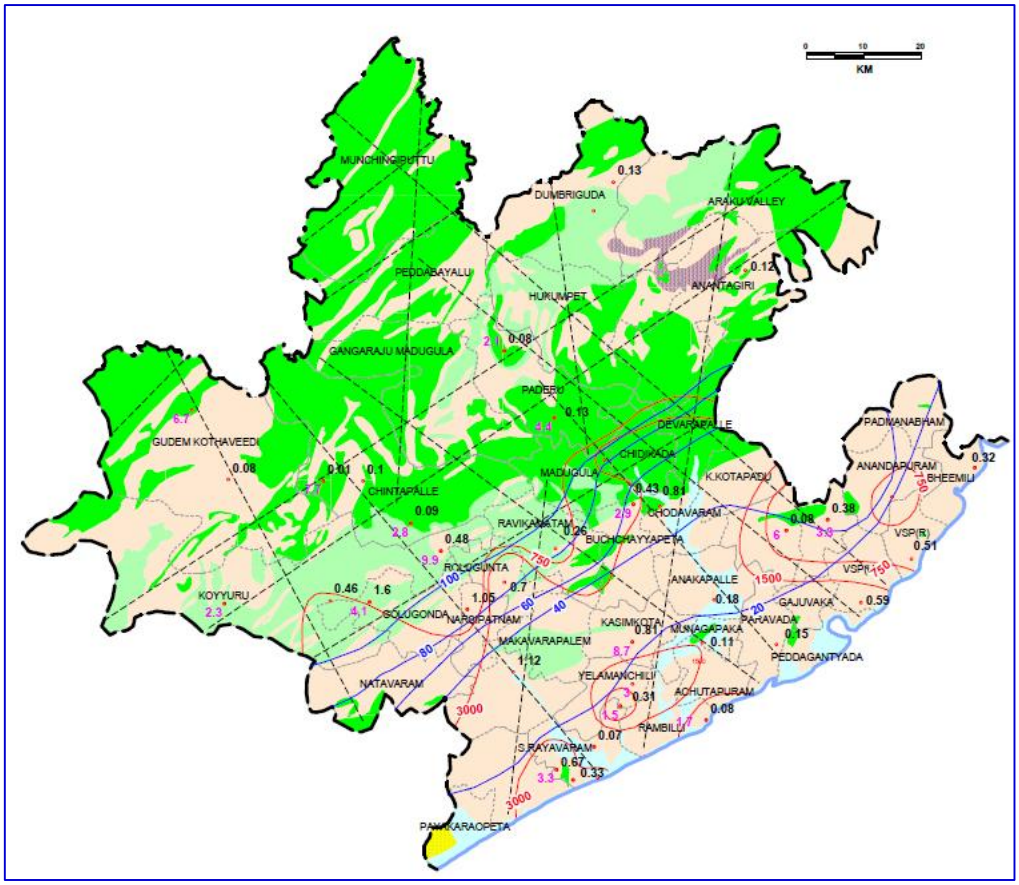
For Official Use Only

CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES
GOVERNMENT OF INDIA

GROUND WATER BROCHURE
VISAKHAPATNAM DISTRICT, ANDHRA PRADESH



SOUTHERN REGION
HYDERABAD
September 2013

CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES
GOVERNMENT OF INDIA

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

BY

G. BHASKARA RAO
SCIENTIST-D

SOUTHERN REGION
GSI Post, Bandlaguda
Hyderabad-500068
Andhra Pradesh
Tel: 040-24225201
Gram: Antarjal

BHUJAL BHAWAN,
NH.IV, FARIDABAD - 121001
HARYANA, INDIA
Tel: 0129-2418518
Gram: Bhumijal

GROUND WATER BROCHURE
VISAKHAPATNAM DISTRICT, ANDHRA PRADESH

CONTENTS

TABLES

FIGURES

VISAKHAPATNAM DISTRICT AT A GLANCE

1. GENERAL INFORMATION

Geographical Areas	:	11,342.84 sq. km
Administrative Divisions		
District HQ	:	Visakhapatnam
Mandals	:	43
Towns	:	10
Villages	:	3,108
Population	:	42,88,113 (2011 census)
Average Annual Rainfall	:	1,116 mm
Annual rainfall (2012)	:	1,218 mm

2. GEOMORPHOLOGY

Major Physiographic Units	:	Structural hills, pediplains, alluvial plains and coastal plains
Major Drainage	:	Machkund, Tandava, Varaha, Sarada & Gosthani

3. LAND USE (ha.)

Forest Area	:	4,41,166
Net Area Sown	:	3,00,371
Cultivable waste	:	10,366

4. SOIL TYPE

Red loams, Sandy loams, Sandy soils, Black cotton soils.

5. IRRIGATION BY DIFFERENT SOURCES (ha.)

Dug Wells	:	5,074
Tube wells/ Bore wells	:	9,604
Tanks/ Ponds	:	30,993
Canals	:	48,507
Other Sources	:	22,964
Net Irrigated Area	:	1,17,142

6. GROUND WATER MONITORING WELLS

Dug Wells	:	38

7. GEOLOGICAL FORMATIONS

Recent	:	Alluvium
Sub-recent	:	Laterite
Gondwana	:	Sandstones
Archaean	:	Migmatites, Charnockites Khondalites

8. Hydrogeology

Water Bearing Formations	:	
Hard Rock	:	Granitic gneisses, Charnockites & Khondalites
Soft Rock	:	Sandstones, Alluvium
Pre-monsoon		
Depth to Water Level (May, 2011):		1.23 to 15.78 m bgl
Post-monsoon		

Depth to Water Level (Nov., 2011)		0.30 to 5.80 m bgl

9. GROUND WATER EXPLORATION

Wells Drilled	:	32
Depth Range	:	17 to 202 m
Discharge	:	0.22 to 11.5 lps
Transmissivity	:	1 to 772 m^2/day

10. GROUND WATER QUALITY

In general, ground water is good and suitable for drinking and irrigation purposes.

11. DYNAMIC GROUND WATER RESOURCES (2008-09) (ha.)

Net Ground water availability	:	71,689
Ground water draft for all uses	:	23,100
Ground water balance	:	48,589
Stage of Ground water development (%)	:	32

12. AWARENESS AND TRAINING ACTIVITY

Mass Awareness Programme	:	1
Date	:	21st March, 2003
Place	:	Elamanchili
No. of Participants	:	250
Ground Water Management Training Programme: I		
Date	:	4th & 5th October, 2005
Place	:	Visakhapatnam
No. of Participants	:	30
Ground Water Management Training Programme: II		
Date	:	8th & 9th February, 2012
Place	:	Paderu (Tribal area)
No. of Participants	:	26

GROUND WATER BROCHURE
VISAKHAPATNAM DISTRICT, ANDHRA PRADESH

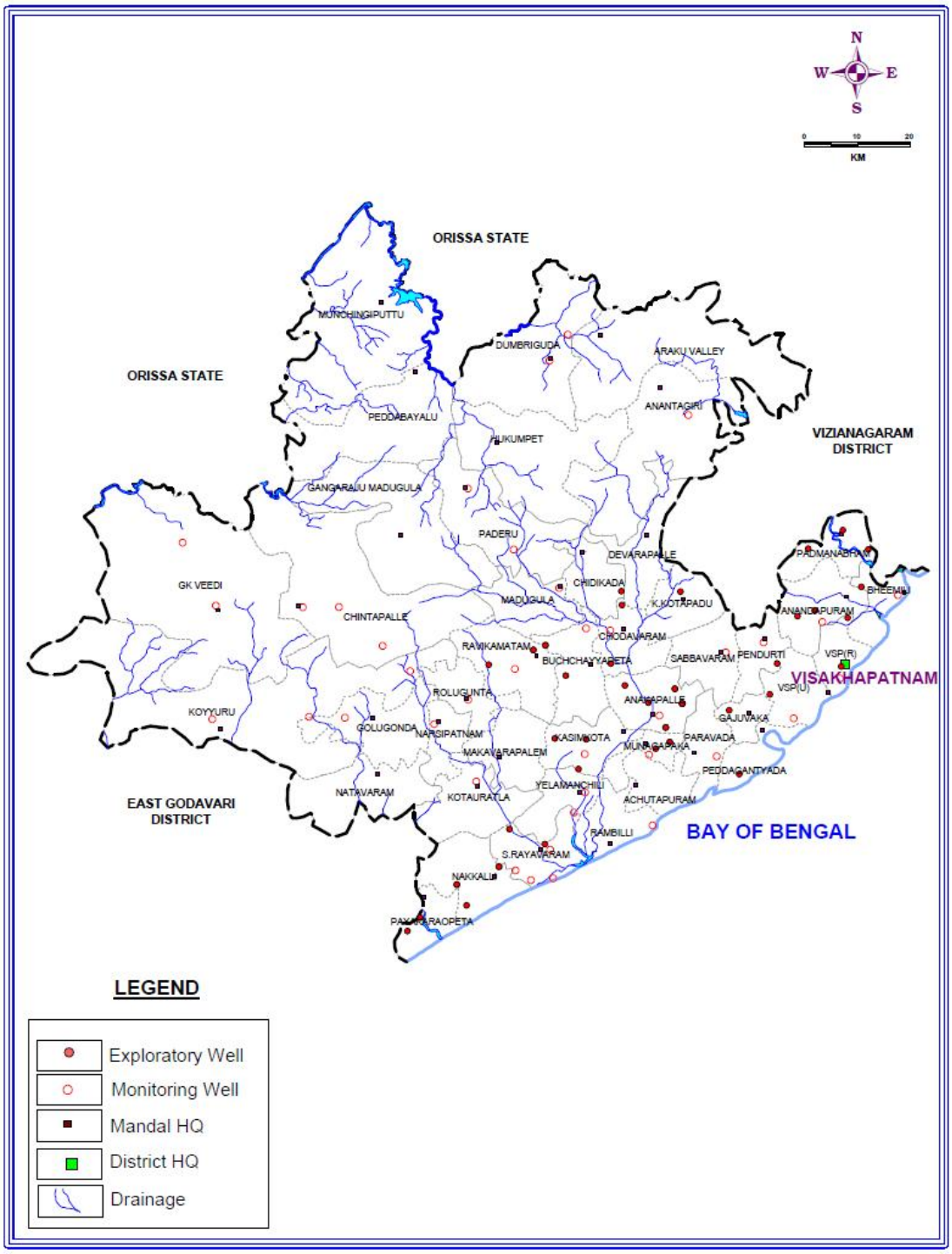
1.0 INTRODUCTION

Visakhapatnam district is one of the north coastal districts of Andhra Pradesh. The district is sandwiched between the Eastern Ghats and Bay of Bengal. Paderu and Araku in the district are having broad picturesque valleys with an altitude of about 900 m amsl. Araku valley is inhabited by aboriginal tribes with different sects. The Araku valley is famous for its beauty, bracing climate and orchards.

The district lies between north latitude 17° 15' and 18° 30' and east longitude 78° 30' and 83° 30' covering an area of 11,342.84 sq.km. The district is bounded on the south east by the Bay of Bengal, on the north east by Vizianagaram district, on the North West by Orissa state and on the south west by East Godavari district. Howrah – Chennai broad gauge railway line and NH-5 are passing through the district almost parallel to the coastline. In addition to the surface transport the district has aerodrome and natural harbor at Visakhapatnam.

Visakhapatnam is the district headquarters. The district is divided into three revenue divisions viz., Paderu, Narsipatnam and Visakhapatnam. Further these revenue divisions are sub divided into 43 revenue mandals **(Fig. 1).** There are towns 3,108 villages in the district. As per the 2011 census the population of the district is 42,88,113**.** The urban population of the district is 20,37,458 whereas rural population constitutes 22,50,655. The density of population of the district is 384 persons per sq. km.

Fig. 1 ADMINISTRATIVE DIVISIONS - VISAKHAPATNAM DISTRICT



1.1 Drainage

The most important rivers drained in the district are Machikund, Tandava, Varaha, Sarada and Gostani. Most of the rivers are ephemeral in nature. However, some of the tributaries of Machikund are perennial with indications of substantial ground water discharge. Almost all the rivers and streams

experience flash floods during rainy season. A good number of springs exist in Paderu and Araku areas. The district is characterized by sub-dendritic to dendritic nature of drainage pattern and is of coarse texture. In general the density is in the range of 0.6 to 1/Km^2. Many of the hill streams in Paderu valley disappear on entering the plains due to high permeability of the pediment gravels. The disappearance of streams in and along the hill slopes is contributing to the ground water, which is again discharged through the silty soils at lower elevations.

1.2 Irrigation

The district is served with both surface and ground water irrigation sources. Medium and minor irrigation projects exist in the district. The important medium irrigation projects are Thandava, Konam, Kalyanapulova and Raiwada reservoirs. The other reservoirs are Ravanapalli and Gambheeramgedda. The total net area irrigated is 1,17,142 ha by means of all sources of irrigation available in the district. The net area irrigated through canals and tanks is 78,500 ha, and other sources is 22,964 ha. The net area irrigated through dug wells and bore/tube wells is 14,678 ha.

1.3 CGWB activities

The Central Ground Water Board took up long term hydrogeological studies since 1969 with the establishment of Network Hydrograph Stations in various hydrogeological environments as a part of the all India programme and presently, there are 39 such hydrograph stations in the district. The systematic hydrogeological surveys were carried out during 1970 – 1985. Ground water exploratory drilling programme was taken up during 2005 – 2008 and drilled 32 wells to evaluate the aquifer properties in the district. Ground Water Management studies, Geophysical surveys, Urban Hydrogeological surveys, Water Balance studies and Pollution studies were carried out in various parts of the district during 1997-2005. Hydrogeological surveys were taken in the area first by the erstwhile G.S.I by Dr. P.Prabhakara Rao and others. Later urban hydrogeological surveys were carried out by Dr. A. Srisailanath, R.D, Dr.P.N.Rao, Sc-D and others in the year 1998-99 and reappraisal

hydrogeological surveys were carried out by S/Shri C.Paul Prabhakar, Sc-D and G.V.V.R.G. Sivaprasada Rao in the year 2003-04. Hydrogeological surveys were carried out in and around Chukkavanipalem, Visakhapatnam urban area during AAP 2001, 2002 by Dr.V.S.R.Krishna, Hydrogeologist (CGWB). Hydrogeological studies were carried out in Visakhapatnam urban area by Sri K.Dwarakanath, Scientist 'D' (CGWB) during AAP 2009-2010.

2.0 RAINFALL & CLIMATE

Climatologically the district experiences tropical sub-humid type of climate with moderate summer and good seasonal rainfall. The southwest monsoon sets in the second week of June and lasts till September end. October and November receive rainfall from northeast monsoon. Winter season with cool and fine weather prevails from December to February followed by summer season upto early June.

The average annual rainfall of the district is 1116 mm. and monthly rainfall ranges from nil rainfall in January to 207.5 mm in October. October is the wettest month of the year. The mean seasonal rainfall distribution is 673.5 mm. in southwest monsoon (June-September), 271.8 mm. in northeast monsoon (October-December), 10.9 mm. rainfall in Winter (Jan-Feb) and 159.6 mm in summer (March – May). The percentage distribution of rainfall, season-wise, is 60.36% in southwest monsoon, 24.36 % in northeast monsoon, 0.97 percentage in winter and 14.3 % in summer.

The annual rainfall ranges from 708 mm in 2002 to 1703 mm in 2010. The annual rainfall departure ranges from -37 % in 2002 to 53% in 2010. The southwest monsoon rainfall contributes about 60 % of annual rainfall. It ranges from 459 mm in 2002 to 864 mm in 2006. The year 2002 and 2009 experienced drought conditions in the district as the annual rainfall recorded in these two years is 37 % and 34% less than the long period average (LPA) respectively. The cumulative departure of annual rainfall from LPA indicates that the rainfall departure as on 2011 is negative i.e. 40%, showing deficit rainfall. The annual rainfall during 2012 is 1218 mm.

3.0 GEOMORPHOLOGY & SOIL TYPES

Geomorphologically the district can be divided into three regions, viz., northern hilly terrain with valleys, middle pediplains and alluvial coastal plains. The northern half of the district is mainly occupied by the structural hills and valleys, which is part of the Eastern Ghats. The hill range trends parallel to coast. The average altitude of hills is over 900 m amsl. The hills are densely forested. By virtue of their topography, these hilly terrains largely form run off areas and are not suitable for ground water development. The valley fill areas underlain by weathered formations in the Araku and Paderu areas posses high infiltration and high permeability. These areas form good to moderate aquifers depending on their thickness. The hard rock terrain exposed in the Tandava-Varaha-Sarada-Gosthani river basins constitutes the vast denudational pediplains, exhibiting the gradational phase of denudational- residual - inselberg - pediment areas. Pediment is well developed around the khondalite outcrops, whereas in the charnockite outcrops, it is not extensively developed. The pediment area accelerates surface run off with moderate to less infiltration along the jointed and weathered zone. The Tandava, Varaha, Sarada and Gosthani rivers and their tributaries have contributed to the formation of extensive flood plain areas. There is not much surface drainage in the plains because of the high infiltration and permeable characteristics of the sediments. The district has a coastline of about 132 km. The coastal plain is a feature of the marine deposition, which is very extensive, wide and even extends to several kilometers inland. The coastline is broken by a number of bold headlands, which protect the land against constant erosion by the sea.

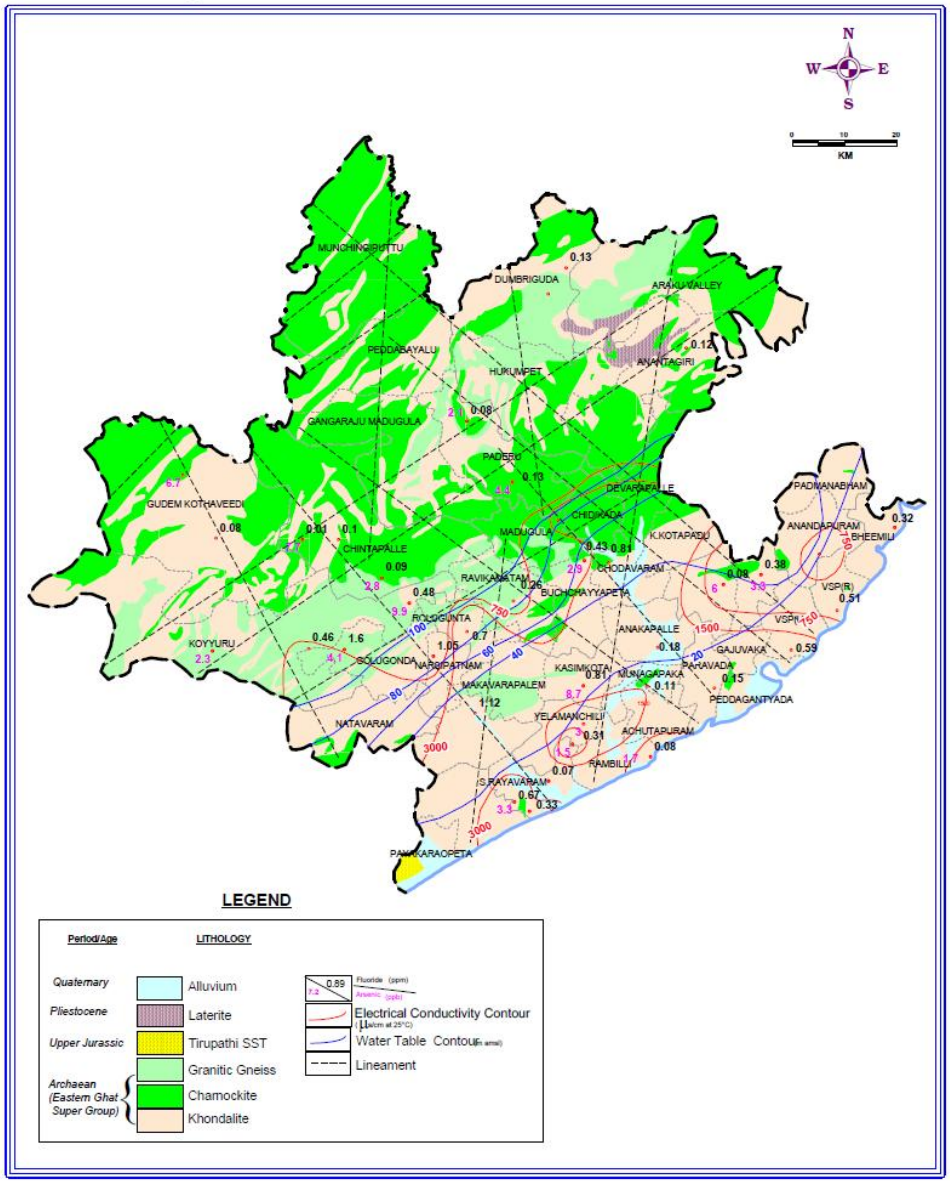
The different soils in the district are red loams, sandy loams, sandy soils and black cotton soils. Red loamy soils are predominate and occupy about 70% in the district. Sandy loamy soils are largely confined to the coastal areas and to certain stretches in the interior mandals of Chodavaram, Narsipatnam, K.Kotapadu and Madugula. Black cotton soils occur in parts of K.Kotapadu, Devarapalli, Chedikada, Paderu and Hukumpeta mandals.

4.0 GROUND WATER SCENARIO

4.1 Hydrogeology

The district is underlain by variety of geological formations from the oldest Archaeans to Recent Alluvium. The Archaean group of rocks includes Khondalites and Charnockites of Eastern Ghat super group and Granitic gneisses of Migmatite group. The Gondwana rocks which are represented by sandstones are in very limited aerial extent. The recent alluvium is prevalent along the rivers. Prominent lineaments are trending in NE-SW, NW-SE and ENE-WSW (**Fig.2**).

Fig. 2 HYDROGEOLOGY - VISAKHAPATNAM DISTRICT



Ground water occurs in almost all geological formations. From the ground water point of view, the aquifers in the district can be broadly classified into hard formations (khondalites, charnockites, granitic gneisses etc.) and soft formations (sand stones and alluvium). Ground water occurs under unconfined to semi-confined conditions in the hard formations, while it occurs under unconfined to confined conditions in soft formations. The yields in the weathered zones of hard formations range from 25 to 100 m^3/day. The bore wells drilled in the hard formations, generally tap the fractured and fissured zones. The yields of the bore wells in these formations range between 5 to 25 m^3/hr. Sand stones are exposed in the small isolated places around Nakkavanipalem and Elamanchili. In these formations, ground water occurs under both unconfined and confined conditions. The depth of dug wells in alluvium formations ranges from 2 to 10 mbgl and the yields generally ranges from 40 to 250 m^3/day. The depth of filter points/tubewells varies from 9 to 35 m with discharges ranging from 15 to 30 m^3/hour.

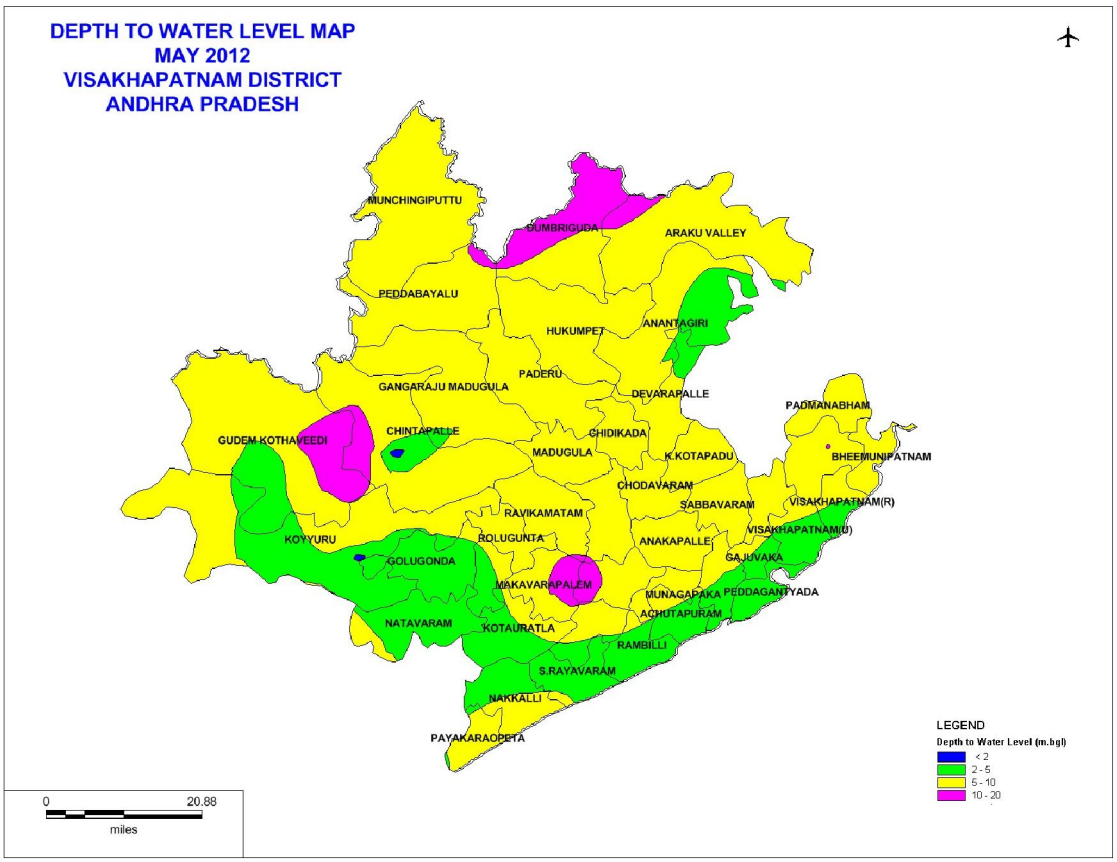
The transmissivity values of the aquifers in the consolidated formations generally vary from 1 to 772 m^2/day, whereas specific capacity ranges from 1 to 290 lpm/mdd.

Water Level Scenario

Based on the water level data (year 2012) of ground water monitoring wells, pre and post monsoon depth to water levels maps are prepared and presented in **Fig.no.3 & 4** respectively. The depth to water level maps show varied water level zones due to underlying terrain and also different geological set up with complex type of hydrogeomorphical structures present in the district. Pre-monsoon (May, 2012) depth to water level map reveals, in general, the water levels are deep particularly in the hilly area of the district. Depth to water levels varies from 5 to 10 mbgl, except at Chintapalli, where water level recorded 15.78 mbgl. In the southern part of the district i.e., near to the coast, the water levels are comparatively shallow (<5.00m) except in Payakaraopeta and Nakkapalli mandals where it is in between 5 and 10m bgl.

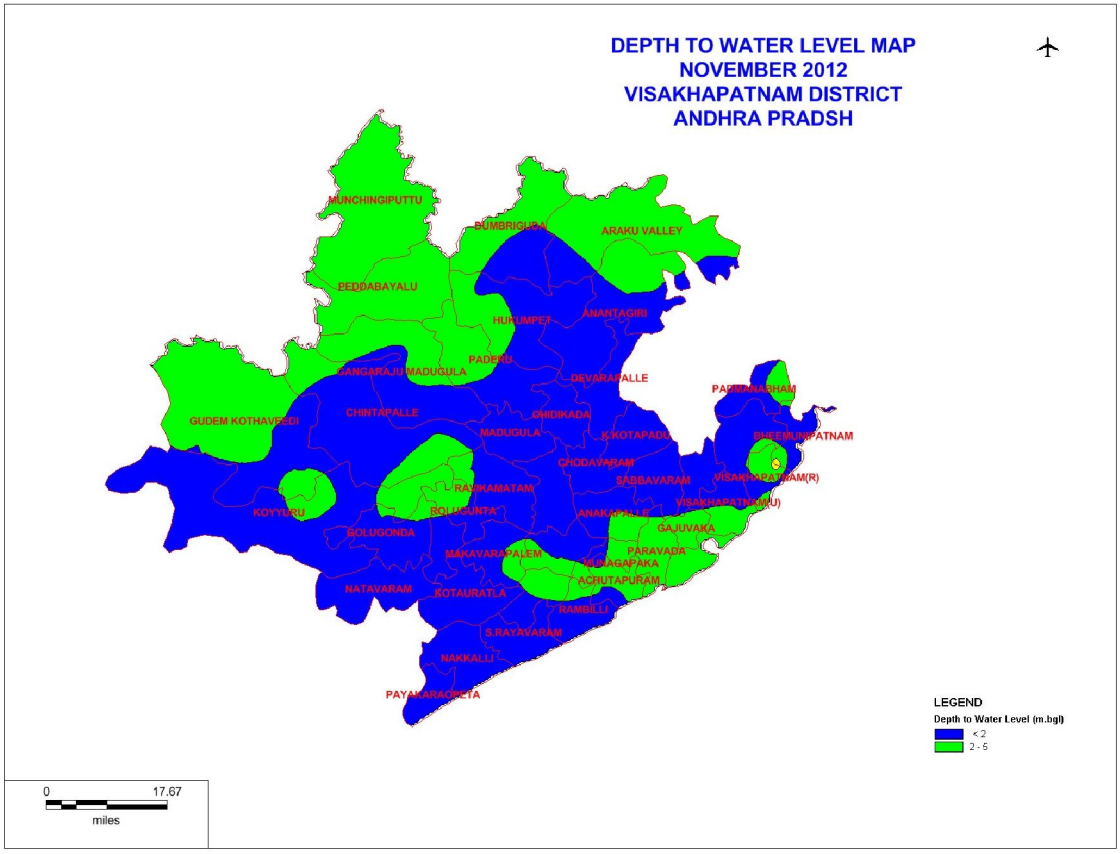
Fig 3. DEPTH TO WATER LEVEL – PRE-MONSOON (MAY, 2012)

VISAKHAPATNAM DISTRICT



During the post monsoon period (November, 2012), in general, the water levels follow nearly same trend. Water levels in the most part of northern area show less than 5 m. except at Potinamallaya Palem (5.80 m). The Shallow water levels, <2m, were observed in South-Western part of the district. The shallow water level was recorded at Addaroddu (0.30 m). The shallow water levels in the area might be due to location of wells close to surface water bodies/ in topographic low levels. From the trend of both pre and post monsoon levels it can be safely concluded that the area, in general, is not prone to water logging.

Fig 4. DEPTH TO WATER LEVEL – POST-MONSOON (NOV, 2012)
VISAKHAPATNAM DISTRICT



The seasonal water level fluctuation varies from 0.03 m. (G.K.veedhi) to 14.22m. (Chintapallii). In general, the seasonal fluctuation is more in the hilly area compared to coastal plains.

Water level fluctuation between decadal mean of May(2001 – 2010) Vs May 2012 shows a total number of 34 wells show rise in water levels between 0.03 m to 4.65 m and water level fall in 03 wells between 0.20 m to 4.00 m.

Water level fluctuation between decadal mean of November (2001 -2010) Vs November, 2012 shows water level rise in 15wells ranging from 0.02m to 1.37m and fall in 19wells ranging from 0.10 in to 3.69m.

The water table elevation ranges between <1 m amsl (Bheemunipatnam) and 927 m amsl (Dimbriguda). The water table contours are almost parallel to the topographic contours. The general ground water flow direction is towards southeast directing towards the sea.

4.2 Ground Water Resources

As per the present ground water resource estimation (2008-2009) the total annual ground water recharge in the district is estimated to be **78,383** ha.m. (Command area = 11,794 ham and Non Command area = 66,689 ham) and the net annual ground water availability in the district after allowing the unavoidable natural discharges is 71689 ham (command area 10683 ham. and in Non command area 61,006 ham.) The gross ground water draft for all purposes is estimated as 23,100 ham out of which 6300 ham is in command area and 16,800 ham is in Non Command area. Thus the ground water available for future irrigation needs after allocating the ground water for future domestic and industrial needs is 38,264 ham in the entire district, which is 3,282 ham in command area and 34,982 ham in non command areas of the district. Mandal-wise ground water resources are given in **Table- 1.**

Table I: Mandal Wise Ground Water Resources of Visakhapatnam District (As on March 2009)

S. No.	Administrative unit/ District	Sub Unit	Net annual ground water availability (ham)	Existing gross ground water draft for all uses(ham)	Ground water balance (ham)	Stage of ground water development %	Category
1	Anakapalli	Com	746	444	302	60	Safe
		N.C	1076	495	581	46	Safe
		Total	1822	939	883	52	Safe
2	Anandapuram	Com	0	0	0	0	
		N.C	2167	790	1377	36	Safe
		Total	2167	790	1377	36	Safe
3	Ananthagiri	Com	0	0	910	0	
		N.C	1136	226	0	20	Safe
		Total	1136	226	910	20	Safe
4	Arakuvalley	Com	0	0	533	0	
		N.C	564	31	0	5	Safe
		Total	564	31	533	5	Safe
5	Atchutapuram	Com	221	130	91	59	Safe
		N.C	1159	522	637	45	Safe
		Total	1380	652	728	47	Safe

S. No.	Administrative unit/ District	Sub Unit	Net annual ground water availability (ham)	Existing gross ground water draft for all uses(ham)	Ground water balance (ham)	Stage of ground water development %	Category
6	Bhimili	Com	0	0	0	0	
		N.C	1335	487	848	36	Safe
		Total	1335	487	848	36	Safe
7	Butachayyapet	Com	0	0	1394	0	
		N.C	1854	460	0	25	Safe
		Total	1854	460	1394	25	Safe
8	Cheedikada	Com	0	0	0	0	
		N.C	1293	409	884	32	Safe
		Total	1293	409	884	32	Safe
9	Chintapalli	Com	0	0	0	0	
		N.C	3922	532	3390	14	Safe
		Total	3922	532	3390	14	Safe
10	Chodavaram	Com	921	598	323	65	Safe
		N.C	1158	554	604	48	Safe
		Total	2079	1152	927	55	Safe
11	Devarapalli	Com	0	0	0	0	
		N.C	1608	553	1055	34	Safe
		Total	1608	553	1055	34	Safe
12	Dumbriguda	Com	0	0	0	0	
		N.C	826	49	777	6	Safe
		Total	826	49	777	6	Safe
13	Elamanchili	Com	825	566	259	69	Safe
		N.C	814	321	493	39	Safe
		Total	1639	887	752	54	Safe
14	G.K.Veedhi	Com	0	0	0	0	
		N.C	1839	111	1728	6	Safe
		Total	1839	111	1728	6	Safe
15	G.Madugula	Com	0	0	0	0	
		N.C	1103	135	968	12	Safe
		Total	1103	135	968	12	Safe
16	Gajuwaka	Com	0	0	0	0	
		N.C	941	116	825	12	Safe
		Total	941	116	825	12	Safe
17	Golugonda	Com	0	0	0	0	
		N.C	1513	296	1217	20	Safe
		Total	1513	296	1217	20	Safe
18	Hukumpeta	Com	0	0	0	0	
		N.C	1781	148	1633	8	Safe
		Total	1781	148	1633	8	Safe
19	K.Kotapadu	Com	0	0	0	0	Safe
		N.C	1650	833	817	50	Safe
		Total	1650	833	817	50	Safe
20	Kasimkota	Com	97	50	47	52	Safe
		N.C	1758	536	1222	30	Safe
		Total	1855	586	1269	32	Safe
21	Kotauratla	Com	0	0	0	0	
		N.C	1702	704	998	41	Safe
		Total	1702	704	998	41	Safe
22	Koyyuru	Com	0	0	0	0	
		N.C	1757	206	1551	12	Safe
		Total	1757	206	1551	12	Safe
23	Makavarpalem	Com	462	167	295	36	Safe
		N.C	1616	785	831	49	Safe

S. No.	Administrative unit/ District	Sub Unit	Net annual ground water availability (ham)	Existing gross ground water draft for all uses(ham)	Ground water balance (ham)	Stage of ground water development %	Category
		Total	2078	952	1126	46	Safe
24	Munagapaka	Com	225	132	93	59	Safe
		N.C	665	302	363	45	Safe
		Total	890	434	456	49	Safe
25	Munchingput	Com	0	0	0	0	
		N.C	1320	62	1258	5	Safe
		Total	1320	62	1258	5	Safe
26	Nakkapalli	Com	0	0	0	0	
		N.C	2004	838	1166	42	Safe
		Total	2004	838	1166	42	Safe
27	Narsipatnam	Com	749	132	617	18	Safe
		N.C	612	264	348	43	Safe
		Total	1361	396	965	29	Safe
28	Nathavaram	Com	0	0	0	0	
		N.C	2420	468	1952	19	Safe
		Total	2420	468	1952	19	Safe
29	Paderu	Com	0	0	0	0	
		N.C	1410	151	1259	11	Safe
		Total :	1410	151	1259	11	Safe
30	Padmanabham	Com	0	0	0	0	Safe
		N.C	1528	655	873	43	Safe
		Total	1528	655	873	43	Safe
31	Parawada	Com	0	0	0	0	
		N.C	1459	486	973	33	Safe
		Total	1459	486	973	33	Safe
32	Payakaraopeta	Com	2325	1676	649	72	Safe
		N.C	206	81	125	39	Safe
		Total	2531	1757	774	69	Safe
33	Pedabayalu	Com	0	0	0	0	
		N.C	1162	36	1126	3	Safe
		Total	1162	36	1126	3	Safe
34	Peda Gantyada	Com	0	0	0	0	Safe
		N.C	1212	81	1131	7	Safe
		Total	1212	81	1131	7	Safe
35	Pendurty	Com	0	0	0	0	
		N.C	1003	274	729	27	Safe
		Total	1003	274	729	27	Safe
36	Rambilli	Com	142	83	59	58	Safe
		N.C	1101	471	630	43	Safe
		Total	1243	554	689	45	Safe
37	Ravikamatam	Com	292	105	187	36	Safe
		N.C	2048	598	1450	29	Safe
		Total	2340	703	1637	30	Safe
38	Rolugunta	Com	0	0	0	0	
		N.C	1525	669	856	44	Safe
		Total	1525	669	856	44	Safe
39	S.Rayavaram	Com	2163	1315	848	61	Safe
		N.C	754	571	183	76	Safe
		Total	2917	1886	1031	65	Safe
40	Sabbavaram	Com	0	0	0	0	
		N.C	1476	455	1021	31	Safe
		Total	1476	455	1021	31	Safe

S. No.	Administrative unit/ District	Sub Unit	Net annual ground water availability (ham)	Existing gross ground water draft for all uses(ham)	Ground water balance (ham)	Stage of ground water development %	Category
41	V.Madugula	Com	1515	902	613	60	Safe
		N.C	1444	236	1208	16	Safe
		Total	2959	1138	1821	38	Safe
42	Vsp Rural	Com	0	0	0	0	
		N.C	1386	323	1063	23	Safe
		Total	1386	323	1063	23	Safe
43	Vsp Urban	Com	0	0	0	0	
		N.C	1699	480	1219	28	Safe
		Total	1699	480	1219	28	Safe
District Total		Com	**10683**	**6300**	**4383**	**59**	
		N.C	**61006**	**16800**	**44206**	**28**	
		Total	**71689**	**23100**	**48589**	**32**	

Stage of Development and Future Prospects

The present stage of ground water development in the district is 32% with a gross ground water draft of 23100 ha.m out of total available ground water resource of 71,689 ham. The stage of ground water development in the command area is 59% and in Non Command area it is 28%. Based on the stage of ground water development and the ground water level trends in each mandal they were categorized and all the mandals are categorized to be 'Safe'.

4.3 Ground Water Quality

To study the quality of ground water in Visakhapatnam district, 37 samples were collected in the month of May, 2011 and analyzed for various chemical constituents. The results of the analysis of important constituents, ranges, and ISI standards are shown in **Table. II.**

Table: II General range of Important Chemical Constituents

Sl. No.	Constituent	Range		ISI Standards Desirable	Permissible
		Min	Max		
1	pH	7.43	8.90	6.5 – 8.5	No range
2	E.C/µS/cm at 25^0C	110	3263	750	3000
3	Total Hardness (mg/l)	45	660	300	600
4	Ca (mg/l)	8	166	75	200
5	Mg (mg/l)	1.0	113	30	100
6	Na (mg/l)	5.0	506	-	-
7	K (mg/l)	1.0	180	-	-
8	Co3 (mg/l)	Nil	87	-	-
9	HCo3 (mg/l)	24	634	-	-
10	Cl (mg/l)	7.0	695	250	1000
11	So_4 (mg/l)	0.5	192	200	400
12	No_3 (mg/l)	0.4	249	45	100
13	F (mg/l)	0.04	1.6	1.0	1.5

Electrical Conductivity: The lowest value of E.C (µS/cm at 25^0C) was recorded at Gudem village as 110. Higher values of E.C more than 3,000 recorded as 3,263 at Addaroad village, 3,202 at Pudimadaka village, and 3,150 at Revupolavaram village. The EC increases from north to south i.e. towards Coast. Higher values of EC are recorded at Addaroad, Pudimadaka, Revupolavaram.

The lowest value of chloride recorded as 7 mg/l at Kottur and higher value was recorded at Pudimadaka village as 674 mg/l. The concentrations of Nitrates in the district range from a minimum of 0.4 mg/l at Lotugadda village, to maximum value of 249 mg/l at Pudimadaka. Fluoride in the area ranges from 0.04 to 1.6 mg/l, by and large the area is free from fluoride hazards. The lowest value of 0.04 mg/l is recorded at Gudem village and maximum value of 1.6 mg/l recorded at Narsipatnam.

Suitability of Water for Irrigation Purposes (Plain Areas)

Out of the 24 samples, 3 samples at Sriharipuram, Pendurthi and Tallapalem villages are falling in C_4S_3 category i.e., High Sodium to very high Salinity Hazard. Four samples are falling in C_4S_2 category i.e. very high Salinity - Medium Sodium Hazard. One sample at Chintapalli is falling in C_3 S_3 category i.e. High Salinity - High Sodium Hazard and one sample at Medivoda village C_3 S_2 category i.e. High Salinity - Medium Sodium Hazard . 9 samples are falling in C_3S_1 category i.e., High Salinity to Low Sodium Hazard. These samples may provide harmful levels of exchangeable sodium in most soils, with adequate drainage for salinity control, high leaching and addition of organic matter.

6 samples are falling in C_2S_1 i.e., Medium Salinity to Low Sodium Hazard. This water may be used on soils with adequate drainage for salinity control. The water may be used on appreciable sodium hazard in fine textured soils having high cat ion exchange capacity when leaching conditions are poor.

Suitability of water for irrigation purpose (Hilly Area)

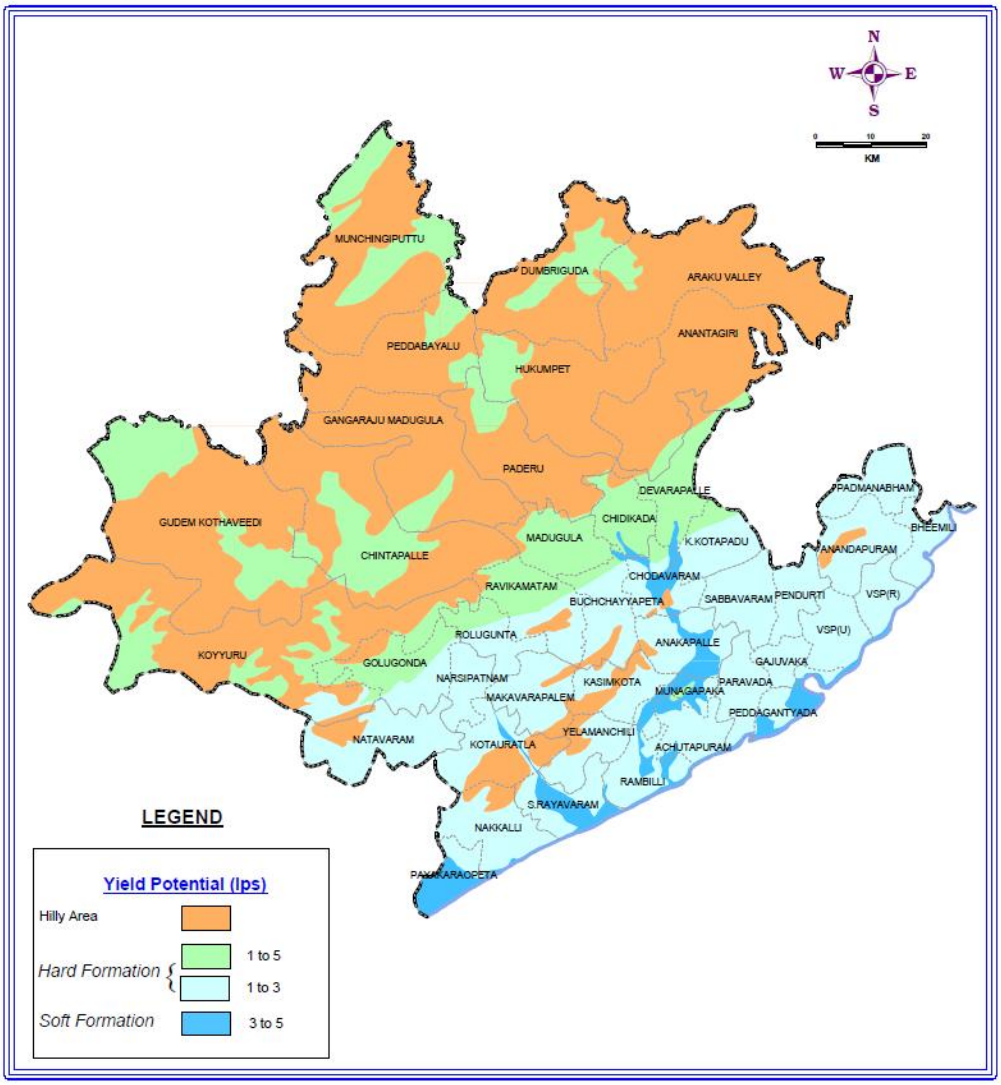
Out of 13 samples 2 samples at Aruku and Paderu are falling in C_3S_1 category. 4 samples are falling C_2S_1 category and 7 samples are falling in C_1S_1 category.

The quality of the ground water in the district is, in general, potable and suitable for domestic, industrial and irrigation purposes except at few locations.

4.4 Status of Ground Water Development

Ground water is one of the most important and essential commodities for agricultural development and thus the judicious and scientific management of the resource are essential. The level of ground water development in the district is in the order of 32% of the annual replenishable resource. There is a huge scope for further development of ground water in order to increase the irrigated area. Though surface water is abundant, during summer season, its availability is very less due to swift nature of streams and rivers of the district. The district is underlain by consolidated formations and to a limited extent by unconsolidated formations, therefore DTH and DR rigs respectively, were suggested for deployment. Based on the yield potential of the aquifers the district is classified as low (1 to 3 lps), Low to Moderate (1 to 5 lps) and Moderate (3 to 5 lps) yield potential areas **(Fig. 5).**

Fig. 5 GROUND WATER YIELD POTENTIAL - VISAKHAPATNAM DISTRICT



At present in the consolidated formations dug wells of 3 to 6m diameter with depths of 5 to 15 m exist. Whereas, in the unconsolidated formations wells with 2 to 3 m diameter in the depth range of 2 to 7 m are prevalent in the district. In unconsolidated formations, wells are either stone or brick lined (masonry lined) and RCC rings are lowered upto sufficient depths. Ground water in the district is also developed through bore wells of 250 to 380 mm diameter with casing upto 10 to 15 m deep and are drilled down to 40 to 60 m depth in consolidated formations. Similarly tube wells in semi-consolidated formations are with 380mm diameter is drilled down to depths of about 100 m, tapping 30 to 40m saturated aquifer material. And also filter point wells of 254 mm diameter are driven down to a depth ranging between 7 and 15 m in the alluvial areas wherever the potential zones available beyond 5 m. In the consolidated and

semi-consolidated formations ground water is also developed through dug cum bore/tube wells as the dug wells are being dried up or not getting sufficient yields during summer season. The depth of inwells of these structures ranges from 40 to 60 m and 30 to 100 m in consolidated and semi-consolidated formations respectively.

Ground water irrigation in the district is not extensive. There are 34,943 ground water abstraction structures (Dug wells, Dug-cum-bore wells and bore wells/tube wells exist in the area. A total area of 34,922 ha is irrigated through ground water, of which 10,530 ha with dug well sources and 24,392 ha by bore/tube wells.

Drinking water supply schemes

Ground water forms the main source for drinking water schemes in both rural and urban areas of the district. The protected water supply schemes (PWS) and de-fluoridation plants are maintained by the Panchayat Raj Depatment, Government of Andhra Pradesh. These schemes include river lift, surface flow lift schemes, bore wells and large diameter dug wells and dug-cum-borewells and hand pumps fitted shallow bore holes. There are 981 protected water supply schemes and 2,149 borewells and 2,755 open wells exist by the year 2009-10 catering the drinking water needs of the district population.

Urban water supply to Visakhapatnam Corporation, Bheemunipatnam and Anakapalli municipalities is being met mostly by surface water and about 10 % of the demand is met by ground water sources. A total number of 785 open wells, 11,256 bore wells and 1,213 protected water schemes are meeting the drinking water requirements of the rural population.

5.0 GROUND WATER MANAGEMENT STRATEGY

5.1 Water Conservation and Artificial Recharge

In the hilly areas where tribal population is facing water problem both for drinking and irrigation purposes, proper planning may be chalked out to harness the existing natural springs. The surplus water in the stream courses should also be conserved by constructing series of stop dams. The conserved water can be utilized to irrigate the limited land available near the streams. Spring water can be stored and supplied to the nearby villagers for drinking purpose. Systematic studies are recommended to locate the natural springs and also utilization of the spring water to water scarcity villages.

Construction of artificial recharge structures like check-dams, contour trenches, percolation tanks and water conservation structures like sub-surface dykes are feasible in the areas where water levels are declining and considerable exploitation of ground water resources is taking place viz. Munagapaka and Payakaraopeta mandals. Rooftop Rainwater Harvesting is to be implemented in the Urban areas wherever deepening of water levels are taking place. Along the coast, large number of rain water conservation structures may be constructed to prevent intrusion of seawater

6.0 GROUND WATER RELATED ISSUES AND PROBLEMS

Overall there is no significant change in water levels in the district. However, at few places decline in water table exists, which suggests that suitable preventive steps to be taken. However the magnitude of the decline is less. Water logging does not exist in the canal command and irrigated areas of the district.

Ground water pollution is not significant in the non industrial area of the district. However localised Nitrate pollution in the district is due to excess use of fertilizers, urban sewerage disposal and improper drainage system. Though district has a coast line of 132 km, no significant sea water intrusion/ ingress is reported. Heavy metal pollution of ground water exists in the Mindi - Chukkavanipalem industrial area due to the industrial effluents. In old city

area of Visakhapatnam i.e. Kotaveedhi, Gnanapuram etc. ground water is already contaminated due to the marshy nature. In such areas well should be limited to shallow zones only.

7.0 AWARENESS AND TRAINING ACTIVITY

Two Training Programmes on Ground Water Management were organised at Visakhapatnam and Paderu. At Visakhapatnam the training was organized on 4th and 5th October, 2005, a total of 30 persons from different organizations (government and non government) and students from Andhra University attended this programme. At Paderu, the training programme was organized on 8th & 9th February, 2012. A total number of 26 trainees were participated from various state government departments. The Mass Awareness programme on ground water conservation and protection was organized in the district on 21st March, 2003 at Elamanchili. About 250 persons representing state government officials, NGO's and farmers participated in the campaign. The importance of groundwater management, conservation, protection, recharge practices and chemical quality were explained and interaction on these themes was taken place. Posters and maps related to importance of ground water conservation and protection were displayed and explained to the participants and visitors in detail.

8.0 AREAS NOTIFIED BY CGWA/ SGWA

As per the ground water resources of the district all the mandals fall under Safe category, hence no area/mandal has been notified.

9.0 RECOMMENDATIONS

Presently the ground water development in the district is rather unplanned. Further development in the areas with considerable exploitation of ground water needs to be viewed with caution to avoid unscientific development of ground water. The ground water available for future irrigation needs after allocating the

ground water for future domestic and industrial needs is 38,264 ham (2009). This resource should be utilized in planned and judicious manner.

In the Northern part of the district, which is marked by hilly area with tribal population, though good amount of rainfall occurs due to higher elevation and steep topographic ground conditions the rain water runs away swiftly during rainy season. The tribal population in the area is facing water scarcity both for drinking as well as irrigation of their limited land available along the stream courses. There are number of natural springs existing in the area and the streams carry rain water during rainy season. The spring water can be harnessed and supplied to the nearby villages / hamlets, to solve drinking water problem. Check dams/Stop dams in series can be constructed along the stream courses and the stored water may be used for irrigation of land available along the streams. Drip and Sprinkler irrigation system may be adopted where the water resource is limited.

In plain areas agricultural activities are increasing day by day. Though there is no significant continuous water level decline noticed and the area fall in safe category, it is observed that people started facing water problem especially in summer months at places. Now the Government started construction of water conservation structures under Mahatma Gandhi Rural Employment Guarantee Scheme. If these structures selected scientifically at favorable hydro geological conditions can act not only for storage of water but also will augment ground water reservoirs by recharging. For the selection of these structures technical experts from State Ground Water department and Central Ground Water Board may be involved and included in the district planning committees.

In urban areas especially in Visakhapatnam municipal areas people already started facing water scarcity besides ground water pollution. Mass awareness programmes may be conducted to aware the people to adopt for construction of roof top rain water harvesting in a large scale so that rain water can be harvested and it will increase ground water resource. In Visakhapatnam Urban area it is evident from the investigations carried out by various agencies and scientific scholars the ground water has also polluted within the vicinity of

industries due to industrial effluents released without proper treatment. It is also reported the polluted ground water affecting adversely the human health of the people who are living in the industrial areas. So it is recommended industry wise systematic micro level ground water quality studies may be taken up immediately and remedial measures may be taken up by the Government organizations and also the agencies involved in water related issues. Strict measures should be implemented to ensure the industrial effluents are properly treated before discharging into canals/ surface drainage.

In the coastal area ground water development has to be taken up very judiciously to avoid any possibility of sea water ingress/intrusion. Along the coast micro level surveys may be taken up to find out the exact reason for salinity and rainwater harvesting structures should be constructed so as to prevent up coning of saline water. Heavy pumping along the coast should be discouraged to prevent salinity ingress into fresh water shallow aquifers.

A multi-sectoral approach is needed to study the ground water development, augmentation and management perspective. Therefore, all the aspects related to conjunctive use, ground water legislation, involvement of NGOs and mass awareness campaign will play an important role in conserving and developing the precious water resources.

ACKNOWLEDGEMENTS

Thanks are due to the Chief Planning Officer, Visakhapatnam District, Visakhapatnam, to the Dy. Director, State Ground Water Department, Visakhapatnam and to other State Government Authorities for providing necessary data.