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

EAST JAINTIA HILLS DISTRICT, MEGHALAYA

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

GOVERNMENT OF INDIA

MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

REPORT
ON

"AQUIFER MAPPING AND MANAGEMENT PLAN OF EAST JAINTIA HILLS DISTRICT, MEGHALAYA"

(AAP 2017-18)

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Preface

Under National Aquifer Mapping and Management Plan (NAQUIM) program, Central Ground Water Board, State Unit Office, Shillong has carried out aquifer mapping and management plan in East Jaintia Hills district of Meghalaya. The objective was to understand the aquifer system down to the depth of 200 meters, decipher the aquifer geometry, its characteristics, quantity, quality and formulate a complete sustainable and effective management plan for ground water development in the study area.

A multi-disciplinary approach of geology, geophysics, hydrology and chemistry was adopted to achieve the objectives of the study. A management plan was made with emphasis on irrigation for agricultural.

This report elaborates the different aquifer system prevailing in the study area, its characteristics and also provides the different scientific data which will help in proposing plans to achieve drinking water security, irrigation facilities etc. through sustainable ground water development.

The groundwater management plan was made with an emphasis in providing irrigation facilities through ground water development as agriculture is the main means of livelihood of the people in the district. To use the groundwater for irrigation purpose, a cropping plan has been designed for the district by using CROPWAT model developed by FAO.

The study of this Aquifer mapping and management plan of East Jaintia Hills district was carried out under the supervision of Shri Tapan Chakraborty, Officer In Charge & Nodal officer of NAQUIM, NER who has helped in all the aspects of technical inputs, report preparation and moral support.

I hope this report will help the stake holders, planners, policy makers, professionals, academicians and researchers dealing with water resources or ground water resources management.

Acknowledgement

I would like to acknowledge all the below mentioned for their untiring help and support in all aspects related to this work.

I would like to extend my heartfelt gratitude to Shri. G L Meena, Regional Director, CGWB, NER, Guwahati for his constant support and guidance during the course of this study.

I render my outmost and sincere thanks to my supervisor Shri Tapan Chakraborty, Officer In Charge, SUO, Shillong& Nodal officer of NAQUIM, NERfor all the help, support, guidance, technical inputs, encouragement and also preparing the ground water resources and management strategies of this report.

Sincere thanks to Shri VekhosaKezo, Scientist-B and Smt. Preeti Pandey, Scientist-B for all the help and support.

I would like to thankDr KeishamRadhapyari, Scientist-B (Chemist) and her team for analysing the ground water samples and providingthe data. I thank all the Engineers and Drilling staff of CGWB, Division VII, Guwahati for their contribution in ground water exploratory drilling activities in the study area.

I sincerely thank Geological Survey of India, North East Space Application Centre, Survey of India and Indian Meteorological Department for providing the valuable data and maps.

I would also like to thank Meghalaya State Government officials of Water Resource Department, Public Health Engineering Department, Statistical Department and Agricultural Department for providing all the necessary information of the study area.

I thank all the officials and staff of CGWB, SUO, Shillongfor their help and support during the course of this work.

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ABBREVIATION

AAP	Annual Action Plan
CGWB	Central Ground Water Board
NER	North Eastern Region
NAQUIM	National Aquifer Mapping and Management Plan
GL	Ground Level
GSI	Geological Survey of India
IMD	Indian Meteorological Department
LPM	Litres per minute
LPS	Litres per second
m	Metre
mbgl	Meters below ground level
MCM	Million Cubic Meter
Mm	Milli meter
mg/l	milligram/litre
m amsl	Metre above mean sea level
Sq.Km	Square Kilometre
µS/cm	Microsimens/centimetre
AMP	Aquifer Management Plan
AQM	Aquifer Mapping
BIS	Bureau of Indian Standards
BDL	Below detectable level
BCM	Billion Cubic Metres
DGM	Directorate of Geology and Mining
DTW	Depth to water table
DW	Dug Well
BW	Bore well
EC	Electrical Conductivity
EW	Exploratory Well
GEC	Ground water Estimation Committee
Ha	Hectare
Ham	Hectare meter
Km	Kilometer
MP	Measuring Point
OW	Observation Well
°C	Degree Celsius
Ppm	Parts per million equivalents to mg/l
Pz	Piezometer
SWL	Static water level
TDS	Total dissolved solid

EXECUTIVE SUMMARY

Aquifer Mapping studies and Management Plan has been carried out in East Jaintia Hills district, Meghalaya under National Aquifer Mapping and Management Plan (NAQUIM) programme with an objective to know the different aquifer system prevailing in the study area, to decipher the vertical and lateral extend of the aquifer down to the depth of 200 m, its characteristic, quantity as well as quality so as to bring a complete sustainable and effective aquifer management plan for ground water resources development in the study area.These studies has been done through multi-disciplinary approach so as to achieve the said objectives.

The total coverage area of aquifer mapping and management plan is 1001 sq.km out of 2040 sq.km of the district and is underlain by consolidated rocks ofSandstone and Limestone.

Occurrence of ground water in the study area is mainly of weathered and fracturedSandstone and Limestone. The different hydrogeological datas are generated through intensive field data collection and testing.The aquifer system in this district can be dividedas a two aquifer systemviz., first aquifer (shallow) and second aquifer (deeper).Shallow or first aquifer consists of weathered residuum where ground water occurs under water table condition and is mainly developed by construction of dug wells or shallow bore wells as hand pump. The second aquifer is the deeper aquifer which tapped the fractured zone. Based on the study of litholog and analysis of depth of construction of dug wells and shallow bore wells, it was found that the first aquifer occur within 2 to 40 m bgl. Ground water in the second aquifer occurs under semi-confined to confined condition in the fractures zoneupto the maximum depth of 192.20 m bgl.

Ground water exploration has been carried out in different parts of the district to delineate the potential aquifers and their geometry and to determine the hydrogeological parameters of the aquifer systems. To know the different parameters of an aquifer, preliminary yield test and slug test were carried out during the course of study.Soil infiltration test wasalso conducted in different parts of the study area to know the infiltration rates at different soil conditions, topography, geology and environment and also to know its suitability and the amount of water recharging in the area and its rainfall infiltration factor.

Study of water level trend and its behavior both in phreatic and confined condition were carried out in the aquifer mapping area. Study of spring was also carried out in the study area.Most of these springs weredepression and topographic or fractured springs. It is

observed that the discharge of springs in this area ranges from 0.36 to 6.6 litre/minute during pre-monsoon and 1.02 to 27 litre/minute during post-monsoon season.

In order to study the chemical quality of ground water in the district, water samples from first aquifer (dug wells and springs) and second aquifer (CGWB Bore well) were collected during the course of field work and were analyzed and it was found that there is a high concentration of iron in deeper aquifer and pH value is low in almost all the springs, dug well and bore well.

Surface Geophysical studies in the study area were carried out to delineate the subsurface geology in the study area. A total of 10 VES were conducted in East Jaintia Hills district during AAP 2010-11.

Dynamic Groundwater Resources of the study area has been estimated based on the methodology recommended by Groundwater Estimation Committee (GEC'97). The net ground water availability was 10697 ham and the stage of ground water development was 0.53% which comes under safe category.

Finally, the aquifer map of the study area is generated based on the inputs from geological, hydrogeological, geophysical and hydrochemical studies and a management plan was made with an emphasis in providing irrigation facilities through ground water development as agriculture is the main means of livelihood of the people living in the district.

1. INTRODUCTION

Central Ground Water Board, North Eastern Region has carried out Aquifer mapping and management plan in East Jaintia Hills district, Meghalaya during AAP 2017-18 covering an entire area of 1001 sq.km. Under National Aquifer Mapping and Management (NAQUIM) program, combination of geologic, geophysical, hydrologic and hydro chemical information is applied to characterize the quantity, quality and sustainability of ground water aquifers. Systematic aquifer mapping will improve ourunderstanding of the geologic framework of aquifers, their hydrogeologic characteristics, quality and also quantifying the available ground water resources potential and proposing plans appropriate to the scale of demand and the institutional arrangements for management.Aquifer mapping at the appropriate scale can help to prepare, implement and monitor the efficacy of various management interventions aimed at long-term sustainability of our precious ground water resources, which, in turn, will help achieve drinking water security, improved irrigation facilities and sustainability in water resources development.

1.1 Objectives

The objectives of this project are;to understand the aquifer systems up to 200 m depth,to define the aquifer geometry, type of aquifers, ground water regime behaviors, hydraulic characteristics and to establish groundwater quantity, quality, and sustainability, and to estimate the dynamic and static resources accurately through a multidisciplinary scientific approach on 1:50,000 scale and finally formulate a complete, sustainable and effectivemanagement plan for ground water development.

1.2 Scope of the Study:

The activities of this Aquifer Mapping and management plan can be envisaged asfollows:

1.2.1 Data Compilation & Data Gap Analysis: One of the important aspect of aquifer mapping program was the synthesis of the large volume of data already collected during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe an aquifer system. The data were assembled, analyzed, examined, synthesized and interpreted from available sources. These sources were predominantly non computerized data, which was converted into computer based GIS data sets. On the basis of available data, data gaps were identified.

1.2.2 Data Generation: There was also a strong need for generating additional data to fill the data gaps to achieve the task of aquifer mapping. This was achieved by multiple activities such as exploratory drilling, hydro-geochemical analysis, remote sensing, besides detailed

hydrogeological surveys to delineate multi aquifer system; to bring out the efficacy of various geophysical techniques and a protocol for use of geophysical techniques for aquifer mapping in different hydrogeological environs.

1.2.3. Aquifer Map Preparation: On the basis of integration of data generated from various studies of hydrogeology, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out characterization of Aquifers, which can be termed as Aquifer maps providing spatial variation (lateral & vertical) in reference to aquifer extremities, quality, water level, potential and vulnerability (quality & quantity).

1.2.4. Aquifer Management Plan Formulation: Aquifer Maps and ground water regimescenarioare being utilized to identify a suitable strategy for sustainable development of theaquifer in the area.

1.3 Approach and Methodology: Aquifer mapping has been carried out by adopting amulti-disciplinary approach:

(i) Geophysical Surveys through Vertical Electrical Sounding (VES)

(ii) Exploratory drilling and construction of bore wells tapping various groups of aquifers

(iii) Ground Water Regime monitoring by establishing monitoring wells tapping different aquifers at different depths for long term monitoring of water level and quality

(iv) Pumping test of bore wells, soil infiltration test, slug tests for determination of ground water recharge scope, intensity and potentials and also to determine the characteristics and performances of existing aquifers at various depths.

(v) Collection of various relevant technical data from the field in aquifer mapping area and also from the concerned State Govt. Agencies and other Institutes dealing with ground water and incorporating these data along with CGWB data for final output.

(vi) Preparations of a micro level mapping of existing aquifers, their potentials depth wise and sideways in 2D and 3D forms viewed from different angles by various GIS Layers.

(vii) Formulating a complete sustainable aquifer management plan for ground water development.

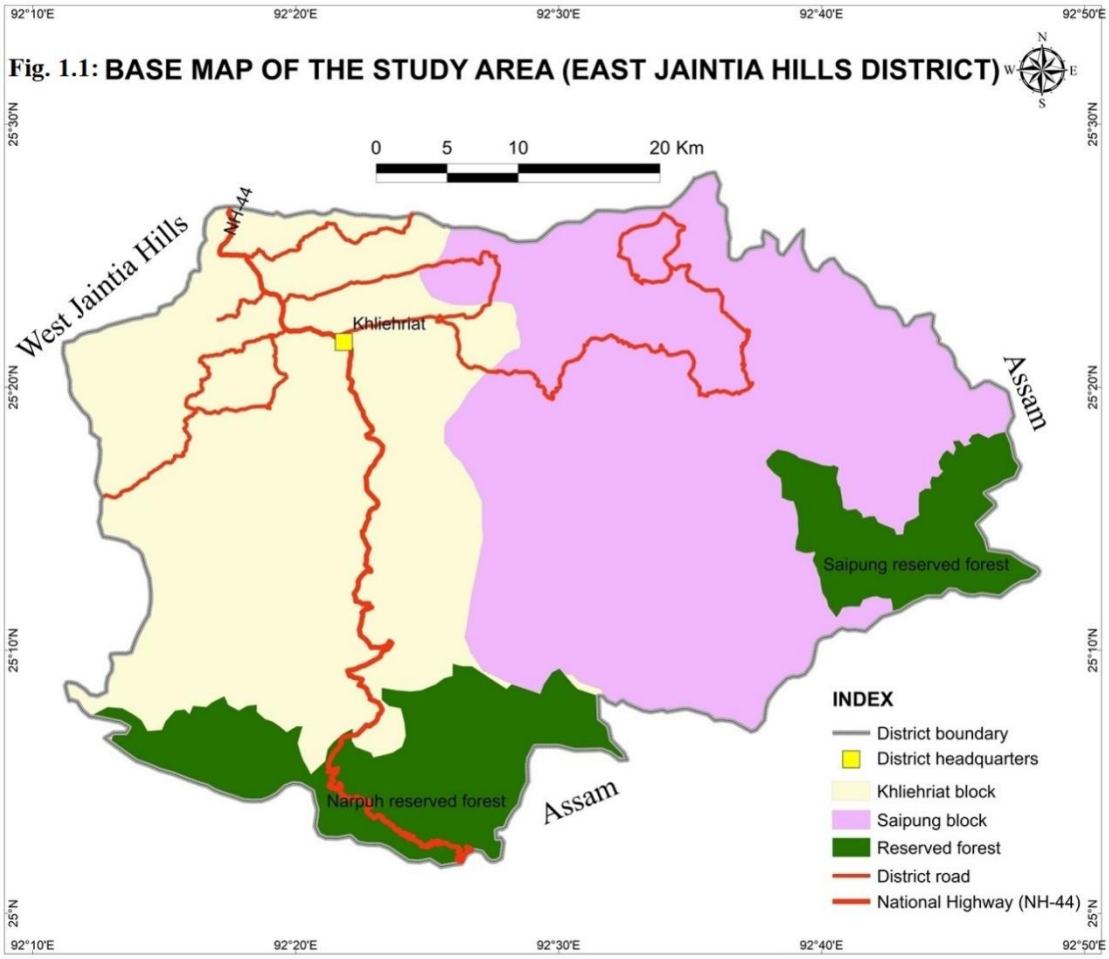
1.4 Area details: East Jaintia Hills district lies between E 92˚00’00” to E 92˚40’00” Longitude and N 25˚06’00” to N 25˚45’00” Latitude. The district is having an area of 2040

sq.km and out of this, 1001 sq.km of map able area was covered under NAQUIM program. The district has two C. &R.D. blocks and the details of the block along with their respective headquarters and populations are given in Table 1.1.

Table 1.1 Administrative setup of East Jaintia Hills district

District/Block	Area(sq Km)	Population (2011 census)		
		Person	Male	Female
East Jaintia Hills	**2040**	**122939**	**61233**	**61706**
1. Khliehriat C & R.D. block		85832	42628	43204
2. Saipung C & R.D. block		37107	18605	18502

This area falls partly or fully in the quadrants of Survey of India Toposheets bearing nos. 83 C/3, 83 C/4, 83 C/7, 83 C/8, 83 C/11, 83 C/12, 83 C/15and 83 C/16and is bounded by North Cachar Hills district of Assam in the East, Cachar Hills district of Assam and Bangladesh in the south and West Jaintia Hills district in the North and West.The base map of the study area is shown in fig.1.1



1.5 Data availability, data adequacy and data gap analysis:

Aquifer mapping and management plan is carried out through collaborative of different data. The required data on various attributes of the study are collected from the available literatures of Central Ground Water Board, State Water Resources Department of Meghalaya and various Central and State Government agencies. The Data Requirement, Data Availability and Data Gap Analysis are presented in table 1.2and annexure 9.

Table1.2 Data Availability and Data Gap Analysis in Aquifer Mapping Studies Area

Sl. No.	Items	Data Requirement	Data Availability	Data Gap
1	Ground Water Exploration Data	Both first aquifer and second aquifer	1 EW	I Aquifer : 21 nos. of EW & OW. II Aquifer : 20 nos.of EW and 21 nos. of OW.
2	Geophysics	Geophysical data of the Study area	10 VES	Entire study area
3	Ground Water Monitoring Regime	Representative Monitoring Wells well distributed over the Study Area for both first and second aquifers.	1 Monitoring Well (DW)	I Aquifer : 37 nos. II Aquifer : 21 nos.
4	Ground Water Quality	Representative Monitoring Wells well distributed over the Study Area for both first and second aquifers.	Water quality data of 1 monitoring well	I Aquifer : 37 nos. II Aquifer : 21 nos.
5	Specific yield (Shallow and deeper aquifer)	Both aquifers	Nil	Entire study area
6	Climate	Season-wise Rainfall pattern	Annual Rainfall of 1Meteorological Station	Time-series data on Rainfall
7	Soil	Soil map and Soil Infiltration Rate	Soil map	Soil Infiltration studies covering the entire study area
8	Land use	Latest Land Use pattern	Latest Land Use pattern	NA
9	Geomorphology	Detailed Information on Geomorphology of the area	District level information	NA
10	Recharge Parameters	Recharge parameters for different soil and aquifer types based on field studies	Recharge parameters given in Ground Water Resources Estimation	Entire study area

1.6 Demography: As per 2011 Census, East JaintiaHillsdistricthas a population of 122939 out of which 61233 were male and 61706 were female respectively.

1.7 Communication: EastJaintia Hills district forms the eastern portion of Meghalaya and the National Highway 44 passes through the heart of the district and serves as the main

communicationline to other districts of the state. The headquarter of the district is at Khliehriat, which is located at 97 km away from the state capital Shillong.

1.8 Climate: The climate of the district is mildly tropical in the northern and southern foothills, while in the central upland zone, the climate is temperate and places at medium altitude in the northern, western and southern parts of the district, experience sub-tropical climate. The district is influenced by the south-west monsoon and rainfall is assured during summer, but differs greatly in intensity from area to area within the district. The average rainfall ranges from 1200 mm to 3000 mm per annum.

1.9 Land use: Land utilization statistics provide detailed information of the land use pattern in the area. Based on the land utilization, the total area is divided into various types of landforms such as forest, cultivable land, fallows lands, crops area etc. which in turn reflects the degree of development of agricultural activities and cultivation potential. The land utilization statistics of the East Jaintia Hills district is shown in the following Table1.3 and land use map is shown in Fig. 1.2.

Table 1.3: Land use pattern in East Jaintia Hills, 2015-16

Land Classifications	Area in hectares
A. Geogrphical Area	204000
B. Reporting Area	203650
1. Forests (classed & unclassed)	84077
2. Area not available for cultivation a.(i) Area under non-agricultural uses	
b. Barren and uncultivalble lands	
c. Water logged land	
d. Social Forestry	683
e. Land under still water	2050
f. Other land	5730
TOTAL = (a+b)	
TOTAL (Column a to f)	8463
(ii) Barren and unculturable lands	7102
TOTAL = Col. i& ii	15565
3. Other uncultivable lands a. Permanent pastures and other grazing lands	
b. Land under Misc. tree crops & grooves etc.	9537
c. Cultivable wastelands	68751
TOTAL = (a+b+c)	78288
4. Fallow lands a. Fallow lands other than cerrent fallows	9205
b. Current fallows	5437
TOTAL = (a+b)	14642
5. Net area sown	11071
6. Area sown more than once	48
7. Total Croped area	11119

Source: Directorate of Economics & Statistics, Shillong, Govt. of Meghalaya.

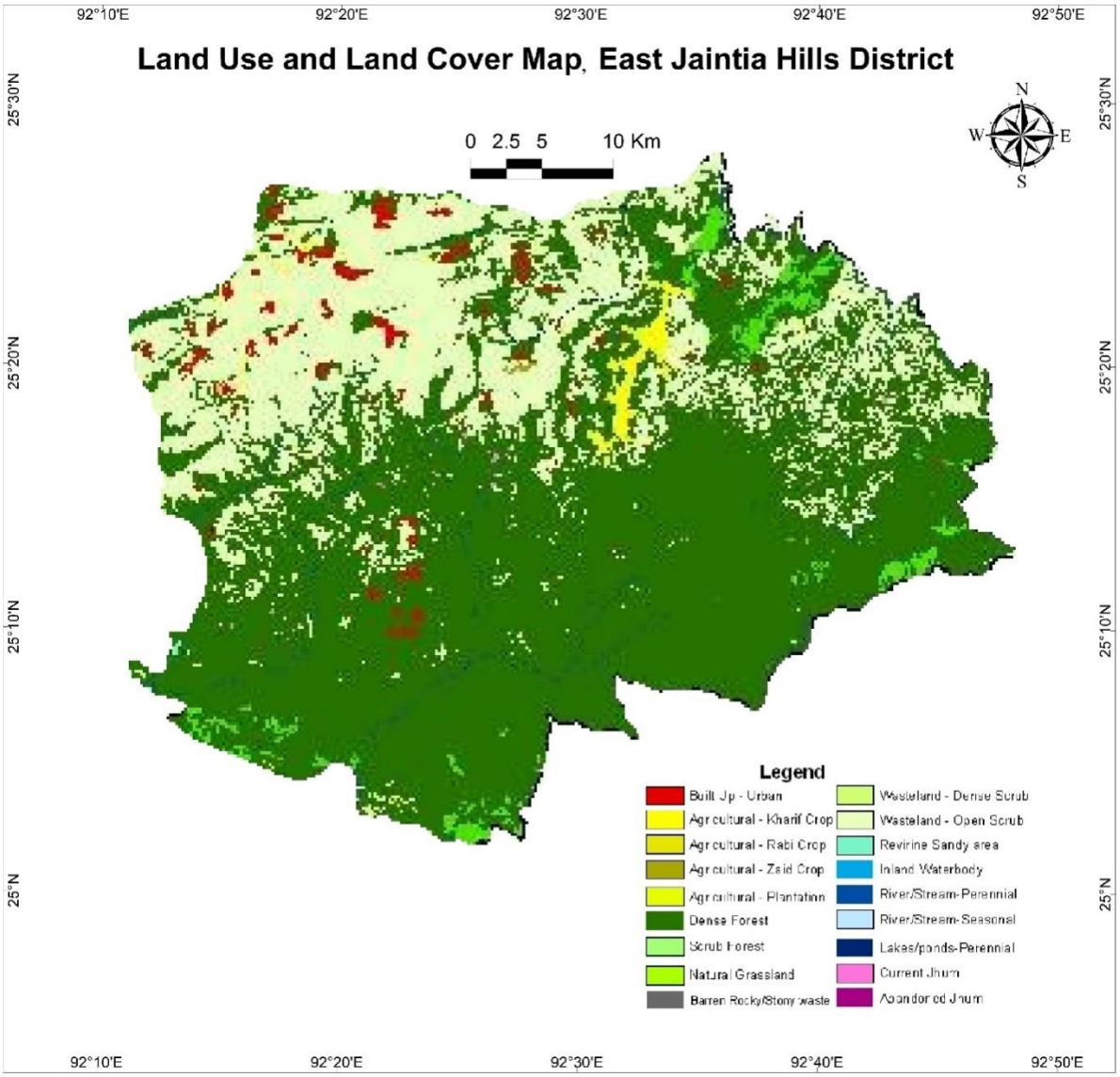


Fig 1.2: Land use map of East Jaintia Hills (*Source: NESAC*)

1.10Soil: High rainfall, humid subtropical climate and favorable topography have resulted in the formation of soil profile (1-10 m) in the study area. The soil in the study area is mostly deep brown, black soil, red soil, alluvial soil, sandy soil and acidic soil. The acidic character is due to leaching of bases caused by high rainfall. The sandstone in the areagave rise to sandy and permeabletexture soils. The soil is mostly sandy, reddish brown to yellow brown in color, acidic in reaction with low water holding capacity and has poor contents of organic matter and nutrients. The soil classification has been conducted by the Regional Center of National Bureau of Soil Survey and Land Use Planning, for the State of Meghalaya. Soil map of the area is given in Fig 1.3.

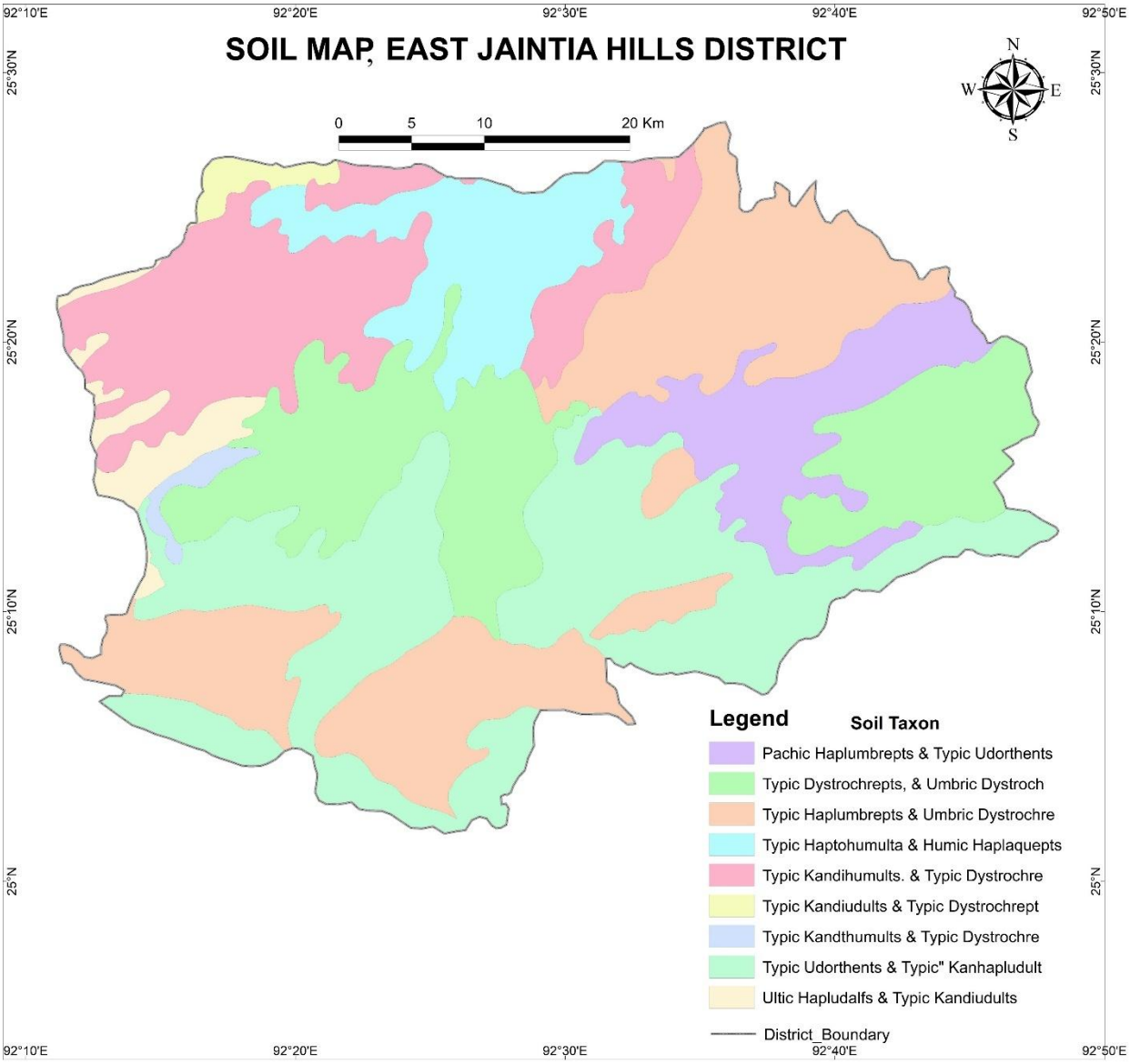


Fig. 1.3: Soil map of East Jaintia Hills(*source: Regional Center of National Bureau of Soil Survey and Land Use Planning*).

1.11 Agriculture: Agriculture is the main means of livelihood of the people in the district and majority of the population is dependent on agriculture. The area is endowed with diversified climatic condition thereby offering good scope for cultivation of temperate and subtropical crops. The principal crops of the study area are paddy, maize, potato, ginger, turmeric, pineapple, tapioca, citrus, banana etc. The season wise cropping pattern of East Jaintia Hills is shown in Table 1.4.

Table 1.4 Season wise cropping pattern of East Jaintia Hills district.

Name of the Crop	Kharif (May to Oct)	Rabi (Nov to April)
Paddy	Ploughing, transplanting inter culture nursery operation, sowing	Harvesting
Maize	Sowing, harvesting	Land preparation, inter culture sowing operation,
Tomato, potato, beans etc	-----do----	-----do-----

Source: Department of Agriculture Office, Govt. of Meghalaya.

Present area under different crops and their productivity is shown in table 1.5.

Table 1.5: Area under different crops and their productivity, East Jaintia Hills district (2015-16)

Crops	**Area (ha)**	**Avg.Yield (kg/ha)**
Autumn rice	28	2464
Winter rice	4347	2085
Spring rice	23	2304
Maize	520	2263
Pulses	41	1024
Rape and mustard	11	909
Soyabean	62	1629
Tapioca	6	9833
Citruis fruits	287	3895
Pineapple	25	8960
Banana	104	3327
Papaya	3	2333
Potato	49	5755
Sweet potato	182	3000
Ginger	14	10714
Turmeric	53	5830
Chillies	20	1050
Black pepper	33	727
Tea	6	3000
Arecanut	264	1235
Rubber	569	72
Coffee	7	1143
Total	**6654**	**73552**

Source: Agriculture Department, Govt. of Meghalaya.

1.12 Irrigation: The district does not have any major or medium irrigation projects. Agriculture is dependent mainly on rainfall. There are 14 nos. of minor irrigation schemes available in the district as per 2016. All these minor irrigation schemes are based on surface water sources. Salient features of minor irrigation schemes in East Jaintia Hills district are given in Table1.6.

Table 1.6 Salient features of minor irrigation schemes/project in East Jaintia Hills

Sl. No.	Name of the Project	Ayacut in Ha	Remarks
A. Khliehriat Block			
1	Ratacherra FIP	60	Completed
2	Doglun FIP	36	Completed
3	Kuliang FIP	33	Completed
4	Umkiang RWHS	10	Completed
5	WahKremKsiar FIP	32.04	Completed
6	Priangkhla FIP	214.3	Completed
7	Urmanik FIP	65.1	Completed
8	Tuber Kmaishning FIP	113.67	Completed
9	Khangmusna FIP	60	Completed
B. Saipung Block			
1	Tisha FIP	10.65	Completed
2	KwaiUmpleng LIP	480	Completed
3	Khonwang LIP	13.68	Completed
4	Kor Bangla FIP	25.3	Completed
5	Madan Soophaw LIP	61	Completed

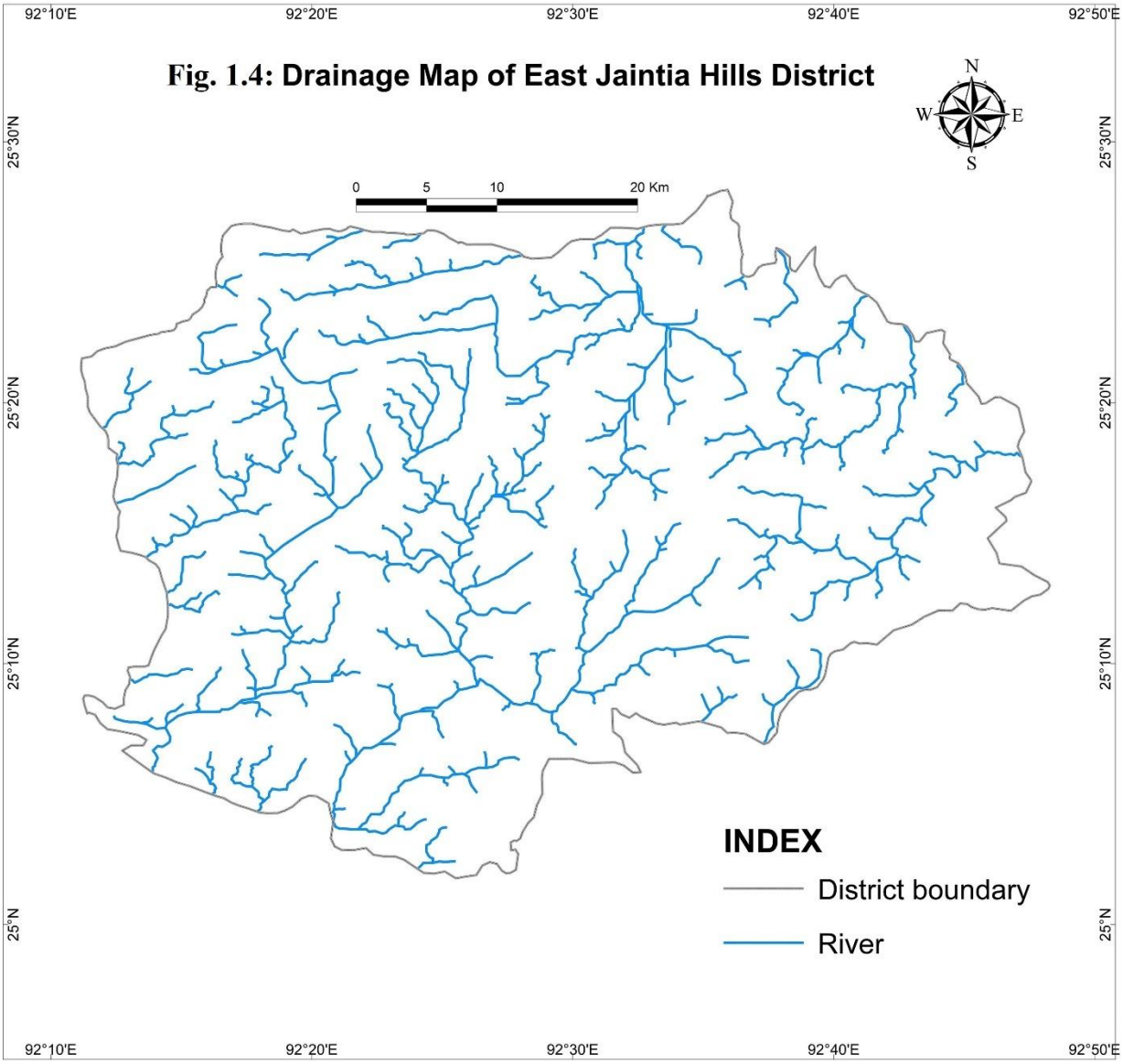
Source:, Water Resource Department, Govt. of Meghalaya.

1.13 Industries: In Jaintia Hills district, there are some major cement industries, coke industries and limestone. There has been a steady increase in the number of registered small scale units which are mostly in the tiny sector covering servicing Industries, bakeries, furniture making, Iron and steel fabrication, tailoring, knitting, leather work, shoe making, Handicrafts, Tin-trunk making, stone crusher, betel nut preservation, turmeric processing, fish fermentation, honey processing, auto servicing, car washing centre, electronic repairing, cartridge manufacturing and refilling centre.Coal is also being mined in the district.

1.14 Forest: The District is very rich in natural resources. The forest types of the District comprises of Sub-Tropical Pine Forest, Tropical Semievergreen, Tropical MoistDry deciduous, Tropical dry and Bamboo mixed. As per Directorate of Economics and Statistics, the forest cover area is about 84077 ha (2015-16). There are two reserved forest in East Jaintia Hills viz. Narpuh and Saipung reserved fores which constitute about 31145.058 ha. These forest areas (both the reserve forest and the private forest) are habitat for varieties of wildlife.

1.15 Drainage: The drainage pattern of dendritic, rectangular types are found in the area which indicates both topographic and structural control. The important river in East Jaintia Hills district includes WahLukha, WahApha, WahMalidor, Umsalih, WahKairang, Umsawai,

WahKalipai, Wah Prang, Wallong river and WahKyrwi. The drainage map is shown in Fig 1.4.



2. DATA COLLECTION AND GENERATION

One of the main objectives of the study was to collect various relevant technical data from the concerned State Government agencies and other Institutes dealing with ground water and incorporating these data along with CGWB data to generate strong data base. Based on the data availability and data gap analysis, the required sub-surface hydrogeological data, groundwater level data, groundwater quality data and Geophysical data were generated but the entire data required could not be generated due to unapproachable/inaccessible and difficult hilly terrain.

2.1 Hydrogeological: Occurrence of ground water in the study area is mainly of weathered and fractured Sandstone and Limestone formation. The different hydrogeological data are generated through intensive field data collection and testing.

2.1.1 Water level monitoring: In the study area, 1 dug well, 2 bore wells and 9 springs were established askey wells to study the water level, quality, spring discharge and its behavior periodically.

Phreatic aquifer: A total of 1 dug well was established as key wells for periodical monitoring to know the water level trend and its behavior. The key observation wells details are presented in Annexure 3 and the pre and post monsoon Depth to Water Level in Fig 3.4 and 3.5.

Confined/Semi-confined aquifer: For study of piezometric head in the district, a total of 2 newly constructed bore wells were monitored periodically. Details of these key observation wells are presented in Annexure 2and the pre and post monsoon Depth to Water Level in Fig 3.6 and 3.7.

Springs: A total of 9 springs were established and monitored to know the type, discharge and their behavior. The locations of these springs are given in table 2.1.

Table 2.1 Location of springs in East Jaintia Hills district

Sl. No.	Location	Block	District	Latitude	Longitude	RL (m)	Type	Lithology
1	Khlieriat	Khlieriat	East Jaintia Hills	25°20’36”	92°22’00”	1126	Depression	Sandstone
2	Byndihati	Khlieriat	East Jaintia Hills	25°19’02”	92°22’32”	1037	Depression	Sandstone
3	ThangkaiLumshnong	Khlieriat	East Jaintia Hills	25°12’27”	92°22’27”	797	Depression	Sandstone
4	Mookympad	Khlieriat	East Jaintia Hills	25°21’12”	92°26’14”	1044	Fracture	Sandstone
5	Tuber	Khlieriat	East Jaintia Hills	25°26’14”	92°17’40”	1361	Fracture	Sandstone
6	Latyrkle	Saipung	East Jaintia Hills	25°20’36”	92°27’41”	983	Fracture	Sandstone
7	Tangnub	Saipung	East Jaintia Hills	25°17’53”	92°30’01”	1070	Fracture	Limestone
8	Narwan	Saipung	East Jaintia Hills	25°24'33"	92°24’52”	1222	Depression	Sandstone
9	Mynthlu	Saipung	East Jaintia Hills	25°25’09"	92°30’48"	985	Depression	Sandstone

2.2.2 Preliminary Yield Test (PYT) and Slug test: A total of 1 preliminary yield tests were carried out during NAQUIM programme and 1 PYT before NAQUIM in the study area to know the aquifer parameters. And 1 slug test was conducted at Mynthly during NAQUIM programme using Ferri's method to ascertain the transmissivity. The details are shown in Annexure 1.

2.1.3Soil Infiltration Studies: Soil infiltration test were conducted using double ring infiltrometer and the constant infiltration rates of different soils were calculated by double ring infiltrometer method. These studies were carried outindifferent locations to know the infiltration rates at different soil conditions, topography, geology and environment. This will provide a scientific approach of groundwater recharge, its suitability and the amount of water recharging in that area, rainfall infiltration factor and will help in calculating ground water resource estimation. The location map where soil infiltration test were conducted is shown in fig 2.1 and the details are shown in table 2.2 and annexure 7.

Table 2.2 Details of Soil Infiltration Test studies results

Sl. No.	Location	Latitude	Longitude	RL (m)	Soil type	Soil thickness (m)	Colour	Infiltration rate (cm/hr)	Date of Test
1	2	3	4	5	6	7	8	9	10
1	Lumshnong	25°12'27"	92°22'26"	801	Typic Udorthents & Typic Kandhapludult	3 to 4	Brownish red	23.4	14.02.2018
2	Nongsning	25°14'37"	92°22'34"	721	Typic Dystrochrepts &UmbricDystroch	1	Brown	1.5	14.02.2018
3	Khliehriat	25°20'36"	92°21'59"	1138	Typic Kandihumults& Typic Dystrochre	1 to 2	Red	0.6	16.02.2018
4	Latykre	25°20'33"	92°28'22"	969	Typic Haptohumulta&HumicHaplaquepts	1 to 2	Reddish brown	0.3	15.02.2018
5	Tangnub	25°19'04"	92°29'44"	1124	Typic Kandihumults& Typic Dystrochre	1 to 2	Brown	1.5	15.02.2018
6	Narwan	25°24'45"	92°25'57"	1187	Typic Haptohumulta&HumicHaplaquepts	1/2 to 1	Brown	3	20.03.2018

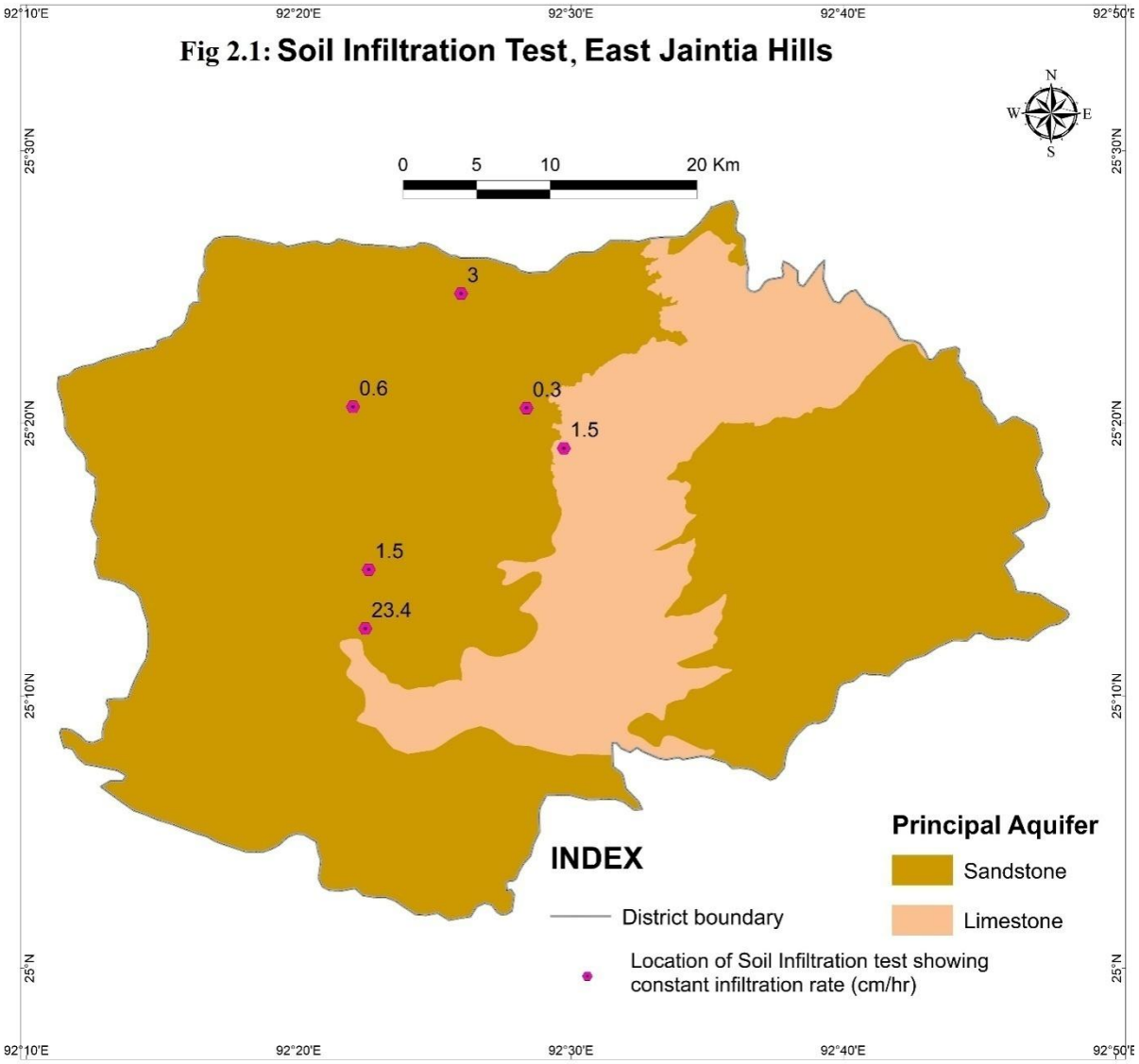


Fig 2.1: Soil Infiltration Test, East Jaintia Hills

2.2 Hydrochemistry: The quality of ground water is as important as that of the quantity. In order to study the chemical quality of ground water in the district, water samples from first aquifer (dug wells and springs) and second aquifer (CGWB Bore well) were collected during the course of field work. Ground water samples were analyzed in the regional chemical laboratory, Central Ground Water Board, North Eastern Region, Guwahati for 16 parameters. The analytical data are given in Annexure 4.

2.3 Geophysical studies: Surface Geophysical studies in the study area were carried out to delineate the subsurface geology as well as supplement the data gap under the assignment of Aquifer Mapping. A total of 10 VES were conducted and HAK, HK, HKH, HAK, KQ, QH, A, K type VES curves were obtained. The inferences drawn on the basis of interpreted results could not be obtained for deeper formation due to the limitations of unavailability of large

and straight stretch for current electrode separation. However, taking into account the interpreted results as well as the apparent resistivity, inferences have been approximated to shallow to deeper depth at fewplaces. The detail results are given in Annexure 6. The locations of the survey carried out are tabulated below;

Table 2.3 Location of VES survey carried out in East Jaintia Hills

Sl. No.	VES No.	District	Village	Location	Coordinates
1	105	East Jaintia Hills	Laiten Valley	110m due N 60°W of the second pillar on Northern side of the bridge.	N25°21’27” E92°33’27”
2	106	East Jaintia Hills	Laiten Valley	140m N 60°W of VES-105.	N25°21’28” E92°33’23”
3	107	East Jaintia Hills	Laiten Valley	120m N 60°W of VES-106.	N25°21’26” E92°33’31”
4	108	East Jaintia Hills	Laiten Valley	By the side of the road leading to the bridge.	N25°21’37” E92°33’18”
5	109	East Jaintia Hills	Nongkhliew	50m SE of river/stream.	N25°21’36” E92°33’32”
6	110	East Jaintia Hills	Nongkhliew	100m North of VES-109.	N25°21’39” E92°33’29”
7	111	East Jaintia Hills	Nongkhliew	100m N of VES-110.	
8	112	East Jaintia Hills	Nongkhliew	Along side of the road leading to the valley.	N25°21’34” E92°33’23”
9	113	East Jaintia Hills	Leken Valley	Near the NE goalpost of the foot ball ground.	N25°21’32” E92°33’12”
10	114	East Jaintia Hills	Leken Valley	120m South 50°E of VES-113.	N25°21’30” E92°33’14”

2.4 Ground water Exploration studies: Ground water exploration has been carried out in different parts of the district to delineate the potential aquifers and their geometry and to determine the hydrogeological parameters of the aquifer systems.Before NAQUIM program startedin the district, only 1 EW was constructed and as a part of data gap generation2 EW and 1 OW were constructed during the course of study. Details of the exploratory wells are presented below in the table 2.4.

Table 2.4 Exploratory wells constructed in East Jaintia Hills district

Sl. No.	Village/ Location	Taluka/ Block	District	Toposheet No.	Longitude	Latitude	Type of well (DW/BW/TW)	Drilled Depth
1	Litang	Saipung	East Jaintia Hills	83 C/11	92°33’55"	25°16’23"	BW	80.3
2	Mynthlu	Saipung	East Jaintia Hills	83 C/11	92°30’50"	25°25’07"	BW	200
3	PowergridKhliehriat	Khliehriat	East Jaintia Hills	83 C/7	92°22’11"	25°20’40"	BW	164.9

The exploratory wells which were constructed before and during NAQUIM is shown in fig 2.2 and Lineament map is shown in fig 2.3.

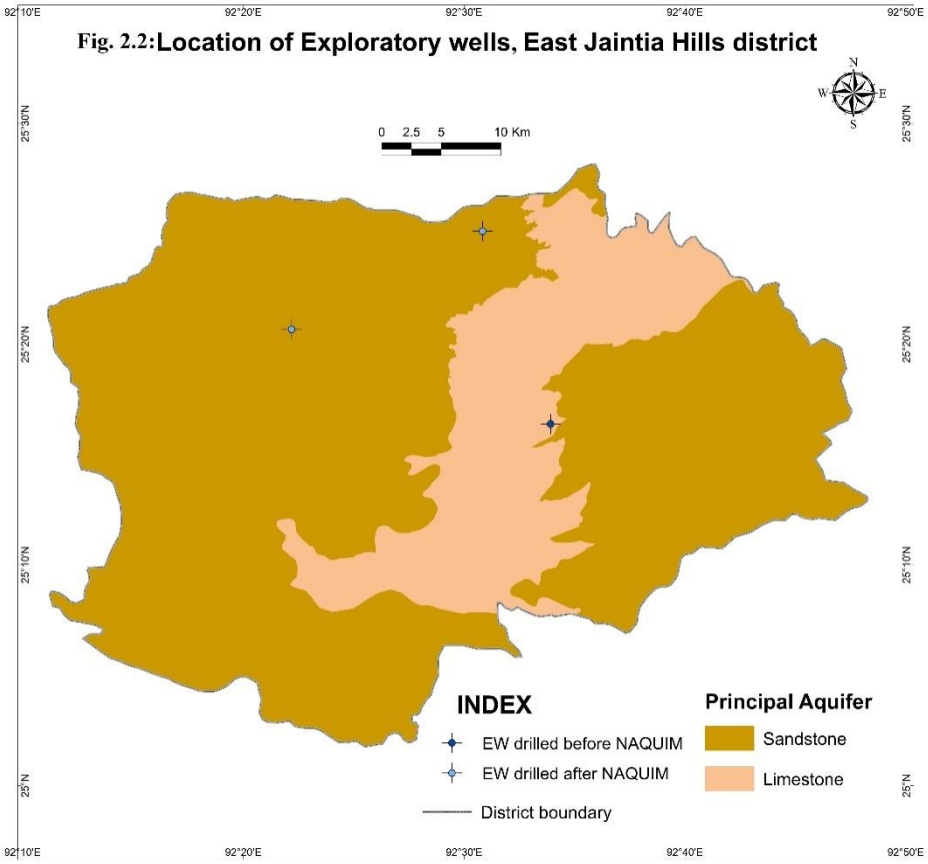


Fig. 2.2: Location of Exploratory wells, East Jaintia Hills district

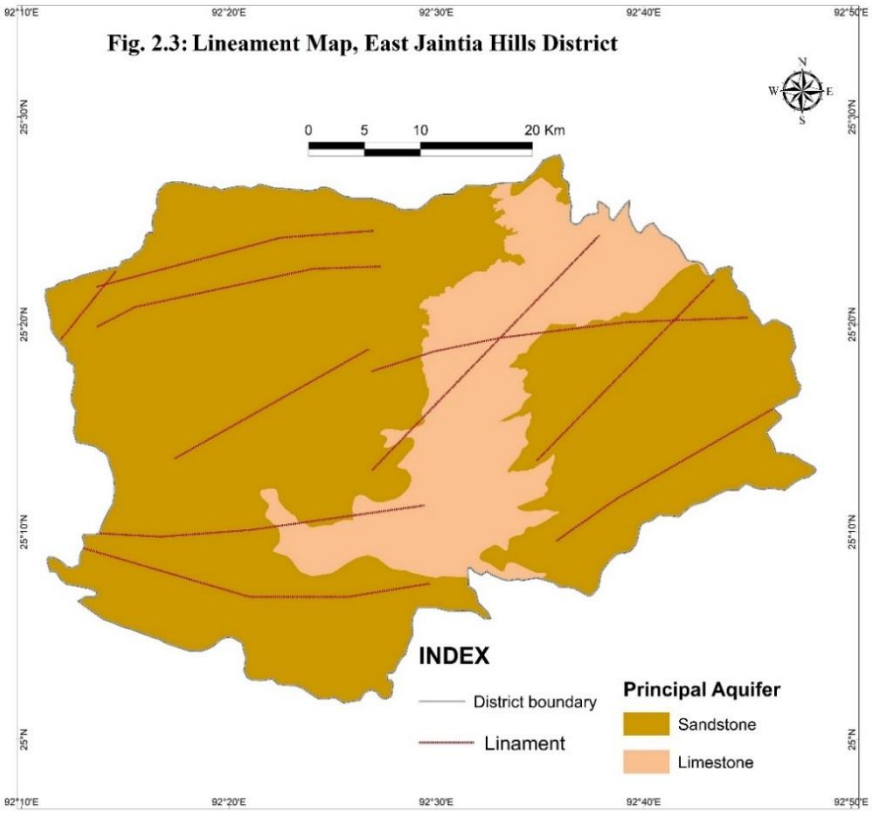


Fig. 2.3: Lineament Map, East Jaintia Hills District

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 General hydrogeology and occurrence of ground water: Thehydrogeological formation of the study area comprised of Sandstone and Limestone of Paleocene-Eocene age. The presence of weak planes like fractures and joints in these hard rock formation forms the principal aquifer in the area. The ground water in the district occurs under unconfined, semi-confined to confined conditions. Study of dug wells and exploration data reveals the presence of phreatic/shallow and deep fractured aquifers in the district. The principal aquifer of the study area is shown in fig 3.1

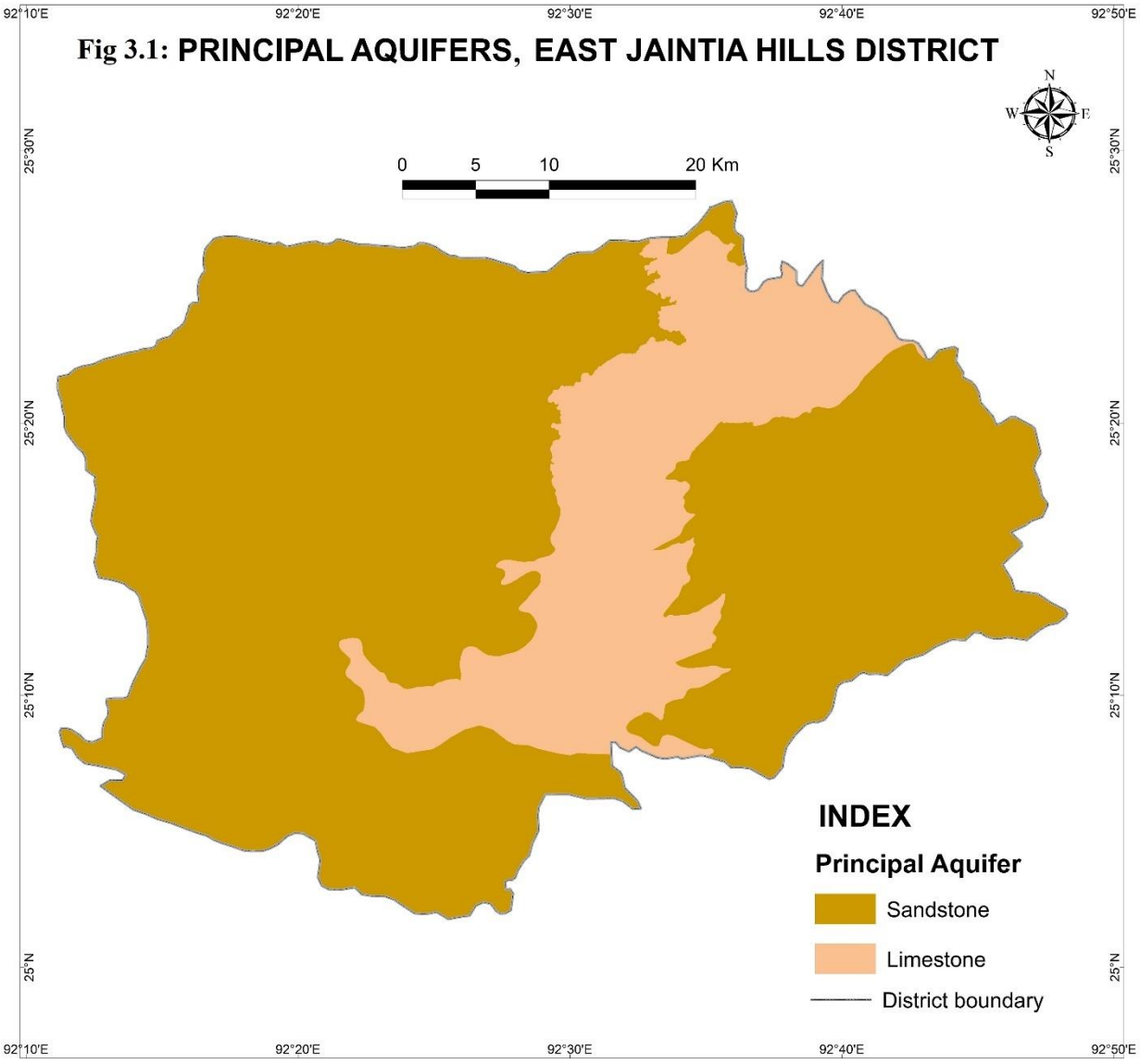


Fig 3.1: PRINCIPAL AQUIFERS, EAST JAINTIA HILLS DISTRICT

3.1.1 Occurrence of ground water in shallow aquifers: The depth of shallow aquifer in the district ranges from 5 to 40 meters. This shallow aquifer occurs under unconfined to semi confined condition. Ground water from shallow aquifer is exploited through different types of ground water extraction structures such as dug wells (Kachha dug wells and ring well). This

dug well tapped the unconfined aquifer generally down to 2 to 6 meters. This unconfined aquifer extendsupto40 meters which is the weathered portion.

3.1.2 Occurrence of ground water in deeper aquifers: The deeper aquifer occurs as semi-confined to confined condition where ground water is found in the fractured zone of consolidated Sandstone and Limestone. The drilled depth of exploratory wells tapping this aquifer ranges from 80.30 to 200 m bgl. The number of fractures and its zones encountered varies in all the places which show the complexity of the hydrogeology of consolidated hard rock formation.

3.1.3 Springs: Spring is defined as a localized natural discharge of ground water appearing at the ground surface as a current of flowing water through well-defined outlets. The discharge may vary from a trickle to a stream. Groundwater flow from springs is governed mainly by three inter-related factors: geology (type, distribution and permeability characteristics of geologic units), topography (landforms and relief), and climate (timing and amount of precipitation). Topography drives the groundwater flow downhill and largely dictates the occurrence of the spring itself. Climate would influence the timing and amount of recharge to the flow system and the volume and variability of discharge. Groundwater obtained from springs is similar to water pumped from shallow wells. The study of spring has been carried out in the aquifer mapping area and it was found that the location of the spring is mainly restricted to foothills and intermontane valleys. Most of the villagers are highly depended on the springs for their drinking and domestic purposes. A total of 9 springs were established and monitored periodically during the course of study. Most of these springs are depression and topographic or fractured springsIt is observed that the discharge of springs in this area ranges from 0.36 to 6.6 litre/minute during pre-monsoon and 1.02 to 27 litre/minute during post-monsoon seasonand is show in fig 3.2 and fig 3.3. It has also been observed that the discharge of springs hasbeen increased during monsoon season and gradually decreases in post-monsoon and pre-monsoon.

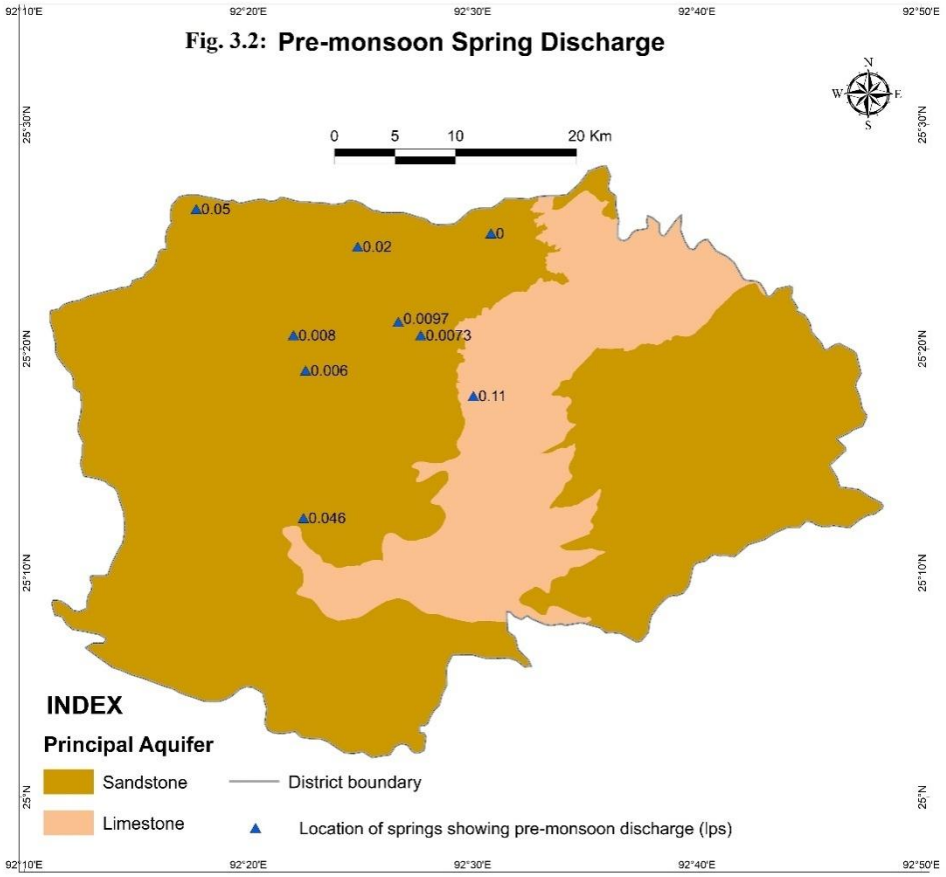


Fig. 3.2: **Pre-monsoon Spring Discharge**

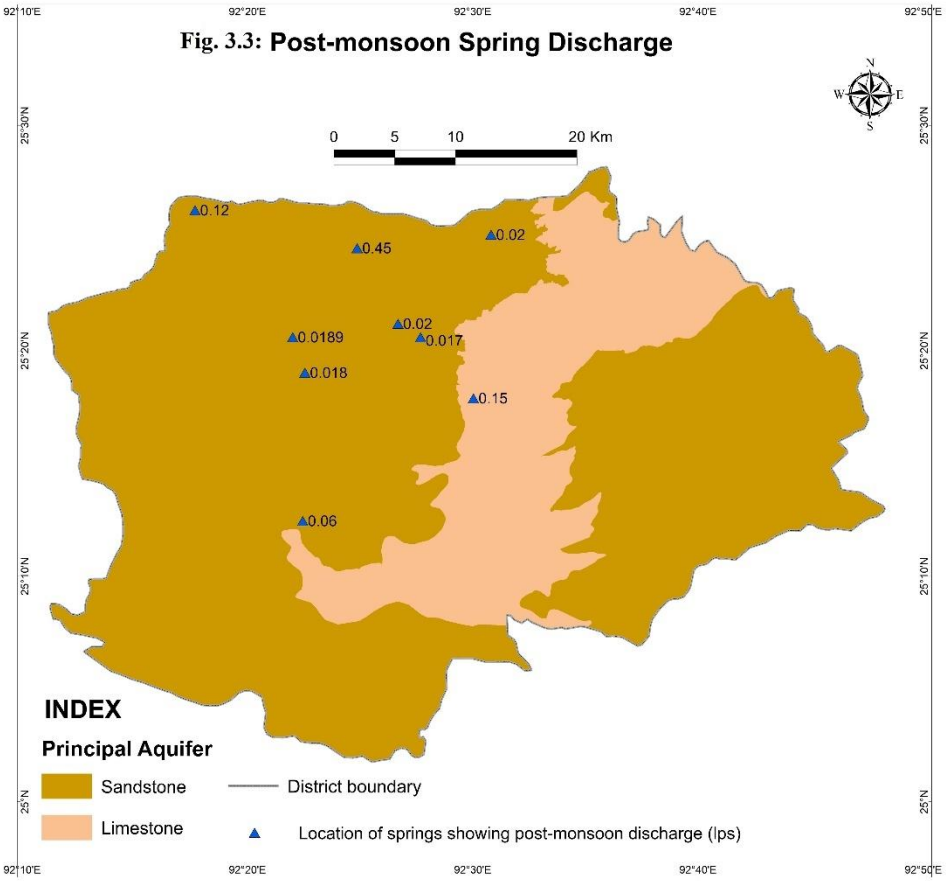


Fig. 3.3: **Post-monsoon Spring Discharge**

3.2 Depth to Water Level: Study of water level and its behaviorboth in phreatic and confined condition were carried out in the aquifer mapping area. A total of 1 Dug well was established as key well for periodical monitoring to know the water level trend and its behavior in phreatic condition. The depth to water level in these dug well was 3.32 m bgl during pre-monsoon and 2.26 m bgl during post-monsoon season and is shown in fig 3.4 and fig. 3.5 and the average water level fluctuation is 1.14 m.

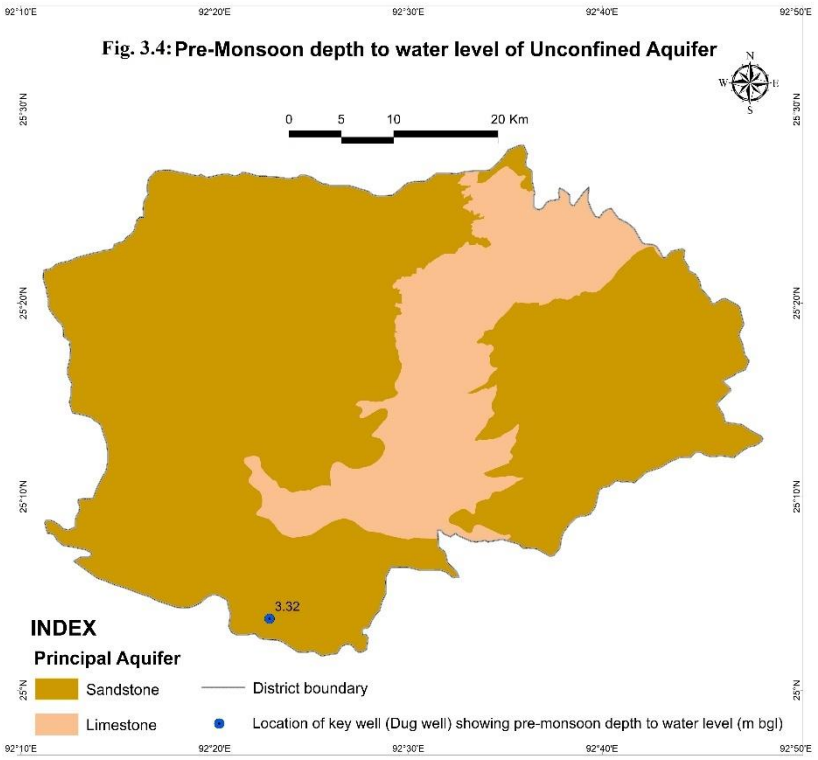


Fig. 3.4: Pre-Monsoon depth to water level of Unconfined Aquifer

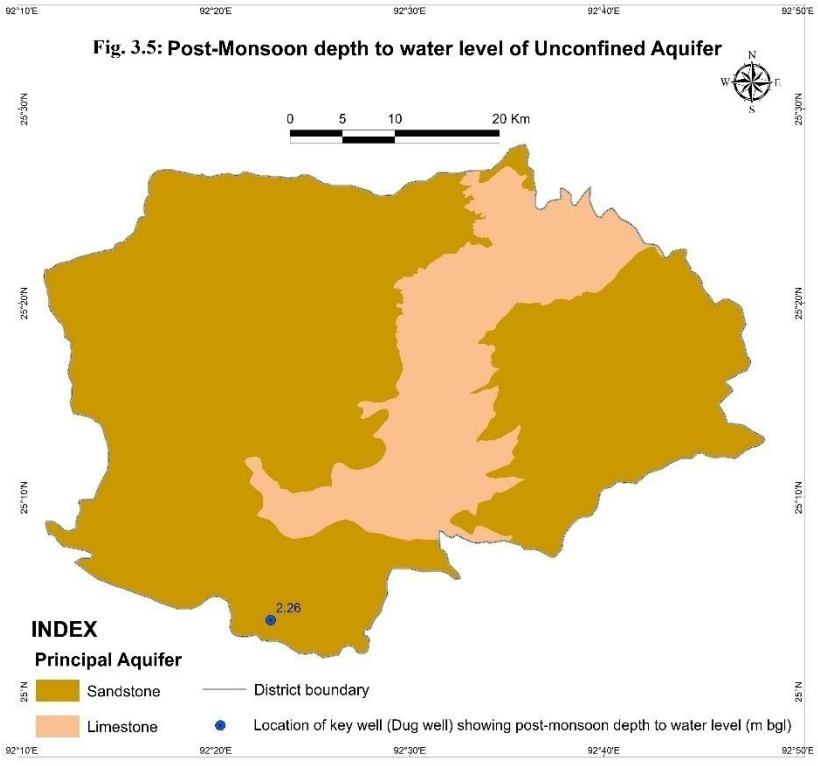


Fig. 3.5: Post-Monsoon depth to water level of Unconfined Aquifer

To study the piezometric head, 2 bore wells were monitored periodically. The piezometric head ranges from 43.16 to 55.15 m bgl during pre-monsoon and 41.62 to 54.85 m bgl during post-monsoon season and is shown in fig 3.6 and fig. 3.7.

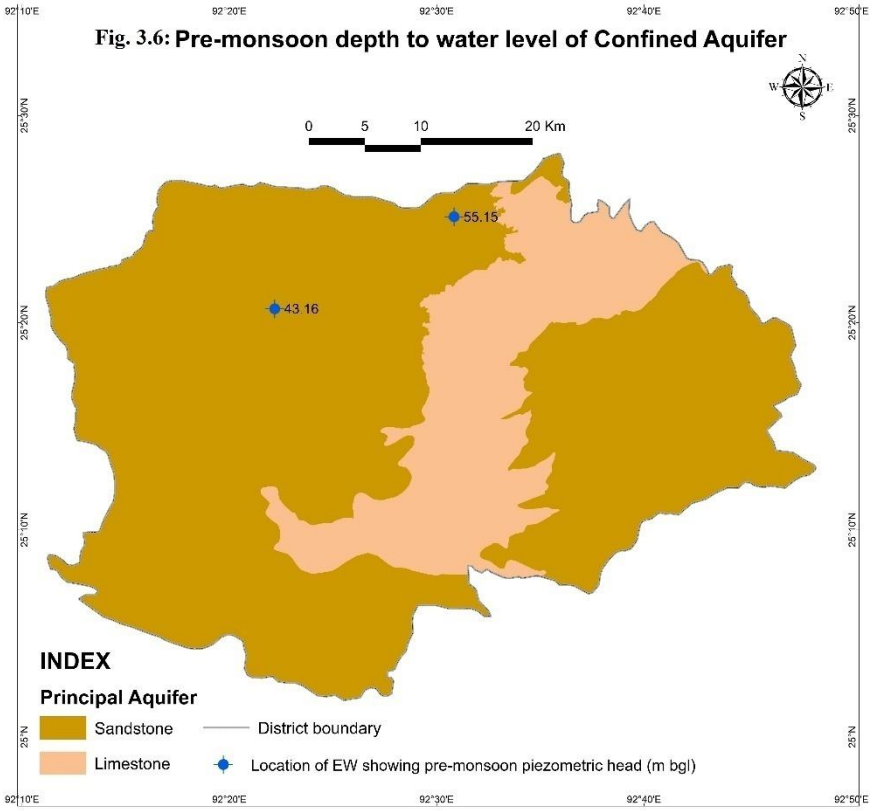


Fig. 3.6: **Pre-monsoon depth to water level of Confined Aquifer**

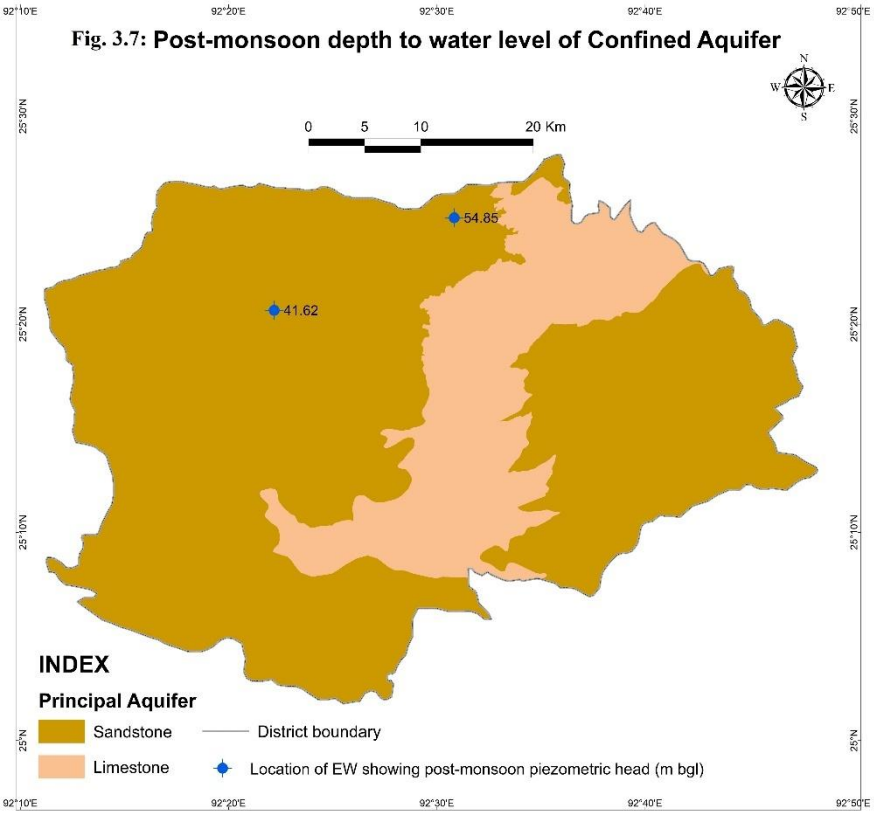


Fig. 3.7: **Post-monsoon depth to water level of Confined Aquifer**

3.3 Aquifer system: The entire study area is underlain by consolidated rocks of Sandstone and Limestone of Paleocene-Eocene age.The aquifer system exists in all the rock formations. It also exists in both weathered formation as well as fractured system down to the explored depth of 200mbgl. The depth of weathered zone varies from 4 to as high as 40 m below ground level. Thus, hydrogeologically, the study area can be categorized into two groups i.e. (i) Sandstone aquifer of Jaintia Group and (ii) Limestone aquifer of Jaintia Group. In fig.3.9, disposition of fractures were shown but were not connected because of huge vertical variation and lateral extension of fractures.

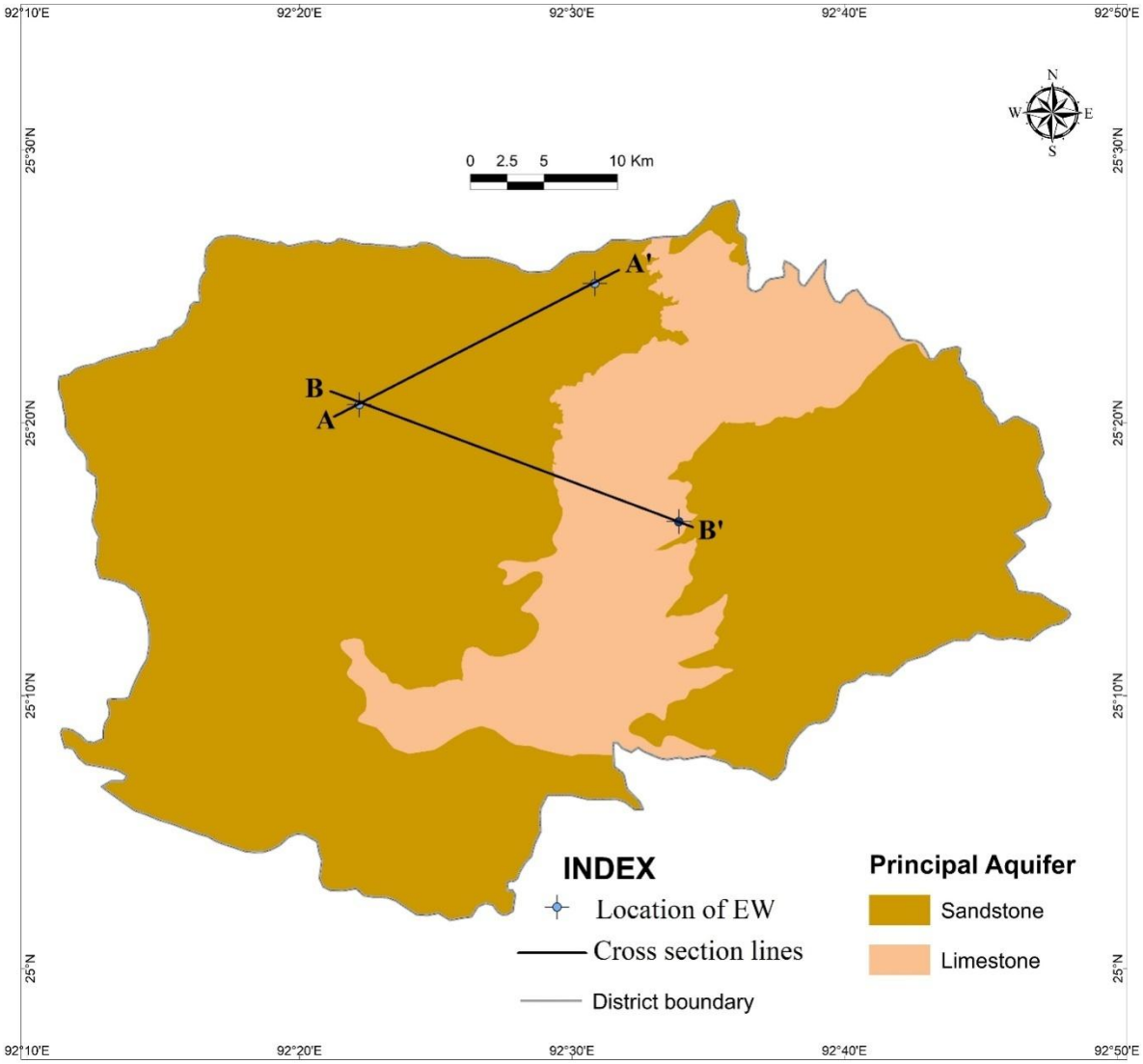


Fig.3.8 Hydrogeological section lines in East Jaintia Hills

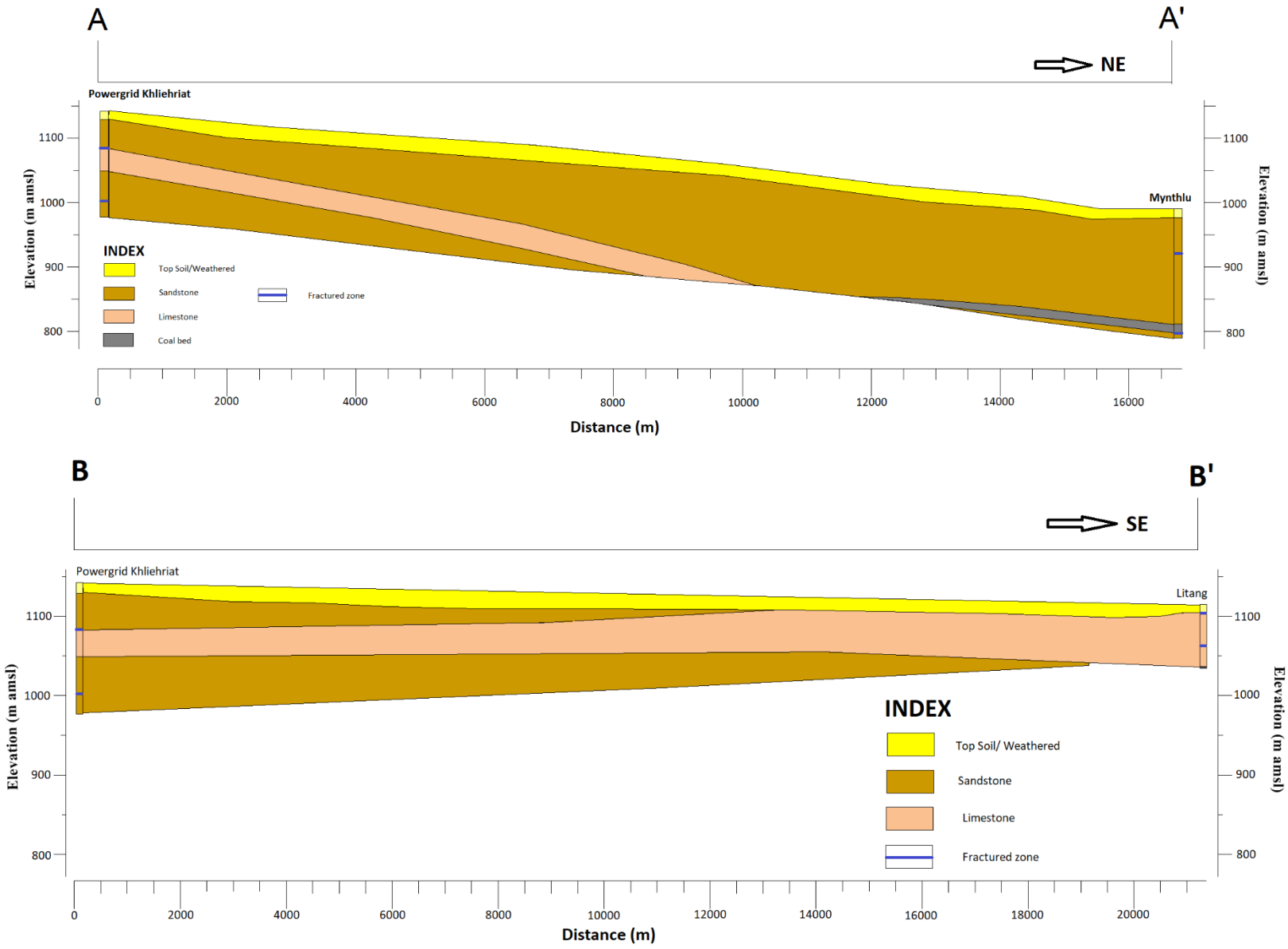


Fig. 3.9Hydrogeological Cross sections along A-A' and B-B'

Formation wise hydrogelogicalbehaviors in the district are discussed below:

3.3.1 Sandstone: The Sandstone covers the major part of the district and are exposed in the eastern and western parts. Theoccurrence of ground water in this formation is largely controlled either by weathering and or by fractures patterns. In fractured rocks, ground water movement mainly takes place along the fracture and their openings. Groundwater in these formations occurs under phreatic conditions in weathered mantle and under semi-confined to confine conditions in the fractured rocks, which is governed by topography and drainage. In this sandstone, depth of first aquifer ranges from 3 to 40 m bgl and the second aquifer ranges from 40 to 192.2mbgl. Discharge of the exploratory wells ranges from 3.3 to 6.15lps Transmissivity is about 2.79 m^2/day. Distribution of fractures at various depth and cumulative discharge is tabulated in table 3.1.

Table 3.1 Location wise details of fracture encountered in Sandstone

Location	Depth drilled in m bgl	Number of fractures encountered					Discharge (in lps)
		0 to 50 m	50 to 100 m	100 to 150 m	150 to 200 m	200 to 250 m	
Mynthlu	200	0	1	0	1		3.3
PowergridKhliehriat	164.9	1	1	1			6.15

The above table reveals that 1 to 3 numbers of fractures were encountered within 200 m depth.

Limestone: Limestone is found on the central part of the district. Ground water occurs in these formations under semi-confined to confine conditions. In this limestone, depth of first aquifer occurs within 40 m bgl. 1 Exploratory bore well was constructed in this formation with a depth range of 80.30 m bgl. Discharge in the wells was3.5lps and Transmissivity was 287 m^2/day. Distribution of fractures at various depth and cumulative discharge is tabulated in table 3.2.

Table 3.2 Location wise details of fracture encountered in Limestone

Location	Depth drilled in m bgl	Number of fractures encountered					Discharge (in lps)
		0 to 50 m	50 to 100 m	100 to 150 m	150 to 200 m	200 to 250 m	
Litang	80.30	2	1				3.5

The above table reveals that most of the fractures were encountered within 50 to 100 m bgl in this aquifer.

3.4 Aquifer geometry: The aquifer system in this district can be dividedas a two aquifer systemviz., first aquifer (shallow) and second aquifer (deeper).Shallow or first aquifer consists of weathered residuum where ground water occurs under water table condition and is mainly developed by construction of dug wells or shallow bore wells as hand pump. The second aquifer is the deeper aquifer which tapped the fractured zone. Based on the study of litholog and analysis of depth of construction of dug wells and shallow bore wells, it is found that the first aquifer occur within 2 to 40 m bgl. Ground water in the second aquifer occurs under semi-confined to confined condition in the fractures upto the maximum depth of 192.2 m bgl. The disposition of these aquifers is shown in fig.3.10.

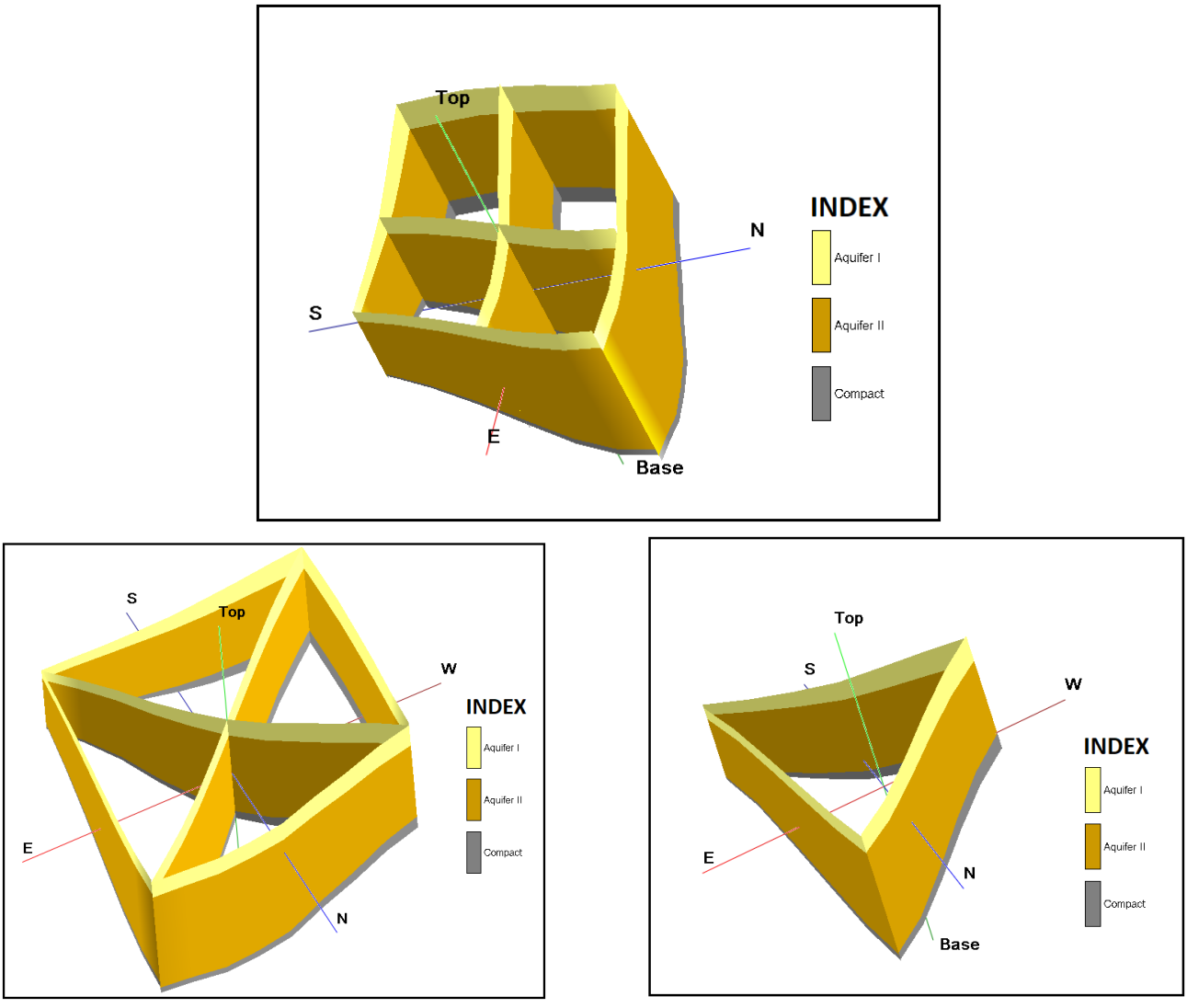


Fig. 3.10 Disposition of aquifers in East Jaintia Hills district, Meghalaya

3.5 Aquifer properties:

Aquifer I: It is the unconfined aquifer where the tapping of aquifer zone ranges within 2 to40 m depth and generally exhibits unconfined nature of the aquifer. The study area is highly undulating terrain and tapping of Aquifer I is not suitable.

Aquifer II: This is the deeper aquifer which occurs as semi confine to confine condition where ground water is found in the fractured zone of consolidated Sandstone and Limestone. The drilled depth of exploratory wells tapping this aquifer ranges from 79.2 to 192.20 m bgl. The number of fractures and zones of encountering fractures varies widely which show the complexity of the hydrogeology of consolidated hard rock formation. The piezometric head ranges from 9.36 to 63.88 mbgl. Through PYT and Slug test, it was found that transmissivity values vary from 2.79 to 287 m^2/day and the discharge in these wells ranges from 3.3 to 6.15 lps.

3.6 Hydrochemistry:

The quality of ground water is as important as that of the quantity. In order to study the chemical quality of ground water in the district, water samples fromsprings, exploratory bore wells and dug wells were collected during the course of field work. The parameters analyzed are pH, EC, Turbidity, TDS, CO_3, Cl, SO_4, Na, K, HCO_3, NO_3, F, Ca, Mg, TH and Fe. The details of chemical analysis were given in the Annexure 2.

3.6.1 Ground water quality of unconfined aquifer:

A total of 1 ground water sample from dug wellwas collected during post-monsoon studies and therange of concentrations of different chemical constituents present in the ground water samples are given in table 3.3.

Table 3.3: Chemical quality of water samples from dug well, East Jaintia district

Sl. No.	Chemical constituents (Concentrations in mg/l except pH & EC)	Range
1	pH	5.99
2	EC (µs/cm) 25°C	171.7
3	TDS	98.28
4	CO3-2	0
5	HCO3-1	50
6	TA (as CaCO3)	50
7	Cl-	28.36
8	SO4-2	
9	NO3-1	0.2759
10	F-	0.09
11	Ca+2	15.31224
12	Mg+2	14.4533
13	TH (as CaCO3)	97.8282
14	Na	8.09
15	K	2.45
16	Fe	0.1324

It is deciphered from table 3.3that all of the chemical parameters are within permissible limit for all uses. The EC values are shown in fig 3.11, pH values in fig 3.12 and Fe conc. in fig. 3.13.

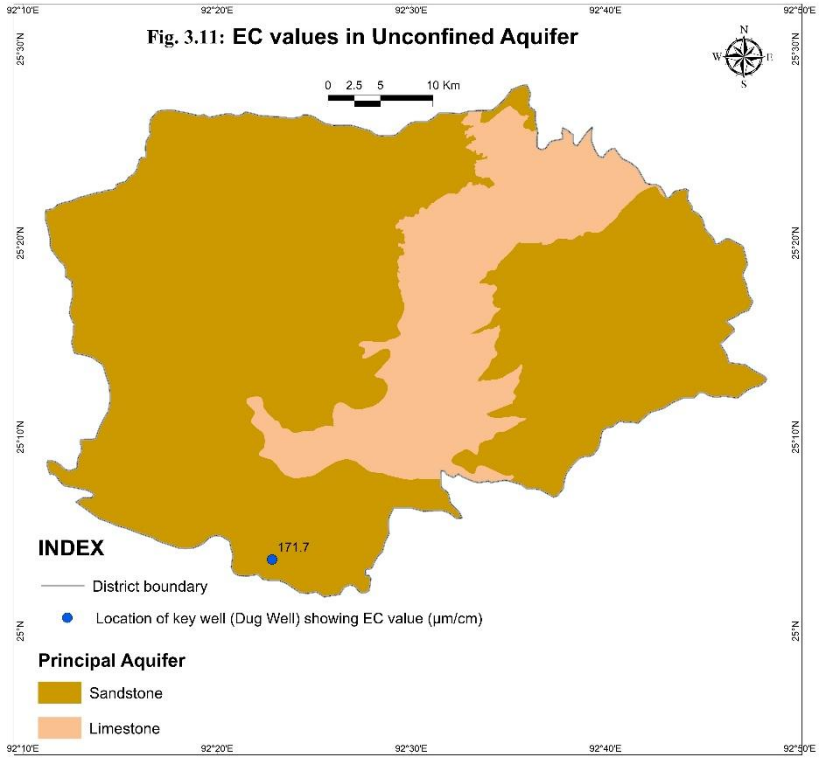


Fig. 3.11: EC values in Unconfined Aquifer

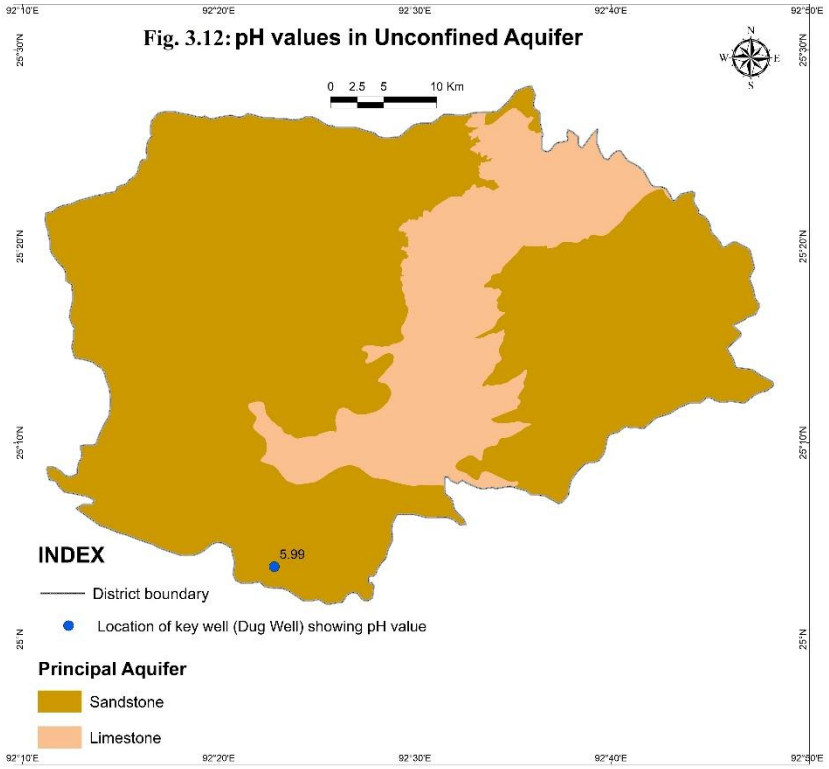
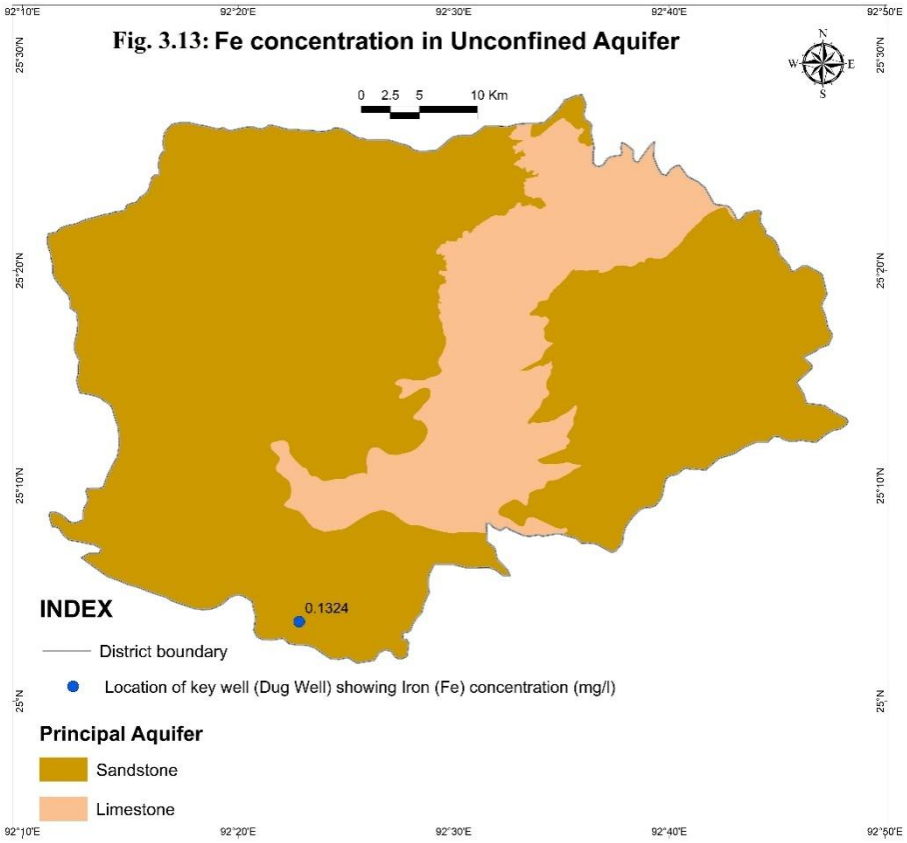


Fig. 3.12: pH values in Unconfined Aquifer



3.6.2 Ground water quality in confined aquifer: A total of 2 water samples were collected during exploratory drilling programme and monitoring during the course of studies. Based on chemical analysis data therange of concentrations of different chemical constituents present in the deeper aquifer samples are given in table 3.4.

Table 3.4: Chemical quality of ground water in deeper aquifer

Sl. No.	Chemical constituents (Concentrations in mg/l except pH & EC)	Range	
		Min	Max
1	pH	4.42	7.56
2	EC (µs/cm) 25°C	230	400
3	TDS	124.4	280
4	CO3-2	0	
5	HCO3-1	10	116
6	TA (as CaCO3)	10	
7	Cl-	7.09	14
8	SO4-2		
9	NO3-1	0.3	
10	F-	0.05	
11	Ca+2	14	34
12	Mg+2	3.6408	18
13	TH (as CaCO3)	100	
14	Na	0.99	2
15	K	1	1.24
16	Fe	0.9	8.06

It can be inferred from table 3.4that except iron and pH, the other parameters are within the permissible limit. pH of 4.2 was found in one well which is acidic and Fe conc. of 8.06 mg/l is found on one of the well. The EC values are shown in fig 3.14, pH values in fig 3.15 and Fe conc. in fig. 3.16.

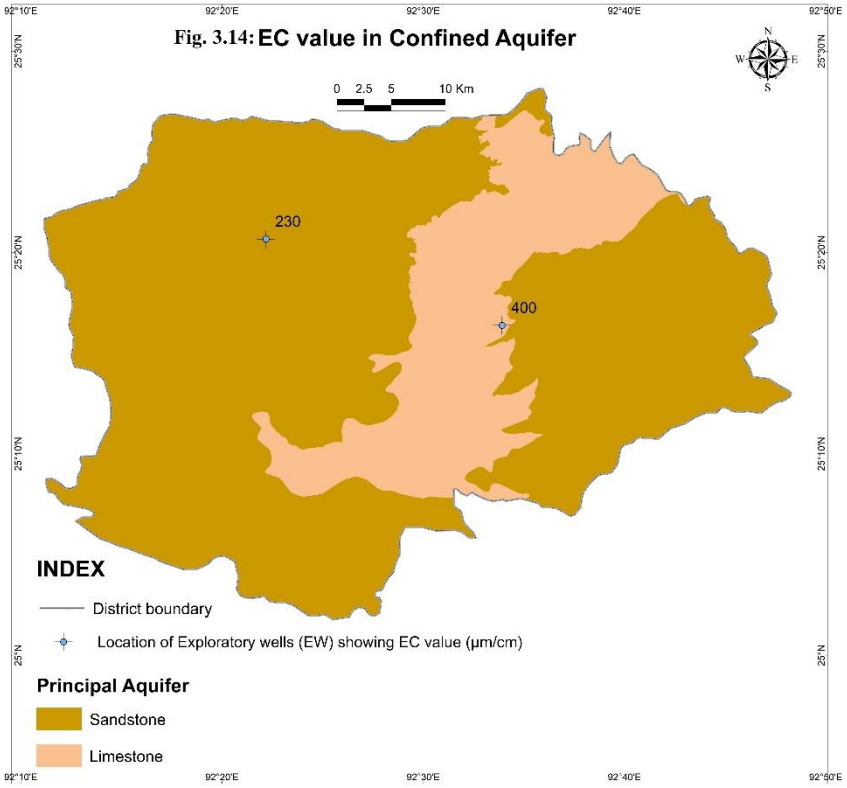


Fig. 3.14: EC value in Confined Aquifer

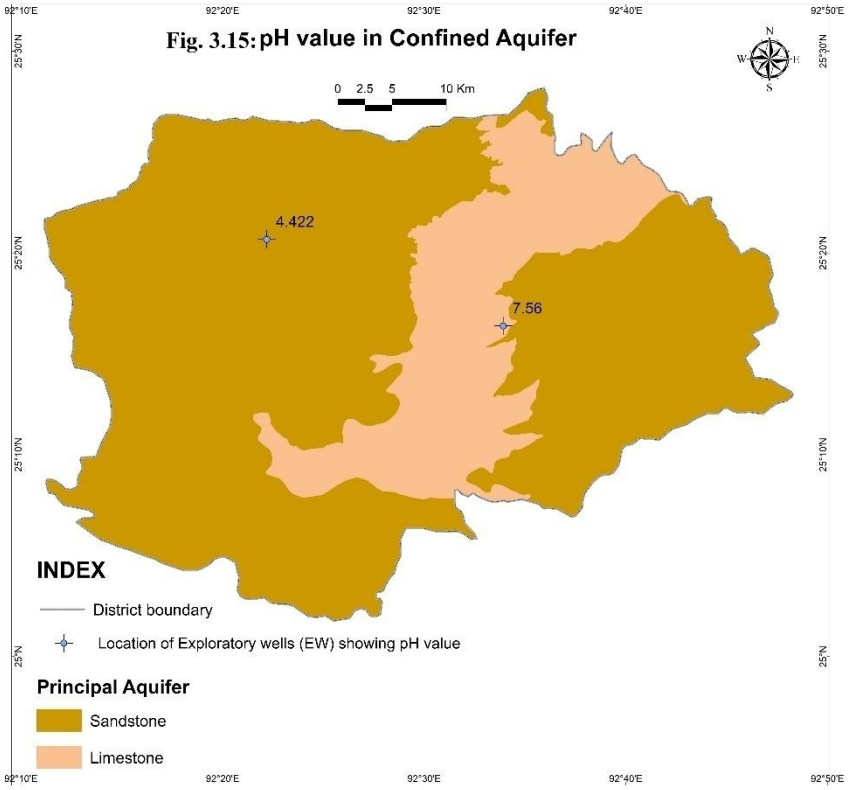
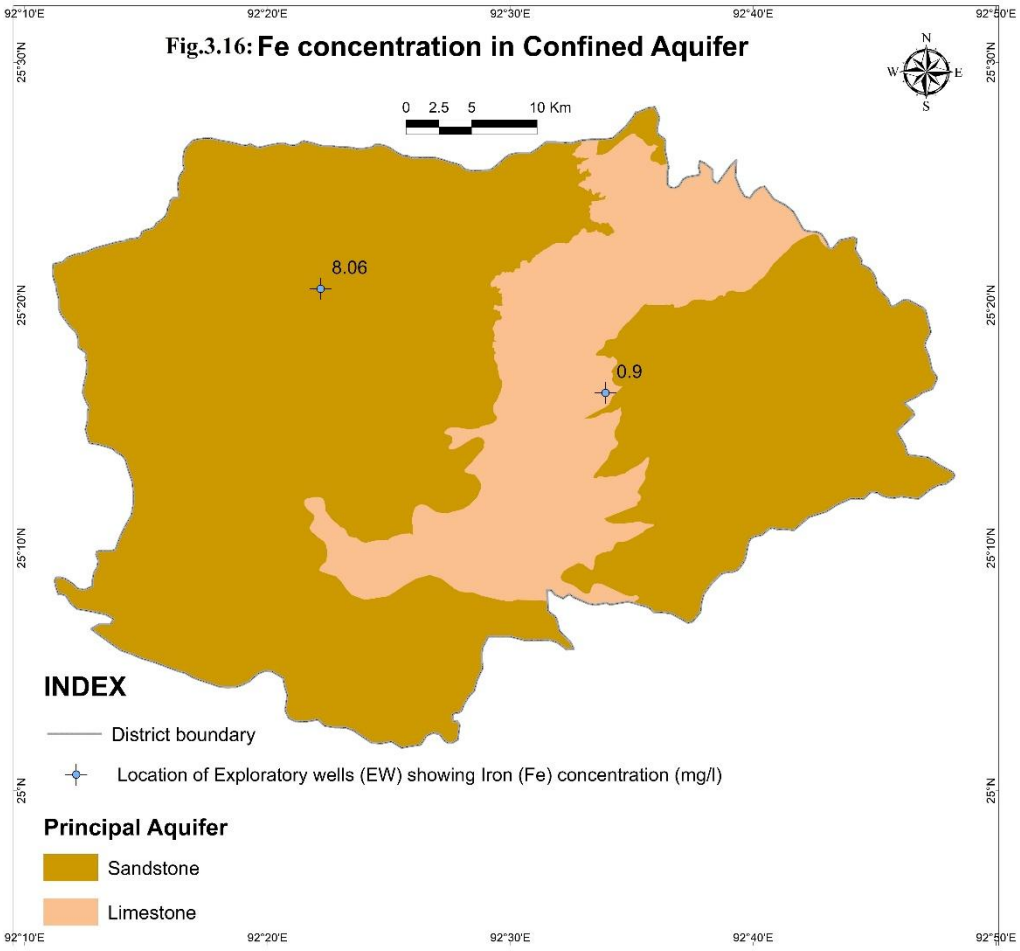


Fig. 3.15: pH value in Confined Aquifer



3.6.3 Water quality of springs: A total of 8 water samples from spring were collected during post-monsoon studies and therange of concentrations of different chemical constituents present in the spring samples is shown in table 3.5

Table 3.5: Chemical quality of spring water, East Jaintia Hills district

Sl. No.	Chemical constituents (Concentrations in mg/l except pH & EC)	Range	
		Min	Max
1	pH	4.81	7.16
2	EC (µs/cm) 25°C	47.24	323.6
3	TDS	27.2	186.7
4	CO3-2	0	0
5	HCO3-1	15	170
6	TA (as CaCO3)	15	170
7	Cl-	21.27	31.905
8	SO4-2		
9	NO3-1	0	3.1985
10	F-	0.03	0.25
11	Ca+2	1.70136	93.5748
12	Mg+2	5.1619	14.4533
13	TH (as CaCO3)	25.5204	276.471
14	Na	0.77	0.23
15	K	0.23	2.6
16	Fe	0	0.1322

Itcan be inferred from table 3.5thatexceptpH, the other parameters are within the permissible limit. Out of 8 samples 5 samples have pH value less than 6. The EC values are shown in fig 3.17, pH values in fig 3.18 and Fe conc. in fig. 3.19.

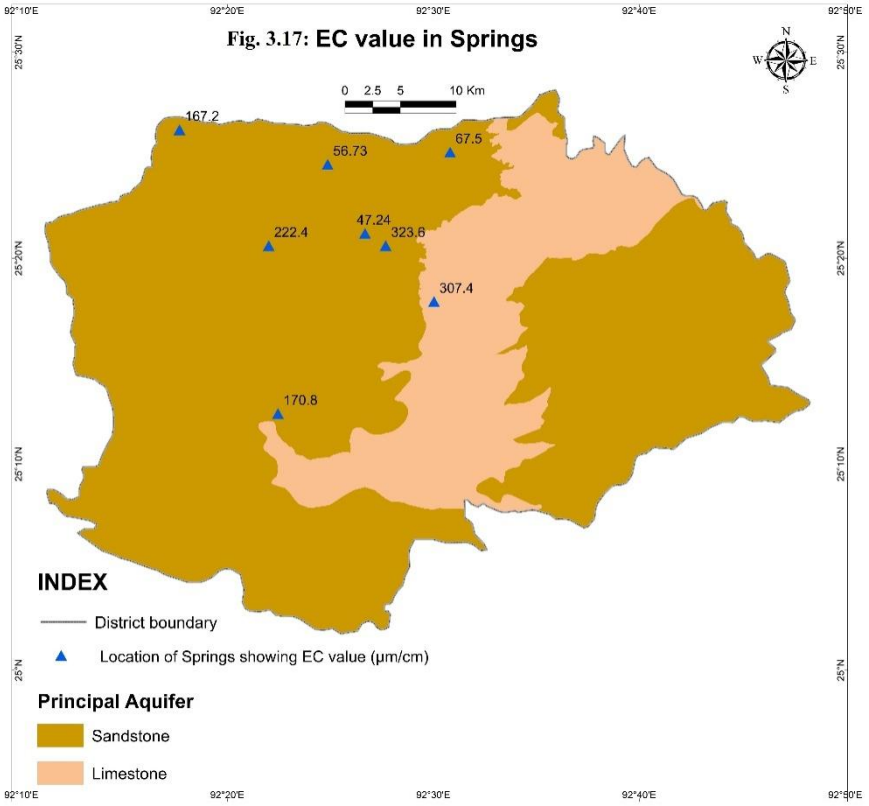


Fig. 3.17: EC value in Springs

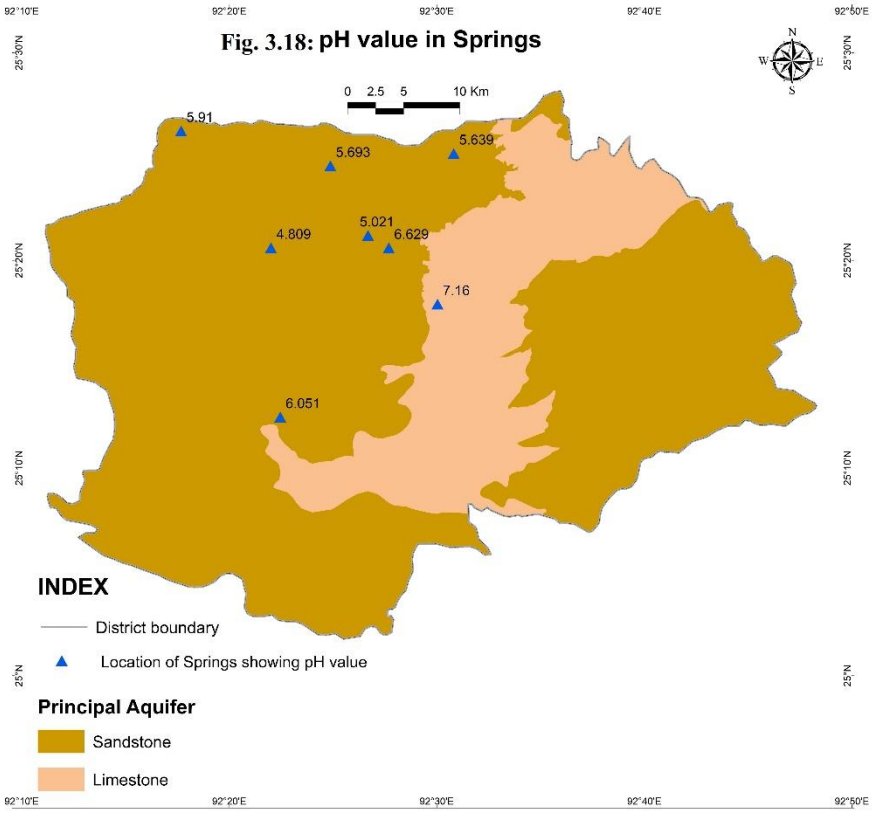


Fig. 3.18: pH value in Springs

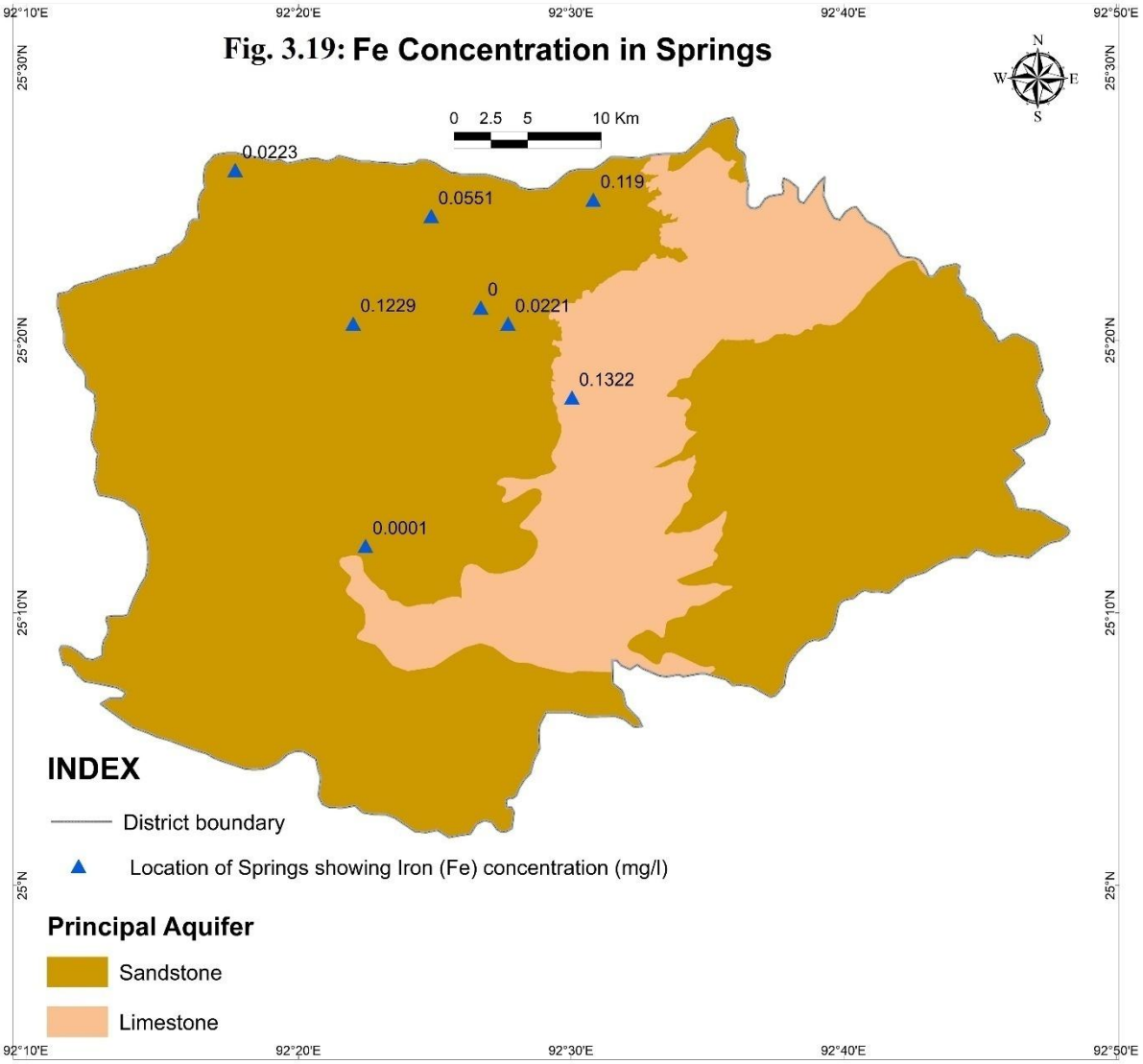


Fig. 3.19: Fe Concentration in Springs

4. GROUNDWATER RESOURCES

Dynamic Groundwater Resources of East Jaintia Hills district has been estimated based on the methodology recommended by Groundwater Estimation Committee (GEC'97). The resources computed for the groundwater year 2017-18. In the present resource estimation, the smallest administrative unit considered for resource estimation is district since block-wise data is not available. The following sub-units are recommended for the computation of various figures in the methodology and these are considered in details below:

Hilly Area: Area with more than 20% slope has been excluded for the recharge computation. As per NESAC, total recharge worthy area in the district is 1001 sq.km.

Poor Groundwater Quality Area: In the district, there is no mappable area, which can be demarcated as poor groundwater quality and hence not considered.

Command and Non-Command Area: The methodology envisages computation of various figures separately for command & non-command area. In the district, there is no major or medium canal irrigation scheme and thus the entire rechargeable area has been considered as a non-command area.

Lithological sub-units: The entire district is underlain by consolidated rocks of Sandstone and Limestone. Different units considered for computation of recharge are Sandstone and Limestone.

4.1 Groundwater Resources – Recharge for Various Seasons: The rainfall infiltration factor recommended by GEC'97 for Sandstoneis 0.12 for Limestone is 0.06. During fieldworks 6 nos. of Infiltration studies were carried out, mostly in area underlain by sandstone. Rainfall recharge factor (RRF) calculated from these studies show that average RRF is 2%.

For calculating recharge from return flow from irrigation, an average water requirement of 1.2 m & 0.1 m for paddy & non-paddy has been considered (as per discussion with Agriculture department, Govt. of Meghalaya). Computation factor for return flow from surface water irrigation is taken as 0.30 – 0.50 as per GEC'97 methodology. Return flow from surface water irrigation has not been considered for monsoon season because aquifers remains fully saturated during the periods of intensive rainfall, additional recharge from ponds & tanks during this period is negligible. Recharge from ponds and tanks during non-monsoon period are considered for 100 days.

Recharge from Rainfall has been computed separately for monsoon and non-monsoon periods for the entire district. The recharge from rainfall during monsoon season has not been computed using water level fluctuation method (WLFM) as Ground Water Monitoring Wells (GWMW) in the district is very few. The rainfall recharge estimated for non-command area of the entire district and the details are shown in annexure 8.

Recharge from All Sources: Total recharge to groundwater has several components, rainfall being the major one. The other components include seepage from canals, return flow from surface water irrigation, return flow from groundwater irrigation, seepage from tanks/ ponds etc. Recharge from various sources has been calculated for monsoon as well as non-monsoon periods and details have been shown in table 4.1.

Table 4.1: Recharge from various sources (ham).

District	Recharge from Rainfall	Return Flow from Surface water Irrigation	Return Flow from Groundwater Irrigation	Recharge from ponds & tanks	Total recharge from other sources	Total Annual Recharge
East Jaintia Hills	10892	983	0	11	994	11886

Recharge from rainfall in the district is 10892 ham .Comparison of monsoon & non-monsoon rainfall recharge shows that monsoon recharge accounts for 73%. In comparison to recharge from rainfall, recharge from sources other than rainfall shows that the later accounts for about than 8% of the total recharge.

4.2 Groundwater Draft for Various Purposes: Groundwater draft for domestic use has been estimated based on number of households using groundwater (Census 2011 data) and number of tube wells used by PHED to supply water and on number of structures used in different industrial units. Unit draft of bore wells used by industries is 1 ham/yr. Groundwater draft for irrigation is nil. It was found that groundwater draft for all uses in the district is 57 ham.

4.3 Stage of Groundwater Development &Categorization of the Blocks: The district falls under "**SAFE"** category. The stage of development is 0.53 %. Summary of groundwater resources, stages of development and categorization are given in annexure 9.

4.4 Comparison with groundwater resource over the years: In table 4.2, a comparison amongst the total annual groundwater recharge, total groundwater resources available, net annual draft and balance groundwater resources available for future development estimated during 2012-13 and modified resource estimation during 2017-18 (taking into consideration infiltration rate) has been presented.

Table 4.2: Comparison between Groundwater Resources Estimatedduring2012-13and 2017-18(Ground water resources in ham)

	2017-18	**2012-13**
Rainfall recharge during monsoon	7927	45056
Rainfall recharge during non-monsoon	2965	2703
Recharge from other sources	994	994
Annual GW recharge	11886	48753
Net GW availability	10697	43878
GW draft for irrigation	0	0
Gross GW draft	57	54
Annual Allocation of ground water for domestic & industrial water supply upto 2025	721	848
Balance GW for future irrigation development	9977	43030
Stage of development	0.53%	0.12%

The reasons behind the differences between the groundwater resources estimated during are as follows;

(1) Difference in Rainfall recharge – (a) Normal monsoon rainfall used in 2012-13 but in the present estimation maximum threshold of 3000 mm was used. (b) Use GEC norm of Rainfall infiltration factor (RIF) in 2012-13 but in the present estimation RIF taken from field studies.

(2) Difference in Balance groundwater available for future irrigation and stage of development – due to above reasons these figures show changes.

5. GROUND WATER RELATED ISSUES

There are two major ground water related issues found in the study area.

5.1 Low stage of ground water development: As per ground water resource estimation 2017-18, the stage of ground water development is just 0.53 % and there is no utilization of ground water for irrigation in this area. All the irrigation schemes in the district are dependent upon the surface water resources. Therefore, there is enough scope for future development of ground water in the study area to bring more area under irrigation practice. At present the irrigation practice by utilizing ground water (constructing bore well) is not accepted by villagers due to small land holding, high cost for construction and running of a well compared to production outcome. Another major obstacle in accelerating ground water irrigation is the absence of power lines in most of the cultivated/cultivable area.

5.2 Ground water quality: As per water quality analysis data, it was found that there is a moderately high concentration of iron in deeper aquifer. pH value is also low in almost all the springs, dug well and bore well and needs to be treated before consumption.

6. MANAGEMENT STRATEGIES

As per dynamic ground water resource estimation of East Jaintia Hills District for 2017-18, net ground water availability is 10697 ham and stage of development is only 0.53%. The district is having balance net ground water availability for future irrigation use in the tune of 9977 ham. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 5986 ham of groundwater resources is available in the district for the future irrigation uses. From this available resource (planned for future development) 5986 nos. of shallow tube wells (considering a unit draft of 1 ham/year) can be constructed in the aquifer mapping area. Therefore, there is enough scope for future development of ground water in the study area to bring more area under irrigation practice.

Present land under irrigation is 1214 ha and source of water for all these schemes is surface water. Present irrigation from ground water source is almost nil. Hence, there is ample scope for ground water development for irrigation purpose which will bring prosperity to the society and help the district in achieving self-reliance on food grain. To use the groundwater for irrigation purpose a cropping plan has been designed for the district by using CROPWAT model developed by FAO. Necessary input to design a cropping plan was taken as advised by the water management section of ICAR, Umiam. Cropping pattern data for the district is presented in table 8.

During 2015-16, net sown area in the district is 11071 ha, area sown more than once is 48 ha and cropping intensity is about 100%. The net sown area included field crops as well as horticulture and plantation crops on slopes and hills. Cropping intensity is calculated generally from field crops, which are of short duration whereas horticulture (like citrus, banana, pineapple) and plantation crops like spices are long duration crops. Again crops grown on the hills like pineapple, turmeric and ginger are having negligible or nil irrigation requirements. During kharif season, paddy is cultivated in 4347 ha and land under Maize cultivation is 350 ha. After Kharif crops were grown major portion of this area remains fallow during Rabi season. The intention of this plan is to bring this fallow land of about 4697 ha under assured irrigation during Rabi season which will help to increase gross cropped area to 9397 ha and thereby increase cropping intensity up to 200%. In rice fallow, pulses, potato, mustard and rabi vegetables can be grown with the support of irrigation and in maize fallow, soyabean can be grown with the support of irrigation. Present cropping pattern, proposed cropping pattern, intended increase in cropping intensity were shown in table 6.2a and 6.2b.

Crop-wise and month-wise irrigation water requirement (Precipitation deficit) has been taken from CROPWAT after giving necessary meteorological, soil, crop plan inputs and the same has been shown in table 6.3 Crop-wise and month-wise Irrigation water requirement in ham has been further calculated in table 6.4.

Table 6.1 CROPPING PATTERN DATA

(File: C:\ProgramData\CROPWAT\data\sessions\East Jaintia Hills.PAT)

Cropping pattern name: East Jaintia Hills

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...ata\CROPWAT\data\	MAIZE (Grain)	11/04	13/08	4
2	...Data\CROPWAT\data	Rice	04/06	01/10	8
3	...Data\CROPWAT\data	Rice	11/06	08/10	15
4	...Data\CROPWAT\data	Rice	18/06	15/10	15
5	...Data\CROPWAT\data	Rice	25/06	22/10	8
6	...\CROPWAT\data\cro	Soybean	25/08	17/11	4
7	rape___mustard.CRO	Mustard	25/10	06/06	11
8	...\CROPWAT\data\cro	Potato	11/11	20/03	6
9	...\CROPWAT\data\cro	Potato	02/02	11/06	5
10	...a\CROPWAT\data\cr	Pulses	11/08	28/11	11
11	...CROPWAT\data\crop	Small Vegetables	02/11	04/02	7
12	...CROPWAT\data\crop	Small Vegetables	01/03	03/06	7

Table 6.2a. Cropping pattern, proposed cropping pattern, intended cropping intensity, East Jaintia Hills District.

Cropping pattern (s)				
Rice based cropping pattern				
1. Rice-Potato 2. Rice-Mustard 3. Rice-Vegetables 4. Rice-Pulses	Present Cultivated area (**ha**)	Area to be cultivated (**%**)	Area to be cultivated (**ha**)	Irrigation requirement (**ha m**)
	1	2 (= % of 1)	3	4
Rice (main crop)	4347		4347	550
Potato	14	23	1000	82
Mustard	11	23	1000	137
Vegetables	?	31	1347	75
Pulses	41	23	1000	60
Net cultivated area	4347		**4347**	
Gross cultivated area (1+potato/+mustard/+Veg)	4413		**8694**	
Total irrigation requirement				904
Cropping intensity	**101% (Present)**		**200% (Intended)**	
Maize based cropping pattern				
1. Maize-soybean 2. Maize-pulses				
Maize (main crop)	350		350	0
Soybean	60	100	350	17
Net cultivated area	350		**350**	
Gross cultivated area (Maize+soybean/+pulses/+Veg)	410		**700**	
Total irrigation requirement				17
Cropping intensity	**117 % (Present)**		**200% (Intended)**	
Total (EastJaintia Hills district)				921

Table 6.2b. Proposed cropping pattern with water deficit months and IWR, East Jaintia Hills district

Rice based cropping pattern			
Crop	**Growing period (Months)**	**Periods/months of water deficit**	**Irrigation requirement (ha m)**
Rice	4	1 – 2	550
Potato	6	6	82
Mustard	6	5 –6	137
Vegetables	3	3	75
Pulses	4	2	60
Maize based cropping pattern			
Maize	4	0	0
Soybean	3	1	17

Table 6.3: Crop-wise and month-wise precipitation deficit (IWR) from CROPWAT 8, East Jaintia Hills District.

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit (in mm)												
1. MAIZE (Grain)	0	0	0	0	0	0	0	0	0	0	0	0
2. Rice	0	0	0	0	147	60.3	0	0	0	2.4	0	0
3. Rice	0	0	0	0	49.3	98	0	0	0	0	0	0
4. Rice	0	0	0	0	49.4	0	0	0	0	0.9	0	0
5. Rice	0	0	0	0	0	144.3	0	0	0	6.9	0	0
6. Soybean	0	0	0	0	0	0	0	0	0	18.6	27.6	0
7. Mustard	8	19.7	27.4	0	0	0	0	0	0	0	34.2	43.1
8. Potato	18.6	31	18	0	0	0	0	0	0	0	18.5	35.6
9. Potato	0	1.1	26.5	0	0	1.9	0	0	0	0	0	0
10. Pulses	0	0	0	0	0	0	0	0	0	18.1	45.4	0
11. Small Vegetables	13.8	1.8	0	0	0	0	0	0	0	0	39.9	46.4
12. Small Vegetables	0	0	12	0	0	0	0	0	0	0	0	0

Table 6.4: Irrigation Water Requirement(in ham), East Jaintia Hills District

Crop	% of total area of 9394 ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation deficit (in ham)														
1. MAIZE (Grain)	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. Rice	8	0.0	0.0	0.0	0.0	110.5	45.3	0.0	0.0	0.0	1.8	0.0	0.0	157.6
3. Rice	15	0.0	0.0	0.0	0.0	69.5	138.1	0.0	0.0	0.0	0.0	0.0	0.0	207.6
4. Rice	15	0.0	0.0	0.0	0.0	69.6	0.0	0.0	0.0	0.0	1.3	0.0	0.0	70.9
5. Rice	8	0.0	0.0	0.0	0.0	0.0	108.4	0.0	0.0	0.0	5.2	0.0	0.0	113.6
6. Soybean	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	10.4	0.0	17.4
7. Mustard	11	8.3	20.4	28.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.3	44.5	136.8
8. Potato	6	10.5	17.5	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4	20.1	68.6
9. Potato	5	0.0	0.5	12.4	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	13.9
10. Pulses	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0	42.6	0.0	59.7
11. Small Vegetables	7	9.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.2	30.5	67.0
12. Small Vegetables	7	0.0	0.0	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9
Total	100.0	27.8	39.5	58.8	0.0	249.6	292.7	0.0	0.0	0.0	32.2	125.0	95.1	920.8

Under ground water exploration programme, CGWB has constructed 3 bore wells in this district and has established that the aquifer in most part of the district is having low potentiality, having an average discharge of about 8 m^3/hrfrom Tertiary sandstone aquifers. More exploration is required to know the aquifers properly.

The ground water potentiality of the area is low to moderate, especially in the low-lying valley areas which are feasible for sustainable ground water development. Therefore, those areas can be brought under irrigation by developing ground water through bore wells or large diameter dug wells of size 2 to 3 m (dia) X 10 to 15 m (depth) can be constructed.

A bore well in the area is expected to yield 8 m^3/hr. If such a bore well runs for 10 hrs/day for 120 days, then it will create a draft of 1 ham. Bore wells can be designed within a depth of 100m, expected to encounter 2 – 3 fractures. Bore wells can be constructed by using $8^{//}$ dia. casing pipe down to 30 m.

In considered net sown area of 4697 ha, 1175 nos. of shallow bore wells can be constructed (considering 200m distance between any two shallow bore well). 1175 nos. of bore wells can extract 1175 ham of water annually.

Annual irrigation water requirement is 921 ham while irrigation water requirement during dry season spanning from October to March it is 371 ham.Again proportionate dynamic groundwater resources available for future irrigation use in the considered area are 282 ham. Hence, there will be a shortage / gap of 89 ham of water during Rabi season and 639 ham for entire year. During Rabi season, by extracting 282 ham of groundwater, about 3500 ha can be covered. So, the gap of 1197 ha (4697 – 3500 ha) during Rabi season can be covered from surface water sources. State Govt. has already constructed a few gravity flow irrigation projects (minor irrigation schemes) based on perennial rivers and streams. A few more gravity irrigation schemes can be easily taken up to cover 1197 ha in the district as it is having many more perennial streams. If 100 nos. of large diameter dug wells are constructed then they may cover 50 ha land and will extract 22 ham of water in a year. The rest demand of 250 ham of groundwater resources can be harnessed by constructing 250 bore wells. At possible places water harvesting structures should be employed.

Groundwater in the area is infested with iron in deeper aquifer, therefore before consumption aeration/ filtering/ installation of Iron Removal Plant is necessary. pH value is also low in almost all the springs, dug well and bore well and needs to be treated before consumption. This acidic water can be treated by acid neutralizing filters or chemical feed pump.

REFERENCES

i. **Central Ground Water Board, Ministry of Water Resources, New Delhi** Dynamic Groundwater Resources of India (as on march 2011).

ii. **Central Ground Water Board, Ministry of Water Resources, NER, Guwahati** Dynamic Groundwater resources of Meghalaya State (as on march 2013)

iii. **Central Ground Water Board, Ministry of Water Resources, NER, Guwahati** Meghalaya State report (as on march 2013)

iv. **Central Groundwater Board, Ministry of Water Resources, New Delhi** Ground Water Information Booklet of Ri Bhoi District, Meghalaya (2011-12)

v. **Central Groundwater Board, Ministry of Water Resources, New Delhi** Manual on Aquifer Mapping

vi. **Directorate of Economics and Statistics, Government of Meghalaya.**Statistical Hand Book of Meghalaya, 2016.

vii. **Geological Survey of India,** Geology and Mineral Resources of the States ofIndia, MISC. PUB. 30 PT.4 VOL. 2

viii. **ICAR-Agricultural Technology Application Research Institute, UmiamBarapani**), East Jaintia Hills district, Inventory of Agriculture 2015

ix. **Todd, D. K. (1959)** Groundwater hydrology; 4th Ed.; John Willy and Sons Inc.; N.Y.; 535 P

x. **District Disaster Management Authority (2017),** East Jaintia Hills district, Khliehriat.

Annexure 1: Hydrogeological details of bore wells constructed by CGWB in Aquifer mapping area.

Sl. No.	Village/ Location	Taluka/ Block	District	Toposheet No.	Longitude	Latitude	Type of well (DW/BW/TW)	Depth (m)	Dia	Date of pumping Test	Draw down (m)	Transmissivity (m^2/day)	Source/ Agency	Remarks
1	Litang	Saipung	East Jaintia Hills	83 C/11	92°33'55"	25°16'23"	BW	80.3	7"/ 5½"	07.05.1991	2.631	287	CGWB	PYT
2	Mynthlu	Saipung	East Jaintia Hills	83 C/11	92°30'50"	25°25'07"	BW	200	7"/ 6½"	04.07.2017		2.79	CGWB	Slug test
3	PowergridKhliehriat	Khliehriat	East Jaintia Hills	83 C/7	92°22'11"	25°20'40"	BW	164.9	7"/ 6½"	17.08.2017	0.02		CGWB	PYT & because of almost zero drawdown T value couldn't be calculated

Annexure 2: Dynamic water level data of borewells and dug well

Sl. No.	Location/Village	Block	District	Latitude	Longitude	RL (m)	Drilled depth (m)	Measuring point (m)	Type (DW/BW/Spring)	DTW (m bgl) Aug-17	DTW (m bgl) Nov-17	DTW (m bgl) Jan-18	DTW (m bgl) April-18
1	Umkiang	Khliehriat	East Jaintia Hills	25°03'41"	92°22'49"	12	5.16	0.8	DW	2.3	2.26	3.15	3.32
2	Mynthlu	Saipung	East Jaintia Hills	25°25'07"	92°30'50"	990	200	0.75	BW	Not constructed	54.85	55.65	55.15
3	PowergridKhliehriat	Khliehriat	East Jaintia Hills	25°20'40"	92°22'11"	1142	164.9	0.6	BW	41.96	41.62	41.65	43.16

Annexure 3: Spring discharge data collected during 2017-18

Location	Block	District	Latitude	Longitude	RL (m)	Type	Lithology	Discharge (lps) May-17	Discharge (lps) Nov-17	Discharge (lps) April-18
Khlieriat	Khlieriat	East Jaintia Hills	25°20'36"	92°22'00"	1126	Depression	Sandstone	0.011	0.0189	0.008
Byndihati	Khlieriat	East Jaintia Hills	25°19'02"	92°22'32"	1037	Depression	Sandstone	0.0057	0.018	0.006
ThangkaiLumshnong	Khlieriat	East Jaintia Hills	25°12'27"	92°22'27"	797	Depression	Sandstone	0.07	0.06	0.046
Mookympad	Khlieriat	East Jaintia Hills	25°21'12"	92°26'14"	1044	Fracture	Sandstone	0.013	0.02	0.0097
Tuber	Khlieriat	East Jaintia Hills	25°26'14"	92°17'40"	1361	Fracture	Sandstone	0.07	0.12	0.05
Latyrkle	Saipung	East Jaintia Hills	25°20'36"	92°27'41"	983	Fracture	Sandstone	0.0084	0.017	0.0073
Tangnub	Saipung	East Jaintia Hills	25°17'53"	92°30'01"	1070	Fracture	Limestone	0.1	0.15	0.11
Narwan	Saipung	East Jaintia Hills	25°24'33"	92°24'52"	1222	Depression	Sandstone	0.12	0.45	0.02
Mynthlu	Saipung	East Jaintia Hills	25°25'09"	92°30'48"	985	Depression	Sandstone	0.04	0.02	0

Annexure 4: Aquifer wise water quality data of Aquifer mapping area

Sl. No.	Village/ Location	Taluka/ Block	District	Toposheet No.	Lat	Long	Aquifer Type	Depth	pH	EC (µs/cm) 25C	TDS	CO 3-2	HCO3-1	TA (as CaCO3)	Cl-	SO 4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe
SPRING																								
1	Khliehriat	Khliehriat	East Jaintia Hills	83 C/7	25°20'36"	92°22'00"	Weathered sandstone	Spring	4.81	222.4	127.9	0	15	15	28.36		0	0.13	44.23536	15.4857	174.3894	3	0.69	0.1229
2	ThangkaiLumshnong	Khliehriat	East Jaintia Hills	83 C/8	25°12'27"	92°22'27"	Weathered sandstone	Spring	6.05	170.8	98.76	0	40	40	24.815		0	0.1	49.33944	7.2267	153.1224	1	0.32	0.0001
3	Mookympad	Khliehriat	East Jaintia Hills	83 C/7	25°21'12"	92°26'14"	Weathered sandstone	Spring	5.02	47.24	27.2	0	15	15	21.27		0	0.08	1.70136	5.1619	25.5204	2.38	0.56	0
4	Latyrkle	Saipung	East Jaintia Hills	83 C/7	25°20'36"	92°27'41"	Weathered sandstone	Spring	6.63	323.6	186.7	0	110	110	28.36		0	0.14	86.76936	14.4533	276.471	5.21	2.02	0.0221
5	Tangnub	Saipung	East Jaintia Hills	83 C/11	25°17'53"	92°30'01"	Weathered Limestone	Spring	7.16	307.4	178.5	0	170	170	21.27		0	0.25	93.5748	5.1619	255.204	3.78	1.89	0.1322
6	Tuber	Khliehriat	East Jaintia Hills	83 C/7	25°26'14"	92°17'40"	Weathered sandstone	Spring	5.91	167.2	88.52	0	25	25	31.905		3.1985	0.05	20.41632	7.2267	80.8146	0.77	0.23	0.0223
7	Narwan	Saipung	East Jaintia Hills	83 C/7	25°24'33"	92°24'52"	Weathered sandstone	Spring	5.69	56.73	32.91	0	25	25	24.815		0	0.04	3.40272	9.2914	46.7874	1.86	1.32	0.0551
8	Mynthlu	Saipung	East Jaintia Hills	83 C/11	25°25'09"	92°30'48"	Weathered sandstone	Spring	5.64	67.5	39.05	0	20	20	21.27		0	0.03	5.10408	5.1619	34.0272	3.06	2.6	0.119
SHALLOW AQUIFER																								
1	Umkiang	Khliehriat	East Jaintia Hills	83 C/8	25°03'41"	92°22'49"	Weathered sandstone	5.16	5.99	171.7	98.28	0	50	50	28.36		0.2759	0.09	15.31224	14.4533	97.8282	8.09	2.45	0.1324
DEEPER AQUIFER																								
1	Litang	Saipung	East Jaintia Hills	83 C/11	25°16'23"	92°33'55"	Fractured limestone	80.3	7.56	400	280		116		14				14	18		2	1	0.9
2	PowergridKhliehriat	Khliehriat	East Jaintia Hills	83 C/7	25°20'40"	92°22'11"	Fractured sandstone	164.9	4.42	230	124.4	0	10	10	7.09		0.3	0.05	34	3.6408	100	0.99	1.24	8.06

Annexure 5: Litholog of exploratory wells

Unique ID	
Village	Litang
Taluka/Block	Saipung
District	East Jaintia Hills
Toposheet No	83 C/11
Latitude	25°16’23”
Longitude	92°33’55”
RL (m amsl)	1115
Drilled Depth	80.3
Casing	4.75
SWL (mbgl)	9.36
Discharge (lps)	3.5
Date/year	Sep-91

Depth range (mbgl)		Thickness (m)	Litholog
From	To		
0	6	6	Top soil, reddish brown
6	11	5	Limestone, weathered, pale grey
11	12	1	Limestone, fractured, pale grey
12	44.7	32.7	Limestone, compact, pale grey
44.7	45.7	1	Limestone, fractured, pale grey
12	50.8	38.8	Limestone, compact, pale grey
50.8	56.9	6.1	Shale, compact, black
56.9	78.2	21.3	Limestone with calcareous shale, compact, grey
78.2	79.2	1	Limestone with calcareous shale, fractured, grey
79.2	80.3	1.1	Coal bed

Unique ID	
Village	Mynthlu
Taluka/Block	Saipung
District	East Jaintia Hills
Toposheet No	83 C/11
Latitude	25°25’07.0”
Longitude	92°30’50.2”
RL (m amsl)	990
Drilled Depth	200
Casing	6
SWL (mbgl)	63.88
Discharge (lps)	3.3
Date/year	Jun-17

Depth range (mbgl)		Thickness (m)	Litholog
From	To		
0	4	4	Top Soil, reddish brown in colour.
4	10.3	6.3	Sandstone, weathered, sample cuttings are medium to coarse grained, dirty white in colour.
10.3	13.43	3.13	Coal seam.
13.43	56.34	42.91	Sandstone, compact, sample cuttings are medium to coarse grained mixed with some clay materials, grey in colour.
56.34	68.6	12.26	Sandstone, compact, sample cuttings are medium to coarse grained, dark greyish brown in colour.
68.6	69.6	1	Sandstone, fractured, sample cuttings are medium grained, dark grey in colour.
69.6	102.25	32.65	Sandstone (Calcareous), compact, sample cuttings are fine to medium grained and the samples react with HCl, dark grey in colour.
102.25	178.94	76.69	Sandstone, compact, sample cuttings are fine to medium grained, brownish grey in colour.
178.94	191.2	12.26	Coal seam.
191.2	192.2	1	Sandstone/coal, fractured, sample cuttings are medium to coarse grained, brownish balck in colour.
192.2	200	7.8	Sandstone, compact, sample cuttings are medium to coarse grained mixed with some coarse grained quartz (Quartz vien), brown in colour.

Unique ID	
Village	PowergridKhliehriatEW
Taluka/Block	Khliehriat
District	East Jaintia Hills
Toposheet No	83 C/7
Latitude	25°20’40.91”
Longitude	92°22’11.44”
RL (m amsl)	1142
Drilled Depth	164.9
Casing	6
SWL (mbgl)	41.96
Discharge (lps)	6.15
Date/year	Aug-17

Depth range (mbgl)		Thickness (m)	Litholog
From	To		
0	4	4	Top Soil, reddish in colour
4	13.43	9.43	Sandstone (Upper Sylhet Sandstone), weathered, sample cuttings are coarse grained size, greyish brown in colour.
13.43	19.56	6.13	Sandstone, compact, sample cuttings are medium to coarse grained size, dark grey in colour.
19.56	22.56	3	Coal seam.
22.56	40.95	18.39	Sandstone, compact, sample cuttings are fine grained size, grey in colour.
40.95	44.08	3.13	Coal seam.
44.08	58.34	14.26	Sandstone, compact, sample cuttings are fine to medium grained size, grey in colour.
58.34	59.34	1	Sandstone, fractured, sample cuttings are fine to medium grained size, grey in colour.
59.34	93.12	33.78	Limestone (Middle Sylhet limestone), compact, sample cuttings are medium to coarse grained size, dark grey in colour.
93.12	123.77	30.65	Sandstone, compact, sample cuttings are medium to coarse grained size, greyish white in colour.
123.77	139.03	15.26	Sandstone, compact, sample cuttings are medium to coarse grained size, reddish grey in colour.
139.03	140.03	1	Sandstone, fractured, sample cuttings are medium to coarse grained size, reddish grey in colour.
140.03	164.9	24.87	Sandstone, compact, sample cuttings are medium to coarse grained size, reddish grey in colour.

Unique ID	
Village	PowergridKhliehriatOW
Taluka/Block	Khliehriat
District	East Jaintia Hills
Toposheet No	83 C/7
Latitude	25°20’40.28”
Longitude	92°22’11.22”
RL (m amsl)	1142
Drilled Depth	62.2
Casing (mbgl)	6
SWL (mbgl)	41.66
Discharge (lps)	2.25
Date/year	Aug-17

Depth range (mbgl)		Thickness (m)	Litholog
From	To		
0	4	4	Top Soil, reddish in colour
4	13.43	9.43	Sandstone (Upper Sylhet Sandstone), weathered, sample cuttings are very fine grained size, greyish white in colour.
13.43	16.43	3	Thin Coal seam.
16.43	47.08	30.65	Sandstone, compact, sample cuttings are very fine grained size, dark grey in colour.
47.08	48.08	1	Sandstone & some coal mixture, fractured, sample cuttings are very coarse grained size, black in colour.
48.08	57.34	9.26	Sandstone, compact, sample cuttings are fine grained size, grey in colour.
57.34	58.34	1	Sandstone, fractured, sample cuttings are veru coarse grained size, grey in colour.
58.34	59.47	1.13	Sandstone, compact, sample cuttings are fine grained size, grey in colour.
59.47	62.2	2.73	Limestone (Middle Sylhet limestone), compact, sample cuttings are fine to medium grained size, grey in colour.

Annexure 6: Geophysical data

Sl. No.	VES No.	District	Village	Location	Coordinates	General Geology	Layer Resistivity in Ohm-m					Layer Thickness in meters						Total Depth in m.
							ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	P_6	h_1	h_2	h_3	h_4	h_5	
1	105	East Jaintia Hills	Laiten Valley	110m due N 60°W of the second pillar on Northern side of the bridge.	N25°21'27" E92°33'27"	Limestone/Sand stone/ Shales	200	3500	90	1000			0.8	2.7	4.5			8
2	106	East Jaintia Hills	Laiten Valley	140m N 60°W of VES-105.	N25°21'28" E92°33'23"	Limestone/Sand stone/ Shales	260	750	150	1500	350		0.7	3.9	8.5	37		50
3	107	East Jaintia Hills	Laiten Valley	120m N 60°W of VES-106.	N25°21'26" E92°33'31"	Limestone/Sand stone/ Shales	500	350	170	1400	400		0.9	2.1	10	42		55
4	108	East Jaintia Hills	Laiten Valley	By the side of the road leading to the bridge.	N25°21'37" E92°33'18"	Limestone/Sand stone/ Shales	70	450	300	1250			0.8	8.2	33			42
5	109	East Jaintia Hills	Nongkhliew	50m SE of river/stream.	N25°21'36" E92°33'32"	Limestone/Sand stone/ Shales	350	850	325	1500			0.6	4.4	17			22
6	110	East Jaintia Hills	Nongkhliew	100m North of VES-109.	N25°21'39" E92°33'29"	Limestone/Sand stone/ Shales	110	5000	150	1500	200		0.5	1.3	9.2	34		45
7	111	East Jaintia Hills	Nongkhliew	100m N of VES-110.		Limestone/Sand stone/ Shales	150	1400	130	900	250		1	2.5	4.5	32		40
8	112	East Jaintia Hills	Nongkhliew	Along side of the road leading to the valley.	N25°21'34" E92°33'23"	Limestone/Sand stone/ Shales	55	1555	240	436			0.6	3.2	5.3			9
9	113	East Jaintia Hills	Leken Valley	Near the NE goalpost of the foot ball ground.	N25°21'32" E92°33'12"	Limestone/Sand stone/ Shales	350	900	220	550			1.1	1.4	7.5			10
10	114	East Jaintia Hills	Leken Valley	120m South 50°E of VES-113.	N25°21'30" E92°33'14"	Limestone/Sand stone/ Shales	170	300	120	750	500		1	2	8	14		25

Annexure 7: Soil Infiltration Test data

a. Location – Lumshnong

Time (t)	Time difference	After filling	Before filling	Depth of Infiltration	Cummulative Infiltration	Infiltration rate	f-fc	Remarks
min	min	cm	cm	cm	cm	cm/hr	f0	
0		26		0	0	f0 = 23.4 from the curve	ft	
1	1	26	24	2	2	120	96.6	
2	1	24	23.1	0.9	2.9	54	30.6	
3	1	23.1	22.4	0.7	3.6	42	18.6	
4	1	22.4	21.5	0.9	4.5	54	30.6	
5	1	21.5	21	0.5	5	30	6.6	
6	1	21	20.4	0.6	5.6	36	12.6	
7	1	20.4	19.7	0.7	6.3	42	18.6	
8	1	19.7	19.2	0.5	6.8	30	6.6	
9	1	19.2	18.7	0.5	7.3	30	6.6	
10	1	18.7	18.2	0.5	7.8	30	6.6	
15	5	26	23	3	10.8	36	12.6	Refilled
20	5	23	20.5	2.5	13.3	30	6.6	
25	5	26	23.5	2.5	15.8	30	6.6	Refilled
30	5	23.5	21	2.5	18.3	30	6.6	
35	5	21	18.7	2.3	20.6	27.6	4.2	
40	5	25.5	23.5	2	22.6	24	0.6	Refilled
45	5	23.5	21.2	2.3	24.9	27.6	4.2	
50	5	21.2	19	2.2	27.1	26.4	3	
55	5	26	23.9	2.1	29.2	25.2	1.8	Refilled
60	5	26	23.9	2.1	31.3	25.2	1.8	Refilled
70	10	26	21.9	4.1	35.4	24.6	1.2	Refilled
80	10	26	22	4	39.4	24	0.6	Refilled
90	10	26	22	4	43.4	24	0.6	Refilled
100	10	26	22	4	47.4	24	0.6	Refilled
120	20	26	18.2	7.8	55.2	23.4	0	Refilled
140	20	26	18.2	7.8	63	23.4	0	Refilled
160	20	26	18.2	7.8	70.8	23.4	0	Refilled
180	20	26	18.2	7.8	78.6	23.4	0	Refilled

b. Location – Nongsing

Time (t)	Time difference	After filling	Before filling	Depth of Infiltration	Cummulative Infiltration	Infiltration rate	f-fc	Remarks
min	min	cm	cm	cm	cm	cm/hr	f0	
0		**23.5**		**0**	**0**	**f0 = 1.5 from the curve**	**ft**	
1	1	23.5	23.2	0.3	0.3	18	16.5	
2	1	23.2	23.1	0.1	0.4	6	4.5	
3	1	23.1	23	0.1	0.5	6	4.5	
4	1	23	23	0	0.5	0	-1.5	
5	1	23	22.9	0.1	0.6	6	4.5	
6	1	22.9	22.9	0	0.6	0	-1.5	
7	1	22.9	22.8	0.1	0.7	6	4.5	
8	1	22.8	22.7	0.1	0.8	6	4.5	
9	1	22.7	22.6	0.1	0.9	6	4.5	
10	1	22.6	22.5	0.1	1	6	4.5	
15	5	22.5	22.3	0.2	1.2	2.4	0.9	
20	5	22.3	22	0.3	1.5	3.6	2.1	
25	5	22	21.7	0.3	1.8	3.6	2.1	
30	5	21.7	21.4	0.3	2.1	3.6	2.1	
40	10	21.4	20.9	0.5	2.6	3	1.5	
50	10	20.9	20.5	0.4	3	2.4	0.9	
60	10	20.5	20.1	0.4	3.4	2.4	0.9	
70	10	23.5	23.2	0.3	3.7	1.8	0.3	Refilled
80	10	23.2	22.9	0.3	4	1.8	0.3	
90	10	22.9	22.6	0.3	4.3	1.8	0.3	
110	20	23.5	22.9	0.6	4.9	1.8	0.3	Refilled
130	20	22.9	22.4	0.5	5.4	1.5	0	
150	20	22.4	21.9	0.5	5.9	1.5	0	
170	20	21.9	21.4	0.5	6.4	1.5	0	

c. Location – Khliehriat

Time (t)	Time difference	After filling	Before filling	Depth of Infiltration	Cummulative Infiltration	Infiltration rate	f-fc	Remarks
min	min	cm	cm	cm	cm	cm/hr	f0	
0		25		0	0	f0 = 0.6 from the curve	ft	
1	1	25	24.7	0.3	0.3	18	17.4	
2	1	24.7	24.5	0.2	0.5	12	11.4	
3	1	24.5	24.2	0.3	0.8	18	17.4	
4	1	24.2	24.1	0.1	0.9	6	5.4	
5	1	24.1	24	0.1	1	6	5.4	
6	1	24	24	0	1	0	-0.6	
7	1	24	23.9	0.1	1.1	6	5.4	
8	1	23.9	23.9	0	1.1	0	-0.6	
9	1	23.9	23.9	0	1.1	0	-0.6	
10	1	23.9	23.9	0	1.1	0	-0.6	
15	5	23.9	23.8	0.1	1.2	1.2	0.6	
20	5	23.8	23.7	0.1	1.3	1.2	0.6	
25	5	23.7	23.6	0.1	1.4	1.2	0.6	
30	5	23.6	23.5	0.1	1.5	1.2	0.6	
40	10	25	24.8	0.2	1.7	1.2	0.6	Refilled
50	10	24.8	24.6	0.2	1.9	1.2	0.6	
60	10	24.6	24.5	0.1	2	0.6	0	
70	10	24.5	24.4	0.1	2.1	0.6	0	
80	20	24.4	24.3	0.1	2.2	0.3	-0.3	
100	20	24.3	24.1	0.2	2.4	0.6	-0	
120	20	24.1	23.9	0.2	2.6	0.6	0	
140	20	23.9	23.7	0.2	2.8	0.6	-0	

d. Location – Latykre

Time (t)	Time difference	After filling	Before filling	Depth of Infiltration	Cummulative Infiltration	Infiltration rate	f-fc	Remarks
min	min	cm	cm	cm	cm	cm/hr	f0	
0		26.5		0	0	f0 = 0.3 from the curve	ft	
1	1	26.5	25.7	0.8	0.8	48	47.7	
2	1	25.7	25.5	0.2	1	12	11.7	
3	1	25.5	25.4	0.1	1.1	6	5.7	
4	1	25.4	25.3	0.1	1.2	6	5.7	
5	1	25.3	25.3	0	1.2	0	-0.3	
6	1	25.3	25.3	0	1.2	0	-0.3	
7	1	25.3	25.2	0.1	1.3	6	5.7	
8	1	25.2	25.1	0.1	1.4	6	5.7	
9	1	25.1	25.1	0	1.4	0	-0.3	
10	1	25.1	25	0.1	1.5	6	5.7	
15	5	25	24.9	0.1	1.6	1.2	0.9	
20	5	24.9	24.8	0.1	1.7	1.2	0.9	
30	10	24.8	24.6	0.2	1.9	1.2	0.9	
40	10	24.6	24.5	0.1	2	0.6	0.3	
50	10	24.5	24.4	0.1	2.1	0.6	0.3	
60	10	24.4	24.3	0.1	2.2	0.6	0.3	
80	20	24.3	24.1	0.2	2.4	0.6	0.3	
100	20	24.1	23.8	0.3	2.7	0.9	0.6	
120	20	23.8	23.7	0.1	2.8	0.3	0	
140	20	23.7	23.6	0.1	2.9	0.3	-0	
160	20	23.6	23.5	0.1	3	0.3	0	
200	40	23.5	23.3	0.2	3.2	0.3	-0	
240	40	23.3	23.1	0.2	3.4	0.3	-0	

e. Location- Tangnub

Time (t)	Time difference	After filling	Before filling	Depth of Infiltration	Cummulative Infiltration	Infiltration rate	f-fc	Remarks
min	min	cm	cm	cm	cm	cm/hr	f0	
0		20		0	0	f0 = 1.5 from the curve	ft	
1	1	20	19.4	0.6	0.6	36	34.5	
2	1	19.4	19	0.4	1	24	22.5	
3	1	19	18.7	0.3	1.3	18	16.5	
4	1	18.7	18.4	0.3	1.6	18	16.5	
5	1	18.4	18.2	0.2	1.8	12	10.5	
6	1	18.2	18	0.2	2	12	10.5	
7	1	18	17.9	0.1	2.1	6	4.5	
8	1	17.9	17.8	0.1	2.2	6	4.5	
9	1	17.8	17.7	0.1	2.3	6	4.5	
10	1	17.7	17.6	0.1	2.4	6	4.5	
15	5	17.6	17.2	0.4	2.8	4.8	3.3	
20	5	17.2	16.9	0.3	3.1	3.6	2.1	
25	5	16.9	16.6	0.3	3.4	3.6	2.1	
30	5	16.6	16.3	0.3	3.7	3.6	2.1	
40	10	20	19.5	0.5	4.2	3	1.5	Refilled
50	10	19.5	19	0.5	4.7	3	1.5	
60	10	19	18.6	0.4	5.1	2.4	0.9	
70	10	18.6	18.2	0.4	5.5	2.4	0.9	
80	10	18.2	17.8	0.4	5.9	2.4	0.9	
100	20	20	19.3	0.7	6.6	2.1	0.6	Refilled
120	20	19.3	18.7	0.6	7.2	1.8	0.3	
140	20	18.7	18.1	0.6	7.8	1.8	0.3	
160	20	20	19.5	0.5	8.3	1.5	0	Refilled
180	20	19.5	19	0.5	8.8	1.5	0	
220	40	19	18	1	9.8	1.5	0	
260	40	18	17	1	10.8	1.5	0	

f. Location – Narwan

Time (t)	Time difference	After filling	Before filling	Depth of Infiltration	Cummulative Infiltration	Infiltration rate	f-fc	Remarks
min	min	cm	cm	cm	cm	cm/hr	f0	
0		**24.2**		**0**	**0**	**f0 = 3 from the curve**	**ft**	
1	1	24.2	23.5	0.7	0.7	42	39	
2	1	23.5	23.2	0.3	1	18	15	
3	1	23.2	23	0.2	1.2	12	9	
4	1	23	22.8	0.2	1.4	12	9	
5	1	22.8	22.7	0.1	1.5	6	3	
6	1	22.7	22.6	0.1	1.6	6	3	
7	1	22.6	22.5	0.1	1.7	6	3	
8	1	22.5	22.4	0.1	1.8	6	3	
9	1	22.4	22.3	0.1	1.9	6	3	
10	1	22.3	22.2	0.1	2	6	3	
15	5	22.2	21.7	0.5	2.5	6	3	
20	5	21.7	21.2	0.5	3	6	3	
25	5	21.2	20.8	0.4	3.4	4.8	1.8	
30	5	20.8	20.4	0.4	3.8	4.8	1.8	
35	5	20.4	20.1	0.3	4.1	3.6	0.6	
40	5	20.1	19.8	0.3	4.4	3.6	0.6	
45	5	19.8	19.5	0.3	4.7	3.6	0.6	
50	5	19.5	19.2	0.3	5	3.6	0.6	
60	10	24.2	23.6	0.6	5.6	3.6	0.6	Refilled
70	10	23.6	23	0.6	6.2	3.6	0.6	
80	10	23	22.5	0.5	6.7	3	0	
90	10	22.5	22	0.5	7.2	3	0	
100	10	22	21.5	0.5	7.7	3	0	
120	20	24.2	23.2	1	8.7	3	0	Refilled
140	20	23.2	22.2	1	9.7	3	0	

Annexure 8: Ground water resource

a) General Description of Ground Water Assessment in East Jaintia Hills district for 2017-18 (area in ha)

Name of Ground Water Assessment Unit	East Jaintia Hills
Type of Ground Water Assessment Unit	District
Type of rock formation	Sandstone and Limestone
Total area of Groundwater Assessment Unit	204000
Hilly area	103900
Command area	0
Non-command area	100100
Poor ground water quality area	0
Area considered for groundwater recharge	100100

b) Ground Water Resource Potential in East Jaintia Hills district during 2017-18

Assessment Unit / District	East Jaintia Hills
Command/ Non-Command/ Total	Total
Recharge from rainfall during monsoon season	7927 ham
Recharge from other sources during monsoon season	0 ham
Recharge from rainfall during non-monsoon season	2965 ham
Recharge from other sources during non-monsoon season	994 ham
Total Ground Water Recharge	11886 ham
Net Annual Ground Water Availability	10697 ham

c) Ground Water Draft for All Uses in East Jaintia Hills district

District	East Jaintia Hills
Total draft for domestic and industrial purpose (as per households)	57 ham
Total draft for irrigation	0 ham
Total groundwater draft	57 ham

d) Balance Ground Water Resources Available and Stage of Groundwater Development in the Study Area as On 31st March 2013

Assessment Unit / District	East Jaintia Hills
Command/ Non-Command/ Total	Total
Net Annual Ground Water Availability	43878 ham
Existing Gross Ground Water Draft for Irrigation	0 ham
Existing Gross Ground Water Draft for domestic and industrial water supply	54 ham
Existing Gross Ground Water Draft for All Uses	54 ham
Allocation for domestic and industrial requirement supply upto next 25 years	848 ham
Net Annual Ground Water Availability for future irrigation development	43030 ham
Stage of ground water development	0.12%

e) Categorization for Ground Water Development of East Jaintia Hills district during 2017-18

Assessment Unit/ District	East Jaintia Hills
Stage Of Ground Water Development (%)	0.53%
Is there a significant decline of pre-monsoon water table levels (Yes / No)	No
Is there a significant decline of post-monsoon water table levels (Yes / No)	No
Categorization For Future Ground Water Development (Safe / Semi-Critical/ Critical/ Over-Exploited)	Safe

Annexure 9: Data gap and data requirement in East Jaintia hills district

Toposheet No.	Grid	Data Existing										Data required									
		Aquifer I					Aquifer II					Aquifer I					Aquifer II				
		EW	OW	VES	CHE	WL	EW	OW	VES	CHE	WL	EW	OW	VES	CHE	WL	EW	OW	VES	CHE	WL
83 C/3	C2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83 C/3	C3	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/4	C1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/4	C2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/7	A1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/7	A2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/7	A3	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/7	B1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/7	B2	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/7	B3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/7	C1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/7	C2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/7	C3	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/8	A1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/8	A2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/8	A3	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/8	B1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/8	B2	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/8	B3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/8	C1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/8	C2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/8	C3	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/11	A1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/11	A2	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0
83C/11	A3	0	0	0	0	0	1	0	0	0	0	1	1	0	1	1	0	1	2	1	1
83C/11	B1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/11	B2	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/11	B3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/11	C2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/11	C3	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/12	A1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/12	A2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/12	B1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0
83C/12	B2	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/12	C1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/15	A3	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
83C/16	A1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	2	1	1
	TOTAL	0	0	0	0	0	1	0	1	0	0	21	21	0	37	37	20	21	72	21	21

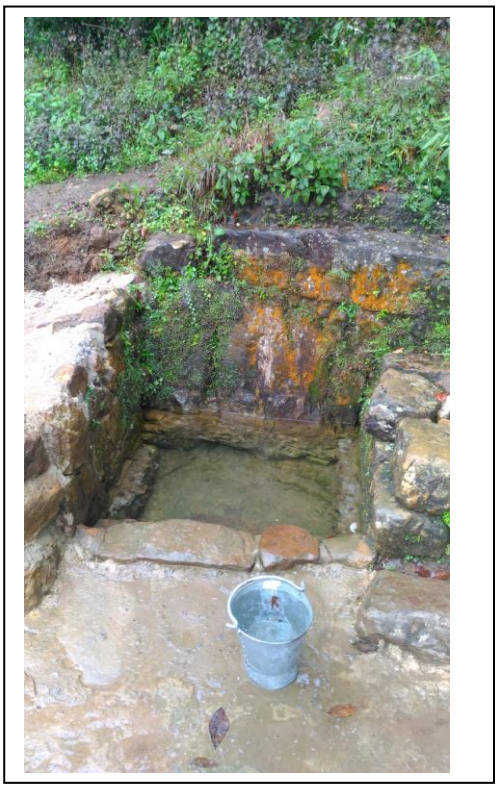
FIELD PHOTOGRAPHS

PYT at PowergridKhliehriat

Ground Water Exploration at Mynthlu

Ground water exploration at PowergridKhliehriat

Soil Infiltration Test studies in East Jaintia Hills district



Springs in East Jaintia Hills district