

CONJUNCTIVE USE STUDIES IN KRISHNA DELTA SYSTEM (PART-I) - STATUS OF DATA AVAILABILITY



आपो हि ष्टा मयोभुवः

DELTIC REGIONAL CENTRE
NATIONAL INSTITUTE OF HYDROLOGY
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FOREWARD

The deltaic regional centre was established at Kakinada in Andhra Pradesh to conduct application oriented research and studies in Eastern Coastal Region and Deltaic Region including the Islands. The Regional Coordination Committee which looks into the various technical and scientific work programmes of the regional centre in its meeting held on December 10, 1992 suggested that regional centre should take up the Conjunctive use studies for which a part of Krishna delta system of Andhra Pradesh was identified. It was also decided that studies would be jointly conducted by the State Ground Water Department of Andhra Pradesh and the Regional Centre of NIH.

Dr. P.V.Seethapathi, Scientist 'F' and Technical Coordinator of the regional centre held detailed discussion with Shri T.Narasimha Reddy, Director, State Ground Water Department regarding various modalities to be undertaken for this collaborative project. It was agreed during their meeting that State Ground Water Department will assist the NIH Regional Centre for collecting the necessary data as is required for conducting the studies. The information, thus, collected will be utilised for conducting the Conjunctive Use studies.

As a part of this collaborative project between State Ground Water Department of Andhra Pradesh and NIH Regional Centre, Kakinada, the State Ground Water department was requested to prepare a Status report (Status regarding the available instrumentation, network, data availability) in the Pilot area of Krishna delta system of Andhra Pradesh for initiating Conjunctive Use Studies by the Regional Centre of the Institute. The present report, thus forms Part-I of the Conjunctive Use Studies for the Krishna delta system and is prepared by the State Ground Water Department of Andhra Pradesh.

Satish Chandra
(Satish Chandra)
Director

PREFACE

Conjunctive use of ground water with surface water resources has been a subject receiving considerable attention in Andhra Pradesh since 1972 and has attained utmost importance during the recent years. The growing demand for providing assured irrigation for more areas to increase the food grain production, in order to meet the requirements of the growing population of our country has made it imperative to take up conjunctive use more seriously. The recent ground water assessment carried out for the State revealed that more than 50% of the groundwater resources available in the State exist in the command areas of surface water projects.

The Ground Water Department has taken up extensive studies in the command areas of four select major irrigation projects in the State. Investigations were also carried out in Krishna- Godavari delta system to study the feasibility of conjunctive use. The use of drain waters conjunctively with canal water in Krishna delta Region was also explored. The Krishna Eastern and Central delta flanked by Kollerulake on the East has got maximum variation in the groundwater quality ranging from potable water to highly saline water. The salt water-fresh water interface was identified in this region. The canal network system existing in this region is not able to cope with the water requirements of the entire extent, especially in the tailend reaches. Paddy is limited to Kharif season in some pockets due to non-availability of water in the Rabi Season. Perennial crops like Sugarcane are limited to smaller extents due to practical problems involved in ensuring canal water supplies throughout the year.

In order to find solutions for these problems and to augment canal supplies to the tailend reaches and extend the duration of

irrigation supplies, detailed studies are to be conducted in this Region.

The Deltaic Regional Centre of the National Institute of Hydrology at Kakinada has proposed to take up conjunctive use studies in a part of Krishna delta system in collaboration with the Ground Water Department, Government of Andhra Pradesh, in 1993-94. The objective of the study is to evolve an appropriate strategy for implementation of conjunctive use and to optimise the benefits. This report has been prepared by the Ground Water Department, to present the status of data availability with regard to various hydrological and hydrogeological aspects for the area selected for the pilot study.

The report has been prepared by Sri D Vijaya Saradhi, Assistant Hydrogeologist, and Sri K Sreenivas, Technical Assistant (Hydrology), Vijayawada under the guidance of Sri P Prakasam, Dy. Director (Hydrology) and Sri Y Srinivasa Rao, Dy. Director (Hg).

Dt:28.4.93

(T Narasimha Reddy)
Director, Ground Water Department
Hyderabad, Andhra Pradesh

1.0. INTRODUCTION

The deltaic regional centre, National Institute of Hydrology, Kakinada, as a part of its collaborative studies for the year 1993-94, proposed to take up Conjunctive Use Studies in Krishna Delta Region in association with the Ground Water Department, Government of Andhra Pradesh. This report has been prepared by the Ground Water Department to reflect the Conjunctive Use practices now in vogue and the present status of groundwater development in this area. The area lies between East longitudes $80^{\circ}40'10''$ - $80^{\circ}52'30''$ and North latitudes $16^{\circ}22'30''$ - $16^{\circ}30'30''$ and falls in the toposheets No. 65 D/11, 65 D/15. A net work of Krishna canal system forms the main source of irrigation in this area. The three major canals passing through this area are 1. East Bank Canal 2. Bandar Canal 3. Ryves Canal. Among these three canals, Bandar Canal has got major and minor channel net work in the proposed area. The east bank canal essentially feeds the lower reaches of the delta region. The Ryves Canal contributes mostly to the Eastern parts of the delta region and its command does not form part of the proposed area of study.

2.0 PHYSIOGRAPHY

A Total area of 253 sq.km was selected for the proposed studies. The list of villages in this area are shown in Annexure VI. The south east boundary is marked by the Vuyyuru Channel and the south western limit of the area is marked by the Vallurupalem lock on the East Bank Canal. The topography of the area taken up for the conjunctive use studies is generally flat with gentle slope towards south and east. The highest elevation in the study area is the northern corner near Yanamalakuduru Lock is 20.2 m. The 10 m contour is passing near the southern boundary of the

proposed area.

The channel net work occupying the entire area of study is originating mostly from Bandar canal. The canal net work is shown in Plate 1. The hydraulic particulars of channels that are existing in the area of study are given in Annexure -I.

The area is influenced by tropical climate. The minimum and maximum temperatures in this zone are 16°C - 41.6°C respectively. The rainfall of this area is contributed through both south west and north east monsoons. Of this, the south west monsoon contributes maximum rainfall in this area. The normal annual rainfall recorded in the rain gauge station at Vijayawada is 959.4 mm. Of this, 854.2 mm comes from the south west monsoon.

3.0 LAND USE

The total geographical area is 25300 hectares. Out of this, an extent of 15364 hectares is under cultivation. The main crops that are grown in this area are paddy and sugarcane. The other crops generally cultivated are jowar, turmeric and vegetables. paddy is grown in Kharif season and vegetables are grown in both kharif and rabi seasons.

Of the total cultivable land, paddy occupies first position with 10,910 hectares of area, forming 71.48% of the total cultivable land. Sugarcane is the second major crop which is grown in 3,369 hectares (22.07%). The other crops viz. turmeric and vegetables are grown in an extent of 632 and 162 hectares respectively. This forms 5.20% of the total cultivable land. The details of land use and the area occupies by various crops are shown in Annexure -II.

The are is generally covered by black cotton soils with the percentage of clay ranging from 65 to 70% and these soils are classified as silt and clay type.

4.0 HYDROGEOLOGY

The area is underlain by recent alluvium of fluvial origin. The hydrogeological map is presented in Plate-2. The formation consists of sand, silt, gravel and clay. Groundwater in this area occurs under watertable, semiconfined and confined conditions. The watertable fluctuations are limited and range from 1 to 2 m. The filter point wells constructed in this area range in depth from 10 to 20 m and shallow tube wells range from 30 to 80 m. The depth to water level ranges from 1 to 6 m bgl. The water table contour map is given in Plate No.3

The yields of filter points and shallow tube wells range from 25,000 to 60,000 lph, for 0.5 to 3.0 m of draw down. The lithological sequence is characterised by the presence of alternative layers of sand and clay. Depth of the fine, medium and coarse sand layers varies with the location. Depth ranges of the sand layers are 15 to 20 m., 30-50m. and 60-80m. Thickness of sand zone varies from 3 to 12 m depending on their location. The granular zone forms a watertable aquifer. At places this is separated by clay lenses forming the semiconfined and confined aquifers. The filter points and shallow tubewells sustain steady pumping levels after 20 to 30 minutes of pumping, indicating high permeability and adequate recharge. In order to understand the subsurface lithology, complete data of a tube well drilled near Badrirajupalem lanka is shown in Annexure-III.

In general, canal water of Krishna delta is of C_2S_1 type. The ESC ranges from 0 to 0.18 epm. The salinity range from 490-756 microseimens/cm. The alkali hazard varies from 1.36 to 1.61. The Na-Mg- HCO_3 -Cl facies of Vuyyuru observation well water indicate shallow water table conditions and the groundwater has slightly higher concentration of dissolved solids due to evaporation with

less concentration of Magnesium- ions. The specific conduction contour map is given in Plate No.6.

The influence of the River Krishna on the ground water potential of the villages near to its banks is most conspicuous. Both the river and the canals influence the shall aquifer. The deep aquifer zones tapped through shallow tube wells are less affected.

A study of the behaviour of water table in terms of recharge and discharge was attempted and it was found that the Poranki village represents the area of recharge which is located outside the present study area. Here the River Krishna continuously contributes to the recharge of the permeable substrata. The river has influent character. This is reflected by the watertable contours which are bent towards the downstream side. The lower reaches of the Krishna delta i.e. the far south of the project study area forms the discharge area.

The local impervious clay barriers in this area held in the development of groundwater mounds at select places. More studies have to be carried out to identify these mounds and to utilise their groundwater potential in areas of poor quality.

5.0 HYDROLOGY

The area is covered by Krishna Canal net work system. Three major canals are running in this area. These are 1. East Bank Canal. 2. Bandar Canals and 3. Ryves Canal. These canals run for 250 days in a year. The East Bank and Ryves Canals branchout mostly outside the area of present study. Bandar Canal is the main irrigation source for this area. Aquifer performance test conducted on a dug-cum-borewell piercing alluvial formation comprising mostly clay and limited thickness of sand showed very negligible drawdown in the observation well situated at a distance

of 100 m. The values of transmissivity and storage coefficient are 6243 cum/d/m and 4.47×10^{-3} respectively, as obtained from analysis of the data of a pumping test conducted on a filter point in the area.

In the observation well network of Krishna district three observation wells fall in the study area. These are 1. Kankipadu 2. Vuyyuru and 3. Thootlavalluru. The hydrograph of the observation well at Vuyyuru is shown Plate No.4. The hydrograph is generally flat showing no decline in the ground water levels This indicates the high potential nature of the aquifer in this area. Marginal water table decline is periodically observed in the month of May indicating the effect of rainfall/ deficit and high ground water utilisation due to closure of the canals during this period, for raising seed beds in and around this area. A statement of the observation well data with chemical quality is given in Annexure-IV. The rainfall data of Vijayawada and Vuyyuru rain gauge stations are given in Annexure-V.

6.0 GROUND WATER POTENTIAL

Ground Water potential was calculated for the four mandals that are falling in the present study area. Among these four mandals, pernamaluru is completely covered and the other three mandals are partially covered. The ground water potential is computed based on the percentage of area falling in the present study area.

As per the calculations, the total geographical area covered under the present study is 253 sq.km and to no. of villages falling in this area are 31. The total utilisable ground water recharge is 86.46 MCM. The total no. of existing wells in this area are 1007. The net annual draft, groundwater balance and no.

of additional wells feasible are shown in annexure VII. The present stage of development is limited to 21% in this area. Based on the high recharge character of the aquifer and limited draft conditions, more exploitation may be taken up in this area. The ground water exploited by means of shallow tube wells and filter points can be utilised in the areas where the aquifer is of poor quality and during the closure of canal system in this zone.

A N N E X U R E - I
STATEMENT SHOWING HYDRAULIC PARTICULARS OF CANALS OF THE PROPOSED AREA FOR CONJUNCTIVE USE STUDIES IN KRISHNA DELTA

S.No.	Name of the Canal Branch	Project	Category	Reach in km. From To	Length (km).	Bed width (m).	Full supply depth (m).	Wetted perimeter (m).	Wetted area (sq.m).	Soil type	Seepage losses (mcum)
1	2	3	4	5(a) 5(b)	6	7	8	9	10	11	12
1	Krishna East Bank Canal	Krishna delta	Main canal	7.486 23.924	16.438	25.60	25.24	34.68	570069 or 570070	Clay	0.310793
2.	Ryves Canal	-do-	-do-	23.924 54.001	4.827					Clay	0.100464
	-do-	-do-	-do-	9.654 14.481	3.209					Clay	0.066789
	-do-	-do-	-do-	14.481 17.690	3.227					Clay	0.0671637
	-do-	-do-	-do-	17.690 20.917	4.013					Clay	0.0835228
	-do-	-do-	-do-	20.917 24.930	7.410					Clay	0.135977
	-do-	-do-	-do-	24.930 32.340						Clay	
3.	Bandar Canal	-do-	-do-	7.486 20.378	12.892	25.90	2.70	33.5356	432341	Clay	0.252141
	-do-	-do-	-do-	20.378 30.175	9.797	13.19	2.43	19.9731	195676	Clay	0.102706
	-do-	-do-	-do-	30.175 35.466	5.291	11.58	2.50	18.65	98677	Clay	0.053286
4.	Upper Pulleru Canal	-do-	-do-	20.278 23.216	2.938	25.90	1.37	29.77	97479	Clay	0.0258968
	-do-	-do-	-do-	23.216 35.106	11.890	28.20	1.82	33.347	396495	Clay	0.155870
	-do-	-do-	-do-	35.106 41.005	5.899	19.81	2.13	25.835	152392	Clay	0.070115
5.	Newnidamaru Channel	-do-	Major Channel	0.00 5.383	5.383	2.440	0.61	4.165	22420		0.029541
	-do-	-do-	-do-	5.383 6.282	0.899	1.676	0.564	3.271	2740		0.003582
6.	Edupugolluchannel	-do-	-do-	0.00 1.416	1.416	2.057	0.92	4.659	6597		0.013109
	-do-	-do-	-do-	1.416 2.430	1.014	1.372	0.61	3.097	3140		0.004137
	-do-	-do-	-do-	2.430 3.825	1.395	0.91	0.46	2.211	3084		0.003064
	-do-	-do-	-do-	3.825 5.031	1.206	0.91	0.31	0.998	1204		0.000006
7.	Kolaveru channel	Krishna Delta	-do-	0.000 1.873	1.873	1.22	0.88	3.709	6947	Clay	0.013205
	-do-	-do-	-do-	1.873 4.024	2.151	1.067	0.64	2.877	6198	Clay	0.008554
	-do-	-do-	-do-	4.024 7.274	3.250	0.91	0.610	2.635	8564	Clay	0.011284

ANNEXURE - I
STATEMENT SHOWING HYDRAULIC PARTICULARS OF CANALS OF THE PROPOSED AREA FOR CONJUNCTIVE USE STUDIES IN KRISHNA DELTA.

S.No.	Name of the Canal Branch	Project	Category	Reach in km.		Length in width (km)	Bed width (m)	Full supply depth (m)	Wetted perimeter in (m)	Wetted area (sq.m)	Soil type	Seepage Losses (mcch)		
1	2	3	4	From	To	5(a)	5(b)	6	7	8	9	10	11	12
8.	Punadipadu Chanel	-do-	-do-	0.0	1.006	1.006	1.18	0.85	3.594	3606	Clay	0.006621		
	-do-	-do-	-do-	1.006	2.618	1.612	0.91	0.80	3.173	5115	Clay	0.008838		
	-do-	-do-	-do-	2.618	4.789	2.170	0.91	0.45	2.183	4737	Clay	0.004604		
9.	Gosala Chanel	-do-	-do-	0.0	0.989	0.989	2.36	0.66	4.227	4180	Clay	0.005959		
10.	Nambigunta Chanel	-do-	-do-	0.0	1.067	1.067	1.676	0.67	3.571	3810	Clay	0.005514		
	-do-	-do-	-do-	1.067	5.837	4.77	1.6	0.53	3.099	14782	Clay	0.016922		
11.	Valluru Chanel	-do-	-do-	0.00	2.215	2.215	2.21	0.59	3.878	8590	Clay	0.010947		
12.	Prodduturu Chanel	-do-	-do-	0.00	0.544	0.544	4.725	1.40	8.685	4725	Clay	0.014288		
	-do-	-do-	-do-	0.544	5.655	5.112	3.50	1.00	6.328	32343	Clay	0.069861		
	-do-	-do-	-do-	5.655	7.507	1.952	2.81	0.96	5.242	10232	Clay	0.019007		
	-do-	-do-	-do-	7.507	9.218	1.609	1.82	0.79	4.056	6525	Clay	0.0111343		
13.	Kunduru Chanel	-do-	-do-	0.00	1.270	1.270	0.99	0.65	2.828	3592	Clay	0.005043		
	-do-	-do-	-do-	1.270	2.053	0.783	0.91	0.43	2.126	1665	Clay	0.001546		
14.	New Kolavennu Chanel	-do-	-do-	0.00	1.540	1.540	3.65	0.61	5.375	8277	Clay	0.010906		
	-do-	-do-	-do-	1.540	2.270	0.730	1.37	0.61	3.095	2259	Clay	0.0029765		
15.	West side Chanel	-do-	-do-	20.237	23.737	3.500	3.88	0.91	6.454	22589	Clay	0.044401		
	-do-	-do-	-do-	23.737	27.177	3.440	2.97	0.91	5.544	19071	Clay	0.037486		
	-do-	-do-	-do-	27.177	28.183	1.006	2.99	1.06	5.888	5923	Clay	0.013561		
15.	West side channel	Krishna delta	Major channel	28.183	30.095	1.912	2.20	0.91	4.774	9128	Clay	0.017942		
	-do-	-do-	-do-	30.095	33.314	3.219	1.82	0.91	4.394	14144	Clay	0.027801		
	-do-	-do-	-do-	0.00	1.213	1.213	3.65	0.99	6.450	7824	Clay	0.016731		
16.	Boddapadu Chanel	-do-	-do-	1.213	1.487	0.274	1.67	0.99	4.470	1225	Clay	0.0026195		
	-do-	-do-	-do-	1.487	1.526	0.039	1.52	0.99	4.320	168	Clay	0.000359		
	-do-	-do-	-do-	1.526	2.490	0.964	1.21	0.58	3.133	3020	Clay	0.004436		
	-do-	-do-	-do-	2.490	3.200	0.710	1.21	0.68	3.133	2224	Clay	0.003266		
	-do-	-do-	-do-	3.200	4.339	1.139	1.37	0.68	3.293	3751	6day	0.005509		
	-do-	-do-	-do-	4.339	5.063	0.724	1.21	0.58	3.133	2268	Clay	0.003331		
	-do-	-do-	-do-	5.063	5.298	0.235	1.21	0.68	3.133	736	Clay	0.001081		
	-do-	-do-	-do-	5.298	5.713	0.415	1.21	0.68	3.133	1300	Clay	0.001909		

ANNEXURE II

Statement showing the land utilisation particulars of the proposed area for conjunctive use studies , Krishna Delta

Sl.No.	Name of the Mandal	Cropping pattern	Extent		
			Khariff	Rabi	Total
(Hectares)					
1.	Penamaluru	Paddy	3590	-	3590
		Jawar	95	6	101
		Sugar cane	988	-	988
		Turmeric	354	-	354
		Vegetables	77	162	239
2.	Kankipadu	Paddy	3516	22	3538
		Sugarcane	961	-	961
		Turmeric	69	-	69
3.	Vuyyuru	Paddy	2559	-	2559
		Sugarcane	590	-	590
		Vegetables	55	20	75
4.	Thotiavalluru	Paddy	1246	-	1246
		Sugarcane	830	-	830
		Turmeric	210	-	210
		Fruits	79	-	79
		Vegetables	45	12	57

LITHOLOGICAL DATA OF BADRIRAJUPALEM LANKA TUBE WELL, KRISHNA DELTA

1. Code No. of Tube well LM-03-024-KR
2. Name of village Badrirajupalem Lanka
3. Mandal : Valluru District : Krishna
4. Location : Latitude : 16°19'25" Longitude : 80°46'30"
5. Programme under which the tube well was drilled S.C. Programme
6. Drilling operations : Date of starting 14.2.86 Date of completion 26.2.86 Financial year 1985-86
7. Whether bed rock encountered or not YES
8. Geology and Age River Alluvium recent
9. Diameter of the tube well 200 mm
10. Lithology of the tube well

Formation	Description	Depth range		Thickness of aquifer m.	Commulative thickness of aquifer m.
		From m.	to m.		
	Sticky clay, Black	0.00	3.00		
	Sandy mixed with clay fine to medium yellowish brown	3.00	12.00		
	Clay mixed with little sandy grey to pale brown	12.00	18.00		
	Sands, medium to coarse yellowish brown	18.00	76.00		
	Clay mixed with fine sand	76.00	79.00		
	Clay semihard, Black	79.00	81.40		

12. Assembly lowered:

From m.	To m.	Diameter mm.	Housing depth m.	Type
0.00	0.50 agl.	Blank 8"	(Housing)	
0.00	30.50 bgl.	Blank 8"	"	
30.50	49.30 bgl.	Slotted 6"		
49.30	51.40 bgl.	Blank 6"		
51.40	76.20 bgl.	Slotted 6"		
76.20	77.30 bgl.	Blank 6" with bail plug		

13. Static Water level (m.bgl) 6.60 m

14. Discharge (LPM) During Drilling

Recommended --

During testing 660 lpm.

15. Drawdown (m) During Testing 1.25 m.

Recommended --

16. Specific Capacity 'C' (1/m/dd) 527.8 lpm/mdd.

17. Transmissibility (T)(M²/day) --

18. Storage Co-efficient (S) --

19. Category --

20. Type of pump/HP recommended Submersible

21. Purpose for which tube well is meant Irrigation

22. Irrigation potential (Hect) -- Wet : -- Dry : 15 Hec

23. Chemical quality of the formation water :

pH	EC	Total	CO ₃	HCO ₃	Na	K	Cl	Ca	Mg
(micro/mhos) hardness									
8.19	7.71	340	nil	275	50	4	44	28	66
				5.5	2.11	0.10	1.24	1.4	5.43

1. The litholog shows that sticky black clay is encountered to a depth of 3 m from the surface. This layer is followed by clay mixed with fine to medium sand down to a depth of 18 m . The main productive aquifer zone starts from 18 m depth and continues upto a depth of 76 m. This zone contains coarse sand, yellowish brown in colour. The aquifer zone is underlain by clay zone, hard and compact in nature. The litholog indicates the semi-confined nature of the aquifer, as the deeper aquifer is connected to the water table through the semi - confined layer of fine sand with clay.

- A I N E A U R E - IV
 CHEMICAL ANALYSIS DATA OF OBSERVATION WELLS IN: THE PROPOSED AREA OF CONJUNCTIVE USE STUDIES IN KRISHNA DELTA

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Month year	Aquifer depth tapped (m)	Date of collection	pH at 28°C	Sp. C. at 25°C in mic. roseina-ns/cm ²	I.D.S. calcilla- ted by multipl- cation of SPC by 0.64	Co ₃ Mg/l	HCO ₃ Mg/l	Cl Mg/l an	F Mg/l	No Na Mg/l	K Mg/l	Ca Mg/l	Mg/l	Total hardness as CaCO ₃	Geology	SAR	% Na	RSC	
May 1985	2.86	16-5-85	8.20	1208	773	n11	276	247	-	158	22	16	53	250	Alluvium	4.28	-	0.36	
November 1985	2.10	28-11-85	8.32	2300	1472	110	5.52	6.97	-	6.87	0.55	0.80	4.36	530	"	C ₅ S ₁	4.17	0.95	
May '86	3.90	29-5-86	7.32	5350	3424	n11	602	1254	-	9.61	1.99	5.20	5.43	1080	"	C ₄ S ₁	8.78	9.53	
November 1986	6.70	4-11-86	7.33	2605	1667	n11	446	415	-	28.53	4.55	3.00	13.57	480	"	OG	5.79	0.69	
May '87	3.20	21-5-87	7.30	2140	1370	n11	326	470	0.10	12.70	2.64	3.20	6.41	280	"	C ₄ S ₂	22.93	4.63	
November 1987	1.58	4-11-87	7.46	1385	580	n11	128	312	0.20	10.70	8.95	0.50	4.77	300	"	C ₄ S ₂	5.19	2.04	
May 1988	3.15	29-5-88	7.60	3960	2534	n11	493	410	0.10	8.96	0.97	1.60	4.36	540	"	C ₃ S ₂	11.95	-0.98	
November 1988	1.82	14-11-88	7.56	3360	2150	n11	678	660	0.10	64.0	102	73	38	640	"	C ₄ S ₄	7.48	0.32	
May '89	4.35	10-5-89	7.92	3280	2099	n11	285	749	0.20	28.96	2.02	5.60	7.24	600	"	C ₃ S ₂	7.28	6.31	
November 1989	1.15	24-11-89	7.60	4350	2764	n11	737	959	0.10	667	77	128	92	700	"	C ₄ S ₂	10.62	0.77	
May 1990	0.69	29-5-90	8.13	2000	1280	n11	252	324	0.10	29.00	1.97	6.40	7.57	250	"	C ₄ S ₃	8.12	-0.12	
November 1990	1.00	27-10-90	8.01	3500	2240	n11	627	490	0.10	13.04	1.20	3.60	1.56	400	"	C ₃ S ₂	12.65	4.57	
May 1991	2.10	7-5-91	7.68	3580	2291	n11	653	764	0.10	25.26	1.76	3.20	4.77	480	"	C ₄ S ₄	11.23	3.49	
November 1991	1.02	17-12-91	8.96	3000	1920	104	5.08	562	0.10	417	70	96	68	520	"	C ₄ S ₃	7.95	1.85	
May 1992	3.11	27-5-92	6.25	2650	1696	n11	291	553	0.10	18.13	1.79	4.50	5.59	380	"	C ₄ S ₂	10.33	1.78	
November 1992	3.15	24-11-92	7.70	2200	1906	n11	519	235	0.50	200	7	136	78	660	"	C ₃ S ₁	3.90	-2.83	
May 1990	3.93	29-6-90	8.32	1481	949	63	221	74	0.10	8.70	0.18	6.30	6.41	380	"	C ₃ S ₁	4.15	-1.92	
November 1990	3.33	25-11-90	8.45	2160	1382	38	241	257	0.50	8.09	0.26	4.80	2.80	420	"	C ₃ S ₁	6.66	-2.82	
May 1991	5.30	7-3-91	7.58	1756	1124	n11	307	235	0.10	13.65	0.26	2.40	6.00	400	"	C ₃ S ₂	5.13	-1.84	
November 1991	3.79	17-12-91	7.58	2600	1664	62	426	245	0.10	10.26	0.08	2.00	6.00	640	"	C ₃ S ₁	4.98	-3.03	
May 1992	7.07	18-5-92	8.50	1100	704	39	272	116	0.10	12.61	0.20	5.60	7.24	420	"	C ₄ S ₂	4.96	-2.15	

11 2 11

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
						3. Thotlavalluru													
November 1989	6.35	24-11-89	7.62	11.50	236	nil	364 7.28	85 2.40	0.50	-	93 4.04	140 3.58	32 1.60	39 3.21	240	Alluvium	2.61 C ₂ S ₁	-	2.4 May
May 1990	6.52	10-6-90	8.60	13.00	8.32	42 0.84	2.21 4.42	138 3.89	0.10	-	101 4.39	145 3.71	56 2.80	34 2.80	280	"	2.62 C ₂ S ₁	-	-0.3 FS
November 1990	6.78	27-1-90	8.03	13.63	872	nil	285 5.70	119 3.30	0.50	-	129 5.61	180 4.81	24 1.20	25 3.38	180	"	4.19 C ₂ S ₁	-	2.1 Marginal
May 1991	8.12	8-5-91	7.32	7.54	483	nil	250 5.00	49 1.38	0.10	-	49 2.13	48 1.23	40 2.00	34 2.80	240	"	1.37 C ₂ S ₁	-	0.2 FS
November 1991	6.74	17-12-91	7.95	11.95	765	42 0.84	229 4.58	86 2.43	0.10	-	112 4.87	116 2.97	40 2.00	29 2.38	220	"	3.29 C ₂ S ₁	-	1.64 FS
May 1992	8.15	27-5-92	8.45	54.6	349	39 0.78	184 3.68	39 1.10	0.10	-	31 2.22	54 1.38	24 1.20	15 1.23	120	"	2.01 C ₂ S ₁	-	2.03 Marg

ANNEXURE - V
STATEMENT SHOWING THE RAINFALL DATA FROM JUNE 1985 OF DIFFERENT RAIN GAUGE STATIONS IN THE PROPOSED AREA FOR CONJUNCTIVE USE STUDIES IN KRISHNA DELTA

S.No.	Name of the Station	Year	Rain fall (mm)												Total rain fall during monsoon (mm)	Annual rain fall (mm)
			January	February	March	April	May	June	July	August	September	October	November	December		
1.	Vijayawada	1985	-	-	-	-	-	116.7	150.3	195.0	48.8	233.1	22.6	87.0	766.5	553.5
		1986	17.8	Nil	Nil	1.2	3.2	97.4	124.6	383.3	100.8	22.0	0.6	5.60	708.7	723.5
		1987	Nil	Nil	92.4	4.5	8.4	32.0	85.8	67.0	79.2	154.8	170.6	13.5	589.4	728.2
		1988	Nil	15.2	4.1	19.8	45.9	107.3	537.6	370.1	153.6	25.2	Nil	40.4	1193.8	1318.2
		1989	Nil	Nil	33.6	Nil	15.2	96.6	526.0	258.7	318.7	44.8	7.4	Nil	1252.2	1311
		1990	28	Nil	38.0	11.4	290.9	173.4	92.8	156.9	13.7	104.8	34.7	Nil	594.3	1052.6
2.	Vuyyuru	1985	-	-	-	-	-	117.0	DNA	265.6	59.2	157.6	12.6	48.2	612	722.2
		1986	30.0	22.8	Nil	36.0	5.0	141.5	108.5	299.8	17.1	20.8	62.4	4.4	650.1	723.3
		1987	Nil	Nil	25.2	40.0	Nil	78.2	90.3	314.4	50.8	172.8	130.4	4.4	836.9	922.5
		1988	Nil	Nil	Nil	52.5	14.2	33.3	402.5	400.7	222.8	16.2	Nil	43.6	1075.5	1152.8
		1989	Nil	Nil	48.7	9.2	6.4	90.4	308.7	244.2	110.4	37.6	17.0	Nil	858.3	922.5
		1990	0.80	39.2	34.2	3.2	352.0	193.7	108.5	122.6	164.6	152.9	25.2	4.2	767.4	1211
1991	Nil	Nil	Nil	Nil	52.2	121.9	64.4	212.6	-	-	-	-	398.9	451.1		

*Complete data not available.

LIST OF VILLAGES FALLING IN THE PROPOSED AREA FOR CONJUNCTIVE USE
STUDIES IN KRISHNA DELTA

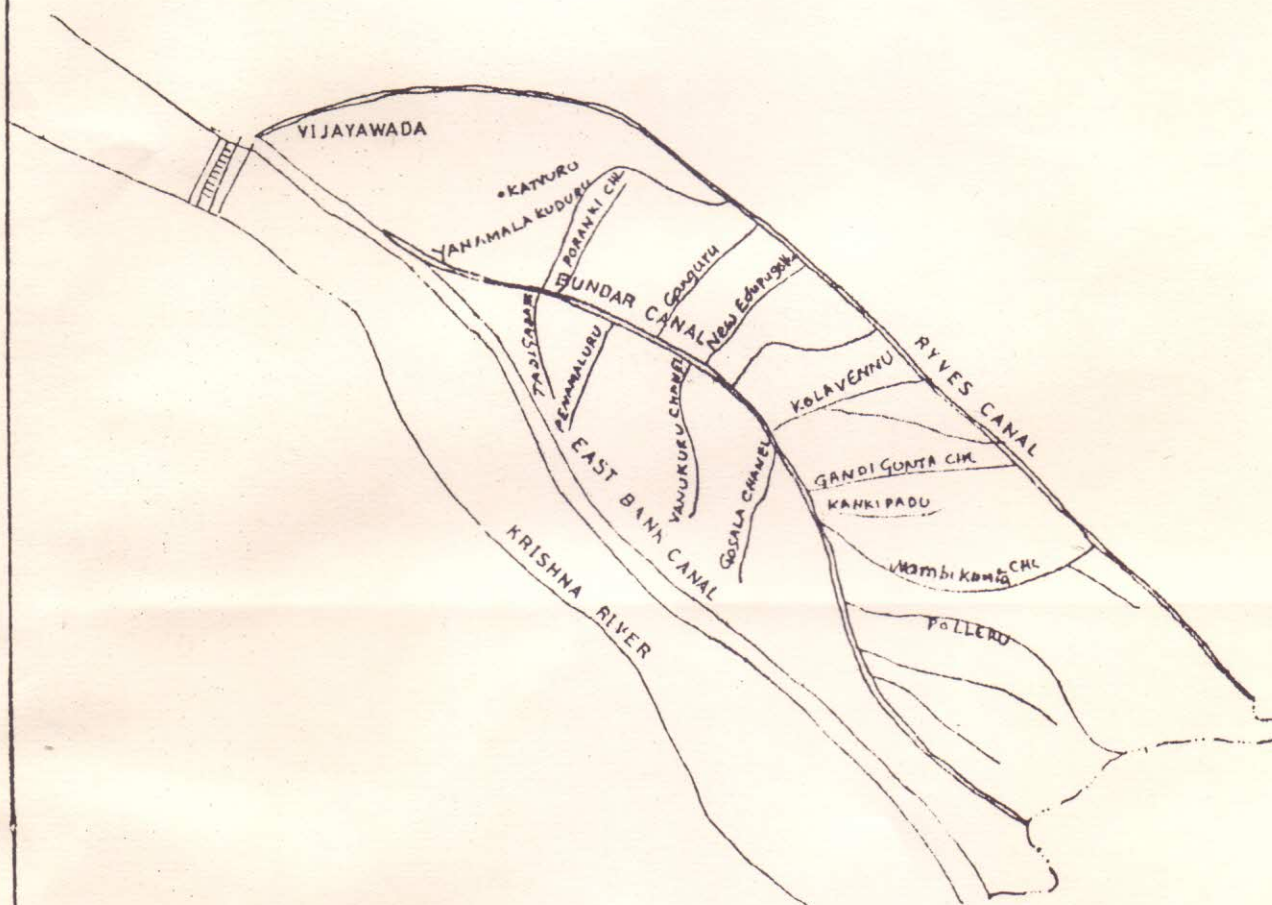
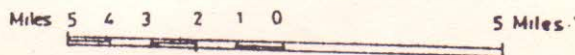
Sl.No.	Name of the Mandal	Name of the village
1.	Penamaluru	1. Kanuru 2. Poranki 3. Pedapulipeka 4. Penamaluru 5. Ganguru 6. Chodavaram 7. Gosala 8. Yenamalakuduru 9. Tadigadapa
2.	Kankipadu	1. Kunderu 2. Kankipadu 3. Kolavennu 4. Punadipadu 5. Prodduturu 6. Godavarru 7. Edupugallu 8. Madduru 9. Jagannathapuram 10. Davuluru
3.	Vuyyuru	1. Vuyyuru Urban 2. Vuyyuru Rural 3. Kodavatikallu 4. Pede Ogirala 5. China Ogirala 6. Almnuru
4.	Thotlavalluru	1. North valluru 2. South valluru 3. Royyuru 4. Boddapadu 5. Kummamuru 6. Yekanuru

ANNEXURE VII

Sl. No.	Name of the Mandal	Total Geographical area (Sq. km)	Total No. of villages	Utilisable recharge (MCM)	Total No. of wells	Unit draft (MCM)	Net draft (MCM)	Balance (MCM)	No. of additional wells feasible	Storage of development (%)
1	2	3	4	5	6	7	8	9	10	11
1.	Kankipadu	70.66	10	29.50	73	0.0323	1.67	27.83	1127	6
2.	Puramaluru	81.11	9	22.32	646	0.0231	10.44	11.88	480	47
3.	Vuyyuru	37.76	6	18.00	99	0.0216	0.873	17.13	694	5
4.	Thotlavalluru	63.42	6	16.64	189	0.0359	4.75	11.89	481	29
		252.95	31	86.46	1007		17.733	68.75	2782	21

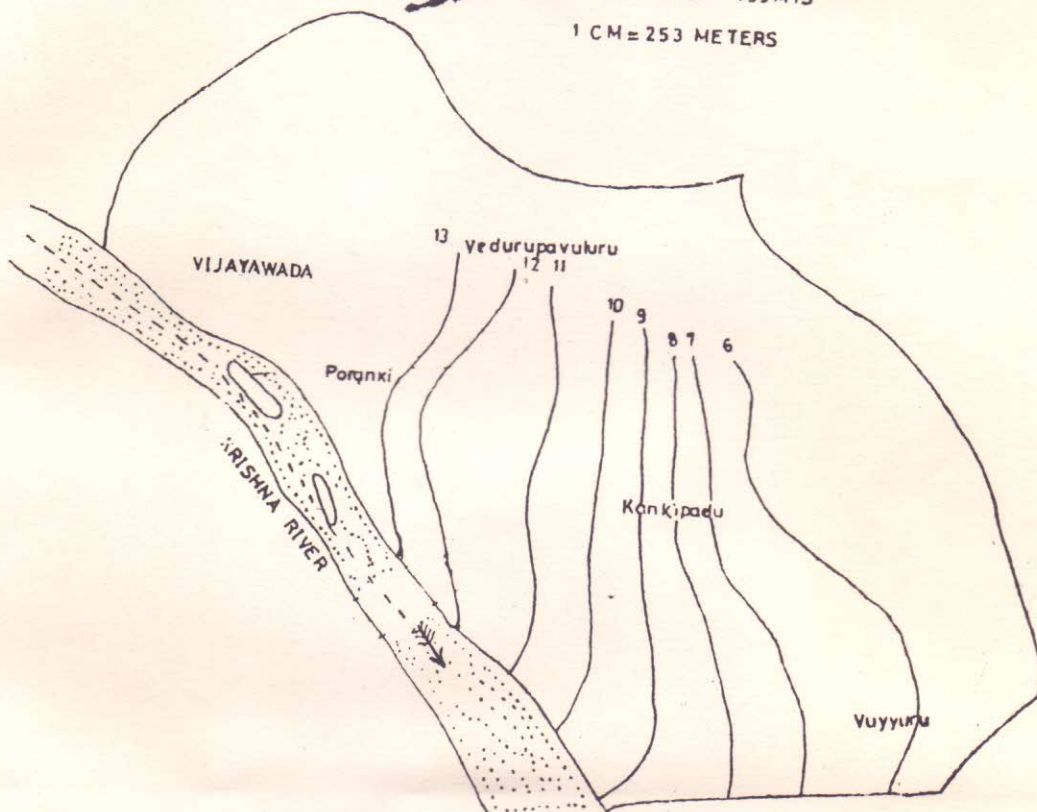
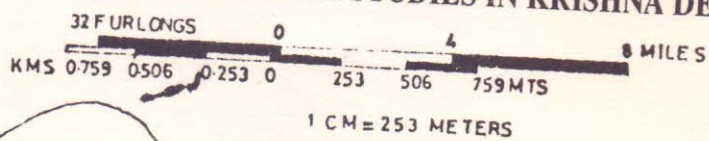
MAP SHOWING THE CANAL NET WORK IN PROPOSED AREA FOR CONJUNCTIVE USE STUDIES IN KRISHNA DELTA

SCALE 1" = 4 miles

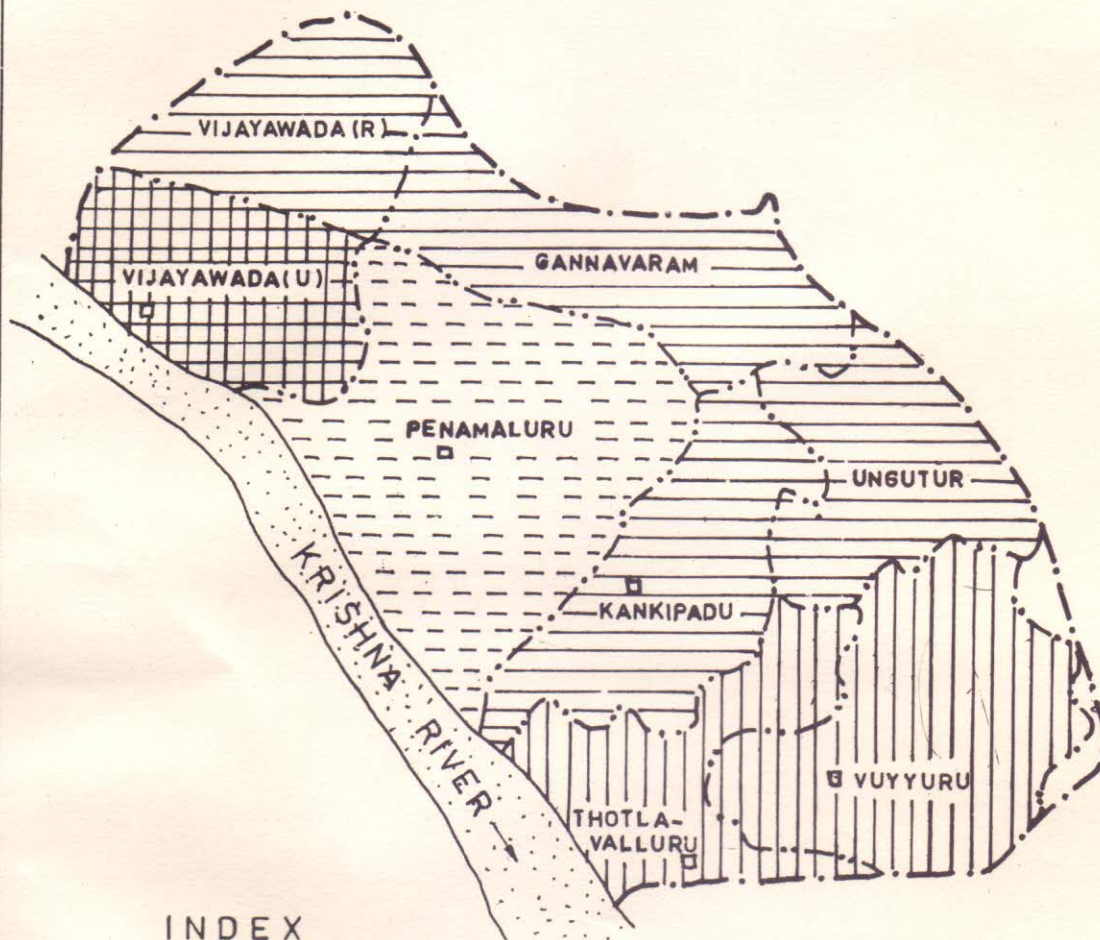
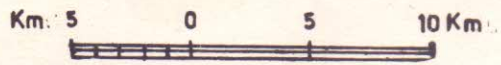


M/4 MAP SHOWING THE WATER TABLE CONTOURS IN PROPOSED AREA FOR CONJUNCTIVE USE STUDIES IN KRISHNA DELTA

SED



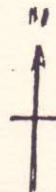
MAP SHOWING THE MANDALWISE WELL DENSITY IN PROPOSED
 AREA FOR CONJUNCTIVE USE STUDIES
 IN KRISHNA DELTA



INDEX

WELL DENSITY		
NO/Sq.Km		
	...	< 2
	...	2 - 4
	...	4 - 6
	...	6 - 8
		MANDAL BOUNDARY
		STUDY AREA
		MANDAL HEAD QUARTERS

MAP SHOWING THE SPECIFIC CONDUCTANCE IN PROPOSED AREA FOR CONJUNCTIVE USE STUDIES IN KRISHNA DELTA



SCALE 1 Cm = 253 Metres

