केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report

on

AQUIFER MAPPING AND GROUND WATER MANAGEMENT

Upper Cauvery Basin, Tamil Nadu

दक्षिण पूर्वी तटीय क्षेत्र, चेन्नई

South Eastern Coastal Region, Chennai

Foreword

Groundwater is the major source of freshwater that caters the demand of ever growing domestic, agricultural and industrial sectors of the country. This renewable resource has been indiscriminately exploited in some parts of the country by several users as it is easily available and reliable. Intensive and unregulated groundwater pumping in many areas has caused rapid and widespread groundwater decline. Out of 6607 ground water assessment units (Blocks/ mandals / taluks etc.), 1071 units are over-exploited and 914 units are critical. These unitshave withdrawal of ground water is more than the recharge (over exploited) and more 90% of recharge (Critical).

Central Ground Water Board (CGWB) has taken up largest Aquifer mapping endeavour in the world, targeting total mapable area of country ~ 23.25 lakh sq. km with a vertical extent of 300 m in soft rock area and 200 m in hard rock area. The extent of aquifer, their potential, resource availability, chemical quality, its sustainable management options will be addressed by National Aquifer Mapping (NAQUIM). The NAQUIM programme will also facilitate participatory management of ground water to provide long term sustenance for the benefit of farmers. Currently, focus is on ground water stressed areas of eight states comprising 5.25 lakh sq.km viz. Tamil Nadu, Haryana, Punjab, Rajasthan, Gujarat, Andhra Pradesh, Telangana, Karnataka and Bundelkhand region.

South Eastern Coastal Region, Central Groundwater Board, Chennai Under NAQUIM has been envisaged with the Mapping of an area of 70,102 sq.km during 2012-17 (XII five year plan) in Tamil Nadu and UT of Puducherry. This report deals with the Aquifer mapping studies carried out in water stressed upper Cauvery basin covering basin area of 4561 sq .km with 3634 sq.km as mappable area. The basin comprises of drought prone districts of Dharmapuri, Krishnagiri and parts of Salem with 32 firkas (15 Over Exploited and 8 Semi-critical), and is mainly dependent on groundwater (85%) for its agricultural needs. The major issues in the basin include declining groundwater levels, sustainability of wells and high Fluoride concentration in patches leading to risk of dental and skeletal fluorosis. Two aquifer units were deciphered with aquifer Unit - I being the weathered, occurs from ground level to 36 m bgl and Aquifer Unit –II is the fractured/Jointed zone existing from 11 to 140 m bgl (2-5 fractures are encountered). In order to arrest the decling groundwater levels and increase the sustainability of wells groundwater management plans were formulated firka wise.

I hope this report will be useful for the district administrators, water managers, stakeholders including farmers in knowing the aquifer and managing it resources effectively.

A.Subburaj
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EXECUTIVE SUMMARY

Detailed hydrogeological studies were conducted in the study basin of Upper Cauvery and huge existing data pertinent to geology, geophysics, hydrology, hydrochemistry was collected, synthesised and analysed to bring out this report. This report mainly comprises the Aquifer geometry and Aquifer properties of the study area which are considered to be measuring scales for groundwater availability and potentiality. Keeping these parameters in view a sustainable management plan has been suggested through which the groundwater needs can be fulfilled in a rational way.

Area experiences semi-arid climate with 875 mm annual normal rainfall covering 4541 km^2 area in Dharmapur, Krishnagiri and Salem districts of Tamil Nadu. About 51 thousand hectares of area is under groundwater irrigation in the basin and accounts for 11.6% of the geographical area. The main crops irrigated are paddy, sugarcane, groundnut, maize, cotton, ragi and other minor crops are turmeric, vegetables and flowers.

Main aquifers constitute, weathered zone at the topfollowed by a discrete anisotropic fractured/fissured zone at the bottom.Groundwater occurs under unconfined condition in the weathered zone and unconfined to semi-confined conditionsin the fractured/fissured zone and flows downward from the weathered zone into the fracture zone. The predominant water levels are in the range of 5-20 m bgl during pre-monsoon season and 2-10 mbgl during post-monsoon season of 2014. The net annual ground water availability is 282 MCM and the gross ground water draft is 335 MCM and the average stage of groundwater development is of 119%.

The fluoride levels in the ground waters of the basin exceed the permissible limit of 1.5ppm in few parts of Dharmapuri and Krishnagiri districts due to geogenic contamination. This problem is addressed through drinking water supply to the affected villages from Hognekal reservoir.

Aquifer systems from the area can be conceptualized as weathered zone down to ~36m and fractured zone between ~20-200 m bgl. The weathered zone is disintegrated from the bed rock (upper part–saprolite zone) and partially/semi weathered in the lower part (sap rock zone) with transmissivity varying between 5–20 m^2/day and specific yield of 1-3 %. The fractured zone is fractured gneiss or Charnockite which occur in limited extent, associated sometime with quartz vein. The average transmissivity of this zone varies between <1–30 m^2/day and storativity varies from 0.00002 to 0.001.

Fast growing urban agglomerations shares the groundwater which otherwise is being used for irrigation purpose resulting in either shortage for irrigation needs or creates excessive draft to meet the both demands in groundwater potential areas. The study formulates management strategies for supply side as well as demand side. The supply side measures include construction of artificial recharge structures of 302 Check dams, 421 Percolation ponds, 300 recharge shafts in addition to the 689 ponds earmarked for rejuvenation with recharge shafts in all the 15 OE firkas of the basin. The estimated cost for construction of these structures is to be Rs. 308 Crores. The estimated recharge to groundwater system through these structures will be in the order of 61.75 MCM withan average rise of water levels of 2.28m/year. In addition water conservation plan is proposed through low pressure water distribution system in 1391 Ha irrigation area and digging of 1362 farm ponds which support storage as well as recharge. The expected savings in groundwater through this water conservation plan is estimated as 10.8MCM/year.

The existing regulatory measures may be modified suitably for optimal utilization of groundwater as well as for sustainable development of rural agricultural based economy. To achieve this goal opinion pool has to be obtained from more user groups and valid suggestions of may be incorporated in the regulatory acts.

REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUNDWATER RESOURCES IN UPPER CAUVERY BASIN, TAMIL NADU
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AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUNDWATER RESOURCES IN UPPER CAUVERY BASIN, TAMIL NADU

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AQUIFER MAPPING AND MANAGEMENT PLAN FOR UPPER CAUVERY BASIN, TAMIL NADU

1.0. INTRODUCTION

National Project on Aquifer Mapping (NAQUIM) initiated by Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India with a vision to identity and map the aquifers at the micro level with their characteristics, to quantify the available groundwater resources, propose plans appropriate to the scale of demand and institutional arrangements for participatory management in order to formulate a viable strategy for the sustainable development and management of the precious resource which is subjected to depletion and contamination due to indiscriminate development in the recent past.

Ground water is being increasingly recognized as a dependable source of supply to meet the demands of domestic, irrigation and industrial sectors of the country. The development activities over the years have adversely affected the ground water regime in many parts of the country. Hence, there is a need for scientific planning in development of ground water under different hydrogeological situations and to evolve effective management practices with involvement of community for better ground water governance.

Aquifer Mapping has been taken up in Upper Cauvery basin in a view to formulate strategies for sustainable management of the dynamic groundwater resource which help in drinking water security and improved irrigation facility. It will also result in better management of vulnerable areas.

1.1.Objective:

The objectives of the aquifer mapping project in Upper Cauvery can broadly be stated as

1. To define the aquifer geometry, type of aquifers and ground water regime behaviors,
2. Hydraulic characteristics and geochemistry of two-layered aquifer systems on 1:50,000 on a 3-D section
3. To develop an Aquifer Information and Management System for sustainable management of ground water resources based on the aquifer maps prepared.

4. And to involve the local community for self governance so that the user community will be aware of the available resource and shoulder responsiblity in proper optimal utilisation.

1.2. Scope of the Study:

The important aspect of the aquifer mapping programme is the synthesis of the large volume of data already generated during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe the aquifer system. The available generated data are assembled, analysed, examined, synthesized and interpreted from available sources. These sources are predominantly non-computerized data, which is to be converted into computer based GIS data sets.

Data gaps have been identified after proper synthesis and analysis of the available data collected from different state organisations like TWAD Board, PWD, Agricultural Engineering. In order to bridge the data gap, data generation programme has been formulated in an organised way in the basin. Exploration work has been carriedout in different segments of the basin and aquifer parameters have been estimated. Groundwater monitoring regime has been strengthened by establishing additional monitoring wells. 2D and 3D sections have been prepared twice, one prior to the generation of data based on the data collected, assembled and synthesized through different sources and two, after generation of data at identified gaps. The latter prepared maps are of more realistic as the data points are more closure.

1.3. Approach & Methodology:

Multi-disciplinary approach has been adopted involving geological, geophysical, hydrological and hydrogeological and hydrogeochemical components of study on toposheet scale of 1:50000 to meet the objectives of study. Geological map of the basin has been generated based on the GSI maps, geophysical data has been generated through vertical electrical soundings and geoelectrical layers with different resistivities have been interpreted in corroboration with the litho stratigraphy of the observation wells and exploratory wells down to depths of 200m bg. Hydrological and Hydrometerologicaldata has been collected from state PWD and IMD departments. Drainage, Soil and Geomorphology of the basin is complied based on the maps collected from Water Resources Department, Anna University, Chennai.

Based on the data gap analysis data generation process has been scheduled through establishing key observation wells, pinpointing exploratory sites, collecting geochemical samples in order to study groundwater regime, geometry of the aquifer and aquifer parameters, and quality of the groundwater respectively. Groundwater recharge and draft have been computed through different methods and resources of the basin estimated through groundwater balance method. A three-dimensional mathematical model of regional groundwater flow wasused.

to provide a mechanistic description of groundwater flow in the aquifer system of Upper-Cauvery basin. The model was simulated using the finite-difference approximation of three-dimensional partial differential equation of regional groundwater flow and was calibrated for steady and transient conditions to forecast the dynamic groundwater flow under different recharge and stress conditions.

Based on the above studies Management strategies have been evolved for augmentation of groundwater through artificial recharge and water conservation and formulated plans for sustainable management of the resource.

1.4. Area:

The Cauvery river enters Tamil Nadu at Hognekal of Dharmapuri district from the west and takes a southern course from Mettur and again takes south-eastern course at Erode and then flows to Bay of Bengal flowing through Trichirapalli, Thanjavur and Cuddalore districts. The study area forms part of Cauvery basin, which lies on left banks of Cauvery river. The total area of the basin is of 4541 sq.km. mainly drained by Chinnar river, tributary of Cauvery which confluences at Hognekal of Dharmapuri district. The other tributaries flows in the selected area for study are Doddahalla, Nagavati and Thoppaiar. Out of the 4541 sq.km total area, hilly part consists of 907 sq.km and the rest 3634 sq.km is mapable and falls in three different districts of Tamil Nadu viz., Krishnagiri, Dharmapuri and Salem.The area lies between 11°46′ and 12°42′ north latitudes and between 77°29′ and 77°29′ east longitudes and falls on Survey of India toposheet numbers 57H/7,8,10,11,12,14,15,16,57L/3,4,8,58E/9,13, and 58I/1&5.

1.5. Data availability

During the Aquifer mapping period, existing data of CGWB i.e. exploration, depth to water level, water quality, geophysical logging and ground water resource data have been collected and compiled. In addition to this, Bore well data, Water quality & Water level data have been collected from Tamil Nadu water Supply and Drainage Board. Cropping pattern and Soil data has been collected from Agricultural Department. Groundwater level and groundwater exploration data have been collected from Public Works Department. Thematic layers such as geology (GSI) soils, land use/landcover,geomorphology, etc., from various State Government agencies has been collected, complied and used in this study.

1.6. Data adequacy

Exploratory well data is available for 122 wells drilled by CGWB and State Departments. Water level and Water Quality monitoring data for 23 Observation wells is available for a period of more than ten years. Landuse, Cropping and irrigation data has been collected from Statistical department. After plotting the available historical data on 1:50,000 scale maps, data gaps have been identified and data generation process has taken up in those gap areas to complete the Aquifer map on the desired resolution of 1:50,000 toposheets.

1.7. Data GapAnalysis & Data Generation:

As per the guidelines of data gap analysis for aquifer mapping, it is proposed to have 98 monitoring wells to monitor the regime of the first aquifer and 8 bore wells for the second aquifer monitoring and to know aquifer parameters. 98 Dug wells have been established to monitor the first phreatic aquifer and 6 bore wells drilled down to a depth of 200m bgl to know the aquifer characters of semi-confined aquifer system which is extensively developed in recent years. It is also proposed to carryout quality monitoringthrough 65 established dug wells for first phreatic aquifer and through 67 irrigation/domestic bore wells for the second semi-confined aquifer and collected water samples from all the 132 wells and analysed in order to assess the groundwater quality for drinking and irrigation purposes. Similarly as per the proposed data gap analysis of aquifer mapping, 52 VES have been taken up down to the depth of 200 m bgl to know the vertical characteristics of the aquifer down to 200m.

1.8. Climate and Rainfall

The basin area experiences tropical climate being hot and dry for the greater part of the year. The period from March to June is generally hot. The temperature ranges from 20° to 40°C. The area receives rainfall through both south-west and north-east monsoons. About 40 percent of the precipitation is contributed by south-west monsoon and north-east monsoon accounts for 30 to 40 percent. The average annual rainfall for the basin area is 875mm.

1.9. Physiography:

The study area is Upper Plateau Region of Tamil Nadu with many hill ranges and undulating plains in between. The highest peak in the basin is Devarabetta (1026mamsl) located in Tali reserve forest area from where the river Chinnar (Sanatkumara) river the tributary of Cauvery, which drains major area of the basin under study. Chinnar river flows towards east from its origin on west of Tali, from the hills of Tali Reserve Forest, till it reaches south of Kelamangalam; and takes a Southern turn at Marandahalli and follows south and reaches Chakkilinnattam and again changes its course towards south-west and joins Cauvery at Uttamalai. Many small swift streams join Chinnar drained from the hill ranges on either side of the Chinnar course.

1.10. Geomorphology:

The western part of the basin is covered with series of hill ranges and form upland. Many lower order streams flowing from this upland region join Doddahalli and Chinnar rivers. Pediments form on northern and eastern parts of the basin. More than ninety percent of the area is occupied by upland and pediment zones. Structural and residual hills, pediplains and Bajadas are the other geomorphic features manifested in the basin in lower proportion. Habitation and agricultural practices are more common in pediment areas, whereas and the Upland zone is fully forested.

1.11. Landuse:

Forests occupy major part of the basin (43%), mainly on western and southern parts of the study area. Deciduous and Evergreen forests occupy one third area each and the other one third area is occupied by scrubs and other forests. The cropping area is 33% of the basin area and 10% of the area is under plantation, mainly consisting of coconut and mango plants. Fallow land accounts for 3% and rural settlements confined to only 1% of the total geographical area. Water bodies including Mettur reservoir and irrigation tanks etc., spread over 3% of the geographical area. The remaining part of the basin is occupied by scrubs and stony waste.

1.12. Soils:

The soils of the basin mainly consist of black and mixed loam red ferruginous. The black or regular loam is very fertile due to its moisture absorbing character. On the other hand the red ferruginous soil is good for plant productivity. The soils in the basin are generally deep, loose and friable with its colour varying from red to dark reddish brown. The soils of the basin have low nitrogen and phosphate content. The highly undulating terrain in the basin especially in the upper reaches accelerates run-off causing soil erosion.

1.13. Hydrology and Drainage:

Doddahalla, Chinnar, Nagavati and Thoppaiyar are the rivers form the Study area and all these are tributaries of Cauvery river. Doddahalli mainly drains forest area of northern basin. The Chinnar also known as Sanatkumara Nadi originates in the State of Karnataka and enters Tamil Nadu at Tali and it has a south-easterly course upto Marandahalli from where it takes a southerly course till it meets Pikkili Malai hills from where it takes a south-westerly course until it joins the Cauvery river immediately after Hoghenakkal Water Falls and drains major part of the study area. The other two rivers Nagavati and Thoppaiyar originate from Pikkili and Yercud hills respectively and flows south-westerly and westerly respectively and join Cauvery river at Stanley Resevoir at Mettur.

1.14. Agriculture:

Agriculture is the main stay of the rural population in the entire study area. The main crops irrigated are Paddy, Sugar cane, groundnut, Maize, cotton, Ragi etc., and other minor crops are turmeric, flowers and vegetables.

1.15.Irrigation:

The total area irrigated under different crops is 50,928 Ha out of the total geographical area of 4,38,300Ha, which accounts for 11.62%. Out of the 32 firkas of the basin the highest area under irrigation is in Bommadi (30% of firka area) followed by Marandahalli (27.8%), Pulikarai (27.6%), Uthanapalli (27.63%), Palakodu (21.4%); while the lowest area irrigated in Mettur, Semmandapatti and Pottaneri firkas (<3% of the respective geographical area). The irrigation area within the basin is relatively more in Dharmapuri district part followed by Krishnagiri and Salem district parts.

1.16. Recharge Practices:

Ground water is being augmented through the recharge structures by departments/ agencies of State such as, Agricultural Engineering Department, Agricultural Department, PWD, TWAD Board and Forest Department. In addition, recently PWD is taking up Repair, Renovation and Restoration (RRR) of surface water bodies with central fund, which will be of immense use in groundwater augmentation in addition to the increase in storage capacity of the tanks.

2. Data Collection and Generation.

Periodical data pertaining to water levels, pumping tests and slug tests were collected during aquifer mapping studies apart from water sample collection to assess the groundwater quality. In addition Geophysical data has been generated through conducting Geo electrical soundings after evaluation of data gap analysis.

2.1. Hydrogeological data:

The periodical monitoring of ground water level implies the groundwater recharge and discharge (natural and manmade) occurring in the aquifer systems. It also reveals that the interaction between surface and sub-surface water systems. In Upper Cauvery basin, 23 no's of groundwater monitoring wells established earlier to the present study were monitored periodically. To fill data gap in the basin, 97 additional wells were established and monitored periodically during the five year aquifer mapping study period in order to record the temporal and special changes in aquifer system. The details of monitoring wells are presented as Annexure-1.The locations of the monitoring wells are presented in **Fig.2.1**.The groundwater level monitoring was carried out four times in an year since May 2014 to Jan 2016.

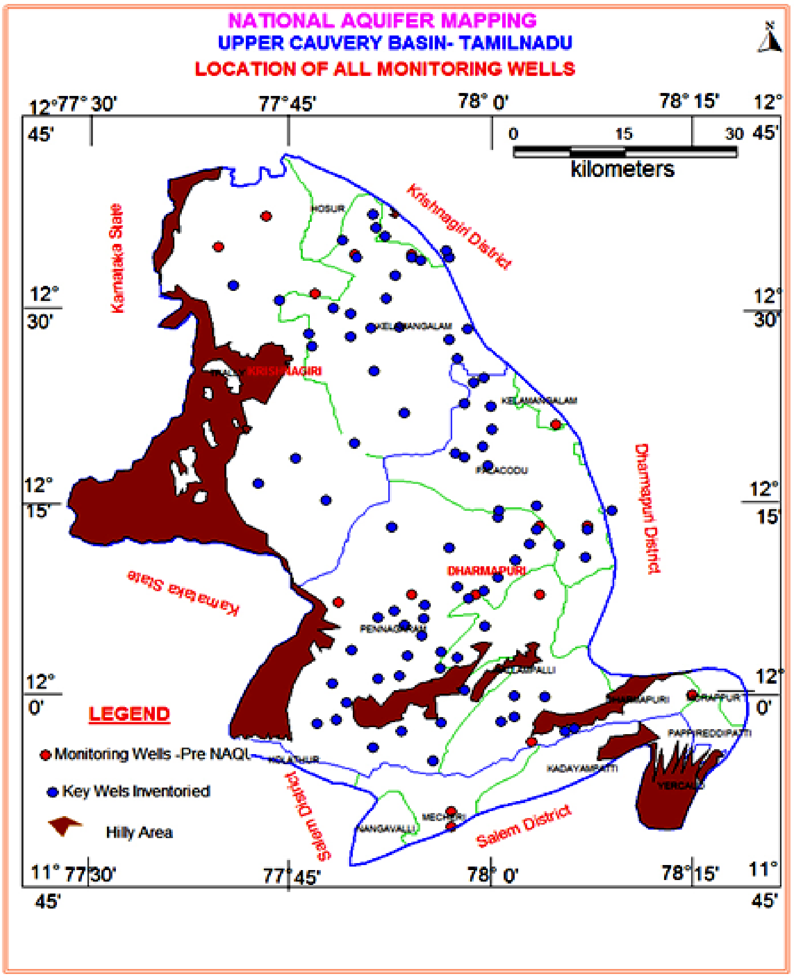


Fig.2.1 Location of All Monitoring Wells

Pumping test data of 8 bore wells was collected from both PWD (Groundwater), Dharmapuri, Govt.of Tamil Nadu and CGWB and results were tabulated in table No.1.

Table-1: Pumping test data

Sl.	Location, Well number ,	Lithology	Results of aquifer performance test						
No.	Co-ordinates,								
	Toposheet Number		SWL (mbgl)	Discharge (lps)	Specific capacity	T (m2/ day)	S	K (m/Day)	Specific yield(%)
	and R.L. of G.L. (mamsl)		Date		(lpm/m of Draw down)				
1	KELAMANGALAM(EW)	Charnockite and Granite Gneiss	11.25	1.65	5.18	8.58	2.6 x		
	(12° 36' 10";77° 51' 50"-57 H/11) 788.29		--			Average	10-3		
	KELAMANGALAM(OW-I)	Sand with Kankar, Granite Gneiss	4.98	1.76	26.59	12.14	2.6 x		
	(12° 08' 38"; 77° 52' 33"-57 H/11) 788.29		18.1.88				10-3		
	KELAMANGALAM(OW-II)	Sand withKankar, Granite		1.65	5.89	--	1.4 x10-3		
2	DODDALAMPATTI	Charnockite		3.85	8.3	19.93		3.54	
	12°13"55':78°03"45'								
3	PAPPARAPATTY	Charnockite		2.31	2.59	24.56		0.6	
4	NAKKALAPATTI	Charnockite		0.24	1.248	3.17	0.0003	0.27	0.03
	12°12"30':78°06"05'								
5	ALAMARATHUPATTY	Charnockite		0.01	0.012	0.702	0.0001	0.012	0.01
	12°10"30':78°01"50'								
6	PIKKILI			0.42	10.42	31.01	0.0378	12.92	3.78
	12°14"15':78°01"30'								
7	KOTTUR			0.174	3.3	9.09	0.0052	2.88	0.5
	12°18"20':77°58"20'								
8	MARANDAHALLI			0.023	0.024	0.856	0.00001	0.015	0.001
	12°10"30':78°06"05'								

Slug tests were conducted on 8 exploratory wells drilled by CGWB during the study period and shown as Table-2.

Table2:SLUG TESTS DETAILS

Sl.No	Location	Co-ordinates		Depth of the well(mbgl)	Lithology	Static water Level(bgl)	T(m2/day)
1	Mugulur	12°32"40’	78°01"11’	176.1	Migmatite	71.4	1.2
2	Odayandahalli	12°29"15’	78°01"24’	101	G.Gneiss	10.85	1.47
3	Maniyambadi	12°27"00’	77°47"06’	200	Charnockite	24.03	0.42
4	Geddahalli	12°25"12’	77°51"12’	200	G.Gneiss	5.14	4.5
5.	Somanahalli	12°08″27.6’	78°01"39’	100	Charnockite	8.03	34.56
6	Elagiri	12°2"36’	78°04"5.3’	100	G.Gneiss	10.01	9.8
7	Anjatti	12°20"00’	77°43"00’	300	Granite	11.20	1.40
8	Konagihalli	12°08"01’	77°58"510’	181.18	G.Gneiss		0.193

2.2. Hydro chemical data:

The groundwater quality of the basin was studied by collecting water samples from dug well and bore well. The sample locations were plotted on the map and identified data gap In the basin, groundwater quality of 12 nos wells were monitored periodically. To fill data gap in the basin, 132nos of water samples were collected. Water samples have been collected from the study area in different aquifers (Aquifer-I & Aquifers-II, **Fig- 2.2**) to assess the groundwater quality for drinking and irrigation purpose. The analytical results are given as (Annexure-1I) & (Annexure-III) for aquifer- I &II respectively.

Ground water quality data has been collected from TWAD, Govt.of Tamilnadu in respect of 6119 locations.

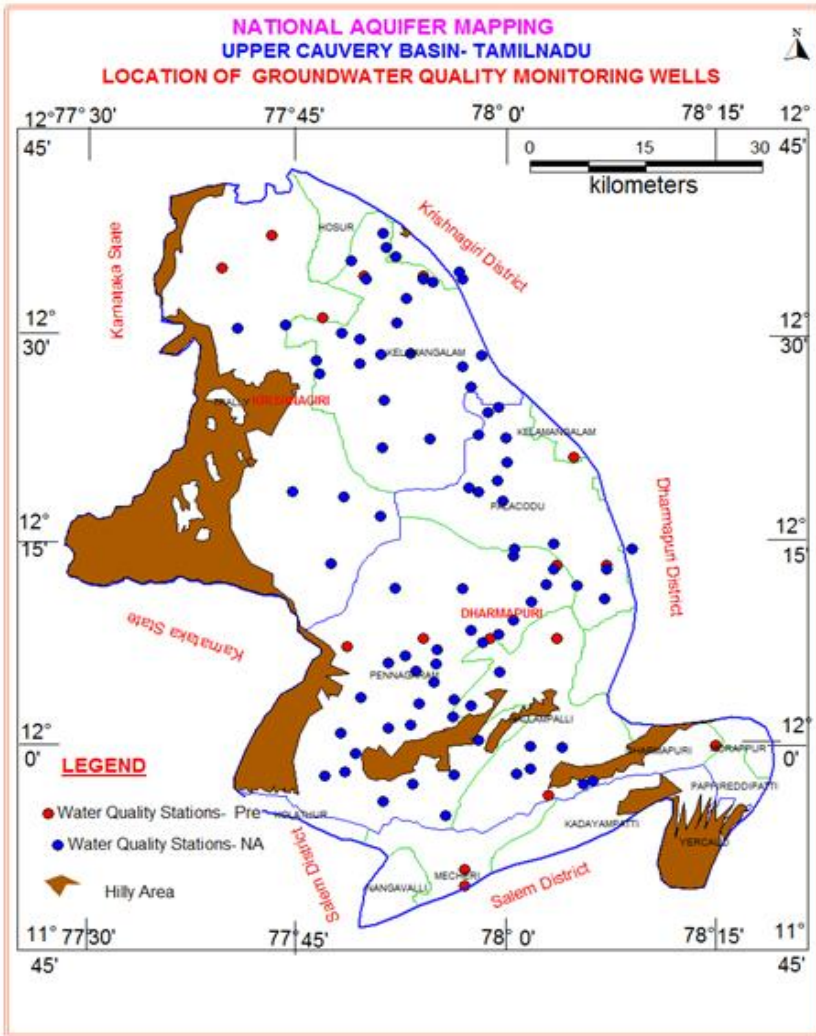


Fig 2.2 Location of Groundwater Monitoring Wells

2.3. Geophysical data:

The geophysical survey was conducted in the study area consisting of Vertical Electrical Soundings (VES) by employing Schlumberger configuration with maximum half current electrode separation of 300m. The objective of the study area is to decipher the sub surface conditions such as weathered and fractured layer resistivity and thicknesses and massive formations up to the depth of 200 m. A total number of 52 VES were carried out and geo electric layers inferred through interpretation of the results obtained. The locations of the VES are presented in the following**Fig-2.3**.

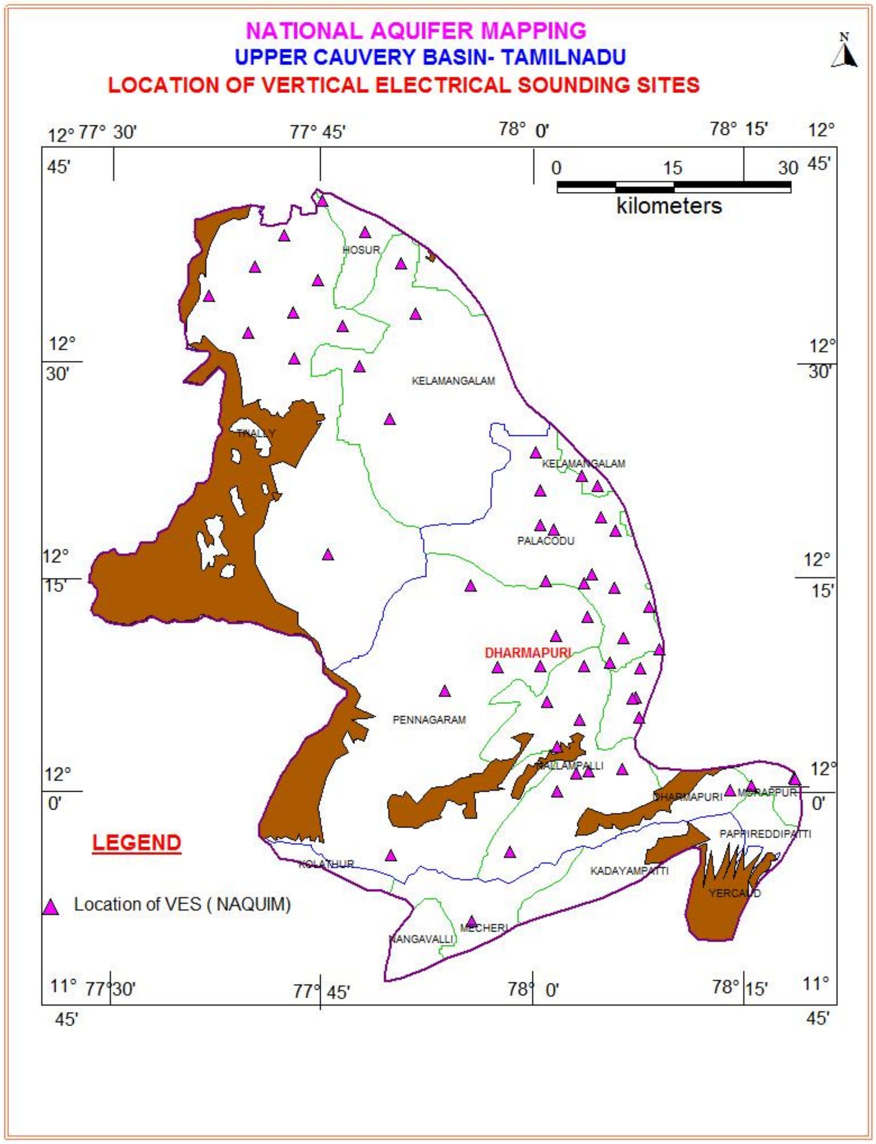


Fig. 2.3 Location of Vertical Electrical Sounding Sites

2.3.1.Data acquisition and interpretation

The Vertical Electrical Soundings (VES) were conducted in the survey area and the data acquired by deploying the CRM 500 Aqua meter and WDDS-2/2B Digital Resistivity meter by adopting the Schlumberger electrode configuration with a maximum current electrode separation (AB) of 400m. The data was processed and interpreted by IPI2Win software developed by MoscowState University, after marginally modifying the manually interpreted results in corroboration with geology and hydrogeology.

Table,3: Geophysical Inferred data.

Sl.No	Location	LAT	LONG	Thickness (m.)					Inferred depths of Fractures in m
				RL	Top Soil	Weathered	Fractured	Massive	
1	BIKKAMPATTI	12.14	78.00	469	2.5	16	Nil		NIL
2	PANGUNATTAM	12.10	78.01	465	0.7	7.3	25	200	8, 15, 25
3	SOMISETTIPATTI	12.02	78.06	487	1.6	18.4	60	200	15, 20, 60
4	JARUGU	12.00	78.02	463	2.8	7.2	50	200	8, 40, 50
5	THADANGAM	12.11	78.12	475	1.5	13.5	185	200	15, 20, 50, 65,
6	ADAGAPADI	12.15	78.09	467	1.5	11	110	200	45, 55, 110
7	NAGARKUDAL	12.08	78.05	368	0.5	17	25	200	20, 25
8	ERRAPATTI	12.05	78.03	363	0.5	8.5	80	200	10, 15, 20, 30,
9	ATHIYAMANKOTTAI	12.10	78.13	484	0.5	2.5	50	200	50
10	KONDAGAPATTI	12.00	78.23	452	0.9	3.5	70	200	50, 60, 70
11	ALAMARATHUPATTI	12.18	78.03	495	1	17.5	90	200	20, 75, 90
12	MARENAHALLI	12.14	78.06	460	0.5	11.5	60	200	15, 60
13	PIKKILI	12.24	78.01	532	0.8	15.2	30	200	20, 30,
14	MARANDAHALLI	12.39	78.00	588	2	20	60	200	25, 40 & 60
15	MALLAPURAM	12.35	78.00	576	3	9	20	200	20
16	PUDUR	12.36	78.17	508	2	16	180	200	50, 150 & 180
17	AATTUKOTTAI	12.31	78.00	528	1	10	150	200	50 & 150
18	BOPPADI	12.30	78.02	524	1	17.5	60	200	25 & 60
19	ODAYANDAHALLI	12.48	78.01	700	1.5	10	50	200	15, 50
20	BAALEYANURKOTTAI	12.51	78.05	653	0.6	5.6	150	200	40, 80, 120 &
21	PATTIPAARA	12.51	78.58	578	1.6	11	30	200	30
22	MUGALUR	12.54	78.03	695	1.0	13	120	200	60, 80 &120
23	DODDATIMMANAHALLI	12.62	77.91	716	2.0	15	-	200	-
24	NAAGAMANGALAM	12.56	77.94	697	1.5	30	-	200	-
25	NAAGADUNAI	12.56	77.91	740	1.5	30	60	200	60
26	IRUTAALAM	12.58	77.9	803	1.0	25	80	200	80

27	MUDHAMPATTI	12.54	77.98	752	1.5	25	60	200	60
28	KUTHANDAHALLI	12.47	77.97	617	2.0	25	-	200	-
29	KURUMARAKOTTAI	12.41	77.98	617	2.5	30	-	200	-
30	ULAGAMPATTI	12.37	77.99	622	1.5	6	40	200	40
31	VELANGAADU JUNCTION	12.38	77.97	613	3.0	25	-	200	-
32	KELAMANGALAM	12.61	77.86	776	2.0	10	80	200	60 & 80
33	KAARUKKONDAPALLI	12.34	78.00	788	2.0	7.5	50	200	50
34	KUTTUR	12.62	77.82	785	2.0	12.5	-	200	-
35	DODDA BELUR	12.58	77.83	788	1.0	20	50	200	25 & 50
36	GOWTHALAM	12.57	77.83	794	1.3	15	150	200	60 & 150
37	PACHAPPANATTI	12.56	77.85	797	2.0	10	30	200	30
38	LAKSHMIPURAM	12.54	77.87	767	3.0	10	-	200	-
39	KOTTAIULIMANGALAM	12.53	77.76	930	1.0	4.0	30	200	30
40	KANDAGAANAPALLI	12.51	77.73	950	1.0	20	-	200	-
41	MANIYAMBADI	12.44	77.79	806	2.4	5	30	200	30
42	JAARKALATTI	12.5	77.83	802	1.3	15	150	200	150
43	GOVINDAPALLI	12.47	77.89	886	3.0	15	-	200	15
44	THIPPASANDIRAM	12.47	77.85	804	3.0	20	-	200	20
45	GADDAHALLI	12.42	77.85	886	1.5	20	-	200	20
46	SAPPARANAPALLI	13.2	80.11	800	1.5	20	-	200	60
47	SANDANAPALLI	12.47	77.82	856	2.0	10	30	200	30
48	PANCHAPATTI	12.45	77.94	633	1.0	15	40	200	40
49	BELAMAARANAHALLI	12.32	77.99	520	1.0	5	50	200	50
50	BELLUHALLI	12.32	77.95	604	3.0	25	-	200	-
51	DODDABHAVILI	12.34	78	567	2.0	10	-	200	-
52	SIRIYANAHALLI	12.31	77.99	538	2.0	10	-	200	-

2.4 Groundwater Exploration data:

A total of 27 Nos of exploratory wells were drilled in the basin under groundwater exploration activity of the Central Ground Water Board, SECR, Chennai prior to National Aquifer

Mapping project. These wells were plotted on the 1:50,000 scale topographical map. As per the National Aquifer Mapping guidelines for the hard rock, data requirements were identified on the plotted topographical map. Based on the data requirements, 9 nos of exploratory wells were drilled in the aquifer mapping area of the basin as part of the data generation. **(Fig-2.4)** The data such as lithology, fracture depth, yield, water level, aquifer properties were generated and utilised to depict the prevailing aquifer systems of the basin (**Annexure-1Va**).

Similarly wells drilled by state department of about 100 no,s wells data has been collected and used for aquifer mapping studies. (**Annexure-1Vb**).

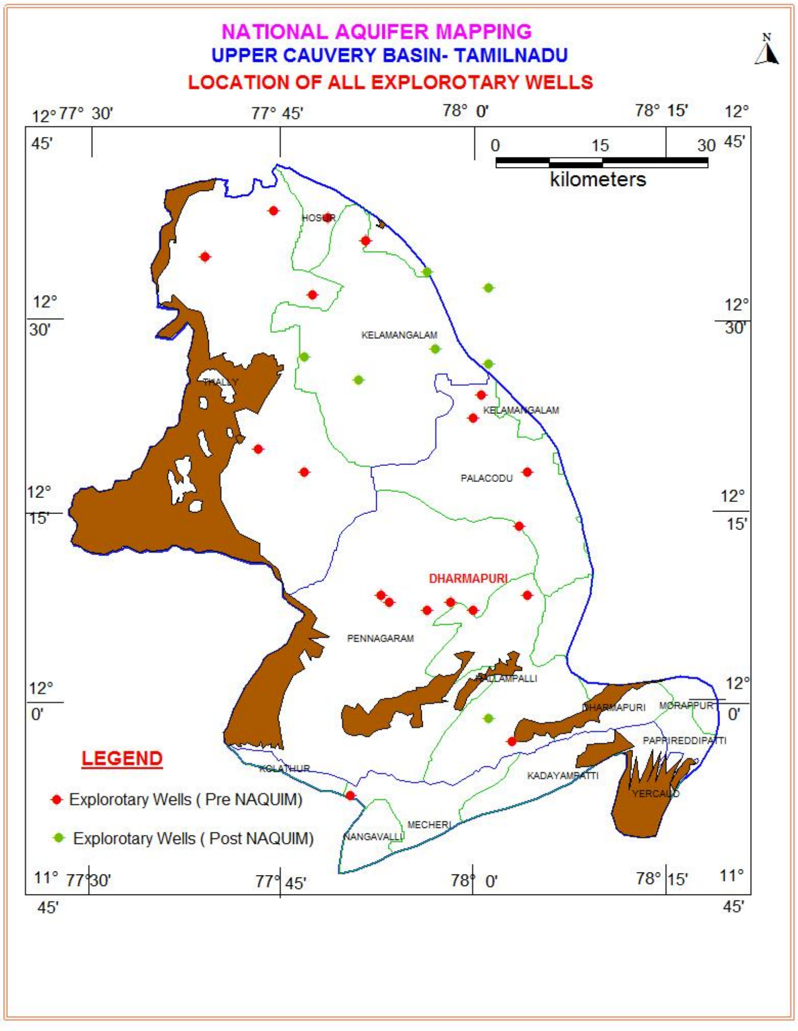


Fig 2.4 Location of all Exploratory Wells

3. Data Interpretation, Integration and Aquifer Mapping

3.1 Hydrogeological Data Interpretation

3.1.1 Groundwater Level

During Aquifer Mapping studies in Upper Cauvery Basin 23 Groundwater monitoring wells which were monitoring regularly were used along with 97 key wells established (**Fig:2.1**) in different formations in order to know the behaviour of the groundwater regime. Out of total 98 wells 46 wells were established in Charnockite, 41 wells were established in Gneiss, 4 wells in Granite, 3 each in Hornblende gneiss and Migmatite formation respectively. The water levels were monitored from May 2014 to Feb 2016(four times in a year). The depth of key wells ranged from 6.00 to 28.75 mbgl.

3.1.1.1 Depth to Water level for aquifer I (May2014)

Based on the data of key well inventoried and NHS wells, the water level data pertaining to the period of May 2014(pre monsoon) was used for the preparation of depth to water level map of the basin (**Fig-3.2**). The depth to water level during May 2014 is varied from 2.85 mbgl (Melur, Kelamangalam block) to 21.55mbgl (Vellakkal, Nallampalli block). Depth to water level ranging from 0 to 2 mbgl was not observed during this period. Water level ranging from 2 to 5 mbgl is shown in 12 wells (12.37%), water level ranging from 5 to 10 mbgl shows in 42 wells (43.29%). Water level ranging from 10 to 20 mbgl is shown in 41wells (42.27 %), only 2 wells (2.1%) shows water level more than 20 mbgl during May2014. Major part of the basin shows water level in the range of 5 to 20mbgl. Only few patches recorded water level in the range of 2 to 5 mbgl and found in North eastern portion and Southern central portion of basin. One patch having water level more than 20 mbgl is found around Vallakkal of Nallampalli block in the central portion of basin. Water levels ranging 5 to 10mbgl are observed in the whole Thally block, southeren part of Kelamangalam block, western part of Palacode block, central part of Pennagaram block, southern part of Nallampalli block and northern part of Kadayampatty blocks of the basin.

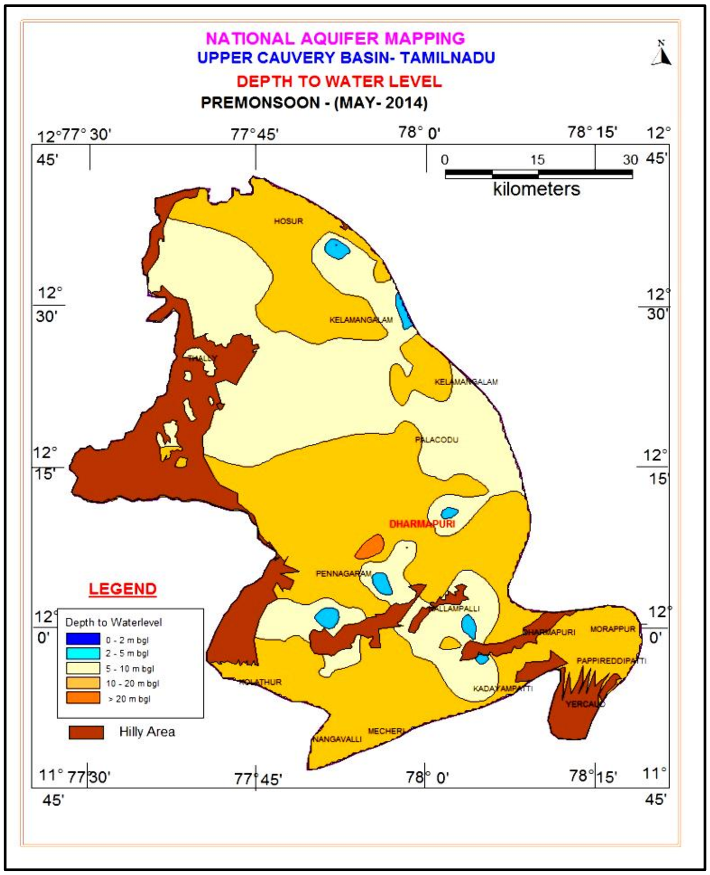


Fig. 3.1 Depth to Water Level – Premonsoon (may 2014)

3.1.1.2. Depth to Water level For aquifer II(May2014)

During May 2014, the depth to piezometric surface in the deeper aquifer in the basin ranged from 11.56 m bgl (Vellar-Mecheri block) to 57.29 (Konnagihalli-Pennagaram block).Depth to piezometric surface less than 2 , 2 to 5 and 5 to 10 mbgl was not observed in the basin. 55% per cent of wells analysed have recorded depth to piezometric surface in the range of 10 to 20 mbgl and noted in Kelamangalam, Palacode, Nangavalli, Mecheri and Nangavalli blocks.22 percent of the wells analysed have recorded 20 to 40 mbgl and noted in Kolathur and Nallampalli blocks. 23 percent of wells analysed have recorded more than 40 mbgl range and noted predominantly in Kadayampatty and Pennagaram blocks.

3.1.1.3. Depth to Water level For aquifer I (Jan-2015)

The depth to water level map for the period of January 2015 based on the key well and NHS data collected from the basin area is presented as **Fig. 3.2**. The depth to water level during Jan

2015 is varied from 1.95 mbgl (Kelamangalam, Kelamangalam block) to 20.7mbgl (Kottai Uliamangalam, Kelamangalam block). Depth to water level ranging from 0 to 2 mbgl was observed in a small patch (1%) near Kelamangalam village. Water level ranging from 2 to 5 mbgl is shown in 31 wells (32%), water level ranging from 5 to 10 mbgl shows in 40 wells (41%), water level ranging from 10 to 20 mbgl is shown in 25 wells (26 %), only 1 well (1%) shows water level above 20 mbgl during Jan 2015. Major part of the basin(73%), shows water level in the range of 5 to 10mbgl, covering Northern part of Thally block, most parts of Kelamangalam block, western part of palacode block, eastren parts of Pennagaram block and north eastern parts of Nallampalli block. Water level ranging 10 to 20 mbgl is observed in central part of Thally block, eastern part of Dharmapuri block, southern part of Nallampalli block and all most all part of blocks in Salem district, i.e. Kolathur, Nangavalli, Mecheri and Kadayampatty blocks. Water level more than 20 mbgl is found in a small pocket around north central portion of the basin (Kottai Uliyamangala of Kelamangalam block).

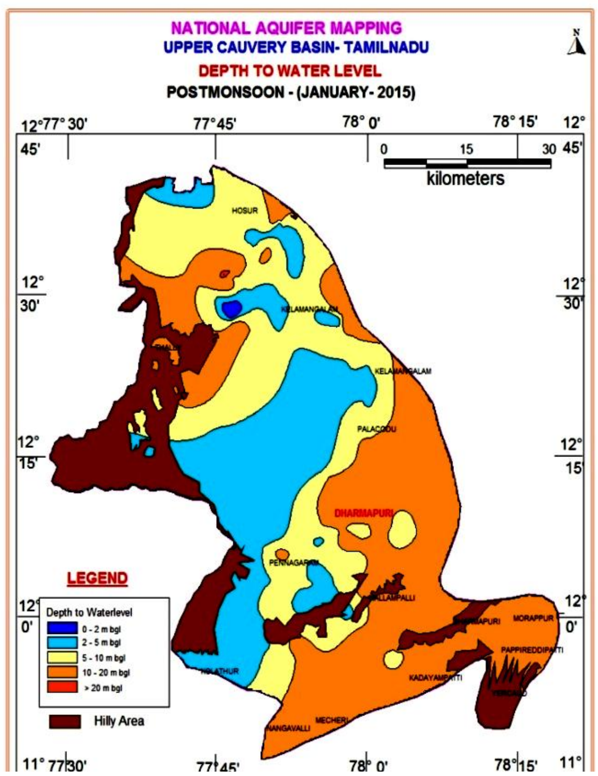


Fig. 3.2 Depth to Water Level for Aquifer 1 (Jan-2015)

3.1.1.4 Depth to Water level for aquifer II (Jan-2015)

During Jan-2015, the depth to piezometric surface of the deeper aquifer in the basin area ranges from 6.6 m bgl (Marandahalli-Palacode block) to 56.26mbgl (Kadayampatty-Kadyampatty block). Depth to piezometric surface less than 5 mbgl was not observed in the basin. Piezometric surface ranging from 5 to 10 mbgl is observed in 20 wells (45%) , 10 to 20 mbgl is observed in 10 wells (22%), in Kolathur and Nallampalli blocks. 10 wells (22%) recorded water levels in the range of 20 to 40 mbgl in Kelamangalam and Pennagaram blocks. 5 wells (11%) have recorded water levels of more than 40 mbgl and noted predominantly in Kadayampatty block. In major part of the basin the depth to the piezometric surface is within the range of 5 to 20mbgl.

3.1.1.5 Water Level Fluctuation:

Water level fluctuation in the observation wells in an area between two periods is indicative of the net changes in the ground water storage during the period in response to the recharge and discharge components and is an important parameter for planning for sustainable ground water development. The seasonal water level fluctuation in the area has been analysed using the water level data of May 2014 and January 2015**(Fig-)**. As both southwest and northeast monsoons are active in the area the fluctuation recorded in ground water levels of January 2015 in comparison to the water levels of May 2014 indicate the extent of replenishment of the shallow aquifer due to the monsoon rainfall.

The water level fluctuation in the basin ranged from a decline of 5.35 m. (Chinnakoundanahalli, Kelamangalam block) to a rise of 13.87m (Panchapalli, Palacode block) during the period. The analysis indicates that water levels have risen during post-monsoon period in comparison to pre-monsoon in the major part of the basin, indicating replenishment of phreatic aquifer due to rainfall recharge. Rise in water levels during the period have been observed in more than 84% of the wells considered. Fall has been observed in 16% of the wells considered. The rise in water levels is in the range of 0.1 to 13.87 m and fall in the range of 0.20 to 5.35m.

Rise in the water levels in the range of 0 to 2 m is observed in 43 wells (51%); 2 to 4 m rise observed in 20 wells (25%); and more than 4 m rise observed in 19 wells (24%). Fall in the water levels in the range of 0 to 2 m is recorded in 12 wells (80%); of 2 to 4 m fall observed in 2 wells (14%); and more than 4 m fall is observed in 1 well (6%).

Fall in water levels is observed in about 16 percent observation wells in the district during the period, indicating recharge insufficient to compensate the withdrawal of ground water from phreatic zone. Decline in water levels during the period was observed in isolated pockets of Kelamangalam, Palacode, Pennagaran and Nallampalli blocks.

3.1.1.6. Water Table Elevation :

Water table elevation map of phreatic aquifer of the basin during May 2014, along with flow lines showing the direction of ground water movement is shown in **Fig-3.4.** The water table elevation ranges from 809.92 (D.Tamandrapalli/Kelamangalam block) to 255.78 mamsl (Puchchur/Pennagaram block) in the basin. The groundwater movement in northern part of the basin is towards south east and then turns south direction .Finally groundwater movement is towards south west, ie., towards main Cauvery river. The general groundwater flow is from east to southwest direction in southern parts of the basin (parts of Salem district).

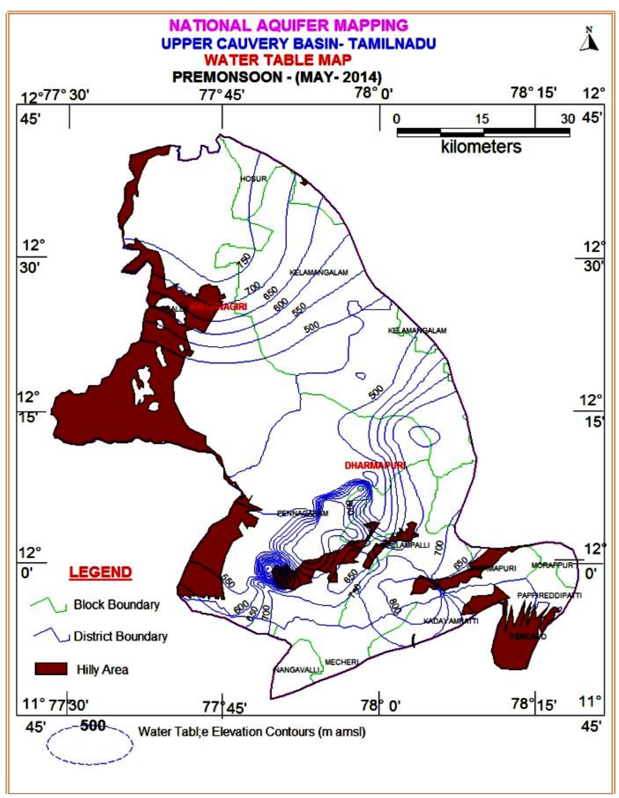


Fig. 3.4Water Table Elevation Map – Pre monsoon (May-2014)

3.1.2. Pumping Tests

The yields of the wells in the study area are widely varied. Many of Dug wells in the area have less than one meter water Colum during most of the year and about 80 to 95 % of wells get dry during summers. Most of the time dug wells are used as storage tanks to collect water from a number of bore wells and to distribute the collected water for irrigation as the yield of each bore well is much less to support irrigation. The wells located in favourable hydrogeological settings like shear zones, topographic lows, river alluvium etc., are able to sustain at a rate of 100 lpm for 2 to 3 hrs of pumping. The yield of large diameter wells tapping the weathered mantle of crystalline rocks ranges from 20-50 m^3/day for a drawdown of 2-3 m and are able to sustain 1-3 hours of pumping. The specific capacity of the porous weathered formation ranges from 7 to 35 lpm/m/dd. The Transmissivity values of the weathered formation computed from pumping tests ranges from 5 to 20 m^2 /day and storativity ranges from $4.37x10^{-4}$ to $7.89x10^{-3}$. At a very few places the weathered mantle extends down to 19 m bgl.

A number of bore wells have come up in the area for Irrigation and drinking water purpose in the recent past. The depths of bore wells generally vary from 150 to 350 mbgl with yields varying from 0.01 to 7.49 lps. The duration of pumping tests vary from 500 to 1000 minutes. The maximum drawdown of the wells ranging 2.5 to 60.10m. The specific capacity value varies from 5.18 to 10.42 lpm per meter drawdown. The Transmissivity value of these aquifer system ranges from 9 to 24.56 m2/day. The computed storativity value ranges between 0.0378 to 0.00026. Permeability value ranges from 0.015 to 3.54 m/day. Slug tests were conducted on the bore wells drilled by the CGWB. Computed Transmissivity value ranges from 0.42 to 4.5 m2/day.

3.2. Hydro chemical Data Interpretation

Chemical composition of Groundwater in aquifer is influenced by various factors such as the chemical composition of litho units, composition and permeability of soils, degree and pattern of weathering etc. It is also influenced by agricultural, drainage and irrigation practices prevalent in the area. The chemical characteristics of ground water in the phreatic zone in Upper Cauvery basin has been studied using the analytical data of groundwater samples collected from key wells, Network stations of Central Ground Water Board and observation wells of State Groundwater Department, Government of Tamil Nadu.

3.2.1. Quality of Groundwater in phreatic aquifer:

The analytical data of groundwater samples collected from key wells during May 2014 have been used for detailed study of various aspects of water quality in the basin. Groundwater in phreatic aquifers in Upper Cauvery basin, in general is colourless, odourless, and slightly alkaline in nature. The range of concentration of the various chemical constituents and the degree of mineralization in groundwater samples of phreatic aquifers in the area are presented in **Table4.**

Table4:**Chemical Constituent**

Chemical Constituent	Range of Chemical constituent	
	From	**To**
pH	7.02	8.06
EC(µS /cm at 25° C)	381	3320
Total hardness	55	1200
Ca	10	295
Mg	7	815
Na	30	800
K	1	42
HCO3	61	647
Cl	10	518
SO^4	11	678
NO^3	5	193
F	0.31	2.6

The waters are generally alkaline with pH varying from 7.02 (Halapuram/Pennagaram block) to 8.02 (Gowdanur / Palacode block).

The Specific electrical conductance of groundwater in phreatic aquifer is in the range of 381 (Dinnur / Kelamangalam block) to 3320 (Doddabavalli/Palacode block) in the basin. In the major part of the basin Electrical Conductivity is in the range of 750 to 2250 µS/cm. Conductance exceeding 3000µS/cm have been observed in parts of Pennagaram and Palacode blocks.

Chloride in phreatic groundwater varies from 10 to 518 mg/l in the basin and is below 500 mg/l in major part of basin. Value 518 mg/l, more than permissible limit only found in Doddabavalli village in Palacode block. This may be due to human activities in and around the area.

Nitrate is one of the major indicators of anthropogenic sources of pollution. The negative charge and high mobility favours its persistence in nature and transport along the ground water flow path. Nitrate is the ultimate oxidized product of all nitrogen containing matter and its occurrence in ground water can be fairly attributed to infiltration of water through soils containing domestic, vegetable and animal waste, fertilizer and industrial pollution. As the lithogenic sources of nitrogen are very rare, its presence in ground water is almost due to anthropogenic activity.The concentration of Nitrate in the phreatic groundwater ranged between 5(Ramakondahalli/Pennagaram block) and 193(Pudur/Palacode block) mg/L. About 45% of the samples showed the drinking desirable limit of nitrate below 45 mg/L, 33% of the samples showed nitrate between 46-100 mg/L and about 22% of the samples showed nitrate 100 mg/L, which are above permissible limit of BIS. These wells are located in Western, Eastern part of Nallampalli block, Eastern, Southern part of Pennagaram and western part of Palacode blocks.

Fluoride exists naturally in all waters derived from the dissolution of fluoride containing minerals. Surface water generally has low fluoride while ground water may have high concentrations of fluoride as has been found in many parts of the world. The formation of high fluoride ground waters is principally governed by climate, composition of bedrock and hydrogeology. Areas with semi-arid climate, crystalline, igneous bedrock, and alkaline soils are the most affected. Fluoride is an impurity commonly found in phosphate fertilizers used in the agriculture. Accumulation of fluoride in the soils eventually results in leaching by percolation into the groundwater aquifer and thereby increases the concentration of fluoride level. In the shallow groundwater, the concentration of fluoride ranged between

0.31(Mudampatty /Kelamangalam block) to 2.6mg/L(Samanur / Palacode block). About 43% of samples showed fluoride < 1mg/L, which is the desirable limit for drinking. About 42% of samples showed fluoride in the range of 1 to 1.5mg/L, the maximum permissible limit in the absence of alternate sources. About 15% of samples showed fluoride > 1.5mg/L. These wells are located predominantly in the central part of Kelamangalam block, Westren part of Palacode block and Southern central part of Pennagaram blocks in the study area.

3.2.2. Quality of Groundwater in The Fractured Aquifers:

Quality of Groundwater in the fractured zones at depth has been studied using the analytical data of water samples collected from Irrigation wells, Hand pumps during well inventory and exploratory bore wells drilled by CGWB. However these samples have been collected represent the cumulative quality of all water yielding fractures in the well, they have been used only to get an idea about the water quality of the deeper aquifer as a whole.

The range of concentration of the various chemical constituents and the degree of mineralization in groundwater samples of fractured aquifers in the area are presented in **Table5**.

Table 5:

Chemical Constituent	Range of Chemical constituent	
	From	**To**
pH	7.03	8.9
EC(µS /cm at 25° C)	301	2910
Total hardness	75	1050
Ca	20	410
Mg	2	640
Na	41	800
K	1	25
HCO3	70	665

Cl	10	405
SO^4	10	729
NO^3	2	253
F	0.24	2.3

The Chemical analysis result indicates that there is considerable variation in the chemistry of groundwater from the deeper aquifer as well.

The Specific Electrical Conductance of ground water in the fracture aquifers ranges from 301(µS /cm at 25° C) (Irudukottai/Kelamangalam block) to 2910(µS /cm at 25° C) (Naganur/Pennagarn block. Chloride ranges from 10 mg/l(Irudukottai/Kelamangalam block) to 405mg/l (Rayakottai/Kelamangalam block),Nitrate ranges from 2 (Melur/ kelamangalam block) to 253(Suligunta/Kelemangalam block) and Fluoride ranges from 0.24(Rayakottai/Kelamangalam block) to 2.3(Samanur/Palacode block). As the occurrence of groundwater in the deeper zone is restricted to fractures which may or may not have continuity on a regional basis, preparation of maps showing the distribution of groundwater quality has not been attempted. Suitability of Groundwater for domestic uses has been analyzed with reference to various constituents and the results are given in **Table6**.

Table - 6: Ground water quality in different aquifers in Upper Cauvery basin, Tamil Nadu.

S.No	**Parameters**	**Range**	**Classification**	**% of samples**	
				Aquifer-I	**Aquifer-II**
1	Electrical Conductivity µs/cm at 25°c	< 750	Fresh	20	18
		75 1- 2250	Moderately Fresh	63	78
		2251- 3000	Slightly mineralized	11	5
		> 3000	Highly mineralized	6	Nil
2	Chloride	< 250	Desirable limit	85	91

	mg/l	251-1000	Permissible limit	15	9
		> 1000	Above permissible limit	Nil	Nil
3	Fluoride mg/l	< 1.0	Desirable limit	44	29
		1.1- 1.5	Permissible limit	41	46
		>1.5	**Above permissible limit**	**15**	**25**
4	Nitrate mg/l	<45	Permissible limit	45	49
		46-100	**Above permissible limit**	55	41
		> 100		Nil	10

In the study area the pH ranged from 7.14 to 8.5 and 7.20 to 8.33 for aquifer- I and aquifer-II respectively. Most of the samples have pH ranging between neutral to slightly alkaline in nature and are within the limits of drinking water standard of BIS 10500:2012.

3.2.3. Electrical Conductivity:

Electrical conductivity is the indicator of the total mineral content of water and hence it indicates the total dissolved solids (TDS) present in water. TDS of water determines its usefulness to various purposes. Generally water having TDS <500 mg/L is good for drinking and other domestic uses. However, in the absence of alternative sources TDS up to 2000 mg/L may be used for drinking purposes. The distribution of EC in different aquifers are in **Fig. 3.5.**

The phreatic aquifer ground water quality is fresh in about 20% , as indicated by the EC value less than 750 µs/cm at 25^{o}C. In about 63% of the Ground Water indicating the moderately fresh showing the EC varies between 751 -2250µs/cm at 25^{o} C, 11% of Ground Water showing EC between 2251-3000 µs/cm at 25^{o} C indicating that the ground water is slightly mineralized and about 6% of groundwater wells the EC is more than 3000 µs/cm at 25^{o}C indicating that the ground water is highly mineralized.

The fractured zone ground water quality is fresh in about 18%, as indicated by the EC value less than 750 µs/cm at 25^{o}C. In about 85% of the Ground Water, the EC varies between 751 - 2250µs/cm at 25^{o} C indicating that groundwater is moderately fresh and 05% of groundwater are between 2251-3000 µs/cm at 25^{o} C indicating that the ground water is slightly mineralized .There was no Ground Water wells the EC is more than 3000 µs/cm at 25^{o}C during this studies.

3.2.4. Chloride:

The classification of concentration of chloride in phreatic aquifer groundwater is that about 85% shows with in desirable limit, where as in fractured aquifer 91%shows with in desirable limit., 15% of samples in phreatic aquifer and 9% of samples in fractured aquifer are within permissible limit respectively. There were no water samples shows above permissible limit of Chloride concentration either in phreatic aquifer or in fracture aquifer.

3.2.5 Nitrate:

The concentration of Nitrate in the phreatic groundwater shows that about 45% of the samples nitrate below 45 mg/L, the desirable limit , 55% of the samples showed nitrate between 46-100 mg/L and no samples showed nitrate 100 mg/L, which are above permissible . Nitrate concentration in the fractured aquifer shows that about 49% of the samples nitrate below 45 mg/L, the desirable limit for drinking and 41% of the samples showed nitrate between 46-100 mg/L and about 10% of the samples showed nitrate more than 100 mg/L, which are above permissible limit of Burea of Indian standard (IS 10500:2012).

3.2.6 Fluoride:

In the Phreatic groundwater, the concentration of fluoride shows that about 44% of samples fluoride is < 1mg/L, which is the desirable limit for drinking. About 41% of samples showed fluoride in the range of 1 to 1.5mg/L, the maximum permissible limit in the absence of alternate sources. About 15 % of samples showed fluoride > 1.5mg/L. In fractured aquifer the groundwater shows that about 29 % of wells fluoride is in the range of 0 to 1.0mg/L, about 46% in the range of 1.1 to 1.5mg/L and about 25% more than 1.5mg/L. It clearly indicates that more number of wells about 25% in deeper aquifers have fluoride more than 1.5mg/L compare to 15% of phreatic aquifer water.High concentration(>1.5 mg/l) of fluoride in fractured aquifer has been restricted to areas of southeren central part &western part in Kelamangalam block and north western part of palacode block.

3.3. Geophysical Data Interpretation

3.3.1 Surface geophysical investigation:

Surface geophysical investigation in the form of Vertical Electrical Soundings (VES) was conducted in the study area. The preliminary objective of the study area is to decipher the sub surface conditions such as weathered and fractured layer resistivity and thicknesses and massive formations up to the depth of 200 m.

3.3.2. Data acquisition and interpretation

In all 52 Vertical Electrical Soundings (VES) were conducted in the survey area. The data was acquired by deploying the CRM 500 Aqua meter and WDDS-2/2B Digital Resistivity meter by adopting the Schlumberger electrode configuration with a maximum current electrode separation (AB) of 400m. The data was processed and interpreted by IPI2Win software developed by MoscowState University, after marginally modifying the manually interpreted results keeping in view the local geology and hydrogeology. Location of VES in the study area shown in **fig 3.6** and some of the VES curves are shown in **fig 3. 7 to 3.10 .**

All the VES data have been interpreted in both qualitative and quantitative manner. Based on the interpreted results of Vertical Electrical Sounding conducted in the area, three to five subsurface geoelectrical layers are revealed by A, H, AA, HA, KH and QHA types of curves. The analysis of the VES results indicates that the first layer resistivity was varying in the range of 11.2 - 255 ohm. m which is Top Soil. The thickness of this layer is varying in the range of 0.5 - 3 m. The second layer resistivity which was varying in the range of 12.2 – 250 ohm. m was considered as weathered formation. In this range the lower order of resistivity indicates higher weathered content and higher order of resistivity indicates dryness. The thickness of this formation is varying in the range of 2.5 – 30 m. The resistivity in the range of 34 - 999 ohm.m was recorded as third and/or fourth and/or fifth layer which was considered as massive formation with fractures at different depths. In general the thickness of this formation was varying in the range of 20 – 185 m. The resistivity ranges for different litho units and hydrogeological conditions was given in **Table7**.

Table 7: Resistivity ranges for different litho units

Resistivity range Ohm.m	Lithological unit
11.2 – 255	Top Soil
12.2 – 250	Weathered granite gneiss
250 – 500	Fractured granite gneiss
More than 500	Massive granite gneiss

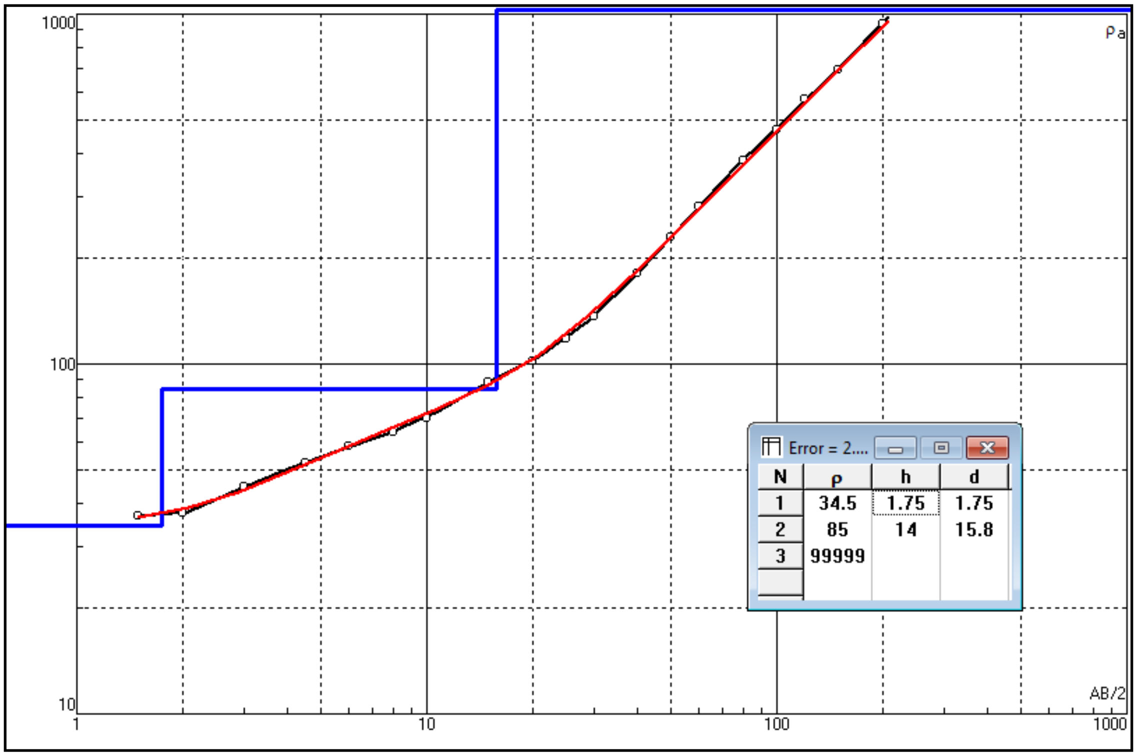


Fig – 3.7 Sandanapalli VES curve

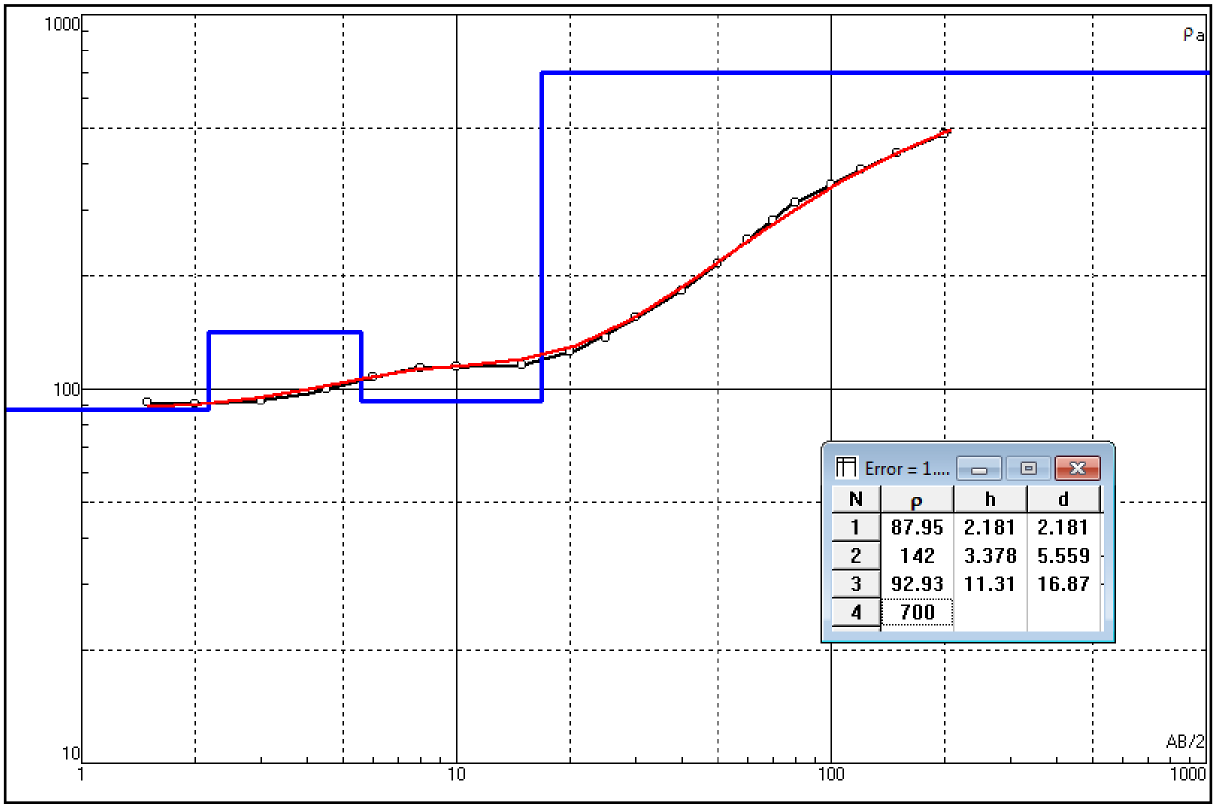


Fig – 3.8 Nadavalur West curve

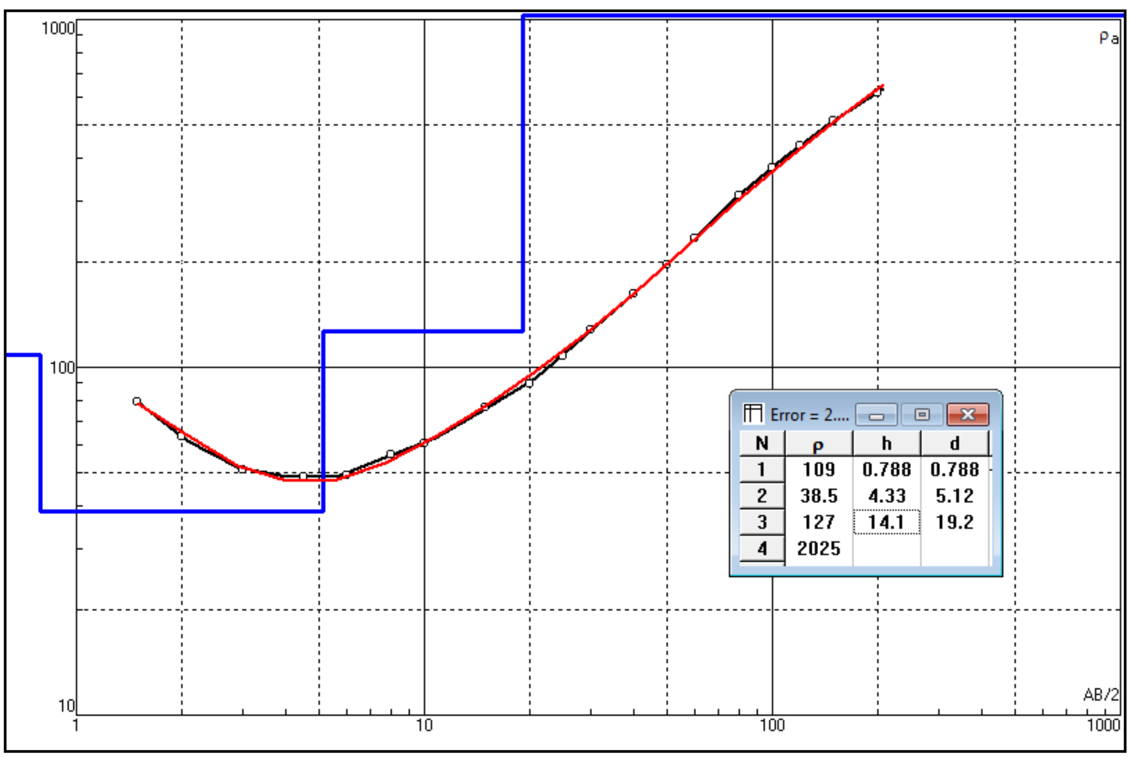


Fig. 3.9. Doddabelur VES curve

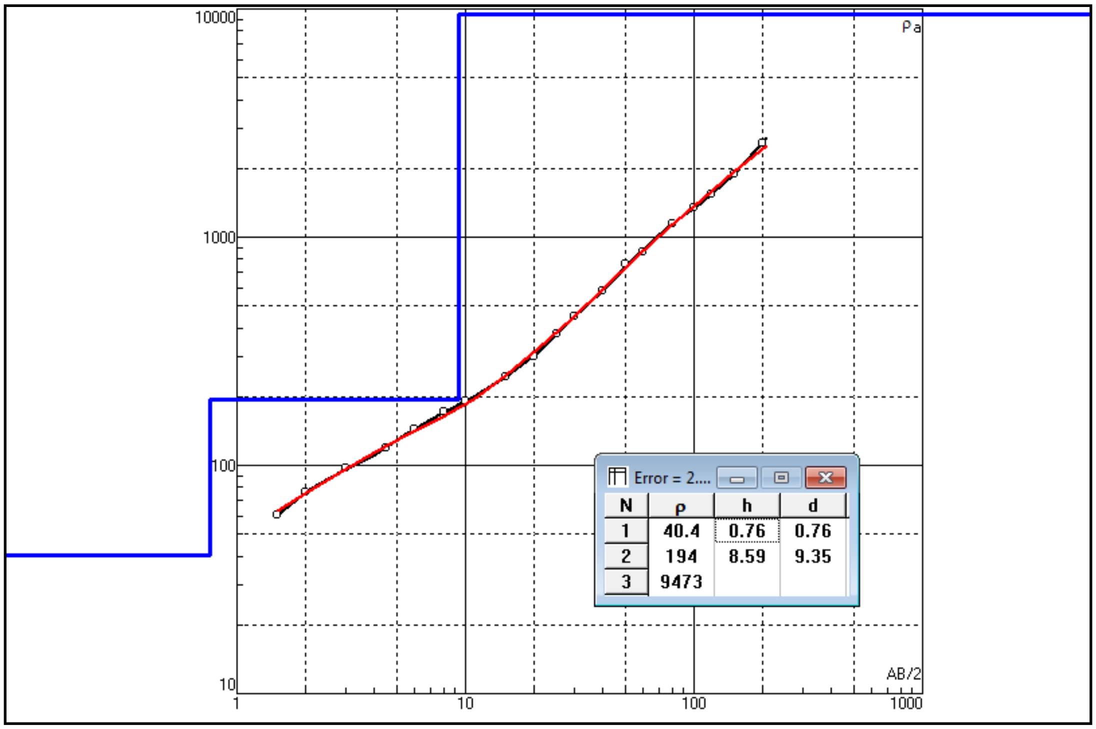


Fig – 3.10 Belamaranhalli VES curve

3.4. Groundwater Exploration data Results:

Groundwater exploration through drilling was taken up by CGWB before National Auqifer Mapping in the Krishnagiri, Dharmapuri and Salem districts. Total 27 exploratory wells have been drilled in the Upper Cauvery basin before national aquifer Mapping. As per the National Aquifer Mapping guidelines for the hard rock terrain, data requirements were identified and plotted on topographical map. Based on the data gap analysis, 9 exploratory wells were drilled in the aquifer mapping area of the basin as part of the data generation. A total number of 36 exploratory wells have been taken in to consideration to assess the thickness of the top weathered zone and the existence of deep seated fractures. The data such as lithology, fracture depth, yield, water level, aquifer properties were generated and utilised to depict the prevailing aquifer systems of the basin. Depth of Exploratory wells drilled in the basin ranging from 40 mbgl (Somanahalli/Palacode block) to 318 m.bgl (Sorangappapudur/Nallampalli block). Drilling data of the exploratory wells has revealed the presence of productive fractures in the area underlain by crystalline rocks. Over all productive fracture zones have been encountered in crystalline rocks at the depth range of 9.43 m. to 249.25 m.bgl in the basin. Depth to fracture zones encountered in Granitic gneisses, Charnockites and Granites at depth ranges of 9.43mbgl to 249.25mbgl, 19.12mbgl to 131.mbgl and 32mbgl to 188.50mbgl respectively. Discharge of these wells varies from 0.014 lps to 5.5lps in Granitic gneiss, 0.01 to 6.88 lps in Charnockite and 0.078 to 3.36 lps in Granite formation.(Annexure-5). The discharge of the 19 wells constructed in Granitic gneisses is moderate to high in comparison to the poor yields of the 14 wells constructed in Charnockite formation and 3 in Granitic formation. The fractures encountered in Granitic gneissic rock formations are more than that of other formations. A few of the wells have been abandoned due to poor yield.

Total 122 bore wells data have been analysed for fracture analysis in the study area. It shows that 1st fracture encountered in 120 wells with depth vary from 9.43 to 205 mbgl. 2ndfracture encountered in 100 bore wells with depth vary from 20.12 to 213 mbgl. Similarly 3 rd fractured encountered in 68 bore wells with depth vary from 52 to 230 mbgl. 4th, 5 th, 6 th fractures were also encountered in 5, 2 & 2 bore wells with depth vary from 88.7 to 231, 169.52 to 185.2 and 195.38 to 215.77 mbgl respectively. 7th set of fracture is encountered in one bore well only at a depth of 249.25 mbgl. Two bore wells show no fractures with the depth of 200mbgl. Data clearly indicates that generally two fractures are available in the study area with depth of 20.12 to 213 mbgl.

The aquifer mapping studies reveals that the presence of two distinct aquifers in the hard rock formations.They are;

3.4.1. **Aquifer I** : It comprises of weathered, partially weathered and first fracture to some extent in Granitic gneisses, Charnockites and Granitic formations. The depth of this first aquifer ranges from 3 to 36 m and contains ground water during monsoon seasons and gets dry by non-monsoon seasons. The aquifer with a thickness of 25 to 30 mbgl is high inCentral eastern part of basinin and around Panchapalli, Samanur and Dasampatty along Chinnar river course. In the Northern (Bevanatham area) and Southern portions (Eriyur, Ramagondapalli, Nerupur area) of the basin the thickness of the aquifer is shallow with a thickness vary from 3 to 12 mbgl. The wells located in this aquifer zone yield ground water of 20-65 M^3/day and sustain 1 to 2 hrs. of pumping. Specific Capacity and Transmissivity value of this aquifer across the basin ranges from 137.5 to 294 lpm per meter drawdown and 5-20 m^2/day respectively.

3.4.2. Aquifer II: Itcomprises of mainly of fractures (secondary porosity) developed during tectonic disturbances**,** occurs at depth generally ranges from 20.12 to 213 mbgl. The maximum yield of wells tapping this aquifer varies from 2.25 to 60 m3 /day and sustain for 2 to 4 hrs. of pumping. The Transmissivity value of the aquifer ranges between 0.19-31.01 m^2/day while the Specific capacity values vary from 0.012 to 26.59 lpm/m drawdown. Storativity of the aquifer ranges from 0.00001 to 0.0378 in the basin.

3.5. Aquifer Maps

3.5.1. 2D models showing Aquifer Dispossition:

Based on the lithologs of the exploratory wells and the well sections observed during field studies as part of Aquifer Mapping studies, 2D models of the aquifer system of the basin has been deciphered by using ROCKWORKS software. The data input for ROCKWORKS is prepared in following format as shown in **Table-8**, to generate 2D models of the basin along different selected sections.

Table8:Databaseprepared for generation of aquifer models.

Data-1

Bore	Township	Longitude	Latitude	Elevation	Total depth	Casing
Denkankottai	krishnagiri	77.79	12.38	883	222.6	12

Data-2

Bore	Depth1	Depth2	Lithology
Denkankottai	0	12	Weathered
Denkankottai	12	188.5	Fractured
Denkankottai	188.5	222.6	Massive

Data-3

Bore	Depth1	Depth2	Aquifer
Denkankottai	82.00	82.50	1stFracture
Denkankottai	188.00	188.50	2ndFracture

Data-4

Bore	Type	Depth1	Depth2	Value(lps)
Denkankottai	Discharge	82.00	82.50	0.215
Denkankottai	Discharge	188.00	188.50	3.36

Data-5

Bore	Depth1	Depth2	Stratigraphy
Denkankottai	0	1	Topsoil
Denkankottai	1	12	Weathered
Denkankottai	12	82.00	Slightly Fractured
Denkankottai	82.00	188.50	Fractured
Denkankottai	188.50	222.6	Massive

3.5.1.1. Section along NW-SE dirction:

Section along Northwest – Southeast (Fig-) direction in the basin indicates that the 1 st Aquifer existis above 850mamsl to 450mamsl with thickness varying from 30 to 23m inbetween very high of 39m along Chinnar river basin, where sudden drop of topography along Chinnar river drainage.Second Aquifer existis 650 amsl to 150amsl with 100m to 140 m thikness and 2 to 3 sets of fractures.

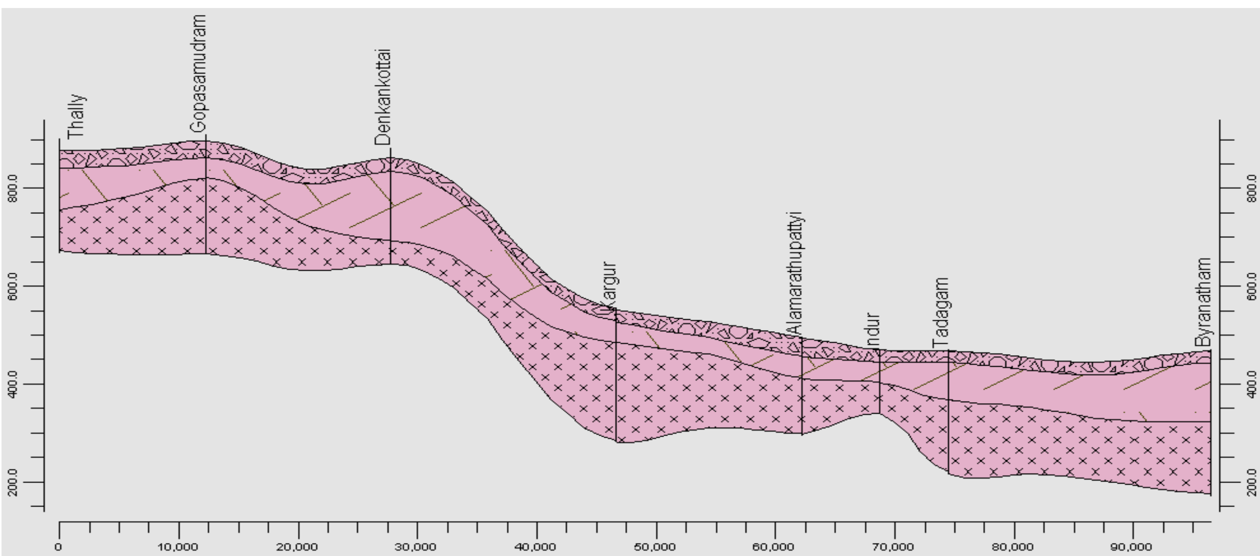


Fig- 3.11- 2D diagram of the Basin along NW-SE

3.5.1.2. Section along NNW- SSE direction:

Section (**Fig-**) shows that Weathered aquifer spreads about 10 to 18 m thickness and it disappears at Thoppur drop where directly fracture aquifer starts in shallow depth.Fractured aquifer has attain its maximum thickness about 180m at stretch of 20 km distance, parallel to

Chinnar river, inthe beginningof section.Rest of the stretch of section the fractured aquifer thickness is considerably very narrow and vary from 10 m to 60mwith 1 to 2 sets of fractures.

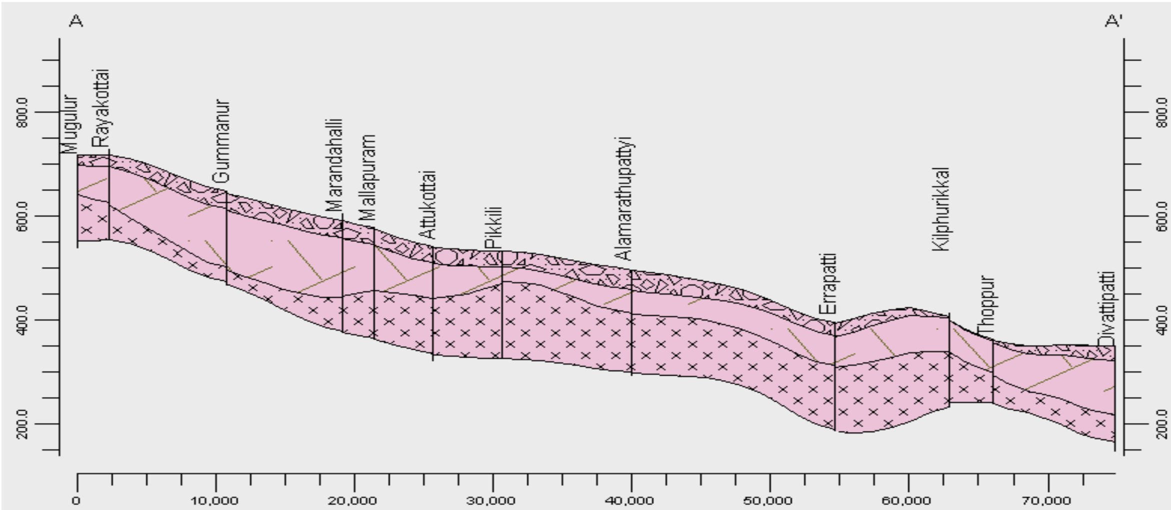


Fig 3.12: 2D Diagram along NNW-SSE direction

3.5.1.3. Section along NE – SW direction:

Section drawn(Map-) almost perpendicular to Chinnar and Thoppiar river basin indicates that the weathered aquifer spreads as a layer with thikness vary from 8 to 13m, middle of the section weathered aquifer is considerably high in thickness duo to river cross at 15 km(Chinnar) and 55km(Thoppiar) distance.Fractured aquifer also considerably very high in thickness vary from 150m to 80m along the section, where ever the river Chinnar and Thoppiar river cut acroos the section.

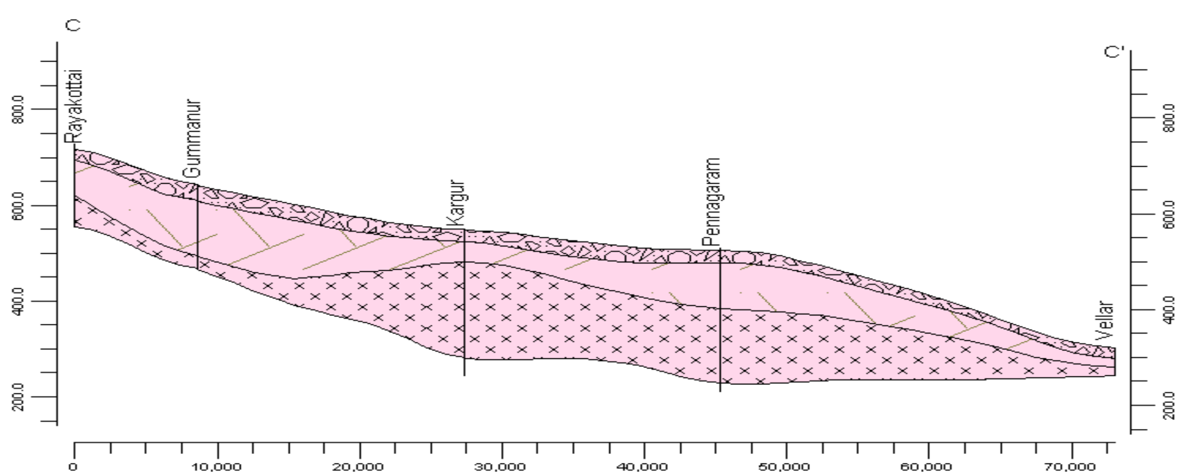


Fig 3.13: 2D Diagram along NE-SW direction

3.5.2. 3 D Model

3D (**Fig3.14**) view shows that spreading of two aquifers throught out the basin with 1 st aquifer thickness vary from 3.7m to 36m and Fracture aquifer spread with thickness vary from 11 to 140m.3D section indicates that thickness of weathered aquifer is considerably high in north portion compare to south.Thickness of fractured aquifer is considerably high in North & South compare to east, west and center of the basin.

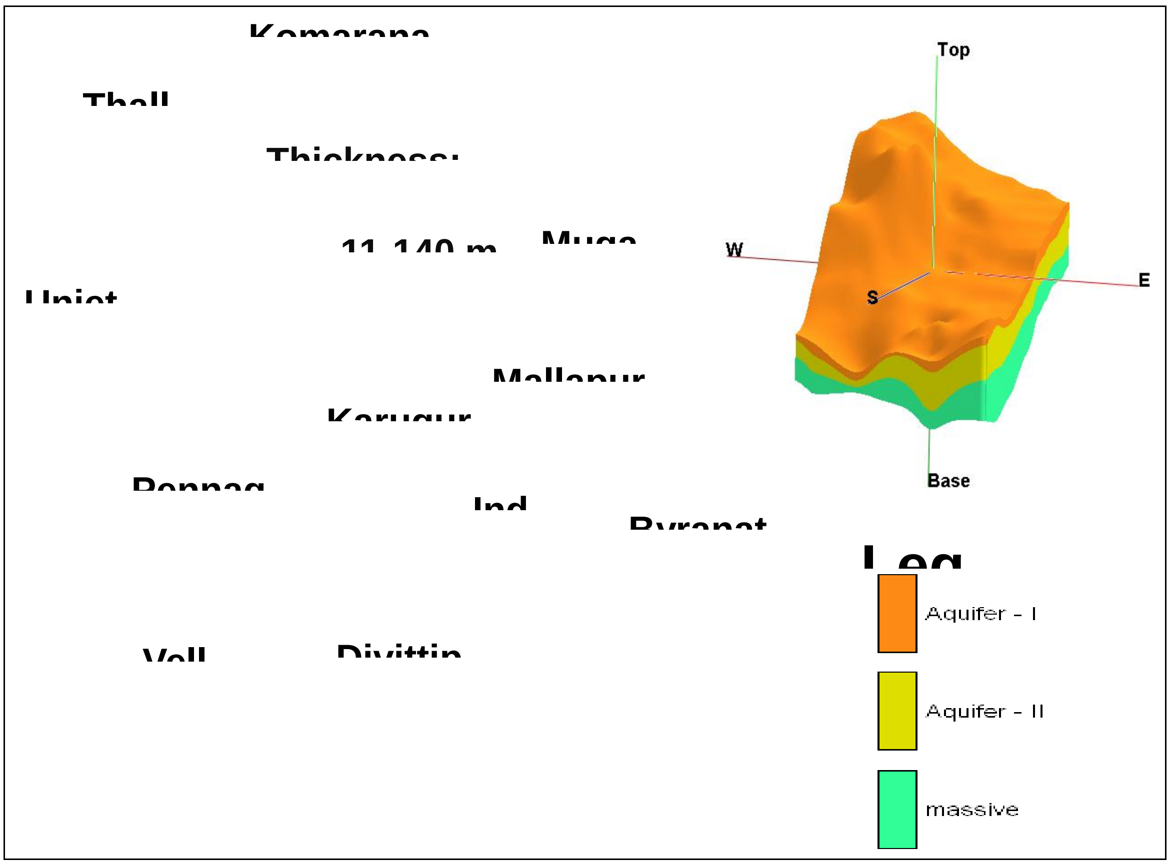


Fig: 3.14: 3D Disposition (Fence Diagram) of the Aquifer system of the Basin

4.0. Ground Water Resources:

The dynamic ground water resources are estimated as on 2010-11 based on the methodology suggested by Ground Water Estimation Committee (GEC) 1997.

The ground water recharge is calculated both by ground water fluctuation-specific yield method and by rainfall infiltration method. The annual replenishable ground water recharge is the summation of four components viz.,

i) Monsoon recharge due to rainfall
ii) Monsoon recharge from other sources
iii) Non-monsoon recharge due to rainfall
iv) Non-monsoon recharge due to other sources

Firka-wise dynamic ground water resources have been taken from the approved resources estimation done as on March 2011, jointly by State PWD of Tamil Nadu and CGWB, to arrive at the total resources available in the study basin. Out of the 31 Firkas of the study basin 15 firkas are falling totally in the basin and the rest 16 are falling partly. The resources have been apportioned to as per the ratio of the firka area within the basin and total firka area for the 16 firkas which are falling partly in the basin.

4.1. Net Ground Water Availability:

The net ground water availability refers to the available annual recharge after allowing for natural discharge in the monsoon season in terms of base flow and subsurface inflow/outflow. This annual ground water potential includes the existing ground water withdrawal, natural discharge due to base flow and subsurface inflow/ outflow in the monsoon season and availability for future development. As the ground water development progresses the natural discharge gets suitably modified and comes down to negligible quantities due to interception by different ground water structures. Hence, natural discharges in the monsoon season may not be considered and the total annual ground water recharge may be taken as net groundwater availability.

The net ground water availability of the basin for the year 2011is arrived at 28,208 Ham, out of which the availability for 14 firkas of Dharmapuri district is 16,884 while 8 firkas of Krishnagiri and 9 firkas of Salem districts have the availability of 7,909 and 3,414 Ham respectively. **(Table 4.1)**

4.2. Ground Water Draft:

The gross ground water draft has been assessed by using Unit draft method for irrigation draft component and by adopting formula suggested by GEC 1997 for domestic and industrial draft components.

The existing ground water draft for irrigation is maximum in Pulikarai Firka (3246 ham) followed by Palakodu (3113 ham), Indur (2411 ham) etc. The gross ground water draft for domestic and industrial uses is maximum at Kadayampatti of Salem district (186 ham) followed by Dharmapuri (113 ham), Mecheri (112 ham). The existing gross ground water draft in Dharmapuri, Krishnagiri and Salem districts is 25,520 ham, 4,615 ham and 3,335 ham respectively. And the total gross ground water draft of the basin is 33,472 ham against the availability of 28,208 ham.

4.3. Stage of Development and Categorization:

The stage of development is defined by stage of ground water development (%)

= (Existing ground water draft/ Net Ground water availability) x 100

The stage of ground water development is calculated for all the 31 firkas of the basin and it varies from 3% (Vellakadai,Salem district) to 260% (Perumbalai, Dharmapuri district). The Categorization has been done by considering the two factors as suggested by GEC 97, viz.,

i) Stage of Development

ii) Long term trend of pre and post monsoon water levels.

The following FOUR categories have been suggested by GEC-97 based on the above two factors.

a) Safe b) Semi-critical c) Critical d) Over-exploited

Based on the above categorization 11 out of the 14 firkas of Dharmapuri district and 4 out of 9 firkas of Salem district falls under Over-exploited Category with a total area of 2103 sq.km (47% of the basin area). On the other hand area under Safe category is of 1828 sq km (40% of the basin area) comprising 6 firkas of Krishnagiri and 3 firkas of Salem districts. The remaining 13% of the basin area (582 sq.km) falls under Semi-critical category comprising a total of 7 firkas; 3 of Dharmapuri, 2 of Krishnagiri and another 2 of Salem districts.(**Table 4.1**)

4.4.Static Ground Water Resource:

The ground water available below the zone of water level fluctuation is called Static Ground Water Resource. But in the present study basin static resource is developed in all the 15 Over-exploited firkas and a total quantity of 10,239 ham is being extracted from static resource as the available dynamic groundwater resource is only 14,656 ham against the gross draft of 24,895 ham. Static water resource of the basin has not calculated as it is not advisable for development under normal conditions.

5.0 REGIONAL GROUNDWATER FLOW MODELLING

Three-dimensional mathematical models of regional groundwater flow are beneficial to the management of groundwater resources as they allow the approximation of the components of hydrological processes and provide a mechanistic description of the flow of water in an aquifer. Such a modeling study was carried out in a part of Upper Cauvery aquifer system, Southern India. The study area is characterizedby weathered and fractured aquifer system with very heavy abstraction of groundwater for agricultural purposes. The model simulates groundwater flow over an area of about 4541 square kilometers with 56 rows, 52 columns, with two vertical layers on the regional model. The detailed study area is divided into rows and columns with a size of 2.0 sq.km grids (Figure.1). The model was simulated in steady and transient state condition using the finite-difference approximation of three-dimensional partial differential equation of groundwater flow in this aquifer from January 2010 to December 2014. The model was calibrated for steady and transient state conditions. There was a reasonable match between the computed and observed heads. Based on the modelling results, it is found that this aquifer system is stable at this pumping rate. The transient model was run until the year 2025 to forecast the dynamic groundwater flow under various scenarios of over pumpingand less recharge. The model predicts the behaviour of this aquifer system under various hydrological stress conditions.

5.1. Modelling objectives

Numerical three-dimensional groundwater flow model was developed for the Upper Cauvery Aquifer system, Southern India with the following objectives,

- to simulate regional groundwater flow to identify the distribution of heads,
- Impact on the aquifer system due to various hydrological stresses.
- To develop few scenarios for proper understanding of the aquifer system.
- For Efficient and sustainable management of the aquifer system.

5.2. Model Input Parameters

The model was developed by incorporating geologic data, measured and inferred hydrologic data. Two sets of data are required for the development of a groundwater model as given in **Table1**. The two sets of data are the physical framework and hydrological stresses.

Groundwater flow equation

Anisotropic and heterogeneous three-dimensional flow of groundwater, assumed to have constant density, and described by the partial-differential equation given by Rushton and Redshaw (1979) was used to model the groundwater flow in this study

$$\frac{\delta}{\delta x} K_{xx} \frac{\delta h}{\delta x} + \frac{\delta}{\delta y} K_{yy} \frac{\delta h}{\delta y} + \frac{\delta}{\delta z} K_{zz} \frac{\delta h}{\delta z} - W = S_s \frac{\delta h}{\delta t}$$

Where,

K_{xx}, K_{yy}, K_{zz} - components of the hydraulic conductivity tensor

h - potentiometric head

W - source or sink term,

S_s - specific storage

t - time

Table 5.1: Data required in developing a numerical model

Physical framework	Hydrological stresses

Aquifer geometry Type of aquifer Aquifer thickness and lateral extent Aquifer characteristics	Groundwater abstraction and recharge Solute concentration Aquifer stress

5.3. Modelling Protocol

The modelling protocol used in this study for the construction of a numerical model involves the following steps:

- Data collection, acquisition and processing of primary data
- Conceptual model building
- Numerical model building
- Model application
- Result generation.

5.4. Model Conceptualisation

The conceptual model of the system was arrived from the detailed study of geology, borehole lithology, geophysical resistivity survey &logs, cross section and water level fluctuations in wells. Groundwater of the study area is found to occur in the weathered formations and in the fractured/jointed formations. Groundwater is found to occur in unconfined conditions in the weathered formation and unconfined/confined in fractured formation.

5.5. Boundary conditions

The study area forms a part of the upper Cauvery River basin. The boundary conditions modeled are as per the watershed boundary (Figure.2). The eastern boundary of the study area is the Upper Ponnaiyar River Basin and western boundary is bounded by Karnataka state. Cauvery river flows from the western boundary to the southwestern boundary and was modeled as river boundary. The remaining sides of north, eastern and southern boundary are no flow boundary. Except these two regions, the remaining boundary was modeled as no flow boundary as the flow from outside the boundary is negligible.There are two dams within the area namely Panchapalli dam and Thoppaiyar dam. These two regions were modeled as general head boundary.

The aquifer top and bottom were derived mainly based on the lithology of boreholes and by intensive field surveys. The study area has been vertically divided into twolayer. First unconfined layer comprises of the top soil andweathered formation, which is underlain, by fractured/jointed formation, which occurs under unconfined/confined conditions.

Grid Design

The geographic boundaries of the model grid covering 4541 km^2 of the study area were determined using the map module. The map was projected using the metric coordinates in the map module and then imported into the MODFLOW. The finite-difference grid was superimposed on the study area was constructed based on the conceptual model representing the physical properties of the groundwater system. The gird network has a constant spacing 2.0 km by 2.0 km. The model gird discredited into **2912** cells with 56 rows and 52 columns, and vertically by 2 layers **(Figure. 5.1).** The length of model cells is 2000 m along the east west and 2000 m along the north- south directions of the study area.

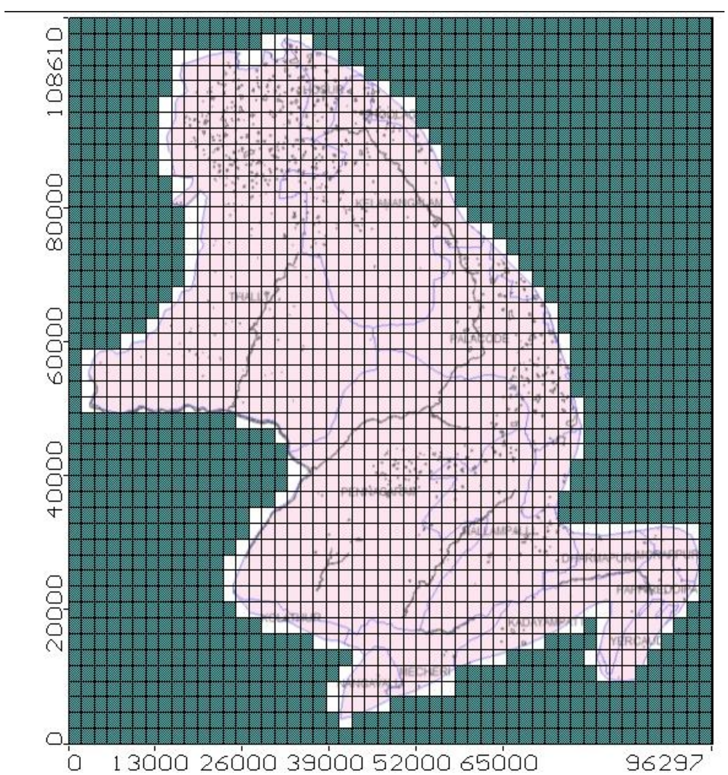


Figure.5.1 Discretisation of the study area.

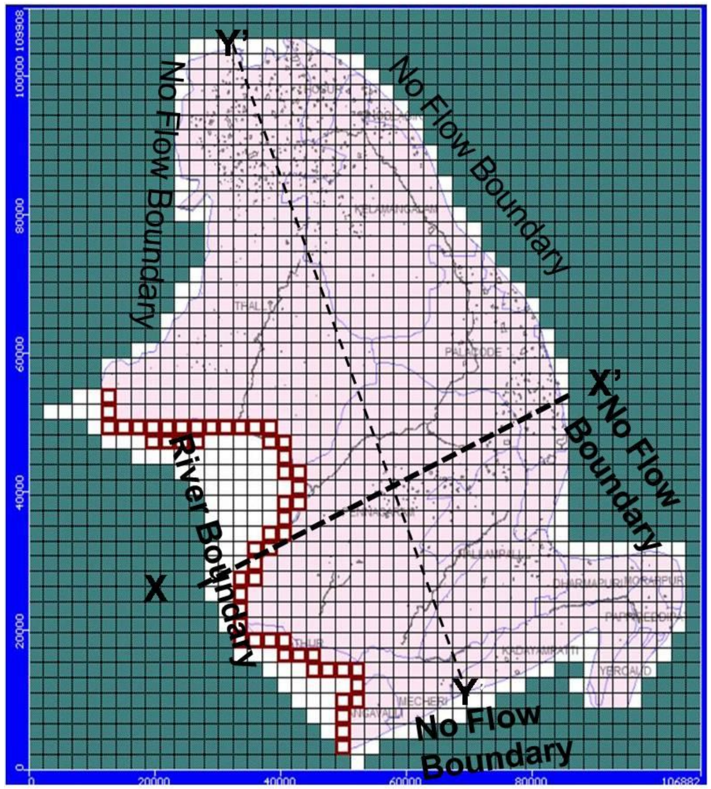


Figure.5.2 Boundary condition of the study area

Input Parameters

Initial Groundwater head

After detailed analysis of the hydrographs, rainfall and water level fluctuation, it was decided that the groundwater head data of Jan'2010 represents the spatial groundwater distribution of the study area. During this period the rainfall was also normal and the groundwater fluctuation was representative of the normal year.

Aquifer Geometry

The aquifer geometry includes defining the aquifer top, bottom of Ist layer and bottom of IInd layer for all the cells. They were mainly derived from the subsurface characterization using the lithologs, resistivity data and geological field work. These values were extrapolated for the entire area considering the lithological variations and field study of well sections. The Ist layer is characterized by weathered formation with a maximum thickness of 36m and is underlained by fractured/jointed formation with a maximum thickness of 140m. Sections west-east and north-south are presented as **figure 5.3a & b.**

Figure 5.3a&b

Model section along two direction X-X’ and Y-Y’ are given below:

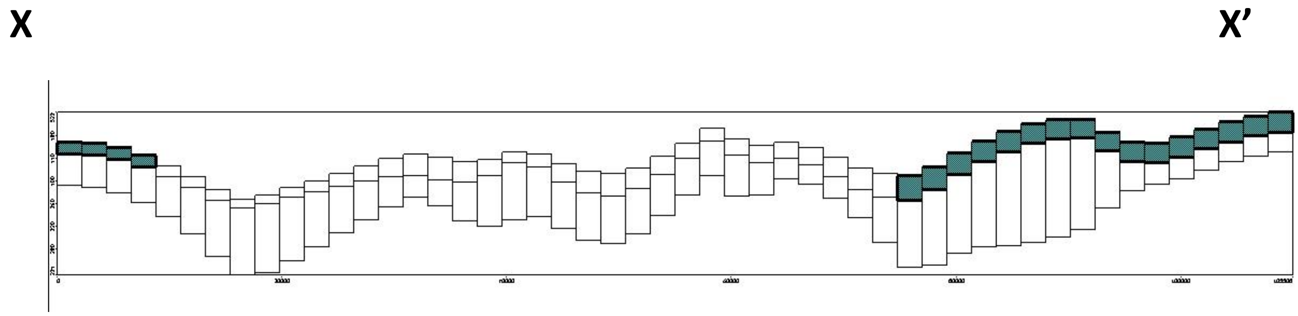


Figure 3a Section along x-x’ direction

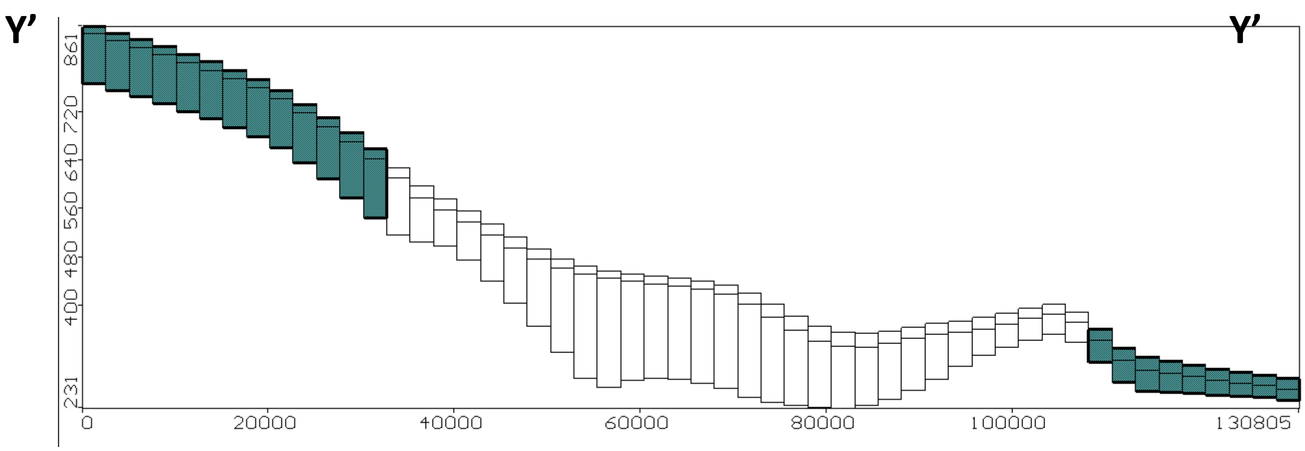


Figure 3b.Section along Y-Y’ direction

Aquifer characteristics

The aquifer properties such as horizontal hydraulic conductivity, Specific yield and storativity used in the model were derived from 29 pumping tests results and is given in the **Table5.2**.

Table.5.2: Summary of the Pumping test results

Formation	Hydraulic conductivity (k in m/day)	Specific Yield (%)	Storativity
Weathered Gneiss	4 to 9	0.015 to 0.06	-
Weathered Charnockite	3 to 7	0.015 to 0.05	-
Fractured/jointed Gneiss	2 to 6	0.034 -0.05	0.00017 to 0.00073
Fractured /jointed Charnockite	2 to 6	0.03 to 0.09	0.00032 to 0.000041
Ultramafic	1 to 2	0.01	-

5.6. Groundwater draft and recharge

5.6.1.Groundwater Abstraction

The groundwater of the study area is abstracted for irrigation, drinking water supply and domestic purposes. Agriculture activity of the study area is mainly dependant on groundwater resource and small region of canal/dam command area. The Landuse and landcover map was prepared to demarcate the area under cultivation. Information on the number of wells (open and borewells) available in the study area was collected from the department of economics & Statistics and also from the electricity board. The data obtained from electricity board included the number of wells energized and their horse power of the pump (**Table.5.3**). The domestic and drinking water requirement of the study area was calculated based on population.

Table.5.3 Groundwater draft details

Sl.no	District	Area (sq.km)	Dug wells	Aquifer I Draft (mcm)	Borewells	Aquifer II Draft (mcm)
1	Krishnagiri	2119	2170	56	3444	21
2	Dharmapuri	1315	39681	193	34333	132
3	Salem	1107	5276	21	1789	15

5.6.2. Groundwater Recharge

The recharge of the study area aquifer varies considerably due to differences in landuse pattern, soil type, geology, topography and relief. The recharge to the aquifer system is from rainfall, irrigation and inflow from the river and storage tanks. Rainfall is the principal source of groundwater recharge. The rainfall hydrograph were studied to understand the recharge pattern in the study area. The aquifer gets recharged and groundwater level shoots with rainfall above 40 mm. The entire portion of the study area is geologically covered by top soil, weathered and fractured/jointed formation. The infiltration capacity of formation ranges from 0 – 12 % (Groundwater resources estimation committee report, 1997). The **table5.4** shows the rainfall infiltration factor used in modeling for groundwater recharge calculation.

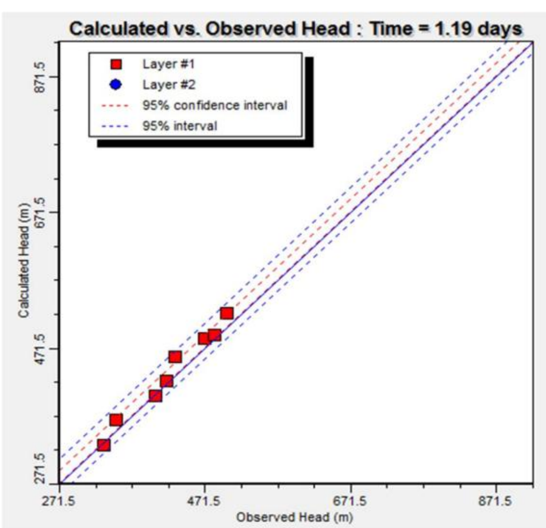
Table 5. 4 Rainfall vs infiltration factor used in groundwater recharge calculations.

S.No.	Rainfall (mm)	Infiltration factor (%)
1	0 -40	0
2	40 -100	8
3	100 -200	10
4	200 -300	12
5	300 -400	10

The rate of leakage between the river and aquifer was estimated using the difference between the river head and groundwater head. The rivers situated in the study area and its contribution to groundwater recharge was calculated based in the difference between the head in the adjoining wells and reservoir head. The data of the river head was inputted in the model. Cauvery river flows only for few days during August, September & October. Three recharge zones have been demarcated in the study area and they comprise of top soil zone, weathered Gniessic/charnockitic formation and ultramafics zone.

5.7. Model Calibration

The calibration strategy was to initially vary the best known parameters as little as possible, and vary the poorly known or unknown values the most to achieve the best overall agreement between simulated and observed. Steady state model calibration was carried out to minimize the difference between the computed and field water level condition. Steady state calibration was carried out with the water level data of Jan2010 in 17 wells distributed over the study area. Out of all the input parameters, the Specific yield value is the only poorly known as only 29 pumping tests were available in this area. The lithological variations in the area and borehole lithology of existing large diameter wells were studied. Based on this it was decided to vary hydraulic conductivity values upto 10% of the pumping test results for layer in order to get a good match of the computed and observed heads (Fig. 5). The figure indicates that there is a very good match between the calculated and observed water heads in most of the wells of the study area. Root mean square error and the mean error were minimized through numerous trial runs.



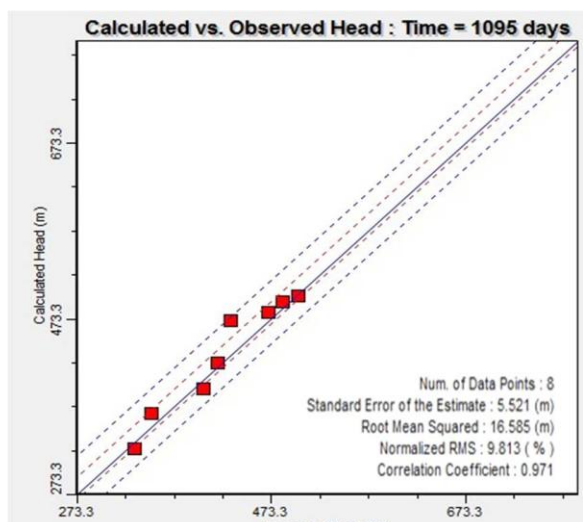


Figure.5.5. Comparison of computed and observed groundwater head under steady state

& Transient state condition.

Transient state simulation was carried out for a period of 5 years from Jan2010 to Dec 2014 with monthly stress periods and 24 hour time step. The trial and error process by which calibration of transient model was achieved by several trials until a good match between computed and observed heads over space and time. The hydraulic conductivity values incorporated in the transient model were modified slightly from those calibrated by the steady state model. Based on the close agreement between measured and computed heads from Jan 2010 to Dec 2014 at 17 observation wells distributed throughout the aquifer, the transient models were considered to be calibrated satisfactorily. The sensitivity of the model to input parameters were tested by varying only the parameter of interest over a range of values and monitoring the response of the model by determining the root mean square error of the simulated heads compared to the measured heads.

5.8. Simulation Results

The model was simulated in transient condition for a period of 5 years from 2010-Dec 2014. There was fairly good agreement between the computed and observed heads **(Figure.6a & b**). A study of the simulated potentiometric surface of the aquifer indicates that the highest heads are found on the Northern side of the study area, which attribute to the topography. During the simulation period, it is observed that most of the cells in the first layer i.e., weathered zone get dried up. The number of dry cells gradually increases with the summer season and number of dry cells reduces with arrival of monsoon. The regional groundwater flow direction is from east to Southwest. The groundwater flow vectors for the month of May & December 2014 are given in figure.**7a & b**. The comparison of observed and computed heads is given in **figure 8a&b**.

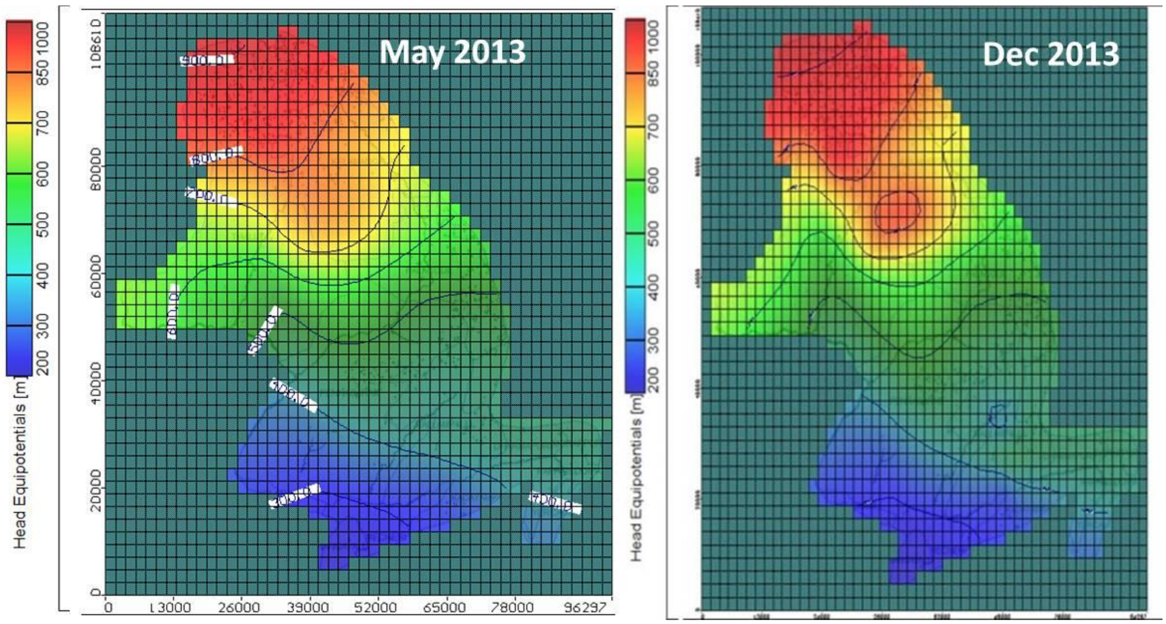


Figure.5.6 a&b Simulatedgroundwater head during May & December 2013.

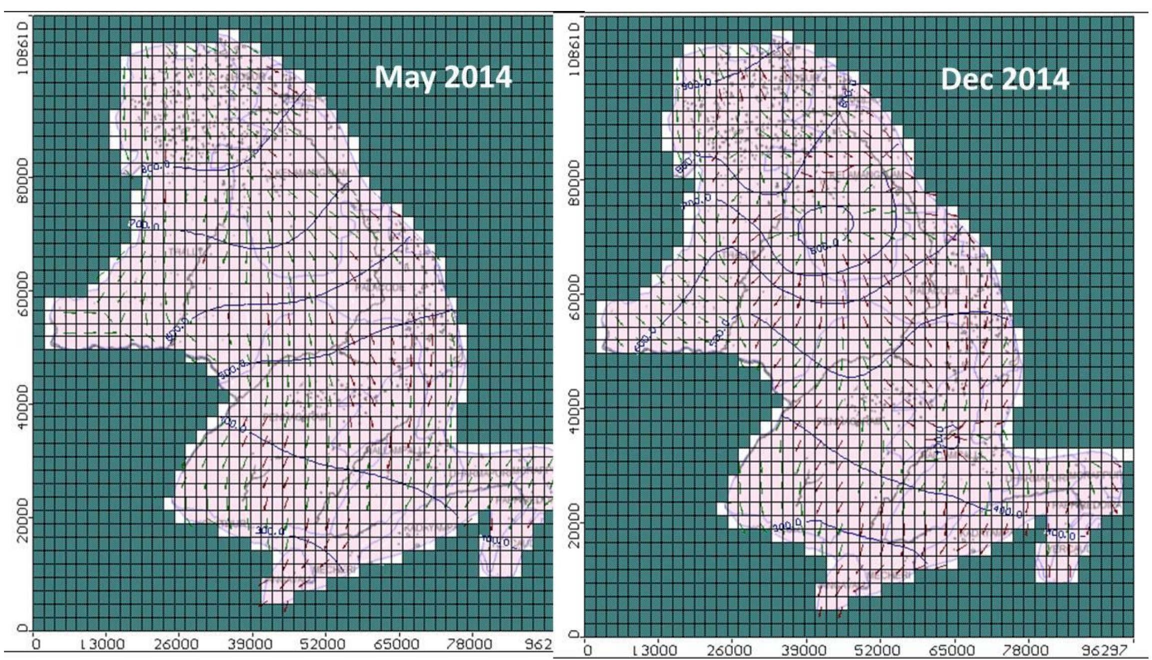


Figure 5.7a & b Groundwater flow vectors during May & December 2014

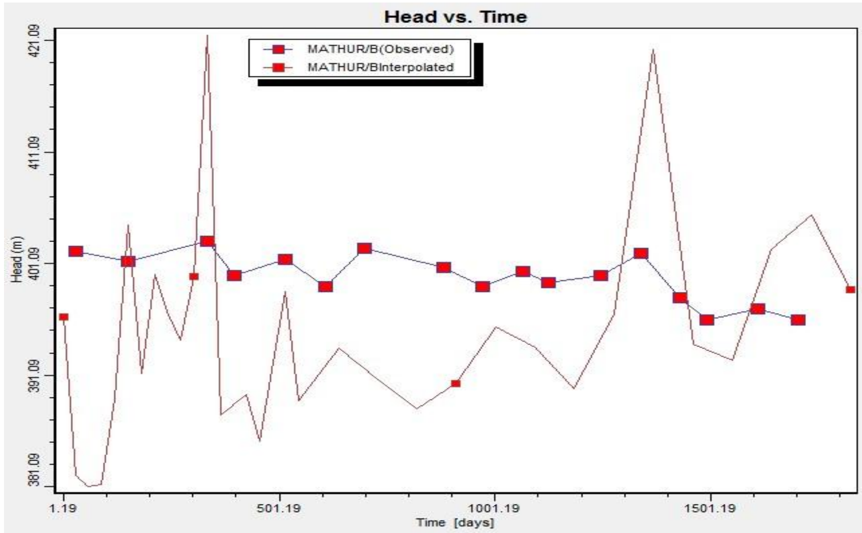


Figure.5.8a Times series analysis of Computed and observed at Kelamangalam

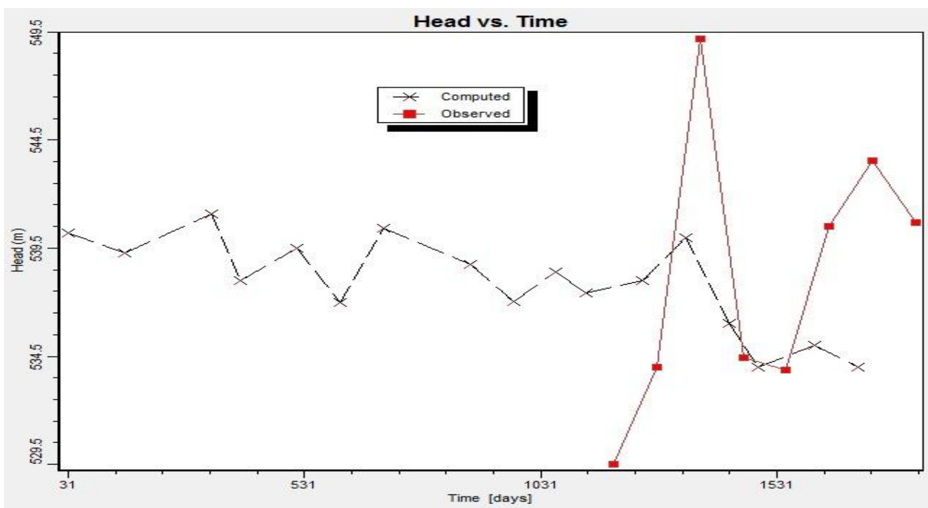


Figure.5.8b Times series analysis of Computed and observed at Palacodu

5.9. Model Forecast

The aquifer response for different input and output fluxes was studied in order to sustainably manage the aquifer system. The model was run for a further period of 11 years from 2014 to 2025. Before commencement of this simulation, the data of average rainfall (100 years), abstraction, river flow and recharge was provided to the model upto 2025.

Two prediction runs were planned to evolve optimal management schemes.

(1) Normal rainfall condition

The model was run to predict the regional groundwater head in this area until the year 2025. For these runs the monthly average rainfall calculated from 100 years rainfall data was used. The present level of groundwater abstraction was considered for this simulation. The simulated regional groundwater head shows that there is not much increase or decrease in water level. Such observation is made in most of the locations.

(2) Drought year once in four years

Analysis of the past 100 years (1901-2000) rainfall data indicates that in 56 years, the rainfall was less than the average of 816 mm/year. The average of these low rainfall years (drought period) was found to be 696 mm/year. In order to study the effect of drought years in this area, the model was predicted by assuming deficit rainfall once in twoyears until 2025. The monthly average of deficit rainfall years was calculated and used for this purpose. However, the groundwater level recovers to the level observed during the normal rainfall within the next year. One good flow in the rivers sees the groundwater levels attaining its normal levels. The contribution of the river to the aquifer system maintains the system in stable condition.

3) Increase in Groundwater withdrawal

The model was run to predict the regional groundwater head in area until the year 2025 with 15% increase in pumping. For these runs the monthly average rainfall calculated from 100 years rainfall data was used. The predicted model indicates that the major portion becomes dry and only central and south eastern portion have groundwater in aquifer I. Model clearly indicates that the groundwater head will decline drastically with increase in pumping. (**Figure.5.9**). This clearly indicates that 15% increase in pumping will have devastating impact on the aquifer system.

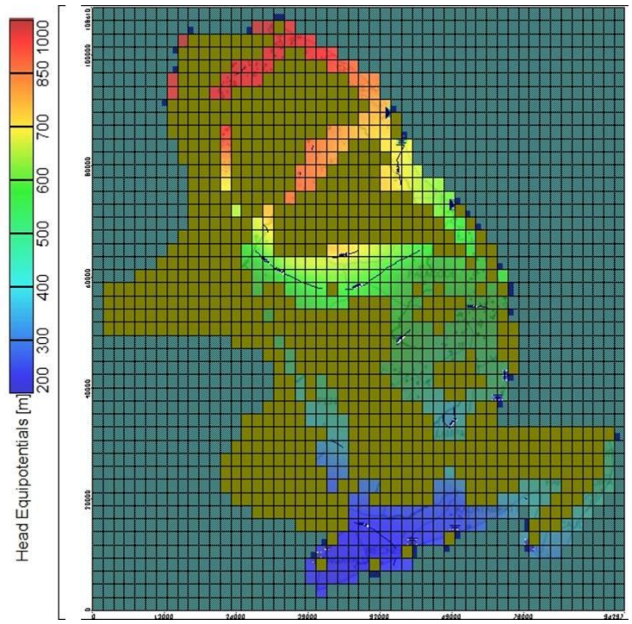


Figure.5.9. Predicted groundwater head 2025 with 15% increase in pumping.

6.0. GROUND WATER RELATED ISSUES:

Ground water is extensively utilized for irrigation in the entire basin area for the past two decades, especially in the 15 over-exploited firkas out of the 31 firkas of the basin. There is no anthropogenic contamination in the basin as there is no much urbanization. However, excess fluoride in ground water in some pockets causes health hazards by utilizing such ground waters for drinking purpose in the absence of protected drinking water supply.

6.1.Geographical distribution & Resource availability :

In the study basin more than 46% of the area (2103 sq.km) is reeling under over development. All the 15 over-exploited blocks (11 of Dharmapuri district and 4 of Salem district) are falling on eastern side of the basin and mainly on the left of Chinnar river course. Entire Dharmapuri district part of the basin except three firkas viz., Dharmapuri, Nallampalli and Sujalnatham all the other 11 firkas having an area of 1970 sq.km are over-exploited through 35,251 dug wells and 523 bore wells. The development level in these firkas is about 170% to the available annual resource. Whereas, the other 4 over-exploited firkas of the basin fall on Thoppaiar drainage comprising an area of 133 sq.km with a level of development of 151%.

The total irrigation wells in the study basin are in the order of 51,542 out of which 47,662 are dug wells and 3,879 are bore wells. More than 80% of the dug wells (38,312) are located in 15 Over-exploited firkas of the basin, while the rest of 20% dug wells (9,348) located in the other 16 firkas.

The balance resource available for future use is left in the 16 firkas of the basin is in the order of 4,974 ham while there is an over draft of 10,239 ham in the 15 Over-exploited firkas. The average level of development in the 16 safe and semi-critical firkas of the basin is at 63% and accounts for 8,577 ham out of the available resource of 13,551 ham.

So there is ample scope for ground water development in the 16 safe and semi-critical firkas comprising more than 50% of the area of the basin, falling in parts of Krishnagiri, Salem and Dharmapuri districts.

6.2. Ground water quality issues:

High fluoride content in groundwater is the major concern in some isolated pockets of the basin falling in Denkanakottai and Kelamangalam firkas of Krishnagiri district and in Sujalnatham, Pulikarai and Marandahalli firkas of Dharmapuri district.

Highest fluoride levels are recorded in the water samples of bore wells collected from aquifer II at Samanur, Dodda Belur, A Pudur of Marandahalli firka (Dharmapuri district) and at Osatti and Karagondanapalli of Denkanakottai firka (Krishnagiri district).

Some dug well waters recorded more than 2 mg/l of fluoride concentration at Aralagundi of Sujalnatham firka, Samnur, Tadikallu, Elugundur of Marandahalli firka (Dharmapuri district) and at Sandanapalli and Dinnur villages of Denkanakottai firka (Krishnagiri district) which were collected from phreatic zone (Aquifer I).

6.3. Future Demand Scenario and Stress on Aquifer system:

Future demand projected for domestic utilization will have little stress on the aquifer system as the anticipated draft by 2025 and 2030 is not going to increase much in comparison to the present gross draft. However, draft can be regulated through increasing the water efficiency practices in irrigation sector.

Already the dependency on ground water for domestic and drinking needs is decreasing in ground water contaminated areas as the alternative surface/ river sources are being harnessed.

7.0.Management Strategies

The ground water management strategies are inevitable either when there is much demand to the resource than the available quantity or when the quality of resource deteriorates due to contamination in a given geographical unit. In recent years water resources are used extensively both for irrigation and industrial needs. In addition, to meet the domestic requirements of the fast growing urban agglomerations the administrators are compelled to allocate a considerable quantum of resource which otherwise is being used for irrigation purpose. So, the urbanization has a negative impact on the food production as well as grabbing the employment of the agricultural laborers. Hence, it is the need of the hour to formulate sustainable management of the ground water resource in a more rational and scientific way.

In the present study area of Upper Cauvery basin, the sustainable management plan for ground water is being proposed after a thorough understanding of the aquifer disposition down to a depth of 200m bgl. The study area is characterized by weathered and fractured system with very heavy abstraction of ground water for irrigation practices.

7.1. Sustainable Management Plan

The groundwater resource is over-exploited in 15 firkas of the basin comprising an area of 2103 Sq.km. out of the 4514 sq.km area of the basin. Irrigation draft of 239 MCM is estimated as per the GEC 2011 against the Net availability of the resource of 146.56 MCM. A total of 100 MCM in excess was drawn from the ground water system of the 15 OE firkas. Therefore, the usage of groundwater has to be reduced by 40 percent of the existing draft for the sustainability of the resource. Or else the availability has to be augmented through artificial recharge methods to bridge the gap between draft and availability. The draft can be reduced through application of water efficiency methods in irrigation sector and through changing the irrigation practices from wet to dry cash crops.

7.2. Augmentation Plan

Augmentation of groundwater can be achieved through construction of percolation ponds and recharge shafts where the top soil zone is clayey which does not allow infiltration. Normally it can be achieved through capturing surface runoff. Surface water transfer also can be planned in the absence of surface runoff during droughts. It needs uncommitted runoff from the adjoining localities to transport to the needy areas through diversion channels.

In the study area easternand southern parts are subjected to Over-exploitation. Normally due to over exploitation of groundwater the water levels are depleting in this zone. The natural rainfall recharge is insufficient to recoup the extracted groundwater.Artificial Recharge and Water Conservation Plans are proposed in the OE firkas of the basin through utilizing the uncommitted surface runoff of 218 MCM.

7.2.1. Artificial Recharge Plan

Based on the water level monitoring in different seasons across the basin, as well as after having better understanding of the disposition and extent of the aquifer system through exploratory drilling, pumping tests etc., the potential volume of void space available within the weathered zone of first aquifer of the basin has been estimated as 463 MCM and tabulated in **Annexure - 6**. But the annual uncommitted runoff is only 218MCM which is less than 50% of required water to fill the available void space of aquiferI. Artificial recharge and Water conservation plan is prepared for the over exploited firkas of the basin area through harnessing just less than 40% of the auunal uncommitted runoff of 37.7 MCM only with a total out lay of 142 Crore rupees.

The suggested Artificial recharge structures are mainly Nala bunds, Check Dams and Recharge Shafts in addition to removal of silt in the surface tanks. Selection of the site locations of these structures are based on the critical analysis of the hydrogeological, geophysical and exploration data of the basin. Particularly geomorphological and drainage aspects are being given more weightage in selection of the Artificial Recharge structures.

A total number of 174 check dams, 234 nala bunds and 99 recharge shafts are proposed in the OE firkas of the basin. A total number of 272 Recharge Rejuvenation ponds are selected for desilting followed by construction of recharge shafts within the tanks. The expected recharge through these artificial recharge structures is in the order of 30.479 MCM.

The expected average water level rise in the 15 OE firka area will be in the order of 2.28m/year

The firkawise details are discussed in Part II of the report.

7.2.2. Water Conservation Plan

Low pressure water distribution system is being proposed in 1391 Ha of cropped area which otherwise is under irrigation through earth channels. The expected savings of water through this method is expected to be 3.573 MCM./ yr. A total number of 1362 Farm ponds are proposed which will act as storage tanks in farm as well as augment groundwater recharge and the expected annual groundwater recharge through these ponds is in the order of 7.355 MCM.

7.3.Demand side Management Plan

Demand side management can be accomplished through irrigation water scheduling, soil moisture management and practicing agronomic measures such asdeep ploughing, straw mulching, and the use of improved strains/ seeds and drought resistant agents. Change in crop type and land use i.e., practicing higher-value crops under green house cultivation or returning a proportion of the wet crop area to dry land cultivation of drought-resistant crops, will lead to a considerable savings of groundwater extraction. It is essential that the savings in groundwater are not spared to expand the irrigated area or to divert to other industrial uses but to leave it to restore the depleted water levels to rise and to build the aquifer storage. This can be achieved through clear incentives for farmers to act in the collective interest of resource conservation.

7.4. Future Demand Stress Aspects

In views of rapid urbanization the domestic water needs are increasing multifold. In this urbanization process the water wastage component is increasing mainly because of leakages through distributor system. Whereas in the agricultural irrigation sector the water demand mainly due to the enthusiasm of the farmers to increase the crop irrigation area.

Hence the policy makers at higher administrative level and rural development authorities at block level should educate the farmers in their jurisdiction in such a way that they should not venture to increase the farm irrigation area. Rather these authorities have to suggest high yielding crop varieties and high-value crops to grow with minimum water requirement with the technical guidance of local agricultural/ agronomic experts.

7.5.Strategies to overcome the future stresses

Future stresses are only hypothetical. If the sustainable management is taken up in a true spirit in consultation with local village level bodies the groundwater depletion will not occur in future. However, it is very difficult to overcome gluttonous user attitude thrives for fullest use of the resource to get maximum output. In this process the vital resource is lost. Therefore a thorough understanding of the consequences of indiscriminate usage of the water should be propagated among users mainly among farmers as they are bulk users of the resource in the study area.

The demand side strategies to overcome future stresses are mainly

- Promoting Crop Change
- Reducing Irrigated Area
- Agronomic Water Conservation
- Reducing Water use reduction in Urban areas

Annexure-1

Key Well details

Sl No.	Name of the Village	Co-Ordinates		May 14 DTW (mbgl)	Feb 15 DTW (mbgl)	water level Fluctuation	water table elevation (pre)	water table elevation (post)
		Latitude	Longitude					
1	Rayakottai	12°31'05''	78°01'58''	19.98	19.4	0.58	719.02	719.6
2	Nagamangalam	12°34'31''	77°56'38''	9.85	7.1	2.75	742.15	744.9
3	Nagadunai	12°33'49''	77°54'45''	8.62	8.17	0.45	671.38	671.83
4	Anusonal	12°34'00''	77°54'00''	7.71	6.05	1.66	780.29	781.95
5	Kelamangalam	12°36'17''	77°51'23''	3.25	1.95	1.3	799.75	801.05
6	D.Tamandrapalli	12°37'20''	77°51'09''	19.08	12.25	6.83	809.92	816.75
7	Virupakshanagara	12°35'37''	77°52'05''	4.25	2.25	2	800.75	802.75
8	Muddampatti	12°32'24''	77°59'06''	12.1	12.3	-0.2	706.9	706.7
9	Suligunta	12°32'59''	78°04'04''	7.95	7.4	0.55	603.05	603.6
10	Balanur Kottai	12°30'54''	78°03'07''	14.52	15.1	-0.58	633.48	632.9

11	Muddampatti(Deep)	12°32'49''	78°58'30''	18.35	14.9	3.45	711.65	715.1
12	Lakshmipuram	12°32'35''	77°52'47''	4.35	3.55	0.8	740.65	741.45
13	Bevanattam	12°30'51''	77°52'10''	7.48	6.2	1.28	770.52	771.8
14	Kowthalam	12°34'2''	77°49'56''	12.58	10.33	2.25	796.42	798.67
15	T.Pudur	12°35'19''	77°48'52''	8.3	4.05	4.25	806.7	810.95
16	Jarakalatti	12°29'39''	77°49'27''	4.64	2.45	2.19	875.36	877.55
17	Govindapally	12°28'35''	77°53'08''	8.74	6.38	2.36	771.26	773.62
18	Tippasandiram	12°28'31''	77°50'58''	4.92	2.82	2.1	818.08	820.18
19	Nemileri	12°26'10''	77°50'47''	5.38	4.82	0.56	820.62	821.18
20	Sandanapalli	12°27'53''	77°49'30''	8.3	6.1	2.2	874.7	876.9
21	Geddahalli	12°25'12''	77°51'12''	5.35	5.25	0.1	891.65	891.75
22	Chapranahalli	12°30'03''	77°48'12.''	7.17	4.1	3.07	875.83	878.9
24	Medhatti	12°27'08''	77°46'37''	12.5	12	0.5	846.5	847
25	Kuthanpalli	12°33'59''	77°56'51''	10.5	8.9	1.6	743.5	745.1
26	Kandaganapalli	12°30'41''	77°44'09''	11.57	10.21	1.36	910.43	911.79
27	Kottai Uliamangalam	12°31'57''	77°45'46''	20.1	20.7	-0.6	902.9	902.3
28	C.K.Halli	12° 2819.3"	78°01'55''	7.1	12.45	-5.35	693.9	688.55
29	Varaganapalli	12° 33 '47"	77°55'09''	5.5	5.3	0.2	763.5	763.7
30	Dinnur	12° 30 '35"	77°43'40''	8.4	8.2	0.2	928.6	928.8
31	Alahalli	12° 27 '52"	77°47'21''	4.65	4.5	0.15	842.35	842.5
32	Melur	12° 24 '37"	77°50'58''	2.85	1.95	0.9	922.15	923.05
33	Tadikallu	12° 28 '20"	77°49'59''	3.15	3.05	0.1	809.85	809.95
34	Sattankallu	12° 29 '8"	77°53'56''	9.4	8.75	0.65	776.6	777.25
35	Mangarai	12°05'23.5''	77°59'29''	6.98	7.5	-0.52	488.02	487.5
36	Dasampatti	12°11'29''	77°56'49''	18.05	19.9	-1.85	344.95	343.1
37	Halayapuram	12°06'34''	77°52'43''	7.13	5.95	1.18	505.87	507.05
38	Halayapuram(A)	12°06'34''	77°52'43''	7.45	6.05	1.4	521.55	522.95
39	Naganur	12°05'27''	77°53'29''	8.58	6.31	2.27	472.42	474.69
40	Jakkampatti	12°06'3.5''	77°51'34''	12.74	10.97	1.77	509.26	511.03
41	PeriaVittlapuram	12°03'30''	77°49'32''	7.9	4.4	3.5	369.1	372.6
42	Eriyur	12°00'56''	77°48'6''	8.55	4.2	4.35	315.45	319.8
43	Neruppur	11°57'49.5''	77°47'0''	6.09	2.79	3.3	269.91	273.21
44	Ramakondahalli	11°58'5.1''	77°48'27''	9.44	2.45	6.99	284.56	291.55
45	Puchchur	11°55'58.9''	77°51'8''	7.73	7.22	0.51	255.27	255.78
46	Aralgundi	11°57'12.5''	77°53'15''	17.45	10.83	6.62	363.55	370.17
47	Malaiyanur	11°59'28''	77°49'10''	7.5	4.43	3.07	302.5	305.57
48	Manikarankottai	12°01'16''	77°51'33''	6.32	8.99	-2.67	348.68	346.01
49	Mutugampatti	12°03'4''	77°53'44''	6.42	5.37	1.05	396.58	397.63
50	Kadamadai	12°03'23''	77°56'12''	8.85	4.81	4.04	461.15	465.19
51	Koppalur	12°02'6''	77°56'11''	7.66	3.41	4.25	469.34	473.59
52	Chinnampalli	12°00'26''	77°58'01''	6.4	4.42	1.98	331.6	333.58

53	Perumbalai	11°57'52''	77°56'13''	14.45	8.7	5.75	291.55	297.3
54	Ayamaranapatti	11°54'53''	77°55'36''	15.95	12.48	3.47	261.05	264.52
55	Pudupatti	12°02'54''	77°57'27''	11.65	6.1	5.55	470.35	475.9
56	Thallapallam	12°01'33''	77°53'09''	5.1	2.48	2.62	353.9	356.52
57	Perithota pudur	12°04'36''	77°54'48''	3.9	3	0.9	454.1	455
58	Kariyampatti	12°05'56''	77°54'55''	10.85	6.8	4.05	471.15	475.2
59	Pennagaran	12°07'30''	77°54'00''	12.44	7.69	4.75	500.56	505.31
60	Hogenikalfalls	12°07'09''	77°46'52''	5.8	3.19	2.61	265.2	267.81
61	Banijagarahalli	12°08'27''	77°57'25''	11.07	10.56	0.51	490.93	491.44
62	Solappadi	12°00'10''	77°48'59''	8.5	7.2	1.3	292.5	293.8
63	Sidumanahalli	12°00'45''	77°49'56''	5.9	4.4	1.5	319.1	320.6
64	Sidumanahalli colony	12°01'06''	77°50'08''	6.95	6.1	0.85	321.05	321.9
65	Kuttandahalli	12°28'27''	77°58'14''	16.4	18	-1.6	623.6	622
66	Panchapalli	12°27'37''	77°56'51''	16.52	2.65	13.87	612.48	626.35
67	Elugundur	12°26'07''	77°57'29''	13.52	9.37	4.15	597.48	601.63
68	Attimutlu	12°24'16''	77°58'42''	11.57	9.85	1.72	582.43	584.15
69	Sanmanur	12°24'38''	77°59'27''	8.06	5.54	2.52	589.94	592.46
70	Bennihalli	12°22'38''	77°57'59''	10.44	3.24	7.2	601.56	608.76
71	Sandirapuram	12°22'25''	77°59'56''	10.53	3.07	7.46	575.47	582.93
72	Doddabavalli	12°20'40''	78°00'00''	4.51	4.11	0.4	569.49	569.89
73	Belamaranahalli	12°19'18''	77°59'19''	10.76	5.93	4.83	557.24	562.07
74	Belluranahalli	12°18'32.5''	77°58'0.3''	6.44	5.68	0.76	568.56	569.32
75	Belluhalli	12°18'46''	77°57'17''	11.2	4.82	6.38	577.8	584.18
76	Siriyanahalli	12°17'49''	77°59'44''	10.1	8.56	1.54	534.9	536.44
77	Gummanur	12°26''40.5"	78°00'58.6"	11.1	11.73	-0.63	625.9	625.27
78	Pudur	12° 23 '06.3"	78° 01' 39.1"	4.75	5	-0.25	579.25	579
79	Belarahalli	12° 17 '35.2"	78° 05' 51.8"	10.85	14	-3.15	500.15	497
80	Timmampatti	12° 19 '4.9"	78° 04' 31.9"	7.15	8.75	-1.6	492.85	491.25
81	Marandahalli	12° 23 '16.6"	78° 00' 25.7"	5.33	3.77	1.56	582.67	584.23
82	Mallapuram	12° 21 '11.7"	78° 00' 44.4"	7.55	7.45	0.1	563.45	563.55
83	Gowdanur	12° 20 '03"	78° 02' 26.7"	7.4	7.65	-0.25	536.6	536.35
84	Boppadi	12° 18 '07.5"	78° 01' 25.3"	5.16	5.7	-0.54	526.84	526.3
85	Tirumalavadi	12° 15 '25.7"	78° 03' 37.3"	11.6	8.6	3	506.4	509.4
86	Somanahalli	12° 14 '32"	78° 05' 56.2"	15.15	14.5	0.65	461.85	462.5
87	Chittampatti	12° 16 '1.8"	78° 08' 35"	13.2	10.2	3	463.8	466.8
88	Nagadasampatti	12°08'8.5''	77°59'26''	11.41	6.86	4.55	460.59	465.14
89	Belanaganahalli	12°06'59''	77°55'00''	4.82	3.97	0.85	484.18	485.03
90	Karibalayanahalli	12°05'23.5''	77°59'29''	14.37	10.76	3.61	455.63	459.24
91	Vellakkal	11°59'52''	78°04'01''	21.55	10.95	10.6	475.45	486.05
92	Jarugu	11°59'59''	78°01'41''	17.25	13.75	3.5	449.75	453.25
93	Melisalpatti	11°58'21''	78°01'43''	14.75	14.4	0.35	501.25	501.6

94	V.R.Kottai	11°57'58''	78°00'43''	14.58	13.95	0.63	467.42	468.05
95	Sekkarapatti	11°57'13''	78°05'31''	13.09	13.42	-0.33	351.91	351.58
96	Thoppaiar Dam	11°57'28''	78°06'10''	12.5	10.55	1.95	351.5	353.45
97	C.Pudur	12°07'31''	77°58'18''	13.9	12.05	1.85	465.1	466.95
98	Thoppur	11°56'36''	78°02'53''	11	9.55	1.45	322	323.45

Groundwater Quality for Aquifer 1

Sl.No	Village/ Location	Block	District	Lat	Long	pH	EC (µS/cm)	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F
								mg/l										
1	C.K.Halli	Kelamangalam	Krishnagiri	12.472	78.032	7.66	1040	350	50	55	76	6	NIL	317	99	86	38	0.92
2	Nagamangalam	Kelamangalam	Krishnagiri	12.575	77.944	7.76	1150	315	52	45	117	4	Nil	488	57	38	65	0.8
3	Nagadunai	Kelamangalam	Krishnagiri	12.564	77.913	8	869	235	38	34	92	8	Nil	366	53	48	20	1.3
4	Kelamangalam	Kelamangalam	Krishnagiri	12.605	77.856	7.3	2410	750	124	107	242	4	Nil	427	454	226	74	1.02
5	D.Thamanrapalli	Kelamangalam	Krishnagiri	12.622	77.853	7.4	1780	705	188	57	76	20	Nil	366	181	278	61	0.8
6	Viruppakshinagar	Kelamangalam	Krishnagiri	12.594	77.868	7.6	1010	270	60	29	104	8	Nil	61	163	158	74	0.64
7	Mudampatti/	Kelamangalam	Krishnagiri	12.54	77.985	7.45	1430	475	120	43	108	4	Nil	360	131	149	99	0.31
8	Suligunta	Kelamangalam	Krishnagiri	12.552	78.06	7.63	1520	525	104	64	104	12	Nil	519	96	173	25	1.4
9	Balanur kothai	Kelamangalam	Krishnagiri	12.515	78.052	7.79	1820	325	56	45	271	4	Nil	580	234	67	50	1.02
10	Mudampatti	Kelamangalam	Krishnagiri	12.547	78.975	7.82	1020	255	60	26	115	5	Nil	73	60	288	68	0.96
11	Lakshmipuram	Kelamangalam	Krishnagiri	12.543	77.88	7.75	1700	485	116	47	170	7	Nil	427	152	274	19	0.92
12	Bevanatham	Kelamangalam	Krishnagiri	12.514	77.869	7.79	1510	410	80	51	159	2	Nil	311	199	182	35	0.92
13	T.Pudur	Kelamangalam	Krishnagiri	12.589	77.814	7.89	1500	300	64	34	202	12	Nil	366	96	240	87	1.5
14	Jarkkaltti	Kelamangalam	Krishnagiri	12.494	77.824	7.72	1200	300	76	27	138	4	Nil	323	135	101	56	1.02
15	Varaganapalli	Kelamangalam	Krishnagiri	12.563	77.919	7.34	893	140	45	95	300	5.5	NIL	250	95	25	75	0.9
16	Bommathattanu	Kelamangalam	Krishnagiri	12.565	77.891	7.3	699	120	61.5	58.5	215	10	NIL	210	20	50	60	1.5
17	puvanapalli	Kelamangalam	Krishnagiri	12.561	77.85	7.25	1420	195	75	120	510	15	NIL	290	50	320	67	1.8
18	Dinnnr	Kelamangalam	Krishnagiri	12.51	77.728	7.2	381	105	55	50	80	5	NIL	100	10	50	28	1.6
19	Kadaganapalli	Kelamangalam	Krishnagiri	12.511	77.736	7.25	484	145	100	45	90	15	NIL	100	50	70	25	1.7
20	Medhatti	Kelamangalam	Krishnagiri	12.452	77.777	7.37	867	200	110	90	200	20	NIL	300	40	60	30	1.3
21	Allahalli	Kelamangalam	Krishnagiri	12.464	77.789	7.33	749	135	65	70	235	2	NIL	250	35	65	35	1.4
22	Nemileri	Kelamangalam	Krishnagiri	12.436	77.846	7.42	556	95	55	40	170	6	NIL	170	60	35	15	0.6
23	Geddahalli	Kelamangalam	Krishnagiri	12.42	77.853	7.44	613	110	50	60	190	7.5	NIL	200	60	40	10	1.1
24	Melur	Kelamangalam	Krishnagiri	12.41	77.849	7.25	650	150	120	30	150	20	NIL	150	55	100	30	0.6
25	Tadikallu	Kelamangalam	Krishnagiri	12.472	77.87	7.41	706	125	50	75	230	1.5	NIL	250	25	45	25	2.1
26	Karibalayamhalli	Nallampalli	Krishnagiri	12.09	77.991	7.7	1960	600	100	85	175	8	Nil	421	209	211	161	1.1
27	Vallakkal	Nallampalli	Krishnagiri	11.998	78.067	7.5	1250	320	50	47	140	4	Nil	500	99	29	62	0.78
28	Jarugu	Nallampalli	Krishnagiri	12	78.028	7.63	1190	310	30	57	129	8	Nil	397	67	158	25	0.41
29	Thoppaiardam	Nallampalli	Krishnagiri	11.958	78.103	7.84	1740	480	60	80	179	8	Nil	433	124	230	143	1.2
30	Marandahalli	Palacode	Dharmapuri	12.388	78.063	8.02	2070	490	44	92	253	3	NIL	647	269	64	65	1.7
31	Mallapuram	Palacode	Dharmapuri	12.353	78.032	7.98	2460	590	72	100	299	23	NIL	647	333	148	155	0.82

32	Gowdanur	Palacode	Dharmapuri	12.334	78.016	8.06	820	240	58	23	74	1	NIL	268	78	23	59	0.82
33	Boppadi	Palacode	Dharmapuri	12.302	78.249	8.01	400	55	10	7	67	1	NIL	195	14	11	7	0.76
34	Gummanur	Palacode	Dharmapuri	12.444	78.016	8	1690	410	70	57	196	7	NIL	610	113	90	124	1.5
35	Pudur	Palacode	Dharmapuri	12.385	78.249	7.6	2360	480	108	51	322	42	NIL	549	319	168	193	0.62
36	Kuttanahalli	palacode	Krishnagiri	12.474	77.971	7.8	1200	165	18	29	200	4	Nil	366	99	149	19	1.45
37	Panchapalli	palacode	Krishnagiri	12.46	77.948	7.86	859	235	46	29	90	2	Nil	378	50	48	9	1.32
38	Tipasandiram	palacode	Krishnagiri	12.475	77.849	7.78	1020	300	66	33	92	12	Nil	366	71	82	43	1.4
39	Sandana palli	palacode	Krishnagiri	12.465	77.825	7.89	418	140	34	13	30	2	Nil	165	28	22	14	1.8
40	Sapranahalli	palacode	Krishnagiri	12.501	77.803	7.6	1270	335	40	57	138	8	Nil	537	106	34	19	1.69
41	Attimutlu	palacode	Krishnagiri	12.404	77.978	7.55	1500	365	44	62	177	4	Nil	580	128	67	33	1.5
42	Bennahallu	palacode	Krishnagiri	12.377	77.966	7.48	1580	380	72	49	186	4	Nil	287	124	302	74	1.4
43	Doddabavahalli	palacode	Krishnagiri	12.344	78	7.54	3320	710	168	70	437	31	Nil	543	518	418	105	0.82
44	Belamaranahalli	palacode	Krishnagiri	12.322	77.989	7.83	2390	800	120	122	186	16	Nil	500	227	374	124	0.59
45	Belluhalli	palacode	Krishnagiri	12.313	77.955	7.84	1870	400	40	73	246	4	Nil	586	195	125	68	1.3
46	Panchapalli Dan	palacode	Dharmapuri	12.47	77.938	7.18	720	135	65	70	229.5	10	NIL	200	35	40	100	1.5
47	Ramanakottai	palacode	Dharmapuri	12.441	77.953	7.34	864	100	50	50	315	10	NIL	225	20	70	105	1.2
48	Elugundur	palacode	Dharmapuri	12.435	77.958	7.3	706	145	50	95	200	5	NIL	300	40	-40	50	2
49	Samanur	palacode	Dharmapuri	12.411	77.991	7.31	2480	520	55	465	750	10	NIL	250	270	678	82	2.6
50	Mangaraiu	Pennagaram	Krishnagiri	12.115	77.929	7.71	3010	900	150	128	308	16	Nil	354	432	562	136	0.82
51	Dasampatti	Pennagaram	Krishnagiri	12.191	77.947	7.69	1880	580	80	92	163	12	Nil	555	121	245	93	0.93
52	Eriyur	Pennagaram	Krishnagiri	12.016	77.802	7.69	3160	1200	280	122	179	8	Nil	500	496	322	192	0.92
53	Neruppur	Pennagaram	Krishnagiri	11.964	77.783	7.86	1970	670	160	66	138	16	Nil	372	195	278	149	1.03
54	Manikarankattai	Pennagaram	Krishnagiri	12.021	77.859	7.94	2330	700	90	115	225	8	Nil	427	227	379	167	1.4
55	Kadamadai	Pennagaram	Krishnagiri	12.056	77.937	8	1140	325	50	49	113	5	Nil	488	82	38	25	0.32
56	Chinnampalli	Pennagaram	Krishnagiri	12.007	77.967	7.93	2920	630	40	129	393	12	Nil	384	383	523	130	0.92
57	Ayamaramapatti	Pennagaram	Krishnagiri	11.915	77.927	7.59	1550	440	60	70	129	10	Nil	366	85	211	112	0.32
58	Banijigarahalli	Pennagaram	Dharmapuri	12.141	77.957	7.5	3120	1110	295	815	490	15	NIL	615	345	600	50	1
59	Halapuram	Pennagaram	Dharmapuri	12.109	77.879	7.02	2120	700	170	530	400	15	NIL	300	230	550	6	0.45
60	Periyavittalapur	Pennagaram	Dharmapuri	12.058	77.826	7.52	2150	300	155	145	800	15	NIL	375	175	550	10	1.3
61	Ramakondahall	Pennagaram	Dharmapuri	11.968	77.808	7.51	1716	315	150	165	520	18	NIL	365	100	380	5	1.4
62	Aralagundi	Pennagaram	Dharmapuri	11.954	77.888	7.54	1189	220	80	140	365	15.5	NIL	300	50	231	20	2.1
63	Malaiyanur	Pennagaram	Dharmapuri	11.991	77.819	7.44	1545	300	140	160	450	10	NIL	115	125	500	30	1.4
64	Thallampallam	Pennagaram	Dharmapuri	12.026	77.886	7.55	1131	175	100	75	400	5	NIL	230	60	270	25	1.5
65	Periya Thotapudur	Pennagaram	Dharmapuri	12.077	77.913	7.51	470	80	30	50	145	10	NIL	135	25	65	10	1

Groundwater quality for Aquifer II

SlNo	Village/ Location	Block	District	Lat	Long	pH	EC (µS/cm)	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F
1	Kelamangalam	Kelamangalam	Krishnagiri	12.603	77.864	8.4	838	175	66	2	127	1	24	354	53			
2	Rayakottai ew	Kelamangalam	Krishnagiri	12.519	78.022	7.61	2180	730	80	129	176	16	0	439	405	144	36	0.24
3	Rayakottai Pz	Kelamangalam	Krishnagiri	12.519	78.022	7.53	1550	580	48	112	97	16	0	439	256	76	74	0.94
4	Kalamangalam	Kelamangalam	Krishnagiri	12.603	77.864	7.74	1030	140	40	10	166	12	Nil	366	113	43	12	1.02
5	Pachchappanatti	Kelamangalam	Krishnagiri	12.553	77.853	7.63	1520	345	104	21	186	12	Nil	458	50	254	64	0.74
6	T.Pudur	Kelamangalam	Krishnagiri	12.589	77.818	7.63	1060	300	76	27	106	2	Nil	488	50	43	19	1.7
7	Kottur	Kelamangalam	Krishnagiri	12.628	77.824	7.7	1950	480	110	50	230	4	Nil	574	128	240	112	1.8
8	Kamandur	Kelamangalam	Krishnagiri	12.449	77.82	7.8	990	320	54	45	78	10	Nil	378	71	58	43	1.9
9	Royakottai	Kelamangalam	Krishnagiri	12.515	78.028	7.35	2090	700	46	142	168	8	Nil	433	284	250	68	0.92
10	Nammandahalli	Kelamangalam	Krishnagiri	12.474	77.971	7.56	2350	750	34	162	198	16	Nil	665	248	197	118	1.4
11	Namari	Kelamangalam	Krishnagiri	12.436	77.846	7.8	947	250	60	24	104	2	Nil	299	50	101	68	1.9
12	Unsetti	Kelamangalam	Krishnagiri	12.428	77.853	7.7	1090	385	66	53	69	12	Nil	323	96	120	37	1.5
13	Tavaraikarai	Kelamangalam	Krishnagiri	12.507	77.761	7.14	2230	1050	114	186	41	8	Nil	354	170	576	19	1.02
14	Melur	Kelamangalam	Krishnagiri	12.448	77.78	7.85	1270	460	100	51	81	2	Nil	311	96	178	74	0.44
15	Suligunta	Kelamangalam	Krishnagiri	12.552	78.06	7.19	1246	240	85	155	360	10	NIL	250	60	50	253	1.2
16	Sajjalapatti	Kelamangalam	Krishnagiri	12.534	78.024	7.6	1230	285	165	120	315	20	NIL	185	160	35	245	1.4
17	Kothapalli	Kelamangalam	Krishnagiri	12.566	77.948	7.29	975	170	55	115	310	5	NIL	240	100	10	132	1.6
18	krishnapuram	Kelamangalam	Krishnagiri	12.536	77.879	7.47	542	80	55	25	185	9	NIL	155	70	25	30	1.2
19	Shankarapuram	Kelamangalam	Krishnagiri	12.626	77.843	7.16	887	175	100	75	245	20	NIL	160	25	130	110	1.4
20	Karagondanapa	Kelamangalam	Krishnagiri	12.657	77.865	7.03	1485	300	155	145	325	7	NIL	175	65	297	95	2.1
21	D,Kohapalli	Kelamangalam	Krishnagiri	12.628	77.859	7.11	1418	315	205	110	390	15	NIL	140	80	415	93	1.4
22	A.pudur	Kelamangalam	Krishnagiri	12.588	77.844	7.1	1419	295	175	120	400	11.5	NIL	205	95	310	89	2.1
23	Dodda belur	Kelamangalam	Krishnagiri	12.583	77.825	7.41	1355	160	175	-15	500	18	NIL	265	100	258	55	2
24	Girisettypalli	Kelamangalam	Krishnagiri	12.543	77.854	7.24	768	160	65	95	200	10	NIL	210	60	55	40	1.6
25	D.Kothanur	Kelamangalam	Krishnagiri	12.542	77.833	7.26	994	165	60	105	315	24	NIL	290	65	100	55	1.5
26	Kottai uliyaman	Kelamangalam	Krishnagiri	12.533	77.763	7.12	1048	225	110	115	274.5	25	NIL	350	110	40	26	1.1
27	osatti	Kelamangalam	Krishnagiri	12.519	77.763	7.13	1049	255	140	115	228.5	20	NIL	160	40	250	48	2.1
28	kandakanahalli	Kelamangalam	Krishnagiri	12.515	77.74	7.07	1084	245	150	95	275	11.5	NIL	165	100	225	29	1.9

29	Dinnur	Kelamangalam	Krishnagiri	12.511	77.73	7.26	536	130	70	60	132	10	NIL	160	25	40	44	1.5
30	Oddarapalyam	Kelamangalam	Krishnagiri	12.459	77.778	7.49	820	145	65	80	250	7	NIL	295	25	40	40	1.6
31	Maniyambadi	Kelamangalam	Krishnagiri	12.43	77.767	7.26	1208	225	110	115	375	14	NIL	225	85	292	12	0.8
32	giriyanahalli	Kelamangalam	Krishnagiri	12.465	77.797	7.18	1231	250	50	200	369.5	12.5	NIL	290	115	189	38	1.1
33	Sandanapalli	Kelamangalam	Krishnagiri	12.466	77.818	7.3	310	100	50	50	50	2.5	NIL	70	60	20	3	1.4
34	Sigutte	Kelamangalam	Krishnagiri	12.458	77.817	7.09	885	200	75	125	240	3	NIL	230	25	159	29	1.5
35	Irudukottai	Kelamangalam	Krishnagiri	12.458	77.829	7.39	301	75	55	20	71.5	5	NIL	115	10	24	3	1.1
36	Hosahalli	Kelamangalam	Krishnagiri	12.448	77.839	7.33	628	95	45	50	220	4.5	NIL	250	25	35	10	1.5
37	Melur	Kelamangalam	Krishnagiri	12.404	77.848	7.24	607	150	75	75	150	6.5	NIL	235	30	43	2	1.1
38	Hanumanthapur	Kelamangalam	Krishnagiri	12.45	77.836	7.69	584	100	50	50	180	9	NIL	150	45	10	85	0.9
39	S.kurobatti	Kelamangalam	Krishnagiri	12.477	77.825	7.49	604	185	75	110	119.5	6	NIL	150	20	50	80	0.85
40	Saprnahalli	Kelamangalam	Krishnagiri	12.501	77.803	7.5	802	115	50	65	290	6	NIL	200	35	100	75	1.6
41	muthur	Kelamangalam	Krishnagiri	12.492	77.833	7.46	443	100	50	50	125	3.5	NIL	100	25	85	20	1.2
42	Govindapalli	Kelamangalam	Krishnagiri	12.476	77.883	7.2	987	175	75	100	290	20	NIL	215	55	150	65	1.2
43	Sattankallu	Kelamangalam	Krishnagiri	12.506	77.898	7.29	666	155	100	55	180	1.5	NIL	135	30	100	65	1.2
44	Mugulur	Kelamangam	Krishnagiri	12.544	78.02	7.3	1350	435	100	49	106	10	Nil	427	131	77	74	1.1
45	Magamangalam	Kelamangam	Krishnagiri	12.565	77.942	7.4	960	350	64	46	55	8	Nil	397	60	53	17	1.0
46	Maniyambadi	Kelamangam	Krishnagiri	12.45	77.785	7.4	830	300	64	34	48	8	Nil	366	46	43	2	0.9
47	Geddahalli	Kelamangam	Krishnagiri	12.42	77.853	8	490	175	20	30	44	3	Nil	256	28	17	7	0.9
48	Kargur	Palacode	Dharmapuri	12.288	77.94		1289								170			
49	Kandiyampatti	Palacode	Krishnagiri	12.367	77.972	7.56	1830	655	204	35	113	12	Nil	299	82	504	37	1.5
50	Belluhalli	Palacode	Krishnagiri	12.314	77.949	7.89	1340	275	34	46	175	20	Nil	543	103	67	25	0.84
51	Kalegoundanur	Palacode	Krishnagiri	12.094	77.968	8.05	1280	335	86	29	140	5	Nil	195	39	403	12	1.03
52	Erikarai	Palacode	Krishnagiri	12.176	77.919	7.85	1450	515	90	70	92	12	Nil	366	266	24	37	1.6
53	Mallapuram	Palacode	Krishnagiri	12.103	77.885	7.2	2170	610	136	66	223	4	Nil	415	99	514	112	1.8
54	Aralgundi	Palacode	Krishnagiri	11.954	77.888	7.89	1270	180	30	26	202	12	Nil	323	96	206	25	1.12
55	Pattabinagar	Palacode	Dharmapuri	12.464	77.951	7.07	898	210	90	120	230	4.5	NIL	240	40	60	100	1.4
56	Samanur	Palacode	Dharmapuri	12.411	77.991	7.4	1732	245	45	200	620	5	NIL	600	115	65	75	2.3
57	Bannihalli	Palacode	Dharmapuri	12.381	77.97	7.45	1022	135	45	90	365	15	NIL	375	20	30	80	1.5
58	Kunddankuttai	Palacode	Dharmapuri	12.371	77.981	7.29	1360	265	55	210	405	10	NIL	290	125	195	75	1.3
59	Sandirapuram	Palacode	Dharmapuri	12.371	77.998	7.37	1026	150	45	105	360	4	NIL	350	70	20	65	1.5
60	Siriyanalli	Palacode	Dharmapuri	12.297	77.996	7.33	2650	540	210	330	800	20	NIL	450	265	600	45	0.65
61	Bevuhalli	Pennagaram	Dharmapuri	12.288	77.94		1289								170			

62	Konangihalli	Pennagaram	Dharmapuri	12.134	77.969	8.9	850	235	28	40	85	5	30	201	58			
63	Chinnaparamnu	Pennagaram	Dharmapuri	12.297	77.929	7.14	1159	255	100	155	315	1	NIL	210	105	175	80	0.65
64	Gettur	Pennagaram	Dharmapuri	12.141	77.964	7.09	1320	280	130	150	390	2.5	NIL	175	170	286	55	0.65
65	Roadside HP	Pennagaram	Dharmapuri	12.152	77.958	7.74	529	135	60	75	125	2	NIL	275	60	-113	40	0.65
66	Naganur	Pennagaram	Dharmapuri	12.091	77.891	7.31	2910	1050	410	640	400	21	NIL	400	285	729	57	0.46
67	Jakkampatti	Pennagaram	Dharmapuri	12.101	77.859	7.53	1368	245	100	145	425	10	NIL	275	105	195	90	0.68
68	Puchchur	Pennagaram	Dharmapuri	11.932	77.855	7.59	967	220	110	110	250	10	NIL	250	50	168	12	0.92

Annexure-4a

List of Exploratory borewells

Sl. No.	Location, Well number , Co-ordinates, Toposheet Number and R.L. of G.L (mamsl).	Year of Drilling	Depth drilled Casing Pipe Lowered (mbgl)	Lithology	Fracture zones encountered(mbgl) / Discharge(lps)	Type of preliminary yield Test & Results (*)	Results of aquifer performance test							
							SWL (mbgl) Date	Discharge (lps) Draw down(m)	Specific capacity(lpm/m of Draw down)	T (m2/ day)	S	EC	Cl	F
1	KELAMANGALAM(EW)	1988	249	Charnockite	16.65-17.65 / 0.021	--	11.25	1.65	5.18	8.58	2.6 x10-3	838	53	
	(12° 36' 10";77° 51' 50"- 57 H/11)		9.7	and	40.51-44.51 / 0.136		--	19.19		Average				
				Granite	85.23-89.23 / 0.250									
				Gneiss	109.09-111.09 / 0.49									
					185.20-187.29 / 0.631									
					215.77-219.77 / 2.17									
	788.29				249.25 - 249.30 4.029									
	KELAMANGALAM(OW-I)	1988	199.53	Sand with	91.85-95.05 / 1.50	--	4.98	1.76	26.59	12.14	2.6 x10-3	--	--	
	12° 08' 38"; 77° 52' 33" 57 H/11		10.3	Kankar,	118.70-119.70 / 1.89		18.1.88	3.97						
				Granite										
	788.29			Gneiss										
	KELAMANGALAM(OW-II)	1988	249.4	Sand with	85.00-86.00 /	--		1.65	5.89	--	1.4	--	--	

					0.20						x10-3			
			11	Kankar,	98.00-99.00 / 1.50			16.78						
				Granite	208.00-209.00 / 2.00									
	788.19			Gneiss	219.00-220.00 / 3.80									
2	ANJATTI(EW)	1990	300	Granite	143.00-145.00 / 0.780	Slug Test	11.2	--	--	--	--	--	--	
	12° 20' 00" ;77° 43'00" 57 H/11		1.5	Charnockite		T=1.40	2.2.90							
	574.32													
3	DENKANIKOTTAI (EW)	2004	222.6	Granite	82.00-82.50/0.215	--	5.8	2.11	1.56	--	--	647	57	1
	12°22'37";77°47'10" 57H/11		12		188.00-188.50/3.36		21.12.04	81						
4	PENNAGARAM (EW)	1988	300.00	Charnockite	129.95-131.95 / 1.00	--	8.96	--	--	--	--	--	--	
	12° 08' 00";77° 53' 30" 58 H/16		8.75				--							
	510.780													
5	MARANDAHALLI(EW)	1989	230.03	Granitic	9.43-12.43 / 0.261	Air Test	1.31	--	--	--	--	2849	702	
	(12°22' 13" ;77° 59'57"-57 L/15)		5.38	Gneiss	46.03-48.03 / 0.316	T=1.97	4.10.89							
					139.53-140.53 / 0.44	DD=0.675								
	604.300				210.73-211.73 / 0.73									
6	KONAGIHALLI(EW)	1990	181.18	Granite	46.03-47.03 / Moist	Slug Test	--	--	--	--	--	--	--	
	(12° 08' 01" ;77° 58'10"-57 L/16)			Gneiss	110.08-112.08 / 0.25	T=0.193								
	482.095													
7	PAPPARAPATTI (EW)	2005	160.00	Granite gneiss	10.5-14.5			16.00	--	--	--	--	--	--
	12°13'40";78°03'35"-57L/4				20.12-21.12									
					90.72-92.32									

8	PAPPARAPATTI (OW)	2005	168.52	Granite gneiss	20.65-21.65/0.32		4.1	5.53	88.24	--	--	--	--	--
	12°13'40";78°03'35"-57L/4				82.8-83.8/1.79			3.76						
					119.18-120.18-2.90									
					165-166.7-5.53									
9	BEVUHALLI (EW)	2004	300	Granite	32.50-33.00/0.078	--	14.60	3.34	5.402	--	--	1289	170	
	KARGUR		11.50		52.00-52.50/1.79		09.12.04	37.1						
	(12°17'17";77°56'24"-57H/15)													
10	DIVATTIPATTI (EW)	1990	195.48	Gneiss	51.08-52.08 / 0.40	--	30.2	--	--	--	--	--	--	
	(11° 53' 00" ;78° 05' 20"-58 I/1)		11.5		145.58-146.68 / 0.166		--							
11	KUMARANAPALLI	2004	170	Granite Gniess	45.5-46/ 0.214		43.66	3.00	9.83	1.8	--			
	(12°41'15";77°45'00")		36.00		152-152.5/ 5.50		25.03.04	18.31						
	57 H/10													
12	KONAGIHALLI(EW)	1990	181.18	Granite	46.03-47.03 / Moist	Slug Test	--	--	--	--	--	--	--	
	(12° 08' 01" ;77° 58'10"-57 L/16)			Gneiss	110.08-112.08 / 0.25	T=0.193								
	482.095													
13	BAIRANATHAM (EW)	2005	16.12	Granite gneiss	154.28-155.28/1.79									
	11°49'30";78°21'00"-57I/5				243.10-244.10/2.50									
14	SORANGAPPANPUDUR	2004	318	Granite gneiss	142-143/0.73		-	0.73	-	--	--	-	-	No test
	(12°01'20";78°03'05"-57L/4)		12.00				-							was conducted
15	THADAGAM	2004	300	Granite gneiss	115-116/ 0.20		-	0.2		--	--		--	No test
	(12°06'30";78°07'05"-57L/4)		6.00				-							was conducted

16	KILBHURIKKAL (EW)	2005	191.38	Charnockite	19.12-20.12		10.38	1.486	--	--	--			
	11°58'46";78°03'00"-58I/1				103.90-104.90			7.1						
17	GOPASAMUDRAM (EW)	2004	238.50	Charnockite	66.00-66.50/6.88	--	18.57	1.4	5.37	--	--	800	74	
	(12°28'56";77°42'01"-57H/11)		35.50				22.12.04	15.64						
														0.4
18	UNSETTI		59	Charnockite	38.2-38.5		35.5	0.014				580		
	12°18'15":774630-57H/15		19.6											
	576.215													
19	THOPPUR		94		88.0-88.1		6.80	0.014				1300		
	11°57'00":780300-57I/11,332.68		13											
20	INDUR		55.7		48.0-48.3		2.90	0.014				3580		
	12°08'30":78°04'00"57L/4,, 465.36		4											
22	MADAGONDANAPALLI	2007	237	Granitic gneiss	21.12,23.74,88.70,169.52, 195.38		14.32	1.5				591	32	
	(12°37'45";77°48'42"-57H/11)													
	MADAGONDANAPALLI		40		21.12,22.74, 36.36		13.01	1				546	28	
23	THALLI		235	Granitic gneiss	11.50,22.74,55.22,231.48		20.12	8.4				282	42	
	(12°34'50";77°39'11")													
	THALLI		20		28.74,42.98		19.62	0.5				529	32	

24	GUMMANUR(Ew)		159	G.Gneiss	70.46-71.46	T=3.1	54.8	2.5		11.3	0.0016	1130	71	
	(12°26'40";78°00'58")		6		154.28-155.28	Q=6.3		40.65						
	Gummanur(ow)		165		153.28-154.28,	Q=6.5						1380	92	
			6					40.1						
25	ODAYANDAHALLIU(Pz)		100		45.10-46.0	Q=0.3	9.2							
	(12°29'15";78°01'24")		3			T=0.93								
26	RAYAKOTTAI(EW)	2007	145.66	G.Gneiss	16.12,92.32,122.80,140.04		19.52	16				2180	405	
	(12°31'10";78°01'19")		39											
	RAYAKOTTAI(OW)				16.12,24.74		24.12					1050	256	
	(12°31'10";78°01'19")		39											
27	MUGULUR(EW)	2015	176.1	Migmatite		Slug test	71.4			1.2		1350	131	
	12°32'40":78°01'11"		5.65											
28	NAGAMANGALAM(EW)		200	G.Gneiss	50.6-51.6		>125					960	60	No test
	12°33'53":77°56'30"		8.5		124.8-125.8									
29	MANIYAMBADI(EW)		200	Charnockite	85.7-86.7		24.03			0.42		830	46	
	12°27'00":77°47'06"		5.65											
30	GEDDAHALLI(EW)		200	G.Gneiss	61.84-62.46		5.14			4.5		490	28	
	12°25'12":77°51'12"		9		160.9-161.9									
31	PANCHAPALLI	2015	194.5	G.Gneiss	77.08-77.6/0.43 , 138.04-39.00/0.75 , 182.7-183.5/4.3	Q=3.5	33.06							
	12°27'55":77°56'56"		12.5											
32	JARUGU	2015	185.14	Charnockite	37.36-38.00/0.8 , 88.5-89.00/0.22	Q=0.15	5.74							
	11°59'56":78°01'34"		12											
33	VELLAR	1998	49.5	G.Gneiss	26.0-26.1,33.0-33.1	Q=0.441	4.1					1130		

	11°53'00":77°50'30"		5.5											
34	KULATHUR		65.5	G.Gneiss	47.0-47.5	Q=0.014	26.6					860		
	11°50'50":77°44'50"		3.5											
35	KADAYAMPATTI		62.35	G.Gneiss	55.6-55.8,56.5-56.6	Q=1.0	17.5					2620		
	11°51'15":78°05'00"		8.7											
36	NANGAVALLI		65.4	G.Gneiss	45.0-45.3	Q=0.014	11.1					600		
	11°45'30":77°53'45"		5.5											

Annexure- 4B

Sl.no.	Location	Block	latitude	Longitude	Depth (mbgl)	Casing depth (m)	Fractured depth(m)				Discharge (lps)	SWL (mbgl)
1	Gopasandiram cross road	Kelamangalam	12.54	77.82	154	26	32,100,147,	32	100	147	1.8	
2	Kommepalli melkottai	Kelamangalam	12.55	77.88	182	18	19,100,124,	19	100	124	1.2	
3	Rajiv Gandhi cross road,Doddametri	Kelamangalam	12.58	77.98	162	18	72,100,160,	72	100	160	1.8	
4	Chinnakanavayur medu	Kelamangalam	12.56	78.07	102	18	18,42,52,	18	42	52	3.3	
5	Erundukottai Laxmipuram	Kelamangalam	12.45	77.83	182	18	32,90,176,	32	90	176	1.2	
6	Muthurayankottai	Kelamangalam	12.46	77.82	220	18	32,140,210	32	140	190	1.8	
7	Hanumanthapuram Laxmipuram	Kelamangalam	12.43	77.85	176	24	100,147,190,	100	147	190	0.1	
8	Ayyur New colony	Kelamangalam	12.43	77.87	91	24	22,60,90,	22	60	90	2.45	
9	Thimmanur	Kelamangalam	12.42	77.89	76	24	30,60,85,	30	60	85	3.3	
10	Kavakuttai Badankuttai	Kelamangalam	12.42	77.89	202	18	20,100,180,	20	100	180	1.2	
11	Kuchuvadi SC colony	Kelamangalam	12.45	77.90	150	24	30,100,150	30	100	150	1.2	
12	Devarulli Mangalam New ADC Colony	Thally	12.55	77.73	196	24	30,70,185,	30	70	185	0.1	
13	Chinna Chandiram New colony	Thally	12.55	77.72	136	24	30,75,140,	30	75	140	1.8	
14	Thally Kotanur New ADC	Thally	12.57	77.70	132	18	27,70,140,	27	70	140	1.8	
15	Bettapalli AD colony	Thally	12.55	77.67	182	18	40,90,110,	40	90	110	0.22	
16	N.Agraharam New ADC	Thally	12.56	77.62	138	12	30,100,150,	30	100	150	1.8	
17	ChudaChandram NewADC	Thally	12.58	77.63	190	30	42,80,190	42	80	190	0.22	
18	Uliveeranpalli New colony	Thally	12.65	77.75	194	6	30,90,172,	30	90	105	1.2	
19	Vamamangalam New ADC96	Thally	12.61	77.01	105	24	62,90,105	62	90	105	3.3	
20	Mel Samayapuram colony	Thally	0.00	0.00	182	18	25,72,172,	25	72	172	0.4	
21	Gummalapuram	Thally	12.63	77.66	200	33	42,200,	42	200		0.04	
22	Mel Samayapuram colony	Thally	0.00	0.00	156	24	40,72,140,	40	72	140	2.54	
23	Devarulli Mangalam ADC Colony	Thally	12.55	77.72	150	30	42,90,130,	42	90	130	2.54	
24	Bettapalli Adcolony	Thally	12.55	77.67	162	18	72,160,172,	72	190	172	0.05	
25	Chudasandiram Adcolony	Thally	12.58	77.62	182	48	47,72,180,	47	72	180	2.54	

26	Belalam AD colony	Thally	12.43	77.65	90	30	38,58,70,	38	58	70	2.6	
27	Kalukondapalli New colony	Thally	12.47	77.75	158	42	98,170,194,	98	170	194	2.5	
28	Kumaranapalli AD colony	Thally	12.28	77.61	158	42	97,142,192,	97	142	192	0.05	
29	Erikadu	Pennagaram	12.01	77.90	180	14	40,90,175,	40	90	175	2.25	20
30	Kullikadu	Pennagaram	11.95	77.88	58	17	20,48,	20	48		4.6	5
31	Vanniyar nagar,Nagamarai	Pennagaram	11.94	77.77	188	36	105,160,	105	160		0.15	10
32	Semmuru goundar Kottai,Manjarahalli	Pennagaram	11.93	77.80	180	18	40,100,170,	40	100	170	0.82	15
33	Erkodalpatty Bathrahalli Kombai,Manjarahalli	Pennagaram	11.93	77.85	160	13	22,120,150,	22	120	150	2.25	10
34	Kadamadai periyar nagar	Pennagaram	12.05	77.94	230	7.6	63,143,230	63	143	230	1.42	6
35	Avvai nagar,Majanaikanahalli	Pennagaram	12.04	77.95	220	9	79,213,	79	213		0.15	20
36	Kariyankattu Valavu	Pennagaram	12.01	77.97	154	16	25,68,140,	25	68	140	1.42	10
37	Tholur Combai	Pennagaram	12.02	77.98	98	20	30,95,	30	95		4.6	20
38	Bodampatty colony	Pennagaram	11.95	77.93	190	21	92,172,	92	172		0.5	20
39	Thallihalli AR colony	Pennagaram	12.03	77.94	200	11.4	100,160,	100	160		0.15	20
40	Kothapaddy Ar colony	Pennagaram	12.12	77.88	190	16	80,100,180,	80	100	180	1.42	25
41	Avvai nagar,Paruvathanahalli	Pennagaram	12.13	77.92	189	12	115,185,	115	185		0.82	20
42	Gettukottai,Paruvathanahalli	Pennagaram	12.13	77.92	200	14	15,90,190,	15	90	190	1.42	5
43	Annanagar mal colony,Paruvathanahalli	Pennagaram	12.13	77.92	180	13	30,70,175	30	70	175	0.82	20
44	Ammam palayam,Koothapadi	Pennagaram	12.12	77.95	197	9	30,125,190	30	125	190	2.25	10
45	Thadiyankuttai,veppilahalli	Pennagaram	12.22	78.04	164.5	22	30,110,160,	30	110	160	0.82	10
46	Uppavapuram,Vettuvanahalli	Pennagaram	12.20	77.97	220	20.6	43,146,210,	43	146	210	0.82	10
47	B.Kodupatty,Vattuvanahalli	Pennagaram	12.19	77.92	202	30	110	110			0.25	30
48	Nagadasampatty AD colony,Piliyanur	Pennagaram	12.13	77.99	201	20	40,140,195,	40	140	195	0.25	49
49	Nagadasampatty Boyen colony,Piliyanur	Pennagaram	12.13	77.99	170	12	30,140,170,	30	140	170	0.32	35
50	Vannathipatty Pallakottai,Mangarai	Pennagaram	12.11	77.93	193	19	110,180,	110	180		0.82	
51	Gundankattukuzhi,Anjehalli	Pennagaram	12.14	77.98	200	13	60	60			0.03	10
52	Anmmasi kottai,Ramagondahalli	Pennagaram	11.97	77.81	183	21.4	60,128,165,	60	128	165	2.25	10
53	Erigolpatty,Manjarahalli	Pennagaram	11.95	77.85	188	12.25	35,90,170,	35	90	170	0.82	15
54	Sellamudi Mel street,Manjarahalli	Pennagaram	11.95	77.84	129	15.4	35,78,115,	35	78	115	2.25	10
55	Vadaku Kombai,Manjarahalli	Pennagaram	11.94	77.84	171	19	20,49,160,	20	49	160	1.25	60
56	Mahalingamkottai,Gendiganahalli	Pennagaram	11.92	77.92	160	24	60,120,152,	60	120	152	2.25	10
57	Naikanoor	Pennagaram	12.09	77.92	147	10.6	40,145,	40	145		2.25	20

	Senkuttai,Kutentamaranahalli											
58	Nallampalli Vannar street,Manjarai	Pennagaram	12.13	77.95	186	7	112,185,	112	185		0.82	15
59	Sakamarathukottai,THONAKUTALAHALLI	Pennagaram	12.00	77.88	190	12	50,180,	50	180		0.82	15
60	Rajarikottai,Koothapadi	Pennagaram	12.13	77.87	123	12	15,100,120,	15	100	120	3.3	15
61	Deepavalikunav,Nallur,	Palacode	12.33	78.01	190	7	47,123,187,	47	123	187	0.38	9
62	Panchiyappankottai,Soodanur	Palacode	12.47	78.01	150	3	30,70,145,	30	70	145	1.42	6
63	Puliyanthoppu colony,Panchapally	Palacode	12.46	77.94	198	6	39	39			3.3	6
64	J.J.Nagar,Belmaranhalli	Palacode	12.32	77.93	198	18	60,120,195	60	120	195	0.53	11
65	Thirumalavadi colony,Ganapathy	Palacode	12.31	77.90	194	9	50,150,190,	50	150	190	0.53	9
66	VattaganapattyIruvar colony,A.Mallapuram	Palacode	12.35	78.02	180	12	100,150,165,	100	150	165	0.82	6
67	Ekkandahalli colony,Gummanur	Palacode	12.45	78.02	170	18	90,152,	90	152		3.3	60
68	Thodda Badaganahalli colony,Semanoor	Palacode	12.43	78.00	198	16.6	60,150,190,	60	150	190	0.82	7
69	Kattumanithankottai,Belmaranahalli	Palacode	12.34	77.92	200	14.32	60,148,183,	60	148	183	0.82	20
70	Puliyanthppu colony,Errahalli	Palacode	12.28	78.08	89	10.5	30,60,85,	30	60	85	2.25	35
71	Kaveriyappankottai,Errahalli	Palacode	12.27	78.06	188	6.8	80,92,170,	80	92	170	1.42	40
72	Karagur Jyothy nagar,Barsehalli	Palacode	12.28	77.99	190	6	73,178,	73	178		0.38	10
73	Gundan Tharisu,Gummanur	Palacode	12.44	77.02	190	6	70,180,	70	180		0.82	9
74	Indiranagar,Samanoor	Palacode	12.41	77.99	182	6	32,141,178,	32	141	178	2.25	6
75	Manthrigoundankottai,Koravandahalli	Palacode	12.42	78.01	206	12.3	102,190,	102	190		0.82	25
76	Kulankottai,Bedarahalli	Nallampalli	12.17	78.04	170	10.4	60,110,160,	60	110	160	2.25	12
77	Kuttampatty colony,Echchanalli	Nallampalli	12.11	77.99	185	24	120	120			1.25	13
78	Siddurankottai,D.B.Halli	Nallampalli	11.99	78.04	220	24	90,200,	90	200		0.15	8
79	Moorkottai,D.B.Halli	Nallampalli	12.03	78.08	200	18	100,195,	100	195		0.15	18
80	Marigoundankottai,D.B.Halli	Nallampalli	12.02	78.07	220	12	110,210,	110	210		0.15	25
81	Sevanthankottai,D.B.Halli	Nallampalli	12.01	78.07	210	13	205	205			0.25	12
82	Kaligoundankottai,D.B.Halli	Nallampalli	12.01	78.07	200	18	70,150,195,	70	150	195	2.25	20
83	Mottukollakottai,Indur	Nallampalli	12.12	78.05	160	14	60,80,155,	60	80	155	1.15	15
84	Kurumpattykottai,Bagalahalli	Nallampalli	12.04	78.10	190	17.4	20,108,187,	20	108	187	1.15	8
85	Driveres colony,A.Jettyhalli	Nallampalli	12.08	78.11	190	12	70,130,185,	70	130	185	0.45	15
86	Periyar nagar,A.Jettyhalli	Nallampalli	12.08	78.11	70	30	70	70			2.15	12

Annexure-5

Resource Estimation of Firkas falling in the Upper Cauvery Basin (Ham)

Sl.No	Firka	District	Area of the Firka (km^2)	Area of the Firka suitable for GW recharge (km^2)	Area of the Firka falling in the Basin (km^2)	Area considered for Resource Estimation	Percentage of the Firka falling in the Basin	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for Irrigation	Existing Gross Ground Water Draft for domestic and industrial water supply	Existing Gross Ground Water Draft for All uses (11+12)	Provision for domestic and industrial requirement supply to 2025	Net Ground Water Availability for future irrigation development (10-11-14)	Stage of Ground Water Development {(13/10)*100} %	Category
1	Bommidi	Dharmapuri	148.79	137.64	110.20	110.20	0.80	1689.95	2338.06	75.22	2413.28	85.47	-733.58	143	Over Exploited
2	Dharmapuri	Dharmapuri	195.11	121.37	94.73	94.73	0.78	1573.14	1117.36	113.02	1230.38	128.44	327.33	78	Semi Critical
3	Indur	Dharmapuri	142.13	124.69	137.70	124.69	1.00	1181.81	2411.45	81.74	2493.19	92.91	-1322.55	211	Over Exploited
4	Kadathur	Dharmapuri	157.32	113.39	4.49	4.49	0.04	59.18	102.66	1.93	104.59	2.19	-45.68	177	Over Exploited
5	Marandahalli	Dharmapuri	132.69	77.69	95.47	77.69	1.00	1174.92	2357.65	53.57	2411.21	60.88	-1243.61	205	Over Exploited
6	Nallampalli	Dharmapuri	91.01	81.75	63.54	63.54	0.78	911.95	729.35	70.19	799.54	79.78	102.82	88	Semi Critical
7	Palacode	Dharmapuri	190.15	122.66	174.90	122.66	1.00	2235.50	3112.65	89.34	3201.99	101.54	-978.69	143	Over Exploited
8	Palayam	Dharmapuri	144.00	116.69	275.30	116.69	1.00	1110.01	2247.30	75.32	2322.62	85.61	-1222.90	209	Over Exploited
9	Papparapatty	Dharmapuri	135.50	117.28	297.30	117.28	1.00	1401.29	2071.20	84.47	2155.67	95.96	-765.88	154	Over Exploited
10	Pennagaram	Dharmapuri	123.48	115.04	374.00	115.04	1.00	1241.84	1992.25	75.01	2067.26	85.25	-835.67	166	Over Exploited
11	Perumbalai	Dharmapuri	160.20	112.46	177.50	112.46	1.00	512.75	1290.30	45.37	1335.67	51.57	-829.12	260	Over Exploited
12	Pulikarai	Dharmapuri	123.63	123.61	305.70	123.61	1.00	2006.88	3245.90	75.74	3321.64	86.08	-1325.10	166	Over Exploited

13	Sunjalnatham	Dharmapuri	225.67	154.20	225.67	154.20	1.00	1545.07	1240.25	79.97	1320.22	87.40	217.43	85	Semi Critical
14	Vellichandai	Dharmapuri	160.41	114.46	17.61	17.61	0.15	240.21	330.74	14.10	344.84	16.03	-106.55	144	Over Exploited
			2130.10	***1632.94***	***2354.11***	***1354.91***		***16884***	***24587***	***935***	***25522***	***1059***	***-8762***	***151***	***Over Exploited***
15	Andevanapalli	Krishnagiri	127.05	116.05	161.40	116.05	1.00	1253.75	369.90	45.24	415.14	51.42	832.43	33	Safe
16	Anjetti	Krishnagiri	176.07	128.21	774.00	128.21	1.00	652.55	188.13	47.32	235.45	53.79	410.64	36	Safe
17	Denkanikotta	Krishnagiri	168.96	120.45	368.70	120.45	1.00	1033.50	551.50	40.43	591.93	45.96	436.04	57	Safe
18	Kakkadasam	Krishnagiri	171.95	160.04	225.70	160.04	1.00	1265.79	709.68	56.19	765.86	63.86	492.25	61	Safe
19	Kelamangalam	Krishnagiri	116.49	86.14	93.91	86.14	1.00	1484.32	1003.40	43.41	1046.81	49.35	431.57	71	Semi Critical
20	Mathigiri	Krishnagiri	128.46	125.93	50.49	50.49	0.40	456.39	288.90	9.61	298.51	29.36	138.13	65	Safe
21	Rayakottai	Krishnagiri	160.20	112.11	31.21	31.21	0.28	470.00	348.77	18.15	366.93	20.63	100.59	78	Semi Critical
22	Thally	Krishnagiri	149.99	146.27	166.80	146.27	1.00	1293.05	835.08	58.97	894.05	92.21	365.76	69	Safe
			1199.18	***995.20***	***1872.21***	***838.86***		***7909***	***4295***	***319***	***4615***	***407***	***3207***	***58***	***Safe***
23	Kadayampatti	Salem	142.95	140.82	81.97	81.97	0.58	1157.17	1493.46	186.32	1679.78	49.20	-385.49	145	Over Exploited
24	Kolathur	Salem	188.51	188.40	1.50	1.50	0.01	22.01	18.52	0.56	19.09	0.64	2.84	87	Semi Critical
25	Mecheri	Salem	90.28	90.28	31.97	31.97	0.35	384.59	436.56	112.20	548.76	24.55	-76.51	143	Over Exploited
26	Mettur	Salem	98.71	98.71	39.90	39.90	0.40	530.64	0.00	21.30	21.30	24.21	506.43	4	Safe
27	Nangavalli	Salem	87.85	87.85	1.85	1.85	0.02	19.55	29.98	4.68	34.66	1.54	-11.97	177	Over Exploited
28	Pottaneri	Salem	101.42	97.91	71.79	71.79	0.73	649.03	504.17	45.78	549.95	52.03	92.83	85	Semi Critical
29	Semmandappatti	Salem	95.06	95.06	16.94	16.94	0.18	240.60	443.37	16.86	460.23	19.16	-221.93	191	Over Exploited
30	Vellakkadai	Salem	53.32	53.30	19.53	19.53	0.37	193.84	0.00	5.76	5.76	6.55	187.29	3	Safe
31	Yercaud	Salem	45.70	45.70	21.83	21.83	0.48	216.29	0.00	15.72	15.72	17.87	198.42	7	Safe

			903.81	*898.04*	*287.28*	*287.28*		*3414*	*2926*	*409*	*3335*	*196*	*292*	*98*	*CRITICAL*
	Total		*4233.09*	*3526.18*	*4513.60*	*2481.04*		*28208*	*31809*	*1664*	*33472*	*1661*	*-5262*	*119*	*OVER EXPLOITED*

Annexure-6

Firka wise Management plan Calculations- Upper Cauvery Basin

Name of Firka	**Marandahalli**	**Indur**	**Pulikarai**	**Kadathur**	**Pennagaram**	**Vellichandai**
District	**Dharmapuri**	**Dharmapuri**	**Dharmapuri**	**Dharmapuri**	**Dharmapuri**	**Dharmapuri**
Area of Firka (in Sq.km)	95.47	137.7	305.7	4.49	374	17.61
Monsoon Rainfall (m)	0.653	0.502	0.766	0.796	0.664	0.728
Uncommitted run-off (MCM)	9.3512865	10.36881	35.12493	0.536106	37.2504	1.923012
Area suitable for recharge (Sq.km)	66.0365	112.221	111.42075	4.041	103.536	15.849
Sy (as per in the GEC- 2011)	0.015	0.015	0.015	0.015	0.015	0.015
Weathering thickness (m)	8	8	8	8	8	8
Total volume of weathered zone (MCM)	11.4564	16.524	36.684	0.5388	44.88	2.1132
Deepest water level in post monsoon season (m bgl)	14.6	16.3	14.6	13	20	18
Total availble potential aquifer volume for groundwater recharge (MCM)	16.61178	27.47115	53.1918	0.6735	95.37	3.96225
Ground water draft for irrigation in MCM	23.57	24.11	32.45	1.02	19.92	3.3
Water effciency						
Area propsoed for Minor irrigation (Ha)	100	100	150	4	150	10
MI cost @ 0.6 lakh (in lakhs)	60	60	90	2.4	90	6
Improving water efficiency in MCM	0.15000	0.15000	0.45000	0.01200	0.45000	0.03000
Groundwater recharge						
Proposed Check Dams	**10**	**15**	**20**	**2**	**20**	**2**
Cost of CD (Rs in Lakhs)	150	225	300	30	300	30
Expected Volume of recharge from above CDs (cu.m)	7200	10800	14400	1440	14400	1440

Proposed Nala Bunds	**15**	**15**	**25**	**2**	**30**	**5**
Cost of Nalla Bund (Rs in Lakhs)	30	30	50	4	60	10
Expected Volume of recharge from above Nala Bunds (cu.m)	5400	5400	9000	720	10800	1800
Rejuvination of Recharge (RR) ponds with recharge shaft (RS)						
Proposed number ofRR cum RSs	20	30	30	3	30	3
Proposed number of exclusive RSs (in bigger tanks and canal beds)	10	10	10	1	10	1
Cost of RR & RSs (Rs in Lakhs)	560	840	840	84	840	84
Cost of only RSs (Rs in Lakhs)	50	50	50	5	50	5
Expected Volume of recahrge from above RR & RSs (cu.m)	1800000	1800000	2700000	0	3600000	360000
Expected Volume of recahrge from above exclusive RSs (cu.m)	600000	900000	600000	0	600000	90000
Total expected annaul GW recharge from the above schemes (MCM)	2.4126	2.7162	3.3234	0.00216	4.2252	0.45324
WATER CONSERVATION						
Farm ponds						
Proposed number of farm ponds (Units)	100	150	150	5	150	10
Expected annaul GW recharge due farm ponds (cu.m)	540000	810000	810000	27000	810000	54000
Cost of Farm pond (Rs in Lakhs)	100	150	150	5	150	10
sub total of Artificial Recharge Cost (Rs in Lakhs)	950	1355	1480	130.4	1490	145
O & M	47.5	67.75	74	6.52	74.5	7.25
Number of PZ propsoed	9	12	12	1	12	2
Cos tof PZ (@ 0.6 Lakhs) In laksh	5.4	7.2	7.2	0.6	7.2	1.2
Total Cost of Project (Rs in Crores)	10.0290	14.2995	15.612	1.3752	15.717	1.5345
Total expected annaul GW recharge (MCM)	2.9526	3.5262	4.1334	0.02916	5.0352	0.50724
Expected raise in water level (m)	**2.98**	**2.09**	**2.47**	**0.48**	**3.24**	**2.13**

Firka wise Management plan Calculations- Upper Cauvery Basin

Name of Firka	**Palacode**	**Palayam**	**Papparapatty**	**Perumbalai**	**Bhommidi**	
District	**Dharmapuri**	**Dharmapuri**	**Dharmapuri**	**Dharmapuri**	**Dharmapuri**	**Dharmapuri (11 firkas)**
Area of Firka (in Sq.km)	174.9	275.3	297.3	177.5	110.2	**1970**
Monsoon Rainfall (m)	0.766	0.837	0.766	0.285	0.753	**0.683**
Uncommitted run-off (MCM)	20.09601	34.563915	34.15977	7.588125	12.44709	**203.409**

Area suitable for recharge (Sq.km)	116.5365	110.85645	105.5565	106.837	130.587	983.478
Sy (as per in the GEC- 2011)	0.015	0.015	0.015	0.015	0.015	**0.015**
Weathering thickness (m)	8	8	8	8	8	**8.000**
Total volume of weathered zone (MCM)	20.988	33.036	35.676	21.3	13.224	**236.420**
Deepest water level in post monsoon season (m bgl)	18	15	20	20	22	**17.409**
Total availble potential aquifer volume for groundwater recharge (MCM)	39.3525	49.554	75.8115	45.2625	31.407	**438.668**
Ground water draft for irrigation in MCM	31.12	22.47	20.71	12.9	23.38	214.950
Water effciency						**0.000**
Area propsoed for Minor irrigation (Ha)	150	150	150	150	100	1214
MI cost @ 0.6 lakh (in lakhs)	90	90	90	90	60	728.40
Improving water efficiency in MCM	0.45000	0.45000	0.45000	0.45000	0.15000	3.192
Groundwater recharge						
Proposed Check Dams	**20**	**20**	**20**	**20**	**10**	**159**
Cost of CD (Rs in Lakhs)	300	300	300	300	150	**2385**
Expected Volume of recharge from above CDs (cu.m)	14400	14400	14400	14400	7200	**114480**
Proposed Nala Bunds	**30**	**30**	**25**	**26**	**20**	**223**
Cost of Nalla Bund (Rs in Lakhs)	60	60	50	52	40	**446**
Expected Volume of recharge from above Nala Bunds (cu.m)	10800	10800	9000	9360	7200	**80280**
Rejuvination of Recharge (RR) ponds with recharge shaft (RS)						**0**
Proposed number ofRR cum RSs	30	30	30	30	20	256
Proposed number of exclusive RSs (in bigger tanks and canal beds)	10	10	10	10	10	92
Cost of RR & RSs (Rs in Lakhs)	840	840	840	840	600	7208
Cost of only RSs (Rs in Lakhs)	50	50	50	50	50	460
Expected Volume of recahrge from above RR & RSs (cu.m)	1980000	1800000	1800000	2700000	4500000	23040000
Expected Volume of recahrge from above exclusive RSs (cu.m)	600000	600000	600000	600000	0	5190000
Total expected annaul GW recharge from the above schemes (MCM)	2.6052	2.4252	2.4234	3.32376	4.5144	28.425
WATER CONSERVATION						**0**
Farm ponds						**0**
Proposed number of farm ponds (Units)	150	150	150	150	100	1265
Expected annaul GW recharge due farm ponds (cu.m)	810000	810000	810000	810000	540000	6831000

Cost of Farm pond (Rs in Lakhs)	150	150	150	150	100	1265
sub total of Artificial Recharge Cost (Rs in Lakhs)	1490	1490	1480	1482	1000	12492.40
O & M	74.5	74.5	74	74.1	50	624.62
Number of PZ propsoed	12	12	12	11	14	109.00
Cos tof PZ (@ 0.6 Lakhs) In laksh	7.2	7.2	7.2	6.6	8.4	65.40
Total Cost of Project (Rs in Crores)	15.717	15.717	15.612	15.627	10.584	131.824
Total expected annaul GW recharge (MCM)	3.4152	3.2352	3.2334	4.13376	5.0544	35.256
Expected raise in water level (m)	**1.95**	**1.95**	**2.04**	**2.58**	**2.58**	**2.39**

Firka wise Management plan Calculations- Upper Cauvery Basin

Name of Firka	**Semmandapatti**	**Mecheri**	**Kadayampatti**	**Nangavalli**		**Total**
District	**Salem**	**Salem**	**Salem**	**Salem**	**Salem (4 firkas)**	**Total Basin (15 Firkas)**
Area of Firka (in Sq.km)	16.94	31.97	81.97	1.85	132.73	**2103**
Monsoon Rainfall (m)	0.756	0.793	0.756	0.793	0.7745	**0.708**
Uncommitted run-off (MCM)	1.920996	3.8028315	9.295398	0.2200575	15.239283	**218.649**
Area suitable for recharge (Sq.km)	15.246	30.3715	73.773	1.665	121.0555	**1105**
Sy (as per in the GEC- 2011)	0.015	0.015	0.015	0.015	0.015	**0.015**
Weathering thickness (m)	8	8	8	8	8	**8**
Total volume of weathered zone (MCM)	2.0328	3.8364	9.8364	0.222	15.9276	**252.348**
Deepest water level in post monsoon season (m bgl)	15	15	15	15	15	**16.77**
Total availble potential aquifer volume for groundwater recharge (MCM)	3.0492	5.7546	14.7546	0.333	23.8914	**462.559**
Ground water draft for irrigation in MCM	4.43	4.37	14.93	0.3	24.03	**238.98**
Water effciency					**0**	**0**
Area propsoed for Minor irrigation (Ha)	25	50	100	2	177	**1391**
MI cost @ 0.6 lakh (in lakhs)	15	30	60	1.2	106.2	**834.6**
Improving water efficiency in MCM	0.07500	0.15000	0.15000	0.00600	0.381	**3.573**
Groundwater recharge						
Proposed Check Dams	**2**	**2**	**10**	**1**	**15**	**174**

Cost of CD (Rs in Lakhs)	30	30	150	15	225	**2610**
Expected Volume of recharge from above CDs (cu.m)	1440	1440	7200	720	10800	**125280**
Proposed Nala Bunds	**2**	**2**	**5**	**2**	**11**	**234**
Cost of Nalla Bund (Rs in Lakhs)	4	4	10	4	22	**468**
Expected Volume of recharge from above Nala Bunds (cu.m)	720	720	1800	720	3960	**84240**
Rejuvination of Recharge (RR) ponds with recharge shaft (RS)					**0**	**0**
Proposed number ofRR cum RSs	3	3	10	0	16	**272**
Proposed number of exclusive RSs (in bigger tanks and canal beds)	1	1	5	0	7	**99**
Cost of RR & RSs (Rs in Lakhs)	90	90	300	0	480	**7688**
Cost of only RSs (Rs in Lakhs)	5	5	25	0	35	**495**
Expected Volume of recahrge from above RR & RSs (cu.m)	0	180000	1800000	0	1980000	**25020000**
Expected Volume of recahrge from above exclusive RSs (cu.m)	0	0	60000	0	60000	**5250000**
Total expected annaul GW recharge from the above schemes (MCM)	0.00216	0.18216	1.869	0.00144	2.05476	30.47952
WATER CONSERVATION					**0**	**0**
Farm ponds					**0**	**0**
Proposed number of farm ponds (Units)	10	15	70	2	97	**1362**
Expected annaul GW recharge due farm ponds (cu.m)	54000	81000	378000	10800	523800	**7354800**
Cost of Farm pond (Rs in Lakhs)	10	15	70	2	97	**1362**
sub total of Artificial Recharge Cost (Rs in Lakhs)	154	174	615	22.2	965.2	**13457.6**
O & M	7.7	8.7	30.75	1.11	48.26	**672.88**
Number of PZ propsoed	2	2	8	0	12	**121**
Cos tof PZ (@ 0.6 Lakhs) In laksh	1.2	1.2	4.8	0	7.2	**72.6**
Total Cost of Project (Rs in Crores)	1.629	1.839	6.5055	0.2331	10.2066	**142.03**
Total expected annaul GW recharge (MCM)	0.05616	0.26316	2.247	0.01224	2.57856	**37.834**
Expected raise in water level (m)	**0.25**	**0.58**	**2.03**	**0.49**	**1.42**	**2.28**