केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

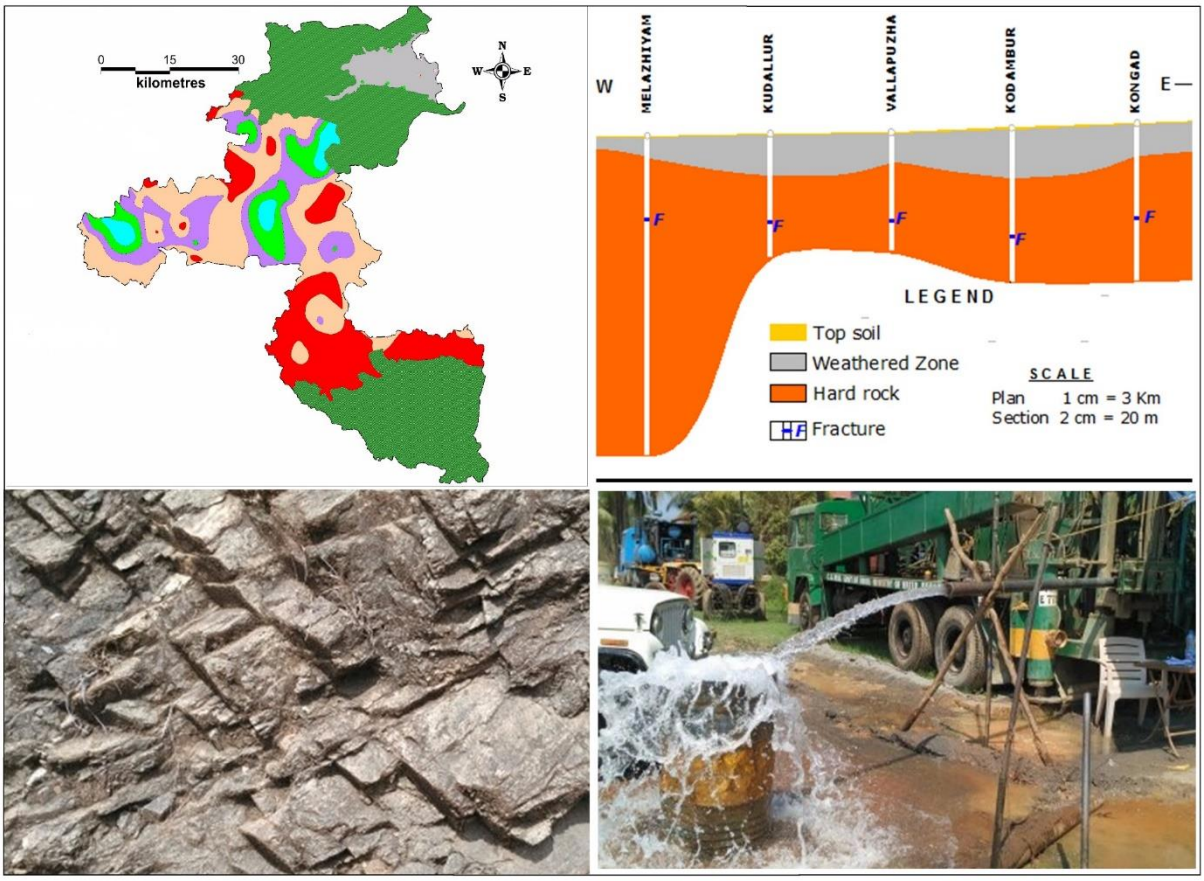
AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

PARTS OF PALAKKAD DISTRICT, KERALA

केरल क्षेत्र, तिरुवनंतपुरम

Kerala Region, Thiruvananthapuram

AUIFER MAPPING AND MANAGEMENT PLAN, PARTS OF PALAKKAD DISTRICT, KERALA



CENTRAL GROUND WATER BOARD

MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

KERALA REGION, THIRUVANANTHAPURAM

AAP 2017 – 18

Foreword

TINKU BISWAL IAS
SECRETARY TO GOVERNMENT

Water Resources & Coastal Shipping
and Inland Navigation Department
Government of Kerala
Secretariat, Thiruvananthapuram-01

Phone { Office : 0471-2322056
0471-2518035
Mobile : 9447713067

FOREWORD

Kerala receives on average annual rainfall of more than 3000 mm and is endowed with large surface water resources. Even so, shortage of fresh water is felt whenever there is a delay in the onset of monsoon because of the geomorphological peculiarities and low water holding capacity of the aquifer systems. To overcome this paradoxical situation, a proper understanding of the disposition, extents, characteristics, status of resource and quality aspects of the water-bearing formations, is required to ensure judicious and planned utilization of water resources aimed at long-term sustainability. Detailed mapping of the aquifer systems in Kerala under the National Aquifer Mapping Programme (NAQUIM) of Central Ground Water Board, Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR,RD&GR) is very significant in formulating aquifer management plans to establish the priorities on groundwater use with community involvement at various levels of implementation.

This report titled 'mapping of hard rock aquifer system in parts of Palakkad district, Kerala State' defines the aquifer systems in the area and addresses various groundwater issues and suggests suitable remedial measures. This report also gives a comprehensive picture of groundwater resources in the area and provides a framework for proper groundwater management in achieving drinking water security, improved irrigation facility and sustainability in water resources development.

I appreciate the efforts of the scientists from CGWB, Kerala Region for the collection, compilation and analysis of voluminous data on various aspects of aquifer system in Palakkad district, Kerala and for bringing out such a comprehensive report. I believe that this document will be of immense use to administrators, planners and other stakeholders to have a better understanding of groundwater scenario as well as ensure long term sustainable development and management of the aquifers.

Thiruvananthapuram
10.10.2018

TINKU BISWAL

Preface

The National Project on Aquifer Mapping (NAQUIM) is an initiative of the Ministry of Water Resources, Government of India, for mapping and managing the entire aquifer systems in the country. The aquifer systems in Kerala are being mapped as part of this Programme and this report pertains to aquifer mapping of the hard rock terrains of Palakkad district. The target scale of investigation is 1:50,000 and envisages detailed study of the aquifer systems up to 200 m depth, to ascertain their resource, water quality, sustainability, and finally evolve an aquifer management plan.

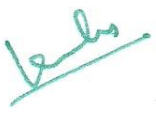
The report titled "Aquifer Mapping and Management plan of aquifer system in parts of Palakkad district, Kerala" gives a complete and detailed scientific account of the various aspects of the hard rock aquifers (except Chittoor and Malampuzha blocks) in the area including its vertical and horizontal dimensions, flow directions, quantum and quality of the resources, of both - the shallow and deeper zones of the hard rock aquifers. Voluminous data were generated consequent to hydrogeological, ground water regime monitoring, exploratory drilling, geophysical studies etc. in the district, and incorporated in the report. The information is further supplemented by various data collected from State departments. It portrays the various ground water issues pertaining to the area along with recommendation for suitable interventions and remedial measures. Thus, it provides a total and holistic solution to the water security problems in the hard rock areas of Pathanamthitta district.

This document has been prepared under the guidance of Dr. N. Vinayachandran, Scientist D & Nodal Officer, and Sh. K Balakrishnan, Scientist D & Team leader. The painstaking efforts of the field hydrogeologist Sh. Singadurai S, Scientist - B in carrying out the aquifer mapping and preparation of this report are well appreciated. Dr. K.R. Sooryanarayana, Suptdg. Hydrogeologist and Dr. V.S Joji, Scientist D deserves appreciation for their meticulous scrutiny of this report before printing. I am also thankful to the Chairman, Members and officers of CGWB, Faridabad for their valuable guidance in finalizing this document. Thanks, are also due to various organizations of Government of Kerala and Government of India for providing data required for the compilation of this document.

This report evolved in the present form through incorporations and modifications as suggested during the presentation of the report before the State Ground Water Coordination Committee (SGWCC) chaired by the Water Resources Secretary, Kerala State, Smt. Tinku Biswal, IAS and before the DM, Palakkad district. Their sincere efforts and encouragements for improvising the content of this report are acknowledged with gratitude.

I hope this compilation will be of much help to the planners, administrators and stakeholders in the water sector in Kerala and will serve as a useful guide for the optimal and sustainable management of ground water resources in the hard rock areas of Palakkad district bases on sound scientific foot.

Thiruvananthapuram,
November, 2019.



(V. Kunhambu)
Regional Director

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1.1 INTRODUCTION

Palakkad district is also called as rice bowl of Kerala, since it's having extraordinary irrigation facilities, there are 12 numbers of reservoirs associated with two major rivers (Bharathapuzha & Bhavani) and its tributaries. The district is traversed by two shear zones, in the southern part by Palakkad-Cauvery shear zone, making the Gap structure (Thara, 1992) "Palakkad Gap" also known as the "Gate way of Kerala" and the Northern part of the district traversed by the Bhavani Shear zone running in the direction of NE – SW, Passing through Attapadi, Mannarkkad, Kanjirapuzha & Sreekrishnapuram. Inasmuch as the two shear zones, the area has been highly shattered and the rocks becomes very good repositories for ground water. In the long run, the ground water depletion has taken place in the study area, because of lesser rain fall & indiscriminate pumping of ground water for irrigation as well as drinking purposes.

A better understanding of the hydrogeological processes that control the distribution and availability of groundwater in the weathered and fracture zones of the aquifer system is imperative for sustainable resource management. The sustainable development and management of hard rock aquifer system involves development of strategies for balancing the water draft and water availability. Integrated studies on various aspects of the groundwater regime have been carried out to know the disposition and productivity of the aquifer systems.

The hydrogeological environment of the study area has been interpreted from the study of historical data (available data) on the groundwater regime and from the available technical reports and publications. The data gaps could be identified from the analysis of historical data which facilitated generation of new data in gap areas. The hydrogeological, hydrological, geophysical, hydrochemical and meteorological data were analyzed for data gaps. Groundwater draft from the aquifer systems has been evaluated from well inventory data and integrated use of lithological and geophysical data used to refine the aquifer geometry of the area.

1.1 Objectives and approach

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. Thus, the main objective of aquifer mapping is to generate an aquifer map of the area in 1:50,000 scale so as to develop a management plan for aquifer sustainability. The major activities envisaged under aquifer mapping to achieve the objectives are data gap analysis, data generation, data integration, preparation of thematic maps and development of aquifer models. The data gap analysis primarily involves compilation, analysis and interpretation of the existing data on the groundwater regime. The data inadequacy or data gaps identified from this study forms the base for additional data generation. The existing data and the new data generated under aquifer mapping activities have been integrated and various thematic maps depicting hydrogeology, hydrology, geomorphology, water quality etc and cross-sections, panel diagrams, elevation models and aquifer geometry (2-D models and 3-D models) were prepared.

The information derived from various activities described above could be used to;

i. Define the aquifer geometry and characterize the aquifer systems.

ii. Define groundwater regime behavior.

iii. Identify the recharge characteristics and resource potential.

iv. Identify the hydro-chemical characteristics of weathered and fracture aquifer systems and the extent of contaminant/pollutant in groundwater, if any. Arrive at an effective groundwater management plan

1.2 About the Area

The Aquifer management study was taken up in parts of Palakkad district, covering an area of 3514 Sq.Km of which, 1336 Sq.Km falls in hilly and forest cover, thus, the actual study area is 2174 Sq.Km, covering of six blocks Attapadi, Mannarkkad, Sreekrishnapuram, Pattambi, Thirthala, & Ottapalam and Partly covering Palakkad, Kuzhalmannam, Alathur, Nenmara & Kollengode blocks of Palakkad district. The area lies between the Latitudes 10^{o} 20' 20" to 11^{o} 14' 24"N and Longitudes 76^{o} 01' 44" to 76^{o} 50' 38"E, the area falls in survey in India Toposheet No:-58B/1, 5, 6, 9, 10 & 14 and 58A/8 12. The area is served by a good network of roads and rail connecting important adjoining places in Kerala and Tamil Nadu. The administrative map of the study area is given in Fig. 1.1.

1.3 Previous work:

The study area covers major part of Palakkad district and has a very good data base on hydrogeology, and geology. The compilation on 'Hydrogeological conditions in Palghat district, Kerala' by John Kurian (1981) details the status of studies up to 1979. Subsequent works include the Reappraisal Hydrogeological Survey in parts of Palakkad carried out by Sri K.Md Najeeb (1990-91) and the environmental hydrogeological studies along Bharathapuzha by V. Dhinagaran (1992-94). Drilling activities were carried out under Technology Mission and regular groundwater exploration was taken up under drought eradication programme during the period 1987-91. Reports on "Ground water resources and development potential of Palakkad district" had been published during the years 1997 and 2005 by CGWB, Kerala Region.

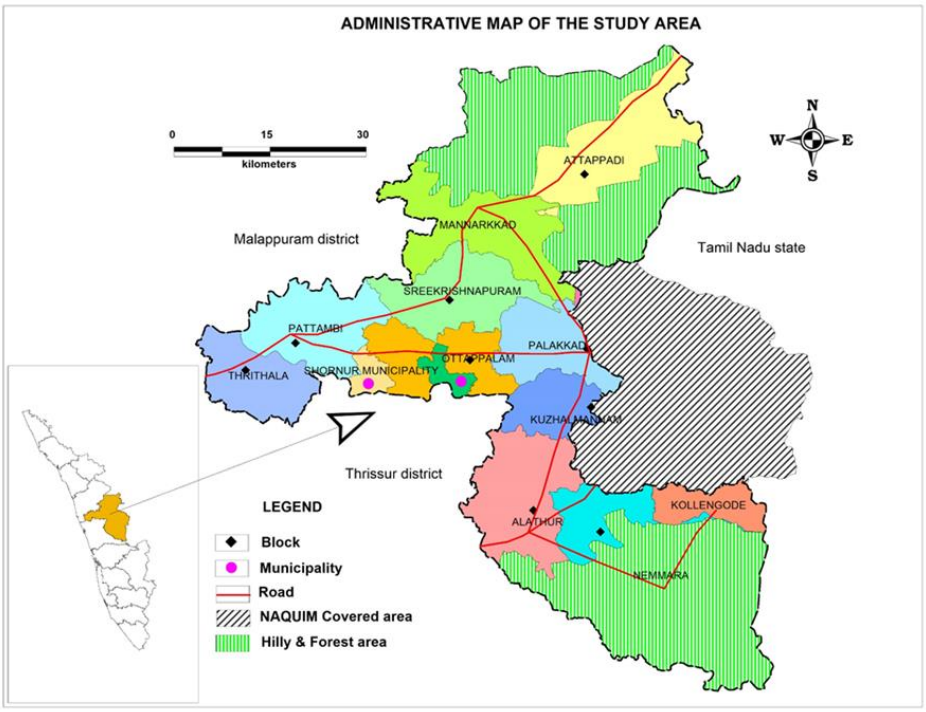


Fig. 1.1: Administrative Map of the study area

2.0 GEOLOGY

The study area is mainly comprised of Archaean metamorphic complex, predominantly the migmatite gneissic complex. Other rock formations such as charnockite and khondalite group of rocks cover less than 5% of the area. Intrusive rocks, pegmatite and quartz veins, are common in the eastern part of the area. The stratigraphic succession of the geology in the area is given below:

Recent : Top soil, valley fill and riverine alluvium.

Archaean : Pegmatite, quartz vein, dolerite, gabbro, granites, quartz-mica schist, Hornblende biotite gneiss, ultramafics, charnockite khondilates and Calc-granulites.

2.1 Recent alluium

Top soil and weathered mantle form the major recent litho-unit and it covers almost the entire area. In the valley portion fill deposits of talus and scree are also observed. Alluvium composed of sand, silt, and clay is observed along the banks of river and their areal extent is very limited and insignificant as a geological unit from a hydrogeological point of view.

2.2 Archaean Crystalline rocks

The geological formations of the Palghat area belong chiefly to the Precambrian metamorphic complex. The study area is mainly composed of migmatitic gneisses. Charnockite, khondalite and calc-granulites occurs as discontinuous bands and is seen in the western and northern part of the area. Lenticular bands of crystalline limestones intimately associated with calc granulites have been observed in the north-eastern part of the area.

Acidic intusives (granitic pegmatites and quartz veins) have also been observed. Within the study area, the predominant rock units are migmatitic gneisses and calc granulites. The migmatitic suite consisting of biotite and hornblende gneisses containing concordant enclaves of amphibolite and associated granulites are mainly seen in the Gap area. Transition from the meta-sedimentary granulites to the migmatitic gneisses is marked by a sequence of hornblende biotite gneisses. The Geology map of the study area is given in **Fig. 2.1.**

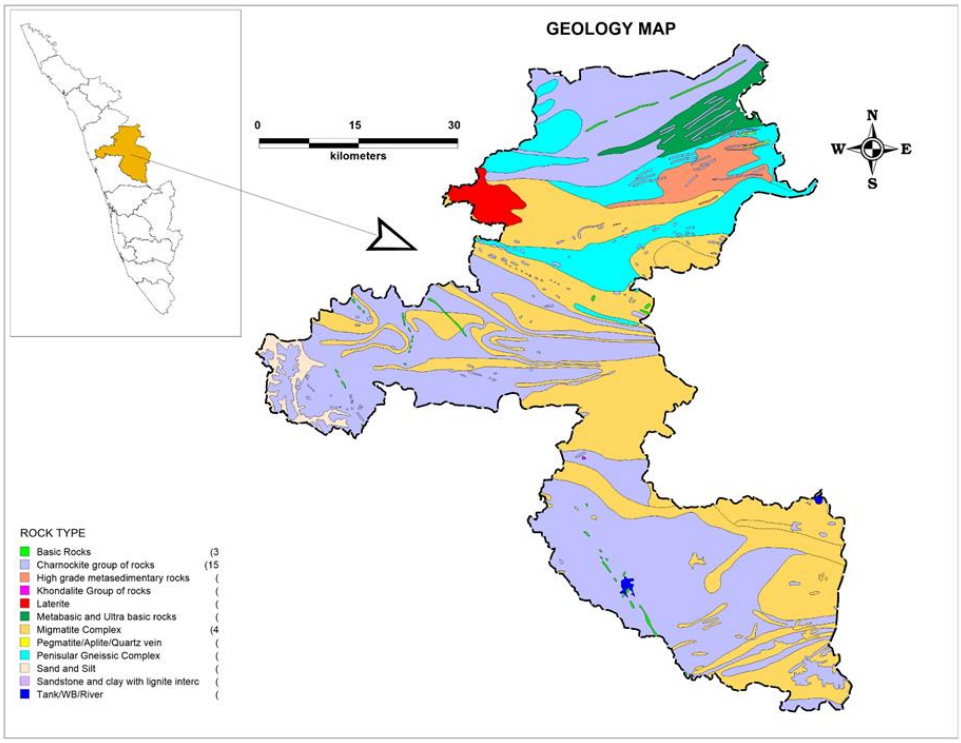


Fig. 2.1: Geology Map of the study area

2.3 Structures

Palghat gap is the major structural feature in the district. Widely contrasting and contradicting hypotheses exist on its origin, advocating marine and fluviatile erosion, crustal upwarp and consequent development of joints and fractures, as well as tectonic processes such as block faulting (Thara, 1992). This clearly shows that the origin of the Palghat Gap is still a controversy, and evinces further geological interest. Different generations of planar and linear structures are recognised in the rocks of the study area. Based on the geometry, orientation and superposition characteristics of the folds, the planar and linear structures of the study area have been grouped into three generations, corresponding to three deformation phases (Thara, 1992).

All the rock units contain a high-grade gneissosity defined by millimetre to decimetre-scale secondary compositional layering which is identified as the earliest recognizable planar structure. In migmatitic gneisses, the planar structure is defined by alternating biotite/hornblende and quartzo feldspathic layers and in khondalite, by quartz, feldspar, garnet and siliimanite-rich layers. Strike of the secondary compositional banding of the rocks in the Gap area is E-W and in the northern flank, it swings generally from NW-SE in the western part to NE-SW in the eastern part. Pervasive nature of the foliation in all the rock

types and its conformity to the general trend of Palghat Gap speaks of a genetic linkage between the two.

Formation of fracture systems is attributed to the late brittle response of rocks to the continuous D3 deformation. The major fracture systems of this deformation stage are in the N-S (parallel to the F3 - fold axis), NE-SW and NW-SE directions. Occurrence of extensive and conspicuous features of faulting is absent in the area. Intense fracturing of rocks, presence of slickensides in the flank and formation of sillimanite augens in khondalite with a steep mineral lineation, are suggestive of mylonitisation and vertical movement close to the flank during /later deformation stage. The tectonic framework of the area may be suggestive of a deep-rooted rupture in E-W direction. The general foliation trend of the gneisses in the E-W direction with steep dip to both sides, also lead the earlier workers (Nageswara Rao & Srinivasan, 1980) to infer the presence of a first order fold system in the Gap area, across which prominent N-S lineaments were identified. Folds in the south were reported by them to be overturned to the north and fractures in the NW-SE, N-S, NNE-SSW, NE-SW and ENE-WSW directions were indicated to be subsequent tectonic features.

3.0 AQUIFER SYSTEMS

The weathered zone and fracture system in crystalline rocks form the repositories of groundwater in the area. Groundwater exists under phreatic condition in shallow/ weathered zone and under semi confined conditions in fracture systems. The weathered zone and the zone of fractures are interconnected and groundwater draft from the fracture system impacts the groundwater levels in the weathered zone. Hence, the area is considered to have a single aquifer system with two distinct horizons of different hydraulic properties such as;

- Weathered zone with associated shallow fractures
- Deeper Fracture zone

3.1 Weathered zone with associated shallow fractures

The shallow aquifers in the weathered zone form the phreatic aquifer system in the study area. Weathered Hornblende Biotite gneisses & Charnockites gneiss, cover a major part of the area and the weathered thickness varies highly in these formations. The occurrence and movement of groundwater in the weathered zone is mainly influenced by the depth of weathering (weathering depth ranges from 5 to 24 m bgl) and topography and generally groundwater follows the topography. Groundwater abstraction structures in this zone include dug wells, dug-cum bore wells and shallow bore wells. The depth of dug wells ranges from 4.00 to 19 m bgl and that of bore well up to the depth of 40 m bgl. The water level ranges from 2 to 12 m bgl during the pre-monsoon period and 0 to 10 m bgl during the post monsoon period. The diameter of the dug well ranges from 1.5 to 4 m. The yield of dug wells ranges from 3 to 10 m^3/day and sustains 1 to 4 hours of pumping. The wells along the canal command area and adjacent to lineaments are yield high.

The yielding capacity of phreatic aquifers varies spatially and is related to the aquifer characteristics, rainfall received, surface water availability, and thickness of weathered residuum. The central and north-western part of the area is having relatively high density of fractures/lineaments, moderate rainfall and surface water recharge to the aquifer systems from the Kanjirapuzha dam.

3.2 Deeper Fracture zone

The Deeper Fracture zone is very potential as the area is tectonically disturbed and groundwater exists there under semi-confined to confined conditions. Since the area experienced several episodes of tectonic deformations, a large number of interconnected fractures developed which offer very good conduits and storage space for groundwater. The Central Ground Water Board has drilled 81 numbers of exploratory wells in the study area, the depth of the bore wells ranges from 40 to 300 mbgl. The depth of potential fracture zones ranges from 45 m to 110 m bgl, the deepest fracture zone, occur at the depth of 190 mbgl (Shreekrishnapuram Exploratory well) and the discharge ranges from 3 to 20 lps. Bore wells located in the block faulted region and along the shear zone of Palakkad-Cauvery and Bhavani shear zone are yielding high compared to the wells located away from the disturbed zones. (Two exploratory wells, Thiruvizhamkunnu & Kappadam bore wells were yielded very less discharge, since these wells falls in compressive zone).

There are five lineament directions observed in the area viz; NE-SW, N-S, ENE-WSW, NE-SW, and NNE-SSW. Lineaments could be identified during field checkup and from satellite imageries and toposheets of 1:50,000 scale. In the study area NE-SW lineaments are the productive zones.

4.0 DATA ADEQUACY AND DATA GAP ANALYSIS

The existing & available data on Geology, Geophysics, Hydrogeology and Hydrochemistry generated under various studies by the department, such as Systematic Hydrogeologial studies, Reappraisal Hydrogeological studies, Groundwater Management studies, Exploratory drilling, Micro level hydrogeological studies and special studies have been utilized for data gap analysis in conjunction with the data collected from various State and Central government departments. The thematic layers on drainage, geomorphology, land use and land cover were reproduced from the data obtained from concerned State departments. The existing data on various themes analysed for finding the data gaps is given in Table 4.1 and the results of the data gap analysis are described in detail in subsequent sections.

Table 4.1: The data availability for data gap analysis

#	Themes	Available data
1	Groundwater level data	71 nos
2	Peizometers	19 nos
3	Groundwater quality Data	7 nos
4	Borehole Lithology Data	72 nos
5	Geophysical Data	27 nos (AP/2 < 200 m)
6	Pumping Test	7 nos
7	Land use and Land Cover	Available
8	Drainage	Available
9	Geology	Available
10	Soil	Available
11	Climate Data	Available

4.1 Water Level Monitoring

In the study area, there are 71 number of NHS monitoring dug wells and 19 number of Piezometers are maintained by CGWB in addition to that another 20 number of Key wells

were established to fill the data gap. The CGWB wells are being monitored four times (January, April, August and November) in a year. The status of water level monitoring wells of CGWB in the area is given in Table 4.2. The historical data from these stations have been used for data gap analysis.

Table: 4.2 Ground Water Monitoring Wells of CGWB

Name of Blocks	CGWB Monitoring wells	
	Dug well	Piezometer
Attapadi	8	4
Mannarkkad	10	1
Sreekrishnapuram	7	2
Ottapalam	5	2
Pattambi	8	2
Thirthala	9	3
Palakkad	5	0
Kuzhalmannom	6	1
Nenmara	3	2
Alathur	4	1
Kollencode	5	1
Total Number of wells	**71**	**19**

4.2 Exploration

From the exploratory drilling data (of the study area), the Aquifer Geometry, Ground water potential of fractures and aquifer characteristics are deduced. Based on the 72 number of exploratory wells made in the study area could be used for data gap analysis and based on this study, the data gaps were identified for 14 number of more exploratory wells. The sites for ground water exploration were selected based on the remote sensing study and Hydrogeological investigation. The Information on weathered thickness and depth of occurrence of fractures are also inferred from geophysical data such as Vertical Electrical Sounding (VES) and profiling. Geophysical methods are normally employed as a reconnaissance study before exploratory drilling. As the cost of geophysical investigation is much less when compared to exploratory drilling it is effectively used to extract subsurface information.

4.2.1 VES and Profiling

In the study area there were 27 number of Vertical Electrical Soundings were carried out in 2012-13 for the purpose of Ground water exploration, the maximum depth of Penetration is up to 140 m (AP/2). Based on the data gap analysis, it's recommended that 13 numbers of Vertical Electrical Sounding and the penetration depth should be 200 m. The Geophysical data on VES and profiling are used to extract information on the weathered thickness, fracture depth, thickness of fracture etc. The aquifer geometry could be refined from the interpretation of geophysical data in conjunction with the available groundwater exploration data.

4.3 Water Quality Monitoring

The study area is having 71 number of Quality monitoring dug well as well as Piezometers and evenly spaced in the study area. The historical data on water quality in the area is available from the water level monitoring stations maintained by CGWB. Water sampling is being done every year from these wells during pre-monsoon period (April).

5.0 DATA GENERATION AND INTEGRATION

Based on the data gap analysis, new data is generated/inventoried by taking up remote sensing studies, Hydrogeological investigation, Geophysical survey, establishment of additional key wells and Ground water exploration. The data gap identified and the new addition of data under various themes is given in Table No 5.1.

Table 5.1: Data requirement and data generated under aquifer mapping

Themes	Existing data	Data Gap	Total	Data generated	Additional data requirement	Remarks
Dug wells	71	Nil	71	Nil	20	
Exploratory wells	72	14	86	14	Nil	
Piezometers	19	Nil	19	0	Nil	
VES	27	13	40	13	Nil	
Water quality	45	Nil	45	0	Nil	
Pumping tests	Nil	Nil	7	7	Nil	

5.1 Climate

The district rainfall data has been taken from IMD for the Preparation of Histogram, the recent year rainfall is gradually come down & erratic in nature, and it varies from 2570 to 1350 mm between the years 2012 – 2016. The intense of rainfall is high and the duration of rainfall is reduced, because of the reason, infiltration rate is reduced.

5.2 Soil

The information on soil types of the area were collected from the soil conservation department, Govt. of Kerala and from the published of reports of CGWB. In the study area, there are five types of soil is occurring, they are Clay, Gravelly-Clay, Gravelly loam, loam and sandy soil.

5.3 Geomorphology

The information on geomorphology is collected from the available literature and from the geomorphology map prepared by the Land Use Board, Govt, of Kerala. The Land Use Board has prepared toposheet wise geomorphology in 1:50000 scale. Based on this information the geomorphology of the area has been defined and the geomorphology map prepared.

5.4 Drainage

The area is mainly drained by Bharathapuzha's tributaries namely Gayathripuzha, Kannadipuzha (Chitturpuzha) and Kalpathypuzha. Gayathripuzha originates in Anamali hills and flows along NW - SE trending faulty valley through Kollengode, Nenmara, Vadakancherry,

Alathur and Pazhayannur before its confluence with Ponnani River (Bharathapuzha) at Mayannur. The Kannadipuzha has three sub-tributaries viz; Palar, Aliyarand and Uppar. Kalpathypuzha originates south of Coimbatore and flows roughly in an E - W trend. It has four sub-tributaries viz - Korayar, Varattar, Walayar and Malampuzha. No additional data on drainage generated and the available information has been used in the present study.

5.5 Groundwater Exploration

In the study area having 72 number of exploratory wells, in addition to that 14 number of exploratory wells (including observation well) were constructed, based on the data gap analysis. In that 7 number of wells were drilled in Mannarkkad block, 6 number of bore wells in Sreekrishnapuram block and one bore well in Palakkad block. The existing wells & the newly constructed wells were integrated to reveal the geometry and characterization of the Aquifer systems of the area. The details of all the exploratory wells are given in Annexure-I.

5.6 Land Use & Land Cover

The data is collected from the Land use board department, the total wet land in the study area is 65283 Ha, Dry land: 185239 Ha, Purampokkuland: 11448 Ha, Forest area: 34210 Ha and Fallow land: 1819 Ha. The block wise details are given in Table No 5.2.

Table 5.2: Land Use Land Cover, Parts of Palakkad district (Area in Ha)

Name of Block	Wet lands	Dry lands	Purampokulands	Forest	Fallow lands
Alathur	7207.5	16207.5	915.1	4854.9	Nil
Attapadi	474.21	49611.63	803.46	24462.18	41.56
Kuzhalmannom	5114.9	3780	229	514.62	592
Kollengode	5410.7	6384	624	Nil	Nil
Mannarkkad	7040.42	29953.15	2280.04	662.56	16.03
Nenmara	9868.5	9804.35	1233.38	1318.56	Nil
Ottapalam	6546.97	14611.37	1651.94	1570.68	566.47
Palakkad	5326.8	11878	Nil	Nil	Nil
Pattambi	4929.42	11155.72	1161.03	167.22	157.12
Sreekrishnapm	4987.31	15710.99	1198.96	493.71	88.32
Thirthala	5349.35	10761.12	827.34	Nil	289.4
Ottapalam Mun	895.76	2161.48	171.06	Nil	38.4
Shoranur Mun	812.63	1882.02	353.07	165.16	29.21
Palakkad Mun	1318.63	1337.45	Nil	Nil	Nil
Total	**65283**	**185239**	**11448**	**34210**	**1819**

5.7 Cropping Pattern

The cropping pattern of the study area seems to be drastically changing, particularly the Paddy cultivation fields are converted in to different land use, like urbanization, industrialization and cultivating different crops like rubber, Arecanut etc. for example in Karimpuzha watershed area majority of the paddy field area are converted in to rubber cultivation, in 1970-71 the paddy growing area is 53.16%, but in 2010-13 it has come down to 12.10%. The declination of the paddy field not only affect the food security of the locality, but

affect more seriously the ground water table and regional microclimate also. The agricultural statistics is given in Table No: 5.3.

Table 5.3: Agricultural Statistics, Parts of Palakkad district: 2010-11 (Area in Ha)

Block	Paddy	Arecanut	Mango	Banana	Plantain	Coconut
Alathur	10897	302.22	956.15	235.45	409.07	4278.12
Attapady	0.22	3296.15	505.1	7952.26	4717.94	7962.33
Kollengode	11180.32	68.57	1605.47	32.92	231.81	4167.28
Kuzhalmannam	15762.8	76.07	547.05	34.66	215.56	2373.28
Mannarkad	283.01	2377.26	1055.42	2249.11	772.35	7323.24
Nenmara	10668.03	113.6 2	398.63	174.14	227.55	2364.59
Ottapalam	3283.93	228.05	1031	1007.51	387.79	4466.27
Palakkad	5084 .15	147.57	353.27	350.64	153.15	2129.05
Pattambi	2194.76	388.67	710.57	368 .8	354.53	4239.3
Sreekrishnapuram	1397.5	729.27	616.6	2556.66	309.5	3123.81
Thrithala	2492.51	895.82	835.04	1 55.1	501.23	4414.62
Municipalities	2021.95	35.37	342.18	41.42	161.67	1481.49
Total	**49285.03**	**8545.02**	**8956.48**	**14634.77**	**8442.15**	**48323.38**

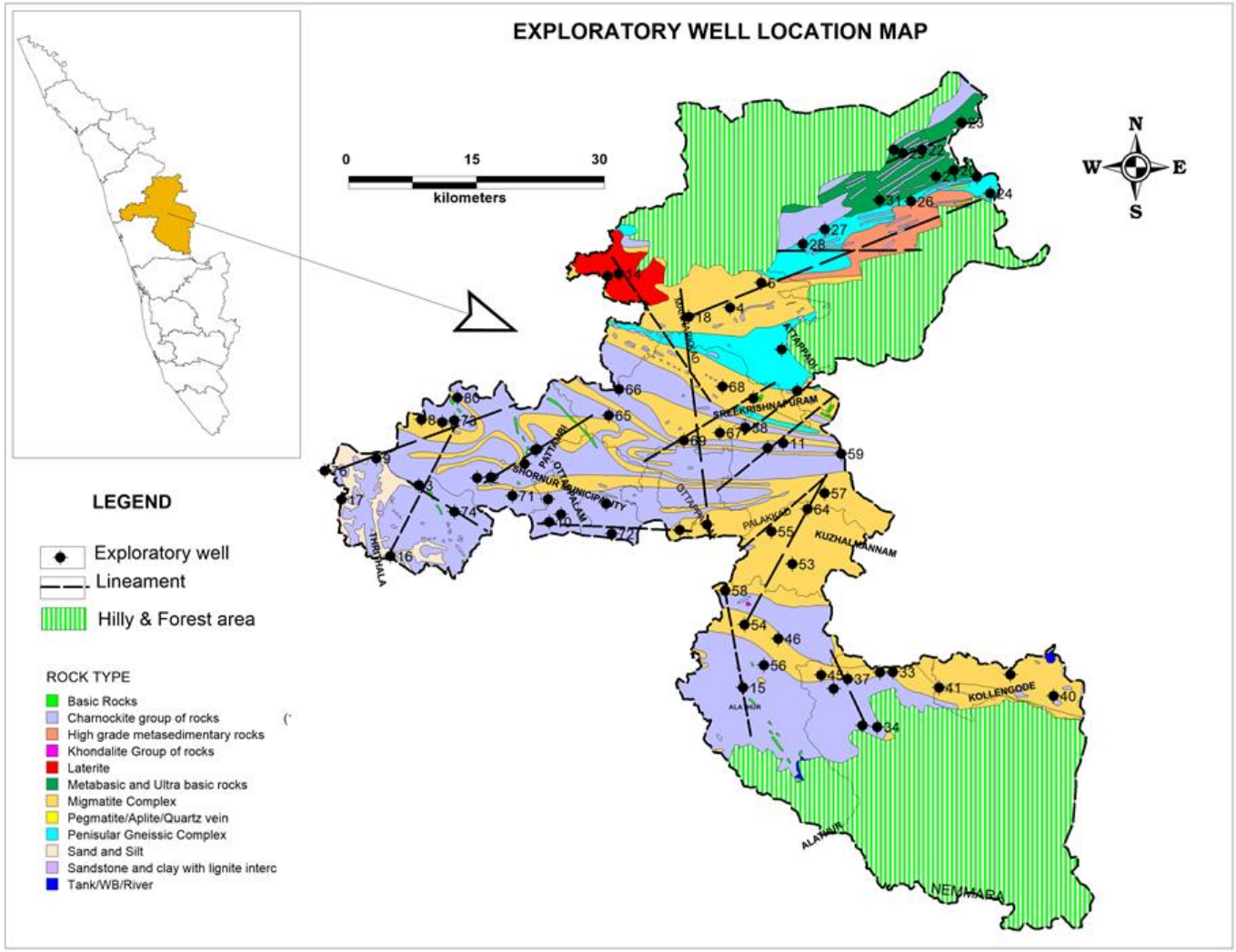


Fig. 5.1: Exploratory well location Map

5.8 Vertical Electrical Sounding (VES)

In the study area, 27 number of Vertical Electrical Soundings were taken up for the purpose of Ground water exploration, during the time of 2012 – 2013, the depth to penetration (AP/2) ranges from 50 to 140 m. Another 13 number of Vertical Electrical Sounding were taken up during the AAP: 2016 -17 for the purpose of Ground water exploration. The details of VES is given in Fig.5.2.

The VES were carried out by employing Schlumberger electrode configuration up to a maximum spread length (AB/2) of 200m. The obtained VES curves were of H, A, HA, AA, QH, KH and HAA type and were interpreted manually as well as by employing computer interpretational techniques. The interpreted results have given rise to 4 to 5- layered geoelectric sections. At majority of the VES (37 VES) the last layer was recorded as massive formation whereas at the remaining VES (5VES) the last layer was extending with depth. The depth to massive formation was varying in the range of 5 - 60 m.

Table 5.4: Details of Vertical Electrical Sounding

#	Location	Longitude	Latitude
1	Mangalam	76.114722	10.815333
2	Alur	76.103444	10.801556
3	Malamakkavu	76.076806	10.818306
4	Melazhiyam -1	76.036694	10.822583
5	Melazhiyam -2	76.036500	10.822556
6	Kodumunda - 1	76.147083	10.815667
7	Kodumunda-2	76.066361	10.824361
8	Muthuthala	76.168222	10.837167
9	Amiyoor	76.189000	10.837194
10	Ongallur	76.223139	10.788833
11	Karakkad	76.229083	10.782250
12	Kayiliad	76.281056	10.815806
13	Padinjara Angadi	76.060444	10.787778
14	Parakkulam	76.070722	10.803056
15	Othallur	76.084722	10.804083
16	Pattithara	76.106944	10.808417
17	Perinkannur	76.180528	10.744444
18	Nellaya	76.284167	10.866472
19	Irimbalassery	76.290083	10.876917
20	Chalavara	76.310167	10.836472
21	Cherukod	76.229639	10.841472
22	Trikaddiri	76.336639	10.856667
23	Panamanna	76.363194	10.782778
24	Kunnathara	76.312972	10.776056
25	Kulapalli -1	76.265750	10.787528
26	Kulapalli-2	76.271167	10.794222
27	Koombankallu	76.203972	10.811389

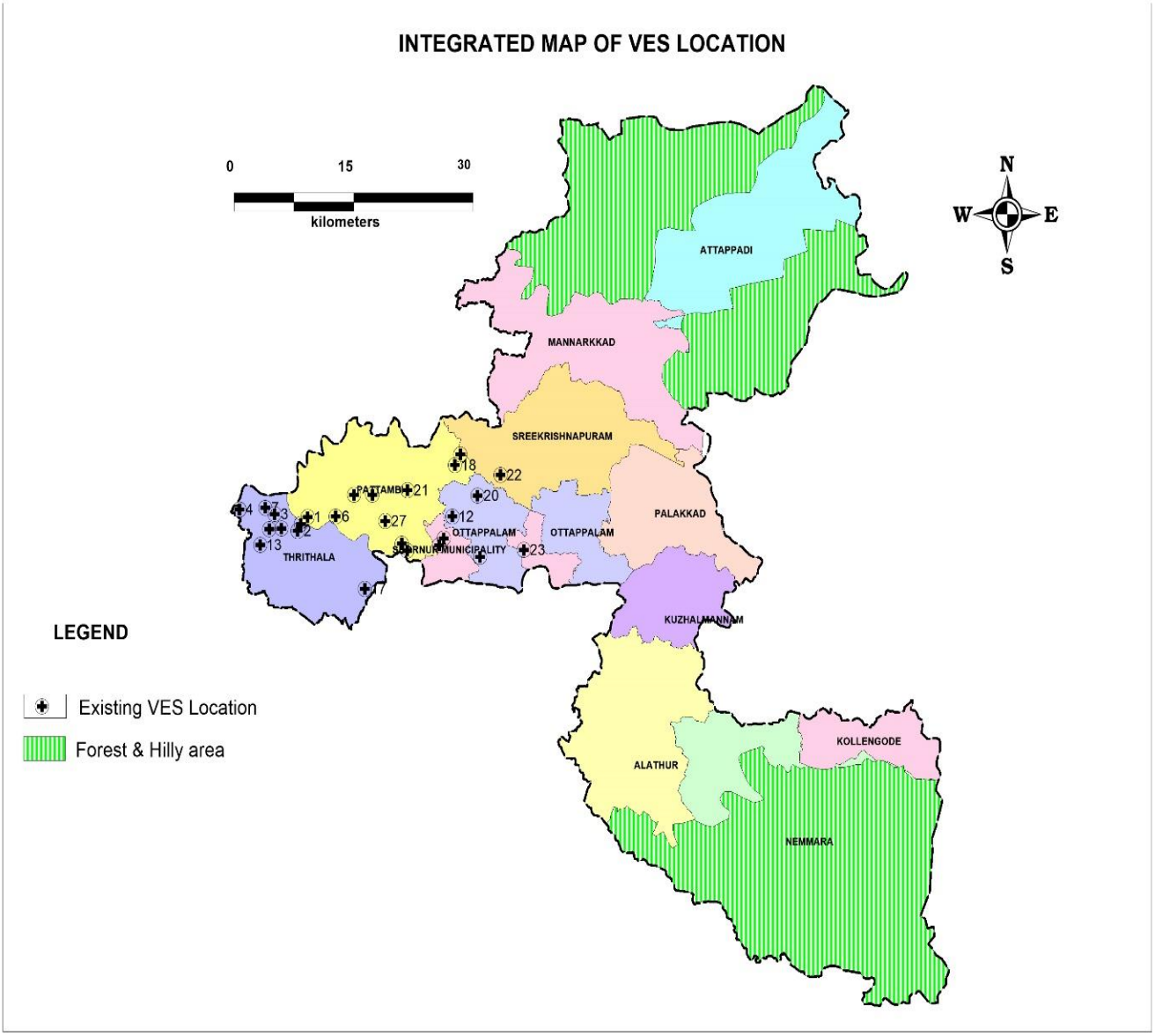


Fig No: 5.2: Integrated VES Location Map

During the time of Ground water exploration In Palakkad district (2016-17), 13 number of VES were taken up (covering the area of Kadambazhipuram, Sreekrishnapuram, Parli(Kinavallur), Edakurussi & Thiruvizhamkunnu to pinpointing drilling site and the interpreted results have given rise to 5 to 6 layered geoelectric sections. Mostly in all sites the last geoelectric layer is showing an increasing trend due to massive formation. The main types of the curve are H, KH, QH, KHA, A, HA and KHKH etc.

The first geoelectric layer resistivity was varying in the range of 124-1362 ohm.m, and the thickness of this geoelectric layer is varying in the range of 0.3-5.8 m. The second geoelectric layer resistivity was varying in the range of 52-3284 ohm.m, and the thickness of this geoelectric layer is varying in the range of 1.1-22.4 m. The third geoelectric layer resistivity was varying in the range of 71-VH ohm.m and the thickness of this geoelectric layer

is varying in the range 6.2-32.8 m., At 5 no of VES the geoelectric layer was extending in nature. The fourth geoelectric layer resistivity was varying in the range of 815-VH ohm.m and the thickness of this geoelectric layer is varying in the range of 8.0-39.8 m., At 3 no of VES the geoelectric layer was extending in nature. The Fifth geoelectric layer resistivity was varying in the range of 505-VH ohm.m., and the thickness of this geoelectric layer is varying in the range of 33.7-52 m. At 3 no of VES the geoelectric layer was extending in nature. The sixth geoelectric layer resistivity was varying in the range of 9680-VH ohm.m. The fractured formation resistivity was varying in the range of 53-263 ohm.m. The apparent resistivity vs AB/2 curve is given in Fig No: 5.2(a) & the interpreted results were presented in Table-5.2(a).

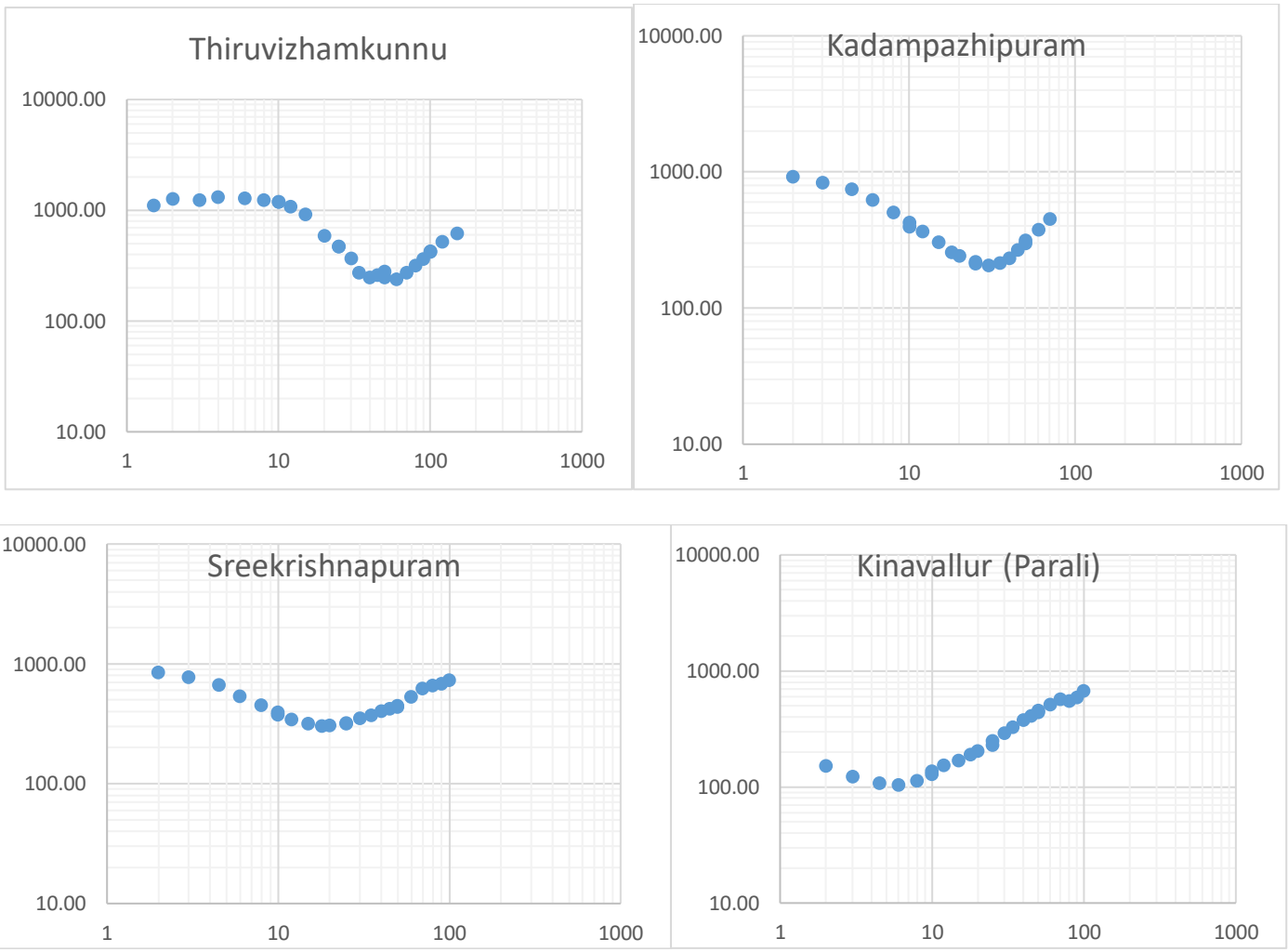


Fig.5.2 (a): Apparent resistivity vs AB/2 at 4 locations in the area

Table No 5.5: Interpreted results of VES in Palakkad district

#	Village	Ves no.	Interpreted Results												Total Spread Length (AB) (m.)	Remarks
			Resistivity (Ohm.m.)						Thickness (m.)					Depth to Massive rock (m.)		
			ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	h_1	h_2	h_3	h_4	h5			
1	Kadambazhipuram	1	124	2900	71	815	VH	-	0.4	2.5	7.9	8	Ext.	19.2	120	Recommended
		2	962	400	71	VH	-	-	2.4	6.6	10.2	Ext.	-	19.2	140	
		3	1362	83	5310	-	-	-	5.8	13.8	Ext.	-	-	19.6	140	
2	Sreekrishna Puram	1	589	2729	410	2609	VH	-	0.7	1.2	13.7	39.8	Ext.	15.6	300	Recommended
		2	861	261	1860	-	-	-	2.8	22.4	Ext.	-	-	25.2	200	
		3	179	241	3555	-	-	-	2.2	11.9	Ext.	-	-	14.1	200	
3	Parli(Kinavallur)	1	351	155	VH	-	-	-	4.8	8	Ext.	-	-	12.8	180	
		2	183	63	189	2379	-	-	1.3	2.2	9.7	Ext.	-	13.2	200	
		3	276	52	110	1284	8609	-	0.6	1.1	7.2	8.3	Ext.	17.2	180	Recommended
4	Edakurussi	1	931	228	901	-	-	-	2.0	12.3	Ext.	-	-	14.3	80	
5	Thiruvizhamkunnu	1	683	1107	287	3152	505	VH	2.2	4.5	6.2	13.9	33.7	13	400	
		2	1218	3284	527	2335	1198	9680	0.8	3.1	9.0	21.2	52.0	13	400	Recommended
		3	714	1423	143	VH	-	-	0.3	8.2	32.8	Ext.	-	41	300	

5.9Water levels and piezometric heads

In the study area, there are 71 number of NHS (CGWB) monitoring dug wells and 19 number of Piezometers are existing, so the data gap is negligible. The wells were monitored four times in a year (January, April, August & September). The integrated data on water level could refine water level maps and resource computations. The data on piezometric head have been collected from 19 piezometers tapping the fracture systems in the area. The integrated data on water level and piezometric heads are given in Table 5.3 and 5.4 respectively and an integrated location map of these sites is shown in Fig. 5.3. Historical data on water levels and piezometric heads are available for different periods for all the monitoring wells in the area. The Key well details are given in Table No.5.3 (a).

5.10 Water quality monitoring

The existing water level monitoring wells are maintained as water quality monitoring wells by CGWB and historical data is available for pH, Electrical Conductivity (EC) and for the ions Ca, Mg, Na, K, Cl,CO_3, HCO_3, SO_4, NO_3 and F. The monitoring wells and piezometers of both are integrated for water quality monitoring through out sourcing. The integrated water quality monitoring well location map is given in Fig.5.4.

Table 5.6: Monitoring wells details of phreatic aquifer

#	Location	Longitude	Latitude	Well depth (m)	Dia (m)	M.P (m agl)	RL (amsl)	Type of well
1	Adipararnda	76.57333	10.51972	09.25	2.62	0.70	65.00	DW
2	Agali	76.64	11.088	12.10	2.90	0.70	150.0	DW
3	Aalanallur	76.34722	11.01	11.90	3.18	0.80	65.00	DW
4	Alathur	76.55444	10.64556	10.00	2.70	0.94	98.00	DW
5	Ambalapara	76.41056	10.8375	10.60	2.80	0.60	82.50	DW
6	Anakatty	76.74611	11.11667	11.00	2.10	0.80	200.0	DW
7	Ariyur	76.40208	10.98111	12.70	2.70	0.68	55.00	DW
8	Athipotta	76.48139	10.6675	18.90	2.60	0.70	45.00	DW
9	Bangalow kunnu	76.535	10.85389	18.00	3.00	0.95	60.00	DW
10	Chalisseri	76.09361	10.73611	13.04	1.50	0.80	35.00	DW
11	Chavadiyur	76.66667	11.1575	05.00	2.55	1.00	180.0	DW
12	Chemmanampathi	76.83111	10.57361	12.42	3.90	0.70	80.00	DW
13	Cherpulassery	76.32056	10.88611	11.61	2.03	0.95	58.00	DW
14	Kakkupady	76.55444	11.06528	08.50	3.10	0.90	170.0	DW
15	Kalladikode	76.53889	10.89389	12.20	3.15	0.80	75.00	DW
16	Kanjirapuzha	76.53472	10.99972	05.00	2.00	0.70	80.00	DW
17	Karimpuzha	76.41944	10.87306	04.00	1.80	0.50	55.00	DW
18	Kadampazhipuram	76.45611	10.87278	10.00	3.50	0.65	80.00	DW
19	Kodunthirapally	76.60611	10.76917	07.34	3.00	0.40	75.00	DW
20	Kollenkode	76.69417	10.6125	06.00	2.50	0.60	55.00	DW
21	Kongad	76.51444	10.85889	08.00	1.60	0.70	90.00	DW
22	Koottanad	76.1175	10.76139	12.70	3.00	0.80	38.00	DW
23	Koppam	76.18917	10.86583	08.30	2.50	0.70	40.00	DW
24	Kottapuram	76.40889	10.9425	12.10	2.50	0.90	58.00	DW
25	Kottathara	76.68917	11.13306	04.00	2.50	1.00	150.0	DW
26	Kottasseri(Vattasseri	76.49944	10.86222	06.10	1.50	0.40	100.0	DW
27	Kottayi	76.54333	10.76583	11.96	2.70	0.70	60.00	DW
28	Kudallur	76.075	10.76556	08.40	2.80	0.60	20.00	DW
29	Kumaramputtur	76.42778	10.98972	06.60	2.60	0.66	70.00	DW
30	Kumaranallur	76.05806	10.78778	12.10	2.40	0.60	30.00	DW
31	Lakkidi	76.33333	10.76111	15.00	3.60	0.80	65.00	DW
32	Mankara	76.49694	10.78667	08.48	3.00	0.90	60.00	DW
33	Mannarkkad	76.46722	10.99333	11.56	3.00	0.70	80.00	DW

34	Mathur	76.57556	10.73917	13.61	2.75	0.80	65.00	DW
35	Meenkara	76.80722	10.61389	11.00	3.00	0.80	69.00	DW
36	Melarkode	76.56361	10.60778	14.00	2.00	0.70	60.00	DW
37	Moochankundu	76.80417	10.58083	11.15	2.50	0.75	50.00	DW
38	Mulayankavu	76.26556	10.86389	10.20	4.00	0.80	45.00	DW
39	Muthalamada	76.76139	10.60389	08.00	3.00	0.72	60.00	DW
40	Naikarapady	76.80889	11.12722	10.00	2.70	0.75	100.0	DW
41	Nellikatteri	76.175	10.7667	10.00	2.50	1.00	35.00	DW
42	Nenmara	76.60028	10.59389	05.90	2.50	0.68	45.00	DW
43	Odannur	76.54556	10.78	09.00	1.68	0.76	70.00	DW
44	Ongallur	76.21944	10.80222	09.50	3.00	0.66	38.00	DW
45	Ottapalam	76.3793	10.771	11.10	3.90	1.10	40.00	DW
46	Padur	76.47389	10.65778	13.00	2.50	0.90	40.00	DW
47	Palamattom	76.50528	10.99583	11.30	2.00	0.70	38.00	DW
48	Palappuram	76.41778	10.76972	13.30	3.25	0.75	35.00	DW
49	Parali	76.56556	10.79389	06.40	2.00	0.50	80.00	DW
50	Pattambi	76.18639	10.80444	10.56	3.00	0.85	35.00	DW
51	Peringode	76.12583	10.74111	11.19	3.50	0.85	55.00	DW
52	Peringottukurussi	76.50472	10.75583	08.90	2.50	0.80	35.00	DW
53	Pullundassery	76.4525	10.86333	04.10	2.50	0.70	60.00	DW
54	Punchapadam	76.41861	10.88111	09.60	3.70	0.70	70.00	DW
55	Shoranur	76.27417	10.76833	12.80	2.60	0.65	38.00	DW
56	Sreekrishnapuram	76.42	10.92028	11.55	2.45	0.88	60.00	DW
57	Tachanattukara	76.34694	10.96889	13.00	2.75	0.78	50.00	DW
58	Thannirkod	76.07833	10.77222	11.00	4.00	0.75	45.00	DW
59	Thavalam	76.58139	11.08472	08.70	2.35	0.47	150.0	DW
60	Tenkara	76.49222	11.0125	04.40	3.50	0.55	80.00	DW
61	Tachanpara	76.50694	10.95917	06.50	3.00	0.80	80.00	DW
62	Thirumattacode	76.1742	10.7522	07.20	3.00	0.80	40.00	DW
63	Thiruvegapuram	76.12694	10.87417	11.00	3.00	0.60	55.00	DW
64	Tholanur	76.50764	10.71667	06.10	3.50	0.80	60.00	DW
65	Trithala	76.12833	10.80306	09.80	2.00	0.50	20.00	DW
66	Vadakkanchery	76.48361	10.59222	07.00	2.20	0.70	80.00	DW
67	Vadanakurussi	76.25236	10.78667	07.50	3.40	1.00	45.00	DW
68	Vallapuzha	76.25	10.83889	08.00	2.95	1.00	40.00	DW
69	Vaniyamkulam	76.32833	10.78222	09.94	3.00	0.80	75.12	DW
70	Vattalukki	76.72417	11.12889	12.00	3.00	0.90	180.0	DW
71	Vilayur	76.18972	10.89278	08.80	3.50	0.50	40.00	DW

Table 5.7: Key well details in the Study area

#	Location	Longitude	Latitude	Well depth,m bgl)	Well dia, m	MP, agl	Type Well
1	Kandamangalam	76.41631	11.03586	09.00	03.00	0.75	DW
2	Puttanikkadu	76.40336	11.01283	13.00	02.50	0.60	DW
3	Parapuram	76.3795	11.00764	11.50	03.50	0.85	DW
4	Thiruvizhamkunnu	76.37056	11.03494	14.00	03.00	0.60	DW
5	Kottapadam	76.3935	10.99625	11.00	03.00	0.9	DW
6	Kodanadu	76.39083	10.94667	11.00	03.00	0.70	DW
7	Kottapllam	76.35111	11.06028	08.00	02.50	0.60	DW
8	Churikkode	76.36722	11.06111	16.00	02.50	0.70	DW
9	Annanthodi	76.35833	10.97	12.50	03.00	0.70	DW
10	Anamoozhi	76.50889	11.02867	08.00	02.00	0.65	DW
11	Kanjiram	76.51314	11.00425	13.00	03.00	0.60	DW
12	Pudukkad	76.53528	10.94406	10.00	03.00	0.54	DW
13	Ponnamkode	76.51389	10.94194	12.00	02.00	0.75	DW
14	Karakurussi	76.49278	10.93194	08.00	02.00	0.60	DW
15	Kallamparambu	76.45	10.89128	20.00	03.00	0.80	DW
16	Adaikkaputhur	76.34917	10.88694	18.00	03.00	0.60	DW
17	Vellinezhi	76.34083	10.90194	12.00	03.00	0.65	DW

18	Amayur	76.18861	10.83722	14.00	03.00	0.70	DW
19	Kavalapara	76.2975	10.77556	09.50	03.00	0.60	DW
20	Ananganadi	76.34667	10.82694	11.50	02.00	0.60	DW
21	Kalluvazhi	76.39111	10.87194	12.50	03.00	0.75	DW
22	Kanjikulam	76.54944	10.87694	11.00	02.50	0.60	DW

Table 5.8: Monitoring well details of fracture aquifer system

#	Name of Village/ Location	Latitude in degrees decimal	Longitude in degrees decimal	RL (mam sl)	Total Depth (mbgl)	Type of well	Dia(mm)	MP
1	**Agali**	76.58778	11.10417	150.0	193.40	P/z	177.8	0.60
2	Anakatty	76.74639	11.11778	200.0	101.00	P/z	177.8	0.50
3	Chavadiyur	76.66539	11.15833	180.0	169.00	P/z	177.8	0.70
4	Karimpuzha	76.46917	10.92028	55.00	101.00	P/z	177.8	0.50
5	Kongad	76.51444	10.85889	90.00	092.00	P/z	177.8	0.60
6	Lakkidi	76.47333	10.75778	65.00	100.00	P/z	177.8	0.70
7	Melarkode	76.56194	10.50806	60.00	101.20	P/z	177.8	0.60
8	Moochangundu	76.8025	10.5825	50.00	101.20	P/z	177.8	0.80
9	Padur	76.47361	10.6575	40.00	086.00	P/z	177.8	0.50
10	Pattambi	76.19181	10.81028	35.00	100.00	P/z	177.8	0.70
11	Peringottukurssi	76.50444	10.75611	35.00	099.00	P/z	177.8	0.60
12	Pudur(Agali)	76.64472	11.15389	150.0	101.00	P/z	177.8	0.50
13	Pullundassery	76.45222	10.86333	60.00	101.00	P/z	177.8	0.80
14	Thenkara	76.49194	11.01278	80.00	085.00	P/z	177.8	0.60
15	Thirumattacode	76.15889	10.74528	40.00	101.00	P/z	177.8	0.60
16	Thiruvegapuram	76.1275	10.87417	55.00	100.00	P/z	177.8	0.80
17	Trittala	76.1275	10.80278	20.00	100.00	P/z	177.8	0.60
18	Nellikattri	76.175	10.7667	35.00	111.00	P/z	177.8	0.70
19	Nenmara	76.61611	10.60194	45.00	101.20	P/z	177.8	0.50

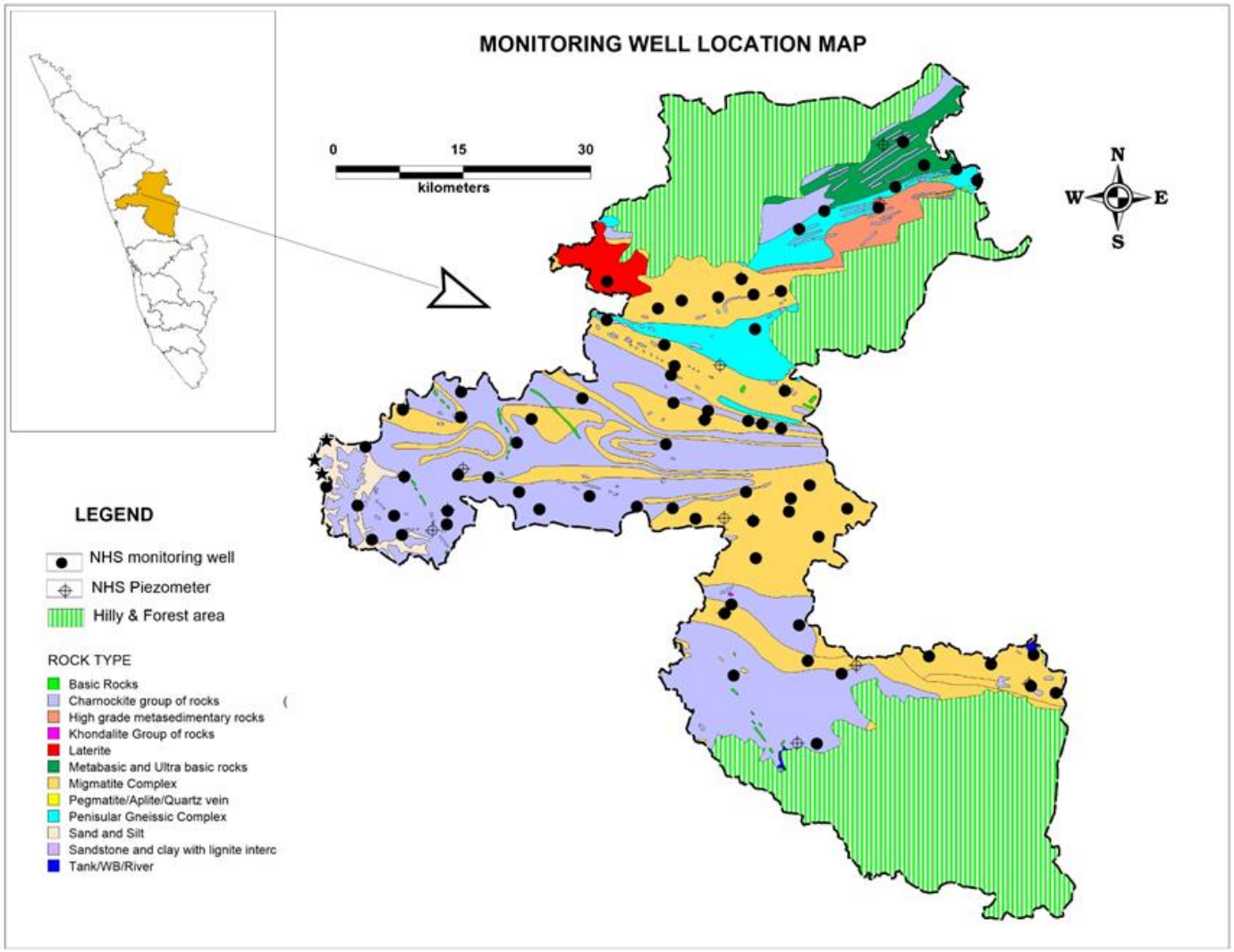


Fig.5.3: Integrated Water level monitoring well location Map

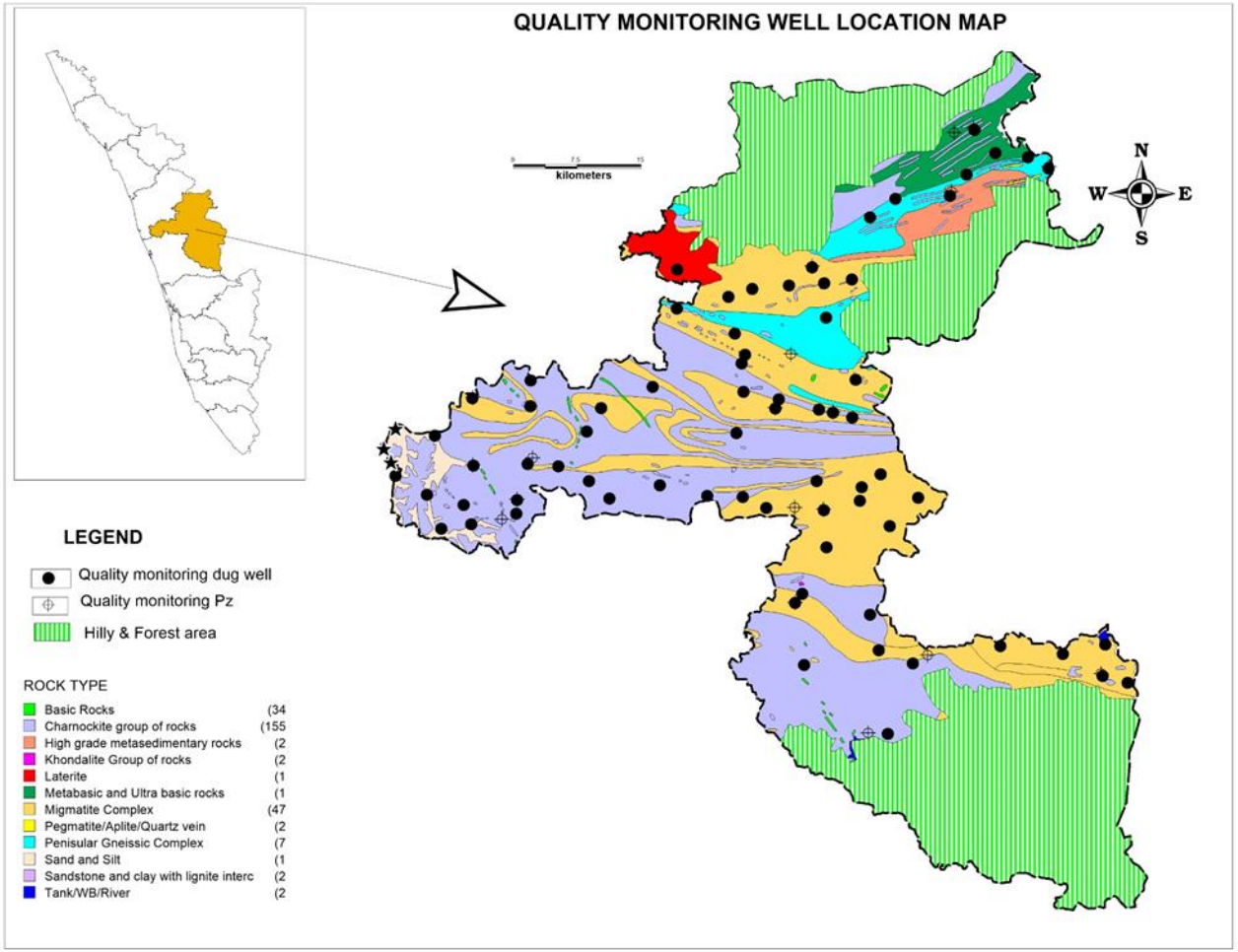


Fig.5.4: Integrated Quality monitoring well location Map

6.0 MAPPING OF AQUIFER SYSTEMS

Based on the data gap analysis & the data generated in the field, the Aquifer maps were prepared. Analysis of geological, geophysical, hydrological, hydrogeological, and hydro-chemical data. In the present study the aquifer disposition and aquifer characterization has been brought out mainly by analyzing the data from 71 lithological logs, 40 electrical logs, 37 hydrograph from dug wells, 19 piezometric heads, hydro-chemical data from NHS, previous literatures and inputs from the field investigations. Aquifer mapping involves extraction of information from the analysis of data and preparation of various thematic maps related to the groundwater regime so as to get any required information about the aquifer system from the thematic layer or from a suitable combination of thematic layers. Various aspects of the groundwater regime such as rainfall, soil, geomorphology, geology, aquifer geometry, aquifer characteristics, water levels, water resources and water quality were studied in detail and thematic maps prepared as part of the aquifer mapping.

Rainfall

The Average annual rainfall of the district is 1976 mm. Southwest monsoon contributes 71% of rainfall from June to September and the northeast monsoon contributes about 18%. The rainfall in 2016 is 1350 mm only, so the drought like situation occurred throughout the district and enormous drilling activities were taken up in the study area for ground water extraction, the pictographic representation of rainfall is given in Histogram Fig.6.1. The spatial variation in rainfall over the area is best represented by isohyetal map (Fig.6.1 (a) which shows a gradual increase in rainfall from south to North western direction. The rainfall data of the district (from the period: 2012-2016) is given in Table No 6.1.

Table No 6.1: Rainfall data of Palakkad district

Year	Jan	Fep	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2012	0	0	6.2	141.6	64.4	386.9	297.5	367	171.7	197	61.6	4
2013	0	43.5	34.1	34.4	55.6	729.2	796.8	279.3	283.7	235.2	74.4	4.6
2014	0	3.1	5.2	36.4	190.8	314	602.2	561.4	230.6	282.5	40.2	12.1
2015	0	2	27.1	184.2	245.6	455.2	281.8	219.2	199.3	141.8	185.8	43.2
2016	0.2	0	4.2	4.1	169.2	461.5	336.6	159.2	77.4	88.2	21.7	27.6

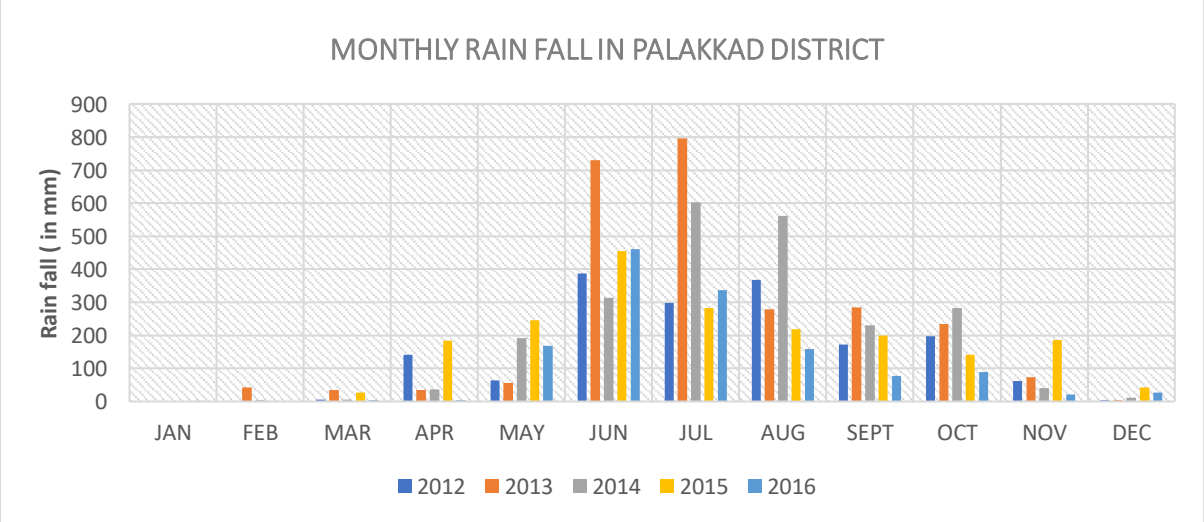


Fig.6.1: Histogram of Palakkad district (rainfall)

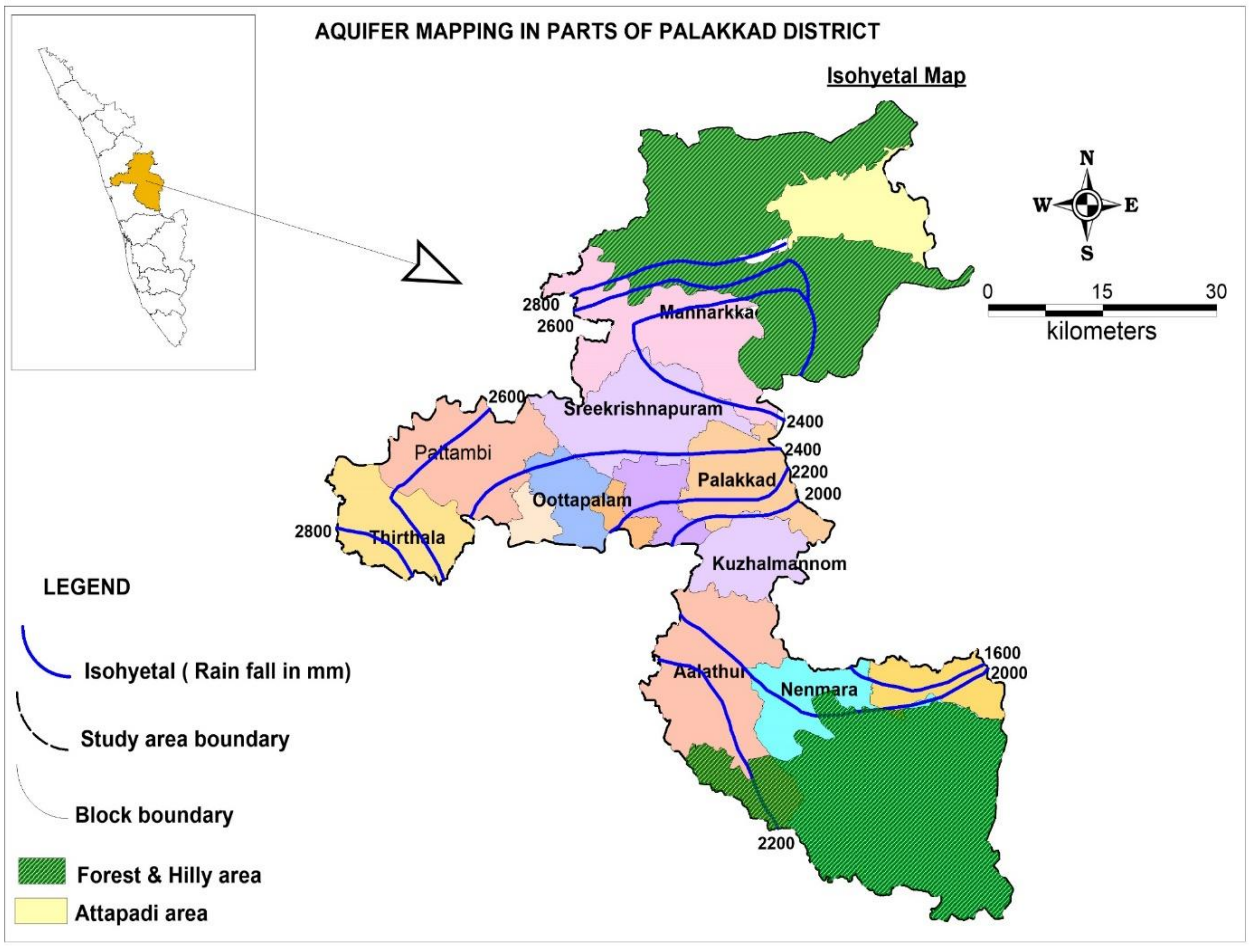


Fig.6.1 (a): Isohyetal Map, Parts of Palakkad district

Climate

The maximum temperature ranges from 32.3 to 41^{0}C and the minimum temperature ranges from 22.2 to 25.3^{0}C. The average annual maximum temperature is 32.3^{0}C and the average annual minimum temperature is 23.4 to 25^{0}C. The wind is predominantly from west and east during morning as well as in the evening hours. The wind speed is high during August (13.6 kmph). The humidity is higher (around 90 %) during the monsoon period i.e. from June to September. During the year 2016 the district rain fall is 1350 mm only, so the drought like situation was occurring in area.

Soil Characteristics

In the study area, five types of soils are occurring, they are Clay soil, Gravely Clay, Gravely loam, Loam & Sandy soil. Predominant soils are Loam soil & gravelly clay soil, they are occupying in the southern and central part of the study area. The gravelly loam soil is occurring in the North eastern part of the district, Particularly Attapady block & Hilly areas. The loam soil is rich in humus and organic matter. Gravelly clay soil is seen along the banks of

rivers. In the valley portion, valley fill deposits such as talus and scree are observed. The soil map of the study area is given in Fig.6.2.

Geomorphology

Geomorphologically the area is characterized by the land features of mid land and high land regions. The elevation of the area varies from 20 to 2386 m amsl. The prominent physiographic feature of the district is the Palghat gap which is a structural gap of about 32km wide developed in the Western Ghats. Palghat. The important peaks in the area are Anginda (2386 m), Padagiri (1585 m) and Karimala Gopuram (1440). The geomorphology map is given in Fig.6.3.

Drainage characteristics

The area is mainly drained by Bharathapuzha's tributaries namely Gayathripuzha, Kannadipuzha Chitturpuzha and Kalpathypuzha. Gayathripuzha originates in Anamali hills and flows along NW - SE trending faulty valley through Kollengode, Nenmara, Vadakancherry, Alathur and Pazhayannur before its confluence with Ponnani River (Bharathapuzha) at Mayannur. The Kannadipuzha has three sub-tributaries viz; Palar, Aliyarand and Uppar. Kalpathypuzha originates south of Coimbatore and flows roughly in an E - W trend. It has four sub-tributaries viz - Korayar, Varattar, Walayar and Malampuzha.

Topo analysis of the area has brought to light remarkable linear, consequent rivers of high orders in the Gap area, as compared to closely spaced, lower order streams of trellis, dendritic, obsequent and subsequent patterns of the hill ranges (Nageswara Rao & Srinivasan, 1980). The drainage pattern of the study area is given in Fig.6.4.

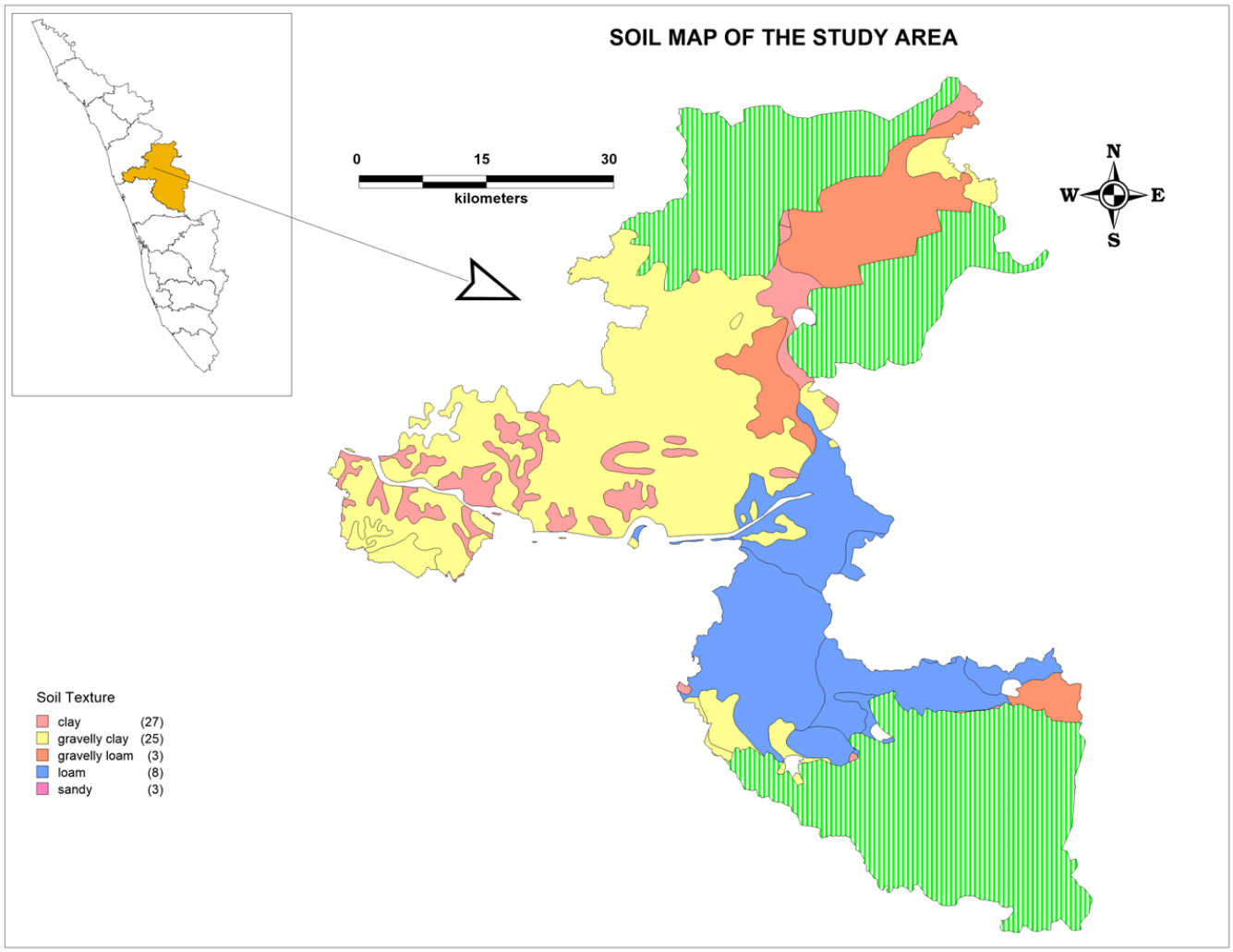


Fig.6.2: Soil map of the Study area

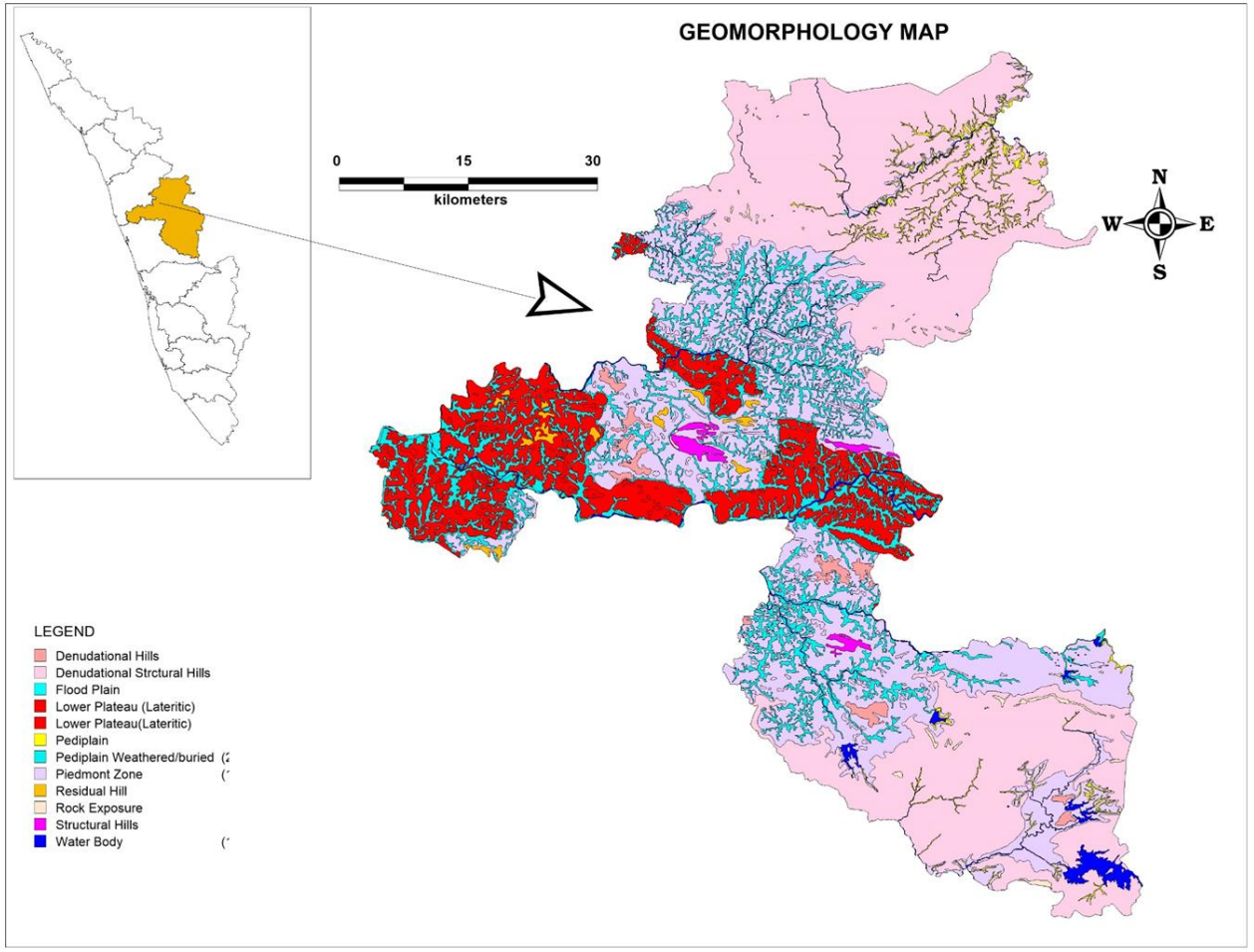


Fig.6.3: Geomorphology Map of the Study area

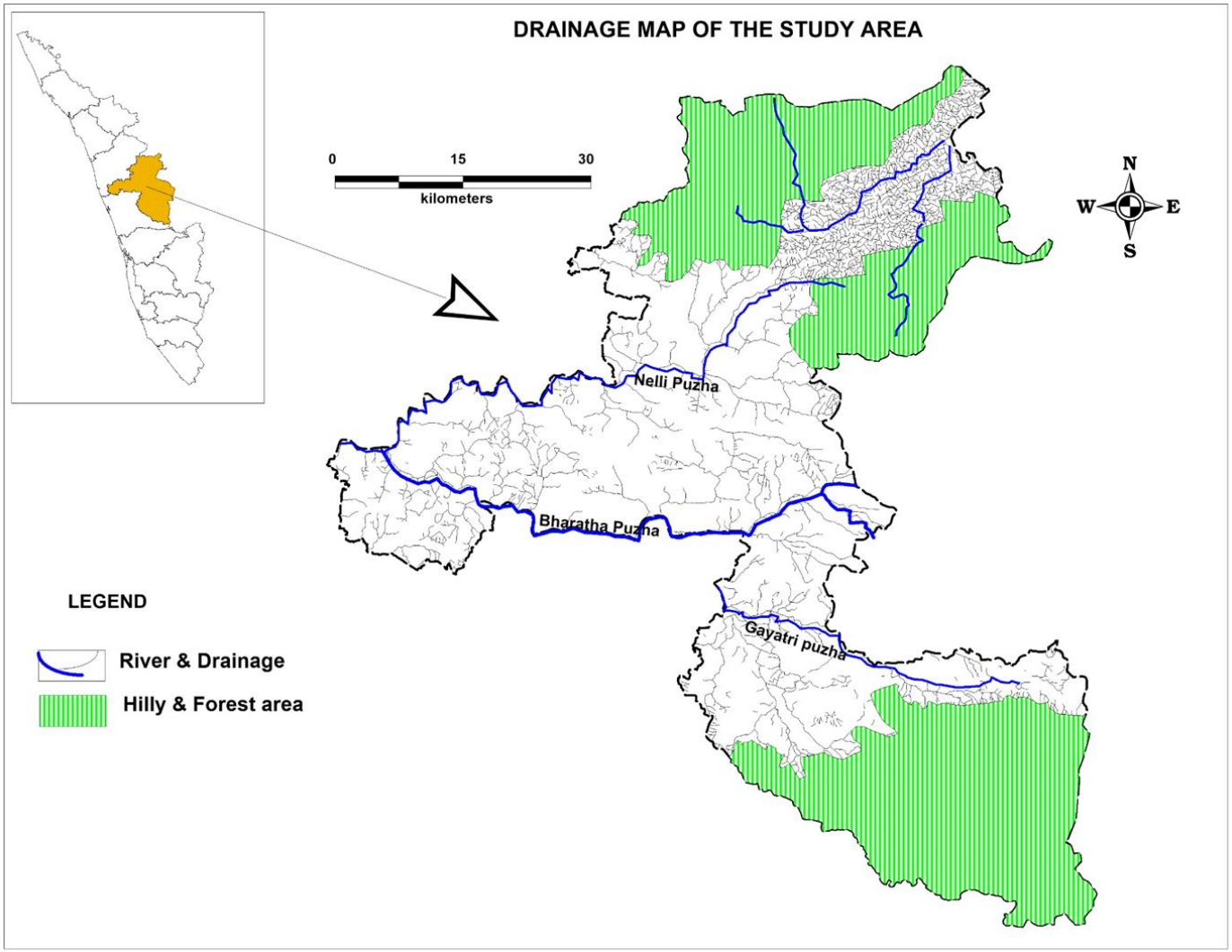


Fig.6.4: Drainage map of the Study area

6.1 The Weathered zone

6.1.1 Thickness of weathered zone

The Depth to weathering map was prepared on the basis of ground water exploratory drilling data of the study area. Two zones were identified in the hard rock terrain, one is weathered zone, occurring below the top soil or Laterite and extending to the depth of hard crystalline rocks. The thickness varies from 3 to 24 m bgl. The weathered thickness in the area vary highly as observed from exploratory drillings and the data have been used to decipher the lateral and vertical changes in weathered zone. The information from 81 bore wells have been analyzed for understanding the spatial variations in the thickness of weathered zone. The weathering thickness is relatively shallow in the southern part & Hill slope of the area. The deep weathering depth is observed from the central and north eastern part of the study area, are highly shattered by the shear zones of Palakkad-Cauvery & Bhavani shear zones. The depth to weathering map is given in Fig.6.5 & the variation of weathered thickness and 3d views are given in Fig.6.5 (a) & (b).

6.1.2 Water levels

Measurements of water levels in wells provide the most fundamental indicator of the status of groundwater resource and are critical to meaningful evaluation of the quantity of ground water and its interaction with surface water. It fosters a more comprehensive and systematic approach to the long-term collection of these essential data. Water levels were monitored four times (April, August, November and January) during the field season from 71 dug wells of CGWB and 20 numbers of additional Key wells established. Premonsoon water level ranges from 2 to 12 bgl. The pre-monsoon water level map show that the eastern part is shallow water level and the western part of the area, the water level becomes deeper. The Post monsoon water level varies from 0 to 10 m bgl. Fluctuation of water level ranges from 0 to 7 m bgl, the fluctuation map shows that the central & southern part of the area the water level fluctuation is very less, in the western part, patches of area, water level fluctuation is high, due to the heavy withdrawal of ground water. The Phreatic aquifer water level data given in Table 6.2. The Premonsoon, Post-monsoon & water level fluctuation maps are given in Fig.6.6, 6.7 & 6.8.

The Water table elevation contour map is prepared by compiling the R.L value and the water level data. In the study area the ground water moving towards the center of the area from both the sides of mountainous regions and further moving towards west, along the faulted valley, by which the Bharathapuzha river flows and finally confluence with the Arabian Sea. The Water table elevation contour map is given in Fig.6.9.

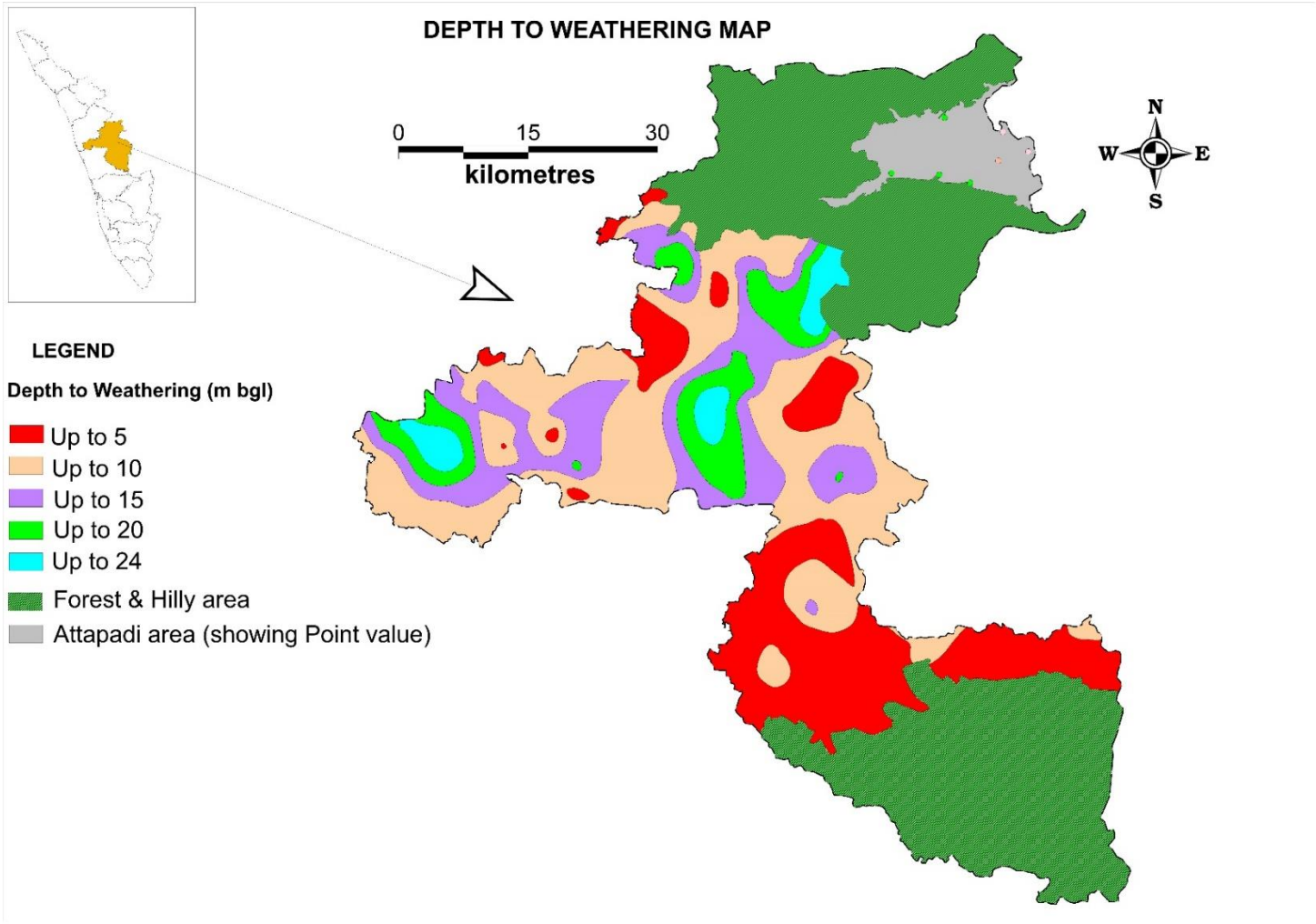


Fig.6.5: Depth to Weathering Map

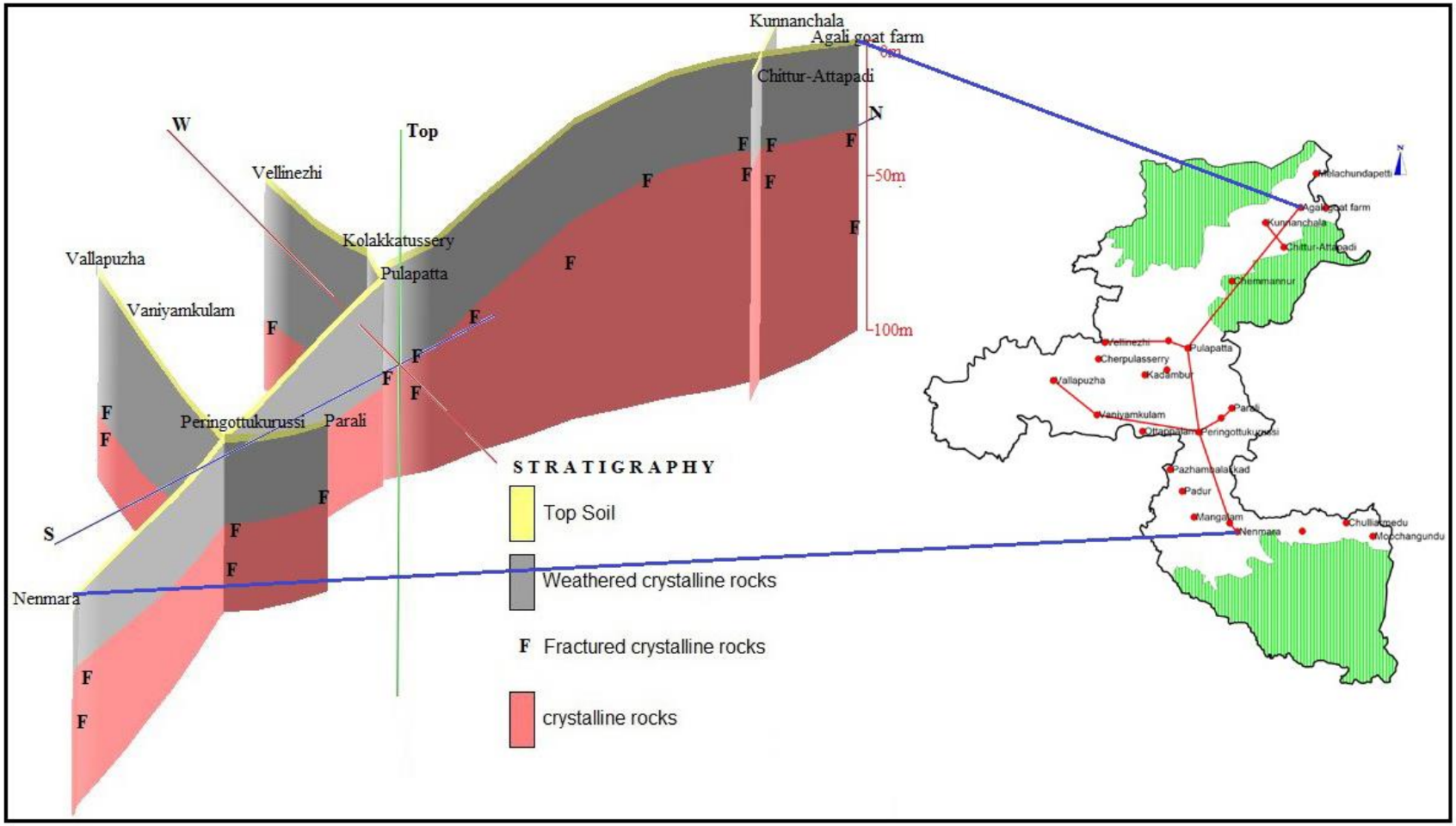


Fig.6.5 (a): lateral and vertical variations in weathered thickness

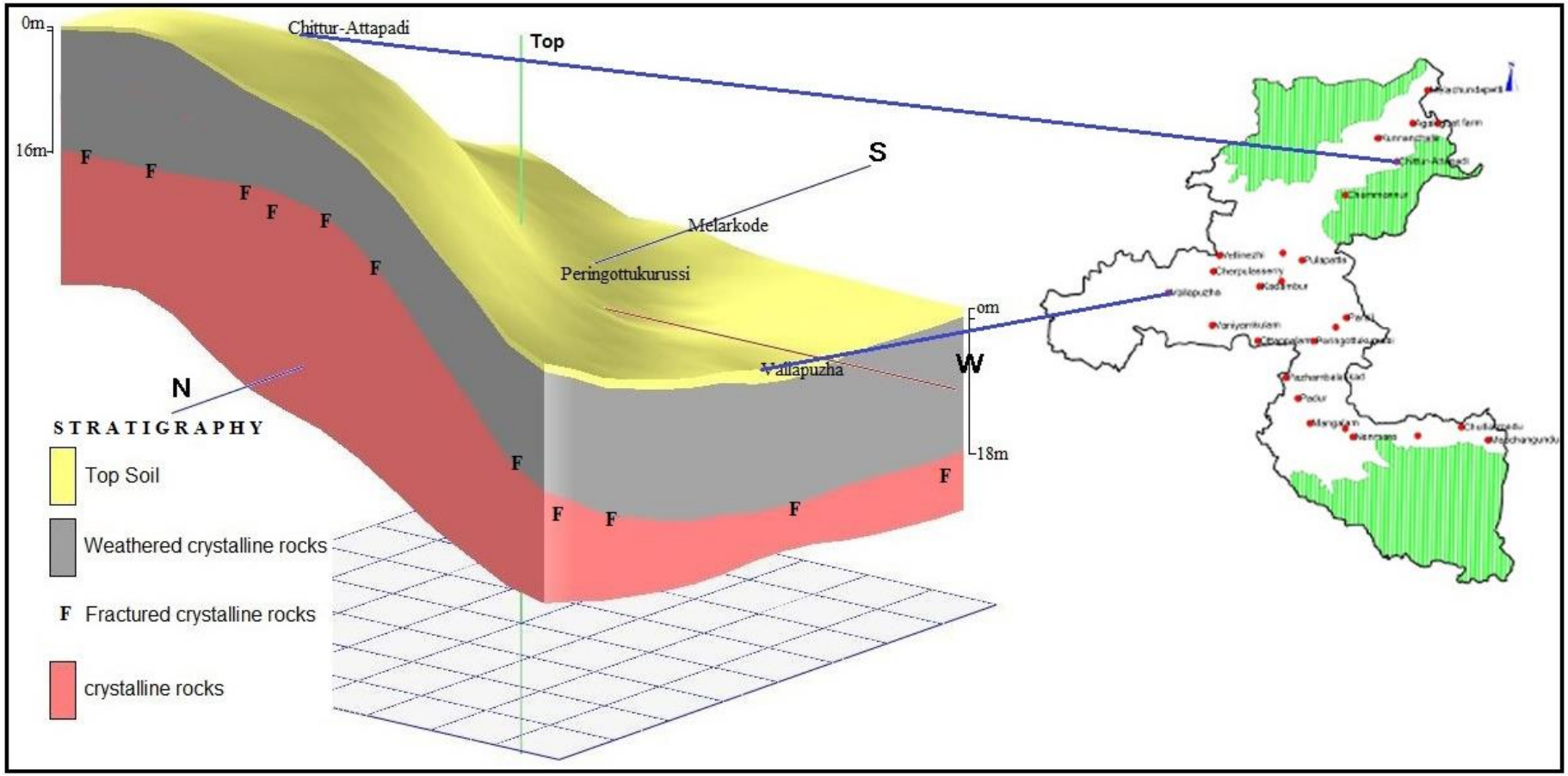


Fig.6.5 (b): 3D View of Weathered Crystalline & Crystalline rocks

Table 6.2: Water Level data of Phreatic Aquifer

#	Location	Longitude	Latitude	Pre-monsoon water level (m bgl)	Post monsoon water level (m bgl)
1	Adipararnda	76.57333	10.51972	06.60	05.30
2	Agali	76.64000	11.08800	09.70	09.35
3	Aalanallur	76.34722	11.0100	09.70	07.90
4	Alathur	76.55444	10.64556	08.46	05.81
5	Ambalapara	76.41056	10.8375	09.20	07.75
6	Anakatty	76.74611	11.11667	06.40	07.25
7	Ariyur	76.40208	10.98111	12.00	10.87
8	Athipotta	76.48139	10.6675	03.40	02.20
9	Bangalow kunnu	76.535	10.85389	09.55	08.55
10	Chalisseri	76.09361	10.73611	09.85	08.00
11	Chavadiyur	76.66667	11.1575	01.10	01.10
12	Chemmanampathi	76.83111	10.57361	10.50	10.20
13	Cherpulassery	76.32056	10.88611	09.23	09.55
14	Kakkupady	76.55444	11.06528	07.70	07.20
15	Kalladikode	76.53889	10.89389	10.30	09.15
16	Kanjirapuzha	76.53472	10.99972	04.90	01.50
17	Karimpuzha	76.41944	10.87306	02.95	03.60
18	Kadampazhipuram	76.45611	10.87278	04.15	03.95
19	Kodunthirapally	76.60611	10.76917	04.00	01.32
20	Kollenkode	76.69417	10.6125	04.80	02.95
21	Kongad	76.51444	10.85889	06.75	05.15
22	Koottanad	76.1175	10.76139	09.30	07.40
23	Koppam	76.18917	10.86583	06.00	05.60
24	Kottapuram	76.40889	10.9425	09.15	07.62
25	Kottathara	76.68917	11.13306	02.05	01.85
26	Kottasseri(Vattasseri	76.49944	10.86222	05.30	03.70
27	Kottayi	76.54333	10.76583	09.70	09.30
28	Kudallur	76.075	10.76556	07.70	05.70
29	Kumaramputtur	76.42778	10.98972	03.74	02.49
30	Kumaranallur	76.05806	10.78778	11.15	07.50
31	Lakkidi	76.33333	10.76111	08.75	08.00
32	Mankara	76.49694	10.78667	05.40	04.20
33	Mannarkkad	76.46722	10.99333	04.75	03.35
34	Mathur	76.57556	10.73917	05.35	03.25
35	Meenkara	76.80722	10.61389	09.50	07.90
36	Melarkode	76.56361	10.60778	07.62	07.20
37	Moochankundu	76.80417	10.58083	08.60	09.10
38	Mulayankavu	76.26556	10.86389	08.10	04.68
39	Muthalamada	76.76139	10.60389	07.18	07.58
40	Naikarapady	76.80889	11.12722	05.75	07.35
41	Nellikatteri	76.175	10.7667	09.40	08.60
42	Nenmara	76.60028	10.59389	03.82	01.95
43	Odannur	76.54556	10.7800	08.16	03.80
44	Ongallur	76.21944	10.80222	08.34	06.64
45	Ottapalam	76.3793	10.771	08.45	06.28
46	Padur	76.47389	10.65778	07.05	04.92
47	Palamattom	76.50528	10.99583	08.50	07.20
48	Palappuram	76.41778	10.76972	09.45	07.97
49	Parali	76.56556	10.79389	03.40	01.90
50	Pattambi	76.18639	10.80444	07.35	04.00

51	Peringode	76.12583	10.74111	09.23	07.75
52	Peringottukurussi	76.50472	10.75583	06.05	05.30
53	Pullundassery	76.4525	10.86333	03.40	04.30
54	Punchapadam	76.41861	10.88111	07.35	05.30
55	Shoranur	76.27417	10.76833	12.35	10.35
56	Sreekrishnapuram	76.42	10.92028	09.02	08.22
57	Tachanattukara	76.34694	10.96889	12.02	10.77
58	Thannirkod	76.07833	10.77222	08.45	07.55
59	Thavalam	76.58139	11.08472	06.08	06.03
60	Tenkara	76.49222	11.0125	02.60	01.40
61	Tachanpara	76.50694	10.95917	03.30	02.00
62	Thirumattacode	76.1742	10.7522	06.40	06.20
63	Thiruvegapuram	76.12694	10.87417	09.24	11.05
64	Tholanur	76.50764	10.71667	04.55	03.70
65	Trithala	76.12833	10.80306	06.30	05.15
66	Vadakkanchery	76.48361	10.59222	05.40	03.50
67	Vadanakurussi	76.25236	10.78667	06.40	03.40
68	Vallapuzha	76.25	10.83889	06.75	03.00
69	Vaniyamkulam	76.32833	10.78222	07.50	05.70
70	Vattalukki	76.72417	11.12889	07.00	11.90
71	Vilayur	76.18972	10.89278	07.01	05.00

Table 6.2 (a): Water Level data of Phreatic Aquifer (Key wells)

#	Location	Lo.tude	La.tude	Pre_Mon 2016	Post_Mon 2016
1	Kandamangalam	76.41631	11.03586	04.90	03.10
2	Puttanikkadu	76.40336	11.01283	11.80	09.80
3	Parapuram	76.3795	11.00764	10.60	09.05
4	Thiruvizhamkunnu	76.37056	11.03494	12.00	08.00
5	Kottapadam	76.3935	10.99625	07.00	03.85
6	Kodanadu	76.39083	10.94667	10.50	06.25
7	Kottapllam	76.35111	11.06028	07.00	03.56
8	Churikkode	76.36722	11.06111	12.00	06.87
9	Annanthodi	76.35833	10.97	11.00	05.56
10	Anamoozhi	76.50889	11.02867	04.50	02.71
11	Kanjiram	76.51314	11.00425	05.30	02.14
12	Pudukkad	76.53528	10.94406	05.40	03.14
13	Ponnamkode	76.51389	10.94194	09.60	04.56
14	Karakurussi	76.49278	10.93194	04.80	02.17
15	Kallamparambu	76.45	10.89128	13.00	08.21
16	Adaikkaputhur	76.34917	10.88694	15.00	09.25
17	Vellinezhi	76.34083	10.90194	08.60	03.65
18	Amayur	76.18861	10.83722	08.00	02.98
19	Kavalapara	76.2975	10.77556	04.50	01.58
20	Ananganadi	76.34667	10.82694	08.00	03.65
21	Kalluvazhi	76.39111	10.87194	09.80	03.78
22	Kanjikulam	76.54944	10.87694	04.80	02.68

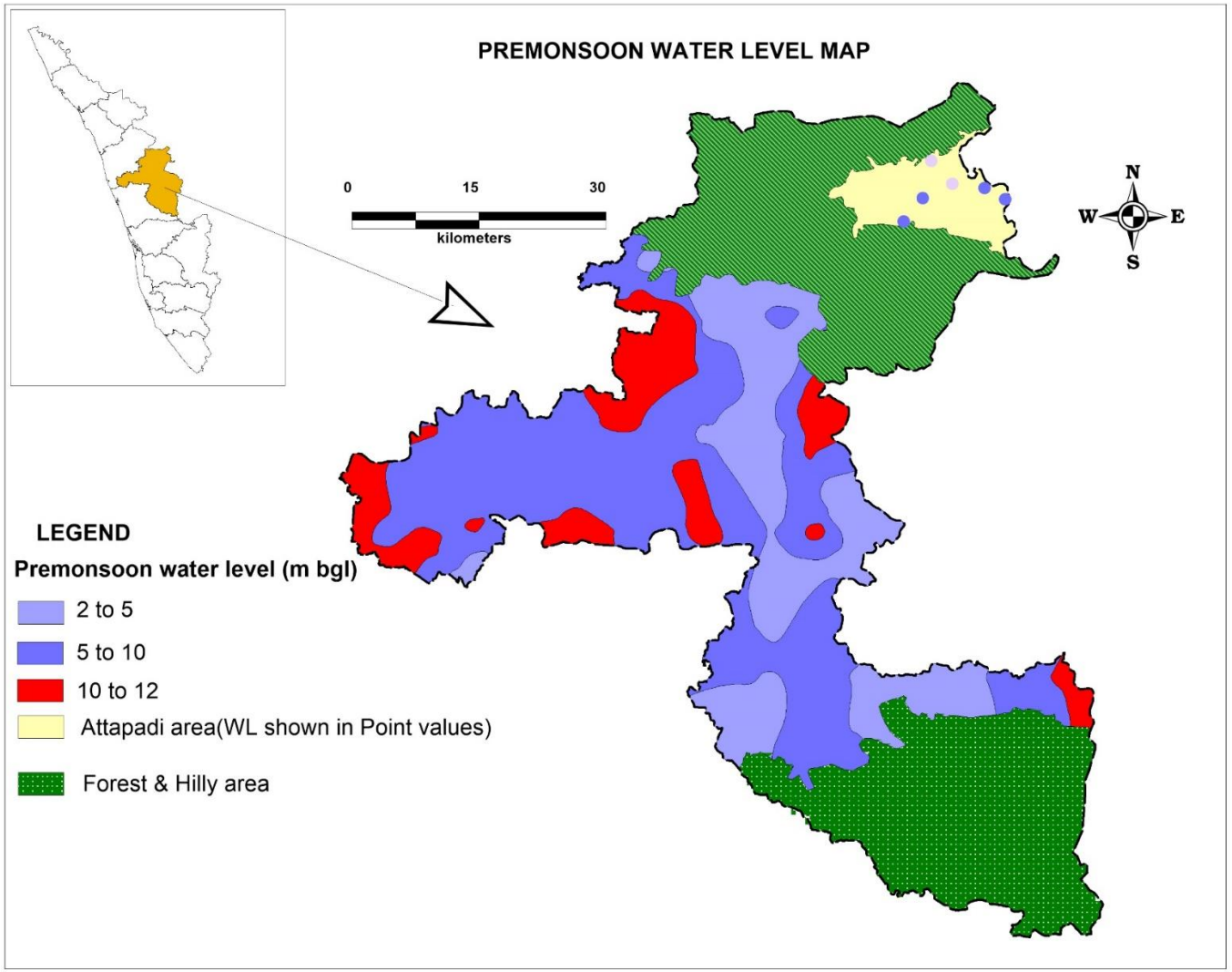


Fig.6.6: Pre-monsoon Water level Map (April 2016)

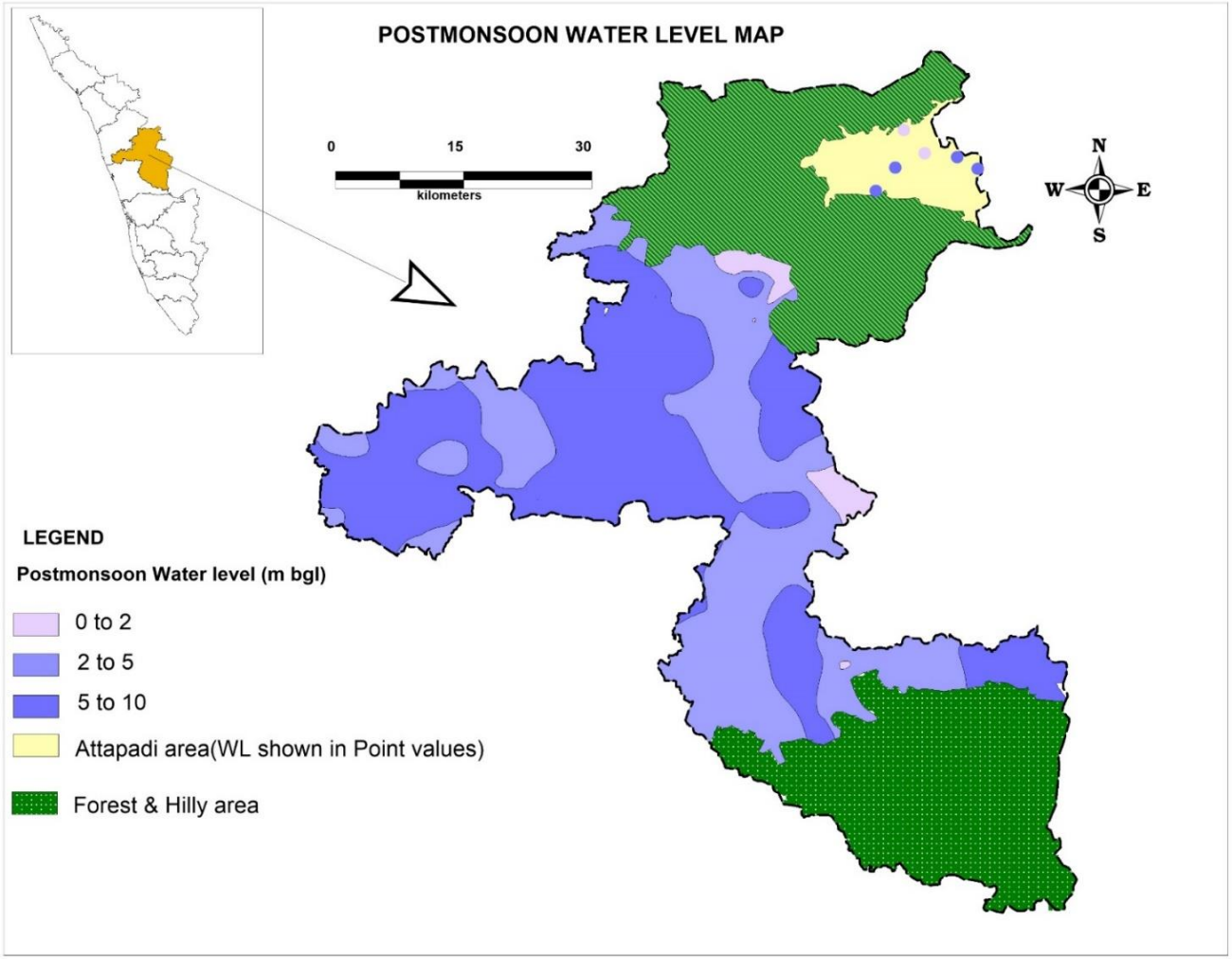


Fig.6.7: Post-monsoon Water Level Map (Nov: 2016)

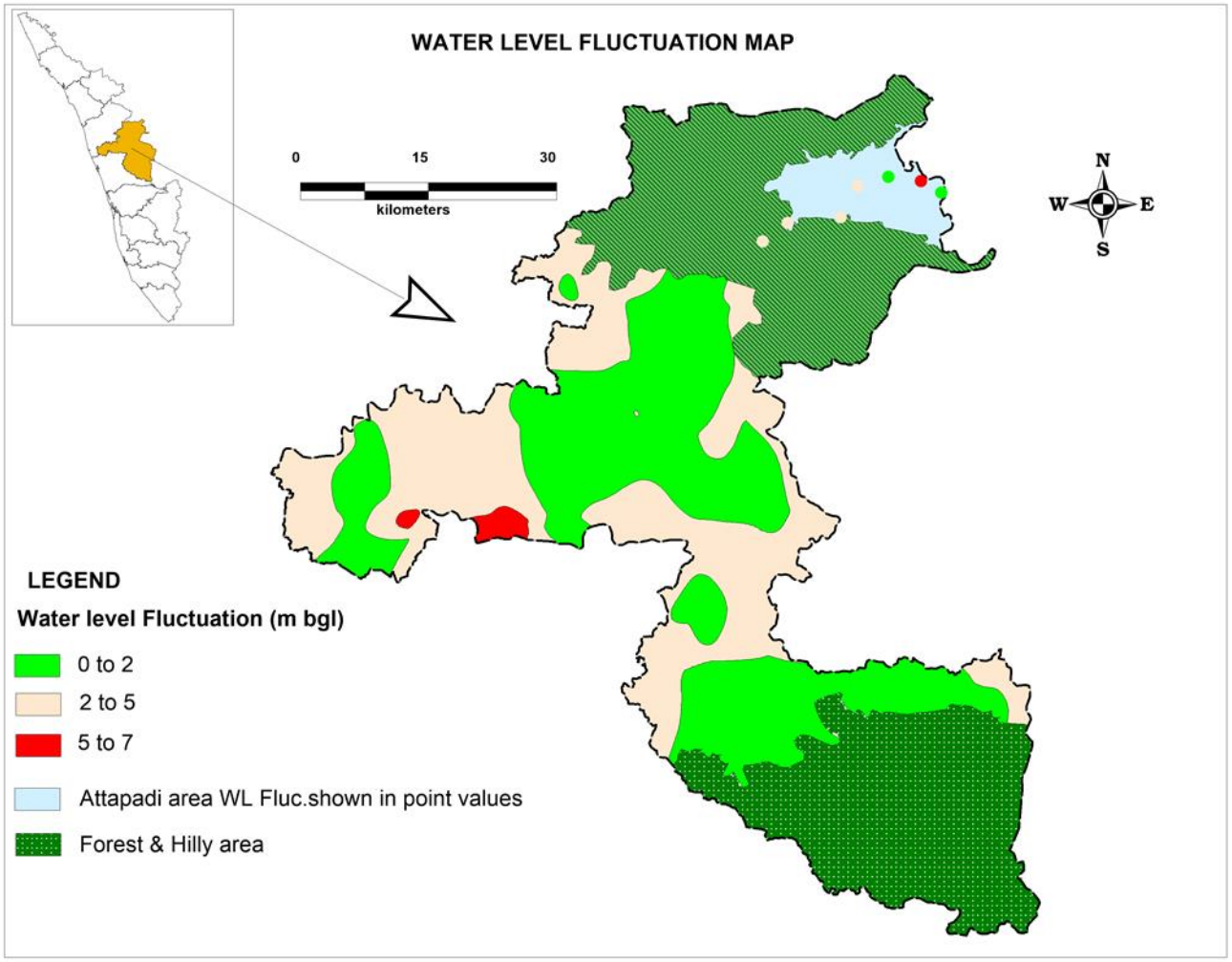


Fig.6.8: Water Fluctuation Map

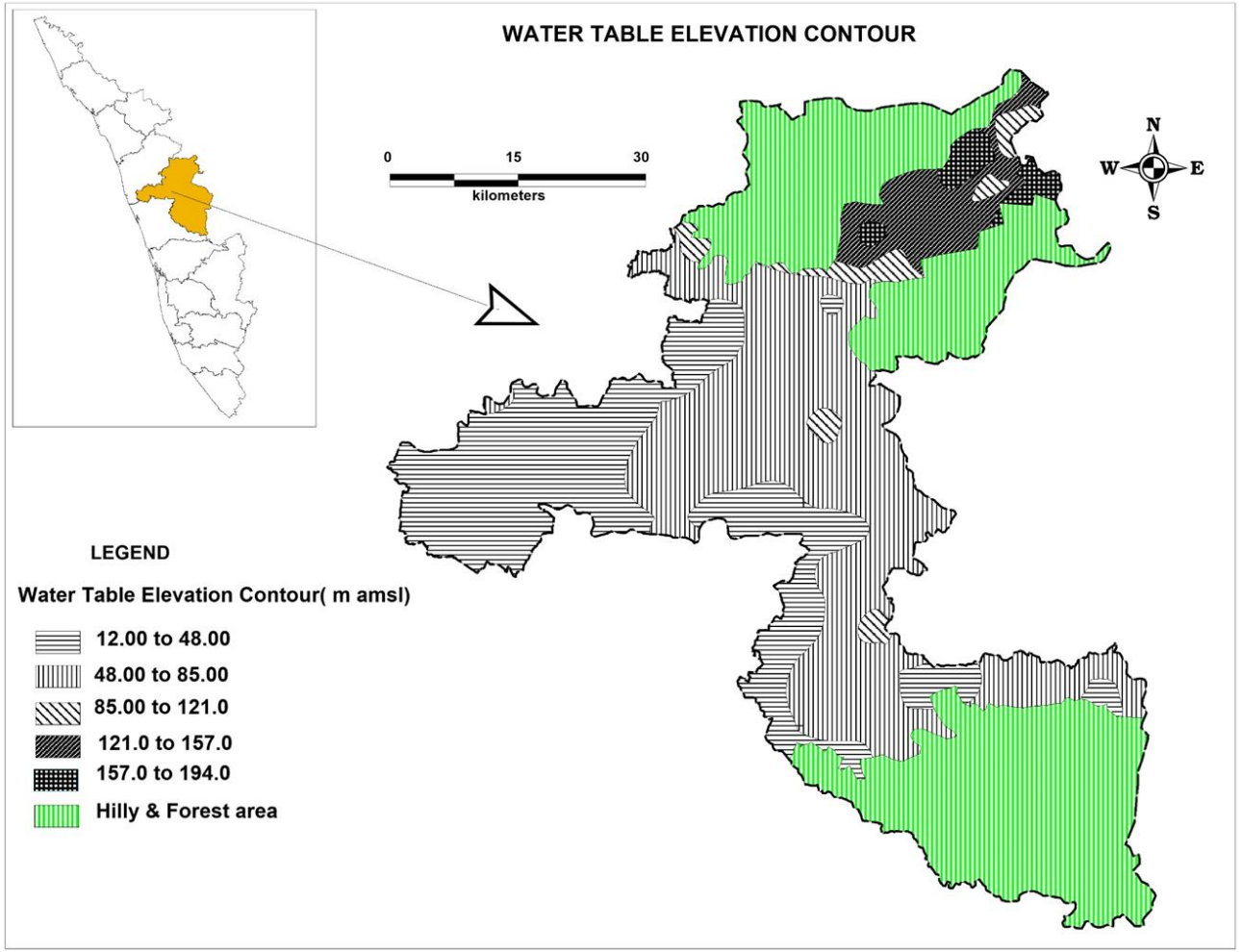


Fig.6.9: Water Table Elevation Contour Map

6.1.3 Saturated thickness of the weathered zone

In the study area the Phreatic Aquifer thickness varies depends on depth to weathering, rainfall & nearness to the water bodies like bond, river & canal etc. Majority of the area, the aquifer thickness is 2 – 5 m during the time of premonsoon as well as in post-monsoon also, In patches of area located along the river, the saturated thickness is 5 – 10 m in Post monsoon and 5 – 8 m in pre monsoon, but in parts of Kollengode, Alathur, Pattambi, Thirthala & Ottapalam blocks the saturated thickness in premonsoon period is 0 – 2 m, so there is a scope for artificial recharge. The aquifer thickness maps are given in Fig.6.9A & 6.10.

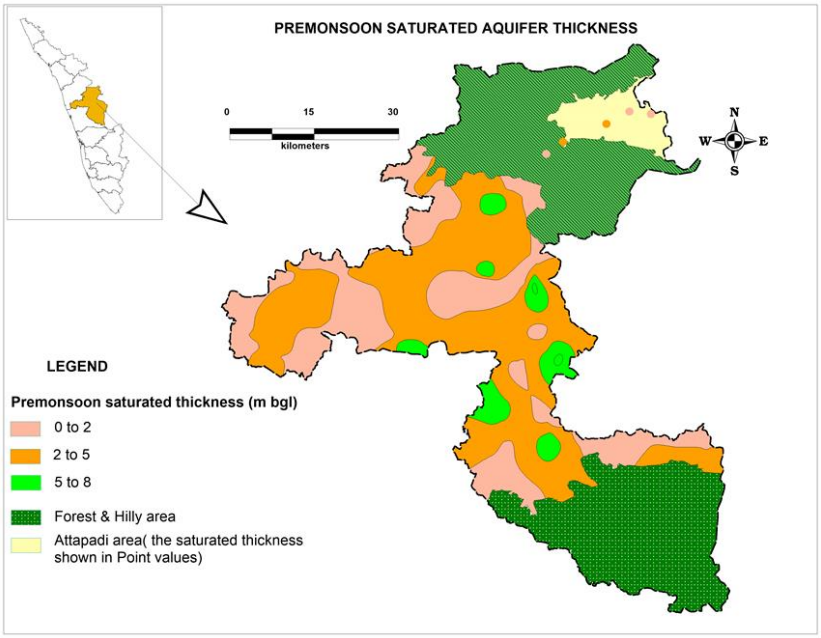


Fig.6.9A: Premonsoon Aquifer thickness

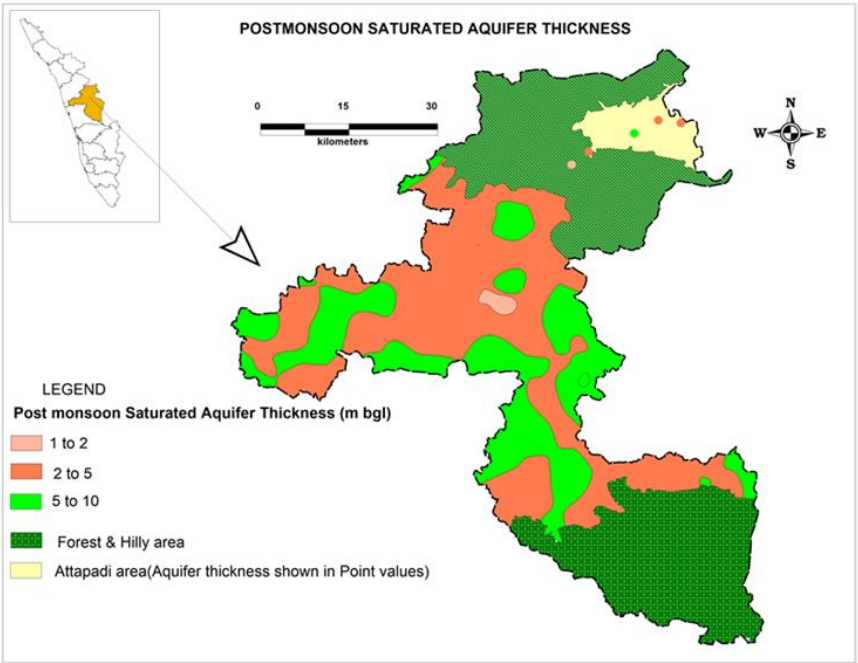
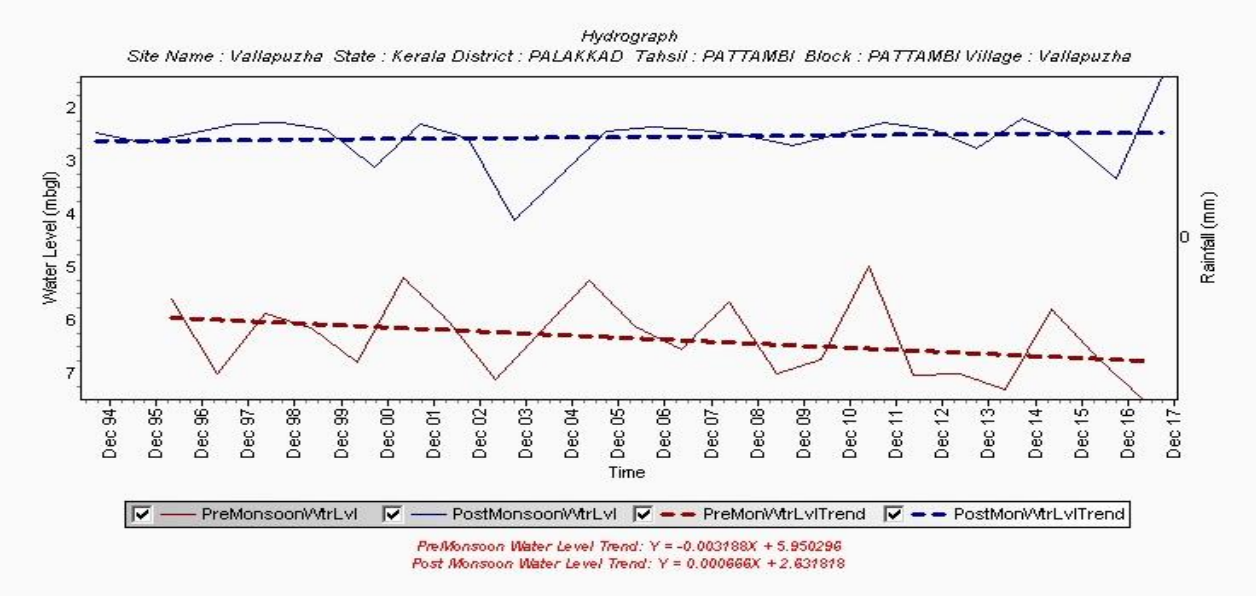
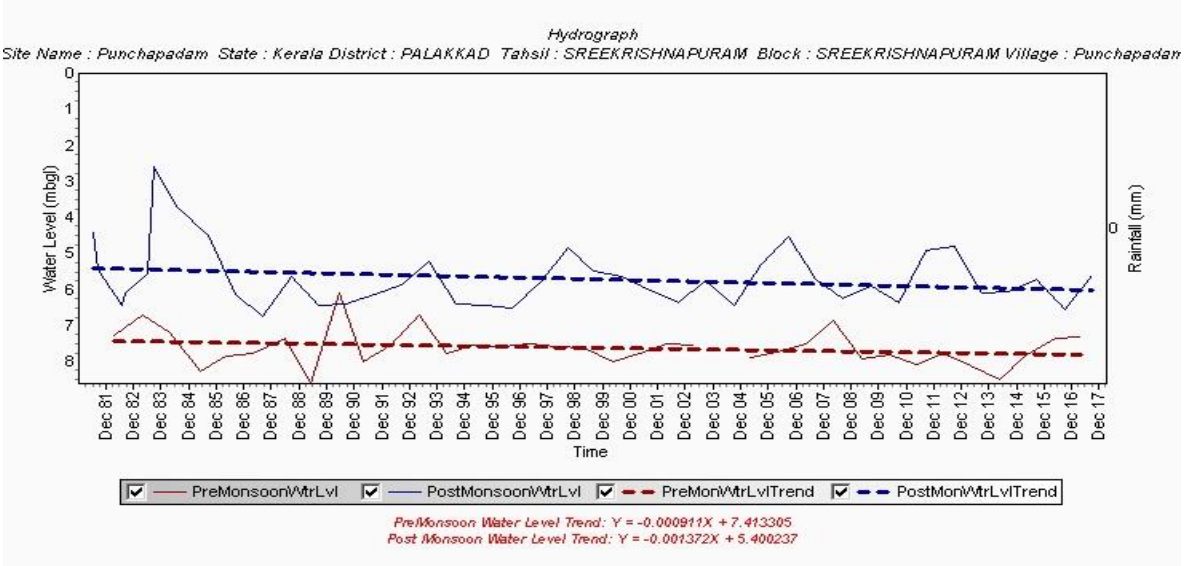


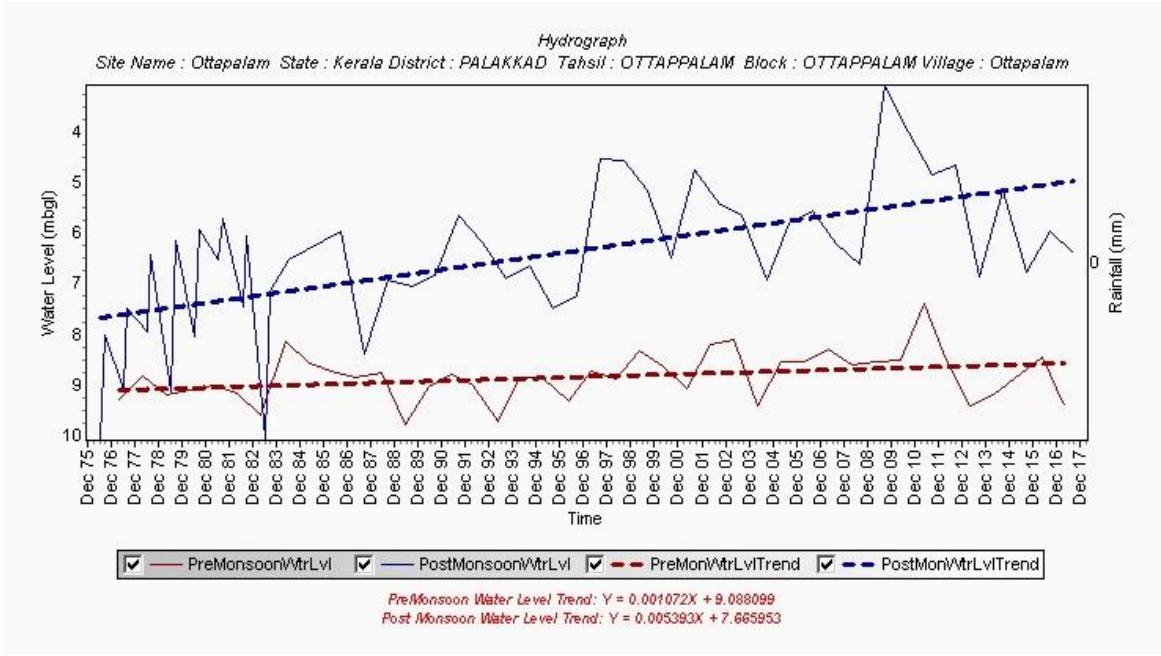
Fig.6.10: Post monsoon Aquifer thickness

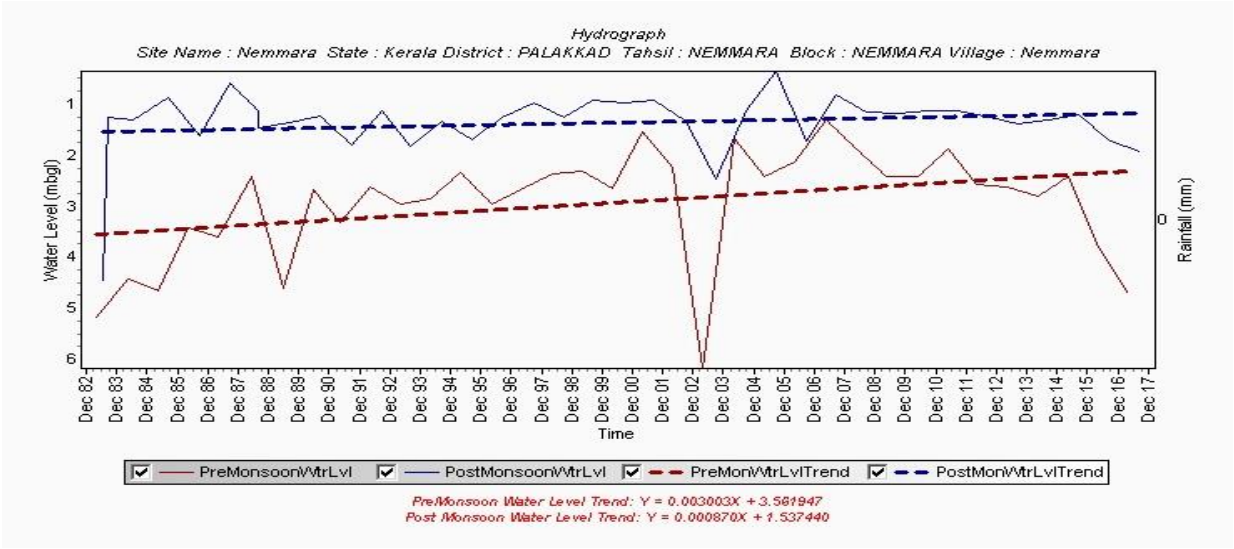
6.1.4 Water level trend

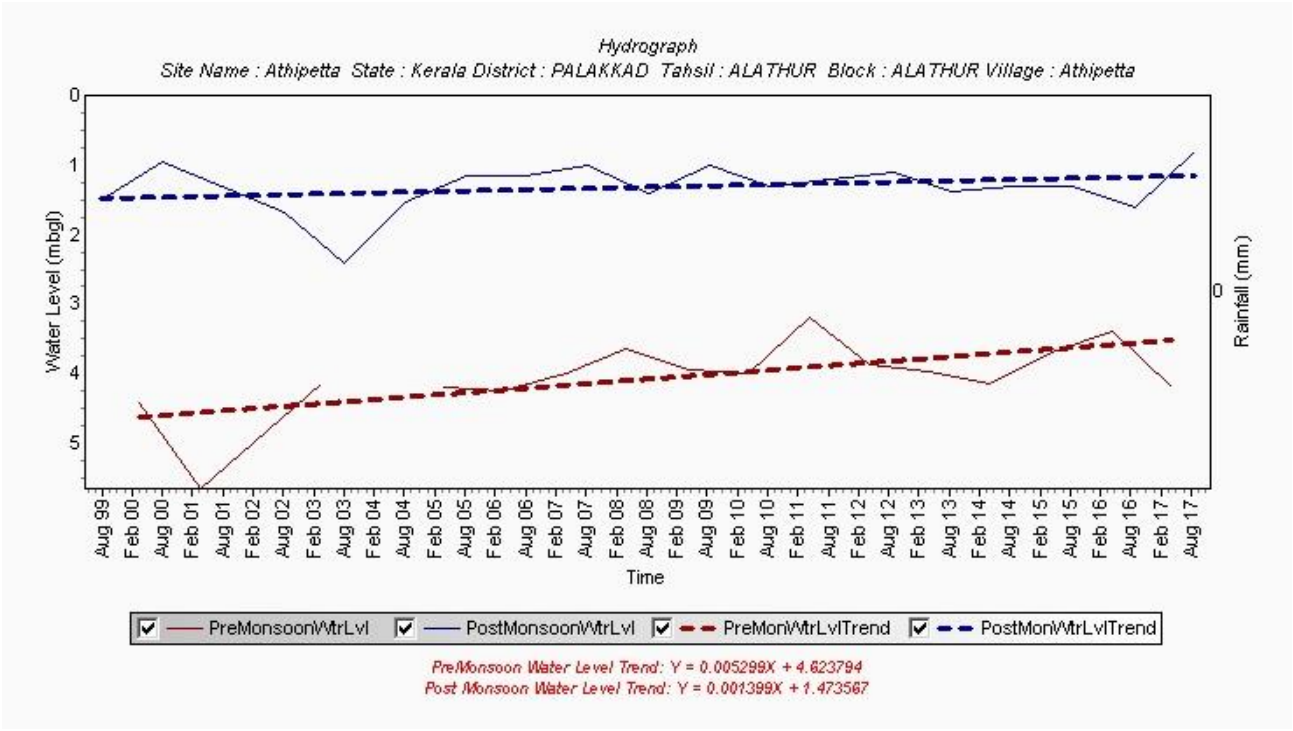
The long-term water level trend data is very much useful for sustainable development, ground water management ect. The 36 number of Hydrographs were taken into analysis. In the central part of the study area shows falling trend, the southern part & western part normally shows rising trend. Some important Hydrographs are given in Fig.6.11 & Pre-monsoon & post-monsoon trend line maps are given in Fig.6.11 (a).

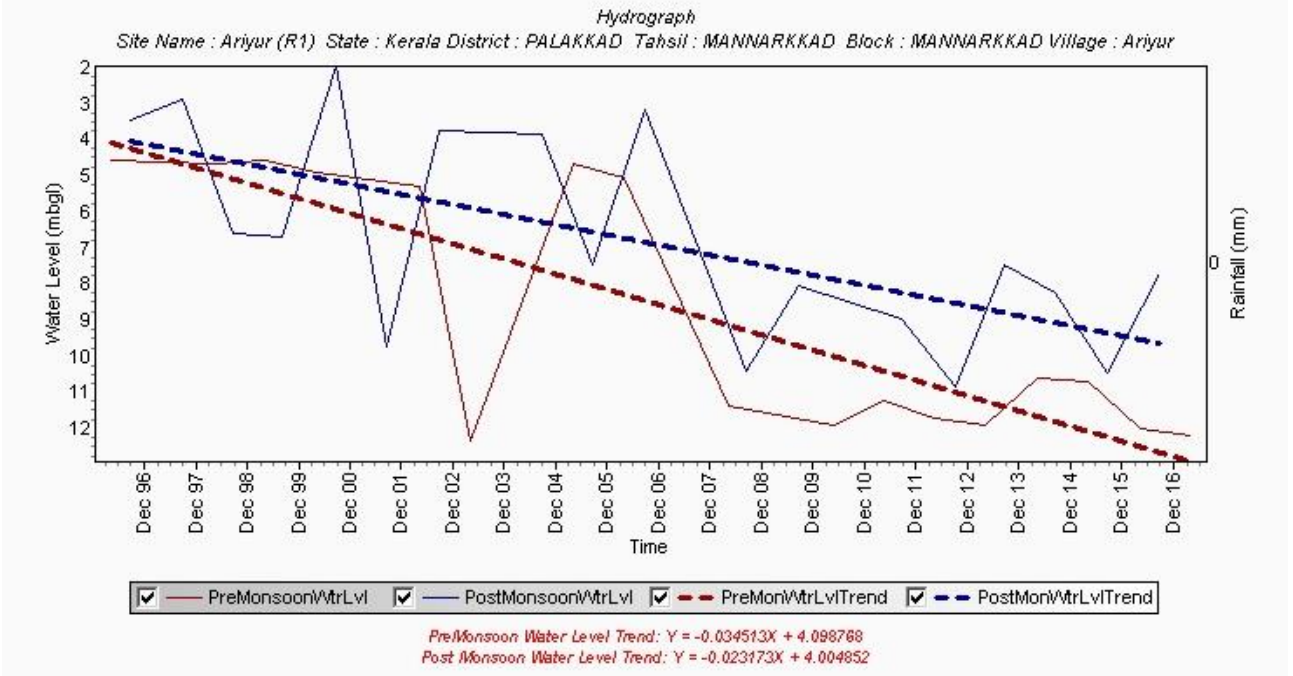


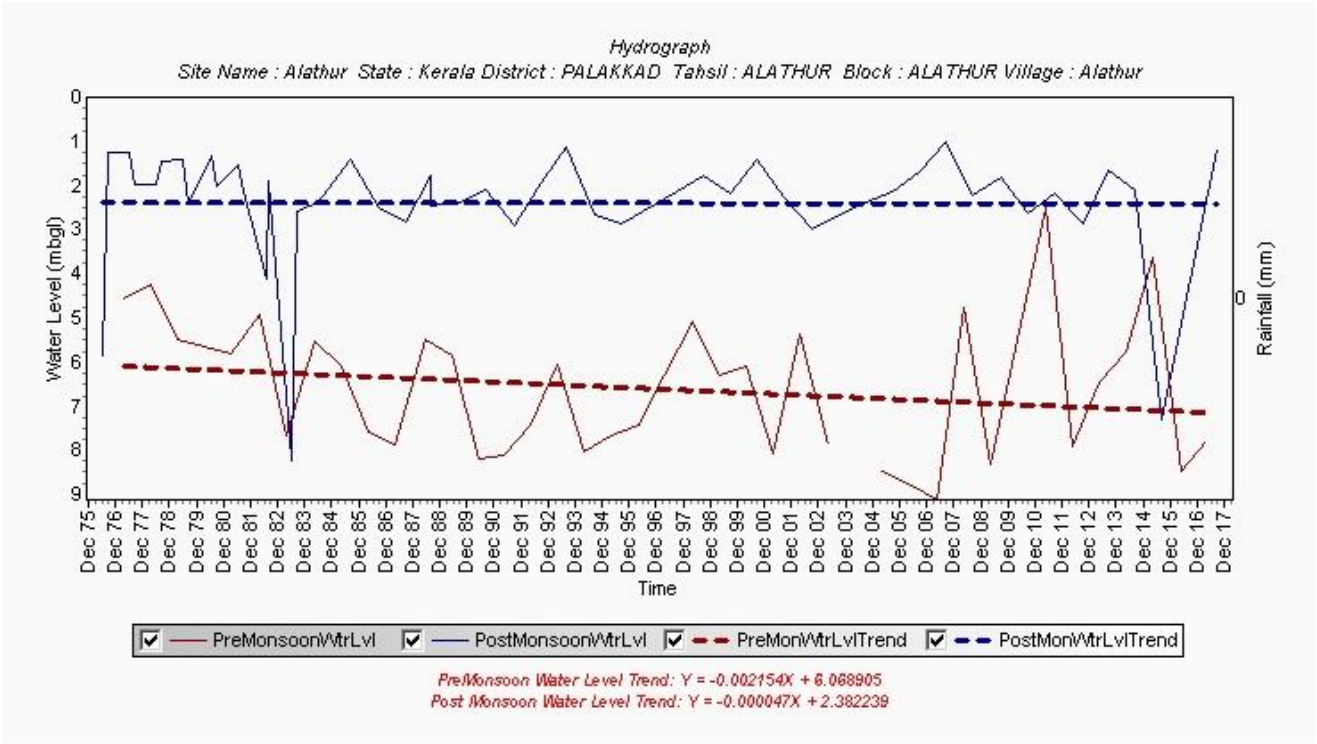


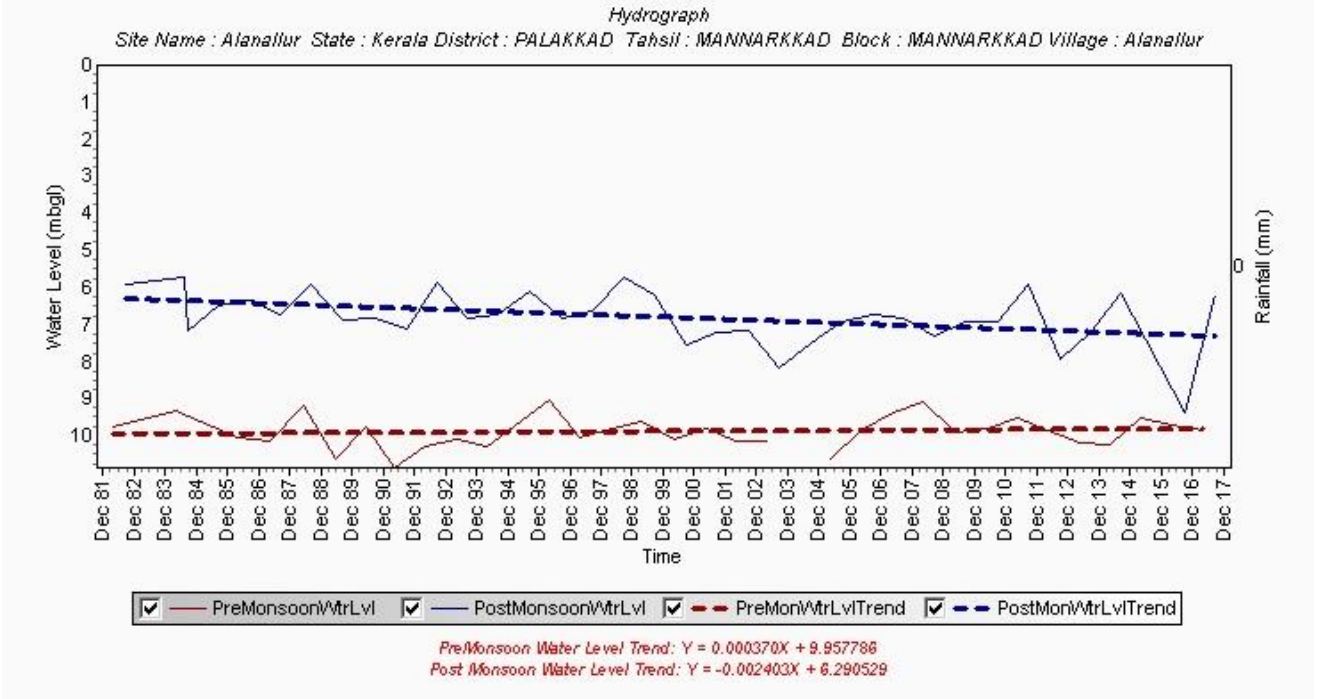

Hydrograph
Site Name : Ottapalam State : Kerala District : PALAKKAD Tahsil : OTTAPPALAM Block : OTTAPPALAM Village : Ottapalam
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMoniWtrLvlTrend
PostMoniWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.001072X + 9.088099
Post Monsoon Water Level Trend: Y = 0.005393X + 7.665953


Hydrograph
Site Name : Nemmara State : Kerala District : PALAKKAD Tahsil : NEMMARA Block : NEMMARA Village : Nemmara
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMoniWtrLvlTrend
PostMoniWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.003003X + 3.561947
Post Monsoon Water Level Trend: Y = 0.000870X + 1.537440


Hydrograph
Site Name : Athipetta State : Kerala District : PALAKKAD Tahsil : ALATHUR Block : ALATHUR Village : Athipetta
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.005299X + 4.623794
Post Monsoon Water Level Trend: Y = 0.001399X + 1.473567


Hydrograph
Site Name : Ariyur (R1) State : Kerala District : PALAKKAD Tahsil : MANNARKKAD Block : MANNARKKAD Village : Ariyur
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.034513X + 4.098768
Post Monsoon Water Level Trend: Y = -0.023173X + 4.004852


Hydrograph
Site Name : Alathur State : Kerala District : PALAKKAD Tahsil : ALATHUR Block : ALATHUR Village : Alathur
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.002154X + 6.068905
Post Monsoon Water Level Trend: Y = -0.000047X + 2.382239


Hydrograph
Site Name : Alanallur State : Kerala District : PALAKKAD Tahsil : MANNARKKAD Block : MANNARKKAD Village : Alanallur
Water Level (mbgl)
Raintall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.000370X + 9.957786
Post Monsoon Water Level Trend: Y = -0.002403X + 6.290529

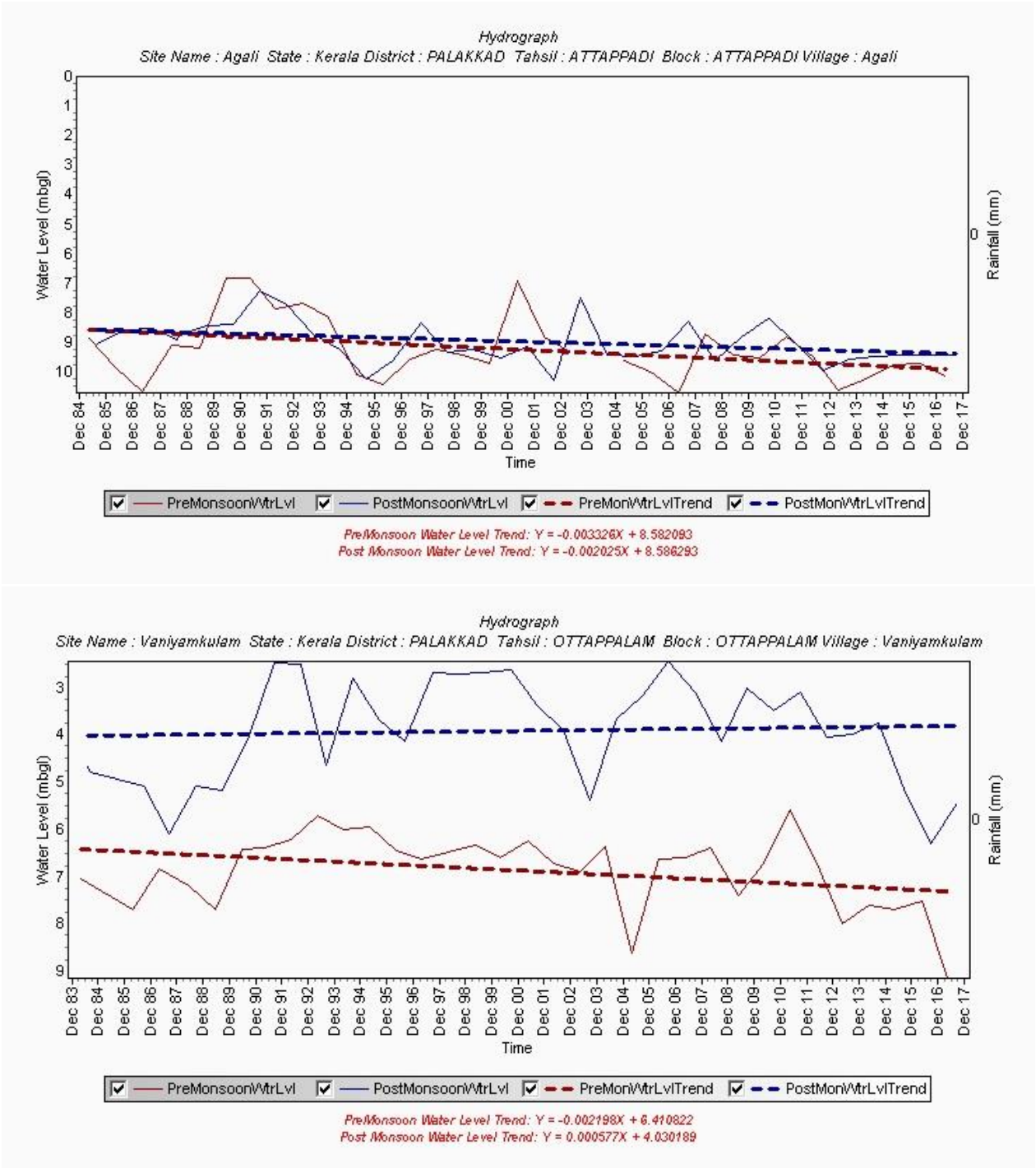


Fig.6.11: Hydrographs for the Monitoring stations in the study area

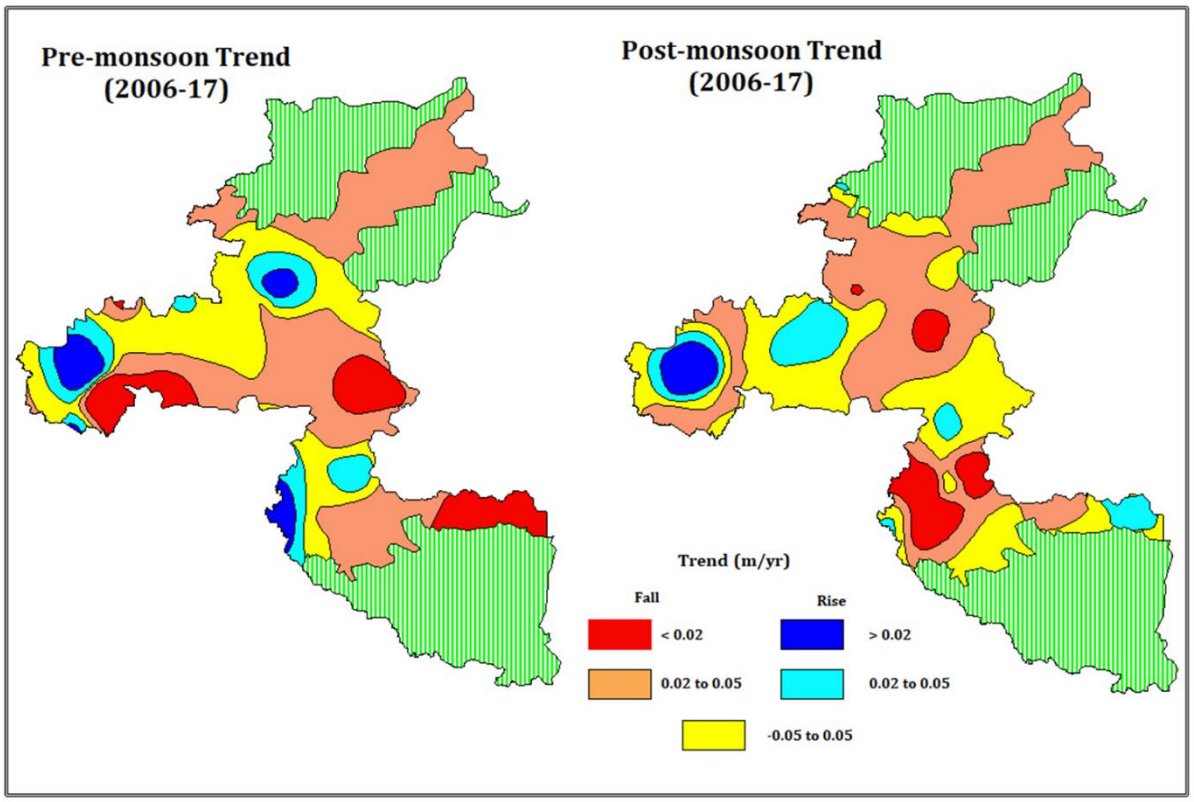


Fig.6.11: (a) Pre-monsoon & Post monsoon water level trend

6.1.5 Groundwater resources:

The phreatic aquifers are major sources for irrigation and drinking water in the area. Groundwater draft for irrigated agriculture in the area has been high and depletion in the resource is observed over the years. Any decision about future utilizations depend on having a clear understanding of the status of the resource, the amount that has already been extracted, the amount remaining, and the impact of further depletion. The dynamic groundwater resources in the area are estimated based on the methodology proposed by Groundwater Estimation Committee (GEC 1997 methodology).

In this study the area under command and non-command could not be separated mainly due to non-availability of data pertaining to canal command areas of the State. Further, the irrigation projects of Kerala are mostly planned for irrigating paddy along the topographic lows and as such the irrigation canals are all centre controlled. Hence in each unit there are large areas along the upstream side of the canal, which do not get benefits of surface water irrigation. Due to the highly undulating topography of the mid land area where most of the canals exist, it is quite difficult to accurately demarcate the areas under command and non-command. In view of the factors mentioned above, the computations have been made by taking all assessment units as non-canal command area. The recharge from canal segments and return seepage from irrigation due to surface water in the command area have, however, been incorporated into the computations.

Ground water Draft

Ground water draft in the study area is mainly for irrigation and domestic uses. In view of the non-availability of data on the number of wells being used for domestic purposes, the ground water draft for domestic uses has been computed block-wise on the basis of 2011 population, projected to the year of assessment (2013). Domestic requirement of water in the study area has been computed as the product of the population and the per-capita water requirement (assumed as 150 L/day/person). The share of ground water in the requirement has been computed as a percentage varying from 25 to 100%, arrived at on the basis of availability of surface water sources for domestic water supply.

The ground water draft has been computed from the data on the block-wise number of irrigation wells collected by the State Ground Water Dept., Government of Kerala. The ground water draft figures are arrived at by multiplying the number of wells with the corresponding unit draft. The Annual Ground Water Draft for all uses in the study area is 54.37 MCM. The block wise resource estimation date is given in Table No: 6.3

Table No 6.3: Ground water resources of the study area

Assessment Year		**2013**							
#	**Block**	**Command/non-Command/ Total**	**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 use up to 2025**	**Net Ground Water Availability for future irrigation development (10-11-14)**	**Stage of Ground Water Development {(13/10) * 100} (%)**
1	2	3	10	11	12	13	14	15	16
1	Alathur	Non-Command	7714.98	2267.39	1260.18	3527.67	1370.73	3615.17	48.64
2	Attappadi	Non-Command	4427.96	753.64	268.01	1021.65	291.43	3382.89	23.07
4	Kollengode	Non-Command	6590.65	1701.35	656.05	2357.40	711.54	4177.76	35.77
5	Kuzhalmannam	Non-Command	7313.51	1271.68	945.11	2216.79	949.41	5092.41	30.31
7	Mannarkkad	Non-Command	5333.72	807.66	1425.00	2232.66	1546.97	2979.09	41.86
8	Nenmara	Non-Command	2706.80	1154.55	614.58	1769.13	126.97	**883.96**	65.36
9	Ottappalam	Non-Command	3226.65	799.47	910.67	1710.14	990.25	1436.93	53.00
10	Palakkad	Non-Command	6529.25	968.96	1451.48	2420.44	1562.44	3997.84	37.07
11	Pattambi	Non-Command	4801.48	2521.12	1540.41	4061.53	1675.03	**605.34**	84.59
12	Sreekrishnapura	Non-Command	3275.85	915.26	964.98	1880.24	971.02	1389.57	57.40
13	Thrithala	Non-Command	2597.90	713.62	1004.22	1717.84	1126.75	**757.52**	66.12
	Total (ha.m)	**Non-Command**	**54518.75**	**14019.40**	**11121.09**	**25140.49**	**11409.54**	**28548.48**	**54.31**
	Total (MCM)	**Non-Command**	**545.19**	**140.19**	**111.21**	**251.40**	**114.09**	**285.48**	**54.31**

6.1.6 Quality of water in the weathered zone

The existing water quality data from the dug wells has been analyzed for extracting information on regional distribution of water quality and their suitability for various uses. In a groundwater flow regime water chemistry constantly undergoes modification due to various processes such as dissolution of minerals, precipitation of dissolved ions under unstable conditions, cation exchange etc. The hydrochemical evolution along the flow paths are significantly altered under anthropogenic interferences and consequent pollution of aquifer systems (Drever, 1982; Langmuir, 1997; Abu-Jabeer, 2001; Singh et al, 2007). The effects of pollution in the flow system can easily be identified from a comparison of dissolved ions and ion ratio studies in simple terms (Hem, 1985).

The chemical quality of the study area is generally good, except some pockets of area particularly in parts of Kollenkode, Palakkad and Attapadi blocks the E.C values are above 800 to 1550 us/cm at 25^{o}C and the Fluoride value is maximum up to 1.5 mg/L. The Chemical quality data is given in Table No. 6.4 & the map is given in Fig.6.12.

Table No 6.4: Quality Monitoring data for Phreatic Aquifer (April 2016)

#	Location	$CaCO_3$	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl	F	NO_3	pH	EC in us/cm at 25°C
1	Adiparanda	86.00	15.00	12.00	15.00	04.90	0	161.0	05.00	21.00	0.44	00.18	8.08	260
2	Agali	190.0	58.00	11.00	87.00	04.30	18	92.00	59.00	167.0	0.72	41.00	8.51	830
3	Alanallur	44.00	10.00	04.40	20.00	06.80	-	-	10.00	44.00	0.46	04.60	9.77	230
4	Alathur	290.0	70.00	28.00	47.00	03.60	0	195.0	40.00	149.0	0.66	00.87	8.03	800
5	Chalisseri	28.00	10.00	00.49	18.00	04.20	0	20.00	01.00	31.00	0.10	24.00	7.95	183
6	Chavadiyur	265.0	46.00	37.00	47.00	02.50	0	378.0	21.00	36.00	0.66	45.00	8.13	680
7	Chemmampathi	485.0	102.0	56.00	108.0	37.00	0	420.0	33.00	270.0	0.54	26.00	8.28	1510
8	Cherpulassery	52.00	13.00	04.90	28.00	25.00	0	117.0	09.00	51.00	0.06	04.80	7.98	330
9	Kalladikode	12.00	03.20	00.97	12.00	07.10	0	04.90	01.50	16.00	0.32	13.00	7.46	92.0
10	Karimpuzha	08.00	03.20	traces	05.20	00.60	0	12.00	02.00	10.00	0.74	02.00	7.60	52.0
11	Kollengode	400.0	102.0	35.00	134.0	10.00	54	476.0	76.00	156.0	1.48	11.00	8.45	1340
12	Koppam	52.00	12.00	05.40	29.00	03.00	0	41.00	01.00	53.00	0.72	21.00	7.78	270
13	Kumaramputhur	28.00	09.60	00.97	07.70	00.50	0	49.00	01.00	11.00	0.94	04.30	7.73	97.0
14	Kuzhalmannam	230.0	58.00	21.00	73.00	07.40	0	250.0	62.00	89.00	0.92	04.80	7.70	720
15	Mankara	82.00	17.00	09.70	25.00	05.60	0	105.0	23.00	37.00	0.40	06.80	7.98	280
16	Mannarghat	122.0	38.00	06.80	31.00	11.00	0	122.0	21.00	58.00	0.34	54.00	7.80	400
17	Nenmara	260.0	92.00	07.30	42.00	07.30	0	336.0	27.00	75.00	0.70	19.00	7.89	670
18	Ottapalam	62.00	14.00	06.30	63.00	01.30	0	73.00	02.00	91.00	0.54	28.00	8.05	420
19	Palakkad	250	52.00	29.00	58.00	02.10	36	256.0	37.00	82.00	1.20	23.00	8.55	720
20	Pattambi	84.00	18.00	09.20	25.00	06.00	0	68.00	24.00	44.00	1.31	15.00	8.17	290
21	Shornur	60.00	15.00	05.40	15.00	04.20	0	100.0	09.00	20.00	0.20	04.50	7.94	174
22	Tavalam	124.0	26.00	15.00	22.00	00.60	0	151.0	08.50	33.00	0.00	17.00	7.89	320
23	Trittala	195.0	50.00	17.00	45.00	02.40	0	232.0	34.00	71.00	0.48	01.70	8.21	530
24	Vadakkancherry	235.0	70.00	15.00	54.00	04.60	0	262.0	36.00	71.00	0.60	31.00	7.75	670

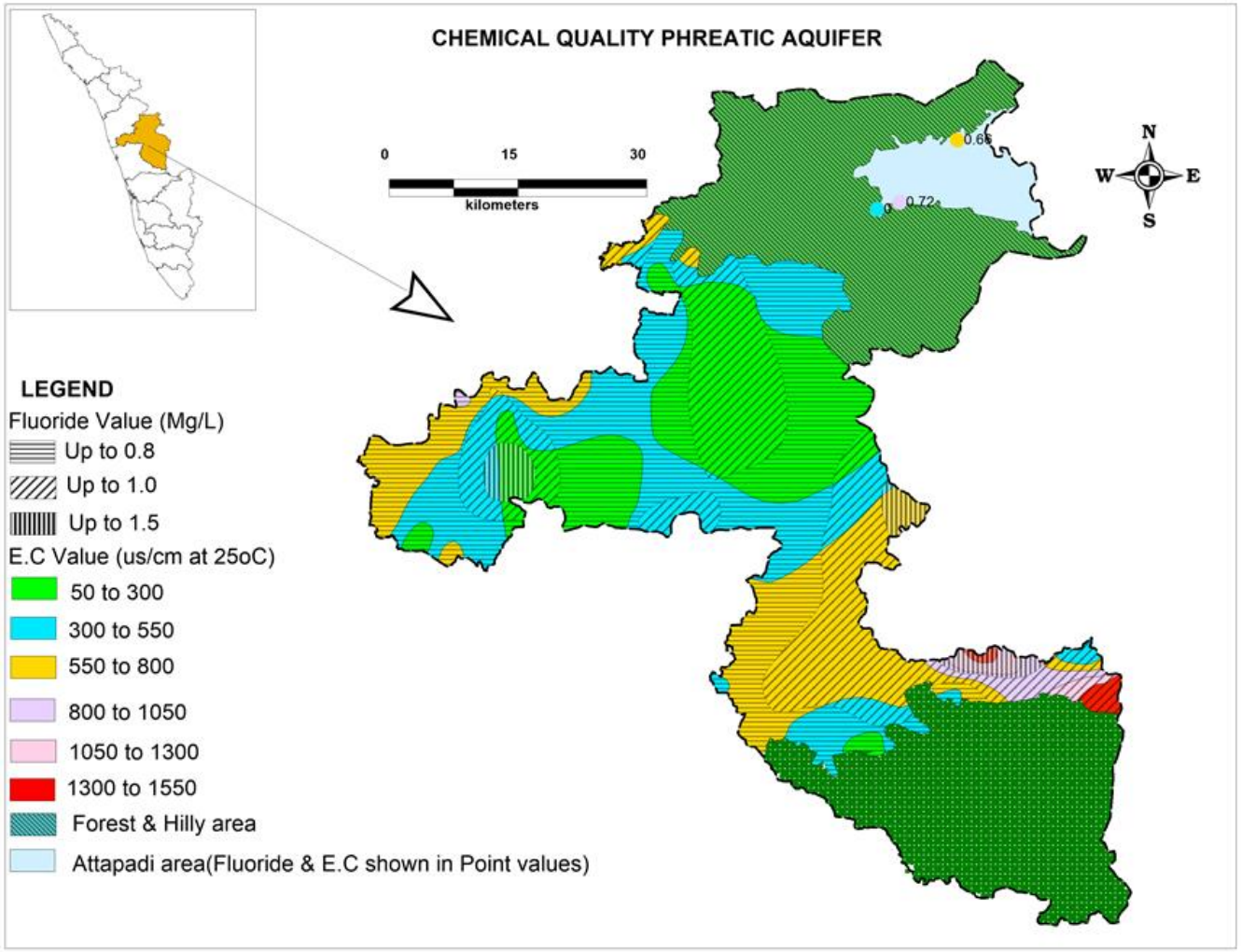


Fig.6.12: Water Quality Map for Phreatic Aquifer

6.1.6 A Hill-Piper Diagram

In the study area, the majority of Phreatic water samples falls in Ca Mg-HCO3 type and Na Cl type of water and remaining samples falls in mixed type of water Ca Na-HCO3 and Ca Mg Cl type of water. The Phreatic water zone shows alkanity in nature. In the southern part of the study area contain Ca Mg-HCO3 type of water. The Na Cl water type is falls in the areas of Ottapalam, Kalladikode, Chalissery and Agali. The mixed type of water falls in the areas of Koppam, Chemmanampathy, Alathur and Cherpulassery areas. The Hill Piper diagram of Phreatic Aquifer is given in Fig.6.13.

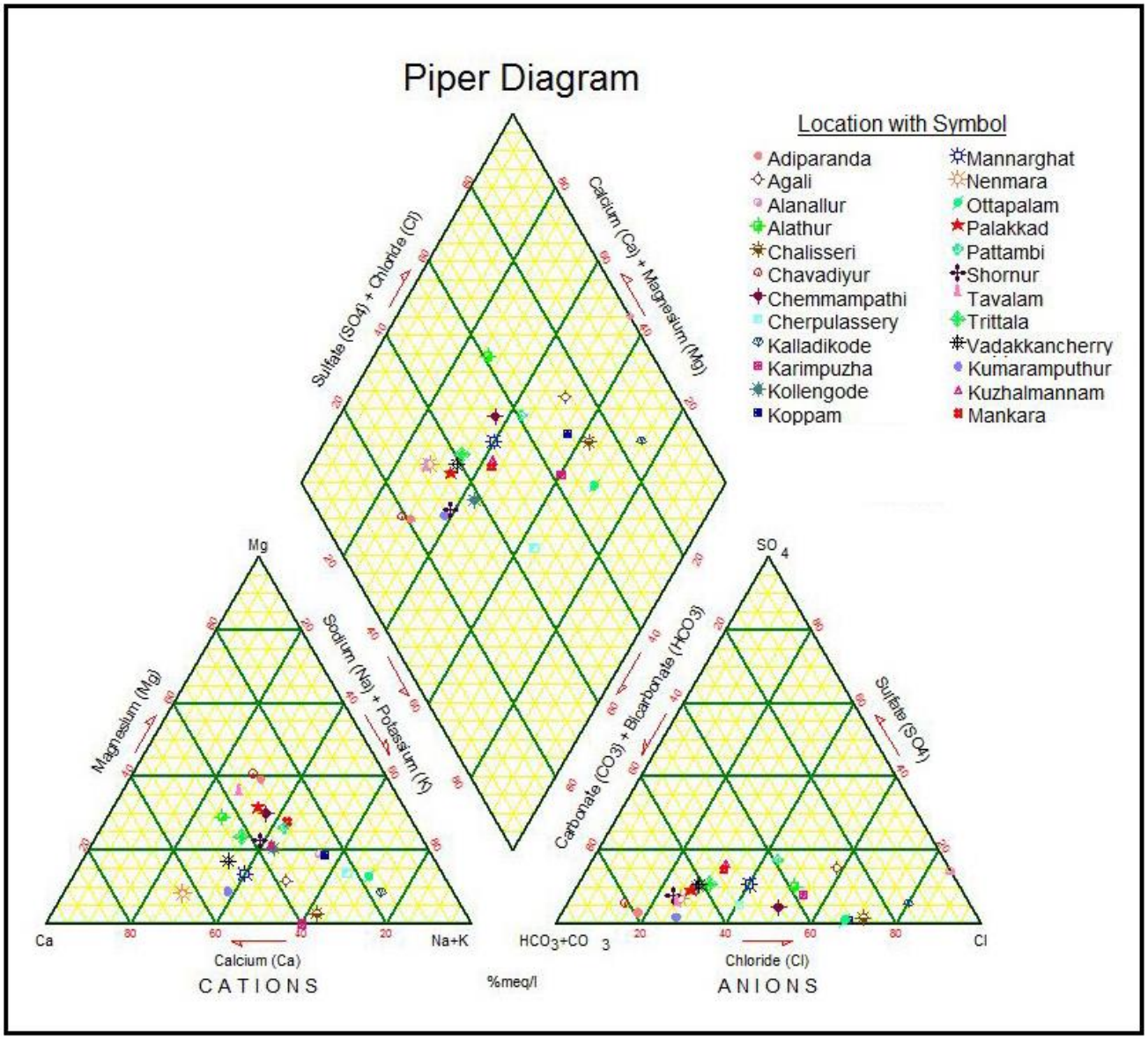


Fig.6.13: Hill-Piper Diagram for Phreatic Aquifer

6.1.7 Ground water Potential in weathered zone

Based on the weathered thickness, aquifer geometry, water levels, ground water yield and hydraulic properties, the ground water Potential map of the phreatic aquifer system is prepared. The Central & North western part of the study area shows high ground water potential ranging from 5 to 10 cum/hour of 2 to 6 hours of pumping & the remaining part of the area, the ground water potential up to 3 cum/hour of 1 to 4 hours of pumping. The Phreatic ground water potential map is given in Fig.6.14 & the phreatic aquifer system is given in Fig. 6.14 (a).

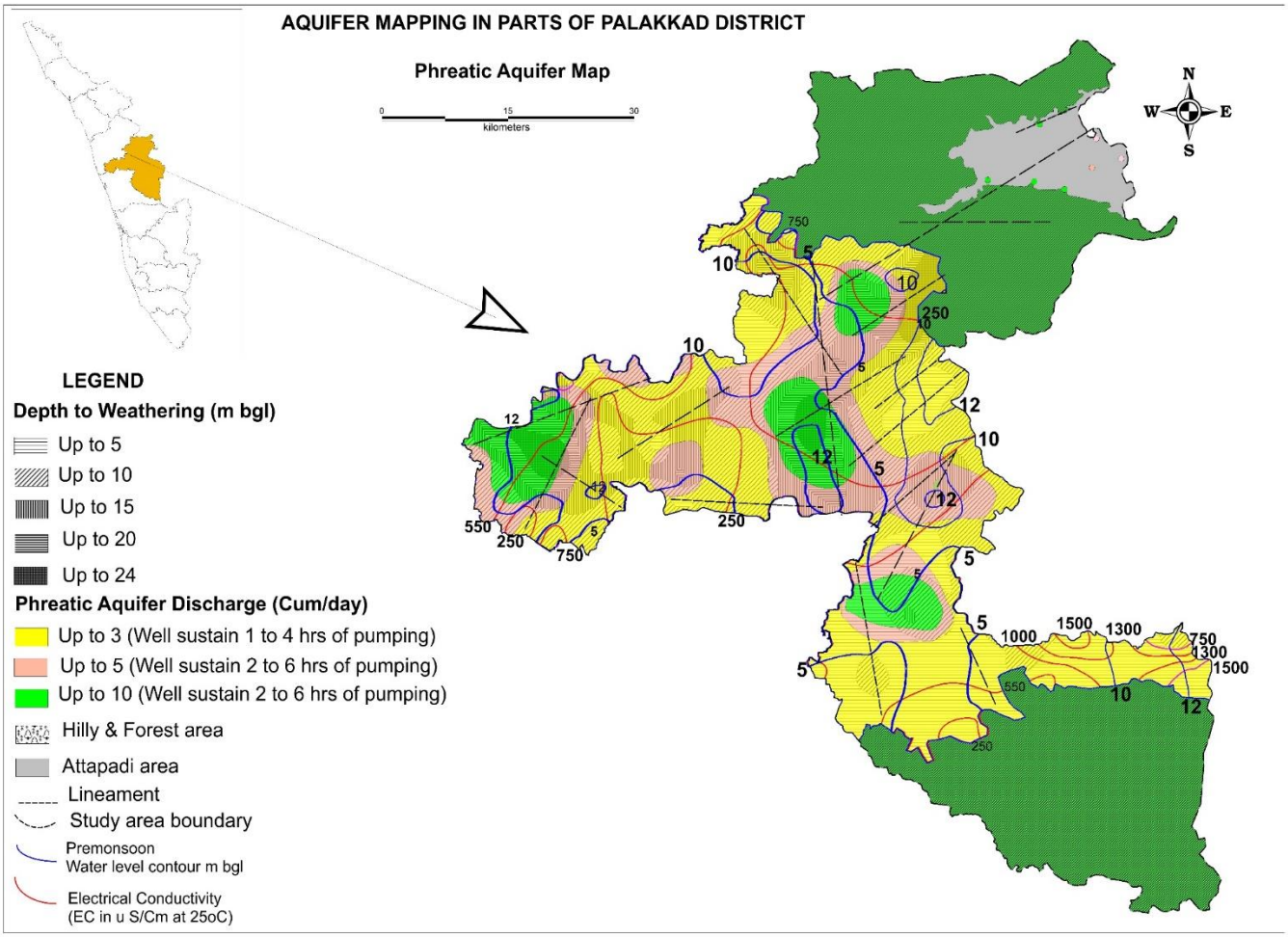


Fig.6.14: Groundwater potential map of phreatic aquifer system

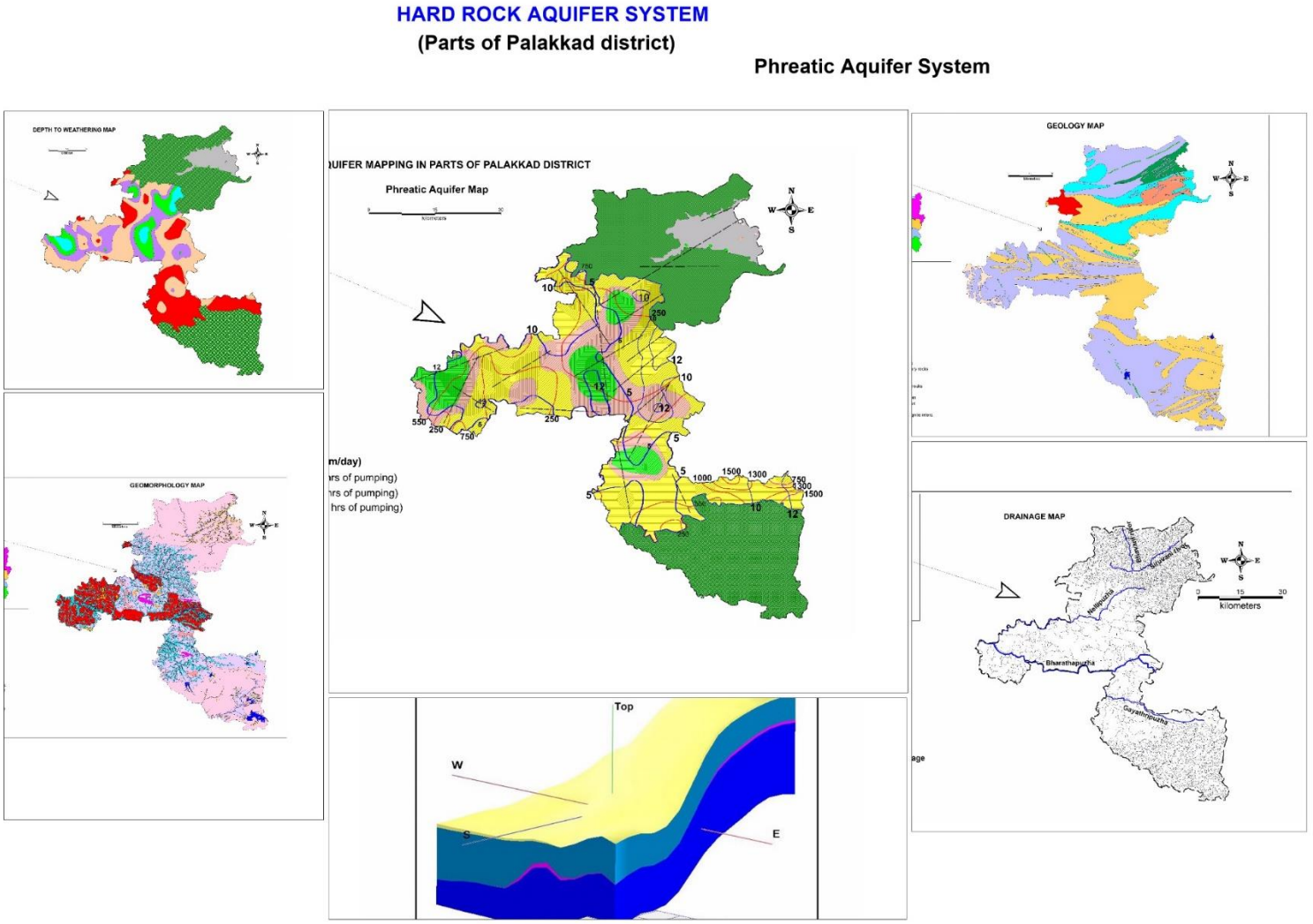


Fig.6.14 (a): Aquifer System of the weathered zone

6.2.1 Fracture zone

The fracture zones start immediate after the depth of fracture varies from 40 to 190 m bgl and the discharge varies from 0.5 to 20 lps, the potential fractures existing between the depth of 45 to 120 m. They are confined to Semi-confined in nature. It is a general practice in the area to go for deep drilling even after encountering a potential zone with the expectation of augmented yield or for long survival of wells. This may not give expected results as the study of exploration data reveals. However, the surface manifestations of fractures in the area are best indicators of deep fractures and proper scientific investigations a prior necessity for deep well drilling. Thus, fracture pattern analysis in conjunction with the exploration data has given meaningful information on the fracture aquifer systems in the area. The fracture aquifer map is given in Fig.6.15 & the Fracture aquifer system map is given in Fig.6.15.

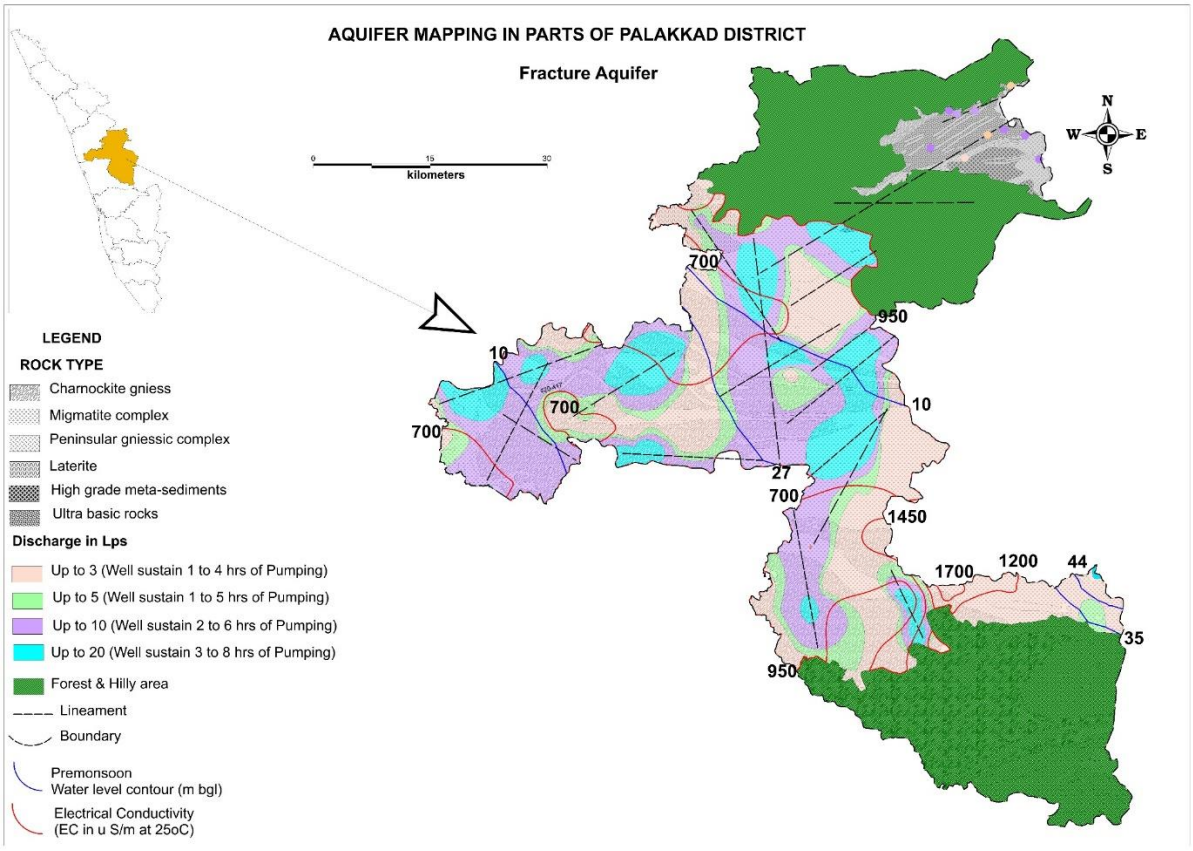


Fig.6.15: Fracture Aquifer map (Deeper Aquifer)

HARD ROCK AQUIFER SYSTEMS

(Parts of Palakkad district)

Fracture Aquifer System

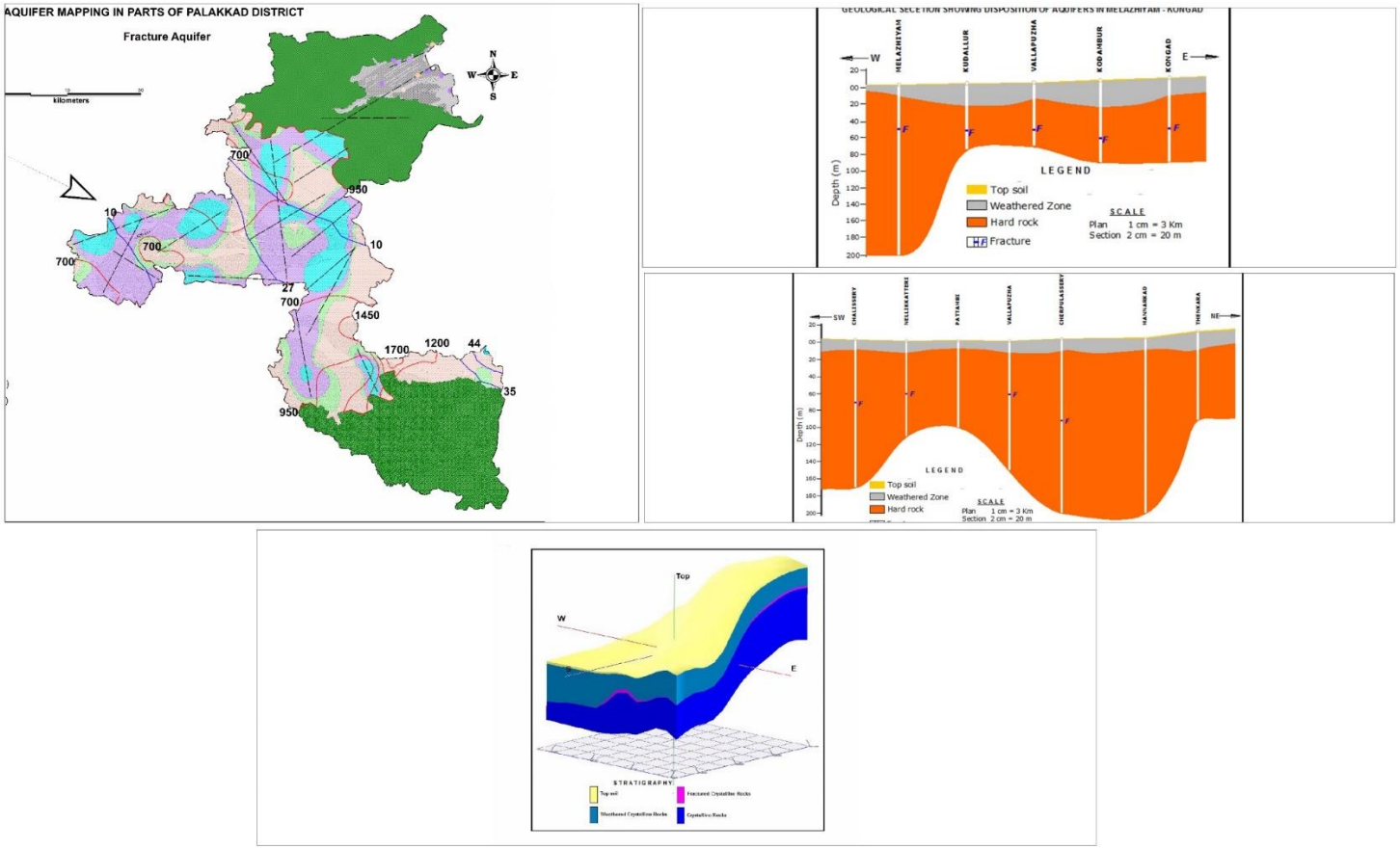


Fig.6.15 (a): Aquifer System of the Fracture zone

6.2.2 Piezometric Head in Fracture Aquifer

The Piezometric head is highly differ from the phreatic aquifers, the water levels of the both premonsoon & Post monsoon water levels are deeper than the shallow aquifers. The piezometric head in Premonsoon varies from 2 to 44 m and the post mosoon piezometric head varies from 1 to 23m. The Pemonsoon Piezometric head map is given in Fig.6.16.

The contour maps on the spatial distribution of piezometric head during pre-monsoon and post-monsoon period's shows a similar pattern with the water level contour maps of phreatic aquifer. This may be the manifestation of the leaky nature of the fracture aquifer system. In both the aquifers deeper water levels are observed in the patches of southern part where irrigated agriculture from bore wells is common. The difference in water levels indicates that vertical recharge from the phreatic aquifers to the fracture system is a slow process and the fracture systems are extensive and interconnected so that the aquifer matrix which contributes water to the fracture conduits takes time for getting fully saturated.

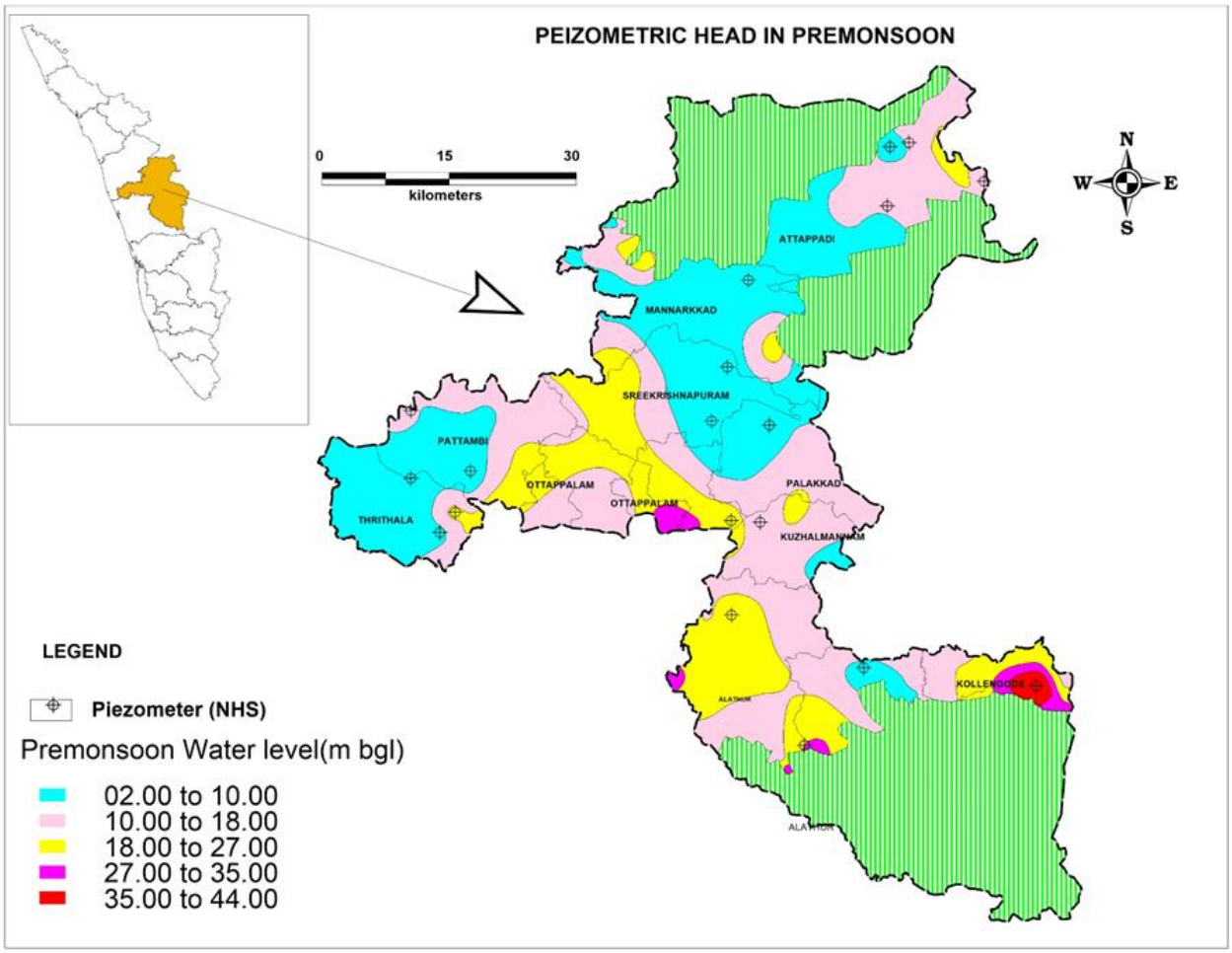


Fig.6.16: Piezometric Head in pre-monsoon

6.2.3 Groundwater and its relation to the geological structures

Geological structures like fractures, lineaments, faults, joints, intrusive rocks etc influence the occurrence and movement of groundwater. Such information extracted from field investigations as well as from the study of topo-sheets and imagery were utilized to identify potential lineaments and fractures in the area. The lineaments identified in the basin trend various directions such as N-S, NNE-SSW, ENE-WSW, E-W, ESE-WNW, and NW-SE. The prominent lineaments in the area mainly trend in NW-SE, NE-SW and E-W direction and is shown as a rose diagram (Fig.6.17). The number of Lineament vs direction is given in Table No: 6.5.

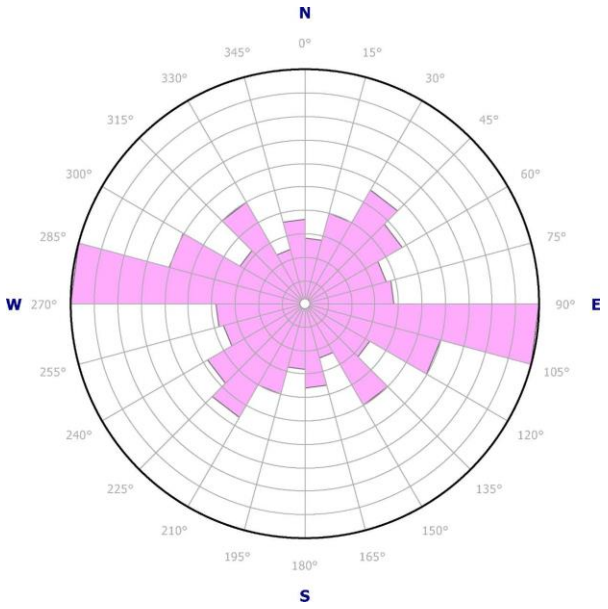


Fig.6.17: Rose diagram showing the lineament trends in the area.

Table No 6.5: Number of Lineaments vs its direction

#	Orientation	Lineament traces	
		Number	Percentage
1	N-S	32	11.68
2	NNE-SSW	49	17.88
3	ENE-WSW	41	14.96
4	E-W	69	10.50
5	ESE-WNW	46	16.79
6	NW-SE	37	13.50

During the Annual action plan 2016 -17, the ground water exploration was taken up along with the Aquifer mapping & Management study to understand the Hydrogeological & Geochemical Propertires of the study area, in that 14 number of exploratory bore wells were drilled including the observation well and found that the study area is traversed by two shear zone ((Thara, 1992), they developed number of structures like, block faulting, Tension gashes, Mylonitization/Pulverization & intrusive body ect, these structure becomes very-good

repositories for the ground water, Inasmuch as the field work, these structures were identified & pinpointed for the ground water exploration and found that the successive rate of well is 90%.

In the study area, the block faulting is very common all along the Bhavani & Palakkad Cauvery Shear zones (especially in the Sahyadri range), because of the faulting (Strike slip & gravitational movement), the Palakkad gap has developed (Thara, 1992). The Bhavani shear zone is passing through the area of attapadi, Kanjirapuzha and Sreekrishnapuram, because of the shear zone, the rocks are highly shattered and it becomes repositories of ground water, Evidence that, the exploratory bore wells drilled in Kanjirapuzha, Mannarkkad, Cherpulassery & Kadampazhipuram are yielding high, the yield ranges from 6.00 to 20.00 Lps, **T**-values ranges from 17.00 to 111.00 m^2/day and the **S**-Values ranges from 0.00046 to 0.00052. The chemical quality of the water also good, since the water is freely flowing through the ruptured longitudinal fractures.

6.2.3.1 Block faulting

The block faulting structures, are identified at Kanjirapuzha, Mannarkkad, Aanamoozhi and near Thavalam (Attapadi), through remote sensing studies and field traverse also taken up to conform. In block faulted area, the cliffs are standing against the valley or plain, are called Food wall and the opposite side plain or valley assumed as hanging wall, the ground water potential occurs in the hanging wall side and concentrated along the longitudinal depressions.

In block faulted area, depth to weathering is deeper than the other area, during the time of ground water exploration (2016 -17) 3 number of sites were selected in the block faulted area (Kanjirampuzha, Kappadam & Mannambetta) and taken up the exploratory drilling and found that, the weathering depth ranges from 19.50 to 24.00 m bgl, the weathered mass becomes very useful for storing huge amount of ground water. In faulted area, even after weathered portion the crystalline rocks are continuously fractured up to the depth of 194 m bgl.

Along the side of Bhavani shear zone, the number of block faulting structure have been developed, because of the stretching movements, so the area is highly disturbed and the rocks become very good repositories of ground water. Some block faulting structures are given in Fig.6.18 (a), (b) & (c).

Fig.6.18 (a): Block faulting along the Bhavani shear zone, near Anamoozhi

Fig.6.18 (b): Differential weathering in block faulted area, Near Mannarkkad.

Fig.6.18 (c): Fault Breccia, near Kajirampuzha, Palakkad district

6.2.3.2 Folding structure

In the study area, intense folding activities were taken place by the shear movement, so the tensional fractures are developed by the compressive movement, the factures are having the space for storing the ground water, the folded structures were identified in the Kanjirapuzha area are given in Fig.6.19.

Fig.6.19: Folding structure, near Kanjirapuzha

6.2.3.3 Tension Gashes

Tension gashes are a special type of vein that can form rather spectacular patterns in the Shear zone area, these features are the indicator of the ground water potential zones, and the tension gashes are the indicator of the ground water potential in the study area, holding the huge quantity of Ground water / can called as underground reservoir. These structures are very commonly seen in the study area near Kadampazhipuram, Sreekrishnapuram, Karakurussi and elsewhere. These structures are developed by stretching and trending perpendicular to the

direction of Shear zones, and filled with pediments & running in the direction of NE –SW and NW-SE direction. The yielding of well ranges from 16 to 20 Lps, the structure is given in Fig.6.20.

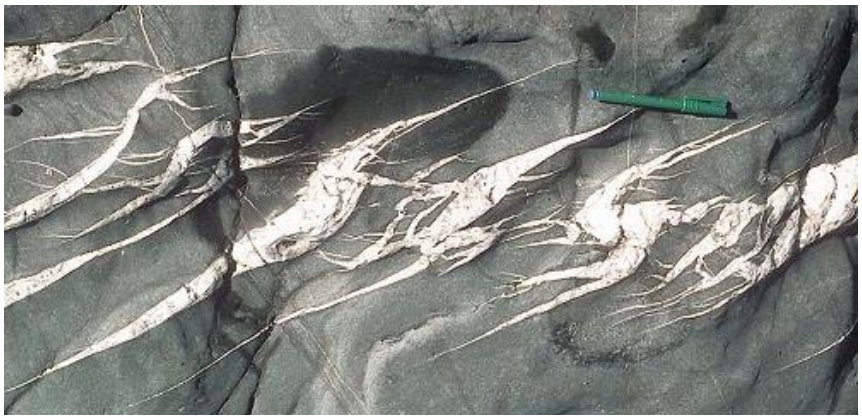


Fig.6.20: Tension gashes, Cherpulassery & Kadampazhipuram

6.2.3.4 Intrusive bodies

The study area is intruded by Quartz & Pegmatites veins and dolerite dykes. these intrusive bodies are the very significant features to locate the ground water potential zones for both Phreatic and fracture aquifers. In and around Alanallur, Kinavallur and Keralassery area Quartz & Pegmatite veins are intruded into the Charnockite ginesse & Hornnblende biotite gneiss. The depth to weathering is shallow, the yielding capacity of bore wells are 4 to 6 Lps the fracture depth is up to 150 m bgl. The pegmatite vein structure is given in Fig.6.21.

Fig.6.21: Pegmatite intruded in to the migmatites, near Keralassery.

6.2.3.5 Ultra-mylonitization/Pulverizations

As the Bhavani shear zone passes through the attapadi area, the rocks are highly affected and it becomes pulverized & powdered, so the mineral elements are released in to the ground water, the NHS monitoring wells in the study shows high concentration of Iron and Fluorides in ground water, (Fluoride up to 1.5 Mg/L) Particularly Kottathara, Naikarapady, Vattalakki and Kulukkur & Thavalam etc. The ultra-myolitization structure is given in Fig.6.22 (a) & (b).

Fig.6.22 (a): Ultra-Mylonitization/Pulverization, near Thavalam.

Fig.6.22 (b): Ultra-Mylonitization near Thavalam(Closer view)

6.2.3.6 Water quality in Fracture system

The fracture aquifer system characterized by low alkalinity, and calcium-magnesium-bicarbonate type water indicates that the water chemistry of fracture aquifer is evolved mainly from the movement of water through the fracture system and associated rock matrix than the vertical leakage from the top phreatic aquifer. The water quality map is given in Fig.6.23 the Hill piper diagram for fracture aquifer is given in Fig.6.23 (a).

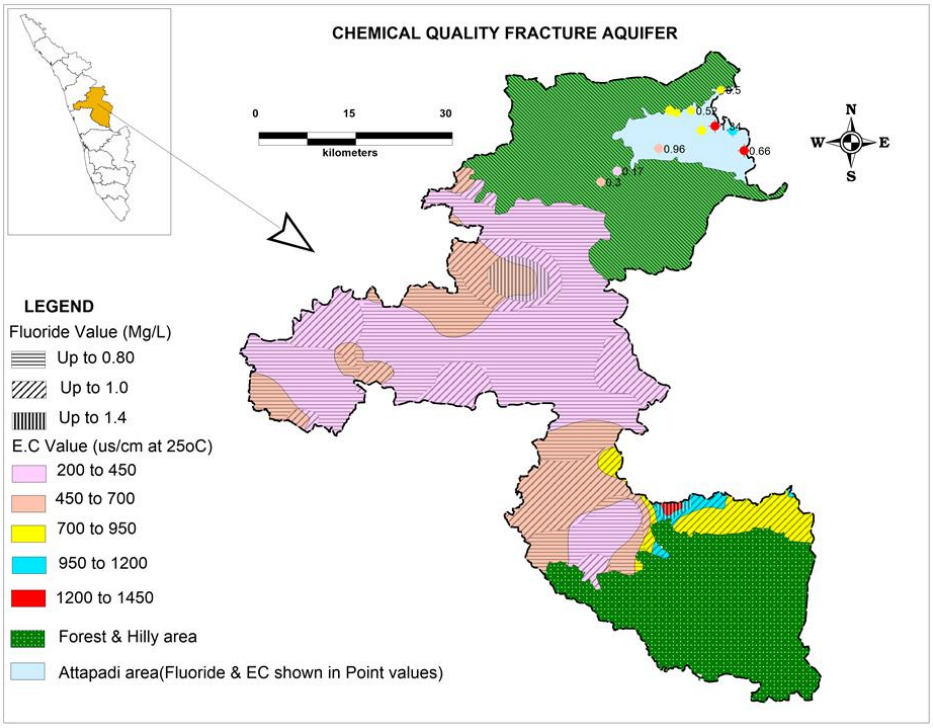


Fig.6.23: Chemical Quality of Fracture Aquifer

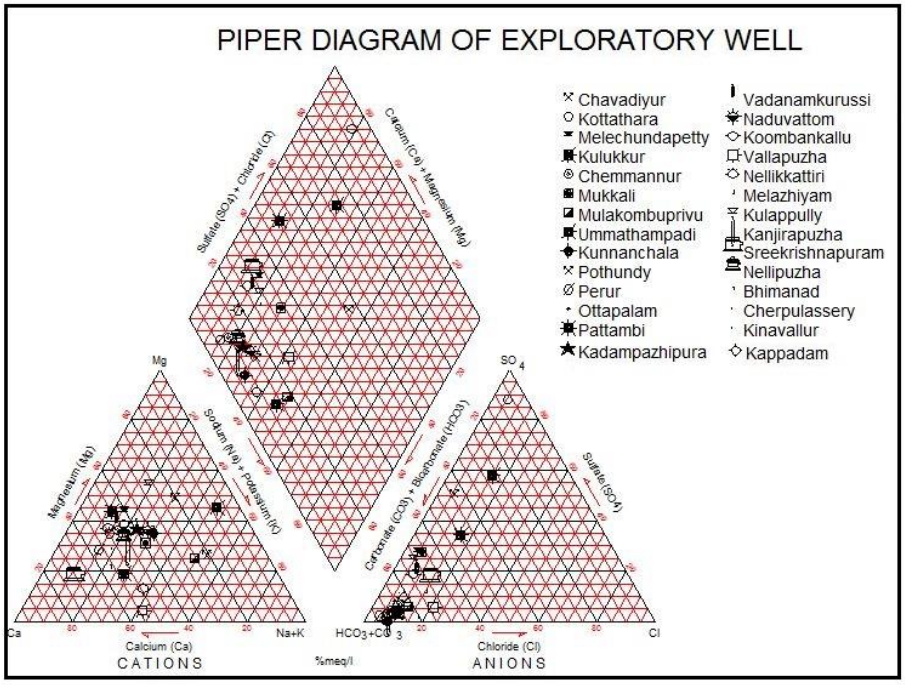


Fig.6.23 (a): Hill-Piper diagram of Fracture Aquifer

7.0 AQUIFER MANAGEMENT PLAN

The households in the study area have own drinking water wells, both dug and bore wells. The dependence on bore wells has gained momentum during the recent years, in 2016 the average annual rainfall of the district is 1350 mm only, so some kind of drought like situation was occurring in the area, most of the dug wells were dried up & the people started doing the bore well everywhere. The bore wells are mainly been used for irrigation. As the area receives good rainfall normally and well drained by the tributaries of Bharatapuzha there is sufficient scope for aquifer management through effective utilization of both rainwater and surface water. The stage of groundwater development in the area is 54.31%, but the areas of Pattambi (Semicritical) and Attapadi blocks struck by of water scarcity during the period of summer months, so it's very much essential to take up the artificial recharge to augment the ground water, through appropriate artificial recharge methods. The major problems, viable solutions and necessary interventions are suggested below in Table 7.1. The Artificial recharge structures and future ground water development is given in Fig.7.1.

Table No 7.1: Viable solutions and interventions suggested for the water issues in the area

Problems /Issues	Viable solution	Innervations suggested for the area
In Pattambi block The GW development is 84.59 % (Semi-Critical)	Augmentation of GW through artificial recharge	7 MCM of water can be recharged through AR structures such as Sub surface dykes, ponds and other Water shed development practices. Through dug well recharge schemes 9 MCM of water can be recharged.
Excess groundwater draft for irrigated agriculture	Promote Water Use Efficient methods through incentives in the place of power subsidies	Water spread Irrigation for coconuts & Arecaunut may be replaced with drip/ sprinkler irrigation. Discourage water spreading methods through awareness.
Water quality problem (Salinity & Fluoride) in Attapadi block.	Implement surface water-Lift irrigation in the area from Bhavani river.	Promote rainwater harvesting & Lift irrigation from Bhavani River.

More stress should be given for watershed development with an integrated approach to conserve soil and augment recharge of rain water. It is observed that many surface water structures like ponds, tanks, irrigation canal and even cultivable land are being encroached for settlement purposes which reduce natural recharge. The existing water resources and dug wells, ponds, streams, need to be cleaned, protected and conserved so as to augment the groundwater resources in the area. The suitable artificial recharge structures are given in Table No: 7.2.

Rainwater harvesting and artificial recharge schemes should be practiced in the study area. In situ collection of rainwater is recommended for the salinity affected areas for direct use as well as for augmenting groundwater recharge.

Table 7.2: Artificial Recharge projects feasible for the area

Block	Area suitable	Volume of water required	Volume of surplus Local/dist ant source	Type	Unit capacity in (MCM)	Number of	Total MCM Rechargeable	Unit cost per	Total cost (Unit cost*Number of structures (Rs.Lakh)
Pattambi	224	15	300	CD	.033	12	0.396	20	240
				P	.033	15	0.495	20	300
				SSD	.003	16	0.036	15	180
				NB	.00225	1000	2.25	2	2000
				DRD	.00013	1000	0.13	0.1	100
				DRI	.0075	200	1.5	.08	16
Thirthala	172.5	10	200	CD	.033	10	0.33	20	120
				P	.033	7	0.231	20	140
				SSD	.003	6	0.018	15	90
				NB	.00225	500	1.125	2	1000
				DRD	.00013	500	0.065	0.1	50
				DRI	.0075	100	0.75	.08	8
Total		**25**	**500**				**7.326**		**4244**

*CD-Check dams, P-Ponds, SSD-Sub Surface Dyke, GP-Gully Plug, NB-Nala Bund, CD-Contour Bund

Table 7.3: Groundwater augmentation from Bore well recharge

Block	Area suitable for recharge	Volume of water required for recharge (MCM)	Volume of surplus Local/distant source available for recharge (MCM	Type	Unit capacity in (MCM)	Number of structures feasible	Total recharge (MCM)	Unit cost per structure (Rs.Lakh)	Total cost (Unit cost*Number of structures (Rs.Lakh)
Pattambi	224	7	300	Bore well	.0315	150	4.73	1	150
Thirthala	172	5	200	Bore well	.0315	100	3.15	1	100
Total		**11**	**500**				**7.88**		**250**

By Adopting **WUE** methods (in 125 Sq.Km area): Saving 10 MCM of Water

Total Ground water recharge from bore well: 7.88

Total GW recharge from AR structures: 7.326

Total Recharge: 25 MCM

Table 7.4: Impact of Groundwater Management Plans

Assessment Block	Net Ground Water Availability for future irrigation development (ha.m)		Stage of Ground Water Development (%)	
	Present scenario	Expected Scenario after implementation of WM plans	Present scenario	Expected Scenario after implementation of WM plans
Pattambi	605.34	2105	84.59	67.59
Thirthala	757.52	1757	66.12	56.12

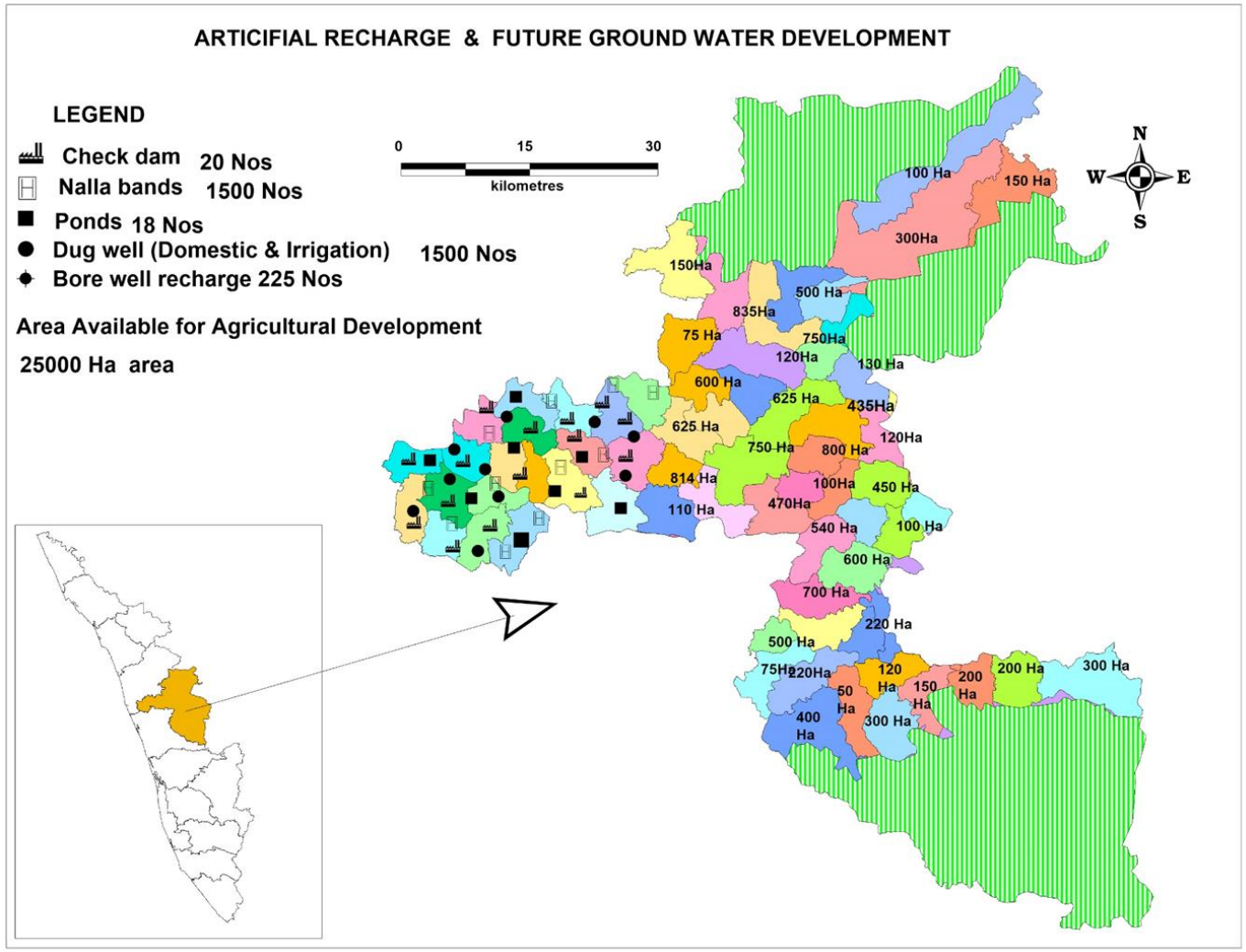


Fig.7.1: Artificial recharge structure & Future Ground water development

Annexure I: Details of Exploratory wells drilled by CGWB in Palakkad district

#	Location	La.tude	Lo.tude	Depth (m bgl)	Casing (m)	Disch.Lps	STWL (m bgl)	Rock type
1	Kalladikode	76.530	10.903	100.00	06.80	10.00	00.90	HB Biotite gneiss
2	Shoranur	76.280	10.772	092.00	08.90	15.00	02.20	HB Biotite gneiss
3	Thrithala	76.130	10.803	100.00	22.25	07.00	04.60	HB Biotite gneiss
4	Mannarkkad	76.460	10.990	101.00	19.00	00.30	08.70	HB Biotite gneiss
5	Tenkara	76.490	11.018	085.00	09.75	12.00	00.85	HB Biotite gneiss
6	Lakkidi	76.436	10.761	100.00	16.00	06.00	12.90	HB Biotite gneiss
7	Naduvattom	76.151	10.869	067.50	09.90	15.00	04.50	Gr gneiss
8	Thiruvegappuram	76.129	10.872	100.00	14.00	07.00	11.40	HB Biotite Schist/Gr. gneiss
9	Kudallur	76.081	10.831	086.00	20.40	20.00	06.70	CH gneiss/HB Biotite Schist
10	Nedungottur	76.267	10.764	100.00	06.90	12.00	13.90	HB Biotite gneiss
11	Kongad	76.518	10.847	092.00	05.50	25.00	05.20	HB Biotite gneiss
12	Pattambi	76.189	10.811	100.00	06.90	00.30	18.60	CH gneiss
13	Karimpuzha	76.420	10.918	100.00	11.50	10.00	03.70	HB Biotitescist
14	Alanallur	76.342	11.026	100.00	12.50	06.00	33.15	Granite gneiss
15	Vadakkancheri	76.475	10.589	137.46	07.62	10.83	04.86	Biotite gneiss
16	Chalisseri	76.096	10.728	170.05	08.70	10.00	03.23	Charnockite gneiss
17	Kumaranallur	76.043	10.788	300.81	07.20	02.50	01.63	Charnockite gneiss
18	Kumarambattur	76.417	10.981	137.50	05.60	17.70	01.71	Biotite gneiss
19	Palakkazhi	76.329	11.024	300.81	13.82	01.30	05.91	Charnockite gneiss
20	Kottathara	76.702	11.136	193.00	10.30	01.80	18.20	Hb-Biotite Gneiss
21	Agali goat farm	76.683	11.130	200.00	05.90	00.80	15.88	Hb-Biotite Gneiss
22	Chavadiyur	76.668	11.157	169.00	17.35	07.70	10.01	Hornblende Gneiss
23	Melachundapetti	76.710	11.186	187.20	06.30	00.50	17.50	Hornblende Gneiss
24	Kulukkur	76.743	11.101	129.00	10.40	15.00	15.30	Granite Gneiss
25	Vattulukki	76.726	11.129	193.40	11.75	00.60	15.36	Quartz feldspar Biotite Schist
26	Agali	76.656	11.103	193.40	22.30	00.80	15.88	Hb-Biotite Gneiss
27	Chemmannur	76.563	11.073	200.00	13.00	00.80	02.64	Hornblende Gneiss

28	Mukkali	76.539	11.058	133.40	09.00	19.00	00.12	Hornblende Gneiss
29	Moolakombupirivu	76.647	11.154	200.00	22.60	07.00	17.70	Hornblende Gneiss
30	Ummathampadi	76.637	11.157	200.00	14.30	04.00	09.44	Hornblende Gneiss
31	Kunnanchala	76.622	11.104	187.30	10.40	00.10	30.35	Hornblende Gneiss
32	Kumbalakode	76.636	10.606	200.00	09.60	01.00	06.00	Biotite Gneiss
33	Pothundy	76.619	10.547	147.70	06.10	02.50	01.85	Biotite Gneiss
34	Kollenkode	76.588	10.598	65.00	06.05	17.00	16.38	Biotite Gneiss
35	Peringode	76.477	10.864	104.00	08.10	10.00	04.17	Biotite Gneiss
36	Chulliarmedu	76.763	10.603	101.20	00.00	00.20	07.29	Hornblende biotite gneiss
37	Moochangundu	76.809	10.580	101.20	05.90	04.30	13.46	Hornblende biotite gneiss
38	Dharmipara	76.686	10.589	101.20	02.65	02.90	06.67	Granite gneiss
39	Nenmara	76.572	10.588	101.20	05.40	01.50	04.50	Granite gneiss
40	Chathamangalam	76.603	10.549	101.20	03.85	14.00	06.62	Charnockite
41	Melarkode	76.559	10.602	101.20	05.40	02.00	00.20	Granite gneiss
42	Vandazhy	76.513	10.641	101.20	11.80	00.70	12.64	Granite gneiss
43	Kunnisserry	76.513	10.641	101.20	11.80	00.20	06.84	Granite gneiss
44	Kavalappara	76.622	10.605	101.20	07.13	00.10	00.20	Granite gneiss
45	Kadiyampara	76.528	10.719	100.00	06.10	03.00	05.65	Hornblende biotite gneiss
46	Padur	76.476	10.656	86.00	06.60	10.00	13.00	Hornblende biotite gneiss
47	Peringottukurussi	76.506	10.754	99.00	09.60	16.00	10.20	Hornblende biotite gneiss
48	Mangalam	76.497	10.613	104.00	03.55	00.10	02.90	Hornblende biotite gneiss
49	Parali	76.563	10.794	100.00	12.00	00.10	04.00	Hornblende biotite gneiss
50	Pazhambalakkod	76.456	10.692	100.00	06.70	07.00	16.60	Hornblende biotite gneiss
51	Mundur	76.581	10.836	100.00	09.80	00.50	17.00	Hornblende biotite gneiss
52	Pulapatta	76.486	10.894	100.00	10.80	00.50	21.50	Hornblende biotite gneiss
53	Ottappalam	76.407	10.756	100.00	14.80	07.00	27.80	Hornblende biotite gneiss
54	Vallapuzha	76.251	10.840	70.00	11.90	16.00	12.50	Hornblende biotite gneiss
55	Vaniyamkulam	76.328	10.783	101.00	07.10	00.50	11.50	Hornblende biotite gneiss
56	Kottayi	76.544	10.778	100.00	16.00	24.00	14.20	Hornblende biotite gneiss
57	Cherpulasserry	76.331	10.876	100.00	06.50	00.80	18.00	Hornblende biotite gneiss

58	Vellinezhi	76.342	10.904	100.00	02.75	00.70	24.80	Hornblende biotite gneiss
59	Pullundasserry	76.450	10.858	101.00	10.90	02.40	04.40	Hornblende biotite gneiss
60	Kolakkattukurissy	76.453	10.907	100.00	12.60	01.20	07.00	Hornblende biotite gneiss
61	Kodambur	76.411	10.850	90.00	21.90	07.00	09.50	Biotite Gneiss
62	Kongad	76.501	10.842	101.00	06.50	05.00	03.70	Hornblende Biotite gneiss
63	Vadanamkurussi	76.227	10.792	101.00	12.00	02.00	08.65	Charnockite
64	Ottapalam	76.32	10.740	100.00	08.00	07.00	07.00	Hornblende biotite gneiss
65	Naduvattom	76.164	10.871	83.00	13.30	10.00	10.20	Hornblende biotite gneiss
66	Nellikkattiri	76.164	10.775	111.00	13.70	05.00	14.58	Hornblende biotite gneiss
67	Koombankallu	76.204	10.811	123.00	14.00	05.00	06.75	Hornblende biotite gneiss
68	Melazhiyam	76.025	10.818	200.00	08.50	00.30	04.89	Hornblende biotite gneiss
69	Vallapuzha	76.253	10.841	150.60	12.10	07.00	15.69	Hornblende biotite gneiss
70	Churakkod	76.240	10.825	200.00	05.90	00.50	18.12	Hornblende biotite gneiss
71	Kulappulli	76.265	10.788	200.00	16.10	00.50	12.40	Hornblende biotite gneiss
72	Vilayur	76.168	10.895	200.00	07.00	00.70	12.80	Hornblende biotite gneiss
73	Kanjirapuzha	76.533	10.992	170.00	24.60	12.00	06.80	Hornblende biotite gneiss
74	Mannambetta	76.437	10.906	200.00	18.50	03.00	11.90	Biotite gneiss
75	Nellipuzha	76.469	10.995	200.00	07.20	06.00	0.55	Hornblende biotite gneiss
76	Thiruvizhamkunnu	76.372	11.046	200.00	10.90	00.20	20.00	Charnockite gneiss
77	Bhimanad	76.375	11.003	142.00	19.50	06.00	07.22	Granite Gneiss
78	Cherpulasserry	76.318	10.877	200.00	11.60	16.00	16.64	Hornblende biotite gneiss
79	Kinavallur	76.562	10.811	173.00	11.40	04.50	10.10	Hornblende biotite gneiss
80	Kadampazhipuram	76.444	10.874	71.30	17.00	20.00	11.10	Hornblende biotite gneiss
81	Kappadam	76.523	10.933	200.00	21.00	00.70	21.00	Hornblende biotite gneiss

Annexure-II: Lithological data of exploratory wells

Litholog of Kanjirapuzha E/W

DRILLING DEPTH(M)		THICKNESS (M)	LITHOLOGY
FROM	TO		
00.00	03.00	03.00	**Top soil:** Lateritic Soil
03.00	16.00	13.00	**Laterite**
16.00	25.00	09.00	**Hornblende biotite gneiss:** Highly weathered, associated with weathered Pegmatite vein.
25.00	30.00	05.00	**Hornblende Biotite Gneiss:** Massive, Mesocratic to melanocratic, medium to coarse grained.
30.00	46.00	16	**Hornblende biotite gneiss:** Mesocratic to melanocratic, medium to coarse grained. Intruded by Pegmatite & Quartz vein having the traces of Chalcoyrit, Pyrite, ect.
46.00	67.00	21.00	**Hornblende Biotite Gniess:** Leucocratic to mesocratic, medium to coarse grained feldspar rich.
67.00	77.00	10.00	**Hornblende biotite gneiss:** Mesocratic to melanocratic, medium to coarse grained.
77.00	116.0	39.00	**Hornblende Biotit Gneiss:** Leucocratic to mesocratic, medium to coarse grained.
116.0	170.0	54.00	**Hornblende biotite gneiss:** Mesocratic to melanocratic, medium to coarse grained,

Litholog of Kanjirapuzha O/W

DRILLING DEPTH(M)		THICKNESS (M)	LITHOLOGY
FROM	TO		
00.00	03.00	03.00	**Top soil:** Lateritic Soil.
03.00	06.00	03.00	**Laterite**
06.00	24.30	18.30	**Hornblende biotite gneiss**: Weathered, associated with Pegmatite vein.
24.30	30.40	6.10	**Hornblende Biotite Gneiss:** Massive, Leucocratic to mesocratic, medium to coarse grained. Intruded by Pegmatite & Quartz vein having the traces of Chalcopyrite, Pyrite, ect.
30.40	36.50	6.10	**Hornblende biotite gneiss**: Massive, Leucocratic to mesocratic, medium to coarse grained.
36.50	54.80	18.30	**Hornblende Biotite Gneiss:** Massive, mesocratic to melanocratic, medium to coarse grained.
54.80	70.00	15.20	**Hornblende biotite gneiss:** Luecocratic to mesocratic, Medium to coarse grained.
70.00	130.00	60.00	**Hornblende biotite gneiss**: Mesocratic to melanocratic, medium to coarse grained.

Litholog of Mannambetta E/W

DRILLING DEPTH(M)		THICKNESS (M)	LITHOLOGY
FROM	TO		
00.00	03.00	03.00	**Top Soil:** Lateritic Soil, Consist of Sand, Silt and Clay.

03.00	18.00	15.00	**Biotite gneiss:** Highly weathered, brownish yellow to buff in colour. Consist of highly weathered plagioclase feldspar and Biotite.
18.00	33.00	15.00	**Biotite gneiss:** Massive, mesocratic to melanocratic, Medium to coarse grained. Consist of Plagiclase feldspar and Biotite.
33.00	36.00	03.00	**Biotite gneiss:** Highly Fractured, Leucocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar and Biotite has been converted in to clay.
36.00	61.00	25.00	**Biotite gneiss:** Massive, Leucocratic to mesocratic,medium to coarse grained. Consists of Plagioclase feldspar and Biotite.
61.00	91.50	30.50	**Biotite gneiss:**Massive, mesocratic to melanocratic, medium to coarse grained. Consists of Plagioclase feldspar and Biotite.
91.50	128.10	36.60	**Biotite gneiss:** Massive, mesocratic, medium to coarse grained. Consists of Plagioclase feldspar and Biotite.
128.00	194.00	66.00	**Biotite gneiss:** Massive, Leucocratic to mesocratic, medium to coarse grained. Consists of of Plagioclase feldspar and Biotite.
194.00	195.00	01.00	**Biotite gneiss:** Fractured, Leucocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar and Biotite.
195.00	200.00	05.00	**Biotite gneiss:** Massive, Leucocratic to mesocratic, medium to coarse grained. Consists of of Plagioclase feldspar and Biotite.

Litholog of Mannambetta O/W

DRILLING DEPTH(M)		**THICKNESS (M)**	**LITHOLOGY**
FROM	**TO**		
00.00	03.00	03.00	**Top Soil:** Lateritic Soil, Consist of Sand, Silt and Clay.
03.00	15.00	12.00	**Biotite gneiss:** Highly weathered, brownish yellow to buff in colour. Consist of highly weathered plagioclase feldspar and Biotite.
15.00	36.60	21.60	**Biotite gneiss:** Massive, Leucocratic to mesocratic, Medium to coarse grained. Consist of Plagiclase feldspar and Biotite.
36.60	61.00	24.40	**Biotite gneiss:** mesocratic to melanocratic, medium to coarse grained. Consists of Plagioclase feldspar and Biotite has been converted in to clay.
61.00	91.50	30.50	**Biotite gneiss:** Massive, Leucocratic to mesocratic,medium to coarse grained. Consists of Plagioclase feldspar and Biotite.
91.50	128.10	36.60	**Biotite gneiss:**Massive, mesocratic to melanocratic, medium to coarse grained. Consists of Plagioclase feldspar and Biotite.
128.10	137.00	08.90	**Biotite gneiss:** Massive, Leucocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar and Biotite.
137.00	200.00	63.00	**Biotite gneiss:** Massive,mesocratic, medium to coarse grained. Consists of of Plagioclase feldspar and Biotite.

Litholog of Nellipuzha E/W

DRILLING DEPTH(M)		**THICKNESS (M)**	**LITHOLOGY**
FROM	**TO**		
00.00	02.00	02.00	**Top soil:** Lateritic Soil, Consists of Sand, Silt & Clay.
02.00	06.00	04.00	**Hornblende Biotite gneiss:** Highly weathered, yellowish brown to buff coloured. Consists of weathered Plagioclase feldspar, Biotite & Hornblende.
06.00	28.00	22.00	**Hornblende biotite gneiss:** Massive, Leucocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblende.

28.00	29.00.00	01.00	**Hornblende Biotite Gneiss:** Fractured, Mesocratic to melanocratic, medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblende.
30.00	46.00	16	**Hornblende biotite gneiss:** Mesocratic to melanocratic, medium to coarse grained. Intruded by Pegmatite & Quartz vein having the traces of Chalcoyrit, Pyrite, ect.
46.00	67.00	21.00	**Hornblende Biotite Gniess:** Leucocratic to mesocratic, medium to coarse grained feldspar rich.
67.00	77.00	10.00	**Hornblende biotite gneiss:** Mesocratic to melanocratic, medium to coarse grained.
77.00	116.0	39.00	**Hornblende Biotit Gneiss:** Leucocratic to mesocratic, medium to coarse grained.
116.0	170.0	54.00	**Hornblende biotite gneiss:** Mesocratic to melanocratic, medium to coarse grained,

Litholog of Nellipuzha O/W

DRILLING DEPTH(M)		**THICKNESS (M)**	**LITHOLOGY**
FROM	**TO**		
00.00	02.00	02.00	**Top soil:** Lateritic Soil, Consists of Sand, Silt & Clay.
02.00	07.00	05.00	**Hornblende Biotite gneiss:** Highly weathered, yellowish brown to buff coloured. Consist of weathered plagioclase feldspars.
07.00	25.00	18.00	**Hornblende biotite gneiss:** Massive, Leucocratic to mesocratic, medium to coarse grained, Consists of Plagioclase feldspar, Biotite & Hornblende.
25.00	26.00	01.00	**Hornblende Biotite Gneiss:** Fractured,Massive, Mesocratic to melanocratic, medium to coarse grained.
26.00	90.00	34.00	**Hornblende biotite gneiss:** Massive, Leucocratic, medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblende.
90.00	180.00	90.00	**Hornblende Biotite Gniess:** Massive, mesocratic to melanocratic, medium to coarse grained . Consists of Plagioclase feldspar, Biotite & Hornblende.
180.00	190.00	10.00	**Hornblende biotite gneiss:** Massive,Leucocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblende.
190.00	200.00	10.00	**Hornblende Biotit Gneiss:** Massive, Leucocratic, medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblende.

Llitholog of Thiruvizhamkunnu E/W

DRILLING DEPTH(M)		**THICKNESS (M)**	**LITHOLOGY**
FROM	**TO**		
00.00	03.00	03.00	**Top soil:** Lateritic Soil
03.00	10.90	07.90	**Charnockite gneiss:** Highly weathered, yellowish brown to buff in colour, consists of highly weathered pyroxene group of minerals & Plagioclase feldspar.
10.90	75.00	64.10	**Charnockite gneiss:** Massive, mesocratic to melanocratic, medium to coarse grained. Consists of Pyroxene group of minerals, Microcline and Plagioclase feldspar.
75.00	76.00	01.00	**Charnockite gneiss:** Fractured, mesocratic to melanocratic, medium to coarse grained. Consists of Pyroxene group of minerals, Microcline and Plagioclase feldspar.
76.00	150.00	74.00	**Charnockite gneiss:** Massive, mesocratic to melanocratic, medium to coarse grained. Consists of Pyroxene group of minerals, Microcline and Plagioclase feldspar.

150.00	200.00	50.00	**Charnockite gneiss:** Massive, Leucocratic to mesocratic, medium to coarse grained. Consists of Pyroxene group of minerals, Microcline and Plagioclase feldspar.

Litholog of Bhimanad E/W

DRILLING DEPTH(M)		**THICKNESS (M)**	**LITHOLOGY**
FROM	**TO**		
00.00	03.00	03.00	**Top soil:** Lateritic Soil, Consists of Silt, Sand & Clay.
03.00	19.50	16.50	**Granite Gneiss:** Highly weathered & the pulverised rock masses, brownish yellow to buff in colour, Consist of feldspar group of mineral.
19.50	76.00	57.50	**Granite gneiss:** Massive, Leucocratic to mesocratic, medium to coarse grained. Consists of feldspar group of mineral.
76.00	87.00	11.00	**Granite gneiss:** Massive, Leucocratic, Leucocratic, medium to coarse grained. Consist of feldspar group of mineral.
87.00	88.00	01.00	**Granite gneiss:** Fractured, Leucocratic, medium to coarse grained. Consist of feldspar group of mineral.
88.00	142.00	54.00	**Granite gneiss:** Fractured, Leucocratic to mesocratic, medium to coarse grained. Consist of feldspar group of mineral.

Litholog of Cherpulassery E/W

DRILLING DEPTH(M)		**THICKNESS (M)**	**LITHOLOGY**
FROM	**TO**		
00.00	0200	02.00	**Top soil:** Lateritic Soil, Consists of Silt,Sand & Clay.
02.00	11.60	09.60	**Hronblende biotite gneiss:** Highly weathered, yellowish brown to buff in colour. Consist of highly weathered Plagioclase feldspar, Biotite & Hornblende.
11.60	30.00	18.40	**Hornblende biotite gneiss:** Massive, Leucocratic to mesocratic, Medium to coarse grained. Consist of Plagioclase feldspar, Biotite & Hornblende.
30.00	40.00	10.00	**Hornblende Biotite Gneiss:** Massive, Mesocratic to melanocratic, medium to coarse grained. Consist of Plagioclase feldspar, Biotite & Hornblende.
40.00	41.00	01.00	**Hornblende biotite gneiss:** Fractured, Mesocratic to melanocratic, medium to coarse grained. Consist of Plagioclase feldspar, Biotite & Hornblende.
41.00	50.00	09.00	**Hornblende Biotite Gniess:** Massive, Leucocratic to mesocratic, medium to coarse grained feldspar rich.
50.00	51.00	01.00	**Hornblende biotite gneiss:** Fractured, Mesocratic to melanocratic, medium to coarse grained. Consist of Plagioclase feldspar, Biotite & Hornblende.
51.00	86.00	35.00	**Hornblende Biotit Gneiss:** Massive, Leucocratic to mesocratic, medium to coarse grained. Consist of Plagioclase feldspar, Biotite & Hornblende.
86.00	87.00	01.00	**Hornblende biotite gneiss:** Fractured, Mesocratic to melanocratic, medium to coarse grained, Consist of Plagioclase feldspar, Biotite & Hornblende.

87.00	92.70	05.70	**Hornblende biotite gneiss:** Highly fractured, Leucocratic to mesocratic, Medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblende. Intruded by dolerite dyke.

Litholog of Cherpulassery O/W

DRILLING DEPTH (M)		THICKNESS (M)	LITHOLOGY
FROM	TO		
00.00	02.00	02.00	**Top soil:** Lateritic Soil, Consists of Silt, Sand & Clay.
02.00	08.00	06.00	**Hornblende biotite gneiss:** Highly weathered, yellowish brown to buff in colour. Consists of weathered plagioclase feldspar.
08.00	40.00	32.00	**Hornblende biotite gneiss**: Massive, Leucocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblede.
40.00	40.50	00.50	**Hornblende Biotite Gneiss:** Fractured, Leucocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblede.
40.50	80.00	39.50	**Hornblende biotite gneiss**: Massive, Leucocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblede.
80.00	158.0	78.00	**Hornblende Biotite Gneiss:** Massive, mesocratic to melanocratic, medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblede.
158.0	200.00	42.00	**Hornblende biotite gneiss:** Luecocratic to mesocratic, Medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblede.

Litholog of Kinavallur E/W

DRILLING DEPTH(M)		THICKNESS (M)	LITHOLOGY
FROM	TO		
00.00	03.00	03.00	**Top soil:** Lateritic Soil
03.00	11.40	08.40	**Hornblende biotite gneiss:** Highly weathered Plagioclase feldspar associated with Clay.
11.40	80.00	68.60	**Hornblende biotite gneiss:** Massive, Leucocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar, Biotite & Hornblende.
68.60	142.50	73.90	**Hornblende Biotite Gneiss:** Massive, Mesocratic, medium to coarse grained. Consists of Plagioclase feldspar, Hornblende & Biotite.
142.00	142.50	0.50	**Hornblende biotite gneiss:** Fractured, Leucocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar,Hornblende & Biotite.
142.50	150.00	07.50	**Hornblende Biotite Gniess:** Massive**,** mesocratic, medium to coarse grained Plagioclase feldspar rich.
150.00	151.00	01.00	**Hornblende biotite gneiss:** Fractured, mesocratic, medium to coarse grained Plagioclase feldspar rich.
151.00	173.00	22.00	**Hornblende Biotit Gneiss:** Massive**,** Leucocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar, Hornblende & Biotite.

Litholog of Kadampazhipuram E/W

DRILLING DEPTH(M)		THICKNESS (M)	LITHOLOGY
FROM	TO		
00.00	03.00	03.00	**Top soil:** Lateritic Soil, Consist of Sand, Silt & Clay.
03.00	17.00	14.00	**Biotite gneiss:** Weathered, Yellowish brown to buff in colour, Consist of highly weathered Plagioclase feldspar, flakes of Biotite.
17.00	25.00	08.00	**Biotite gneiss:** Massive, Luecocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar & biotite.
25.00	30.00	05.00	**Biotite Gneiss:** Massive, Mesocratic to melanocratic, medium to coarse grained. Consists of Plagioclase feldspar & biotite.
30.00	35.00	05.00	**Biotite gneiss:** Massive, Luecocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar & biotite.
35.00	36.00	01.00	**Biotite Gniess:** Fractured**,** Leucocratic to mesocratic, medium to coarse grained .Consists of Plagioclase feldspar & biotite
36.00	40.00	04.00	**Biotite gneiss:** Mesocratic to melanocratic, medium to coarse grained. Consists of Plagioclase feldspar & biotite.
40.00	41.00	01.00	**Biotit Gneiss:** Highly fractured, mesocratic to melanocratic, medium to coarse grained. Consists of Plagioclase feldspar & biotite.

Litholog of Kadampazhipuram O/W

DRILLING DEPTH(M)		THICKNESS (M)	LITHOLOGY
FROM	TO		
00.00	03.00	03.00	**Top soil:** Lateritic Soil, Consist of Sand, Silt & Clay.
03.00	13.40	10.40	**Biotite gneiss:** Weathered, Yellowish brown to buff in colour, Consist of highly weathered Plagioclase feldspar, flakes of Biotite.
13.40	20.00	06.60	**Biotite gneiss:** Massive, Luecocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar & biotite.
20.00	20.30	00.30	**Biotite Gneiss:** Fractured, Mesocratic to melanocratic, medium to coarse grained. Consists of Plagioclase feldspar & biotite.
20.30	45.00	24.70	**Biotite gneiss:** Massive, Luecocratic to mesocratic, medium to coarse grained. Consists of Plagioclase feldspar & biotite.
45.00	46.00	01.00	**Biotite Gniess:** Fractured**,** Leucocratic to mesocratic, medium to coarse grained .Consists of Plagioclase feldspar & biotite
46.00	69.00	23.00	**Biotite gneiss:** Massive, Mesocratic to melanocratic, medium to coarse grained. Consists of Plagioclase feldspar & biotite.
69.00	71.30	02.30	**Biotit Gneiss:** Highly fractured, mesocratic to melanocratic, medium to coarse grained. Consists of Plagioclase feldspar & biotite.

Litholog of Kappadam E/W

DRILLING DEPTH(M)		THICKNESS (M)	LITHOLOGY
FROM	TO		
00.00	05.00	05.00	**Top soil:** Yellowish brown in colour, Consist of sand, Silt and clay.

05.00	16.00	11.00	Laterite
16.00	21.00	05.00	**Hornblende biotite gneiss:** yellowish brown to buff in colour, Consist of highly weathered Plagioclase feldspar, Hornblende & Biotite.
21.00	35.00	14.00	**Hornblende biotite gneiss:** Massive, Leucocratic to Mesocratic, Medium to coarse grained. Enriched with Plagioclase feldspar
35.00	36.00	01.00	**Hornblende biotite gneiss: Fractured**
36.00	56.00	20.00	**Hornblende biotite gneiss:** Massive, Leucocratic to Mesocratic, Medium to coarse grained. Enriched with Plagioclase feldspar
56.00	57.00	01.00	**Hornblende biotite gneiss: Fractured**
57.00	110.00	53.00	**Hornblende biotite gneiss:** Massive, Leucocratic to Mesocratic, Medium to coarse grained. Enriched with Plagioclase feldspar
110.00	165.00	55.00	**Hornblende biotite gneiss:** Massive, Mesocratic to melanocratic, Medium to coarse grained. Consist of Plagioclase feldspar, Hornblende & Biotite.
165.00	200.00	35.00	**Hornblende biotite gneiss:** Massive, Leucocratic to Mesocratic, Medium to coarse grained. Enriched with Plagioclase feldspar

Annexure III: Composite logs of exploratory wells constructed in the area

Fig. 2 Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at KANJIRAPUZHA E/W

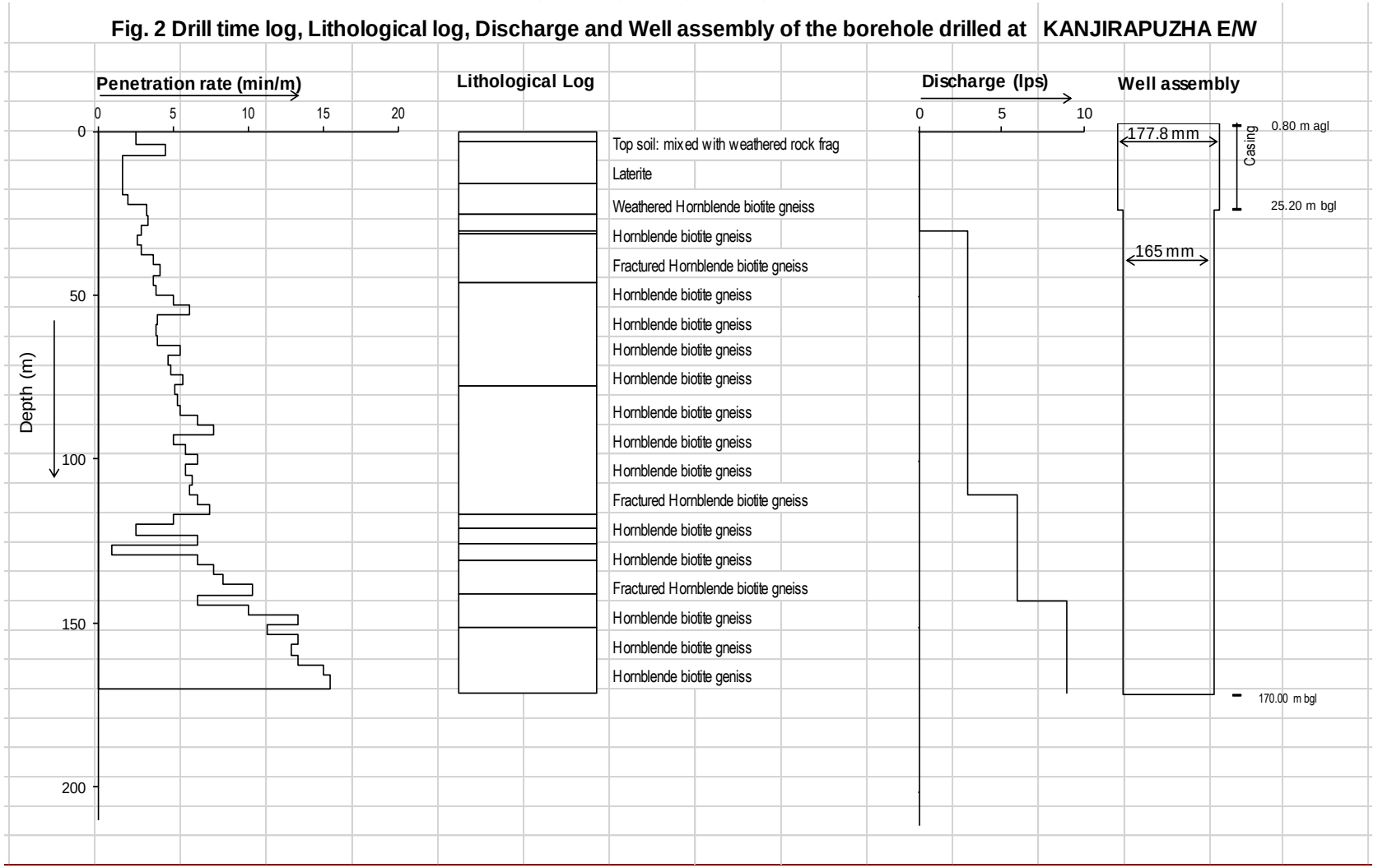


Fig. 2 (a) Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at KANJIRAMPUZHA O/W

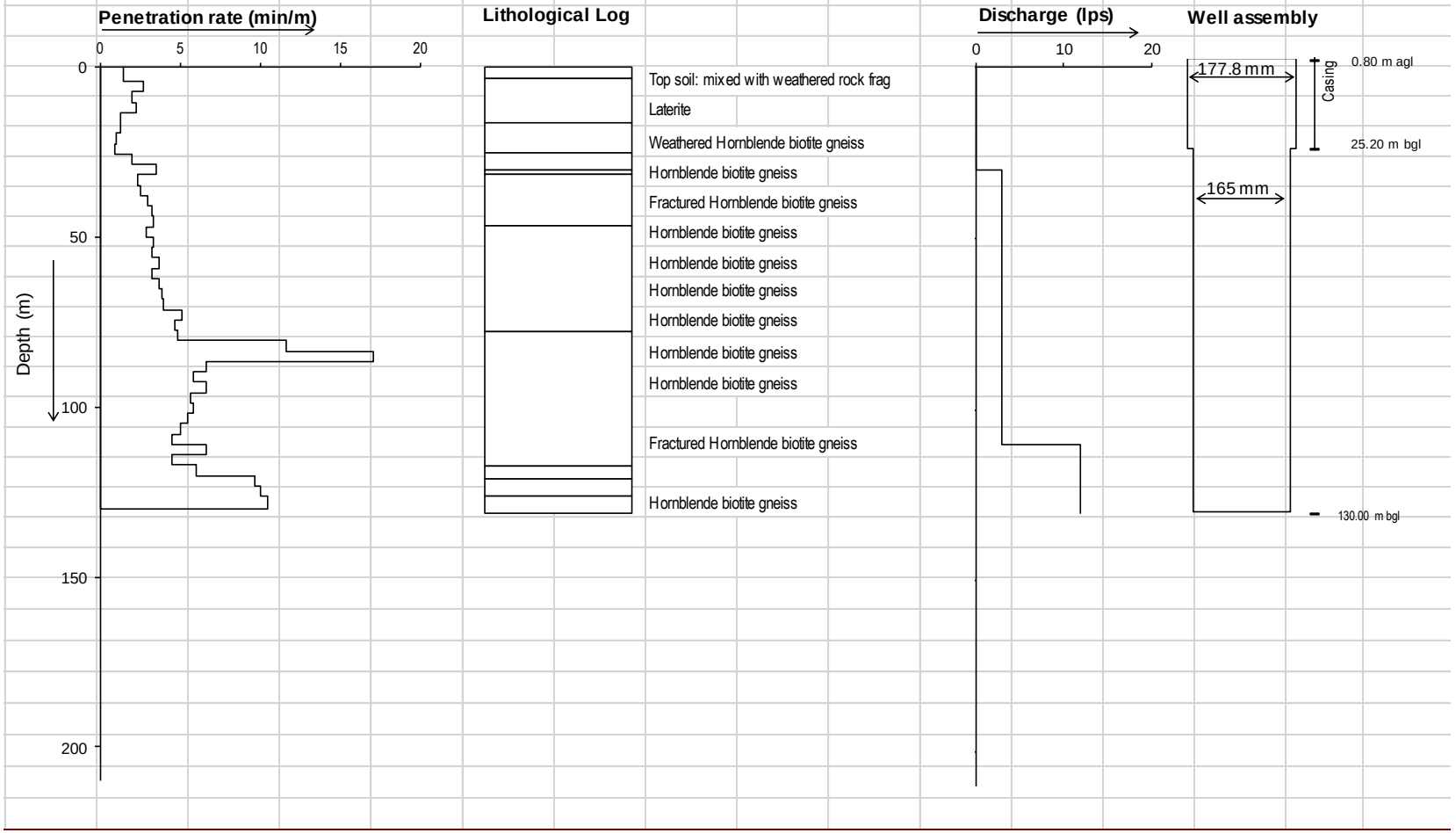


Fig. 2 Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at MANNAMBETTA E/W

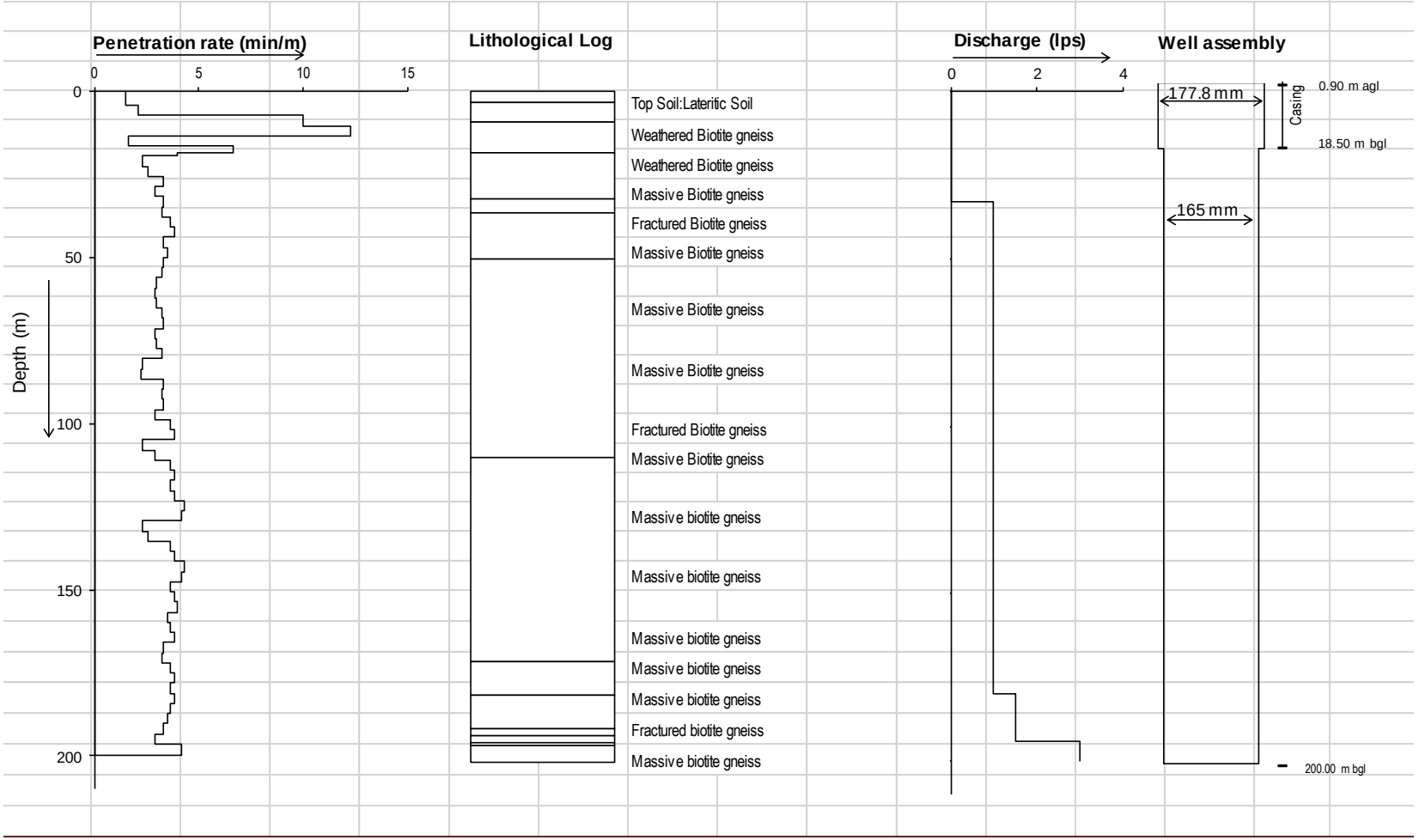


Fig. 2(a) Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at Mannambetta O/W

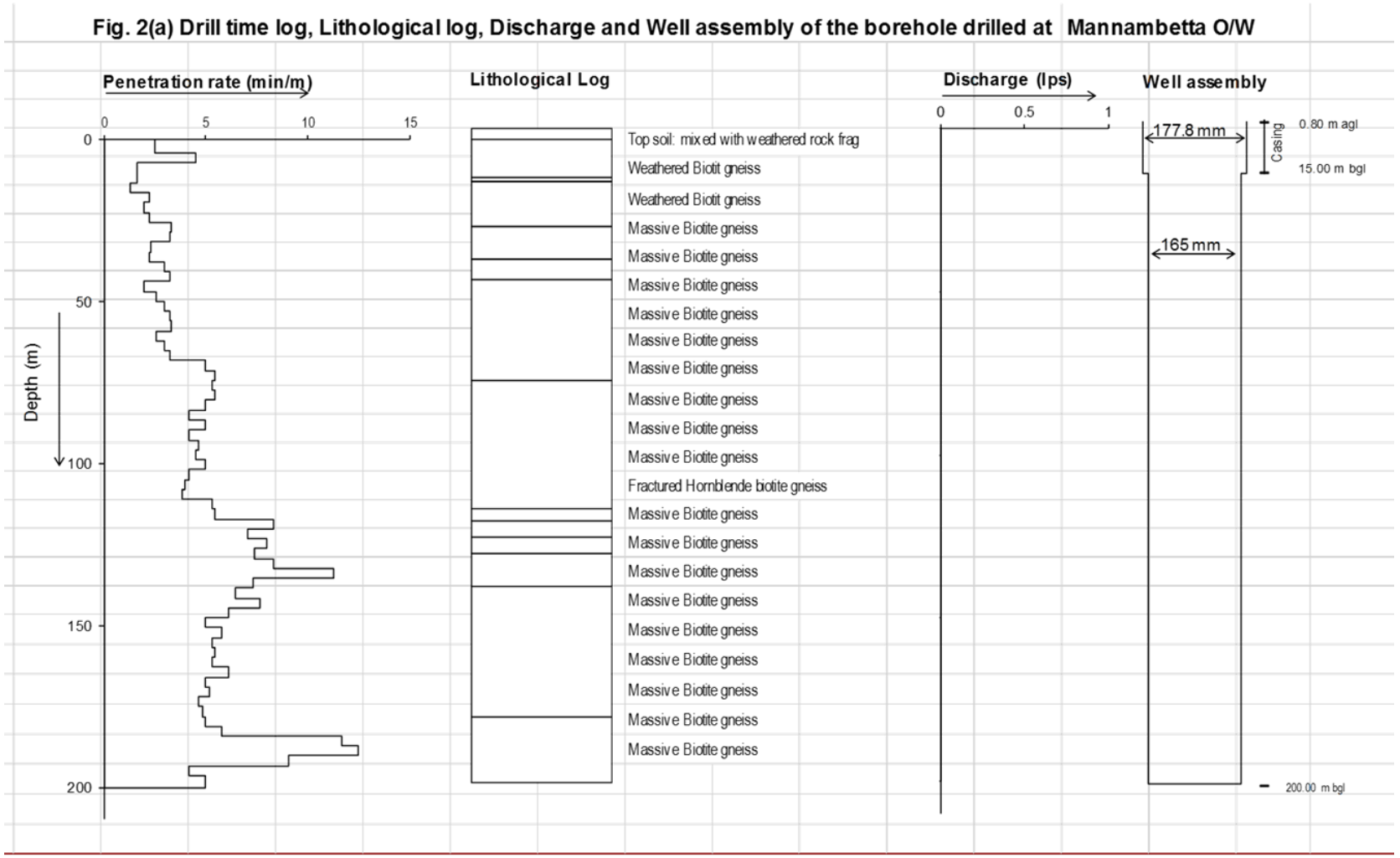
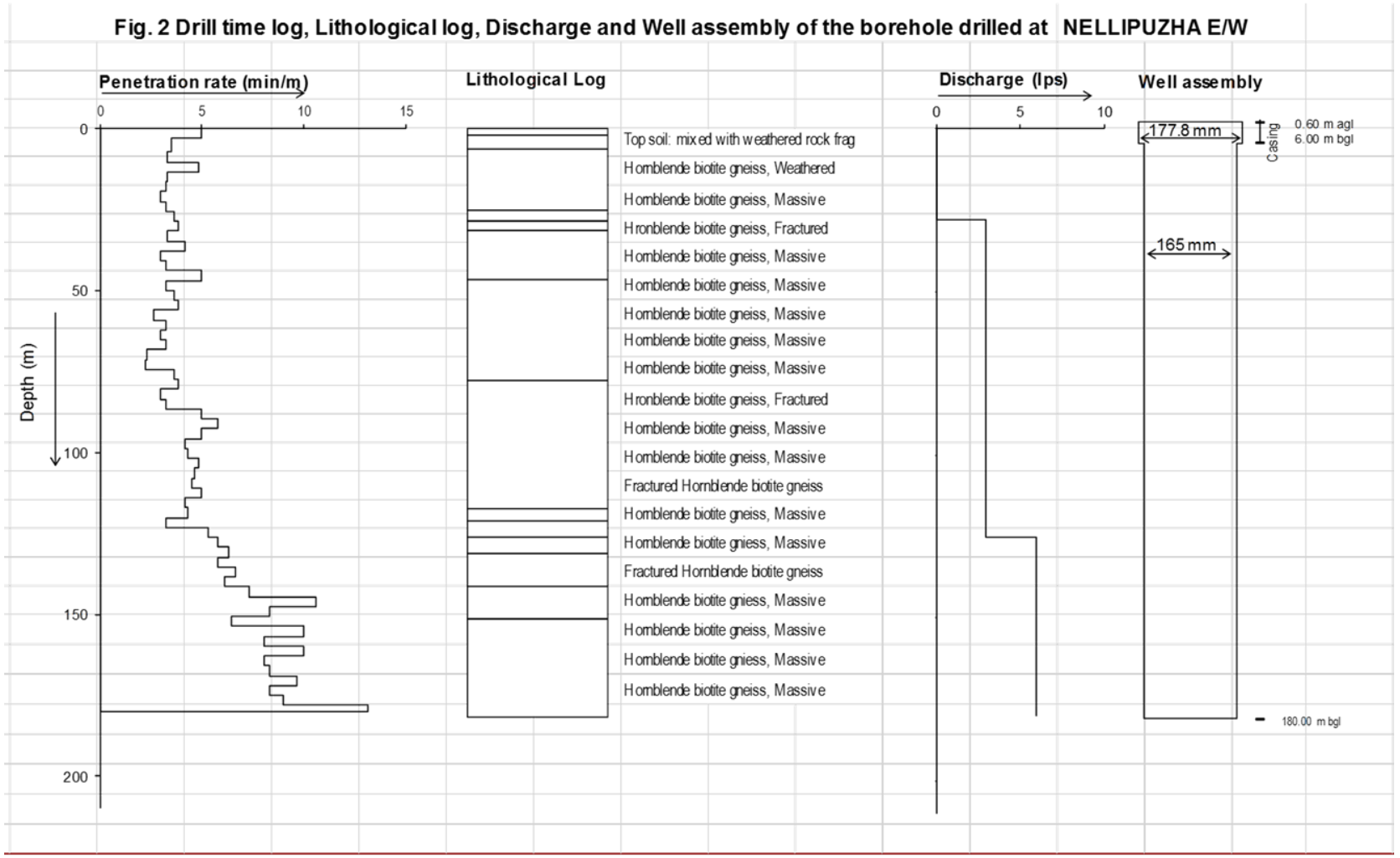


Fig. 2 Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at NELLIPUZHA E/W



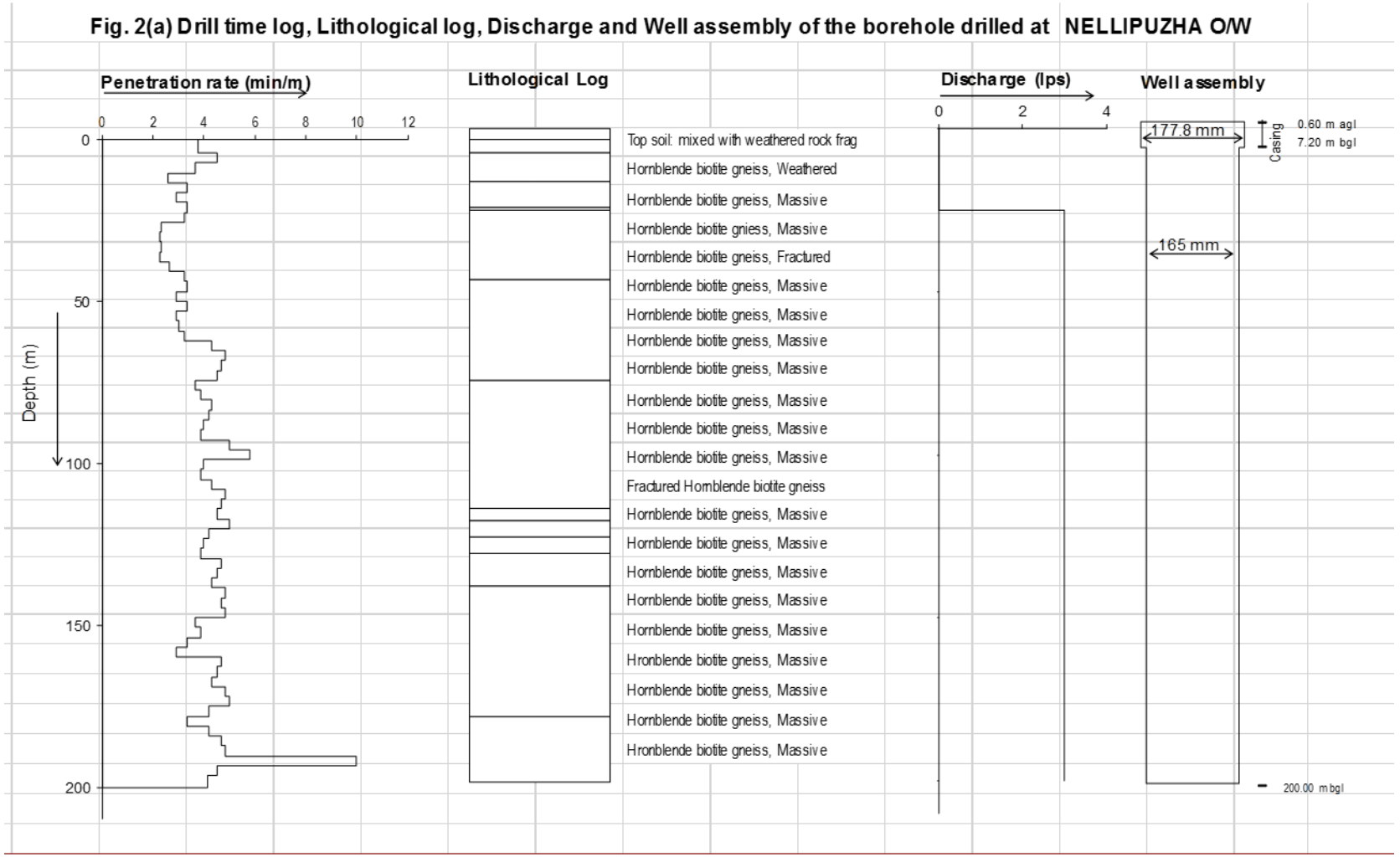
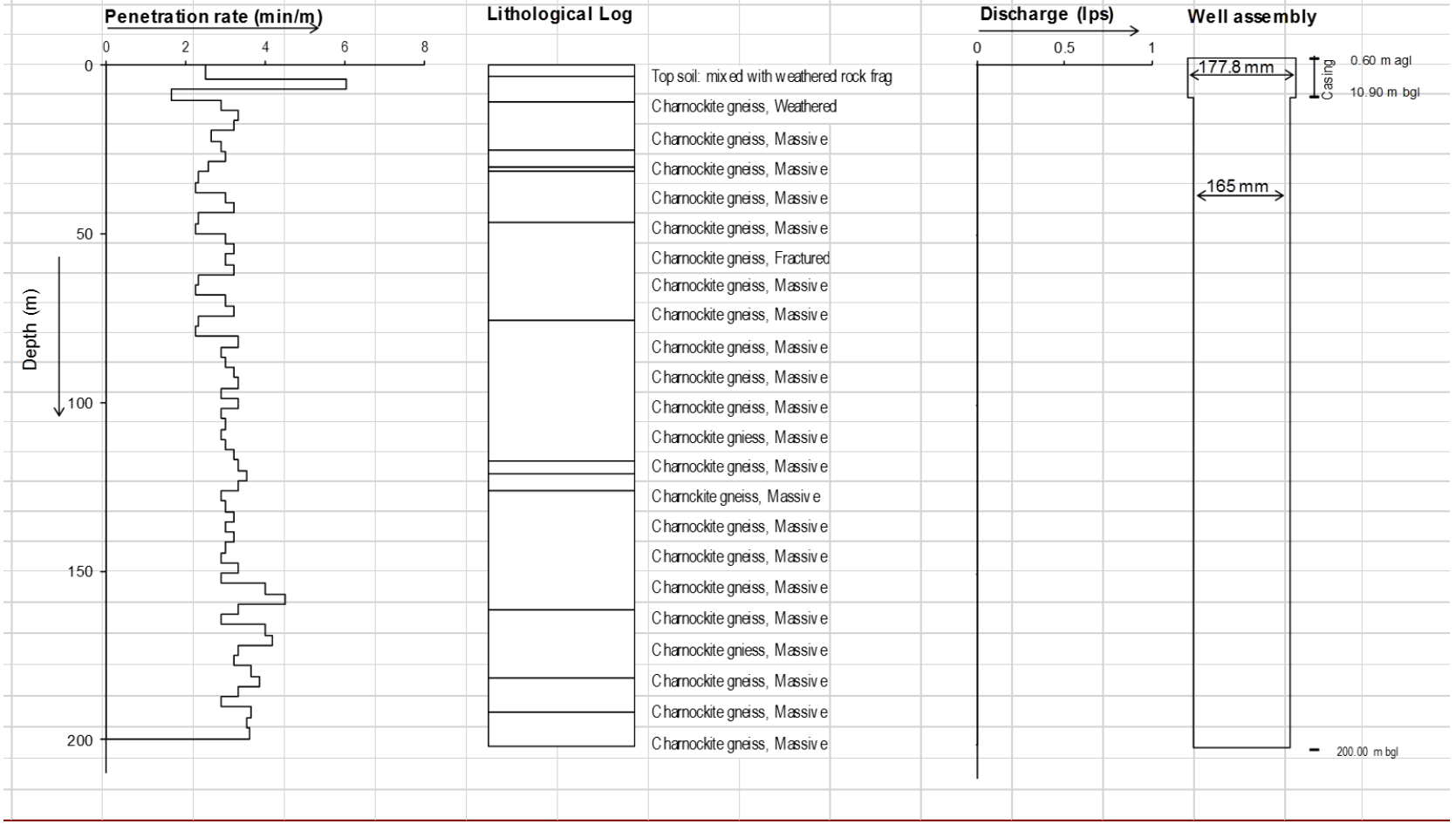


Fig. 2(a) Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at NELLIPUZHA O/W
Penetration rate (min/m)
0
2
4
6
8
10
12
Depth (m)
0
50
100
150
200
Lithological Log
Top soil: mixed with weathered rock frag
Hornblende biotite gneiss, Weathered
Hornblende biotite gneiss, Massive
Hornblende biotite gniess, Massive
Hornblende biotite gneiss, Fractured
Hornblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Fractured Hornblende biotite gneiss
Hornblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Hronblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Hornblende biotite gneiss, Massive
Hronblende biotite gneiss, Massive
Discharge (lps)
0
2
4
Well assembly
177.8 mm
Casing
0.60 m agl
7.20 m bgl
165 mm
200.00 m bgl

Fig. 2 Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at THIRUVIZHAMKUNNU E/W



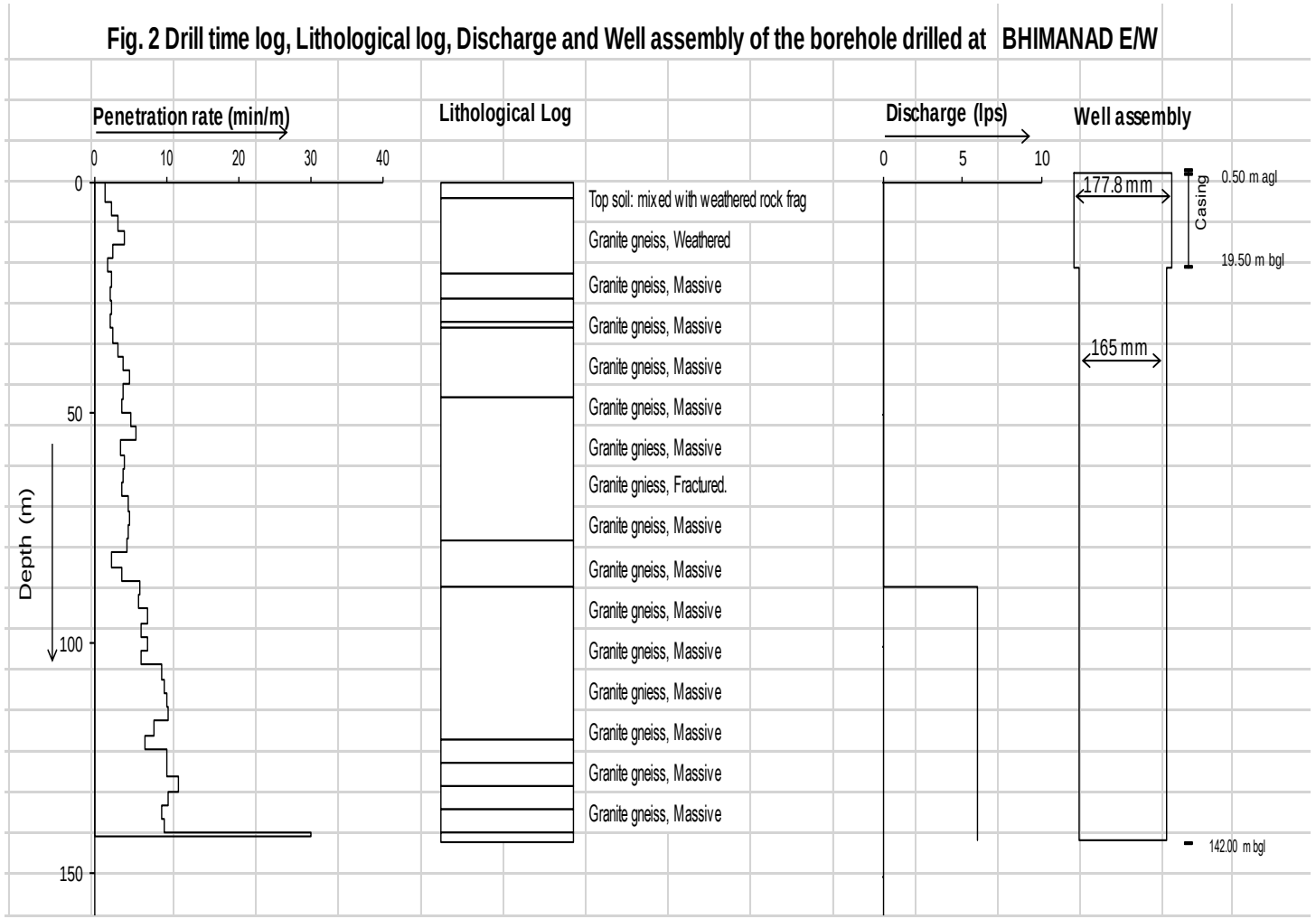


Fig. 2 Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at BHIMANAD E/W
Penetration rate (min/m)
0
10
20
30
40
Depth (m)
0
50
100
150
Lithological Log
Top soil: mixed with weathered rock frag
Granite gneiss, Weathered
Granite gneiss, Massive
Granite gneiss, Massive
Granite gneiss, Massive
Granite gneiss, Massive
Granite gniess, Massive
Granite gniess, Fractured.
Granite gneiss, Massive
Granite gneiss, Massive
Granite gneiss, Massive
Granite gneiss, Massive
Granite gniess, Massive
Granite gneiss, Massive
Granite gneiss, Massive
Granite gneiss, Massive
Discharge (lps)
0
5
10
Well assembly
177.8 mm
Casing
0.50 m agl
19.50 m bgl
165 mm
142.00 m bgl

Fig. 2 Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at CHERPULASSERY E/W

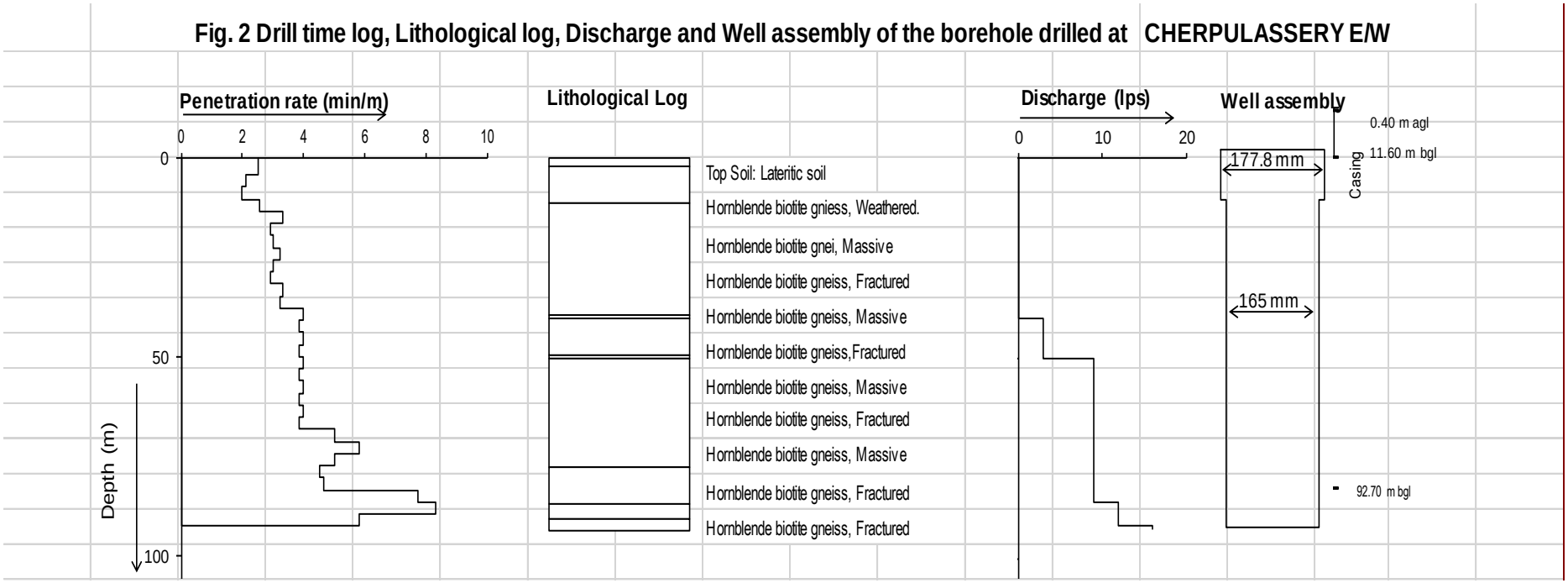


Fig. 2(a) Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at CHERPULASSERY O/W

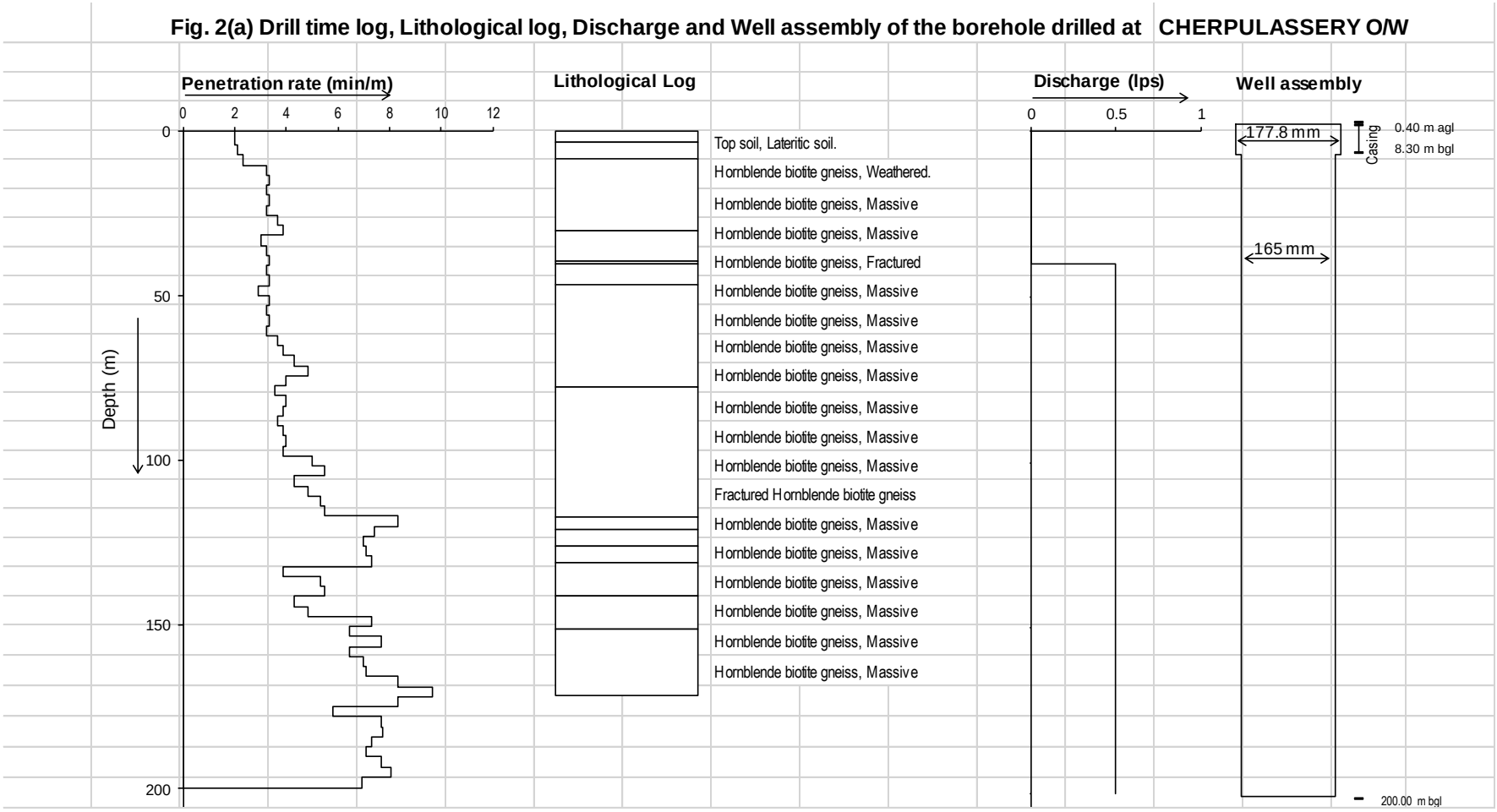
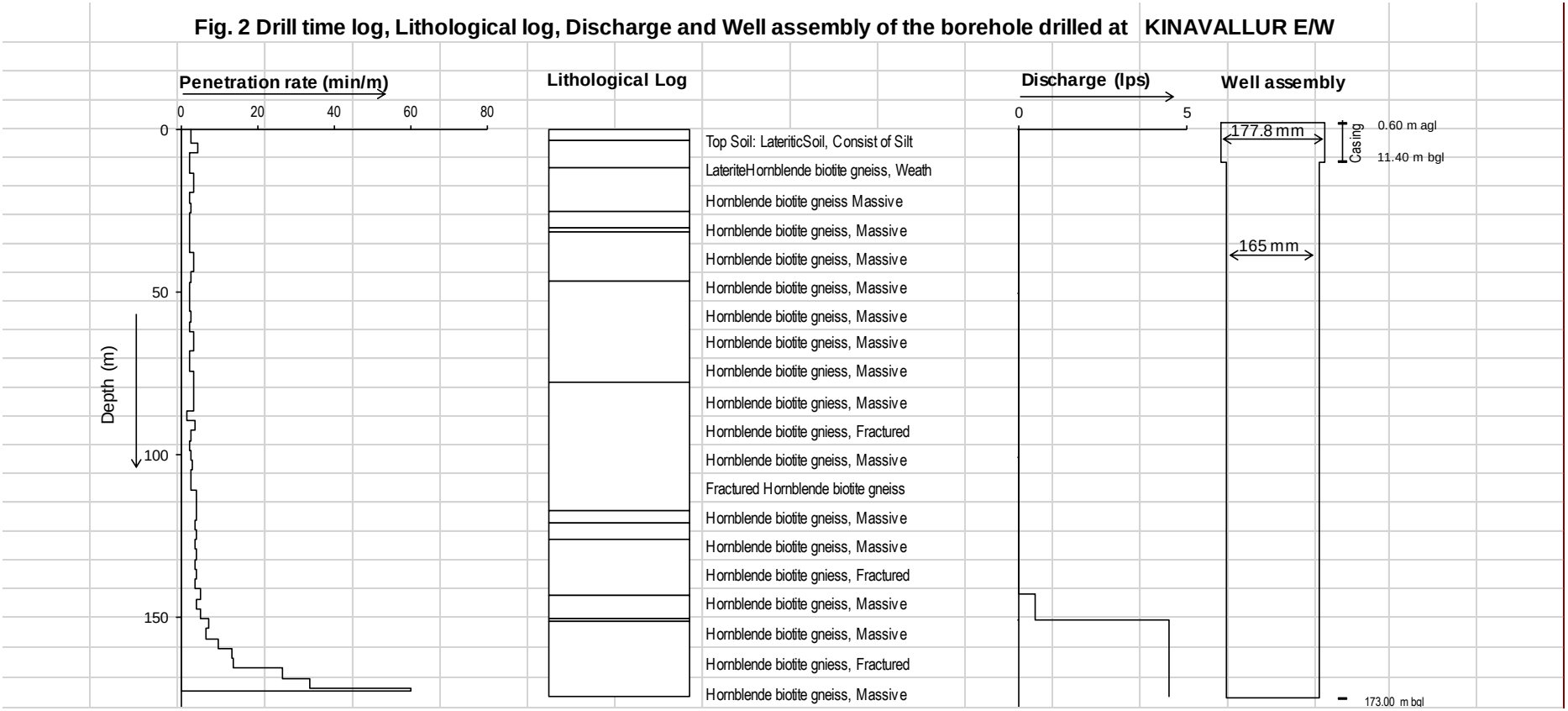


Fig. 2 Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at KINAVALLUR E/W



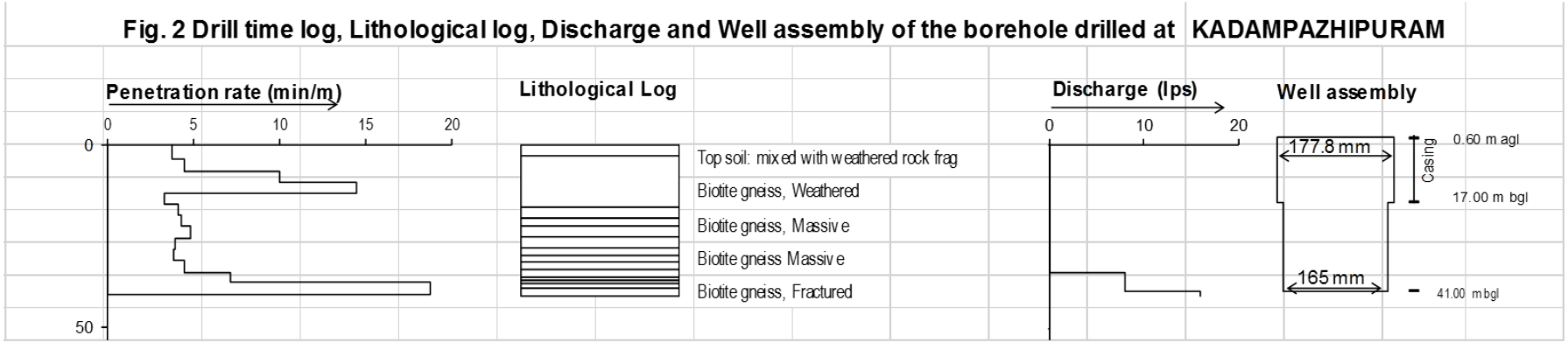


Fig. 2 Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at KADAMPAZHIPURAM
Penetration rate (min/m)
0
5
10
15
20
0
50
Lithological Log
Top soil: mixed with weathered rock frag
Biotite gneiss, Weathered
Biotite gneiss, Massive
Biotite gneiss Massive
Biotite gneiss, Fractured
Discharge (lps)
0
10
20
Well assembly
177.8 mm
Casing
0.60 m agl
17.00 m bgl
165 mm
41.00 mbgl

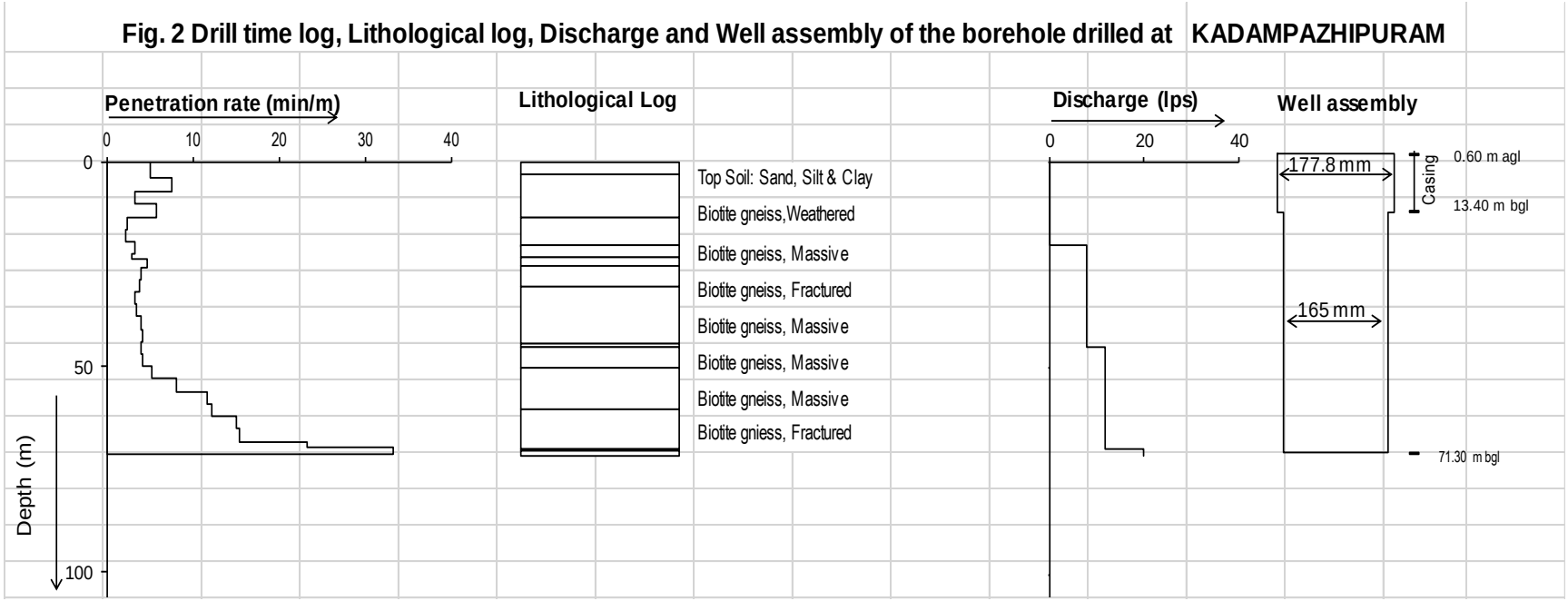
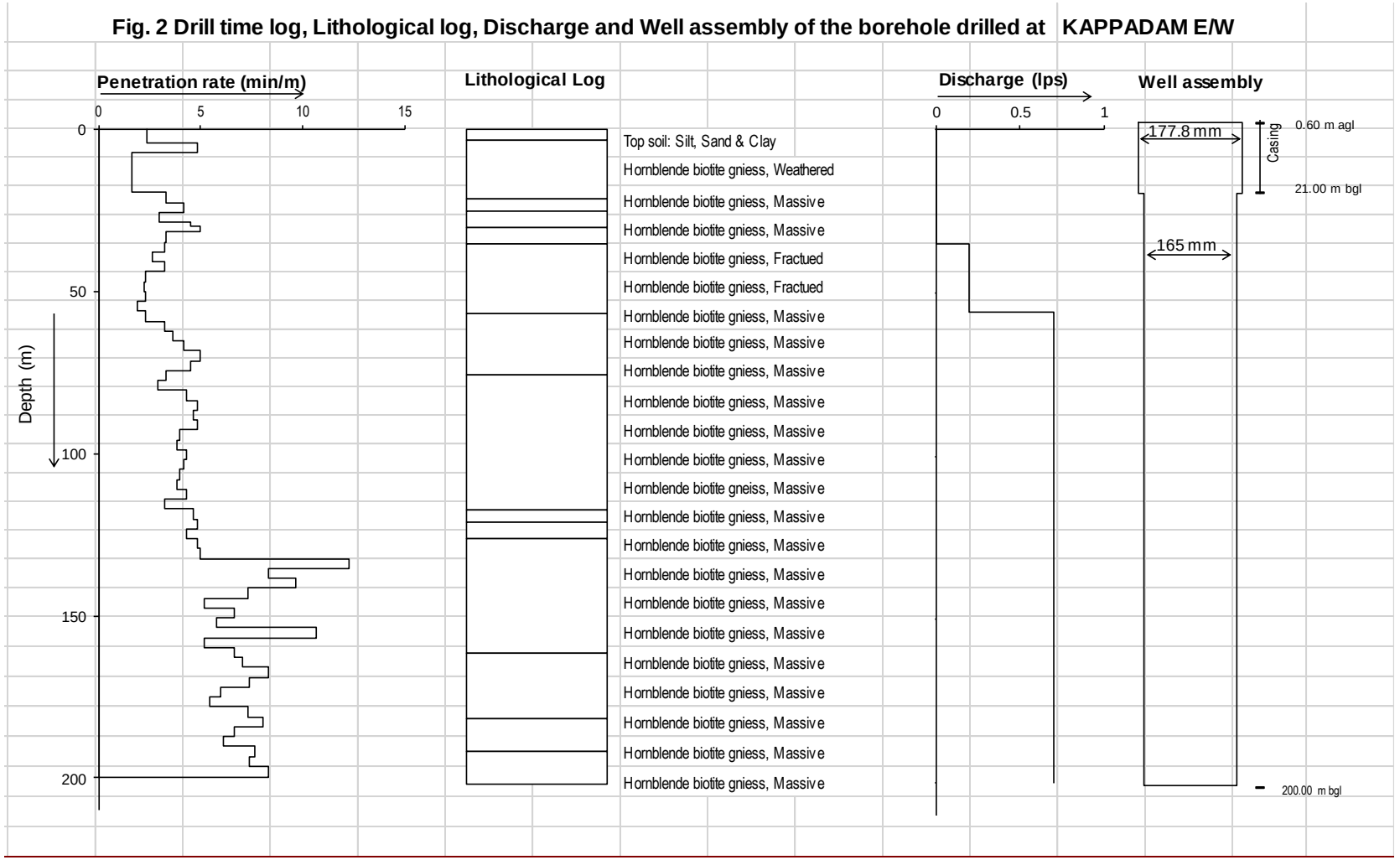


Fig. 2 Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at KADAMPAZHIPURAM
Penetration rate (min/m)
0
10
20
30
40
0
50
100
Depth (m)
Lithological Log
Top Soil: Sand, Silt & Clay
Biotite gneiss,Weathered
Biotite gneiss, Massive
Biotite gneiss, Fractured
Biotite gneiss, Massive
Biotite gneiss, Massive
Biotite gneiss, Massive
Biotite gniess, Fractured
Discharge (lps)
0
20
40
Well assembly
177.8 mm
Casing
0.60 m agl
13.40 m bgl
165 mm
71.30 mbgl

Fig. 2 Drill time log, Lithological log, Discharge and Well assembly of the borehole drilled at KAPPADAM E/W



RD-1
4/1/18

GOVERNMENT OF KERALA

No.GW1/426/2017/WRD

Water Resources (GW) Dept.,
Thiruvananthapuram,
Dated, 28/12/2017.

From

The Secretary to Government.

To

Shri V.Kunhambu, Regional Director& Member Secretary, CGWB.

Shri John Kurian , Former CGM, NABARD.

Shri John Koshy, Executive Engineer, KWA.

Shri Thomas Scaria, District Officer, GWD.

Shri. Jose James, Director, Suptdg HG, GWD.

Smt Ambili G K, Scientist, CWRDM.

Shri Jayakumaran Nair, Deputy Director, Industries & Commerce.

Shri Raju Varghese, Administrative Assistant, Directorate of Panchayath.

Shri K Shoukathali, Additional Development, commissioner, Rural Development Department.

Shri K Balakrishnan, Scientist D, CGWB.

Dr.N.Vinayachandran, Scientist D, CGWB.

Smt.T.S. Anitha Shyam, Scientist D, CGWB.

Smt Minichandran, Scientist D, CGWB.

Smt. Rani V. R, Scientist C, CGWB.

Triple Send copy to ① all member of SCTCC ② MSwathy ③ PMU, CWRDM Pandit

Sir,

Sub:-WRD– Minutes of the 5th meeting of the State Level Coordination Committee for NAQUIM Kerala forwarding of - reg.

I am to forward herewith the minutes of the meeting held on 13.12.2017 in the South Conference Hall, Secretariat for information and necessary action.

Yours faithfully,

S. MURALEEDHARAN
DEPUTY SECRETARY
FOR SECRETARY TO GOVERNMENT

Approved for issue,

Section Officer.

Minutes of the 5th meeting of the State Level Coordination Committee for NAQUIM Kerala

The Fifth meeting of the State Level Coordination Committee of National Aquifer Mapping Programme of CGWB was held on 13.12.2017 at 15.00 hours in the South Conference hall, Secretariat. Smt. Tinku Biswal, IAS, Secretary, Water Resources Department, Govt. of Kerala and Chairman, SLCC of NAQUIM chaired the meeting.

The following Members attended the meeting:

Sl.No	Name & Designation	Organization
1.	Shri V.Kunhambu, Regional Director& Member Secretary	CGWB
2.	Shri John Kurian , Former CGM	NABARD
3.	Shri John Koshy, Executive Engineer	KWA
4.	Shri Thomas Scaria, District Officer	GWD
5.	Shri. Jose James, Director, Suptdg HG	GWD
6.	Smt Ambili G K, Scientist	CWRDM
7.	Shri Jayakumaran Nair, Deputy Director	Industries & Commerce
8.	Shri Raju Varghese, Administrative Assistant	Directorate of Panchayath
9.	Shri K Shoukathali, Additional Development commissioner	Rural Development Department
10.	Shri K Balakrishnan, Scientist D	CGWB
11.	Dr.N.Vinayachandran, Scientist D	CGWB
12.	Smt.T.S. Anitha Shyam, Scientist D	CGWB
13.	Smt Minichandran, Scientist D	CGWB
14.	Smt Rani V R, Scientist C	CGWB

At the outset, the Chairperson welcomed the members and invited Regional Director, CGWB to appraise the members of the developments and progress of NAQUIM as per agenda set up for the meeting.. Shri V Kunhambu, Regional Director, CGWB, Kerala Region informed that all actions as decided in previous meeting has been completed except the data on rainfall not received from Irrigation department. The Chairperson agreed to do the needful to make available the required data from Irrigation department. Regional Director informed that 22 exploratory wells are to be constructed in sedimentary areas per NAQUIM

recommendations has been allocated to WAPCOS. Followed by this item, a power point presentation on report on Aquifer Mapping and Management plan of Kollam and Palakkad district presented by Dr N Vinayachandran, Sc- D and Nodal Officer, CGWB. The committee appreciated the contents of report. Chairperson also desired that after completing the report district wise, it is to be apportioned to make River basinwise aquifer mapping and management plan including Modeling. Based on the recommendations of the report a comprehensive management plan for Bharathapuzha Basin is to be prepared for submission to Govt of India for financial support.

Action: CGWB, GWD & Irrigation Dept

Additional item:

Regional director, CGWB informed that major rainfall in Kerala goes as runoff and most of the river under the bridge areas prone to sand mining. A proposal can be made for construction of Bridge cum regulator so that the water covered upstream can reach the flood plain which can act as repository of saturated water from where water can be extracted for various purposes including for minor irrigation.

Chairperson agreed to this and advised to prepare a feasibility report of one most suitable river basin for onward submission to Govt of India.

Action: CGWB, Irrigation Dept & KWA

The meeting ended with thanks to the Chair.

Minutes of the
Second meeting of the National Level Expert Committee
held under the Chairmanship of Chairman, CGWB
during 1-2 Nov 2017 in CGWB, Jamnagar House New Delhi.

List of participants is annexed

Second meeting of the National Level Expert Committee for review and finalization of aquifer maps and management plans was held during 1st and 2nd Nov 2017 in CGWB, Jamnagar House, New Delhi under the Chairmanship of Joint Secretary, MoWR, RD & GR and Chairman, CGWB. Presentations were made in respect of 13 states viz. Maharashtra, Andhra Pradesh, Telengana, Karnataka, Tamil Nadu, Kerala, Jammu and Kashmir, Madhya Pradesh, Rajasthan, Bihar, Chhattisgarh, Northeastern States and West Bengal. Major points that emerged during the presentations/deliberations are summarized hereinafter.

1. Aquifer maps and management plans in respect of the concerned states were reviewed by the expert Committee. It was decided to seek clarifications from the Regional Directors NHR, Dharamsala and SER, Bhubaneswar for not attending the meeting, though the presentations in respect of these states were scheduled during this meeting.
   - Action: Member (East) and Member (N&W)

2. Major modifications were recommended in respect of maps and management plans in respect of Bihar, Chhattisgarh and Jammu and Kashmir. It was recommended that these presentations would be revised and presented again before the NLEC. Detailed suggestions for improvement in other cases were given by the Committee, which were noted by the respective regional offices for compliance.
   - Action: Regional Director, CGWB, MER, Patna/ NCCR, Raipur/ NWHR, Jammu.

3. Since the maps and management plans are prepared for blocks or districts or aquifers as a whole, specific issues concerning urban areas are getting glossed in. It was suggested that the reports should contain separate sections on issues and management alternatives in urban areas. It was also suggested that wherever feasible, the management plans should also indicate aquifers which can be exploited for industrial applications.
   - Action: All concerned Regional Directors

4. JS (A&GW), MoWR,RD & GR and Chairman, CGWB advised that CGWB should prepare artificial recharge/ rainwater harvesting plan for one block each in the eight priority states, which can be shared with concerned authorities for implementation through MNREGS. He added that in similar lines, CGWB should also prepare irrigation

efficiency and cropping pattern change proposals for one block each in the eight priority states and hand it over to concerned state govt department for implementation.

- Action: Regional Director, CGWB, SR, Hyderabad/ SWR, Bangalore/ SECR, Chennai/ WR, Jaipur/ NWR, Chandigarh/ WCR, Ahmedabad/ NR, Lucknow/NCR, Bhopal.

5. JS MoWR, RD & GR advised to explore possibility of creation of a Chair of professor in ground water in IIT, Delhi and other similar organisatons. Dr. Keshari, Professor, IIT, Delhi informed that IIT, Delhi will extend all possible cooperation if such a proposal is initiated.
   - Action: Regional Director (I), CHQ, Faridabad

6. Attempt made by NER, Guwahati to refine the rainfall infiltration factors based on site specific tests were appreciated. It was suggested that as a part of aquifer mapping programme, attempts should be made to refine existing assessments of, aquifer parameters, recharge factors and water balance components.
   - Action: All concerned Regional Directors

Meeting ended with thanks to the Chair.

List of participants

1. Shri Akhil Kumar, Joint Secretary (MoWR,RD&GR) and Chairman, CGWB - in Chair
2. Shri K C Naik, Member (CGWA)
3. Dr. Dipankar Saha, Member (CGWB)
4. Dr. E Sampath Kumar, Member (South)
5. Dr .D K Chadha, Ex Chairman, CGWB
6. Shri Sushil Gupta, Ex Chairman, CGWB
7. Dr. A K Keshari, Professor, IIT, Delhi
8. Dr. Bharat Sharma, scientist Emeritus (WR), IWMI
9. Shri C Paul Prabhakar, RD, SECR, Chennai
10. Shri Subbu Raj, Supt Hydrogeologist. CGWB, SECR, Chennai
11. Dr. P K Jain, Supt Hydrogeologist, CR, Nagpur
12. Shri K M Viswanath, Regional Director, SWR, Bangalore
13. Shri Subba Rao, Regional Director, CGWB, SR, Hyderabad
14. Dr Praveen Kumar, CGWB, SR, Hyderabad
15. Shri S Marwaha, Regional Director, CGWB, Faridabad
16. Shri R K Ray, Scientist 'D', CGWB, Faridabad
17. Shri V Kunhambu, Regional Director, KR, Thiruvananthpuram
18. Dr. Shaista Khan, Scientist 'B', NWHR, Jammu
19. Dr. S K Jain, Regional Director, WR, Jaipur

20. Dr. Waseem Ahmed, Superintending Hydrogeologist, WR, Jaipur
21. Shri A K Agrawal, Regional Director, MER, Patna
22. Shri Tapan Chakraborty, Scientist 'D', CGWB, NER, Guwahati
23. Dr. O N Tiwari, Superintending Hydrogeologist, NCCR, Raipur
24. Shri L N Mathur, Scientist 'D', CGWB, NCR, Bhopal

Contributors' Page

Principal Authors

S.Singathurai, Scientist-B

Supervision & Guidance

V.Kunhambu, Regional Director

Dr.N.Vinayachandran, Scientist-D(Nodal officer)

K Balakrishnan, Scientist-D (Team Leader)

Scrutiny

Dr.N.Vinayachandran, Scientist-D

Dr V S Joji, Scientist-D

Hydrogeology

S.Singathurai, Scientist-B

K Balakrishnan, Scientist-D (Team Leader)

Mohammad Rafi STA (HG)

Geophysics

N Veera Babu, STA (Geophysics)

A Ramadevi, STA (Geophysics)

Hydrometeorology

C.Rajkumar, Scientist-C

Hydrochemistry

V.N.Sreelatha, Scientist-D

Bindu.J.Viju, Scientist-B