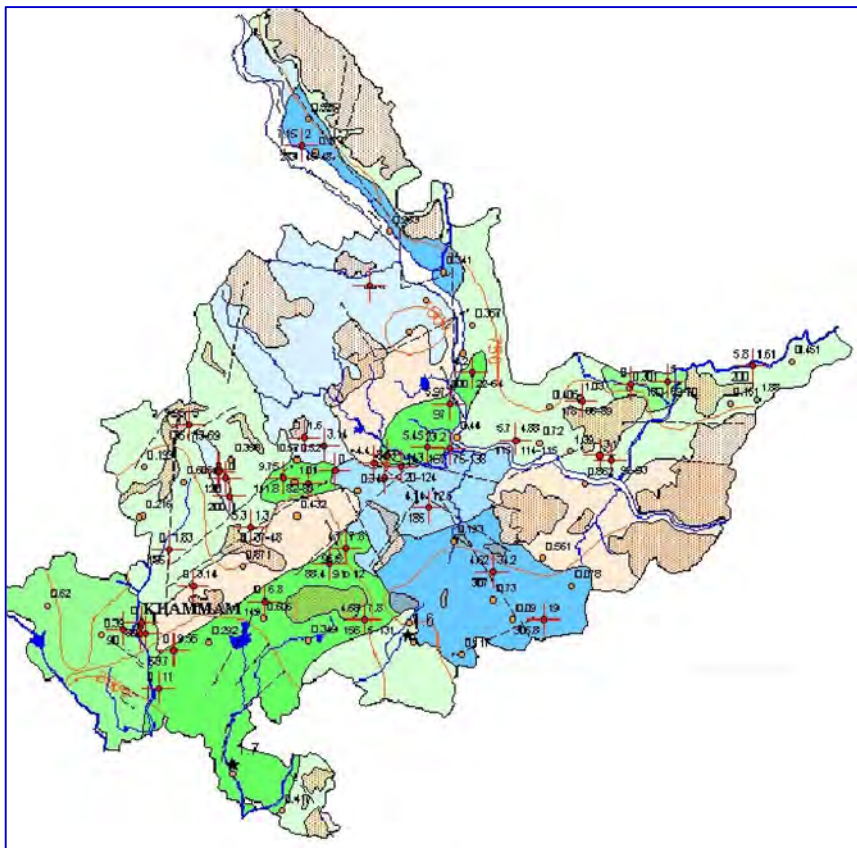




CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES
GOVERNMENT OF INDIA

GROUND WATER BROCHURE
KHAMMAM DISTRICT, ANDHRA PRADESH



SOUTHERN REGION
HYDERABAD
September 2013



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GROUND WATER BROCHURE
KHAMMAM DISTRICT, ANDHRA PRADESH
(AAP-2012-13)

BY

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GROUND WATER BROCHURE KHAMMAM DISTRICT, ANDHRA PRADESH

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KHAMMAM DISTRICT AT A GLANCE

1 GENERAL

Location	North Latitude	16°45' : 18°35'
	East Longitude	79°47' : 81°47'
Geographical area (sq.km)		16,069 sq.kms
Headquarters		Khammam
No. of revenue Mandals		46
No. of revenue Villages		1,242
Population (2011)	Urban	6,55,674
	Rural	21,42,540
Population density (persons/ sq.km)		175
Major rivers		Godavari, Kinnerasani, Sabari, Munneru, Wyra
Soils		Chalaka, Dubba and black soils
Agroclimatic zone		South eastern plateau & hill zone

2 RAINFALL

Normal annual rainfall (mm)	Total	1124
	Southwest monsoon	890
	Northeast monsoon	130
Cumulative departure from normal rainfall for the last 5 years		-30%

3 LAND USE (2012) (Area in ha.)

Forest	7,59,438
Barren and uncultivated	88,887
Cultivable waste	14,570
Current fallows	64,380

Net area sown		4,57,538
4	IRRIGATION (2012) (Area in ha.)	
Source of irrigation	Canals	64,875
	Tanks	43,299
	Dug wells	33,085
	Bore / Tube wells	48,897
	Others	15,983
Net area irrigated		2,06,139
Gross area irrigated		2,42,852
Major irrigation projects		Nagarjunasagar Left bank canal
Medium irrigation projects		Wyra, Lanka sagar, Pedavagu, Mookamamidi and Bayyaram Tank
5	GEOLOGY	
Major rock types		Granites & gneisses, shales, phyllites and dolomites, sandstones etc.
6	GROUND WATER	
Exploration by CGWB	No. of wells drilled	96
Major aquifer zones	Hard rocks	40 - 70 m
	Soft rocks	50 - 220 m
Depth to Water Level		
Pre-monsoon (min-max)		0.65 to 14.00 m bgl.
Post monsoon (min-max)		0.36 to 9.26 m bgl.
Aquifer parameters		
Transmissivity (sq.m/day)	Hard rock	7.8 - 257
	Soft rock	37 - 954
Storage Co-efficient	Hard rock	8.4×10^{-6} - 8.19×10^{-3}
	Soft rock	2×10^{-4} - 4.64×10^{-4}

	Monitoring Wells	50
	No. of observation wells	
	Dug wells	38
	Piezometers	12
	Range of water levels (2012)	
	Minimum (m below ground level)	1.27 m (Pre-Monsoon) 0.70 m (Post-Monsoon)
	Maximum (m bgl)	12.37 m (Pre-Monsoon) 9.26 m (Post-Monsoon)
	General range (m bgl)	2-10 m
7	GROUND WATER RESOURCES (Ha.M)	
	Net annual ground water availability	202827
	Existing Gross Ground water Draft for all uses	60288
	Net Ground Water availability for future Irrigation development	138953
	Provision for Domestic and Industrial requirement supply to 2025	10635
	Stage of ground water development	30
8	GROUND WATER DEVELOPMENT CATEGORY	
	No. of Mandals categorised as	41
	Safe (<70 % of net available resource)	
	Semi Critical(70 – 90 %)	1
	Critical (90 - 100 %)	0
	Over exploited (> 100 %)	4
	No. of villages Notified for restricted Ground water development (Under APWALTA Act)	23
9	CHEMICAL QUALITY	
	Electrical Conductivity	207 - 4350
	(micro Siemens / cm at 25 deg. C)	
	Chloride (mg/l)	18 – 1028
	Fluoride (mg/l)	0.05 -3.6
	Nitrate (mg/l)	10 - 386

GROUND WATER BROCHURE

KHAMMAM DISTRICT, ANDHRA PRADESH

1.0 INTRODUCTION

Since the day a coal boulder was found by chance by a pilgrim, who was on his way to the abode of Sri Rama at Bhadrachalam, the Khammam district entered into the mineral map of India and attained distinct place in coal mining. The district enjoys a unique place in the state with the presence of extensive green forests and by rivers with lyrical names like Godavari, Kinnerasani, Sabari etc. The district also abounds in mineral wealth backed by many power projects and notable industries.

The district lies between 16°45' and 18°35' of the north latitude and 79°47' to 81°47' of the east longitudes. The district is bounded on the north by Chhattisgarh and Orissa states and on the other three sides by different districts of the state. The district has geographical area of 16,029 sq.km with a total population of 25, 78,927 (2001). The district is divided into four revenue divisions with headquarters at Khammam, Kottagudem, Bhadrachalam and Palwancha. The district comprises 46 revenue mandals(Fig-1).

There are nine towns including four municipalities and 1,242 revenue villages with a population of 5.08 lakhs. The density of population is 161 per sq.km that is increased by 23 per sq.km from 1991 census. Tekulapalli, Chinturu, Gundala, Dummugudem, Velairpad, V R Puram, Mulkalapalli, Kunavaram and Singareni are main tribal mandals. The district has largest forest area of 8.4 lakh hechares.

Fig-1: Administrative Divisions of Khammam District.



The district is drained by Godavari and Krishna river systems. The district forms part of Godavari river basin. The main crops of the district are rice, jowar, bajra, cotton and chillies. The total cropped area in the district is 4,39,050 ha which forms about 30 percent of the total geographical area. Of the total cropped area 42 percent area is irrigated out of which 18 percent area is irrigated (81161 ha) through Canal, tank and lift irrigation. Groundwater irrigation accounts for 22 percent of the total irrigated area (1,00,382 ha). The source wise net irrigation for the year 2011-12 is presented in Table - 1.

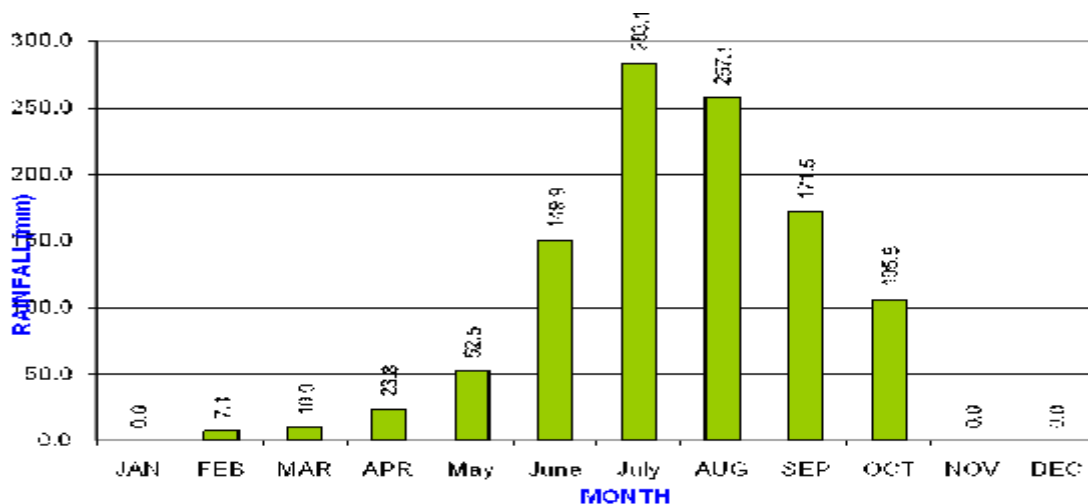
Table-1 Source wise net irrigation (2011-12)

S. No.	Source of Irrigation	2011-12
1	Canals	52605
2	Tanks	13275
3	Lift Irrigation	14440
4	Tube Wells	56979
5	Dug wells	43403
6	Other Sources	841
7	Gross Area Irrigated	181543
8	Area Irrigated more than Once	23021
9	Net Area Irrigated	158522

2.0 RAINFALL

The average annual rainfall of the district is 1061 mm, monthly rainfall ranges from nil rainfall in November, December and January to 283.1 mm in July. July is the wettest months of the year. The mean seasonal rainfall distribution is 861.6 mm in southwest monsoon (June-September), 105.8 mm in northeast monsoon (Oct-Dec), 7.1 mm rainfall in winter (Jan-Feb) and 86.3 mm in summer (March – May). The percentage distribution of rainfall, season-wise, is 81.22% in southwest monsoon, 9.97 % in northeast monsoon, 0.67 percentage in winter and 8.13 % in summer. The mean monthly rainfall distribution is given in Fig-2.

Fig-2 Mean monthly rainfall distribution



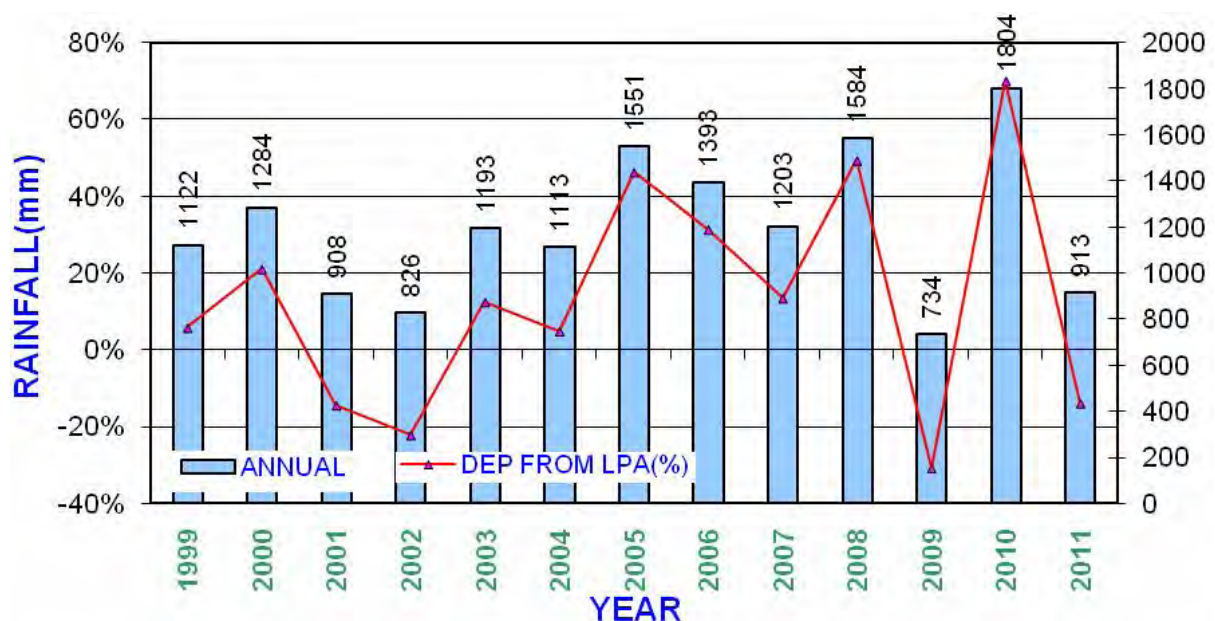
The annual and seasonal rainfall distribution with its departure from mean along with year-wise percentage distribution is given in Table-1. The annual rainfall ranges from 734.1 mm (2009) to 1803.7 mm in 2010. The annual rainfall departure ranges from -31 % in 2009 to 70 % in 2010. The southwest monsoon rainfall contributes about 81 % of annual rainfall. It ranges from 538 mm in 2009 to 1377 mm in 2010. The year 2009 experienced drought conditions in the district, as the annual rainfall recorded is 31 % less than the long period average (LPA) respectively. The cumulative departure of annual rainfall from LPA is presented in Fig-3. It indicates that, the rainfall departure, as on 2011 is positive i.e. 173%, showing rainfall excess.

TABLE-2: MONTHLY RAINFALL DISTRIBUTION (1999-2011)

ANNUAL	SWM	NEM	WINTER	SUMMER
1122.0	926.0	83.0	5.0	108.0
1284.0	1151.0	56.0	23.0	54.0
907.5	736.0	116.5	0.0	55.0
825.6	635.6	114.0	37.0	39.0
1193.1	976.1	201.0	3.0	13.0
1112.7	943.4	109.9	7.8	51.6
1551.1	1309.5	178.3	33.0	30.3
1393.4	1199.4	72.3	0.0	121.7
1203.0	1016.1	147.6	9.0	30.3
1583.8	1287.9	96.5	43.1	156.3
734.1	537.9	115.0	0.0	81.2
1803.7	1376.8	232.5	34.2	160.2
913.4	793.1	20.1	10.5	89.7
1060.8	861.6	105.8	7.1	86.3

Source: India Meteorological Department
And Directorate of Economics and Statistics

Fig-3: Annual Rainfall and Rainfall departure from LPA



3.0 GROUND WATER SCENARIO

The groundwater occurrence is mainly dependent on the type of formation, depth of weathering and the extension of fractures, fissures and joints. Dug well irrigation is more extensive in the district compared to bore well/tube well irrigation.

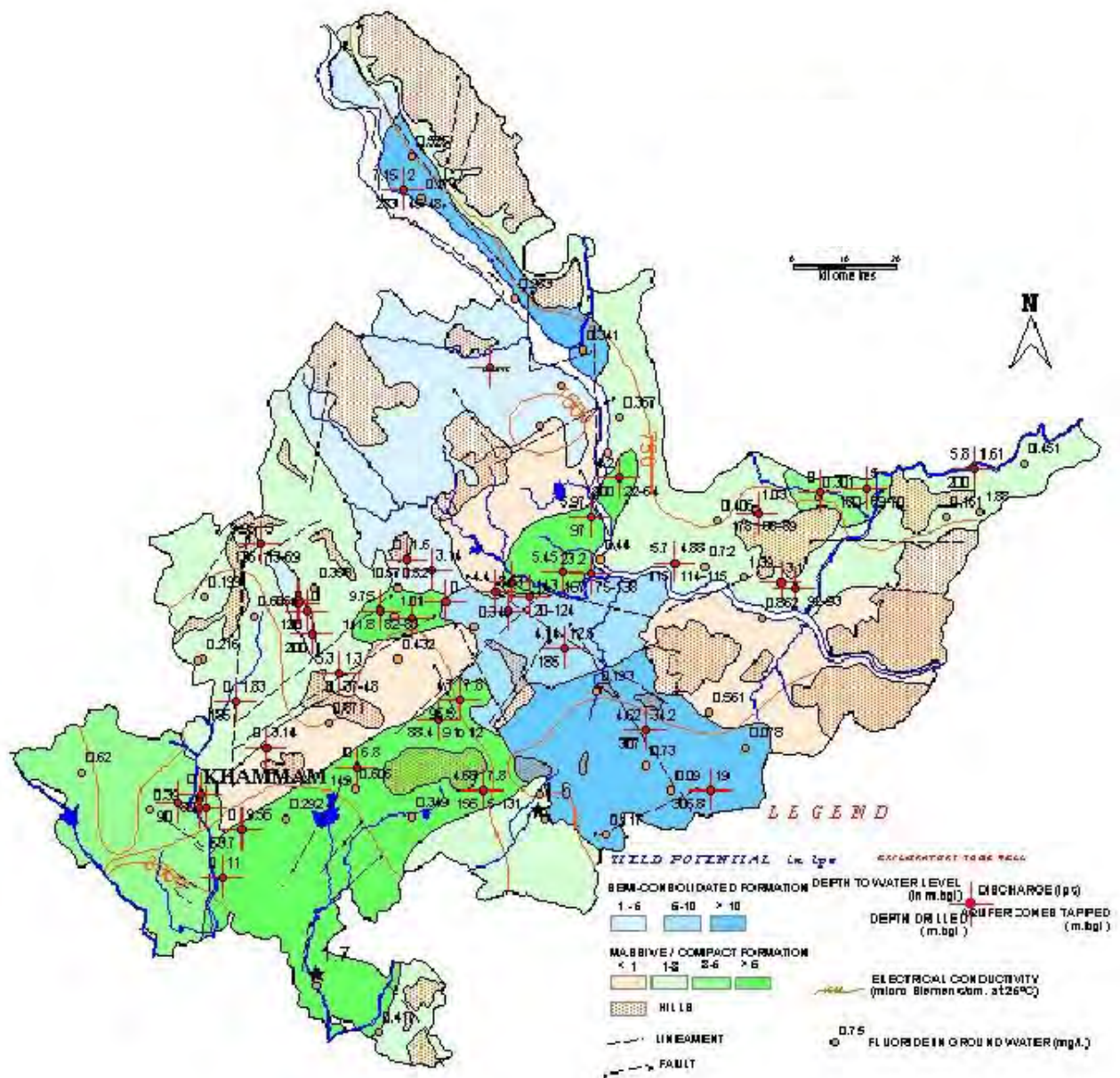
3.1 Hydrogeology

The rock units of the district can be broadly divided into three distinct groups viz.;

- Consolidated formations, comprising granites and gneisses of Archaean group and schists, phyllites and limestones of Pakhal Series;
- Semi-consolidated formations, comprising conglomerates, shales and sandstones of Lower and Upper Gondwana Supergroup;
- Unconsolidated formations, comprising river alluvium along riverbanks.

The hydrogeological map of the district is presented as Fig.4.

Fig-4: Hydrogeology of Khammam District



3.1.1 Consolidated formations

Crystalline Formations

Archaean crystalline formations occupy more than 50% of the district. Weathered and fractured granites and gneisses form aquifer system; the depth of weathering varies between 10 and and fractures extend from 30 to 60m bgl. Beyond 60m depths the possibility of encountering fracture zones is rare but not uncommon. Ground water is generally tapped from shallow weathered zones through large diameter open wells located in granitic terrain ranging in depth from 5 to 16m with depths to water levels range from 4 to 15.75m bgl. The average yield of these dug wells range between 10 and 30 m³/day. A number of bore wells come up in the recent five years, tapping the fractured zones in the depth range of 30 to 75m bgl, with yields of 1-3 lps.

Pakhals

These rocks comprising shales, phyllites and silicious limestones occur in parts of Bayaram, Yellandu and Gundala mandals on western part of the district and in parts of Manuguru, Paloncha, Kothagudem and Aswapuram mandals in central northeastern part and in Wazeed and Venkatapuram Mandals in northern part of the district. Ground water occurs under water table conditions in the intergranular secondary pores of weathered rocks. In shales and phyllites the depth of weathered zone varies between 3 and 15m bgl and the well depths range between 4 to 17m bgl and the depth to water levels range between 2 to 16m bgl. The yields of wells are generally less than 30 m³/day. In the limestone formations bore wells have been constructed in the depth range of 15 to 105 m bgl and the depth to water levels are shallow ranging between <1 and 6m bgl, with yields up to 5 lps. The ground water exploration by CGWB revealed the availability of fracture system between 80 and 165 m bgl with yields ranging from <1 to 12.75 lps. The general range of specific capacity of the exploratory wells range between 6 and 87 lpm/ mdd; transmissivity (T) between 7.8 and 257 sq.m/day; and Storage co-efficient between 8.4×10^{-6} and 8.19×10^{-6} .

3.1.2 Semi-consolidated formations

This group consists of mainly conglomerates, sandstones and shales of Lower and Upper Gondwana members. Groundwater occurs in unconfined and confined conditions in these formations. The sandstones of Upper Gondwana group are very good aquifers and tube wells constructed in this formation at Naravarigudem, Dammapeta and Rudrakshpalli villages yield in the range of 10 – 30 lps. The lower Gondwana members are also productive but not as that of Upper members. The yields in Lower members of Barakars are in the range of 4 – 10 lps. These formations occur in central part of the district falling in Sathupalli, Dammapeta, Aswaraopet, Pinapaka, Manuguru, Aswapuram, Kottagudem, Paloncha and Mulkalapalli mandals, occupying about 30 percent of the district area. These formations form very good aquifer systems and groundwater occurs under water table conditions as well as confined conditions in these aquifer units. The water table aquifers occur down to 15m bgl whereas the confined aquifers occur at different depths ranging from 40 to 300m. The Specific Capacity of the wells ranges between 10 and 367 lpm/mdd. The Transmissivity (T) and Storage co-efficient ranges between 2×10^{-4} and 4.64×10^{-4} respectively.

3.1.3 Unconsolidated formations

The river alluvium along the river banks of Godavari and Kinnerasani constitute aquifer system with alternate clay, silt, sand, gravel and kankar. Productivity of the wells depends on the thickness of sand and gravel layers. The width of alluvium vary from <1km to 6km from the river bank with a thickness of 3 to 20m. Filter points are the common groundwater extraction structures. The depth of filter points varies from few meters to 25m. The yields range between 3 to 15 lps.

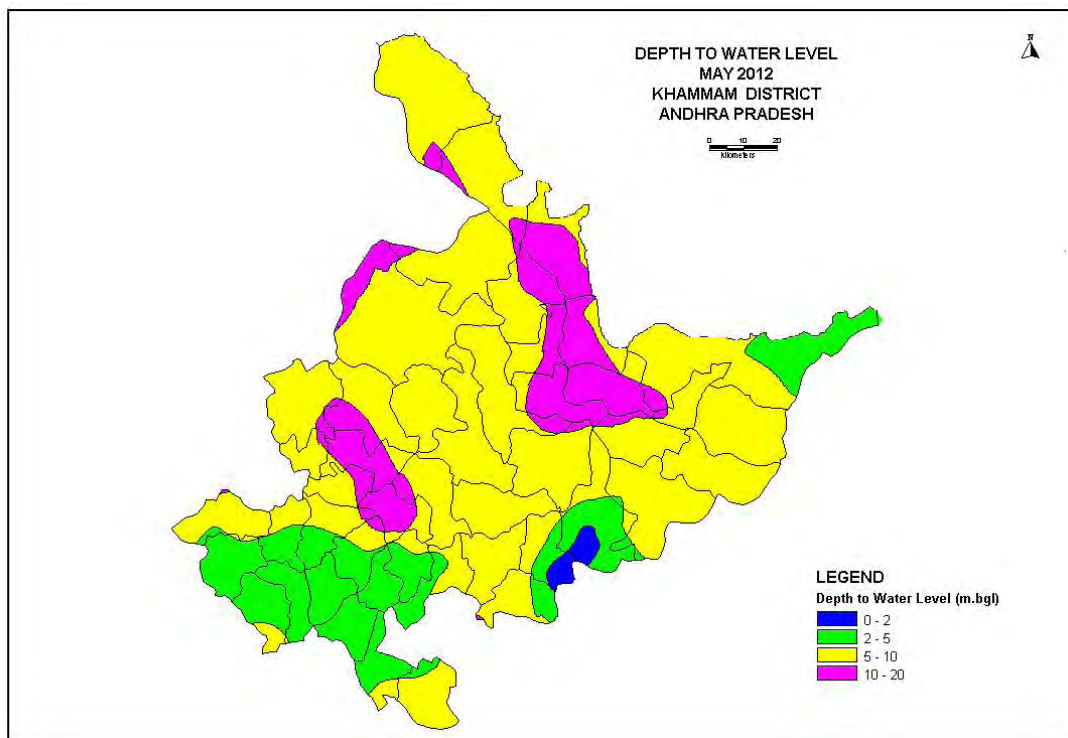
3.2 Depth to Water levels

Depths to water levels are monitored four times in a year from 56 ground water monitoring wells including 21 piezometers. State ground water department is monitoring 80 observation wells. Decadal trend of pre and post monsoon seasons has been computed using the water level data of monitoring wells.

3.2.1 Pre monsoon water levels

The depth to water level during pre-monsoon season (May-2012) ranges from 1.65 to 14.00 m bgl. In general the water levels in the district range between 5 and 10 m bgl (Fig-5). Shallow water levels (<5 m) are recorded in south and north. Deep water levels exist in parts of east and north-western parts of the district.

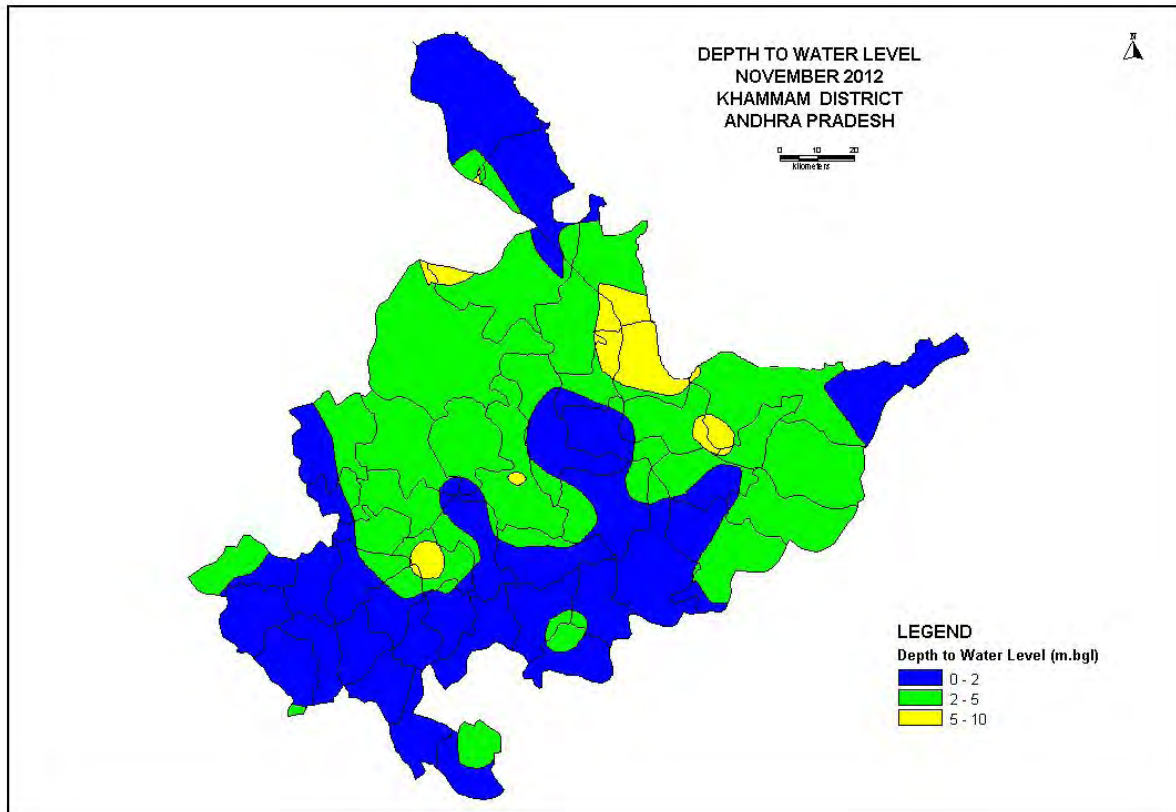
Fig-5 Depth to Water Level (Pre-Monsoon)



3.2.2 Post monsoon water levels

Depth to water levels between 5-10 m bgl have been recorded in more than 17 % of the monitoring wells during (post monsoon) November 2012 (Fig-6). Relatively deep water levels (10.0 to 20.0 m) have been registered in parts of eastern, central and southern of the district.

Fig-6: Depth to Water Level (Post-Monsoon)



3.2.3 Water level Fluctuation

Water level fluctuation map has been prepared based on pre and post monsoon water levels (Fig-7). Out of the 41 wells considering, 27 wells show fluctuation of $> +4\text{m}$. Fluctuation of $+ 0-2\text{m}$ is observed in the proximity of coal mining area at Manuguru and Ellandu.

3.2.4 Long term water level trends

Declining trend of 0.2 m/ year has been observed in 42% of monitoring wells and 18 % of the observation wells shows declining trend of less than 0.2 m/ year . During post monsoon season only 22 % of the wells are showing declining trend of $< 0.2\text{ m/ year}$. Falling trend of about 0.4m/year prevail in parts of Tirumalayapalem, Sathupalli, Kallur, Chintakani, Kunavaram, Khammam (Rural), Dammapeta, Aswaraopeta and Penuballi mandals in pre and post monsoon seasons (Fig-8).

Fig-7 Water Level Fluctuation

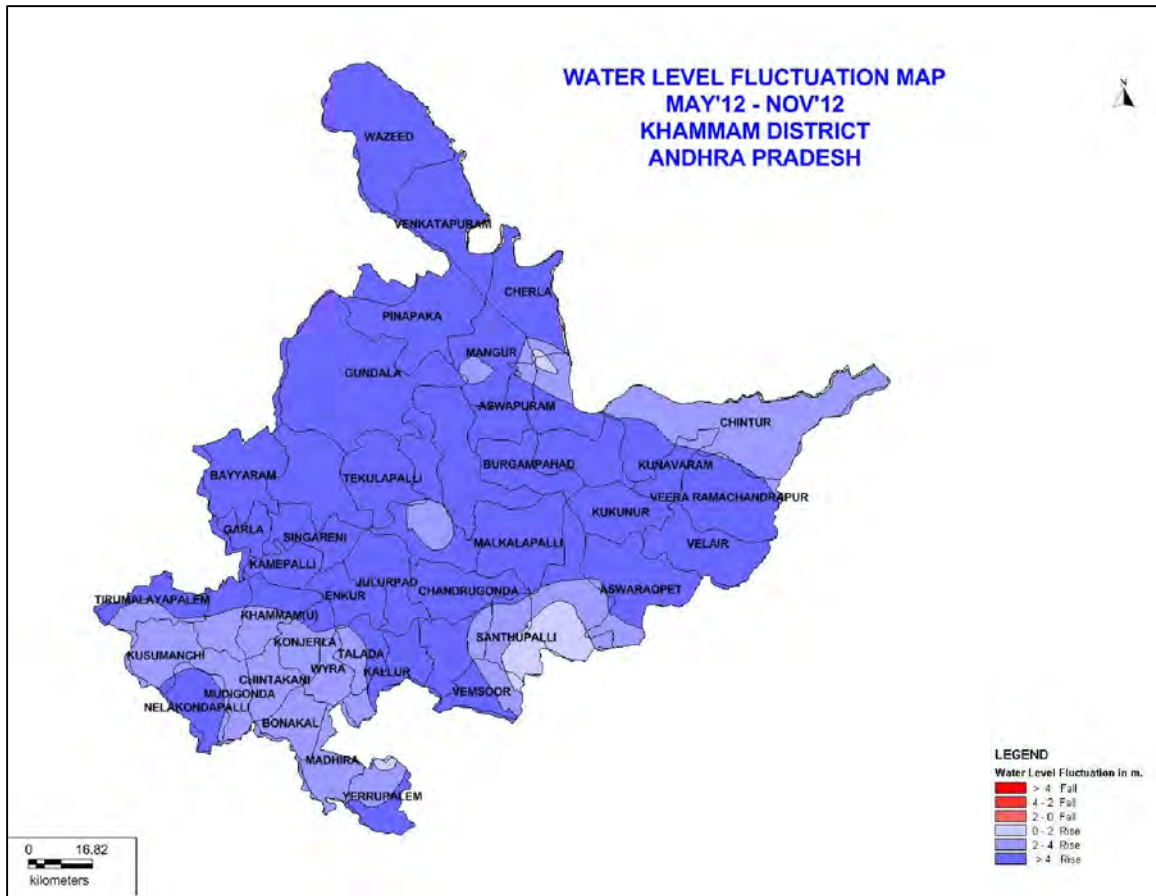
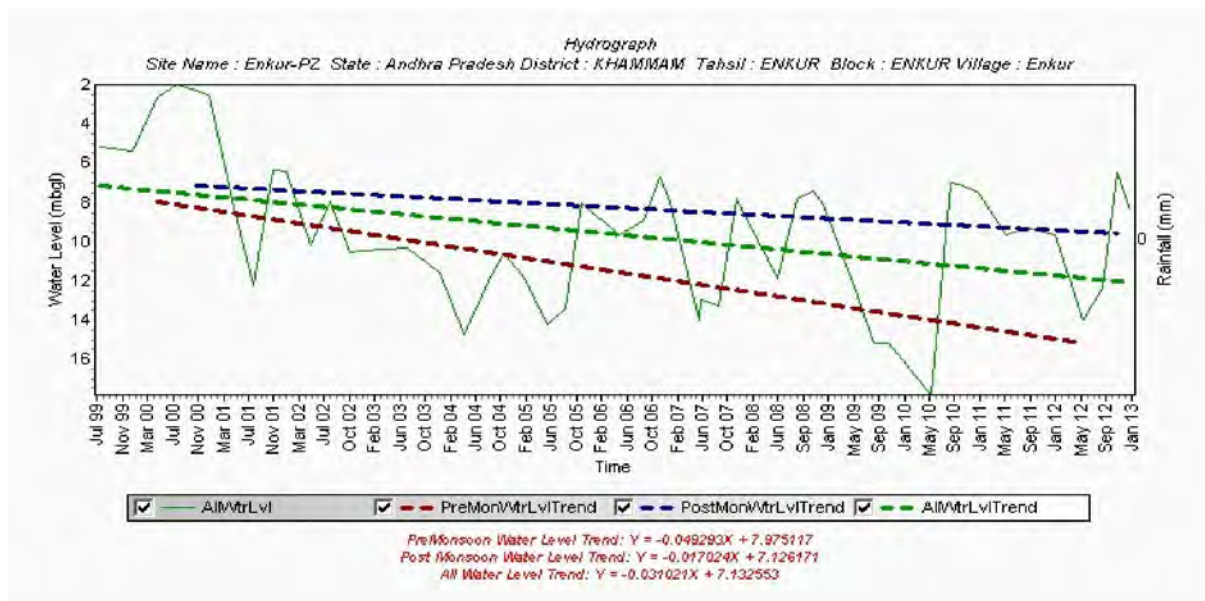


Fig-8 Hydrograph showing long-term Water level Trends



4.0 GROUND WATER RESOURCES

Based on the Groundwater Estimation Committee recommendations, groundwater assessment of the district was done latest in 2009. The net annual ground water availability of the district is 202827 ha.m, (45966 ha.m in Command area and 156861 ha.m in Non-Command area) while the existing ground water draft for all uses is 60288 ha.m (16587 ha.m in Command ares and 43701 ha.m in Non-Command ares) and the net ground water availability for future irrigation purposes is 138953 ha.m (27744 ha.m in command areas and 111209 ha.m in non-command area). The Mandal wise categorization in respect of ground water development is furnished in the Table-3 and Fig.8. The list of villages proposed for Notification is given in the Table-4.

Table-3 Mandal Wise Categorisation in respect of ground water development [2008-09] Khammam District

Sl. No	Mandal	C/ NC/ T	Stage of ground water development [%]	Pre-monsoon		Post monsoon		Category [safe/ semicritical/ Critical/ Over exploited]
				Water level trend cm/yr	Is there a significant decline [YES/NO]	Water level trend cm/yr	Is there a significant decline [YES/NO]	
1	2	3	4	5	6	7	8	9
1	Nelakondapalli	C	37	-2.63	No	-1.19	No	Safe
		NC	0					
		T	37	-2.63	No	-1.19	No	Safe
2	Mudigonda	C	46	-25.93	No	-20.52	No	Safe
		NC	0					
		T	46	-25.93	No	-20.52	No	Safe
3	Khammam(U)	C	47	-38.4	No	-20.83	No	Safe
		NC	68	-98.96	No	-118.93	No	Safe
		T	64	-68.5	No	-69.88	No	Safe
4	Konijerla	C	33	-38.4	No	-20.52	No	Safe
		NC	0					
		T	33	-38.4	No	-20.52	No	Safe
5	Chintakani	C	38	-28.4	No	-45.42	No	Safe
		NC	94					
		T	40	-28.4	No	-45.42	No	Safe
6	Kusumanchi	C	23	-32.71	No	-29.26	No	Safe
		NC	110	10.71	Yes	11.48	Yes	Over Exploited
		T	69	-11.00	No	-8.89	No	Safe
7	Khammam(R)	C	39	-25.28	No	-20.52	No	Safe
		NC	85	11.67	Yes	5.84	No	Semi-Critical
		T	62	-6.8	No	-7.34	No	Safe
8	Tirumalayapalem	C	0					
		NC	106	16.74	Yes	11.48	Yes	Over Exploited
		T	106	16.74	Yes	11.48	Yes	Over Exploited
9	Yerrupalem	C	47	-11.19	No	-29.67	No	Safe
		NC	69	-15.67	No	-2.73	No	Safe
		T	54	-13.43	No	-16.2	No	Safe
10	Madhira	C	35	-1.48	No	-16.18	No	Safe
		NC	12	-15.67	No	-2.73	No	Safe
		T	35	-8.57	No	-9.45	No	Safe
11	Bonakal	C	30	-21.04	No	-33.96	No	Safe
		NC	0					
		T	30	-21.04	No	-33.96	No	Safe
12	Wyra	C	18	-38.4	No	-20.83	No	Safe
		NC	0					
		T	18	-38.4	No	-20.83	No	Safe

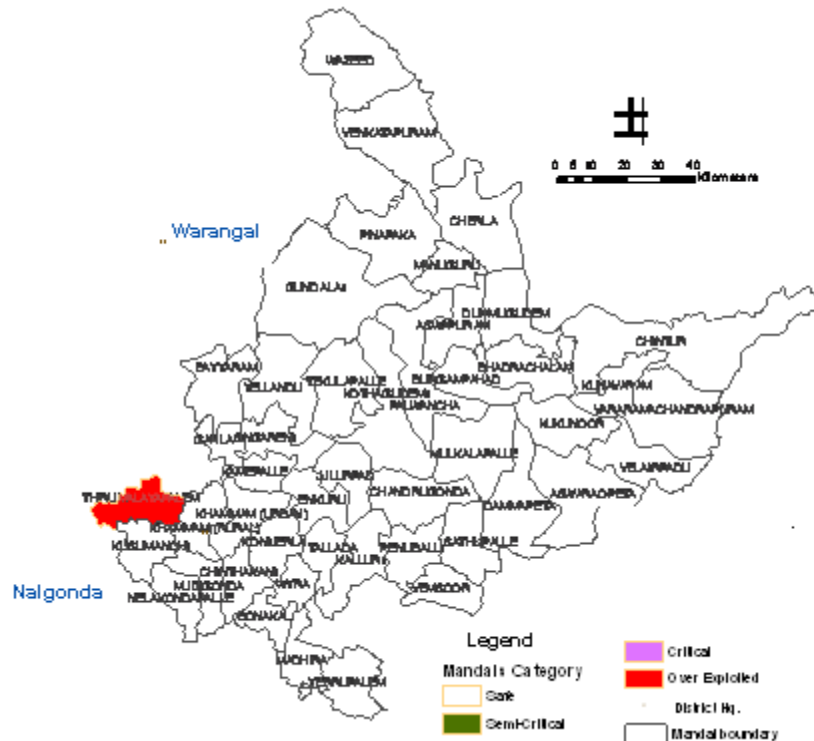
1	2	3	4	5	6	7	8	9
13	Thallada	C	26	-7.98	No	-2.76	No	Safe
		NC	0					
		T	26	-7.98	No	-2.76	No	Safe
14	Kalluru	C	28	2.22	No	-4.48	No	Safe
		NC	30	-7.98	No	-2.76	No	Safe
		T	28	-2.88	No	-3.67	No	Safe
15	Penuballi	C	0					
		NC	59	-0.63	No	-0.54	No	Safe
		T	59	-0.63	No	-0.54	No	Safe
16	Vemsur	C	0					
		NC	77	1.1	No	-3.74	No	Safe
		T	77	1.1	No	-3.74	No	Safe
17	Sathupalli	C	66	-70.75	No	-86.28	No	Safe
		NC	57	1.1	No	-3.74	No	Safe
		T	62	-34.82	No	-45.01	No	Safe
18	Yellandu	C	0					
		NC	39	-14.34	No	8.15	No	Safe
		T	39	-14.34	No	8.15	No	Safe
19	Singareni	C	0					
		NC	63	5.23	No	-18.89	No	Safe
		T	63	5.23	No	-18.89	No	Safe
20	Kamepalli	C	0					
		NC	82	-19.68	No	-29.16	No	Safe
		T	82	-19.68	No	-29.16	No	Safe
21	Garla	C	0					
		NC	53	-44.67	No	-24.99	No	Safe
		T	53	-44.67	No	-24.99	No	Safe
22	Bayyaram	C	0					
		NC	29	-10.13	No	1.27	No	Safe
		T	29	-10.13	No	1.27	No	Safe
23	Gundala	C	0					
		NC	1	-12.69	No	-24.57	No	Safe
		T	1	-12.69	No	-24.57	No	Safe
24	Tekulapalli	C	0					
		NC	15	-22.16	No	-10.93	No	Safe
		T	15	-22.16	No	-10.93	No	Safe
25	Kothagudem	C	0					
		NC	18	-93.64	No	-74.21	No	Safe
		T	18	-93.64	No	-74.21	No	Safe
26	Julurpadu	C	40	1.21	No	3.2	No	Safe
		NC	59	-0.2	No	-11.55	No	Safe
		T	54	0.5	No	-4.17	No	Safe
27	Chandrugonda	C	0					
		NC	31	-0.2	No	-11.55	No	Safe
		T	31	-0.2	No	-11.55	No	Safe
28	Enkur	C	36	-7.98	No	-2.76	No	Safe
		NC	528	12.8	Yes	10.11	Yes	Over Exploited
		T	52	8.8	No	8.7	No	Safe
29	Dammapeta	C	0					
		NC	60	-12.57	No	-24.18	No	Safe
		T	60	-12.57	No	-24.18	No	Safe
30	Aswaraopeta	C	0					
		NC	27	-33.07	No	-29.46	No	Safe
		T	27	-33.07	No	-29.46	No	Safe
31	Mulakalapalli	C	0					
		NC	21	-20.79	No	-10.95	No	Safe
		T	21	-20.79	No	-10.95	No	Safe
32	Palwancha	C	0					
		NC	21	-63.01	No	-40.59	No	Safe
		T	21	-63.01	No	-40.59	No	Safe
33	Burgampadu	C	0					
		NC	14	-63.01	No	-40.59	No	Safe
		T	14	-63.01	No	-40.59	No	Safe

1	2	3	4	5	6	7	8	9
34	Kuknoor	C	0					
		NC	9	-17.51	No	-6.9	No	Safe
		T	9	-17.51	No	-6.9	No	Safe
35	Velairpadu	C	0					
		NC	3	-13.79	No	-25.67	No	Safe
		T	3	-13.79	No	-25.67	No	Safe
36	Manugur	C	0					
		NC	24	-0.56	No	-3.48	No	Safe
		T	24	-0.56	No	-3.48	No	Safe
37	Aswapuram	C	0					
		NC	12	-28.59	No	-26.72	No	Safe
		T	12	-28.59	No	-26.72	No	Safe
38	Pinapaka	C	0					
		NC	36	-55.5	No	-11.18	No	Safe
		T	36	-55.5	No	-11.18	No	Safe
39	Dummugudem	C	0					
		NC	4	0.83	No	-3.43	No	Safe
		T	4	0.83	No	-3.43	No	Safe
40	Bhadrachalam	C	0					
		NC	13	-26.42	No	-29.59	No	Safe
		T	13	-26.42	No	-29.59	No	Safe
41	Kunavaram	C	0					
		NC	13	-0.11	No	0.78	No	Safe
		T	13	-0.11	No	0.78	No	Safe
42	V.R.Puram	C	0					
		NC	4	-0.11	No	0.78	No	Safe
		T	4	-0.11	No	0.78	No	Safe
43	Chintoor	C	0					
		NC	2	-10.73	No	-1.98	No	Safe
		T	2	-10.73	No	-1.98	No	Safe
44	Wazeedu	C	0					
		NC	12	-24.25	No	-41.29	No	Safe
		T	12	-24.25	No	-41.29	No	Safe
45	Venkatapuram	C	0					
		NC	8	-21.18	No	-7.11	No	Safe
		T	8	-21.18	No	-7.11	No	Safe
46	Cherla	C	7	-6.08	No	-10.15	No	Safe
		NC	6	-3.22	No	-7.64	No	Safe
		T	6	-4.65	No	-8.9	No	Safe

Table-4 List of Over-Exploited Villages Proposed for Notification

S.No.	Mandal	Village
1	Dammamet	Gunnepalli
2		Mandalapalli
3		Wadlagudem
4	Khammam Rural	Gudurpadu
5	Kusumanchi	Chowtapalli
6		Gaaigollapalli
7		Kusumanchi
8		Pocharam
9	Tirumalayapalem	Bandamaplli
10		Beerolu
11		Bochodu
12		Hydarsaipeta
13		Jallepalli
14		Laxmidevipalli
15		Mohammadapuram
16		Mujahidpuram
17		Painampalli
18		Patharlapadu
19		Pindiprolu
20		Raghunadhapalem
21		Solipuram
22		Sublaid
23		Tippareddygudem

Fig-8 Mandal-Wise Categorization in Khammam District



Mandal-wise resource estimation shows that two Mandals Viz., Tirumalayapalem and Kusumanchi are categorized as over exploited (OE), while the other 44 mandals are categorized as Safe (Fig- 8). Village level categorisation indicates that 23 OE villages

spreading over 4 mandals are notified under APWALTA (Table-4). A maximum of 14 villages are under OE category in Tirumalayapalem mandal itself. The other mandals having more number of villages under OE category are Dammapeta and Kusumanchi and Khammam (Rural).

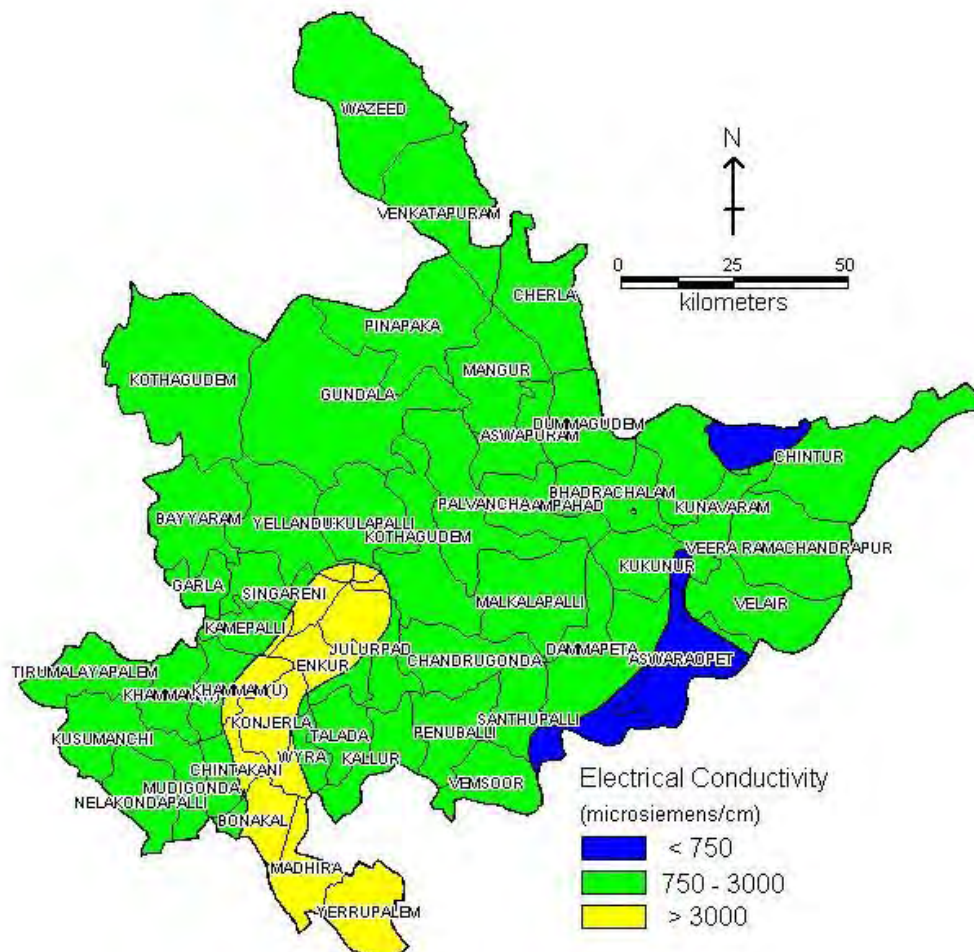
5.0 GROUND WATER QUALITY

The groundwater quality in the district in general is suitable for both domestic and irrigation purposes. The electrical conductivity ranges between 330 and 3490 micro Siemens/ cm at 25°C. The nitrate content in the ground water is beyond permissible limits in some pockets of canal command areas. High fluoride content beyond the permissible limit of 1.5 mg/l is observed in ground waters of 12 villages, distributed among 4 Mandals. The distribution EC in ground water is shown in Fig-9.

6.0 STATUS OF GROUND WATER DEVELOPMENT

Ground water development in the district is mostly through dug/bore wells in consolidated formations and through dug/ shallow tube wells in semi-consolidated formations and by dug wells/ filter points in unconsolidated formations. Bore wells in the depth range of 50–100m bgl in hard rock areas and tube wells of 40–150m bgl depth in semi-consolidated and unconsolidated formations have been constructed by Panchayat Raj department for drinking water supply.

Fig-9 Distribution of EC in ground water (2011) in Khammam District



42% of the net irrigation in the district is through ground water sources. Majority of the irrigation dug wells sustain 2–4 hrs of pumping with 3/ 5 HP pump sets with yields ranging from 20–120 cu.m/day. The average yield of irrigation bore wells in hard rock terrain (40 – 80m depth), varies from 2 to 4 lps.

7.0 GROUND WATER MANAGEMENT STRATEGY

Hence, the strategy of groundwater management starts with the precipitation of the rainfall at the higher reaches of surface basins, through arresting the surface water and allowing it to percolate into ground in order to recharge the ground water system by means of constructing suitable artificial recharge structures.

Once ground water is artificially recharged, its optimal management is the important issue where public should be educated about the importance of the precious mineral – ‘WATER’. In the water scarce areas the government authorities should offer planning and management techniques to the common public and cultivators to seek for low water required crops. Many command areas are in the threat of polluting ground waters due to excess irrigation practices, application of more pesticides and improper drainage facilities. Economic alleviation plans should be framed by integrating the technical expertise of different departments of district and mandal level authorities, like horticulture, sericulture, small scale industries, and agro based industries etc., in order to lower the pressure on water / ground water utilisation.

8.0 GROUND WATER DEVELOPMENT

There is large scope for ground water development in the district as the level of ground water utilisation is only 20% out of the available resources. While water levels are depleting much beyond the safe limits in other districts, Khammam district is meeting water demands for irrigation through dug wells. It is a positive sign as per the level of development of the resource is concern. In addition to the existing dug wells, bore wells can be attempted in all most all parts of consolidated rock formations after thorough scientific investigations. The depth of the bore wells should be restricted to 60 – 70m bgl, as there is limited scope for encountering potential aquifer zones further below 70m bgl. Depending on the overburden casing of the well can be constructed and pumps can be selected depending on the yield, depth to water level and specific capacity of the wells.

Further dug well construction in the OE mandal of Tirumalayapalem and in other OE, Critical and Semi-critical villages of western mandals may be regulated or even stopped and shallow bore well construction may be encouraged in lieu of dug well construction.

In semi consolidated soft rock terrain ground water development is in progress through construction of tube wells of 40 – 120m depth range with 152mm diameter. However, the well construction is not being done with scientific approach. The proper placement of slotted pipe exactly against the aquifer zones and their optimal size and usage of gravel of suitable size and volume should be taken care while constructing tube wells. While developing the ground water through construction of different groundwater structures, the spacing norms recommended by NABARD may be followed (Table.5).

Table-5 Spacing norms for different ground water abstraction structures

(Source: NABARD)

S. No	Situation	Spacing between any two wells (m)			
		Piccota wells	Dug wells	Filter point/ shallow wells	Bore wells /Tube wells
1	Non-Ayacut	60	160	120	250-300
2	Ayacut	40	100	160	150-200
3	Near perennial source like river of tank (within 200m)	40	100	160	200-300
4	Non-perennial streams	50	150	180	200-500

9.0 WELL DESIGN

In hard rock terrains the bore wells may be constructed down to a depth of 50 to 75 m bgl by casing the overburden. The optimal diameter of the bore well is 165 mm. Dug well construction also may be taken up in parts of the district where the dug well density is less than 8 wells/ sq.km. In semi-consolidated formations shallow and deep tube wells are most feasible. Tube wells down to a depth of 45 to 120m with a diameter of 152-mm/178 mm may be constructed with slotted pipes against the granular zones. Proper gravel packing is necessary for the tube well to minimize the well losses.

10.0 UNIT COST OF WELLS

The unit cost of different type of wells was worked out based on NABARD norms and approved by the State Unit Cost Committee for financing the ground water abstraction structures for irrigation and cost of pump sets. The details are furnished in the following table.

Geology	Type of well	Dimensions of DWs			Dimensions of bore wells		Existing unit cost (Rs)
		Diameter (m)	Depth (m)	Staining depth (m)	Diameter (mm)	Depth (m)	
Granites and Gneisses	a. DW	6	10	4	-	-	21,000
	b. DW	6	12	4	-	-	27,200
	c. DW	5	16	4	-	-	44,500
	d. BW	-	-	-	165	50	14,500
Sandstones	a. TW	-	-	-	165	<=70	53,000
	b. TW	-	-	-	165	100-120	1,02,000

Source: NABARD DW: Dug well; BW: Bore well; TW: Tube well

11.0 WATER CONSERVATION & ARTIFICIAL RECHARGE

Ground water conservation and artificial recharge have been taken up by District Ground Water Management Agency (DWMA) on a large scale in the district under the schemes like DPAP, IWDP and RIDF and a total number of 3991 recharge structures such as percolation tanks, check dams, rock fill dams etc., have been constructed in parts of 25 revenue mandals. The total irrigation potential created with the order of 11,733 ha. More number of artificial recharge structures have come up in

Tirumalayapalem (636 nos.), Enkur (556), Kottagudem (441), Kusumanchi (232), Chandrugonda (194) etc., where ground water utilisation is high.

12.0 RECOMMENDATIONS

1. The Stage of ground water development of the district is 30% indicating the scope for proper ground water development. Adopting suitable artificial recharge methods and water conservation practices can enhance ground water development of the district.
2. Periodic training programs on artificial recharge methods for the govt and Non-Govt. Organization are to be conducted to adopt better water harvesting methods.
3. Tribal people in the district should be encouraged to adopt crop and water management practices in the district.