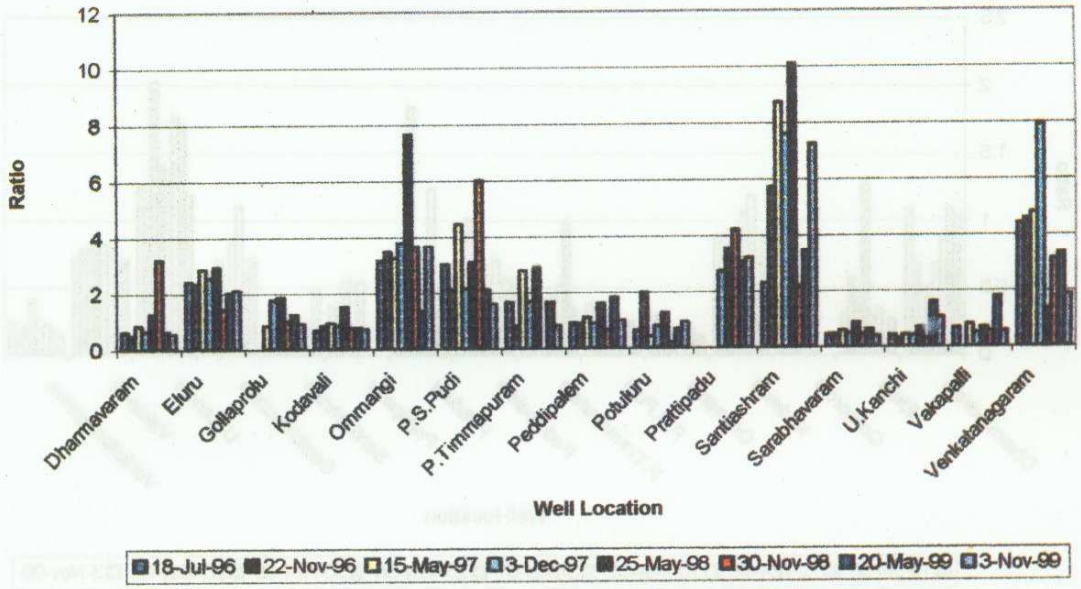


Fig. No. 38 **HCO3:Cl series for groundwater**

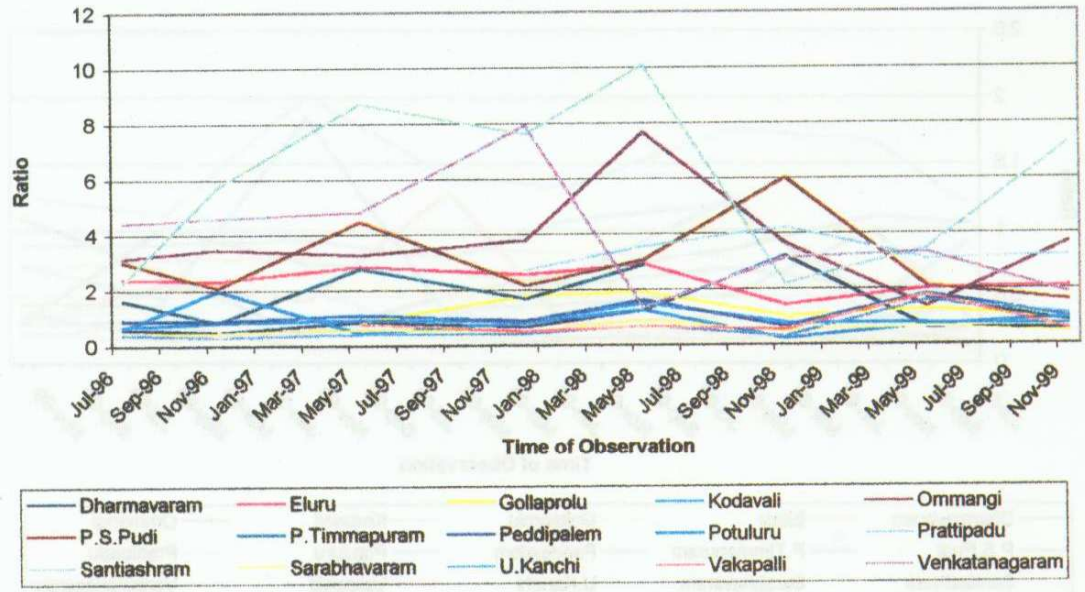
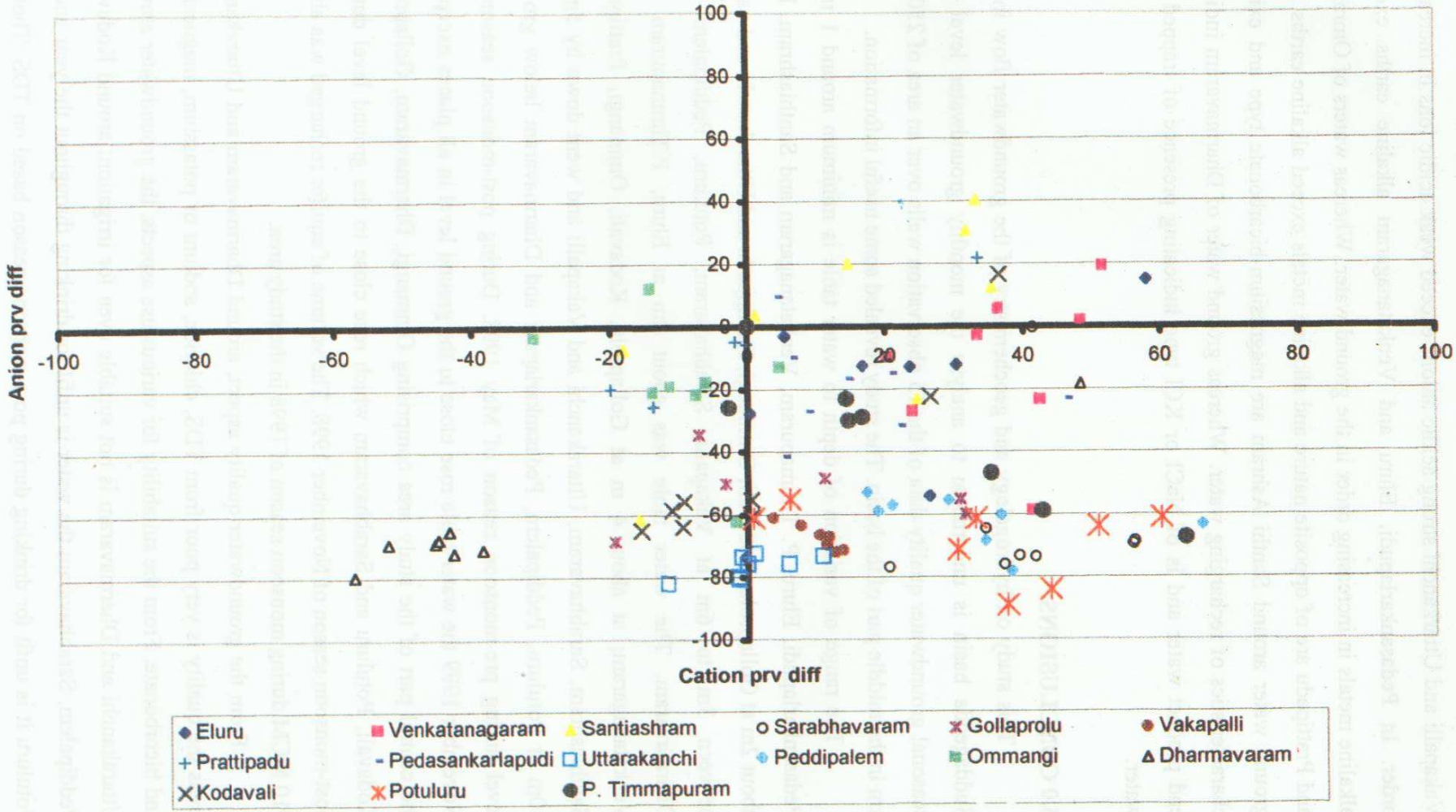


Fig.No. 39 **OB well water: CGWB chemical classification**



water with chloride as dominant one. In groundwaters of Gollaprolu, Kodavali, Vakapalli and Uttarkanchi strong acidic anions exceed weak acidic ions in increasing order. In Pedasankarlapudi, Eluru and Venkatanagaram alkaline earths exceed alkaline metals in increasing order in the ground water. Whereas waters of Ommangi and Prattipadu are of opposite nature and alkaline metals exceed alkaline earths. The ground water around Santhi Ashram are magnesium-bicarbonate type and exhibit characteristics of recharging water. Whereas ground water of Dharmavaram indicate end product water and is of NaCl or KCl type indicating presence of trapped sea water.

6.0 CONCLUSIONS:

This study on hydrogelogy and geochemistry of the groundwater flow in the Suddagedda basin is undertaken to analyse the monthly groundwater level and seasonal groundwater quality data of the 15 observation wells over an area of 250 sq. km in the middle part of the basin. The study revealed some useful information.

The range of variation of depth to water table is minimum around 1 m at Pedasankarlapudi, Eluru, P. Timmapuram, Venkatanagaram and Santhiashram. It is about 2m at Gollaprolu, Kodavali, Ommangi, Prattippadu and Uttarakanchi and varies between 3m to 6m at Vakapalli, Sarabhavaram, Potuluru, Peddipalem and Dharmavaram. The water table was about 2m at Eluru, P.Timmapuram and Venkatanagaram; at about 4 m at Gollaprolu, Kodavali, Ommangi, Prattipadu, Santhiashram, Sarabhavaram, Uttarakanchi and Vakapalli and went down by 5m to 10m at Potuluru, Peddipalem, Pedasankarlapudi and Dharmavaram below ground level during pre-monsoon season of May 1998. During post-monsoon season of November 1999 the water table rose close to the ground level in all places except in the central part of the study area comprising Ommangi, Dharmavaram, Gollaprolu, Kodavali, Potuluru and Sarabhavaram which rose close to the ground level during post-monsoon season of November 1998. The volume of aquifer recharged was about 910 MCM during monsoon season of 1998 in the study area.

From the groundwater quality aspect, around Dharmavaram and Uttarakanchi areas the quality is very poor from TDS, chloride, sodium or potassium, magnesium and bicorbonate. From the suitability for various use aspects, the groundwater around Uttarakanchi and Dharmavaram is not suitable even for irrigation; around Kodavali, Peddipalem, Sarabhavaram the water is unfit for drinking throughout the year and at Potuluru it is unfit for drinking during post-monsoon season based on TDS. Though the groundwater in the study area is fit for irrigation from %sodium, RSC and SAR

aspects, around Dharmavaram, Kodavali, Peddipalem, Potuluru, Sarabhavaram, Uttarakanchi and Vakapalli it is not suitable due to high concentration of chlorides.

By using the CGWB chemical classification the groundwaters of the basin are classified into six groups namely calcium-magnesium chloride type with chlorides as dominant; strong acidic ions exceed weak acidic ions; alkaline earths exceed alkaline metals; alkaline metals exceed alkaline earths; Magnesium bicarbonate type and end product waters.

The data and analysis of the hydrogeology and geochemistry of the basin will be useful and will give a direction for undertaking groundwater balance and modelling studies of the study area in future.

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Depth to water table at OB wells in Suddagedda basin (in m)

Annex -1

Month/Year	Eluru	PSPudi	Uttarkanchi	Peddipalem	Ommangi	Dharmavaram	Kodavali	Potuluru	PTPuram	Sarabhavaram	V nagaram	SantiAshram	Gollaprolu	Vakapalli	Prattipadu
R.L of M.P	53.373	67.078	65.148	76.428	49.799	46.54	33.187	43.395	43.027	58.279	64.825	61.694	11.875	49.654	36.957
Jul-96	1.7	7.65	2.54	5.5	3.54	6.62	2.9	3.75	2.5	4.75	1.3				2.87
Aug-96	1.72	7.42	1.53	3.99	2.42	5.75	2.23	2.49	1.33	2.79	1.2				1
Sep-96	1.59	7.06	1.43	3.75	1.81	5.02	2.11	2.52	1.11	2.62	1.51	2.55			1.11
Oct-96															
Nov-96	1.93	7.2	1.78	4.43	1.63	3.59	1.86	1.97	1.23	1.75	1.37	2.78			0.94
Dec-96	2.05	7.76	2.54	4.8	2.17	4.58	2.78	2.97	2.2	2.88	1.44	3.26			2
Jan-97	2.12	7.83	2.84	4.98	2.69	5.27	3.18	3.49	2.31	3.49	1.4	3.32	2.98	2.63	2.14
Feb-97	2.39	7.9	3.53	5.67	3.22	6.55	3.43	4.15	2.65	3.92	1.46	3.5	3.55	3	2.44
Mar-97	2.17	7.98	3.97	6.74	3.7	7.23	3.82	5	3	4.28	1.42	3.57	3.65	3.51	2.78
Apr-97	2.41	8.08	3.44	6.7	3.42	7.2	3.49	4.87	2.41	4.47	1.95	3.58	4.02	4.24	2.14
May-97	2.52	8.07	3.97	7.14	3.85	7.6	4	5.18	2.76	4.89	1.46	3.63	4.43	4.13	2.54
Jun-97	2.7	8.12	4.4	7.61	4.3	8.05	4.58	5.73	2.9	5.21	1.23	4.08	5.6	4.81	
Jul-97	2.17	8.13	4.04	7.63	4.45	7.9	4.4	5.88	2.68	5.09		3.8	4.24	4.54	
Aug-97	1.58	7.77	3.04	7.21	4.15	7.25	3.92	5.12	2.28	4.28		2.9	3.68	3.64	
Sep-97	2.47	8.07	3.27	7.52	4.51	9.06	4.04	5.3	1.86	4.84	1.53	3.09	4.32	4.75	2.75
Oct-97	1.51	7.41	2	5.12	2	5.93	1.84	3.12	1.04	1.92	0.95	2.2	1.49	2.39	1.8
Nov-97															
Dec-97	2.31	7.96	2.29	5.78	3.18	6.61	3.02	3.95	1.81	4.12	1.66	3.18	2.82	3.47	2.57
Jan-98	2.45	8.13	2.72	7.09	3.57	7.55	3.36	4.1	2.04	4.54	1.57	3.2	3.25	3.2	2.77
Feb-98	2.54	8.25	3.01	8.05	4.07	7.78	3.49	5.11	2.51	4.91	1.61	3.32	3.34	3.49	2.8
Mar-98	2.45	8.61	2.82	7.88	4.43	8.12	4.12	5.53	2.74	5.15	1.7	3.53	3.85	4.42	3.05
Apr-98	2.78	8.2	3.1	8.45	4.68	9.45	4.16	5.72	3.4	5.5	2.01	3.58	4.03	4.92	3.28
May-98	2.98	8.35	4	9.35	5.3	10.46	4.75	6.18	3.59	6	2.1	3.65	3.96	5.62	3.35
Jun-98	3.42	8.36	3.8	9	5.13	9.61	4.1	5.35	3.32	5.16	1.56	2.86	2.03	4.41	2.45
Jul-98															
Aug-98	1.63	7.73	1.46	7.32	3.33	7.97	2.25	3.66	2.19	3.34	1.27	2.16	1.52	2.74	1.83
Sep-98	1.41	7.57	0.85	4.84	1.98	5.65	1.6	2.1	1.21	1.98	0.9	2.36	1.34	2.3	2
Oct-98	1.19	7	0.8	4	1.7	4.82	1.4	1.81		1.36	0.86	1.91	0.93	1.71	1.73
Nov-98	2.3	7.74	1.6	4.4	1.53	4.15	2.22	2.1		1.62	1.33	2.82	1.53	2.24	2.1
Dec-98															
Jan-99	2.33	7.9	2.76	5.3	2.54	4.38	3.13	3.4	2.11	3.2	1.46	3.3	2.37	2.6	2.9
Feb-99	2.4	8.12	2.8	5.34	2.71	4.99	3.1	4.05	2.29	3.91	1.3	3.24	2.57	2.54	3.03
Mar-99	2.91	8.7	3.3	6.54	3.54	5.3	3.55	5.07	2.64	4.04	1.32	3.54	3.2	4.12	3.3
Apr-99	3.4	9.22	4.49	7.61	4.03	6	4.17	5.52	2.79	4.5	2.13	3.8	3.86	4.76	3.5
May-99	4.63	9.28	4.1	8	4.43	7.99	4.55	5.79	2.94	4.69	2.23	3.81	4.07	4.72	3.79
Jun-99	4.45	7.9	2.8	7.04	4.26	8.17	4.08	5.7	2.22	4.43	1.44	3.53	2.79	4.4	3.3
Jul-99	1.72	7.4	2	6.46	3.45	7.04	3.38	4.85	2	3.7	1.3	2.7	1.9	3.73	2.09
Aug-99	1.5	7	1.8	6.01	3.17	6.88	2.92	4.5	1.2	3.24	1,17	2.3	1.93	3.51	1.88
Sep-99	1.71	7.82	2.13	6.3	3.47	7.02	3.07	4.74	1.36	3.5	1.27	2.51	2.68	3.7	2.2
Oct-99															
Nov-99	1.58	7.3	1.2	3.23	2.83	6.36	2.35	3.14	0.94	2.88	1.2	2.05	1.86	2.22	1.82
Dec-99	2.64	8.02	2.09	4.31	3.6	7.2	3.15	4.7	1.2	4.1	1.4	3.16	2.68	2.94	2.62

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1.ELURU

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
18/07/1996	1.7	7.12	1460	954	0	420	174	0.1	113	64	128	34	460	2.29	-0.8
22/11/1996	1.93	7.32	1623	1039	0	426	183	0.1	54	8	120	44	460	3.05	-1.1
15/05/1997	2.52	7.01	1465	936	0	424	148	0.1	150	10	64	53	380	3.35	0.89
03/12/1997	2.31	7.13	1514	969	0	409	160	0 1	117	9	112	53	500	2.28	-1.78
25/05/1998	2.98	6.85	4500	2880	0	369	133	0.5	500	94	120	219	1200	8.21	-16.23
30/11/1998	2.3	7.49	1480	947	0	333	232	0.5	153	34	96	34	380	3.41	-0.94
20/05/1999	4.63	7	1586	1016	0	222	110	0.1	128	10	136	39	500	2.49	-5.57
03/11/1999	1.58	6.35	1340	858	0	380	180	0.1	118	13	88	54	440	2.44	-1.24

2.PSPudi

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
18/07/1996	7.65	6.98	1050	672	0	290	96	0.1	46	95	96	24	340	1.09	-0.97
22/11/1996	7.2	6.82	890	570	0	216	104	0.1	54	6	64	44	340	1.27	-2.46
15/05/1997	8.07	8.1	704	451	0	232	52	0.1	40	62	48	15	180	1.29	1.01
03/12/1997	7.96	7.06	905	579	0	190	88	0.1	37	76	64	29	280	1	-1.78
25/05/1998	8.35	6.52	808	517	0	178	58	0.1	44	68	56	19	220	1.29	-0.8
30/11/1998	7.74	7.37	1004	643	0	289	48	0.5	69	75	96	10	280	1.79	0.16
20/05/1999	9.28	6.42	830	531	0	211	100	0.1	41	89	64	19	240	1.15	-0.54
03/11/1999	7.3	6.88	1030	659	0	190	120	0.1	72	75	88	15	280	1.87	-1.83

3.Uttarkanchi

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
18/07/1996	2.54	7.3	7100	4544	0	610	1462	0.5	725	172	168	345	1840	7.35	-24.57
22/11/1996	1.78	7.36	8720	5581	0	520	1722	0.5	867	267	224	394	2180	8.07	-32.2
15/05/1997	3.97	7.7	8250	5280	0	505	1183	0.1	889	125	40	472	2040	8.56	-30.72
03/12/1997	2.29	7.24	6740	4314	0	494	1184	0.5	650	127	168	331	1780	6.7	-25.74
25/05/1998	4	7.17	7520	4813	0	555	797	0.5	780	141	128	379	1880	7.62	-26.47
30/11/1998	1.8	6.94	8070	5165	0	455	1512	0.5	917	233	96	384	1820	16.69	-27.26
20/05/1999	4.1	7.75	7400	4736	0	621	390	0.1	689	156	144	427	2120	6.51	-29.9
03/11/1999	1.2	6.92	3760	2406	0	310	290	0.1	389	100	104	170	960	5.46	-12.98

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4.Peddipalem

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
18/07/1996	5.5	7.1	2800	1792	0	410	448	0.1	233	67	192	88	840	3.49	-8.64
22/11/1996	4.43	7.22	3450	2208	0	478	540	0.1	267	33	248	126	1140	3.44	-13.52
15/05/1997	7.14	7.52	3260	2086	0	404	365	0.1	289	20	192	117	960	4.05	-11.14
03/12/1997	5.78	7.1	3320	2125	0	428	480	0.1	250	9	240	146	1200	3.13	-15.45
25/05/1998	9.35	7.22	2960	1894	0	400	249	0.1	275	2	176	117	920	3.94	-10.42
30/11/1998	4.4	7.09	3430	2195	0	355	536	0.5	263	25	304	117	1240	3.24	-17.72
20/05/1999	8	6.95	3010	1926	0	199	110	0.1	202	19	80	204	1040	2.72	-10.8
03/11/1999	3.2	6.46	3120	1997	0	360	360	0.1	111	25	248	175	1340	1.32	-19.59

5.Ommangi

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
18/07/1996	3.54	7.27	1350	864	0	340	108	0.5	50	196	72	34	320	1.21	0.4
22/11/1996	1.63	7.32	1300	832	0	333	96	0.1	50	208	64	34	300	1.25	0.66
15/05/1997	3.85	8.46	1135	726	61	283	87	0.1	67	184	64	10	200	2.05	2.66
03/12/1997	3.18	7.41	1350	864	0	333	88	0.1	58	209	80	24	300	1.46	0.69
25/05/1998	5.3	7.08	1310	838	0	444	58	0.1	58	191	64	29	280	1.51	3.3
30/11/1998	1.53	7.66	1200	768	0	322	88	0.1	35	167	88	24	320	0.85	0.07
20/05/1999	4.43	6.15	1415	906	0	177	130	0.1	54	215	88	39	360	1.2	-4.07
03/11/1999	2.83	6.65	1296	829	0	330	90	0.1	97	125	64	39	320	2.36	0.19

Dharmavaram

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
18/07/1996	6.62	7.1	4940	3162	0	430	696	0.1	452	636	144	88	720	7.31	-5.84
22/11/1996	3.59	7.29	5700	3648	0	364	740	0.1	400	1100	136	68	6620	6.99	-5.11
15/05/1997	7.6	7.7	4650	2976	0	444	522	0.1	378	760	88	83	560	6.93	-2.35
03/12/1997	6.61	7.02	4350	2784	0	418	640	0.1	283	763	136	63	600	5.03	-3.62
25/05/1998	10.46	6.92	4530	2899	0	500	400	0.1	254	876	144	73	660	4.3	-3.2
30/11/1998	4.15	7.55	940	602	0	255	80	0.5	55	10	88	39	360	1.23	-2.51
20/05/1999	7.79	7.03	4860	3110	0	500	800	0.1	336	864	128	92	700	5.52	-3.97
03/11/1999	6.36	6.49	4050	2592	0	380	700	0.1	417	450	160	63	660	7.06	-5.58

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7.Kodavali

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
19/07/1996	2.9	7.12	3850	2464	0	470	696	0.1	426	43	128	165	1000	5.86	-10.57
23/11/1996	1.86	7.16	2500	1600	0	322	383	0.1	150	33	296	44	920	2.15	-11.98
15/05/1997	4	7.77	4470	2861	0	485	522	0.5	578	40	120	160	960	6.12	-9.46
03/12/1997	3.02	7.2	3800	2432	0	437	512	0.1	467	54	128	141	900	6.77	-9.26
25/05/1998	4.75	6.96	3460	2214	0	500	332	0.1	392	45	136	141	920	5.62	-8.4
30/11/1998	2.22	7.75	3700	2368	0	477	608	0.1	440	70	104	141	840	6.56	-7.26
20/05/1999	4.45	7.1	3730	2387	0	500	640	0.1	448	28	104	141	840	6.72	-6.8
03/11/1999	2.35	6.6	3170	2029	0	410	580	0.1	361	50	120	136	860	5.35	-8.98

8.Polukuru

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
19/07/1996	3.75	7.04	2800	1792	0	280	452	0.1	117	2	304	97	1160	1.5	-17.58
23/11/1996	1.97	7.15	1120	717	0	312	157	0.1	103	2	64	44	340	2.43	0.58
15/05/1997	5.18	7.26	3250	2080	0	162	365	0.1	200	20	72	243	1180	2.53	-20.34
03/12/1997	3.95	7.06	2400	1536	0	285	352	0.1	180	9	296	15	800	2.77	-10.33
25/05/1998	6.18	6.94	2800	1792	0	333	266	0.1	115	23	320	76	1120	2.49	-15.75
30/11/1998	2.1	7.42	2510	1606	0	89	416	0.5	164	40	80	170	900	2.36	-16.2
20/05/1999	5.79	6.73	3130	2003	0	365	520	0.1	170	18	104	229	1200	2.13	-16.83
03/11/1999	3.14	6.31	2070	1325	0	300	320	0.1	222	25	96	83	580	4	-5.63

9.Timmapuram

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
18/07/1996	2.5	7.15	1125	720	0	270	165	0.1	94	4	72	44	360	2.15	-1.82
23/11/1996	1.23	7.41	4500	2880	0	551	661	0.1	550	117	128	160	980	7.65	-8.54
15/05/1997	2.76	8.26	1006	644	0	242	87	0.1	124	4	40	39	260	3.34	-0.37
03/12/1997	1.81	7.14	1184	758	0	266	160	0.1	117	9	56	53	360	2.69	-1.89
25/05/1998	3.59	6.94	1237	792	0	311	106	0.1	127	6	48	63	360	2.84	-1.36
30/11/1998	ple not collected				0										
20/05/1999	2.93	6.94	1320	845	0	311	190	0.1	134	6	72	58	420	2.85	2.15
03/11/1999	0.94	6.37	1210	966	0	250	300	0.1	111	6	80	78	520	2.11	-5.41

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.Venkatanagaram

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
19/11/1996	1.3	6.98	7.8	453	0	270	61	0.1	35	11	88	15	280	0.91	-0.23
23/11/1996	1.37	7.06	763	488	0	239	52	0.1	43	17	72	24	280	1.12	-0.79
15/05/1997	2.13	8.27	694	444	0	212	44	0.1	49	10	56	24	240	1.38	-0.53
03/12/1997	1.66	7.02	566	362	0	190	24	0.5	35	14	64	10	200	1.07	-0.22
25/05/1998	2.1	6.98	2600	1664	0	333	249	0.1	135	75	224	92	940	1.92	-12.11
30/11/1998	1.33	6.9	710	454	0	200	64	0.5	41	64	72	24	280	1.07	-1.57
20/05/1999	2.23	6.67	616	394	0	200	60	0.1	33	9	48	29	240	0.92	-0.78
03/11/1999	1.2	6.25	5.2	321	0	130	70	0.1	31	10	48	19	200	0.96	-1.36

.Santi Asramam

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
19/07/1996	2.2	7.61	1256	804	0	360	157	0.5	171	2	48	34	260	4.61	2
22/11/1996	2.78	7.29	865	554	0	332	56	0.5	67	2	80	29	320	1.63	0.26
15/05/1997	3.63	7.21	1036	662	0	364	44	0.1	100	5	56	39	300	2.51	1.67
03/12/1997	3.18	7.19	867	555	0	304	40	0.5	64	3	64	34	300	1.61	0.08
25/05/1998	3.65	7.01	777	497	0	333	33	0.1	58	3	56	29	260	1.57	1.48
30/11/1998	2.82	7.28	883	565	0	211	96	0.5	76	3	64	29	260	1.98	-1.38
20/05/1999	3.86	6.97	877	561	0	277	80	0.1	86	23	64	15	220	2.51	1.11
03/11/1999	2.05	6.51	726	465	0	280	40	0.1	56	2	40	34	240	1.57	1

2.Sarabhavaram

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
19/07/1996	4.75	7.03	3400	2176	0	260	628	0.1	200	67	320	97	1200	2.51	-18.28
22/11/1996	1.75	7.05	3000	1920	0	270	557	0.1	167	133	280	73	1000	2.3	-14.6
15/05/1997	4.69	7.11	3450	2208	0	253	435	0.1	280	80	304	78	1080	3.7	-16.55
03/12/1997	4.12	7.02	3210	2054	0	238	460	0.1	200	60	280	102	1120	2.6	-17.63
25/05/1998	6	6.81	3000	1920	0	289	332	0.1	138	23	312	97	1180	1.75	-17.6
30/11/1998	1.62	7.6	2770	1773	0	222	472	1	153	54	112	170	980	2.13	-15.14
20/05/1999	4.69	6.82	3100	1984	0	377	590	0.1	229	59	312	97	1180	2.78	-16.04
03/11/1999	2.88	6.33	2450	1568	0	240	600	0.1	93	82	264	83	1000	1.28	-15.23

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13.Gollaprolu

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
15/05/1997	4.43	7.33	3700	2368	0	364	435	0.1	420	165	240	39	760	6.62	-7.93
03/12/1997	2.82	7.52	1880	1203	0	380	216	0.1	145	150	104	44	440	3	-1.22
25/05/1998	3.96	7.43	1830	1171	0	276	149	0.1	150	112	104	44	440	3.1	-3.26
30/11/1998	1.53	7.6	1860	1190	0	277	260	0.5	153	13	80	112	480	2.59	-7.67
20/05/1999	4.07	7.22	3460	2208	0	544	440	0.1	213	238	240	88	960	2.99	-8.46
03/11/1999	1.86	6.65	1525	976	0	200	220	0.1	81	81	120	58	540	1.52	-6.77

14.Vakapalli

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
19/07/1996	3.2	6.97	2520	1613	0	260	383	0.1	183	133	160	73	700	3.01	-8.8
22/11/1996															
15/05/1997	4.13	6.99	2600	1856	0	303	383	0.1	240	110	200	83	840	3.6	-10.77
03/12/1997	3.47	6.74	2200	1408	0	200	400	0.1	164	120	168	58	660	2.78	-1.22
25/05/1998	5.62	6.45	2200	1408	0	200	291	0.1	173	79	160	49	600	3.07	-8.03
30/11/1998	2.24	7.65	2390	1530	0	233	416	1	184	135	272	19	760	2.91	-10.5
20/05/1999	4.72	6.67	2280	1459	0	266	150	0.1	204	83	176	49	640	3.5	-7.51
03/11/1999	2.22	6.17	1900	1216	0	230	410	0.1	163	87	120	49	500	3.16	-5.43

15.Prattipadu

Date	DTW	Ph	Sp.Cond.	TDS	CO3	HCO3	Cl	F	Na	K	Ca	Mg	T Hardness	SAR	RSC
03/12/1997	2.57	7.41	1730	1107	0	437	160	0.5	236	18	56	53	360	5.42	1.58
25/05/1998	3.35	7.26	1639	1049	0	444	125	1	85	11	48	68	400	4.02	0.89
30/11/1998	2.1	7.16	1802	1153	0	422	100	1	235	13	80	49	400	5.1	0.41
20/05/1999	3.79	7.46	1607	1028	0	555	180	0.1	214	13	48	88	480	4.24	1.4
03/11/1999	1.82	6.81	1405	899	0	460	140	0.1	163	31	72	49	380	3.63	1.37

Annex-3

Description & Location of OB wells in Suddagedda Basin

Sl.No.	Well location	Longitude	Latitude	Total Depth	Diameter	Msl of M.P	M.P above G.L	Geology
1	Eluru	82°09'45"E	17°15'40"N	8.65	4.39	53.373	1.05	Alluvium
2	PSPudi	82°10'40"E	17°17'45"N	10.19	2.8	67.078	1.25	Crystalline
3	Uttarkanchi	82°12'36"E	17°17'38"N	7.82	2.25	65.148	0.825	Alluvium
4	Peddipalem	82°13'00"E	17°18'50"N	11	1.8	76.428	0.855	Alluvium
5	Ommangi	82°13'35"E	17°15'30"N	10.95	2.85	49.799	1.145	Crystalline
6	Dharmavaram	82°13'40"E	17°13'40"N	16.9	2.58	46.54	0.885	Crystalline
7	Kodavali	82°16'40"E	17°13'40"N	8.3	2.48	33.187	1.06	Crystalline
8	Potuluru	82°16'25"E	17°15'36"N	9.75	2.45	43.385	1.071	Crystalline
9	Ptimmapuram	82°13'30"E	17°10'15"N	4.08	1.95	43.027	0.325	DeccanTrap
10	Vnagaram	82°17'55"E	17°17'22"N	8.3	1.8	64.825	0.7	Crystalline
11	S Ashram	82°17'37"E	17°17'50"N	6.74	2.42	61.694	1.325	Crystalline
12	Sarabhavaaram	82°15'45"E	17°17'07"N	11.2	1.95	58.279	0.77	Crystalline
13	Vakapalli	82°17'03"E	17°16'22"N	8.3	2	49.654	1.535	Crystalline
14	Prattipadu	82°12'00"E	17°13'30"N	7.45	2.02	36.957	0.96	Alluvium
15	Gollaprolu	82°17'15"E	17°09'20"N	6.25	0.75	11.875	0.53	Alluvium

* All units are in metres

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