**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 GARO HILLS DISTRICT, MEGHALAYA

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

**Govt. of India**

**MINISTRY OF JAL SHAKTI**
**DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION**

**CENTRAL GROUND WATER BOARD**

# REPORT
# ON
# "AQUIFER MAPPING AND MANAGEMENT PLAN OF EAST GARO HILLS DISTRICT, MEGHALAYA"
# (AAP 2019-20)

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# 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. Biplab Ray, HOO, 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, NER for all the help, support, guidance, technical inputs, encouragement and also preparing the ground water resources and management strategies of this report.

I would like to thank the officers and staff of the Regional Chemical Laboratory, CGWB NER Guwahati for analysing the ground water samples and providing the data.

I sincerely thank Mr. Shasinlo Kent , Scientist B and Ms. Rinku Rani Das, Scientist-B for their technical inputs and support during the course of study.

I would also like to thank Meghalaya State Government officials for providing the necessary information of the study area.

I thank all the officials and staff and drivers of CGWB, SUO, Shillong for 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 Garo 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 have been done through multi-disciplinary approach so as to achieve the said objectives. The total mappable area of the district under aquifer mapping and management plan is 661.17 sq. km of the district, falling under Survey of India Toposheet No. 78K/5, 78K/6, 78K/7, 78K/9, 78K/10, 78K/11, 78K/13,78K/14 lying between North latitudes 25° 25' to 25° 50' and East longitudes 90° 15 to 91°00' , forms the central part of the Shillong Plateau and falls in East Garo Hills district of Meghalaya state. Apart from Williamnagar, which is the district headquarters, Songsak, Samanda and Rongjeng are some of the important localities of the area. Major part of the area identified for aquifer mapping is under forest cover.*

*Physiographically,the area can be described as highly dissected curvilinear/rectilinear hill ranges separated by valleys. The country slopes towards both north and south from the central highlands. The area is mainly drained by Simsang River, which flows towards southwest. The area shows an immature topography with high drainage density. The drainage pattern varies from dendritic type to rectangular to trellis pattern in lower orders. The geomorphological pattern indicates limited lithological and structural control.*

*Geologically,the district has a variety of rock formations ranging in age right from the Archaean to Tertiary and also Recent Alluvium occurring as valley-fills. Major parts of the district have been covered by the Archaean Gnessic Complex intruded by acid/basic intrusive viz., Granites, Pyroxenite and Amphibolites. The Older of Tertiary Formation occurs in and around Williamanagar Town. The Gneissic complex represents the remnant of an Archaean Peninsular landmass which covers almost the entire district. These crystalline rock masses were subjected different grades of weathering which has formed the loose weathered mantle over the parent rock. The Tertiaries overlying the basemant gneissic complex are represented by Jaintia Group of rocks of Eocene age. Older alluvium occurs along the bank of Simsang river near Williamnagar. Newer or recent alluvium forms superficial blanket in the river valley.*

*The study area is underlain broadly by consolidated rocks, semi consolidated and unconsolidated rocks. Consolidated group of rocks comprises Archaean Gneissic Complex, acid / basic intrusive. Semi-consolidated formation includes sandstone, and shale inter bedded with the coal seams. The area is sparsely populated and has negligible ground water development except some dug wells with deepest water level being less than 5.7 m bgl. Perusal of the data shows that during the last one decade there is no change in ground water development.*

*The consolidated unit lack primary porosity and the movement and occurrence of ground water is controlled by secondary porosity like joints, faults etc. Yield is expected to be moderate in the intermontane valleys and moderate to good along the fractures where intersection of more than one set of fractures and joints are present. The weathered portion acts as ground water reservoir within shallow depth. Groundwater occurs under unconfined* *condition in the weathered residuum and semi-confined conditions in secondary pore spaces like fractures, fissures etc. The valley areas are found to be favourable for the construction of dug wells and bore wells. In semi consolidated unit, where dissection is severe, the ground water prospect is good. Sandstone with limited porosity yields water through secondary fissures. The aquifers are thick and discontinuous in nature. The areas which are favourable for construction of shallow as well as deep tube well are the synclinal and intermontane valleys.*

*The aquifer system in this district can be divided as a two aquifer system viz., 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 through construction of dug wells or shallow bore well. The second aquifer is the deeper aquifer which tapped the fractured zone and is mainly developed through boring and construction of tube wells. Based on the study of litholog and analysis of depth of construction of dug wells and bore wells, it is found that the first aquifer occurs within 2 to 30 m bgl. Ground water in the second aquifer occurs under semi-confined to confined condition in the fractures upto the maximum explored depth of 202.3 m bgl.*

*Study of water level trend and its behaviour, both in phreatic and semi-confined condition, were carried out in the aquifer mapping area.Eighteenkey observation wells (dug wells) were established and monitored to study the Depth to Water Level and ground water quality. In these wells, depth to water level ranges between 1.2 to 5.7 m bgl and ground water, in general, is of potable quality. Ground water exploration has been carried out under NAQUIM in different parts of the district to delineate the potential aquifers and their geometry and to determine the hydrogeological parameters of the aquifer system. Exploration to this virgin area commenced with a DTH Rig. During the course of study, eight exploratory wells were drilled at Songsak, Chidmit, Naringirre, Dobu-Rimding, Nengkhra, Nokilawe, Somgong and JNV Williamnagar ranging in depth between 75.50 to 202.30. The discharge ranged between 0.8 to 18lit/sec during drilling. Main aquifer is formed by fractured granite gneiss.*

*A total of thirteen springs were studied in the district.The springs are gravitational fractured springs. Discharge of the springs varies between1.5&30litre/minuteduring pre-monsoonperiod and 18.46 & 34 during post monsoon. Previous study indicated that most of the springs dry up during the lean period. Some perennial springs flow throughout the year but their yield decrease during the dry season (March – April). These springs are the lifeline of the habitations as people depend heavily for their domestic water supply needs on these springs. Jhum or shifting cultivation is one of the main reasons for depleting yield of springs. Catchment area of these springs has to be maintained and jhum cultivation has to be stopped to revive and sustainable management of this important source.*

*In order to study the chemical quality of ground water in the district, water samples from dug wells, springs anddeep tube wellswere collected during the course of field work and were analysed. Chemical analyses reveal that water from some dug wells is slightly acidic at some places. All the other parameters in shallow aquifer are within permissible limits. Iron is found to be beyond permissible limit in some deep tube wells.*

*Surface geophysical studies (7 VES) were conducted during NAQUIM studies to delineate the subsurface geology.*

*Dynamic groundwater resources of the district, were estimated based on the methodology recommended by Groundwater Estimation Committee (GEC'2015). The annual* *extractable ground water resources, were estimated at4349.81ham, the stage of ground water extraction is 0.47 % and the district falls under "**safe**" category.*

*Finally, the aquifer map of the study area is generated based on the inputs from geological, hydrogeological, geophysical and hydro chemical studies and a management plan is prepared with an emphasis on providing irrigation facilities through ground water development as agriculture is the main means of livelihood of the people living in the district. With the help of agricultural professionals and using "CROPWAT" model, developed by FAO; a cropping plan was designed for the district through groundwater irrigation.*

## AQUIFER MAPPING OF EAST GARO HILLS DISTRICT, MEGHLAYA

## 1. INTRODUCTION

Central Ground Water Board, North Eastern Region has carried out Aquifer Mapping and Management plan in East Garo Hills district, Meghalaya 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 hydrogeological 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 behaviours, 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 1:50000 scale and finally formulate a complete, sustainable and effective management plan for ground water development.

### 1.2 Scope of the Study

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

**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, analysed, 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 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 regime scenario is utilized to identify a suitable strategy for sustainable development of the aquifer in the area.

**1.3 Approach and Methodology**

Aquifer mapping has been carried out by adopting a multi-disciplinary approach:

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

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

(iii) Groundwater 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 for determination of ground water recharge scope, intensity and potentials and also to determine the characteristics and performances of existing aquifers at various depths.

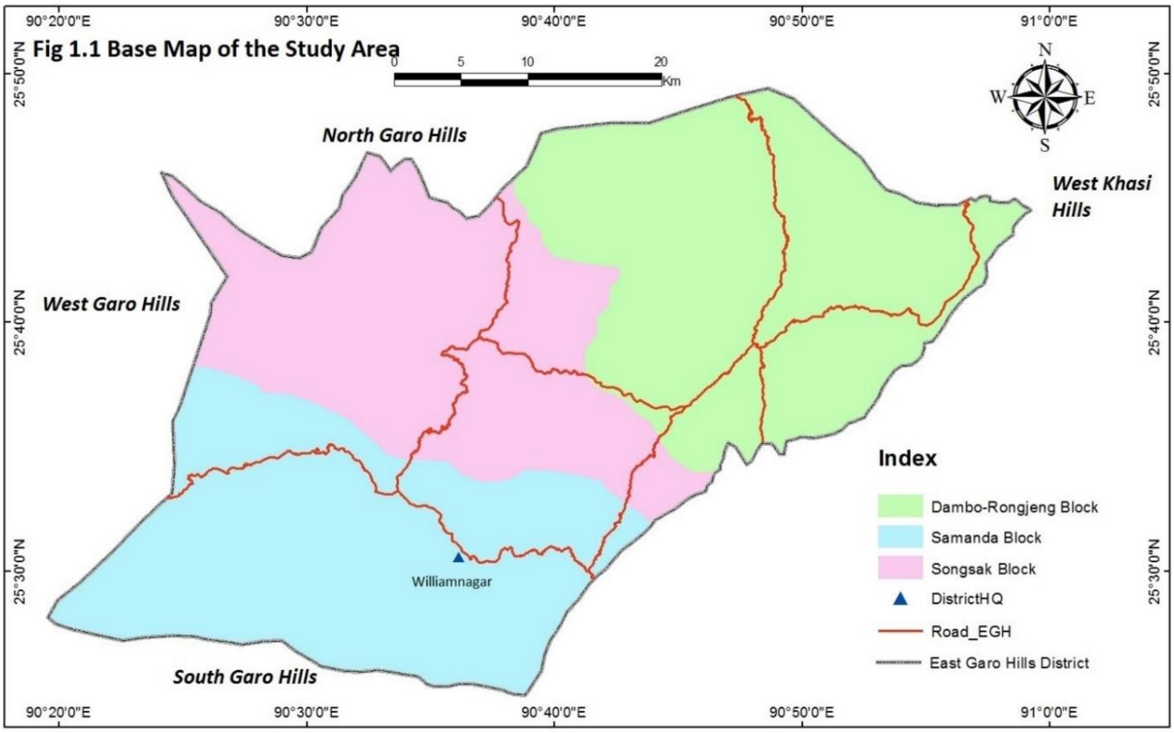
(v) Collection of various relevant technical data from the field in aquifer mapping area and also from the concerned State Govt. Agencies and other Institutes dealing with ground water and incorporating these data along with CGWB data for final output.

(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 Garo Hills district lies between E 90˚15' to E 91˚00' Longitude and N 25˚25' to N 25˚50' Latitude. Its forms the western part of the Shillong Plateau. The district is having an area of 1443 sq.km and out of this mappable area of 661 sq.km was covered under NAQUIM program during AAP 2012-13 (614 sq.km) and AAP 2019-20 (47 sq.km). Hilly areas were studied through hydrogeological study of springs. Williamnagar, is the district headquarters of East Garo Hills District. Songsak, Samanda and Rongjeng are some of the other important localities in the district. The study area covers parts of three CD Blocks namely, Songsak ,Samanda and Dambo-Rongjeng blocks of East Garo Hills district. The total population of the East Garo Hills district as per 2011 census is 145798.The area falls partly or fully in the quadrants of Survey of India Toposheet bearing nos. *78K/5,78K/6, 78K/7, 78K/9, 78K/10, 78K/11, 78K/13,78K/14*and is bounded by West Khasi Hills district in the East, South Garo Hills in the south and North Garo Hills district in the North and West GaroHillsin the West. The base map of the district 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 Departments of Meghalaya and various Central and State Government agencies. The Data Gap is shown in Fig.1.2 and Data Requirement, Data Availability and Data Gap Analysis are presented in table 1.1and Annexure-6.

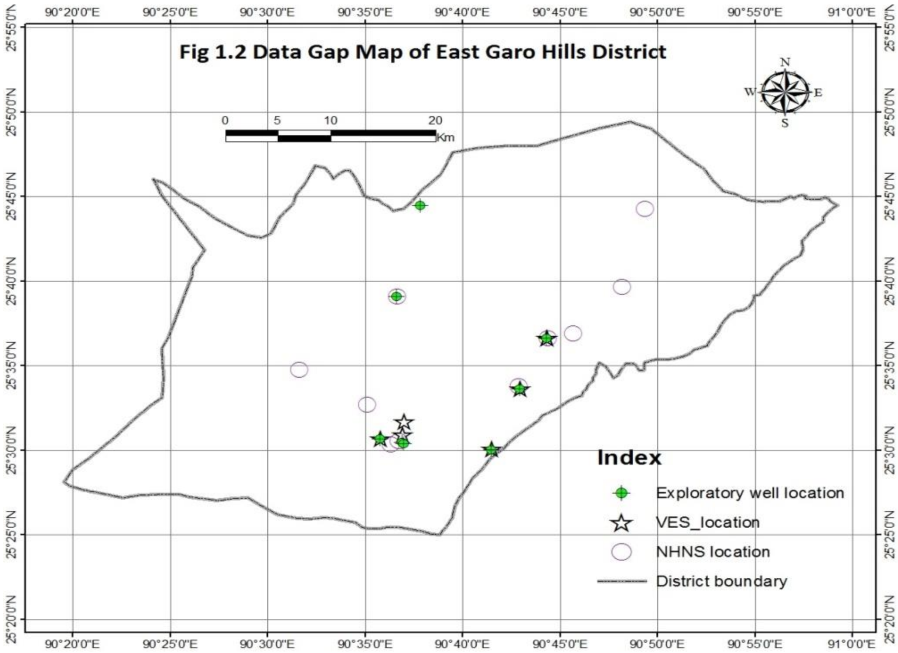



Table1.1 Data Availability and Data Gap Analysis in Aquifer Mapping Studies Area

| Sl. No. | Items | Data Requirement | Data Availability | Data Gap |
|---|---|---|---|---|
| 1 | Ground Water Exploration Data | Both first aquifer and second aquifer | 8 EW | I Aquifer : 16 nos. of EW & OW.<br>II Aquifer : 11 nos.of EW &16 nos. of OW. |
| 2 | Geophysics | Geophysical data of the Study area | 7 VES | I Aquifer : 56 nos.<br>II Aquifer : 50 nos. |
| 3 | Ground Water Monitoring Regime | Representative Monitoring Wells well distributed over the Study Area for both first and second aquifers. | 10 | I Aquifer : 21 nos.<br>II Aquifer : 16 nos. |
| 4 | Ground Water Quality | Representative Monitoring Wells well distributed over the Study Area for both first and second aquifers. | 16 | I Aquifer : 21 nos.<br>II Aquifer : 15 nos. |
| 5 | Specific yield (Shallow and deeper aquifer) | Both aquifers | Nil | Entire study area |
| 6 | Climate | Season-wise Rainfall pattern | Nil | Monthly rainfall data for the past 10 years. |
| 7 | Soil | Soil map and Soil Infiltration Rate | Soil map and 10 Soil infiltration studies | 2 nos. of soil Infiltration studies |
| 8 | Land use | Latest Land Use pattern | Land Use pattern data of 2017-18 | NA |
| 9 | Geomorphology | Detailed Information on Geomorphology of the area | District level information | Data available |
| 10 | Recharge Parameters | Recharge parameters for different soil and aquifer types based on field studies | Recharge factor calculated from Infiltration studies | No Gap |

## 1.6 Demography

The total population of the East Garo Hills district are as per 2011 Census is 145798with 74352 males and 71446 females.

| East Garo Hills District | Rural | Urban | Total |
|---|---|---|---|
| Total population | 121201 | 24597 | 145798 |
| Male population | 61617 | 12735 | 74352 |
| Female population | 59584 | 11862 | 71446 |
| Total workers population | 51035 | 7293 | 58328 |
| Cultivators (Main+Marginal) | 36882 | 727 | 37609 |
| Agricultural Labourers (Main+Marginal) | 7340 | 179 | 7519 |

The block wise population of the community and Rural Development Blocks ofEast Garo Hills District as per the 2011 census is as below: -

| Name of Block | Total no. of household | Population | | |
|---|---|---|---|---|
| | | Male | Female | Total |
| Rongjeng C & RD Block | 9454 | 26634 | 25950 | 52584 |
| Songsak C & RD Block | 7003 | 18815 | 18164 | 36979 |
| Samanda C & RD Block | 10128 | 28903 | 27332 | 56235 |

## 1.7 Communication

The district is accessible through NH-62 from Dudhnoi, Goalpara district, Assam which is 84 km from Williamnagar via Nengkra-Rongjeng and 285 km from Shillong, the State Capital and via Jengjal (Tura-Williamnagar road). It is also approachable via Nongstoin with a distance of 246 km from Shillong.

## 1.8 Climate

The climate of the district is largely controlled by South–West monsoon and seasonal winds. East Garo Hills district being relatively lower in altitude to the rest of Khasi hills, experiences a fairly high temperature for most part of the year. The climate shows a variation from warm, humid tropical in the plain and temperate climate is experienced in the hilly areas. The climatic conditions vary substantially from place to place due to wide difference in altitude. Therefore, according to the prevailing weather condition over the years, the district can be grouped into four conspicuous seasons namely summer, monsoon or rainy, autumn and winter. The summer season extends from end of March to mid-May, which is characterized by relatively high temperature, occasional thunderstorm, and high wind velocities. The study area experiences sub-tropical to humid climate. The temperatures are fairly high during the months of February to October. During the hottest months the mean maximum temperature hovers around $35^0$C and the minimum temperatures is $13.5^0$C. January is the coldest month and the mean maximum and minimum temperatures being $22.3^0$C and $10^0$C respectively. The study area has an average annual rainfall of 2540 mm. The rainy season commences with the onset of South-West monsoon in June and lasts up to October. Bulk of the precipitation occurs between April and October, with July accounting for the maximum rainfall of the year. Non-monsoon precipitation contributes about 34.29% of the total annual rainfall. Short autumn commences from mid-October to November. This season indicates the slow retreating of monsoon with clear and sunny sky. The winter season extends from December to the end of March. This is the coldest season of the year with sharp decline in the temperature. Winter is basically dry with reducing diurnal range of temperature.

## 1.9 Land use

Land utilisation statistics provide detailed information of the land use pattern in the area. The socio-cultural factor plays a dominant role in land use both in rural and urban areas. Landforms, slope, soil, natural calamities and natural resources are the important factors which control the land use pattern of the area. Based on the land utilization, the total area is divided into various types of landforms such as forest, cultivable land, fallows land, crops area etc. which in turn reflects the degree of development of agricultural activities and cultivation potential. The net sown area in the district is 15.59% of total geographical area. The land utilization statistics of East Garo Hills district is shown in the following Table1.2.

Table 1.2: Land use statistics in East Garo Hills District (2017-18)

| **Land Classifications (in ha)** | **East Garo Hills** |
|---|---|
| 1. Geographical Area | 144300 |
| 2. Reporting Area | 144086 |
| 3. Barren and Uncultivable land | 2195 |
| 4. Other uncultivated land<br>a. Land under Misc tree crops and grooves etc<br>b. Cultivable waste land | <br>13778<br>17930 |
| 5. Fallow land<br>a. Fallow land other than current fallows<br>b. Current fallows | <br>10905<br>2486 |
| 6. Net Area Sown | 22496 |
| 7. Area sown more than once | **2675** |
| 8. Total cropped area | **25171** |

*Source: District Agriculture Office, East Garo Hills, Govt. of Meghalaya.*

## 1.10 Soil

High rainfall, humid subtropical climate and favorable topography have resulted in the formation of soil profile (1-8 m) in the study area. The soil in the study area is mostly clayey and sandy loam, deep brown, red soil, sandy soil and acidic soil. The acidic character is due to leaching of the soil's profile basic elements caused by high rainfall. Soil map of the area is given in Fig 1.3.

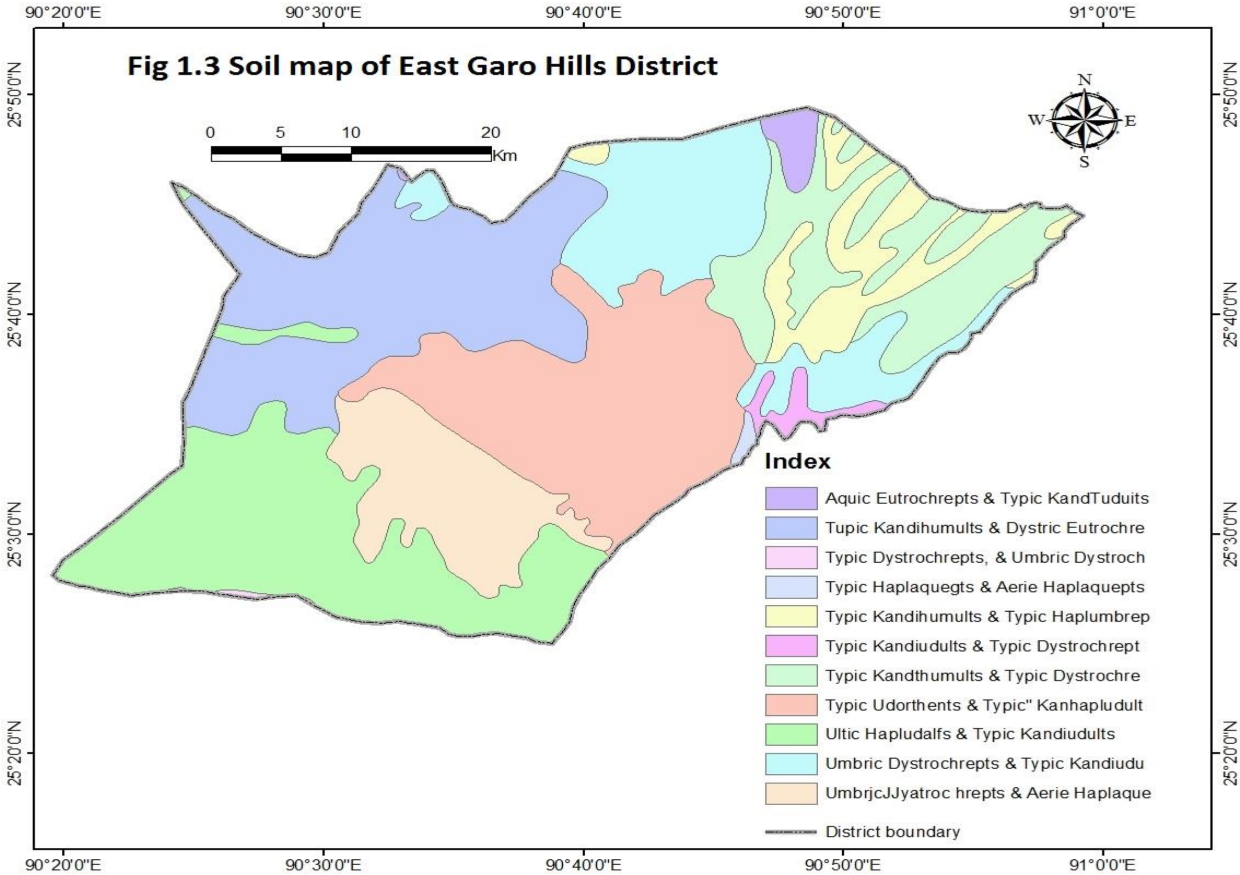


**Fig 1.3 Soil map of East Garo Hills District**

(*Source: Regional Center of National Bureau of Soil* Survey and Land *Use Planning*).

Soil cover plays an important role in the ground water recharge. Hence, data are generated on the attribute of the soil which characterizes the infiltration capacity of the soil. Soil infiltration tests have been conducted in different types of soils across the district to determine the infiltration rate of the soil.

**Soil Infiltration Test**

The soil infiltration rates are useful in determination of recharge parameters and demarcation of areas feasible for artificial recharge. The experiments are conducted at 10 sites in East Garo Hills District in 2015-16 and 2 sites in 2019-20. Soil infiltration testswere conducted by using Double Ring Infiltrometer. A Double-ring Infiltrometer consists of two concentric metal rings. The rings are driven into the ground and filled with water. The outer ring helps to prevent divergent flow. The drop in water level or volume in the inner ring is used to calculate an infiltration rate. The infiltration rate is determined as the amount of water per surface area and time unit that penetrates the soils. The final infiltration rate at which the rate of infiltration becomes constant in time scale is taken as the infiltration rate. The details of the soil infiltration tests results are given in table below.

Table 1.3: Soil infiltration test results in the study area

| Sl. No. | Location | Co-ordinates | | Soil Type | Season | Infiltration Rate (cm/hr) |
|---|---|---|---|---|---|---|
| | | Longitude | Latitude | | | |
| 1 | Circuit House, William Nagar | 90.61201667 | 25.50861667 | Fine loamy soil | Post monsoon 2015-16 | 2.4 |
| 2 | Don Bosco School, Nariangre | 90.73868333 | 25.61063333 | Coarse loamy soil | Post monsoon 2015-16 | 2.4 |
| 3 | Forest House 1, SongkhanaDiurion | 90.63506667 | 25.68043333 | Loamy | Post monsoon 2015-16 | 0.6 |
| 4 | Forest House 2, SongkhanaDiurion | 90.6350469 | 25.6804242 | Loamy | Post monsoon 2015-16 | 0.6 |
| 5 | Govt. L.P. School, Naringre | 90.7309 | 25.61033333 | Coarse loamy | | 4.2 |
| 6 | JNV, Willliamnagar | 90.6147 | 25.51625 | Fine loamy | Post monsoon 2015-16 | 0.6 |
| 7 | PHED, Songsak | 90.61053333 | 25.652 | Fine loamy | Post monsoon 2015-16 | 7.2 |
| 8 | PHED, Water treatment plant, Nokilawe | 90.59575 | 25.5117 | Fine loamy | Post monsoon 2015-16 | 0.7 |
| 9 | SanandaMegapgre L.P. School 1 | 90.5242 | 25.58175 | Fine loamy | Post monsoon 2015-16 | 1.8 |
| 10 | SanandaMegapgre L.P. School 2 | 90.5242529 | 25.5816563 | Fine loamy | Post monsoon 2015-16 | 1.8 |
| 11 | Daroggre | 90.75858 | 25.61235 | Fine loamy | Post monsoon 2019-20 | 7.2 |
| 12 | Jamge, Fishery Department campus | 90.69315 | 25.62761 | Fine loamy | Post monsoon 2019-20 | 48 |

A perusal of the above table would indicate that the soils have wide range of Infiltration rate from 0.6 cm/hr to 48 cm/hr depending on whether the top soil is compact because of hard pans or carbonate deposits.From the study, it is observed that infiltration rate is affected by different soil conditions. It provides increased understanding of the local soil infiltration and its variability. It was found that the result obtained from the test was varied from soil to soil and soil condition. It is concluded that the infiltration rate is high for ploughed soil when compared to the compacted soil and unploughed soil.

## 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. Due to peculiar geographical set up, the land available for cultivation is limited. The agricultural activity is mainly confined to limited valley areas and hill slopes. In spite of best efforts by most of the inhabitants, being tribal, practice ‘Jhum’ or shifting cultivation. This type of cultivation causes extensive damage to ecological balance, causing soil erosion and loss to soil fertility. Permanent or settled cultivation is limited to valley areas in and around Songsak, Darugiri, Samanda and Rongreggiri, etc.Paddy is the main food crops. Maize, wheat, millets, mustard, potato Betel Nuts & Betel Vine, Kharif& Rabi Vegetables, Spices, Mandarin Oranges, Plum, Peach, Papaya, Pineapple, Tamarin, and Bananaetcare the other food crops grown in the study area. The district is endowed with diversified climatic condition thereby offering good scope for cultivation of temperate and subtropical crops. Crop statistics of main crops under East Garo Hills districtis shown in table 1.4.

Table 1.4: Crop statistics of main crops under East Garo Hills district (2017-18)

| **CROPS** | | **Area ( ha)** |
|---|---|---|
| **Agricultural crops** | | |
| **1. Rice** | | |
| | Autumn rice | 5960 |
| | Winter rice | 3166 |
| | Spring rice | 33 |
| 2. Maize | | 801 |
| 3. Soyabean (Green) | | 99 |
| 4. Cotton | | 1795 |
| 5. Wheat | | 15 |
| 6. Small Millets | | |
| | a) Finger Millet | 218 |
| | b) Foxtail Millet | 164 |
| | c) Pearl Millet | 51 |
| | Total small Millets | 433 |
| 7. Gram Pulses | | 321 |
| 8. Other Rabi Pulses | | |
| | a) Pea | 218 |
| | b) Cow Pea | 138 |
| | c) Lentil | 18 |
| | Total Rabi Pulses | 374 |
| 9. Sesamum | | 262 |
| 10. Rapeseed & Mustard | | 334 |
| **Horticulture crops** | | |
| **1. Rice Sweet Potato** | | **228** |
| 2. Ginger | | 3230 |
| 3. Tapioca | | 1278 |
| 4. Banana | | 895 |
| 5. Papaya | | 129 |
| 6. Pineapple | | 912 |
| 7. Winter Potato | | 76 |
| 8. Chillies (Green) | | 327 |
| 9. Turmeric (Green) | | 76 |
| 10. Arecanut (Green) | | 1490 |
| 11. Citrus Fruits | | |
| | a) Khasi Mandarin | 431 |
| | b) Assam lemon | 73 |

| | | |
|---|---|---|
| | c) Pomelo | 21 |
| 12. Cashewnut (Green) | | 230 |
| 13. Tea leaf (Green) | | 104 |
| 14. Black-Pepper | | 52 |
| 15. Beetroot | | 130 |
| 16. Cabbage | | 139 |
| 17. Cauliflower | | 84 |
| 18. Radish | | 101 |
| 19. Tomato | | 100 |
| 20. Carrot | | 60 |
| 21. Cucumber | | 38 |
| 22. Capsicum | | 34 |
| 23. Beans | | 15 |
| 24. Brinjal | | 196 |
| 25. Ladies finger | | 22 |
| 26. Bottle Gourd | | 17 |
| 27. Knol-Knol | | 12 |
| 28. Pumpkin | | 205 |
| 29. Onion | | 21 |
| 30. Bitter Gourd | | 25 |
| 31. Ridge Gourd | | 27 |
| **Total** | | |

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

## 1.12 Irrigation:

There is no major or medium irrigation scheme in the district, agriculture is mainly rainfed. However,a few minor irrigation schemes based on surface water sources like Flow Irrigation Projects (FIP) and Lift Irrigation Project (LIP) exist. Flow Irrigation Projects (FIP) are gravity flow type which involves water diversion from rivers/streams and irrigating the field by the aid of gravitational flow. It is used widely where water is spread across land using basin, border and furrow method. Lift Irrigation Project (LIP) involves pumping/lifting water from the river using electric pump and irrigating the fields. Irrigation through ground water is not yet practiced. Not a single irrigation well could be traced in the district area during the course of present study. Irrigation statistics in East Garo Hills district are given in Table1.5.

Table 1.5 Irrigation statistics in East Garo Hills for the year 2017-18

| District | Net irrigated area | | | Gross irrigated area | | |
|---|---|---|---|---|---|---|
| | Govt. | Private | Total | Govt. | Private | Total |
| East Garo Hills | 3388 | 3945 | 7333 | 3573 | 4168 | 7741 |

*Source:Directorate of Economics and Statistics, Govt. of Meghalaya.*

## 1.13 Industries

There are no major industries in the district.

### 1.14 Forest

The district is very rich in natural resources. The forest types of the district comprise of Sub-Tropical Pine Forest, Tropical semi-evergreen, Tropical Moist dry deciduous, Tropical dry and Bamboo mixed. As per Directorate of Economics and Statistics, the forest cover area is about 69120 ha (2017-18).

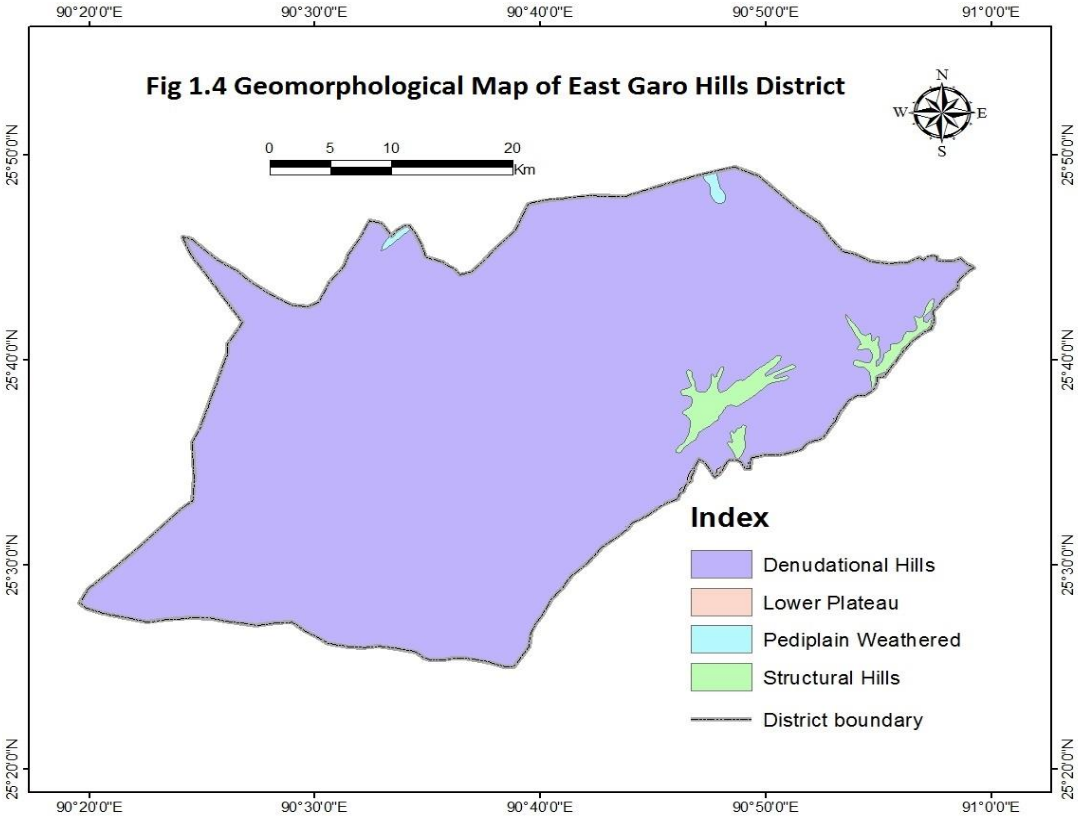
### 1.15 Geomorphology

Geomorphologically the district is an undulatory terrain. Broadly, the district can be differentiated into the following geomorphic units:

Intermontane Valleys/Lower plateau: These are narrow valleys surrounded by hills.

Denudational Hills**:** Denudational Hills of Archaean Gneissic Complex comprising of granite gneisses intruded by basic and acid intrusives. These are highly weathered at places and form valleys.

Structural Hills:This unit is comparatively higher than low denudational hills. These are highly deformed massive rocks comprising mostly of granitic gneisses of Archaean age. The valleys are deep formed by the severe dissection of the plateau. The Geomorphological map is shown in Fig 1.4.



## 1.16 Drainage

The drainage system of the study area is mainly controlled by physiographic features and geological structures, e.g., faults and joints, etc., The drainage pattern varies from dendritic type to rectangular to trellis pattern in lower orders, which indicates both topographic and structural control. The area is mainly drained by Simsang River, which flows towards southwest. Williamnagar located in East Garo Hills of Meghalaya is supplied with gravity and pumping schemes of Simsanggre Water Supply Scheme by pumping raw water from Simsang River.The area shows an immature topography with high drainage density. The geomorphological pattern indicates limited lithological and structural control. The drainage map is shown in Fig 1.5.

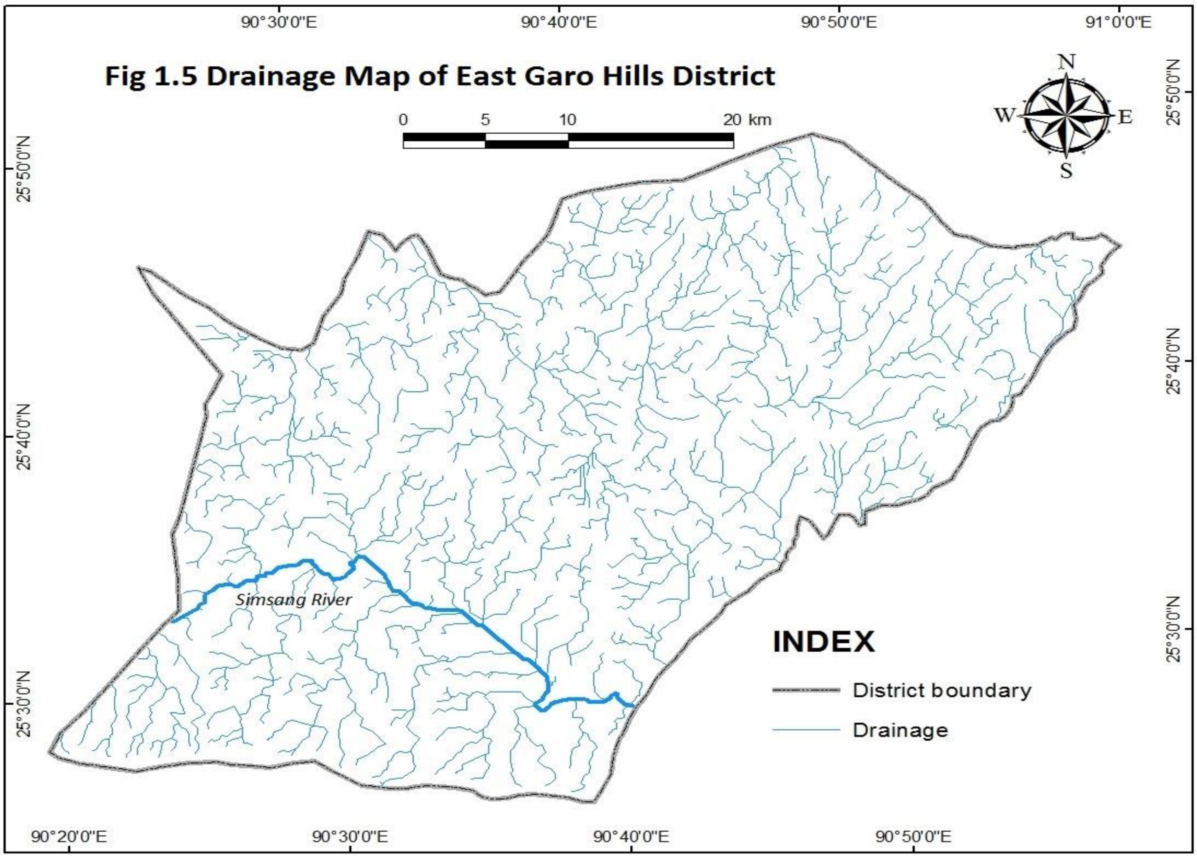



Fig 1.5 Drainage Map of East Garo Hills District

## 2 DATA COLLECTION AND GENERATION

One of the main objectives of the study was to collect various relevant technical data from previous works/data of CGWB, concerned State Government agencies and other Institutes dealing with ground water and incorporating these 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 data

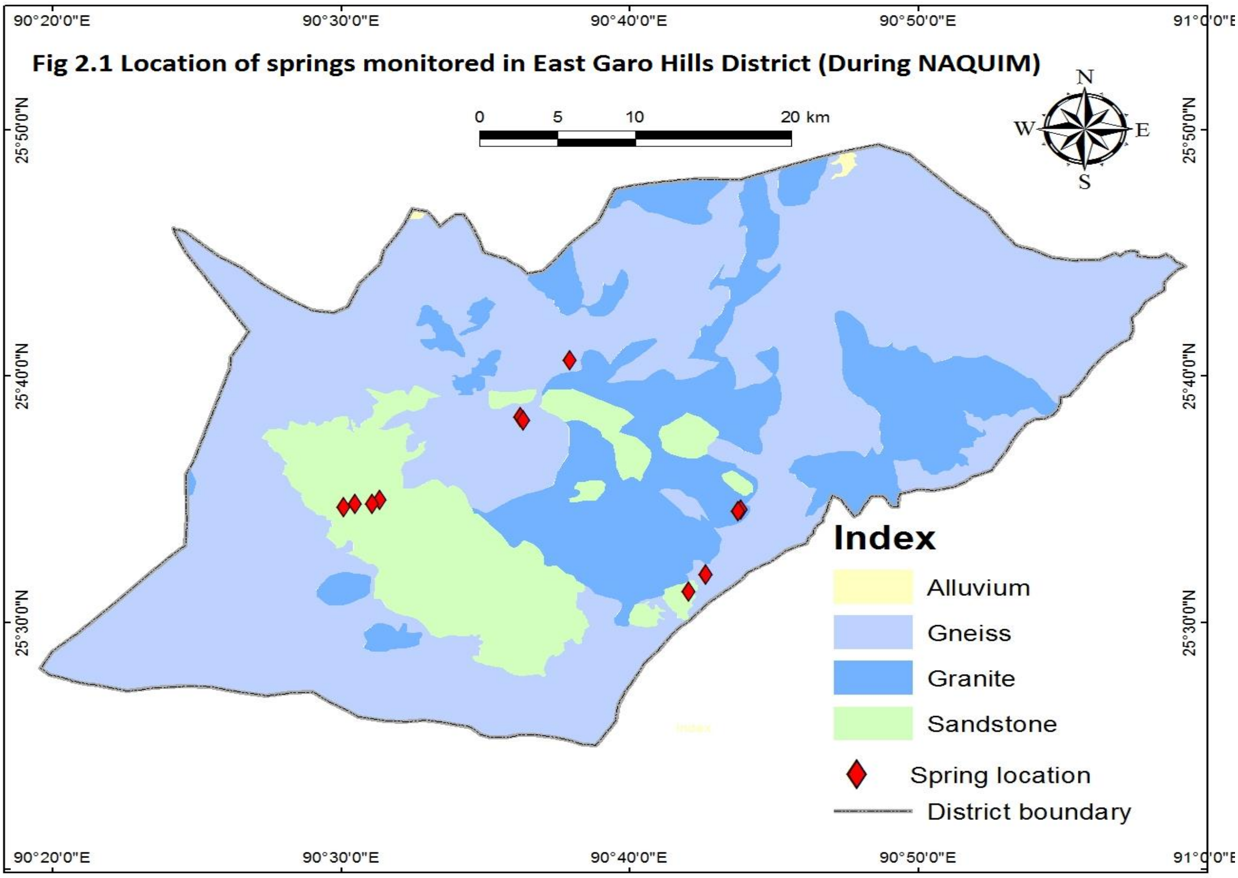
Occurrence of ground water in the study area is mainly of weathered and fractured Gneiss, Granite, Sandstone and alluvium formation. The different hydrogeological data are generated through intensive field data collection.

**2.1.1 Water level monitoring:**In the study area, 18 dug well and 2 springs were established as key wells to study the water level, quality, spring discharge and its behaviour periodically.

**Phreatic aquifer:** A total of 18 dug well was established as key wells for periodical monitoring to know the water level trend and its behaviour. The key observation well details are presented in Annexure 1 & 2 and the Depth to Water Level of dug wellduring Pre-Monsson and Post-Monsoon is shown in Fig 3.2and 3.3.

**Confined/Semi-confined aquifer:**For study of piezometric head in the district, static water level of earlier 8 numbers of bore wells drilled under Ground Water Exploration programme of CGWB are taken into account. The exploratory wells location is shown in fig 2.1.

**Springs:** A total of 13 springs (2 nos. during 2019-20 and 11 nos. during 2012-13) were established and monitored to know the type, discharge and their behaviour. A comparison between discharge of a few springs studied during 2012 and 2019 does not show any significant change. Map showing the location of all the springs is given in fig 2.1. Details of spring monitored during NAQUIM (2012 and 2019) is given in Annexure 2 and 2A.




## 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) were collected during the course of field work. Ground water samples were analysed in the regional chemical laboratory, Central Ground Water Board, North Eastern Region, Guwahati for 17 parameters. The analytical data are given in Annexure 3.

## 2.3 Geophysical studies

Surface Geophysical studies in the study area were carried out during previous AAP to delineate the subsurface geology as well as supplement the data gap under the assignment of Aquifer Mapping. During the course of these studies 07 Schlumberger VES were conducted with maximum available electrode spread (AB) of 200m respectively as part of electrical prospecting. Q, H, A type multi-layered VES curve were obtained and the manual interpretation of VES curve taking into account the apparent resistivity also provided the following results tabulated below. 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 few places. The plots of representative VES curve are given in Annexure 9

The results of interpretation of VES conducted at the proposed site provided the following inferences:

- The top soil with resistivity in the range of 3000 and 6000 Ohm being approximately 5m thick comprises massive / compact nature.
- The composite layer below the top soil/ massive formation in the depth range of 5m and 80m occasionally with resistivity of the order of 140 and 660 Ohm m is indicative of semi-consolidated or slightly less compact formation while the comparatively less resistivity in range within 100 Ohm m is indicative of probably the saturated formation comprising loose/ weathered with sands and clay perhaps being the saturated layer at almost all the places.
- The inferences aredrawn on the basis of interpreted results of surface resistivity surveys, apparent resistivity pertaining to extreme portion of VES curves and considering the available hydrogeological data.

### 2.4 Ground Water Exploration Studies

Ground water exploration has been carried out in different parts of the districtduring previous AAPto delineate the potential aquifers and their geometry and to determine the hydrogeological parameters of the aquifer systems.Deeper horizons were explored down to the depth of 202 m bgl depth during the course of study where 08 EWs within a depth range of 75.35 to 202.3 m. Exploration data reveals the presence of semi-confined to confined, moderate to deep aquifer system comprising of fractured hard rocks, namely, Granitic gneiss, sandstone. Two to three sets of fractures were encountered between 33.0 – 200.0 m bgl depth. The first two fracture zones are in general occurring between 33.0 – 100.0 mbgl depth and the third promising fracture zone was encountered below 100.0 m bgl depth. These fracture zones are found to have yielded discharge varying between 0.8 to 18 litres per second during drilling. The depth to water level in this deeper aquifer system ranges between 5.07 to 15.2 m bgl. The exploratory wells which were constructed under NAQUIM during previous AAP are shown in fig 2.2.

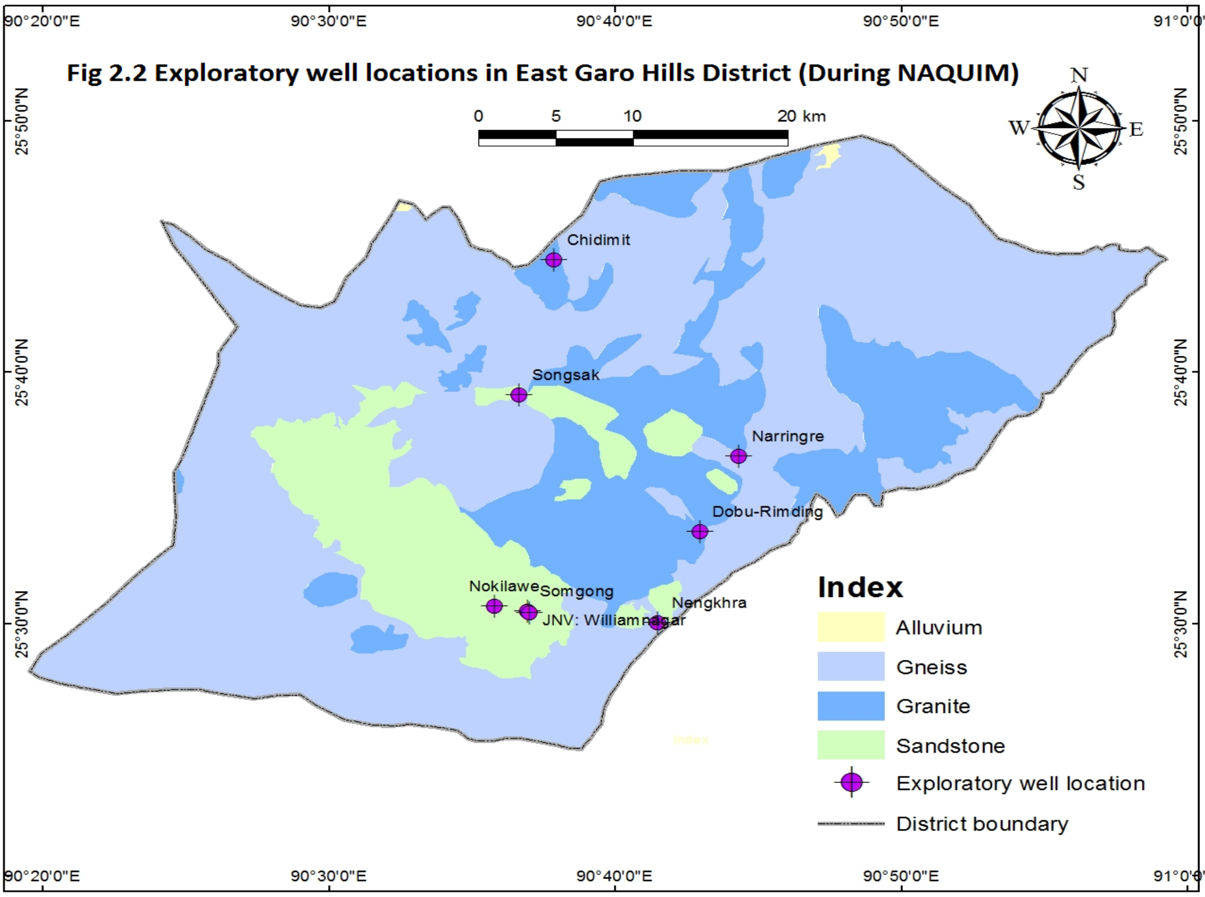


Fig 2.2 Exploratory well locations in East Garo Hills District (During NAQUIM)

| Exploratory findings | |
|---|---|
| Depth of drilling | 75.35 to 202.30 mbgl |
| Fracture encountered | 26 to 196 m |
| Drawdown | 4.19 to 33.42 m |
| Transmissitivity | 2 to 115 $m^2$/day |
| Depth of casing | 10.60 to 56.00 m |
| Drilling discharge | 0.8 to 18lps |
| Sp. Capacity | 1.79 to 70.03 lpm/metre |

Semi-consolidated formations in the study area are gently dipping sedimentary sequences comprising of sandstone, shale and alternate bands of sandstone and shale/clay. This unit covers a very small area and is found exposed in and around Williamnagar. Weathered shale and sandstone form the shallow aquifer in the area. Ground water occurs under water-table conditions. Depth to water level as observed from the wells is found to range between 1.2 – 2.82m bgl. During lean periods, these wells yield about 1.51 – 2.53 $m^3$/ day. Their yield can be increased by increasing their diameter and depth and thereby tapping maximum saturated thickness and to create more storage. Exploratory wells drilled at Nokilawe, Samgong and JNV, Williamnagar have encountered these semi-consolidated formations. At Nokilawe exploratory well, consolidated formations were encountered at 44 m depth. At JNV, Williamnagar exploratory well site, fractured sandstone was encountered at 59 – 62 m depth, which yielded a modest discharge of 36 $m^3$/hr. In the study area, semi-consolidated formations (in and around Williamnagar) are having good potential and can be developed with construction of suitable abstraction structures depending upon field conditions. Unconsolidated formations are also seen in the study area. These are alluvial sediments comprising of sand, silt, clay with gravel and pebbles occuring in the planes bordering foothills in valley fill areas and in inter-montane valleys. At Nokilawe exploratory well site, at a depth of 25 m depth, water bearing coarse sand bed was encountered, but it could not be tapped due to drilling problems and the sandy aquifer was cased to facilitate drilling further down to the targeted depth of the study. This aquifer comprising of shallow unconsolidated formations can be developed for construction of shallow tube wells in the study area. The detail of exploratory wells is given below in table 2.3:

Table 2.3: Detail of exploratory wells, East Garo Hills District

| Village/ Location | Drilled Depth | Main Yielding Zones in m bgl | Depth to water level (mbgl) | Drilling Discharge (lit/sec) | Draw down (m) | T ($m^2$/day) | Specific Capacity (lpm/m of dd) |
|---|---|---|---|---|---|---|---|
| Songsak | 196.2 | 48.0 – 56.0 (4)<br>190.0 – 196.0 (6) | 11.38 | 6 | 11.02 | 10 | 16.34 |
| Chidmit | 170.85 | 93.0 – 102.0 (0.5)<br>161.0 – 170.0 (12) | 8.11 | 12.0 | 10.88 | 115 | 19.31 |
| Narringre | 113.8 | 33.0 – 35.0 (3)<br>65.0 – 71.0 (11)<br>111.0 – 113.8(15) | 4.53 | 15.0 | 4.19 | 45 | 70.03 |
| Dobu-Rimding | 202.3 | 62.0 – 65.0 (0.5)<br>93.0 – 95.0 (1) | 15.20 | 1.0 | 33.42 | 2 | 1.79 |
| Nengkhra | 141.3 | 22.0 – 23.0 (2)<br>129.0 – 141.0 (16) | 5.07 | 16.0 | 22.8 | 5 | 5.89 |
| Nokilawe | 119.9 | 25.0 – 26.0 (4)<br>129.0 – 141.0 (18) | 3.18 | 18.0 | 13.15 | 25 | 10.68 |
| Somgong | 75.35 | 61.0 – 68.0 (1) | 18.00 | 0.8 | - | - | - |
| JNV: Williamnagar | 104.7 | 56.0 – 59.0 (10) | 9.10 | 10 | 7.51 | 55 | 24.84 |

# 3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

## 3.1 General hydrogeology and occurrence of ground water

The occurrence and behaviour of ground water is controlled by climate, topography, geology, structures of the rocks etc. Ground water occurs in permeable formation known as aquifers. Movement of ground water in Tertiary formation is controlled by intergranular porosity, fractures and joints. Basic dykes and sills traversing the Archaean formation also play significant role in the sub-surface movement of groundwater. The hydrogeological formation of the district comprised of Archaean Gneissic Complex of Archaean to Proterozoic age. The presence of weak planes like fractures and joints in these hard rock formation forms the principal aquifer in the area. Jaintia group of rocks of Paleocene to Eocene age comprise mainly of sandstone and shale. The yield of wells drilled in these formations is good. Alluvium of Quaternary age comprising of sand, gravel and clay is very limited in extent and is found in very narrow area adjoining to North Garo Hills and Assam boundary of the district. The yield of wells drilled in this alluvium is very good as indicated by some of the high yield wells drilled in other districts in Meghalaya and Assam.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 study area forms a part of the pre-Cambrian Indian peninsular shield, uplifted to the present height due to effect of large scale block faulting and represents a Horst. The gneissic complex is pierced by intrusives, which occur in the area in the form of dykes. Springs have been found to develop along the major lineament directions of NE – SW and N – S.The principal aquifer of the district along with the lineament is shown in fig 3.1.

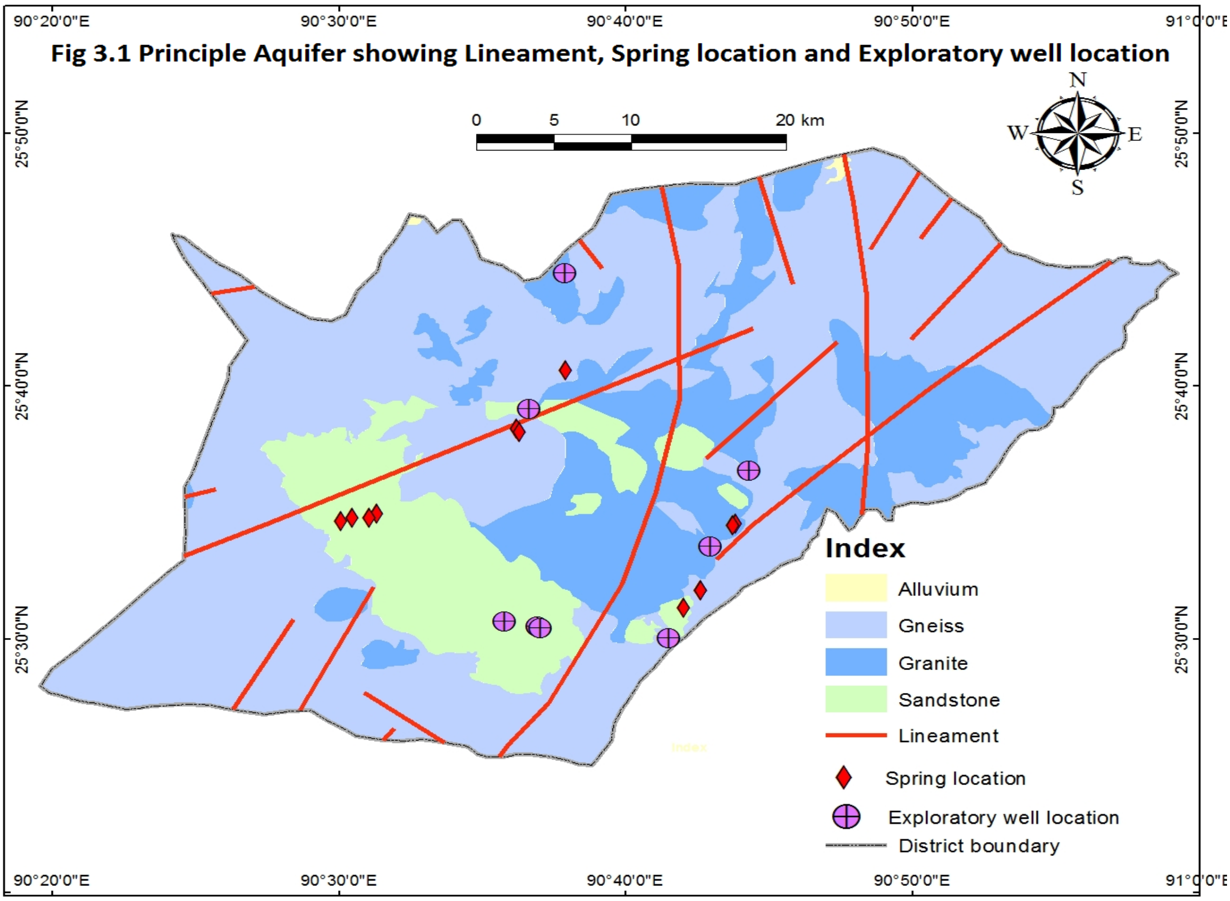



**Fig 3.1 Principle Aquifer showing Lineament, Spring location and Exploratory well location**

**3.1.1 Occurrence of ground water in shallow aquifers:** The shallow aquifer in the district occurs within ground level to 30 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 extends up to 30 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 occurs in the fractured zone of consolidated sandstone, granite and Archaean gneissic rock. The drilled depth of exploratory wells tapping this aquifer ranges from 75 to 202 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 springs is mainly restricted to foothills and intermontane valleys. Most of the villagers are highly dependent on the springs for their drinking and domestic purposes. A total of 2 springs were established during 2019-20 and 11 springs were established during previous AAP (NAQUIM)for periodical monitoring during the course of NAQUIM study. It is observed that the springs are fractured springs and contact springs. Discharge of springs in general varies from 6 to 9.36 litre/minute during pre-monsoon and from 18.46 to more than 34.29litre/minute during post-monsoon season and is shown in fig 3.2 and 3.3 respectively. It is observed that the discharge of springs increases during post-monsoon. Most of the springs showed drastic increase in discharge during post-monsoon season suggesting the direct influence of rainfall on the discharge of springs. During the fieldwork, it was reported by some villagers that they are dependent on springs but some spring go dry or discharge became very less during lean periods.

### 3.2 Depth to Water Level

Study of water level and its behaviour both in phreatic and confined condition were carried out in the aquifer mapping area. In addition to the 16 key wells established during previous NAQUIM study in the district (2012), a total of 18 Dug wells were established in 2019-20as key well to fill the gap and to monitor the water level periodically, to know the water level trend and its behaviour in phreatic condition. The lowest depth to water level in these dug well was 1.20 m bgl and highest was 5.70 m bgl during pre-monsoon and during post monsoon lowest water level was 1.25 mbgl and highest water level was 5.60 mbgland the average water level fluctuation is 0.05 m. Comparison of water level in these dug wells indicated that there is no significant change in the water level. The depth to water level and discharge of spring is shown in fig 3.2 and fig. 3.3 respectively.

Fig 3.2 Depth to water level (Unconfined aquifer) and Spring discharge- Pre monsoon

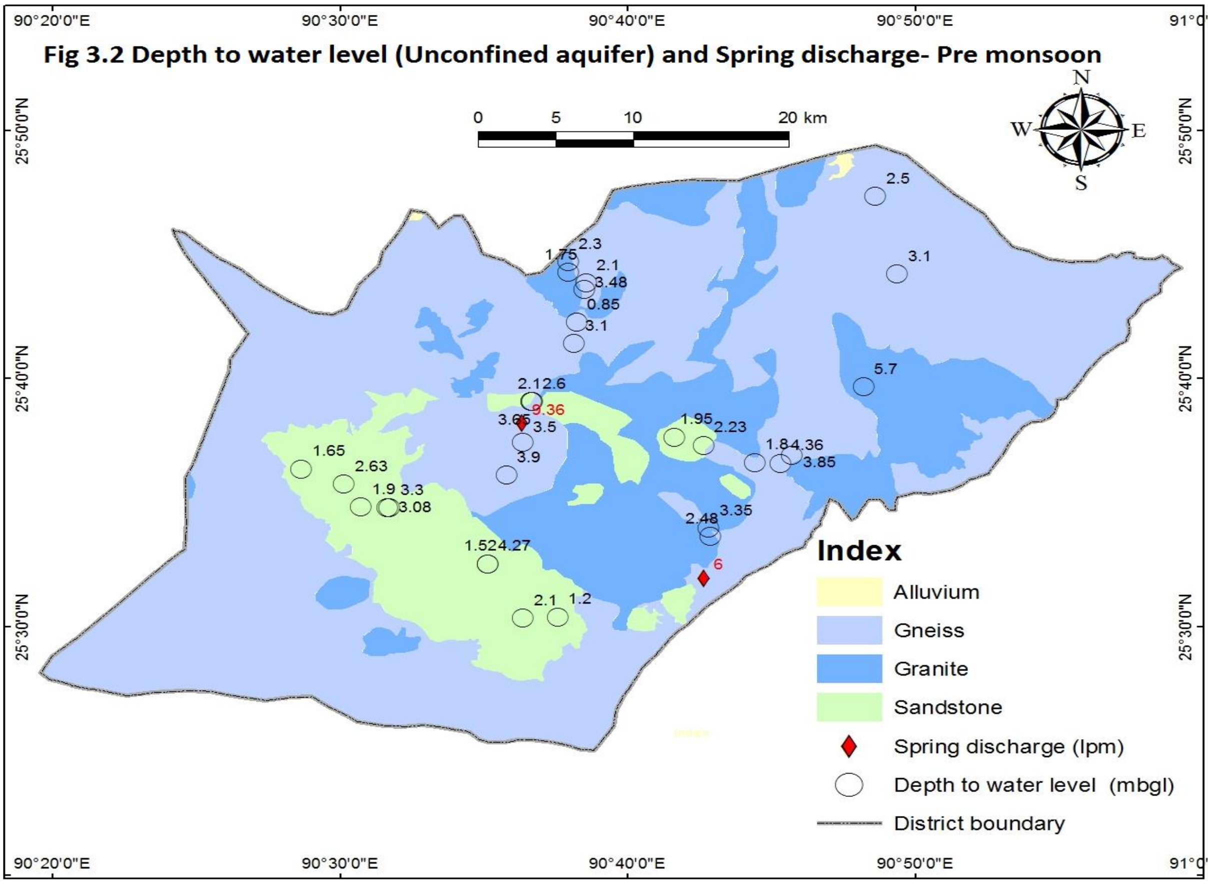
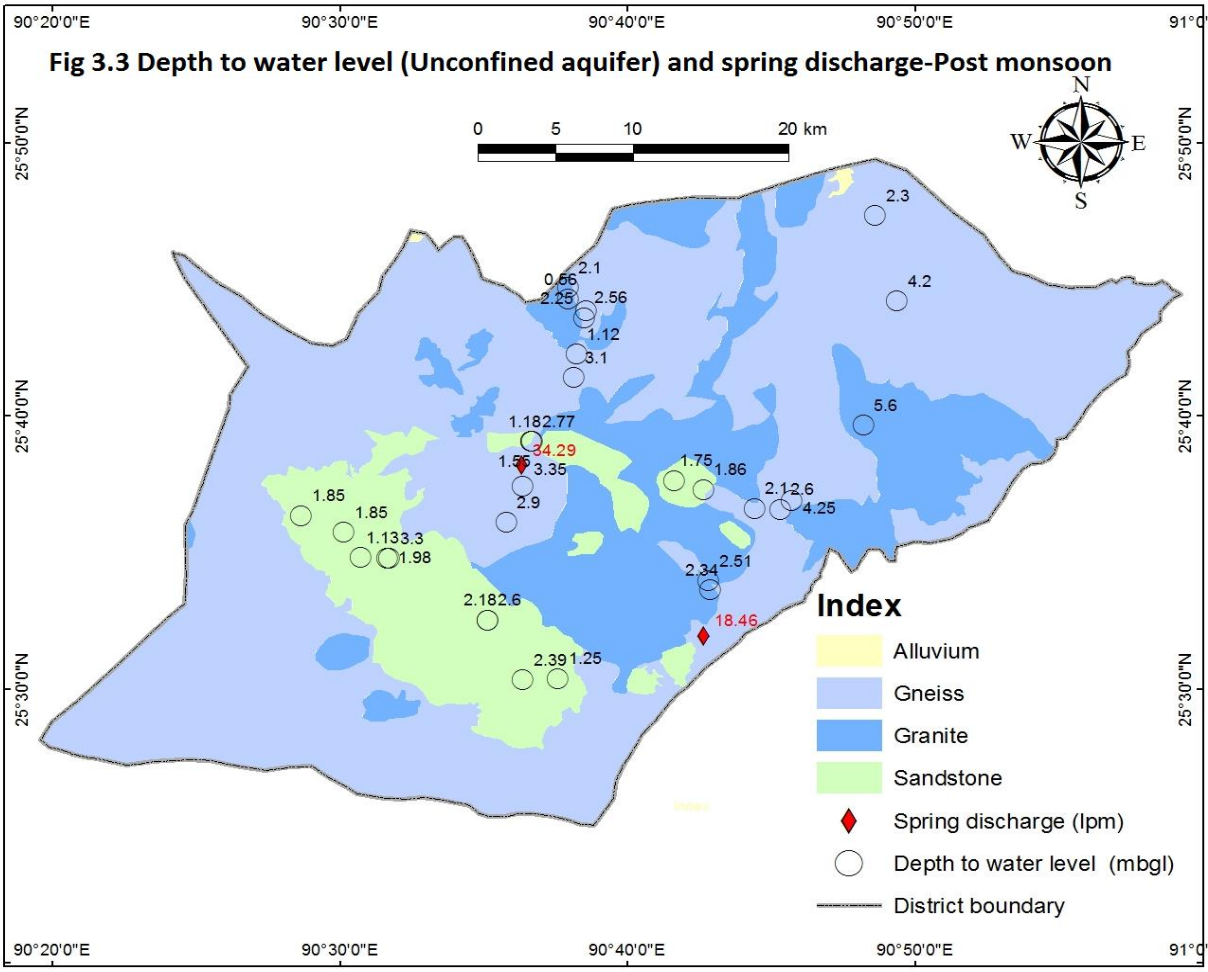



Fig 3.3 Depth to water level (Unconfined aquifer) and spring discharge-Post monsoon



To study the piezometric head, water level of exploratory wells drilled in the district were measured and it was found that the peizometric head varies from 3.18 to 18 mbgl. Regular monitoring of these wells could not be done during NAQUIM studies because either the wells were abondoned, or not functional or fitted with pump.

Further, long term water level data of 10 years were collected in GWM stations to know the water level trend and its behaviour over the years. Based on depth to water level data collected from this ground water monitoring station, the hydrograph of Williamnagar GWMS and Songsak GWMS showing pre monsoon and post monsoon water level trend shows that the fall of water level trend during pre-monsoon period is compensated by rise in water level trend during post monsoon. Hence it can be deciphered that no significant rise or fall in the water level trend and is shown in fig. 3.4 and 3.5.

**Fig: 3.4 Hydrograph of Williamnagar GWMS**

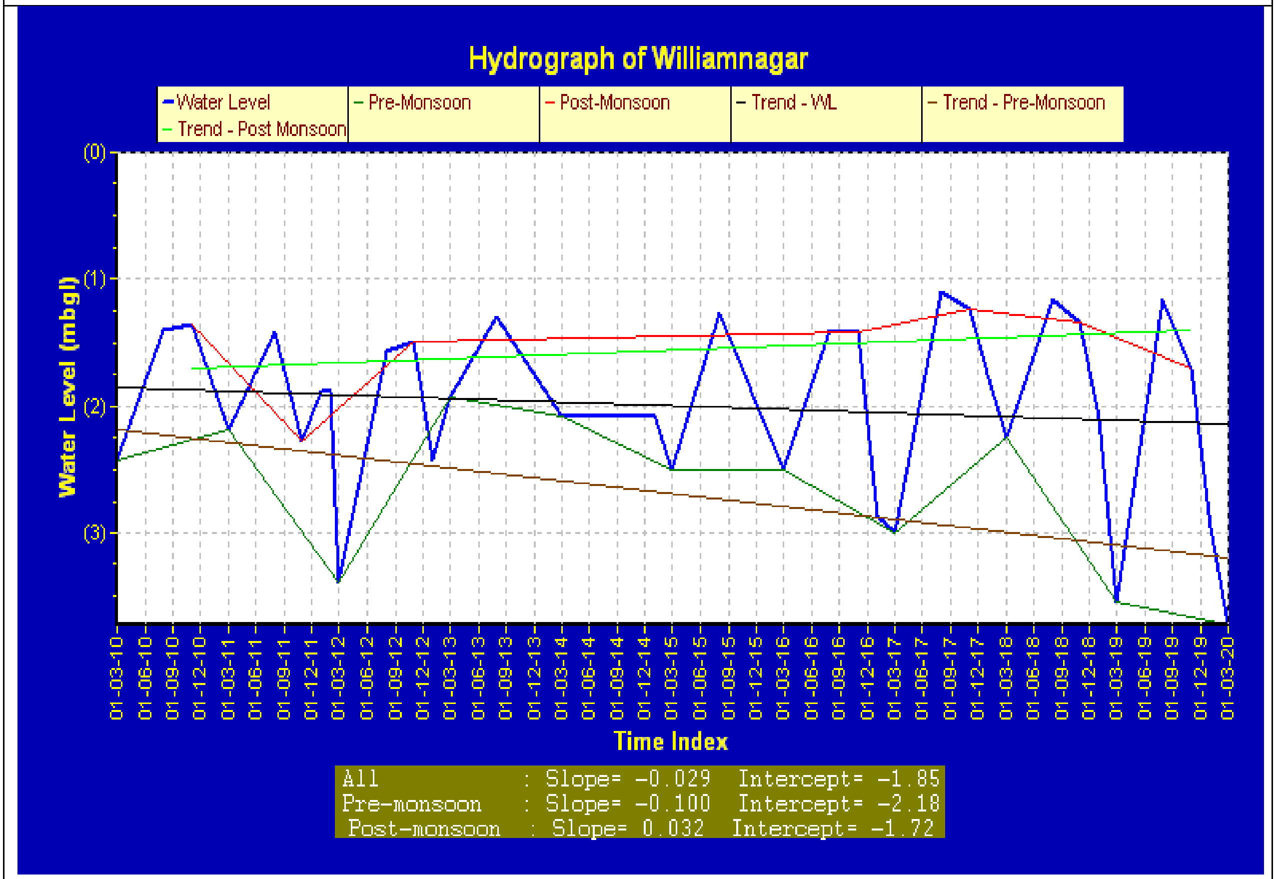
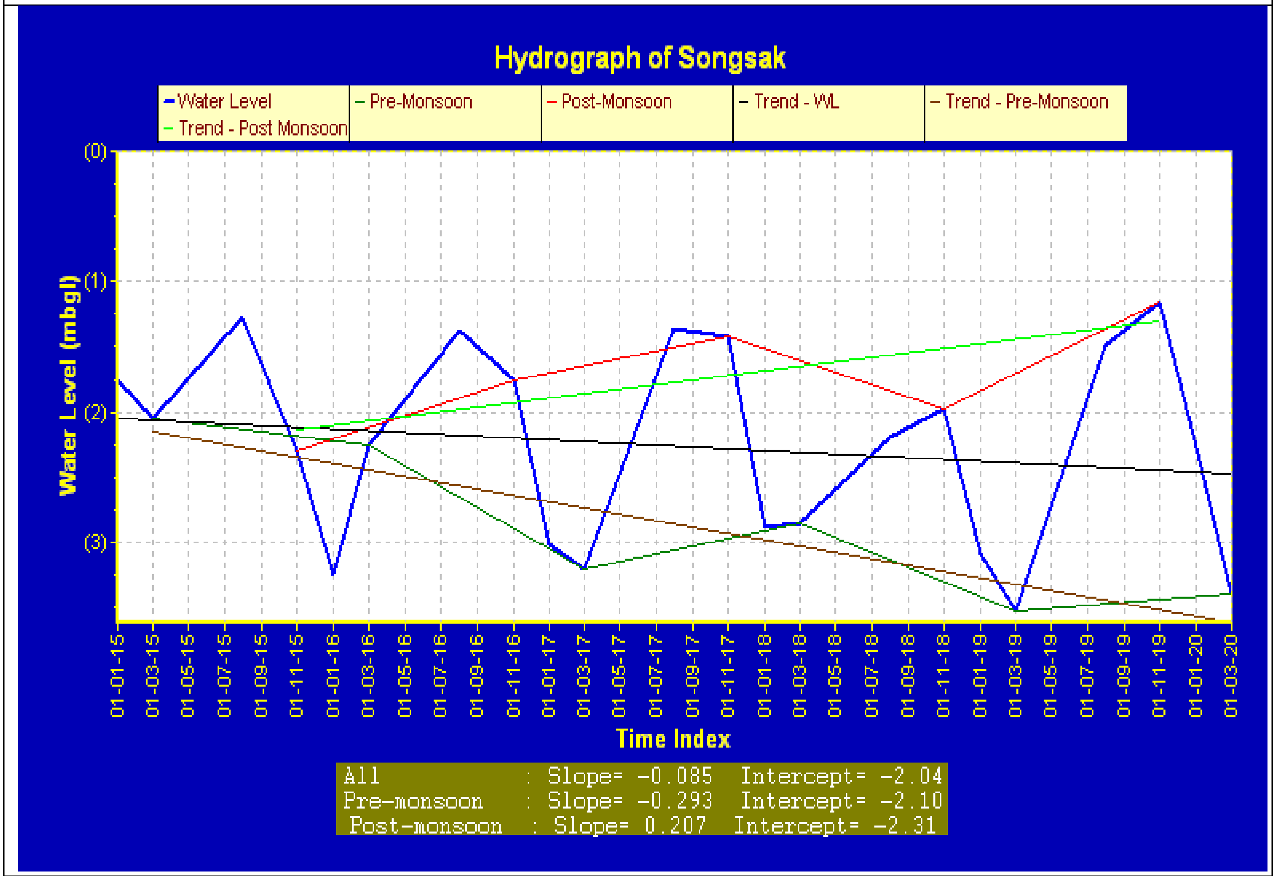


**Fig: 3.5 Hydrograph of Songsak GWMS**




## 3.3 Aquifer System

Study of exploration data and dug wells reveals the presence of shallow and deep aquifers in the district. Almost the entire district is underlain by consolidated rocks like granite gneiss, with basic and ultra-basic rocks of Archaean age, with a small patch of semi-consolidated formations occurring in the southern parts of the study area. Unconsolidated Alluvium occurs as small isolated patches of limited areal extent in the area bordering North Garo Hills. The aquifer system exists in both weathered formation as well as fractured system down to depth of 202 m as deciphered from the exploration data of CGWB. The thickness of weathered zone varies from place to place and it varies from 3 to 30 m. Thus, hydrogeologically, the study area can be categorized into three units, i.e., consolidated formations, semi-consolidated formations and unconsolidated formations. The principle aquifer map is presented in Fig 3.1.

The consolidated formations occupy almost 95% of the district occurring as low to high irregular hill ranges with highly deformed massive rocks, these formations form the basement for the deposition of the semi-consolidated and unconsolidated formations in topographic depressions. These gneissic rocks have undergone tectonic disturbances e.g., faulting and fracturing. The weak planes such as fractures and joints have served as conduits for movement and storage of ground water. These planes obtain their recharge from precipitation through the overlying weathered zone. The thickness of weathered / overburden is found to be ranging between 3 to 30 meters as deciphered from the exploration data, but it is less in hilly areas. Depth of dug wells inventoried in the study area are found to be 4 - 7m depth and depth to water level in the range of less than 0.7 to and 5m bgl during pre-monsoon periods.

Fig 3.6 Cross section of boreholes in East Garo Hills

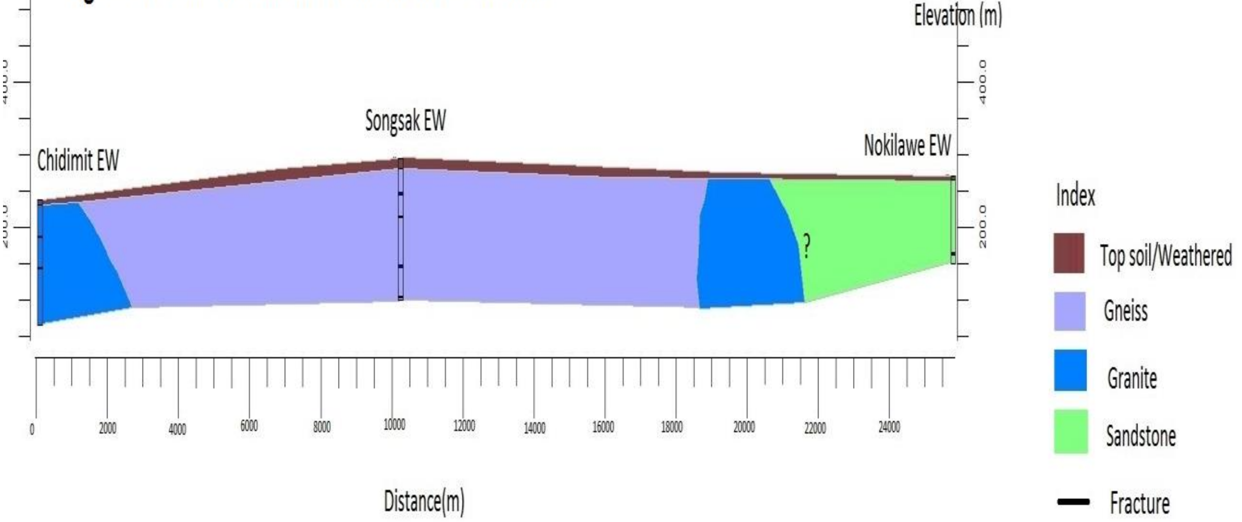
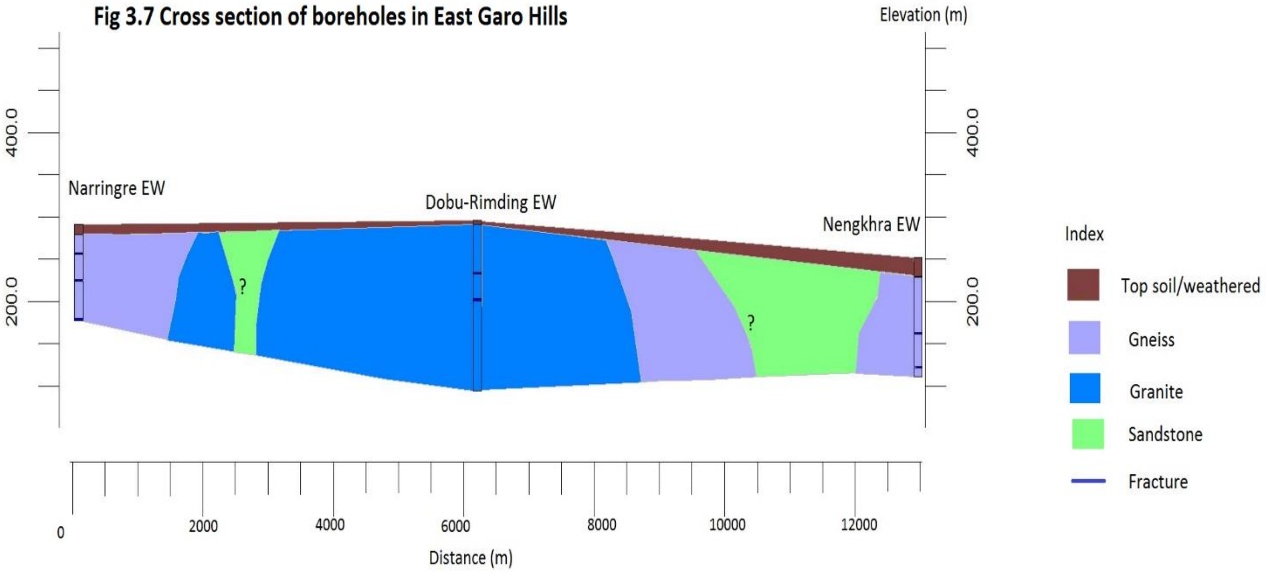


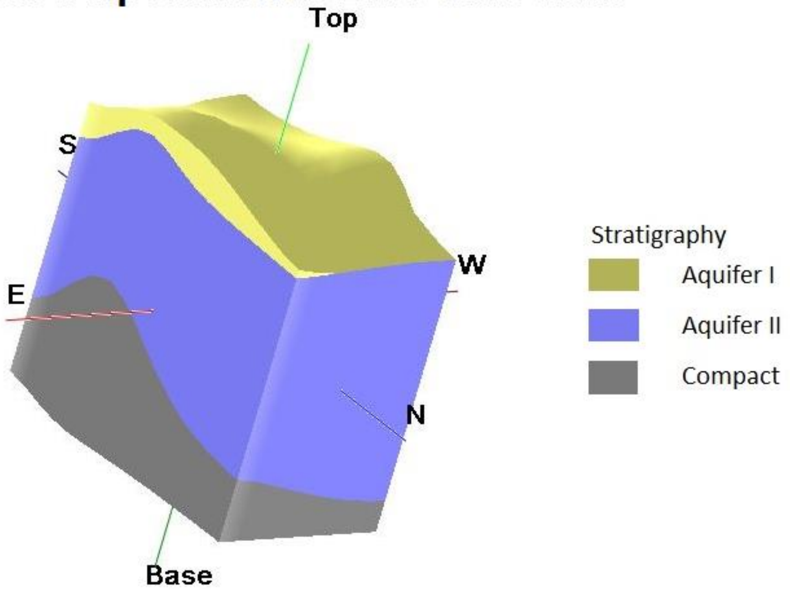

Fig 3.7 Cross section of boreholes in East Garo Hills




### 3.4 Aquifer Geometry

The aquifer system in this district can be divided as a two aquifer system viz., 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. The second aquifer is the deeper aquifer which tapped the fractured zones. 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 occurs within 2 to 30 m bgl. Ground water in the second aquifer occurs under semi-confined to confined condition in the fractures up to the maximum depth of 202 m bgl. The 3D Disposition of Aquifer in East Garo Hills is shown in fig 3.8.

Fig 3.8 3-D Aquifer Disposition in East Garo Hills




### 3.5.1 Aquifer Properties

**Aquifer I:** It is the unconfined aquifer which occurs within 30 m depth.

**Aquifer II:** This is the deeper aquifer delineated in Gneiss and Granite where groundwater occurs under semi-confined condition. Drilled depth of the exploratory wells ranges from 75.35 to 202.03 m bgl. The number of fractures and depth of encountering fractures varies widely which show the complexity of the hydrogeology of consolidated hard rock formation. The piezometric head ranges from 3.18 to 18.00 m bgl. Through PYT tests, it is found that discharge from these wells ranges from 0.8 to 18litre/sec with drawdown varying from 4.19 to 33.42 m. The details of Aquifer properties are given in table 3.1

| Aquifer | Depth range of the aquifers (in m) | Thickness (in m) | Yield in lps | T (m2/day) |
|---|---|---|---|---|
| Aquifer - I | G.L. to 30 | 4 to 10 | 0.5 to 1 | - |
| Aquifer– II: Hard rock /Tertiary Sediments | 12 to 114<br>61 to 92 | 1 to 10<br>5 to 30 | 0.43 to 12<br>0.8 to 10 | 2 to 45<br>55 |

## 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 from springs and dug wells were collected during the course of fieldwork. The parameters analysed 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 are given in the Annexure 3 and Annexure 4.

**3.6.1 Ground water quality of unconfined aquifer:** A total of 18ground water samples from dug well were collected during pre-monsoon and post-monsoon studies and therange of concentrations of different chemical constituents present in the ground water samples are given in table 3.1.

**3.6.2 Water quality of springs:** A total of 2 water samples from springs were collected during AAP 2019-20 and therange of concentration of different chemical constituents present in the spring samples is shown in table 3.1.

**3.6.3. Ground water quality in deeper aquifer:** A total of 6 number of water samples were collected during exploratory drilling of CGWB in the district. Based on chemical analysis data the range of concentration of different chemical constituent present in the deeper aquifer are given in table 3.2.

Table 3.2: Chemical Quality of water samples from Dug wells, Springs and Borewell

| Sl. No. | Chemical constituents (Concentrations in mg/l except pH & EC) | Dug well | | Spring | | Deeper Aquifer (EW) | |
|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max |
| 1 | pH | 5.31 | 7.14 | 7.27 | 7.60 | 7.3 | 8.4 |
| 2 | E.C. in *micro seimens/cm at 25°C* | 28.32 | 302.60 | 53.16 | 81.58 | 84.4 | 402 |
| 3 | Turbidity(NTU) | BDL | 0.30 | BDL | BDL | BDL | BDL |
| 4 | TDS | 15.13 | 180.70 | 31.49 | 48.25 | 40 | 191 |
| 5 | TH | 30 | 140 | 70 | 80 | 31 | 144 |
| 6 | Ca | 4.0 | 34.03 | 6 | 14.01 | 6.8 | 38 |
| 7 | Mg | 4.84 | 20.62 | 10.92 | 13.35 | 1.94 | 13.1 |
| 8 | Na | 1.17 | 28.69 | 7.49 | 10.45 | 33.6 | 0.58 |
| 9 | K | 0.84 | 20.01 | 1.34 | 1.84 | 2.63 | 4.62 |
| 10 | $CO_3$ | BDL | BDL | BDL | BDL | BDL | 40 |
| 11 | $HCO_3$ | 20.02 | 100.08 | 45.04 | 55.04 | 40 | 176 |
| 12 | $SO_4$ | 4.25 | 30.00 | 4.76 | 22.16 | 1.93 | 12.43 |
| 13 | $NO_3$ | BDL | 10.25 | BDL | 9.88 | BDL | 0.7 |
| 14 | Fe | BDL | 0.52 | 0.09 | 0.39 | 0.12 | 2.75 |

It is deciphered from table 3.1 that all the chemical parameters are within permissible limit for all uses except a few dug wells which is found to be slightly acidic in nature, details of which is provided in Annexure-III. As deciphered from the water quality analysis of exploratory wells drilled by CGWB during NAQUIM, 4 bore wells have concentration of Iron (Fe) beyond the permissible limit of 1 mg/lit. The chemical quality of dug well, spring and bore well is given in Annexure 3 & 4 respectively. The pH values, EC values and Fe conc. of water samples collected from spring, dug wells and EW (deeper aquifer) are shown in fig 3.9, fig 3.10 and fig. 3.11 respectively.

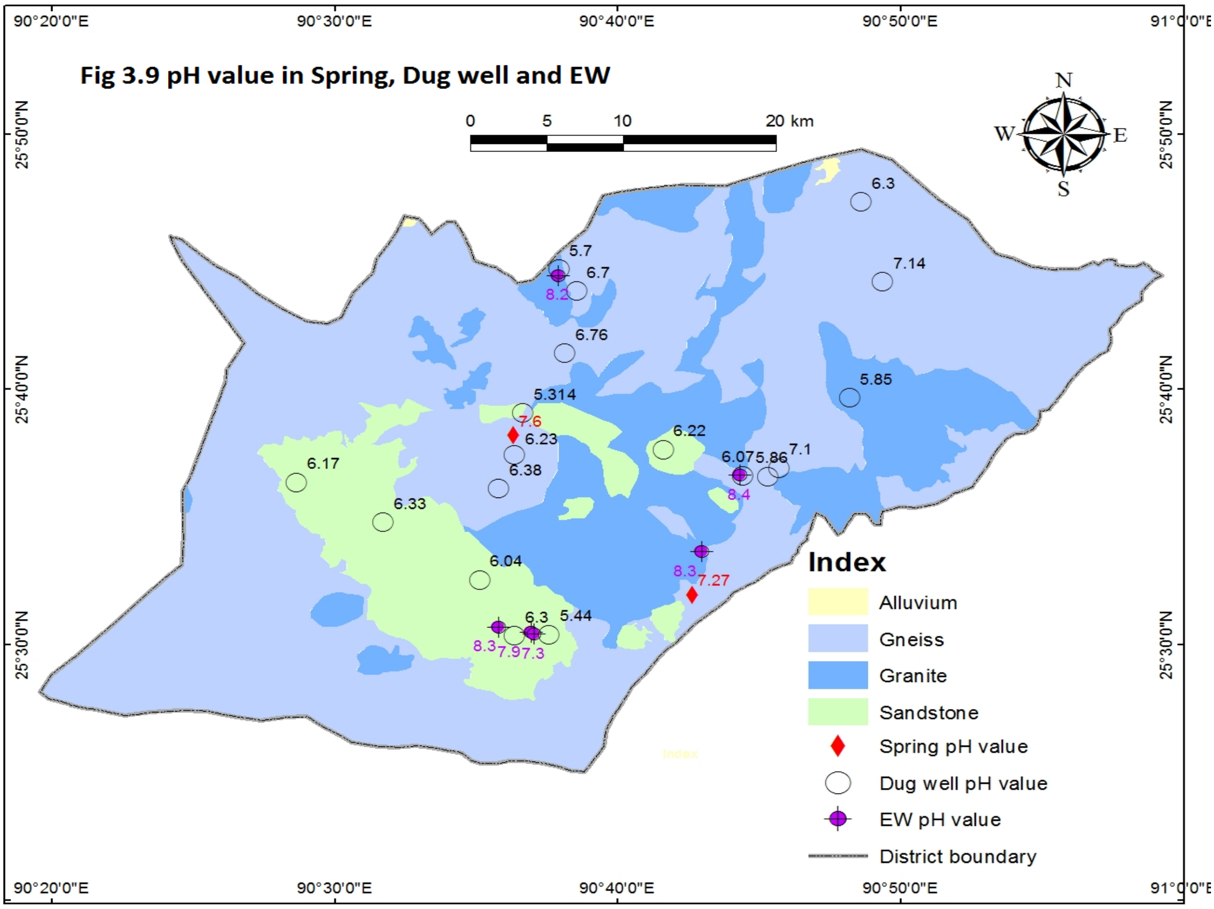


Fig 3.9 pH value in Spring, Dug well and EW

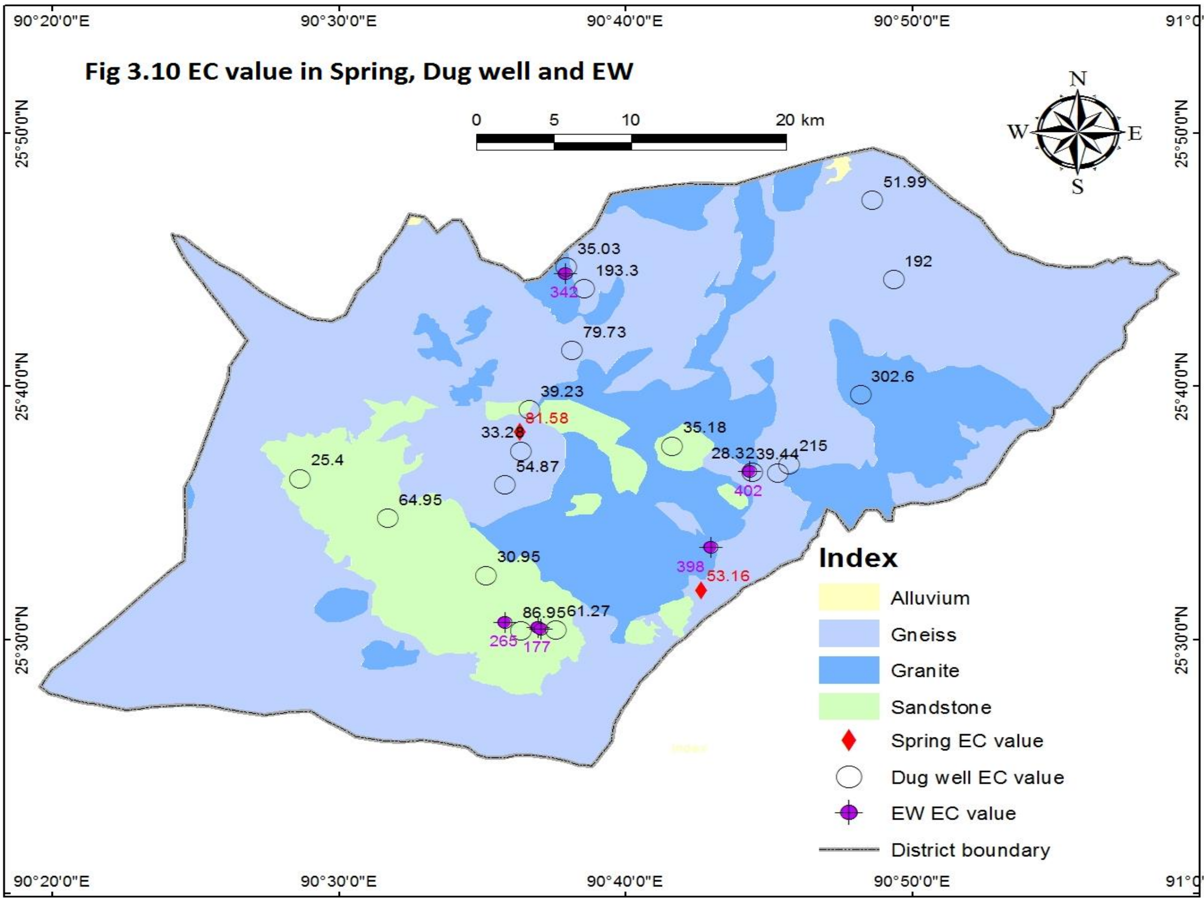



Fig 3.10 EC value in Spring, Dug well and EW

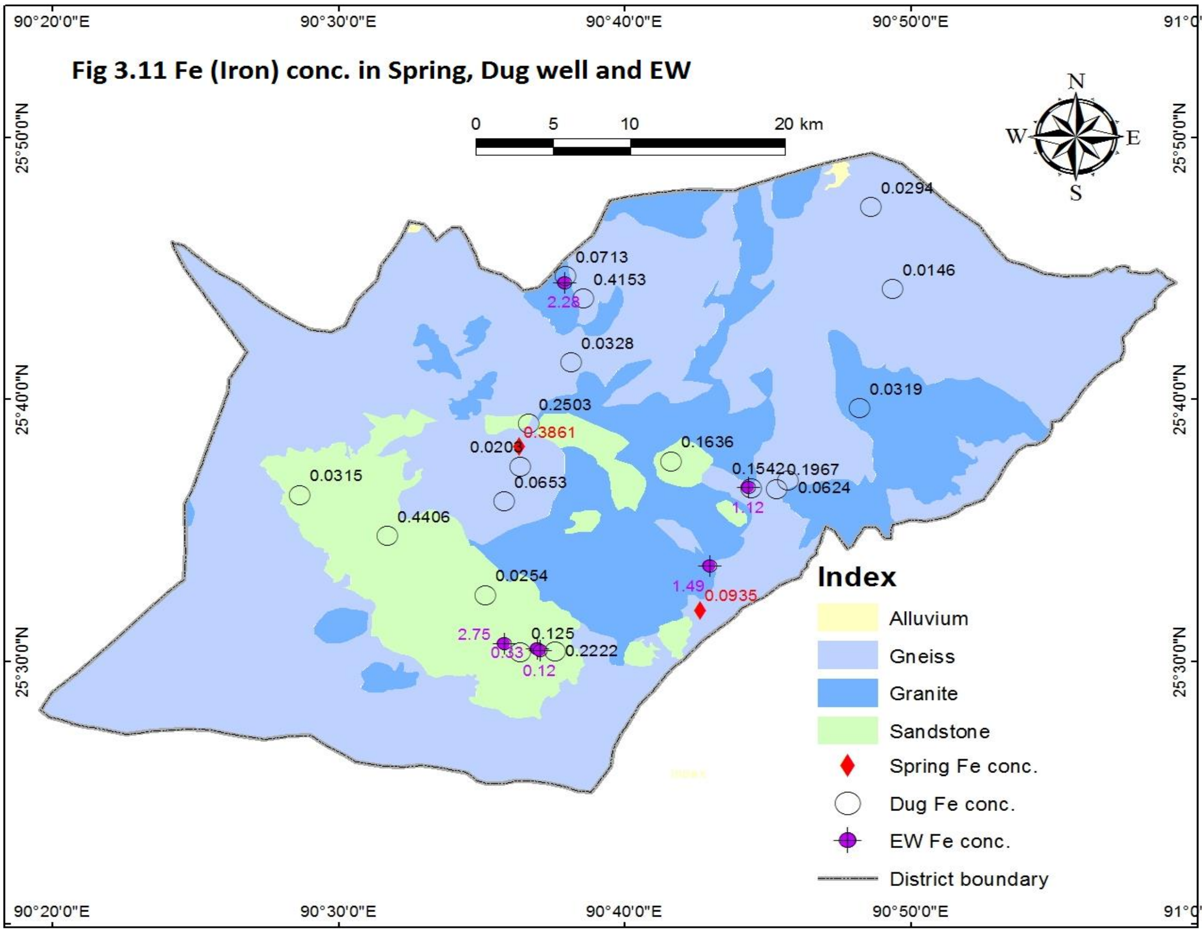



Fig 3.11 Fe (Iron) conc. in Spring, Dug well and EW

## 4. GROUNDWATER RESOURCES

Dynamic Groundwater Resources has been estimated for the district by employing GEC'2015 methodology, recommended by Groundwater Estimation Committee. The revised methodology GEC-2015 recommends aquifer wise ground water resource assessment. In GEC'2015, two approaches are recommended – water level fluctuation method and norms of rainfall infiltration method.The dynamic groundwater resources computed for the groundwater year 2017-18. 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. Total recharge worthy area in the district is 66117 sq. km.

**Poor Groundwater Quality Area:** In the district, there is no mappable area, be which can 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 district is underlain by consolidated rocks like Archaean Gneissic complex, semi consolidated rock such as sandstone and shale and unconsolidated rock of sand and clay.

Ground water Resource Potential for the district as on March 2017 is as follows.

Table: 4.1 Net ground water availability (ham)

| *Annual Replenishable GW resources* | | | | *Total annual ground water recharge* | *Provision for natural discharge* | *Net ground water availability* |
|---|---|---|---|---|---|---|
| *Monsoon season* | | *Non-monsoon season* | | | | |
| *Rainfall recharge* | *M* | *Recharge from rainfall* | *Recharge from other source* | | | |
| *2745.11* | *57.85* | *2014.64* | *15.53* | *4833.13* | *483.31* | *4349.81* |

Table 4.2: Categorization of Ground Water Resources (ham)

| *Net Ground water availability* | *Annual GW draft* | | | *Domestic and industrial uses upto 2025* | *Ground water availability for future development* | *Stage of ground water development (%)* | *Categorization* |
|---|---|---|---|---|---|---|---|
| | *Irrigation* | *Domestic and industrial uses* | *Total* | | | | |
| *4349.81* | *0* | *20.42* | *20.42* | *40.84* | *4308.97* | *0.47* | *SAFE* |

### 4.1 Groundwater Resources – Recharge for Various Seasons

The rainfall infiltration factor recommended by GEC'15 for Granite & Gneiss is 0.05 and Sandstone & Limestone is 0.06.

**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 5.

**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 4.3.

**Table 4.3: Recharge from various sources (ham).**

| *District* | *Recharge from Rainfall during monsoon season* | *Recharge from other sources during monsoon season* | *Recharge from rainfall during non-monsoon season* | *Recharge from other sources during non-monsoon season* | *Total Annual Ground Water Recharge* | *Provision for Natural Discharges* | *Annual Extractable Ground Water* |
|---|---|---|---|---|---|---|---|
| *East Garo Hills* | *2745.11* | *57.85* | *2014.64* | *15.53* | *4833.13* | *483.31* | *4349.81* |

Recharge from rainfall in the district is 4759.75 hams. Comparison of monsoon & non-monsoon rainfall recharge shows that monsoon recharge accounts for 60%. Recharge from other sources is 73.38ham.Comparison of recharge from rainfall, to recharge from sources other than rainfall shows that the later accounts for only about 1.5% of the total recharge.

### 4.2 Groundwater Extraction for Various Purposes

**Domestic Extraction:** Due to paucity of data, groundwater extraction for domestic use has been estimated on projected population for 2017, based 2011 Census data of number of households using groundwater as "Main source of drinking water". Groundwater extraction for irrigation is nil whereas for domestic and industrial supply it is 20.42 ham in the district. Hence, groundwater extraction for all uses in the district is 20.42 ham. Provision for domestic and industrial requirement supply to 2025 is 40.84 ham.Net Ground Water Availability for future development in the district is 4308.97 ham.

### 4.3 Stage of Groundwater Development &Categorization of the Blocks

The stage of Ground Water development is defined as the ratio between the existing gross ground water drafts for all uses by net annual ground water availability multiplied by 100. The various units of assessment are categorized based on the stages of Ground Water development and long term trend of pre and post monsoon water level. The stage of ground water development for East Garo Hills district as on March 2017 is 0.47%. Based on the stages and development and long-term water level trend analysis the district can be categorized under **safe** category. Summary of groundwater resources, stages of development and categorization are given in Annexure 5.

## 5. GROUND WATER RELATED ISSUES

Approach to most parts of the area was main constraint due to prevailing atmosphere and heavy rains during June to September. Also 47.90 % of the district is occupied by forest cover. The area is sparsely populated and have negligible irrigation facility available.

As deciphered from water quality analysis of bore wells drilled by CGWB during NAQUIM, higher concentration of iron is reported in groundwater. During lean period, people suffer from water shortage. There are some major ground water related issues found in the district.

### 5.1 Low Stage of Ground Water Extraction

As per ground water resource estimation 2017-18, the stage of ground water development is just 0.47 % and there is no utilization of ground water for irrigation in the area. 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 practiced 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 is found that all the chemical parameters are within permissible limit, except a few dug wells were found to be slightly acidic. As per Ground Water Exploration, higher concentration of iron is reported in groundwater where the depth of the well ranges from 113 to 202 m bgl.

## 6. MANAGEMENT STRATEGIES

The objective of management is to utilize the available ground water resources to fulfill human needs and also to boost economy of an area without hampering the interest of future generation. That objective can be achieved by finding out demand of various sectors and adjusting the demand with available resource.

Groundwater management involves the optimum utilization of sub-surface water based on geological, hydrological, economic, ecological and legal consideration for the welfare and benefit of the society. The management of the ground water resources has to be taken up after understanding the varied hydrogeological characteristics. In addition, the development of ground water requires thorough understanding of the heterogeneity of the formation. Therefore, there is a need for scientific approach for proper management of the ground water resource for the sustainability of the resource for the present and future generation. There is also an inherent need to educate the general public as a whole for management of this precious resource and to accept the benefits of many development scheme of government for utilisation of ground water resources.

As the area is characterized by undulatory terrain, the scope for development of ground water lies in low lying depression, and valley fills which hold good prospects for ground water development. Ground water development is being done through dug well and tube well/ bore well in the intermontane valley. The development of spring is seen mainly along the foothills. Therefore, there is ample scope for future development of ground water. The peneplained surfaces, buried pediments and valley fills are the most favourable localities for development of ground water. The fractures and lineament too hold prospect for the development of ground water. Moreover, the narrow and linear valleys offer ample scope of development of ground water. Structures like dug wells, shallow as well as deep tube wells are the feasible ground water structures. The fractured, fissured rocks and intersection of faults /lineaments hold good prospects for ground water. The weathered mantle holds good prospect for dugwell within the depth range of 4 to 10m depending on topographical setting. Large diameter dug wells can sustain moderately higher yield. Dug wells need to be properly lined with cement rings to avoid collapse of weathered zone. As very good quantity of dynamic ground water resources is available, dug wells are the preferred structures as of now in low-lying areas and valleys. The shallow water level condition gives scope to maintain sufficient water column in the dug wells. In future, if there are water crises, bore well within the depth of 100 m can be constructed.

As per dynamic ground water resource of East Garo Hills District for 2017, net ground water availability is 4349.81 ham and stage of development is 0.47%. The district is having balance net ground water availability for future development in the tune of 4308.97 ham. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 2586 ham of groundwater resources is available in the district for future irrigation uses. The source of water for all these schemes is mainly from surface water. Hence, there is ample scope for ground water development for irrigation purpose which will help the district in achieving self-reliance on food grain.

In East Garo Hills District (144300 ha), net sown area is 22496 ha, area sown more than once is 2675 ha and cropping intensity is about 125%. 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. Moreover, crops grown on the hills like pineapple, turmeric and ginger are having negligible or nil irrigation requirements.

During kharif season, paddy is cultivated in 3166 ha. After kharif crops are grown the area remains fallow during rabi season. The intention is to bring this fallow land of 3166 ha under assured irrigation during rabi season which will help to increase gross cropped area to 6332 ha and thereby increase cropping intensity up to 200%. In rice fallow, mustard, pulses, millet, potato and small vegetables can be grown with the support of irrigation.

To use groundwater for irrigation purpose a cropping plan has been designed for the district by using CROPWAT model developed by FAO. Crop-wise and month-wise irrigation water requirement (Precipitation deficit) has been taken from CROPWAT after giving necessary meteorological, soil, crop plan inputs. Present cropping pattern, proposed cropping pattern, intended increase in cropping intensity are shown in table 6.1 and 6.2. Proposed cropping pattern with water deficit months, IWR and peak water requirement for Irrigation is shown in table 6.3.Crop-wise and month-wise precipitation deficit and Irrigation water requirement in ham has been further calculated in table 6.4 and table 6.5 respectively.

**Table 6.1** CROPPING PATTERN DATA
(File: C:\ProgramData\CROPWAT\data\sessions\East Garo.PAT)

```
Cropping pattern name: East Garo Hills

                                                         Planting   Harvest    Area
No.  Crop file              Crop name                     date       date       %

 1   ...Data\CROPWAT\data   Rice                          04/06      01/10      15
 2   ...Data\CROPWAT\data   Rice                          11/06      08/10      15
 3   ...Data\CROPWAT\data   Rice                          18/06      15/10      10
 4   ...Data\CROPWAT\data   Rice                          25/06      22/10      10
 5   rape___mustard.CRO     Mustard                       15/10      26/02      10
 6   ...a\CROPWAT\data\cr   Pulses                        25/10      11/02      10
 7   ...a\CROPWAT\data\cr   MILLET                        05/01      19/04      10
 8   ...\CROPWAT\data\cro   Potato                        05/02      14/06      10
 9   ...CROPWAT\data\crop   Small Vegetables              10/02      15/05      10
```

Table 6.2: Cropping pattern, proposed cropping pattern, intended cropping intensity

| | | | | |
|---|---|---|---|---|
| Cropping pattern (s) | | | | |
| Rice based cropping pattern | | | | |
| Rice-Mustard | Present Cultivated area | Area to be cultivated | Area to be cultivated (ha) | Irrigation requirement (ha m) |
| Rice-Vegetables | (ha) | (%) | | |
| Rice-Pulses | | | | |
| Rice-Millet | | | | |
| | 1 | 2 (= % of 1) | 3 | 4 |
| Rice (main crop) | 3166 | | 3166 | 253.41 |
| Mustard | 0 | 20 | 633 | 55.53 |
| Pulses | 0 | 20 | 633 | 51.10 |
| Millet | 0 | 20 | 633 | 26.59 |
| Potato | 0 | 20 | 633 | 11.43 |
| Small vegetables | 0 | 20 | 634 | 13.23 |
| Net cultivated area (Paddy) | 3166 | 100 | 3166 | |
| Gross cultivated area (Paddy + Pulses +Millet+ Veg) | 3166 | | 6332 | |
| Cropping intensity | 100% (Present) | | 200% (Intended) | |

Table 6.3: Proposed cropping pattern with water deficit months, IWR and peak water requirement for Irrigation

| Crop | Growing period (Months) | Periods/months of water deficit | Irrigation requirement (ham) | Peak water requirement for Irrigation |
|---|---|---|---|---|
| Rice | 4 | 1 – 2 | 253.41 | June |
| Mustard | 5 | 4 | 55.53 | December |

| | | | | |
|---|---|---|---|---|
| Pulses | 4 | 4 | 51.10 | December |
| Millet | 4 | 3 | 26.59 | November |
| Potato | 4 | 4 | 11.43 | May |
| Small Vegetables | 3 | 3 | 13.23 | March |

During kharif season, rice is cultivated from June to mid-July. Since this huge area cannot be cultivated in a single day (one planting date), so it is considered/ planned to cultivate rice in four stages during this period. It is planned to utilize rice fallow of 3166 ha for the cultivation of mustard, pulses, millet, potato and small vegetables. It is considered to cultivate mustard in 633 ha, pulses in 633 ha, millet in 633 ha, potato in 633 ha and small vegetable in 634 ha, including present cultivation area for these crops. Area under vegetable cultivation is also considered/ planned to cultivate in two stages during this period.

Table 6.4: Crop-wise and month-wise precipitation deficit (mm) using CROPWAT 8 for East Garo Hills District

| Crops | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precipitation deficit (mm) | | | | | | | | | | | | |
| 1. Rice | 0 | 0 | 0 | 0 | 147.4 | 61 | 0 | 0 | 0 | 3 | 0 | 0 |
| 2. Rice | 0 | 0 | 0 | 0 | 49.4 | 96.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3. Rice | 0 | 0 | 0 | 0 | 61.3 | 52.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4. Rice | 0 | 0 | 0 | 0 | 0 | 145.4 | 0 | 0 | 0 | 5.5 | 0 | 0 |
| 5. Potato | 48.6 | 35.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 42 | 49.5 |
| 6. Mustard | 60.3 | 14.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 27.3 | 59.6 |
| 7.Small Vegetables | 16.9 | 55.4 | 11.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8.Small Vegetables | 0 | 26.4 | 6.5 | 3.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 6.5: Irrigation Water Requirement (in ham), East Garo Hills District

| Crop | Area (%) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total IWR (ham) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Rice | 15 | 0 | 0 | 0 | 0 | 70.00 | 28.97 | 0 | 0 | 0 | 1.43 | 0 | 0 | 100.39 |
| 2. Rice | 15 | 0 | 0 | 0 | 0 | 23.46 | 45.88 | 0 | 0 | 0 | 0 | 0 | 0 | 69.34 |
| 3. Rice | 10 | 0 | 0 | 0 | 0 | 19.41 | 16.49 | 0 | 0 | 0 | 0 | 0 | 0 | 35.90 |
| 4. Rice | 10 | 0 | 0 | 0 | 0 | 0 | 46.03 | 0 | 0 | 0 | 1.74 | 0 | 0 | 47.78 |
| 5. Mustard | 10 | 15.38 | 11.18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13.29 | 15.67 | 55.53 |
| 6. Pulses | 10 | 19.09 | 4.49 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8.64 | 18.87 | 51.09 |
| 7. Millet | 10 | 5.35 | 17.54 | 3.71 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 26.59 |
| 8. Potato | 10 | 0 | 8.36 | 2.06 | 1.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11.43 |
| 9.Small Vegetables | 10 | 0 | 9.97 | 3.26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13.23 |
| Total | 100 | 39.83 | 51.54 | 9.02 | 1.01 | 112.87 | 137.37 | 0 | 0 | 0 | 3.166 | 21.94 | 34.54 | 411.29 |

Under ground water exploration programme, CGWB has constructed 8 bore wells in this district and has established that the aquifer is having discharge of 0.8 lps to 18 lps. In these valley/ areas borewells can be sustainably developed for irrigation purpose. Bore wells can be designed within a depth of 100 m, expected to encounter 1 to 2 fractures with good yield. Low-lying valley areas are feasible for sustainable ground water development through bore wells.

The ground water potentiality especially in the low-lying valley areas is low to moderate, 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. This type of dug wells can be used to irrigate 0.2 ha of land especially under Rabi vegetables.

A bore well in the area is expected to yield 9 $m^3$/hr. If such a bore well runs for 10 hrs/day for 120 days, then it will create a draft of 1.08 ham. Bore wells can be designed within a depth of 100m, expected to encounter 1 to 2 fractures. Bore wells can be constructed by using 8// dia. casing pipe down to 30 m.

In considered net sown area of 3166 ha, 792 nos. of shallow bore wells can be constructed (considering 200m distance between any two shallow bore well).

Annual irrigation water requirement is 412 ham while irrigation water requirement during dry season spanning from October to March is 160 ham. Again proportionate dynamic groundwater resources available for future irrigation use in the considered area are 2586 ham. Hence, this area can be brought under assured irrigation from groundwater sources. The demand of 160 ham can be harnessed by constructing 100 nos. of large diameter dug well and 145 nos. bore wells. At possible places water harvesting methods should be employed.

When managing a precious and scarce resource such as groundwater, it is essential that the resource is not subjected to pollution. The chemical quality of ground water indicates that groundwater in the area is good for domestic, irrigation and industrial use. However, iron content in deeper aquifer in some wells are found to be beyond the permissible limit, which warrant proper treatment before use. Removal of the iron is best effected by aeration process followed by sedimentation and filtration. Potassium permanganate or chlorine/chloride may be employed to oxidize the iron, which is then filtered from the waters. The process is applicable very much when bacteria is present in the water. Iron can also be removed by addition of a mixture of sodium carbonate and sodium phosphate to precipitate iron as insoluble, followed by settling and filtration. Acidity of water should be treated before consumption. This acidic water can be treated by acid neutralizing filters or chemical feed pump

# 7. MICRO LEVEL AQUIFER MANAGEMENT PLAN

## 7.1 Micro level aquifer management plan of Ampanggre village, Samanda C&RD Block

Ampanggre village has a total household of 123 and a population of 628. Agriculture is the mainstay of livelihood of the people in the village. The village is accessible through NH-62 from Dudhnoi, Goalpara district, Assam which is 84 km from Williamnagar via Nengkra-Rongjeng and 285 km from Shillong, the State Capital and via Jengjal (Tura-Williamnagar road). It is also approachable via Nongstoin with a distance of 246 km from Shillong.

The major water related issue is management and utilization of Groundwater. The dug wells are abandoned because majority of the villagers use surface water for domestic use as well as drinking purpose.

**Management Plan**

The villagers depend on surface water for domestic use as well as drinking purpose, however, it is advised to rejuvenate the available dug wells in the village and use ground water for proper management and utilisation. The study area is located on a hilland difficultfor drilling rig to be deployed, hence it is suggested that if the demand of water increases in future, then a number of shallow large diameter dug wells can be constructed in the area. The water from these dug wells can meet the water requirement of the villagers. Awareness need to be created among the villagers for proper maintanence and usage of ground water. It is advised not to throw waste in the well, which can pollute the aquifer and ultimately result in health hazard. In addition to this, rainwater harvesting structure is advised to be constructed.

## 7.2 Micro level aquifer management plan of Songmagre village,Samanda C&RD Block

Songmagre village has a total household of 124 and a population of 545. Agriculture is the mainstay of livelihood of the people in the village. The village is accessible through NH-62 from Dudhnoi, Goalpara district, Assam which is 84 km from Williamnagar via Nengkra-Rongjeng and 285 km from Shillong, the State Capital. It is also approachable via Nongstoin with a distance of 246 km from Shillong.

Major water related issue is management and utilization of Groundwater-the dug wells are abandoned because majority of the villagers use surface water for domestic use.

**Management Plan**

The check dam constructed under MGNREGA 2019-20 is the main source of water supply to the villagers. However, it is advised to rejuvenate the available dug wells present in the village and use ground water for proper management and utilisation. As observed, the dug wells are at a very shallow depth, because of the inability to increase the depth of the well due to presence of hard rock below, and also the study area is located on a hilland difficultfor drilling rig to be deployed, hence it is suggested that if the demand of water increases in future, then a number of shallow large diameter dug wells can be constructed in the area. The water from these dug wells can meet the water requirement of the villagers. Awareness need to be created among the villagers for proper maintenance and usage of ground water. It is advised not to throw waste in the well, which can pollute the aquifer and ultimately result in health hazard. In addition to this, rainwater harvesting structure is advised to be constructed.

### 7.3 Micro level aquifer management plan of GabilAding village,Rongjeng C&RD Block

Gabil Ading village has a total household of 90 and a population of 813. Agriculture is the mainstay of livelihood of the people in the village. The village is accessible through NH-62 from Dudhnoi, Goalpara district, Assam which is 84 km from Williamnagar via Nengkra-Rongjeng and 285 km from Shillong, the State Capital. It is also approachable via Nongstoin with a distance of 246 km from Shillong.

The major water related issue is scarcity of water and smelly and muddy water.

#### Management Plan

It is observed that majority of the villagers depend on dug wells for domestic use and drinking purpose. The study area is located on a hilland difficultfor drilling rig to be deployed, hence it is suggested that if the demand of water increases in future, then a number of shallow large diameter dug wells can be constructed in the area. The water from these dug wells can meet the water requirement of the villagers. Awareness need to be created among the villagers for proper maintenance and usage of ground water. Muddy water can be avoided by proper maintenance of the well, by keeping the area around the well clean, avoiding washing and bathing near the vicinity of the well. In addition to this, rainwater harvesting structure is advised to be constructed.

### 7.4 Micro level aquifer management plan of TebilBonegre (A) village,Songsak C&RD Block

TebilBonegre (A) village has a total household of 99and a population of about 600.Agriculture is the mainstay of livelihood of the people in the district. The village is accessible through NH-62 from Dudhnoi, Goalpara district, Assam which is 84 km from Williamnagar via Nengkra-Rongjeng and 285 km from Shillong, the State Capital. It is also approachable via Nongstoin with a distance of 246 km from Shillong. Average annual rainfall in the area is about 3293 mm. The area is drained by a few small streamlets and is a part of Simsang river basin.

The major water related issue is shortage of water during lean season.

**Management Plan**

The villagers depend on dug wells and water supply from government agency for their use. However, it is suggested that more rainwater harvesting technique can be adopted through construction of rainwater harvesting structure. Also the study area is located on a hill and difficult for drilling rig to be deployed, hence a number of shallow large diameter dug wellscan be constructed in the area. The water from these dug wells can meet the water requirement of the villagers.

It is advised to regularly monitor the dug well by keeping the area around the well clean, avoiding washing and bathing near the vicinity of the well, and regular monitoring and repairing of the parapet & platform of the dug well.

The village is located on a hill and small intermontane valleys are under wet rice cultivation during Kharif season. Here, potential for major irrigation scheme is low. Deploying heavy duty drilling rig is also difficult due to approachability problem. However, minor irrigation schemes like construction of large dug well is possible in the valleys which remain fallow during dry season. If irrigation systems are developed, then small vegetables and crops with lesser water demand, can be grown during dry season.

The area receives very good amount of rainfall, hence, rainwater harvesting structure like check dam and farm ponds is advised to be constructed.

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## Annexure 1: Dynamic water level data of dug well during 2019-20

| Sl. No . | Block* | Village | Lat* | Long* | Well* Type | MP* (m) | RL* (m) | Drilled depth* m) | Dia* (m) | Water Level (mbgl) March-20* | Water Level (mbgl) Nov-19* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Dambo-Rongjeng | Gamsura | 25°47'21.10" | 90°48'35.49" | Dug Well | 0.8 | 328 | 3.5 | 0.6 | 2.12 | 1.5 |
| 2 | Dambo-Rongjeng | Rongmil | 25°44'13.69" | 90°49'21.10" | Dug Well | 0.8 | 328 | 5.3 | 1.6 | 3.99 | 3.4 |
| 3 | Dambo-Rongjeng | Rongjeng | 25°39'40.77" | 90°48'10.39" | Dug Well | 0.7 | 344 | 8.6 | 0.9 | 5.83 | 4.9 |
| 4 | Dambo-Rongjeng | Darugre | 25°36'55.50" | 90°45'40.79" | Dug Well | 0.9 | 335 | 6.2 | 1 | 4.45 | 3.35 |
| 5 | Dambo-Rongjeng | Narringgre | 25°36'37.51" | 90°44'22.93" | Dug Well | 0.6 | 328 | 3.7 | 1 | 1.91 | 1.5 |
| 6 | Dambo-Rongjeng | DarugreNengphachi | 25°36'35.33" | 90°45'16.16" | Dug Well | 0.8 | 335 | 7.4 | 1.5 | 4.73 | 1.8 |
| 7 | Samanda | BaizaRongreng | 25°32'33.0" | 90°35'05.67" | Dug Well | 0.8 | 259 | 5.7 | 1 | 4 | 1.8 |
| 8 | Samanda | Williamnagar | 25°30'21.43" | 90°36'19.84" | Dug Well | 1 | 261 | 4.9 | 1 | 1.7 | 1.39 |
| 9 | Samanda | SamandaMegapgre | 25°34'48.0" | 90°31'41.24" | Dug Well | 0 | 289 | 5.7 | 1.1 | 6.16 | 3.3 |
| 10 | Samanda | Dobetkolgre | 25°30'23.71" | 90°37'32.38" | Dug Well | 0.7 | 242 | 4.3 | 1.2 | 0.68 | 0.55 |
| 11 | Songsak | Jamge | 25°37'39.45" | 90°41'35.28" | Dug Well | 0.7 | 349 | 3.3 | 0.95 | 0.83 | 1.05 |
| 12 | Songsak | Songsak | 25°39'4.93" | 90°36'37.97" | Dug Well | 0 | 271 | 2.6 | 1 | 3.38 | 1.55 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **13** | Songsak | Wagopgre | 25˚37'27.53" | 90˚ 36'19.24" | Dug Well | 0.8 | 564 | 4.1 | 0.7 | 2.73 | 2.55 |
| **14** | Songsak | SaminSongkama | 25°41’25.55” | 90°38’06.23” | Dug Well | 0.3 | 210 | 4.4 | 0.9 | 2.89 | 2.8 |
| **15** | Songsak | Koksinengsai | 25˚43'51.50" | 90˚ 38'31.23" | Dug Well | 0.7 | 223 | 3.2 | 0.8 | 1.74 | 1.55 |
| **16** | Songsak | Chidimit | 25°44’42.93” | 90°37’54.16” | Dug Well | 0.4 | 215 | 4.1 | 1.6 | 2.21 | 1.7 |
| **17** | Songsak | Megagre | 25°36’21.67" | 90°28’37.37” | Dug Well | 0.7 | 437 | 2.68 | 0.95 | 1.26 | 1.15 |
| **18** | Songsak | Nengsamgre | 25°36’07.47” | 90°35’45.44” | Dug Well | 0.8 | 514 | 4.5 | 1 | 3.49 | 2.1 |

## Annexure 1A: Dynamic water level data of East Garo Hills collected during previous AAP (NAQUIM)

| Sl. No. | Location | DTW (bgl) June 2012 | DTW (bgl) Oct 2012 | DTW (bgl) March 2013 | DTW (bgl)August 13 | DTW (bgl)November 13 | DTW (bgl)January 14 | DTW (bgl)March 14 | DTW (bgl)August 14 | DTW (bgl)November 14 | DTW (bgl)January 15 | DTW (bgl)March 15 | DTW (bgl)August 15 | DTW (bgl)November 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Dobetkolgiri | 0.79 | 0.77 | 1.63 | 1.75 | 0.72 | 1.32 | 2.45 | 2.36 | 1.56 | 2.85 | 3.65 | 2.66 | 1.23 |
| 2 | Dawachipit | 0.12 | 0.11 | 0.23 | 0.11 | 0.11 | 0.21 | 1.01 | | 0.11 | 0.2 | 0.3 | 0.2 | 0.12 |
| 3 | Dobu | 2.15 | 1.56 | 2.48 | 2.41 | 2.34 | 2.36 | 2.83 | 2.26 | 1.87 | 2.45 | 2.95 | 2.2 | 2.1 |
| 4 | Dobu-Rimding | 3 | 2.63 | 3.35 | 2.53 | 2.51 | 3.15 | 3.49 | 2.45 | 2.45 | 2.45 | 3.55 | 2.59 | 2.43 |
| 5 | Naringgiri | 0.22 | 2.73 | 2.02 | 1.25 | 1.41 | 1.93 | 3.89 | 1.89 | 1.51 | 2.13 | 4.05 | 1.71 | 2.18 |
| 6 | Naringgiri - Chakodilsu | 1.75 | 1.98 | 2.23 | 2.05 | 1.86 | 2.12 | 2.86 | 2.21 | 1.95 | 2.35 | 3.05 | 2.36 | 2.1 |
| 7 | William Nagar | 1.35 | 1.25 | 1.93 | 1.3 | 1.26 | 1.56 | 2.08 | 1.46 | 1.38 | 2.06 | 3.4 | 1.26 | 1.5 |
| 8 | BaizaRongreng | 3.82 | 0.87 | 4.27 | 2.17 | 2.18 | 3.92 | 4.23 | 2.02 | 1.85 | 4.11 | 5.1 | 2.41 | 2.1 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | Samanda-Megapagre | 2.8 | 2.6 | 3.08 | 2.01 | 1.98 | 2.72 | 3.3 | 1.89 | 1.5 | 2.71 | 4.55 | 3.52 | 1.76 |
| 10 | Samanda-Dolwarigre | 1.45 | 1.35 | 1.9 | 1.26 | 1.13 | 1.45 | 2.42 | 1.35 | 1.26 | 1.85 | 3.26 | 1.45 | 1.2 |
| 11 | Savaigere | 3.07 | 2.15 | 2.63 | 1.96 | 1.85 | 2.36 | 2.68 | 2.02 | 1.98 | 2.41 | 3.1 | 2.35 | 1.88 |
| 12 | Songsak | 2.5 | 1.22 | 2.6 | 1.78 | 1.18 | 2.42 | 2.96 | 1.98 | 1.56 | 1.75 | 2.9 | 1.27 | 2.3 |
| 13 | Songkama | 2.89 | 2.87 | 3.65 | 2.92 | 2.77 | 2.95 | 3.46 | 2.8 | 2.65 | 3.09 | 3.67 | 2.96 | 2.5 |
| 14 | SongkamaWaksogre | 1.65 | 1.32 | 0.85 | 1.25 | 1.12 | 1.24 | 1.46 | 1.36 | 1.35 | 1.3 | 2.62 | 1.66 | 1.5 |
| 15 | Koksinengsath | 2.95 | 2.79 | 3.48 | 2.81 | 2.56 | 2.82 | 3.28 | 2.9 | 2.4 | 2.96 | 3.45 | 2.45 | 2.35 |
| 16 | ChidimitNengsat | 1.65 | 0.71 | 1.75 | 0.82 | 0.56 | 1.66 | 1.87 | 1.01 | 0.67 | 1.72 | 2.51 | 1.2 | 0.85 |

## Annexure 2: Spring discharge data collected during 2019-20

| Sl. No. | Block | Location | Latitude | Longitude | RL (m) | Type of Spring | Lithology | Discharge (lpm) March-20* | Discharge (lpm) Nov-19* |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Songsak | Wagopgre Spring | 25°38'11.53" | 90°36'17.99" | 445 | Fracture | Gneiss | 9.36 | 34.29 |
| 2 | Samanda | Ronguguthan Spring | 25°31'57.06" | 90°42'37.40" | 328 | Fracture | Gneiss | 6.0 | 18.46 |

## Annexure 2A: Spring data collected during previous AAP (NAQUIM)

| Sl.No. | Location | Block | Latitude | Longitude | RL (mamsl) | Discharge (lpm) |
|---|---|---|---|---|---|---|
| 1 | DobuAnalgiri -I | Songsak | *25°34'35.6"* | *90°43'50.7"* | *333* | 30 |
| 2 | DobuAnalgiri-II | Songsak | *25°34'31.0"* | *90°43'44.9"* | *341* | 30 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | DobuRongmugithim | Samanda | 25°31'57" | 90°42'37.2" | 321 | 36 |
| 4 | Nengkhra | Samanda | 25°31'14" | 90°42'01" | 265 | 06 |
| 5 | Rangnalgri | Samanda | 25°34'58" | 90°31'19.6" | 298 | 02 |
| 6 | Rongsak | Samanda | 25°34'48" | 90°31'03" | 327 | 01 |
| 7 | Songkalwari | Samanda | 25°34'48" | 90°30'27" | 349 | 01 |
| 8 | Rongwagri | Samanda | 25°34'40" | 90°30'03.6" | 459 | 01 |
| 9 | Songkhama | Songsak | 25°40'38.9" | 90°37'54.8" | 226 | 11 |
| 10 | Songsak I | Songsak | 25°38'20.2" | 90°36'11.7" | 407 | 1.5 |
| 11 | Songsak II | Songsak | 25°38'11.3" | 90°36'17.8" | 441 | 05 |

## Annexure 3: Aquifer wise water quality data of Aquifer mapping area

| Sl. No | Location | Source | pH* | EC* µS/cm at 25°C | Turbidity(NTU) | TDS | $CO_3$ | $HCO_3$ | TA as $CaCO_3$* | Cl* | $SO_4$ | $NO_3$ | $F^-$ | Ca* | Mg* | TH* | Na* | K* | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Mg/l | | | | | | | | | | | | |
| 1 | Gamsura | Dug well | 6.30 | 51.99 | BDL | 31.02 | BDL | 40.03 | 40.03 | 17.73 | 8.36 | 7.87 | 0.11 | 8.01 | 9.70 | 60.00 | 7.20 | 1.98 | 0.03 |
| 2 | Rongmil | Dug Well | 7.14 | 192.00 | BDL | 114.90 | BDL | 100.08 | 100.08 | 17.73 | 13.76 | 8.43 | 0.11 | 34.03 | 4.84 | 105.00 | 12.19 | 6.75 | 0.01 |
| 3 | Rongjeng | Dug Well | 5.85 | 302.60 | BDL | 180.70 | BDL | 30.02 | 30.02 | 74.45 | 18.30 | 9.24 | 0.46 | 22.02 | 20.62 | 140.00 | 10.08 | 8.84 | 0.03 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | Darugre | Dug Well | 7.10 | 215.00 | BDL | 128.20 | BDL | 85.07 | 85.07 | 39.00 | 30.00 | 4.89 | 0.23 | 34.03 | 13.33 | 140.00 | 9.98 | 10.63 | 0.06 |
| 5 | Narringgre | Dug Well | 6.07 | 28.32 | BDL | 17.01 | BDL | 25.02 | 25.02 | 17.73 | 6.56 | BDL | 0.05 | 4.00 | 8.49 | 45.00 | 2.63 | 1.85 | 0.15 |
| 6 | DarugreNengphachi | Dug Well | 5.86 | 39.44 | BDL | 23.51 | BDL | 20.02 | 20.02 | 14.18 | 15.13 | 7.88 | 0.04 | 4.00 | 8.49 | 45.00 | 5.46 | 3.13 | 0.20 |
| 7 | BaizaRongreng | Dug Well | 6.04 | 30.95 | BDL | 18.52 | BDL | 25.02 | 25.02 | 81.54 | 4.37 | BDL | 0.02 | 4.00 | 7.28 | 40.00 | 28.69 | 19.19 | 0.03 |
| 8 | Williamnagar | Dug Well | 6.30 | 86.95 | BDL | 52.00 | BDL | 35.03 | 35.03 | 28.36 | 7.63 | 10.25 | 0.05 | 8.01 | 10.92 | 65.00 | 11.82 | 2.09 | 0.13 |
| 9 | SamandaMegapgre | Dug Well | 6.33 | 64.95 | BDL | 38.67 | BDL | 40.03 | 40.03 | 28.36 | 17.69 | BDL | 0.26 | 8.01 | 7.28 | 50.00 | 14.37 | 5.29 | 0.44 |
| 10 | Dobetkolgre | Dug Well | 5.44 | 61.27 | BDL | 36.54 | BDL | 25.02 | 25.02 | 17.73 | 18.48 | BDL | 0.02 | 8.01 | 7.28 | 50.00 | 6.86 | 2.31 | 0.22 |
| 11 | Jamge | Dug Well | 6.22 | 35.18 | BDL | 20.93 | BDL | 25.02 | 25.02 | 24.82 | 4.95 | BDL | 0.04 | 8.01 | 8.49 | 55.00 | 1.27 | 0.84 | 0.16 |
| 12 | Songsak | Dug Well | 5.31 | 39.23 | 0.30 | 23.32 | BDL | 20.02 | 20.02 | 28.36 | 15.07 | BDL | BDL | 6.00 | 7.28 | 45.00 | 13.15 | 3.97 | 0.25 |
| 13 | Wagopgre | Dug Well | 6.23 | 33.28 | BDL | 19.73 | BDL | 30.02 | 30.02 | 21.27 | 4.87 | BDL | 0.05 | 10.01 | 8.49 | 60.00 | 1.17 | 1.00 | 0.02 |
| 14 | SaminSongkama | Dug Well | 6.76 | 79.73 | BDL | 48.75 | BDL | 50.04 | 50.04 | 42.54 | 6.22 | BDL | 0.11 | 10.01 | 12.13 | 75.00 | 9.83 | 2.34 | 0.03 |
| 15 | Koksinengsai | Dug Well | 6.70 | 193.30 | BDL | 114.90 | BDL | 75.06 | 75.06 | 24.82 | 39.15 | 8.58 | 0.21 | 20.02 | 13.34 | 105.00 | 12.44 | 20.01 | 0.42 |
| 16 | Chidimit | Dug Well | 5.70 | 35.03 | BDL | 20.72 | BDL | 25.02 | 25.02 | 21.27 | 6.14 | BDL | 0.04 | 6.00 | 6.07 | 40.00 | 8.15 | 3.28 | 0.07 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | Megagre | Dug Well | 6.17 | 25.40 | BDL | 15.13 | BDL | 25.02 | 25.02 | 21.27 | 4.25 | BDL | 0.03 | 4.00 | 4.85 | 30.00 | 9.18 | 1.70 | 0.03 |
| 18 | Nengsamgre | Dug Well | 6.38 | 54.87 | BDL | 32.39 | BDL | 35.03 | 35.03 | 17.73 | 13.67 | 8.58 | 0.08 | 6.00 | 13.35 | 70.00 | 4.55 | 2.20 | 0.07 |
| 19 | Wagopgre Spring | Dug Well | 7.60 | 81.58 | BDL | 48.25 | BDL | 55.04 | 55.04 | 14.18 | 22.16 | 9.88 | 0.52 | 14.01 | 10.92 | 80.00 | 10.45 | 1.84 | 0.39 |
| 20 | Ronguguthan Spring | Spring | 7.27 | 53.16 | BDL | 31.49 | BDL | 45.04 | 45.04 | 31.91 | 4.76 | BDL | 0.21 | 6.00 | 13.35 | 70.00 | 7.49 | 1.34 | 0.09 |

## Annexure 4 :Water quality data of Deeper Aquifer

| Unique ID | Village/ Location | Taluka/Block | Aquifer Type | Depth | pH | EC (mS/cm) | Turbidity | TDS (mg/L) | TH | Ca | Mg | Na | K | $CO_3$ | $HCO_3$ | $SO_4$ | $NO_3$ | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Mg/l** | | | | | | | | | |
| MEG-78 K10-02 | Chidmit | Songsak | Granitic gneiss | 170.85 | 8.2 | 342 | BDL | 163 | 116 | 33. 2 | 8 | 19.1 | 3.8 1 | BDL | 176 | 1.9 3 | BDL | 2.28 |
| MEG-78 K10-03 | Narringre | Dambo-Rongjeng | Granitic gneiss | 113.8 | 8.4 | 402 | BDL | 191 | 133 | 33. 6 | 11. 8 | 24.8 | 2.6 3 | 40 | 152 | 2.09 | BDL | 1.12 |
| MEG-78 K10-04 | Dobu-Rimding | Songsak | Granitic gneiss | 202.3 | 8.3 | 398 | BDL | 189 | 144 | 36 | 13. 1 | 33.6 | 4.6 2 | 24 | 156 | 9.6 1 | BDL | 1.49 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEG-78 K10-06 | Nokilawe | Samanda | Sandstone | 119.9 | 8.3 | 265 | BDL | 125 | 110 | 38 | 3.6 4 | 1.14 | 3.5 8 | 16 | 92 | 11.0 2 | 0.7 | 2.75 |
| MEG-78K10-07 | Somgong | Samanda | Sandstone | 75.35 | 7.9 | 177 | BDL | 84. 4 | 31 | 9.2 | 1.9 4 | 19.6 | 2.8 5 | BDL | 56 | 12.4 3 | BDL | 0.33 |
| MEG-78 K10-08 | JNV: Williamnagar | Samanda | Sandstone | 104.7 | 7.3 | 84. 4 | BDL | 40 | 38 | 6.8 | 5.0 9 | 0.58 | 2.7 2 | BDL | 40 | 11. 8 | BDL | 0.12 |

## Annexure 5: Ground water resource

**a) General Description of Ground Water Assessment East Garo Hillsdistrict for 2017-18 (area in ha)**

| | |
|---|---|
| Name of Ground Water Assessment Unit | East Garo Hills |
| Type of Ground Water Assessment Unit | District |
| Type of rock formation | Gneiss, Granite, Sandstone |
| Total area of Groundwater Assessment Unit | 144300 |
| Hilly area | 78183 |
| Command area | 0 |
| Non-command area | 66117 |
| Poor ground water quality area | 0 |
| Area considered for groundwater recharge | 66117 |

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

| | |
|---|---|
| Assessment Unit / District | East Garo Hills |
| Command/ Non-Command/ Total | Total |
| Recharge from rainfall during monsoon season | 2745.11ham |
| Recharge from other sources during monsoon season | 57.85ham |

| | |
|---|---|
| Recharge from rainfall during non-monsoon season | 2014.64 ham |
| Recharge from other sources during non- monsoon season | 15.53ham |
| Total Ground Water Recharge | 4833.13ham |
| Annual Extractable Ground Water | 4349.81 ham |

**c) Ground Water Extraction for All Uses in East Garo Hills district**

| | |
|---|---|
| District | East Jaintia Hills |
| Total ground water extraction for domestic and industrial purpose | 20.42 ham |
| Total ground water extraction for irrigation | 0 ham |
| Total groundwater extraction | 20.42 ham |

**d) Balance Ground Water Resources Available and Stage of Groundwater Extraction in the Study Area as On 31st March 2017**

| | |
|---|---|
| Assessment Unit / District | East Garo Hills |
| Command/ Non-Command/ Total | Total |
| Annual Extractable Ground Water | 4349.81 ham |
| Existing Gross ground water extraction for irrigation | 0 ham |
| Existing Gross Ground Water extraction for domestic and industrial water supply | 20.42 ham |
| Existing Gross Ground Water Draft for All Uses | 20.42 ham |
| Provision for domestic and industrial requirement supply upto next 25 years | 40.84 ham |
| Net Annual Ground Water Availability for future irrigation development | 4308.97 ham |
| Stage of ground water development | 0.47% |

**e) Categorization for Ground Water Extraction of east Garo Hills district during 2017-18**

| | |
|---|---|
| Assessment Unit/ District | East Garo Hills |
| Stage Of Ground Water Extraction (%) | 0.47% |
| Validation of Assessment using GW Level trends (Valid/to be Re-assessed) | Could not validate, WL data not sufficient/representative |
| Categorization (Safe / Semi-Critical/ Critical/ Over-Exploited) | Safe |

## Annexure 6: Data gap and data requirement in East GaroHills district

| Toposheet No. | Grid | *Data Existing* | | | | | | | | | | *Data required/Data gap* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Aquifer II* | | | | | *Aquifer I* | | | | | *Aquifer II* | | | | | *Aquifer I* | | | | |
| *Toposheet No.* | *Grid* | *EW* | *OW* | *VES* | *CHE* | *WL* | *EW* | *OW* | *VES* | *CHE* | *WL* | *EW* | *OW* | *VES* | *CHE* | *WL* | *EW* | *OW* | *VES* | *CHE* | *WL* |
| | | | | | | | | | | | | | | | | | | | | | |
| **78K/09** | **A3** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **78K/09** | **B3** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| **78K/09** | **C3** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **78K/13** | **A3** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **78K/13** | **B3** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| **78K/06** | **B3** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| **78K/06** | **C1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **78K/06** | **C2** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| **78K/06** | **C3** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **78K/10** | **A1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **78K/10** | **A2** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| **78K/10** | **A3** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 0 | 0 |
| **78K/10** | **B1** | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| **78K/10** | **B2** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 0 | 0 |
| **78K/10** | **B3** | 3 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| **78K/10** | **C1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **78K/10** | **C2** | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| **78K/10** | **C3** | 2 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 2 | 0 | 0 |
| **78K/14** | **A1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 0 | 0 |
| **78K/14** | **A2** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| **78K/14** | **B1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| **78K/14** | **B2** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **78K/14** | **C1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **78K/07** | **B1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| **78K/07** | **C1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **78K/11** | **A1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **78K/11** | **B1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| **78K/11** | **C1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| | **Total** | **8** | **0** | **7** | **6** | **0** | **0** | **0** | **0** | **10** | **10** | **11** | **16** | **50** | **15** | **16** | **16** | **16** | **56** | **21** | **21** |

**Annexure 7: LITHOLOG**

| | |
|---|---|
| Unique ID | **MEG-78K10-01** |
| Village | **Songsak** |
| Taluka/Block | Songsak |
| District | East Garo |
| Toposheet No | 78 K/10 |
| Latitude | $25^{0}$39’04.86’’N |
| Longitude | $90^{0}$36’37.92’’E |
| RL (m amsl) | 296 |
| Drilled Depth | 196.2 |
| Casing | 13 |
| SWL (mbgl) | 11.38 |
| Discharge (lps) | 6 |
| Date/year | Aug-12 |

| Depth range (mbgl) | | Thickness (m) | Litholog |
|---|---|---|---|
| From | To | | |
| 0 | 1 | 1 | Top soil: mixed with Weathered. rock fragments |
| 1 | 13 | 12 | Granitic gneiss, Highly Weathered and altered clayey |
| 13 | 48 | 35 | Granitic gneiss, partially Weathered |
| 48 | 56 | 8 | Dolerite dyke,Highly fractured, Water bearing |
| 56 | 80 | 24 | Granitic gneiss, grey, massive |
| 80 | 98 | 18 | Pegmatite, pink, massive, partially fractured at 80 - 83m |
| 98 | 147 | 49 | Granitic gneiss, grey, massive |
| 147 | 150 | 3 | Pegmatite, pink, partially fractured |
| 150 | 190 | 40 | Granitic gneiss, massive, grey |
| 190 | 196 | 6 | Dolerite, Highly Fractured, Water bearing |

| Unique ID | **MEG-78K10-02** |
|---|---|
| Village | **Chidimit** |
| Taluka/Block | Songsak |
| District | East Garo |
| Toposheet No | 78 K/10 |
| Latitude | 25$^{0}$44'27.7''N |
| Longitude | 90$^{0}$37'51.8''E |
| RL (m amsl) | 238 |
| Drilled Depth | 170.85 |
| Casing | 10.6 |
| SWL (mbgl) | 8.11 |
| Discharge (lps) | 12 |
| Date/year | Sep-12 |

| Depth range (mbgl) | | Thickness (m) | Litholog |
|---|---|---|---|
| From | To | | |
| 0 | 6 | 6 | Top Soil, mixed with Weathered rock fragment & altered clayey |
| 6 | 49 | 43 | Granitic gneiss, grey, massive |
| 49 | 76 | 27 | Granitic gneiss, partially fractured |
| 76 | 93 | 17 | Granitic gneiss, grey, partially fractured with chalcopyrite nodules |
| 93 | 102 | 9 | Granitic gneiss, Highly fractured, with chalcopyrite nodules Water bearing |
| 102 | 161 | 59 | Granitic gneiss, grey, massive |
| 161 | 171 | 10 | Granitic gneiss, Highly fractured, Water bearing |

| Unique ID | **MEG-78K10-03** |
|---|---|
| Village | **Narringre** |
| Taluka/Block | Dambo-Rongjeng |
| District | East Garo |
| Toposheet No | 78 K/10 |
| Latitude | $25^{0}$36’38.8’’N |
| Longitude | $90^{0}$44’18.4’’E |
| RL (m amsl) | 291 |
| Drilled Depth | 113.8 |
| Casing | 11.3 |
| SWL (mbgl) | 4.53 |
| Discharge (lps) | 15 |
| Date/year | Oct-12 |

| Depth range (mbgl) | | Thickness (m) | Litholog |
|---|---|---|---|
| From | To | | |
| 0 | 5 | 5 | Top soil, Red clayey mixed with Weathered rock fragments |
| 5 | 12 | 7 | Granite, pink, weathered |
| 12 | 19 | 7 | Granitic gneiss, grey, partially fractured |
| 19 | 33 | 14 | Granite, pink, partially fractured |
| 33 | 35 | 2 | Granitic gneiss, grey, Highly fractured, Water bearing |
| 35 | 65 | 30 | Granite, pink partially fractured, |
| 65 | 71 | 6 | Granitic gneiss, grey, Highly fractured, Water bearing |
| 71 | 111 | 40 | Granite, pink, partially fractured |
| 111 | 114 | 3 | Granitic gneiss, grey, Highly fractured, Water bearing |

| | |
|---|---|
| Unique ID | **MEG-78K10-04** |
| Village | **Dobu-Rimding** |
| Taluka/Block | Songsak |
| District | East Garo |
| Toposheet No | 78 K/10 |
| Latitude | $25^0$33’38.6’’N |
| Longitude | $90^0$42’57.1’’E |
| RL (m amsl) | 296 |
| Drilled Depth | 202.3 |
| Casing | 7.1 |
| SWL (mbgl) | 15.2 |
| Discharge (lps) | 1 |
| Date/year | Oct-12 |

| Depth range (mbgl) | | Thickness (m) | Litholog |
|---|---|---|---|
| From | To | | |
| 0 | 5 | 5 | Top soil, mixed with weathered and altered rock fragment clayey |
| 5 | 51 | 46 | Granite, pink, massive |
| 51 | 62 | 11 | Granite, pink, partially fractured |
| 62 | 65 | 3 | Granitic gneiss, grey, Highly fractured, Water bearing |
| 65 | 93 | 28 | Granite, pink, massive |
| 93 | 95 | 2 | Granite, pink fractured, Water bearing |
| 95 | 202 | 107 | Granite, pink, massive |

| Unique ID | **MEG-78K10-05** |
|---|---|
| Village | **Nengkhra** |
| Taluka/Block | Samanda |
| District | East Garo |
| Toposheet No | 78 K/10 |
| Latitude | $25^0$30’02.4’’N |
| Longitude | $90^0$41’29.4’’E |
| RL (m amsl) | 252 |
| Drilled Depth | 141.3 |
| Casing | 24 |
| SWL (mbgl) | 5.7 |
| Discharge (lps) | 16 |
| Date/year | Dec-12 |

| Depth range (mbgl) | | Thickness (m) | Litholog |
|---|---|---|---|
| From | To | | |
| 0 | 3 | 3 | Top soil, brown, sandy |
| 3 | 10 | 7 | Sandy material, brown, highly Weathered and altered |
| 10 | 16 | 6 | Sand- medium to coarse grained mixed with weathered and altered rock |
| 16 | 24 | 8 | Quartz vein (smoky and pink pegmatite), highly fractured with sec coating, Water bearing |
| 24 | 37 | 13 | Granite, pink partially fractured |
| 37 | 89 | 52 | Granite, pink, massive |
| 89 | 94 | 5 | Granite, pink, partially fractured |
| 94 | 101 | 7 | Dolerite, fractured |
| 101 | 123 | 22 | Granite, pink, massive |
| 123 | 125 | 2 | Dolerite, massive |
| 125 | 129 | 4 | Granite, pink, massive |
| 129 | 141 | 12 | Dolerite, highly fractured, Water bearing |

| Unique ID | **MEG-78K10-06** |
|---|---|
| Village | **Nokilawe** |
| Taluka/Block | Samanda |
| District | East Garo |
| Toposheet No | 78 K/10 |
| Latitude | $25^0$30’38’’N |
| Longitude | $90^0$46’38.2’’E |
| RL (m amsl) | 271 |
| Drilled Depth | 119.9 |
| Casing | 45 |
| SWL (mbgl) | 3.18 |
| Discharge (lps) | 18 |
| Date/year | Jan-13 |

| Depth range (mbgl) | | Thickness (m) | Litholog |
|---|---|---|---|
| From | To | | |
| 0 | 5 | 5 | Top Soil, Brown and sandy material |
| 5 | 10 | 5 | Sand, Coarse grained mixed with altered rock |
| 10 | 19 | 9 | Clay/ Kopili Shale (?), fine grained, grey |
| 19 | 37 | 18 | Sand, Coarse grained mixed with altered rock |
| 37 | 44 | 7 | Sand, fine grained mixed with altered rock |
| 44 | 95 | 51 | Granitic gneiss, grey, massive |
| 95 | 106 | 11 | Granitic gneiss, grey, partially fractured |
| 106 | 119.9 | 13.9 | Dolerite Dyke (?), Highly fractured, Water bearing Zone |

| | |
|---|---|
| Unique ID | **MEG-78K10-07** |
| Village | **Somgong** |
| Taluka/Block | Samanda |
| District | East Garo |
| Toposheet No | 78 K/10 |
| Latitude | $25^0$30’28.8’’N |
| Longitude | $90^0$36’55’’E |
| RL (m amsl) | 293 |
| Drilled Depth | 75.35 |
| Casing | 75 |
| SWL (mbgl) | 18 |
| Discharge (lps) | 0.8 |
| Date/year | Mar-13 |

| Depth range (mbgl) | | Thickness (m) | Litholog |
|---|---|---|---|
| From | To | | |
| 0 | 5 | 5 | Top Soil: mixed with Clay, brown |
| 5 | 19 | 14 | Kopili Shale, grey, Clayey,mixed with sand |
| 19 | 61 | 42 | Kopili Shale, grey, fine grained, Clayey and sticky |
| 61 | 68 | 7 | Kopili Shale, fractured mixed with sand, fine – coarse grained |
| 68 | 75.35 | 7.35 | Kopili Shale, grey, fine grained, Clayey and sticky |

| Unique ID | **MEG-78K10-08** |
|---|---|
| Village | **JNV, Williamnagar** |
| Taluka/Block | Samanda |
| District | East Garo |
| Toposheet No | 78 K/10 |
| Latitude | $25^0$30’25’’N |
| Longitude | $90^0$36’60’’E |
| RL (m amsl) | 267 |
| Drilled Depth | 104.7 |
| Casing | 56 |
| SWL (mbgl) | 9.6 |
| Discharge (lps) | 10 |
| Date/year | Mar-13 |

| Depth range (mbgl) | | Thickness (m) | Litholog |
|---|---|---|---|
| From | To | | |
| 0 | 7 | 7 | Top Soil, mixed with and altered rock fragments , Clayey |
| 7 | 56 | 49 | Kopili Shale, grey, fine grained, Splintery |
| 56 | 59 | 3 | Sandstone, medium grained, fractured, Water bearing |
| 59 | 92 | 33 | Sandstone, fine to medium grained, pale brown color |
| 92 | 104.7 | 12.7 | Kopili Shale, grey, fine grained |

## Annexure 8: AQUIFER PARAMETERS

| Unique ID | Village/ Location | Taluka/ Block | Toposh eet No. | Lat | Long | Type of well | Depth | Di a | Date of pumping Test | Drawdown (m) | Transmisivity ($m^2$/day) | Specific Capacity (lpm/ m of dd) | Source/ Agency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEG78K10 -01 | Songsak | Songsak | 78 K/10 | $25^0$39'0 4.86''N | $90^0$36'37 .92''E | BW | 196. 2 | 7"/ 6½" | 07.08. 2012 | 11. 02 | 10 | 16.3 4 | CG WB |
| MEG78K10 -02 | Chidmit | Songsak | 79 K/10 | $25^0$44'27 .7''N | $90^0$37'51 .8''E | BW | 170. 85 | 7"/ 6½" | 15.09. 2012 | 10. 88 | 115 | 19.3 1 | CG WB |
| MEG78K10 -03 | Narringr e | DamboR ongjeng | 80 K/10 | $25^0$36'38 .8''N | $90^0$44'18 .4''E | BW | 113. 8 | 7"/6½" | 09.10. 2012 | 4.1 9 | 45 | 70.0 3 | CG WB |
| MEG78K10 -04 | Dobu- Rimding | Songsak | 81 K/10 | $25^0$33'38 .6''N | $90^0$42'57 .1''E | BW | 202. 3 | 7"/6½" | 31.10. 2012 | 33. 42 | 2 | 1.79 | CG WB |
| MEG78K10 -05 | Nengkhr a | Samanda | 82 K/10 | $25^0$30'02 .4''N | $90^0$41'29 .4''E | BW | 141. 3 | 7"/6½" | 11.12. 2012 | 22. 8 | 5 | 5.89 | CG WB |
| MEG78K10 -06 | Nokilaw e | Samanda | 83 K/10 | $25^0$30'38 ''N | $90^0$46'38 .2''E | BW | 119. 9 | 7"/6½" | 07.01. 2013 | 13. 15 | 25 | 10.6 8 | CG WB |
| MEG78K10 -07 | Somgon g | Samanda | 84 K/10 | $25^0$30'28 .8''N | $90^0$36'55 ''E | BW | 75.3 5 | 7"/6½" | | | | | CG WB |
| MEG78K10 -08 | JNV: William nagar | Samanda | 85 K/10 | $25^0$30'25 ''N | $90^0$36'60 ''E | BW | 104. 7 | 7"/6½" | 28.03. 2013 | 7.5 1 | 55 | 24.8 4 | CG WB |

Annexure 9 :

| | |
|---|---|
| Unique ID | MEG-78K10-05 |
| Village | Naringgre |
| Talluka/block | Dambo-Rongjeng |
| District | East garo |
| Toposheet No. | 78K/10 |
| Lattitudes | 25$^0$36’38.8’’N |
| Longitudes | 90$^0$44’19’’E |
| RL(m amsl) | 291 |
| Date/year | 2012 |
| Nearby DW/DCBW/BW Depth | - |
| Yield/Discharge | - |
| Whether BH was drilled at this point? If Yes, | Yes |
| Depth drilled | 113.8 |
| Discharge (lps) | 15 lps |
| Transmissivity ($m^2$/day) | 45 |
| Storativity | |

| Depth range (mbgl) | | Layer Resistivity in Ohm m | Inferred subsurface geology |
|---|---|---|---|
| From | To | | |
| 0 | 3.9 | 3000 | Top soil with massive rock |
| 3.9 | 26.1 | 210 | Fractured formation |
| 26.1 | 47 | 338 | Partially fractured formation |
| 47 | 77 | 150 | Highly fractured formation |
| Below 77m | | 420 | Semi consolidated consolidated formation |

| | |
|---|---|
| Unique ID | MEG-78K10-01 |
| Village | Songsak |
| Talluka/block | Songsak |
| District | East garo |
| Toposheet No. | 78K/10 |
| Lattitudes | 25º36′38″ N |
| Longitudes | 90º44′19″ E |
| RL(m amsl) | 296 |
| Date/year | 2012 |
| Nearby DW/DCBW/BW Depth | - |
| Yield/Discharge | - |
| Whether BH was drilled at this point? If Yes, | Yes |
| Depth drilled | 196.2 |
| Discharge (lps) | 6 |
| Transmissivity ($m^2$/day) | 10 |
| Storativity | |

| Depth range (mbgl) | | Layer Resistivity in Ohm m | Inferred subsurface geology |
|---|---|---|---|
| From | To | | |
| 0 | 3 | 2300 | Top soil with massive rock |
| 3 | 51 | 460 | Highly fractured formation |
| 51 | 80 | 1150 | Partially fractured formation with less degree of saturation |
| Below 80m | | 136 | Weathered/loose formation |

| | |
|---|---|
| Unique ID | MEG-78K10-05 |
| Village | Nengkhra |
| Talluka/block | Samanda |
| District | East Garo |
| Toposheet No. | 78K/10 |
| Lattitudes | 25º30′04″ N |
| Longitudes | 90º41′29″E |
| RL(m amsl) | 252 |
| Date/year | |
| Nearby DW/DCBW/BW Depth | - |
| Yield/Discharge | - |
| Whether BH was drilled at this point? If Yes, | Yes |
| Depth drilled | 141.3 |
| Discharge (lps) | 16 |
| Transmissivity ($m^2$/day) | 5 |
| Storativity | |

| Depth range (mbgl) | | Layer Resistivity in Ohm m | Inferred subsurface geology |
|---|---|---|---|
| From | To | | |
| 0 | 2.9 | 600 | Top soil |
| 2.9 | 14.5 | 180 | Sandy / loose formation |
| 14.5 | 39.7 | 735 | Massive/Partially fractured formation |
| 39.7 | 57 | 450 | fractured formation |
| Below 57m | | 3150 | consolidated to semi consolidated formation |

| | |
|---|---|
| Unique ID | MEG-78K10-04 |
| Village | Dobu |
| Talluka/block | Songsak |
| District | East Garo |
| Toposheet No. | 78K/10 |
| Lattitudes | 25º33′39" N |
| Longitudes | 90º42′57″ E |
| RL(m amsl) | 296 |
| Date/year | |
| Nearby DW/DCBW/BW Depth | - |
| Yield/Discharge | - |
| Whether BH was drilled at this point? If Yes, | Yes |
| Depth drilled | 202.3 |
| Discharge (lps) | 1 |
| Transmissivity ($m^2$/day) | 2 |
| Storativity | |

| Depth range (mbgl) | | Layer Resistivity in Ohm m | Inferred subsurface geology |
|---|---|---|---|
| From | To | | |
| 0 | 3.8 | 6600 | Top soil with massive rock |
| 3.8 | 21.1 | 660 | Semi consolidated formation |
| 20.1 | 60 | 140 | fractured formation |
| Below 60m | | 76 | Weathered/fractured/loose formation |

| | |
|---|---|
| Unique ID | MEG-78K10-06 |
| Village | Nokilawe |
| Talluka/block | Samanda |
| District | East Garo |
| Toposheet No. | 78K/10 |
| Lattitudes | 25º30′42″N |
| Longitudes | 90º35′46″ E |
| RL(m amsl) | 271 |
| Date/year | |
| Nearby DW/DCBW/BW Depth | - |
| Yield/Discharge | - |
| Whether BH was drilled at this point? If Yes, | Yes |
| Depth drilled | 119.9 |
| Discharge (lps) | 18 |
| Transmissivity ($m^2$/day) | 25 |
| Storativity | |

| Depth range (mbgl) | | Layer Resistivity in Ohm m | Inferred subsurface geology |
|---|---|---|---|
| From | To | | |
| 0 | 5.8 | 640 | Semi consolidated formation |
| 5.8 | 41 | 64 | Loose formation |
| Below41m | | 56 | Loose formation with less compact fragments |

| | |
|---|---|
| Unique ID | MEG-78K10-07 |
| Village | Somgong |
| Talluka/block | Samanda |
| District | East Garo |
| Toposheet No. | 78K/10 |
| Lattitudes | 25º31′42″ N |
| Longitudes | 90º37′00″E |
| RL(m amsl) | 293 |
| Date/year | |
| Nearby DW/DCBW/BW Depth | - |
| Yield/Discharge | - |
| Whether BH was drilled at this point? If Yes, | Yes |
| Depth drilled | 75.35 |
| Discharge (lps) | 0.8 |
| Transmissivity ($m^2$/day) | |
| Storativity | |

| Depth range (mbgl) | | Layer Resistivity in Ohm m | Inferred subsurface geology |
|---|---|---|---|
| From | To | | |
| 0 | 4.6 | 3000 | Top soil with massive rock |
| 4.6 | 26 | 450 | Loose formation |
| Below 26m | | 90 | Sandy/loose formation |

| | |
|---|---|
| Unique ID | MEG-78K10-08 |
| Village | JNV Williamnagar |
| Talluka/block | Samanda |
| District | East Garo |
| Toposheet No. | 78K/10 |
| Lattitudes | 25º30′55″N |
| Longitudes | 90º36′54″E |
| RL(m amsl) | 267 |
| Date/year | |
| Nearby DW/DCBW/BW Depth | - |
| Yield/Discharge | - |
| Whether BH was drilled at this point? If Yes, | Yes |
| Depth drilled | 104.7 |
| Discharge (lps) | 10 |
| Transmissivity ($m^2$/day) | 55 |
| Storativity | |

| Depth range (mbgl) | | Layer Resistivity in Ohm m | Inferred subsurface geology |
|---|---|---|---|
| From | To | | |
| 0 | 1.2 | 3000 | Top soil with massive rock |
| 1.2 | 4.6 | 150 | Loose / semi consolidated formation |
| 4.6 | 29 | 39 | Sandy/loose formation |
| Below 39 m | | 180 | Semi consolidated/loose formation |

## PHOTOGRAPHS

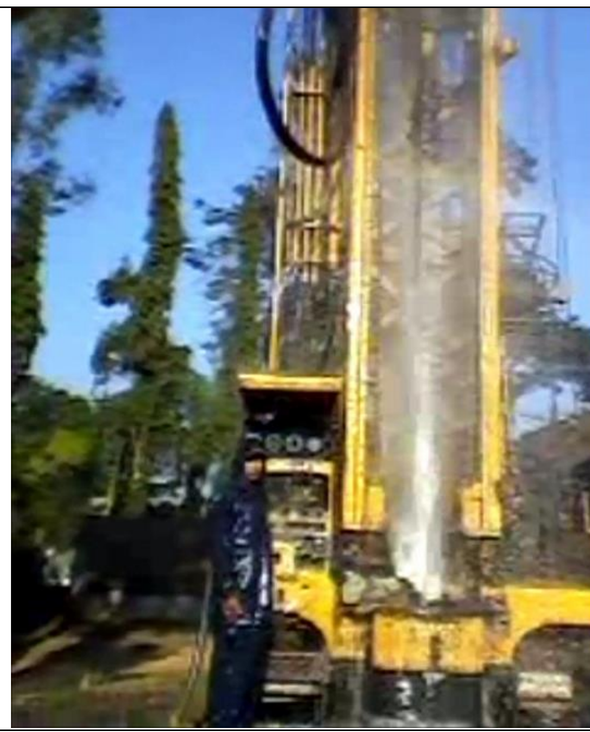
| | |
|---|---|
|  |  |
| **Ground Water Monitoring** | **Ground Water Sample Collection** |
|  |  |
| **Soil infiltration test at East Garo hills** | **Ronguguthan Spring, East Garo Hills** |

**PHOTOGRAPHS**

**SPRING AT DOBU**

**SPRING AT SONGKHAMA**

**GROUND WATER EXPLORATION AT CHIDMIT**



**GROUND WATER EXPLORATION AT NOKILAWE**

PUBLIC INTERATION PROGRAM AT GABL ADING VILLAGE, EAST GARO HILLS DISTRICT