



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
μ S/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 Gneissic Complex intruded by acid/basic intrusive viz., Granites, Pyroxenite and Amphibolites. The Older of Tertiary Formation occurs in and around Williamnagar 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 basement 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. Eighteen key 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-Rinding, 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 between 1.5 & 30 litre/minute during pre-monsoon period 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 and deep tube wells were 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 at 4349.81ham, 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, MEGHALAYA

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 our understanding 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.

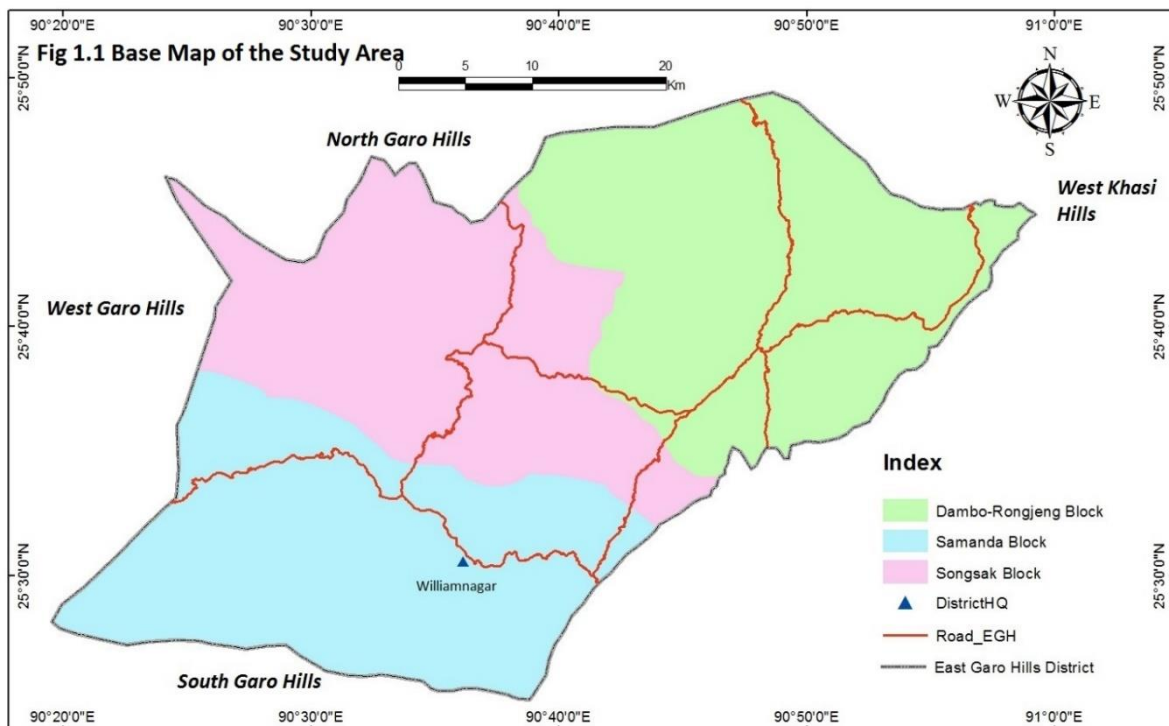
1.3 Approach and Methodology

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/14and 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 Garo Hills in 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.

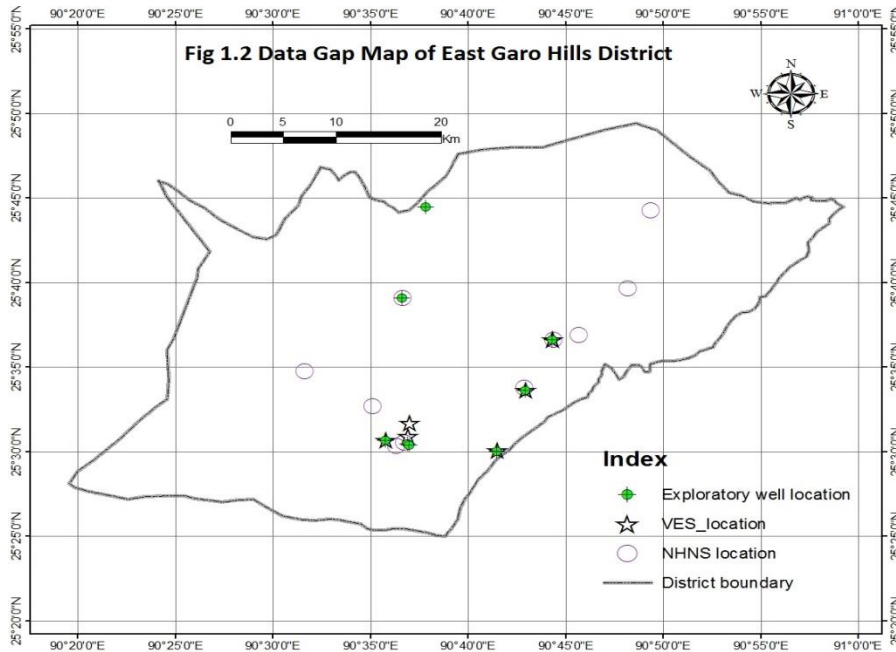


Table 1.1 Data Availability and Data Gap Analysis in Aquifer Mapping Studies Area

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. II Aquifer : 11 nos. of EW & 16 nos. of OW.
2	Geophysics	Geophysical data of the Study area	7 VES	I Aquifer : 56 nos. 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. 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. 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 145798 with 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 of East 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 35⁰C and the minimum temperatures is 13.5⁰C. January is the coldest month and the mean maximum and minimum temperatures being 22.3⁰C and 10⁰C 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 Table 1.2.

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

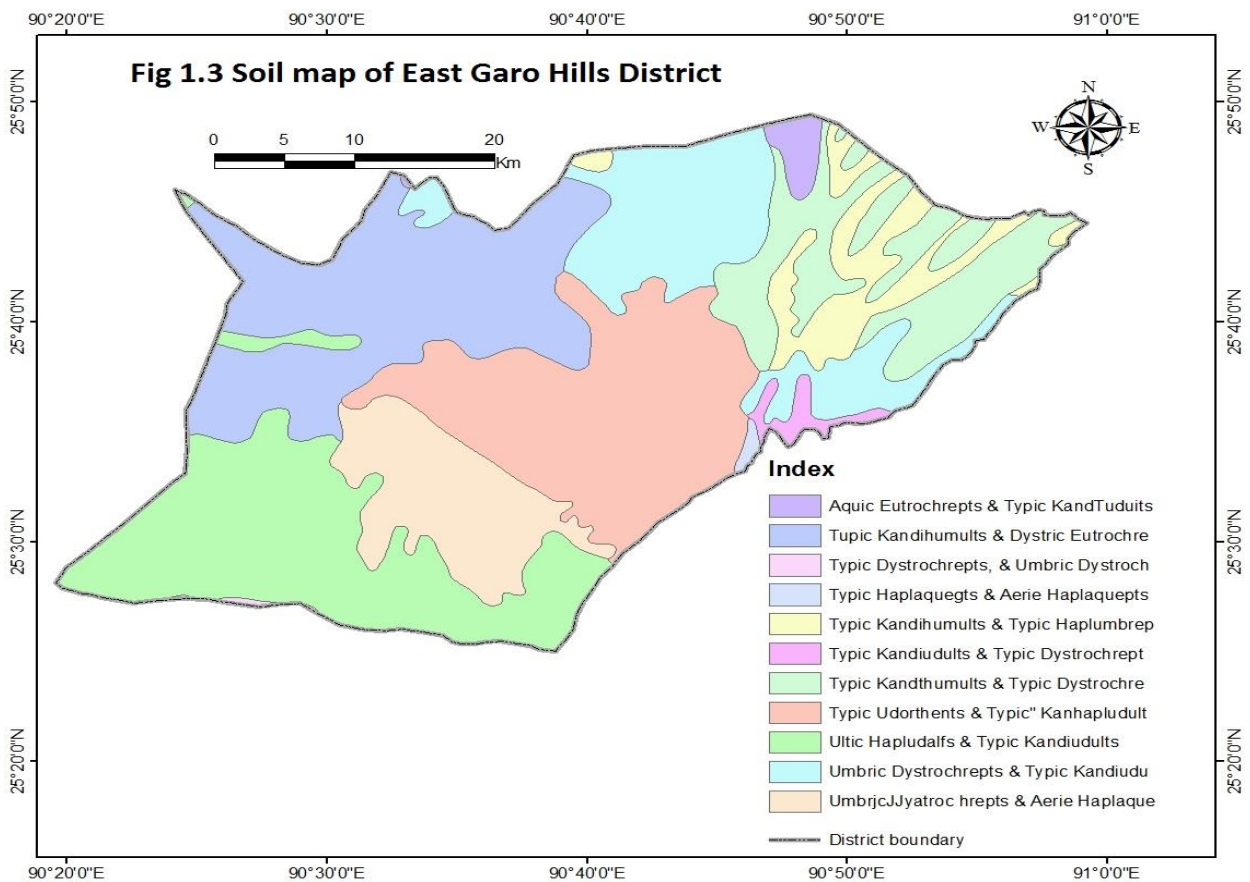
Land Classifications (in ha)	East Garo Hills
1. Geographical Area	144300
2. Reporting Area	144086
3. Barren and Uncultivable land	2195
4. Other uncultivated land	
a. Land under Misc tree crops and grooves etc	13778
b. Cultivable waste land	17930
5. Fallow land	
a. Fallow land other than current fallows	10905
b. Current fallows	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.



(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 tests were 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, Williamnagar	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 Banana etc are 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 district is 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 Table 1.5.

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).

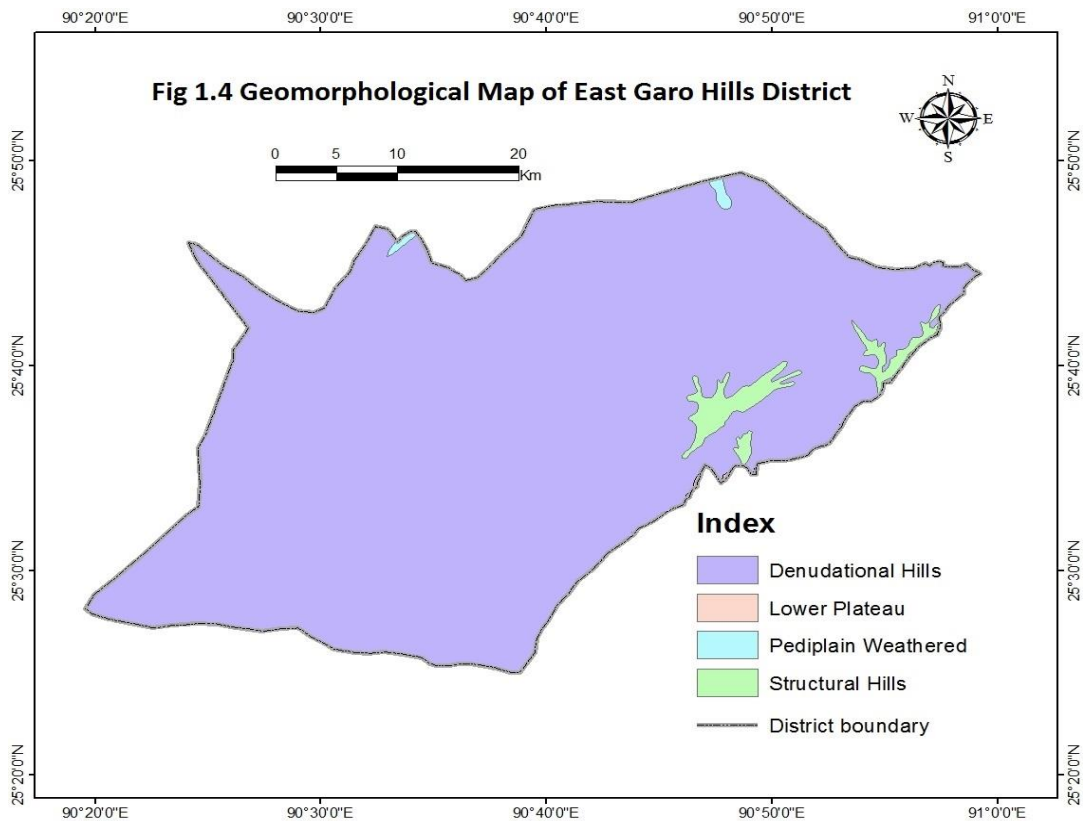
1.15 Geomorphology

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.

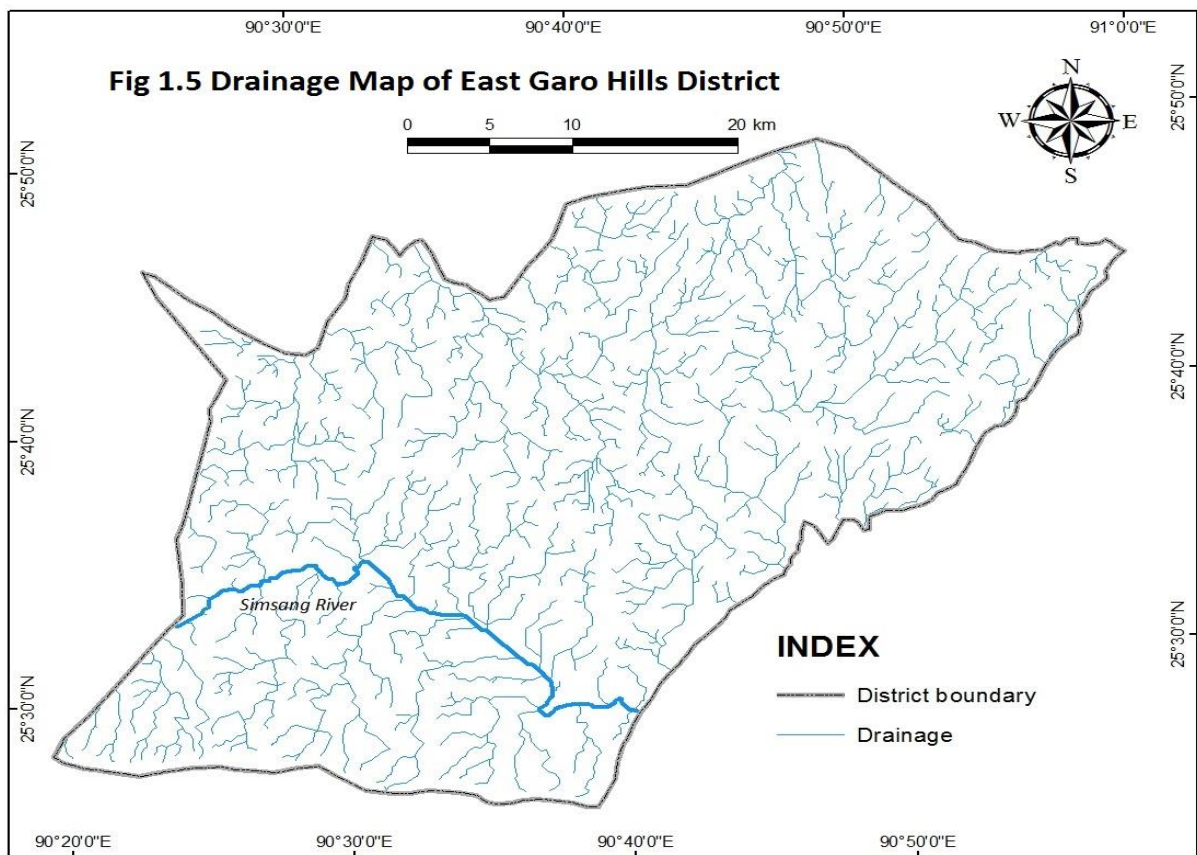
Denudational Hills: Denudational Hills of Archaean Gneissic Complex comprising of granite gneisses intruded by basic and acid intrusives. These are highly weathered at places and form valleys.

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.



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

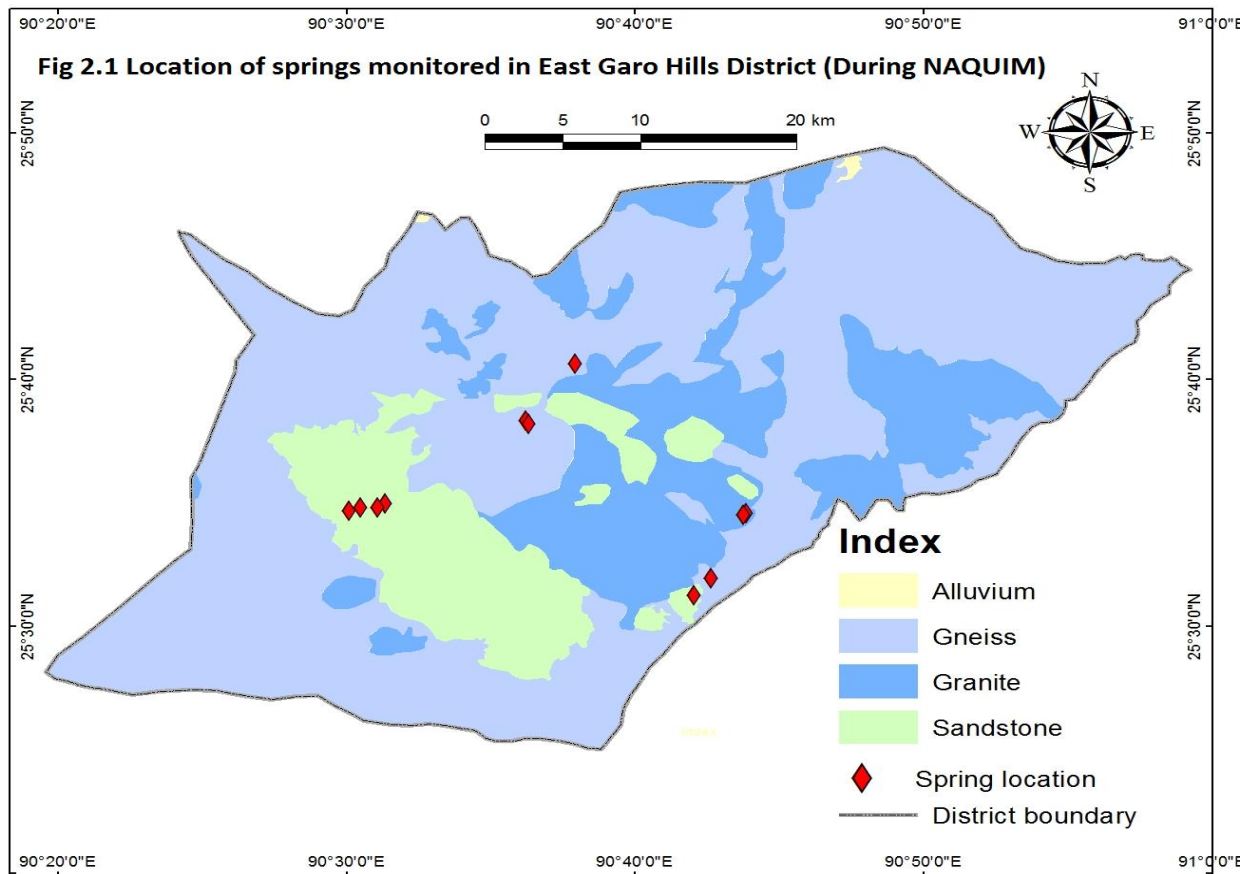
Occurrence of ground water in the study area is mainly of weathered and fractured Gneiss, Granite, Sandstone and alluvium formation. The different hydrogeological data are generated through intensive field data collection.

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 well during Pre-Monsoon and Post-Monsoon is shown in Fig 3.2 and 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

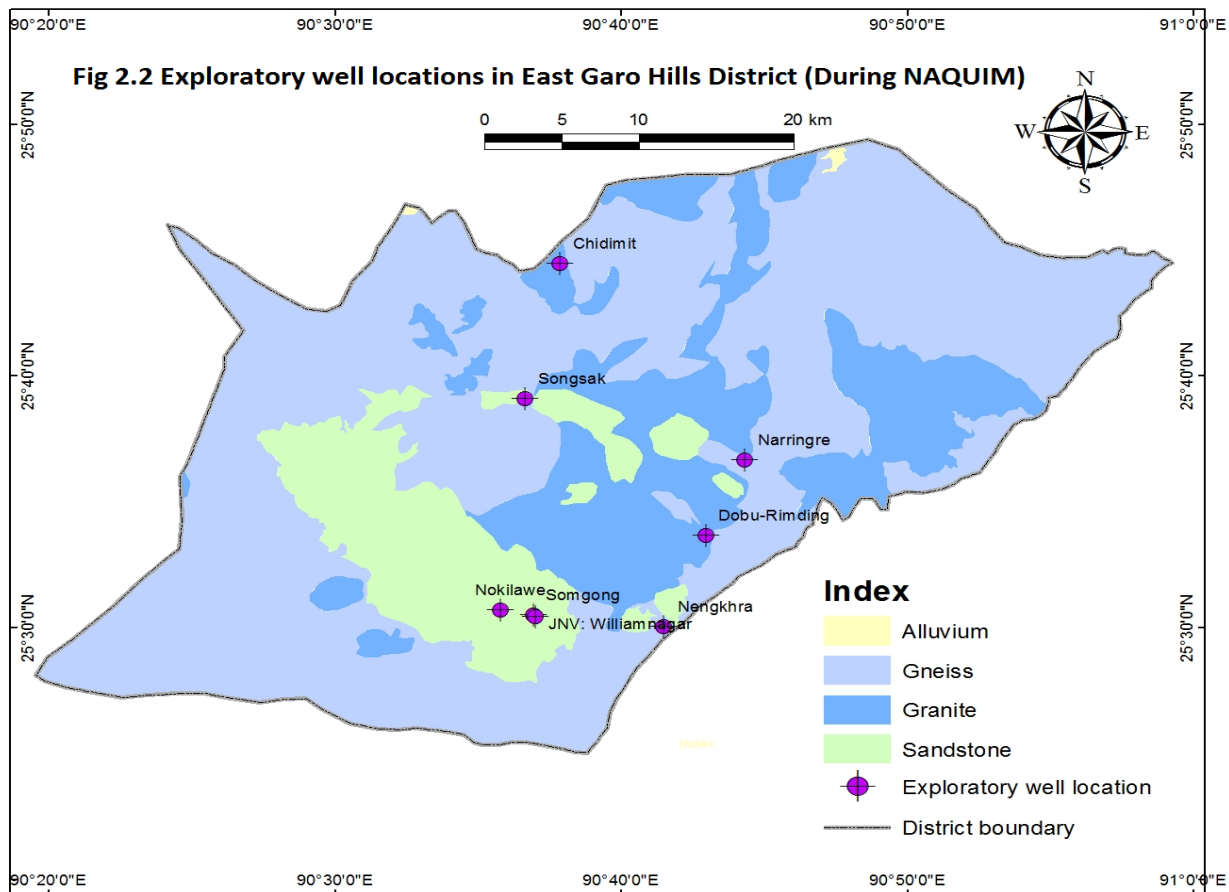
apparent resistivity, inferences have been approximated to shallow to deeper depth at few places. The plots of representative VES curve are given in Annexure 9

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 are drawn 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 district during previous AAP to 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 m bgl 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.



Exploratory findings	
Depth of drilling	75.35 to 202.30 mbgl
Fracture encountered	26 to 196 m
Drawdown	4.19 to 33.42 m
Transmissivity	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 m³/ 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 m³/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 occurring 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

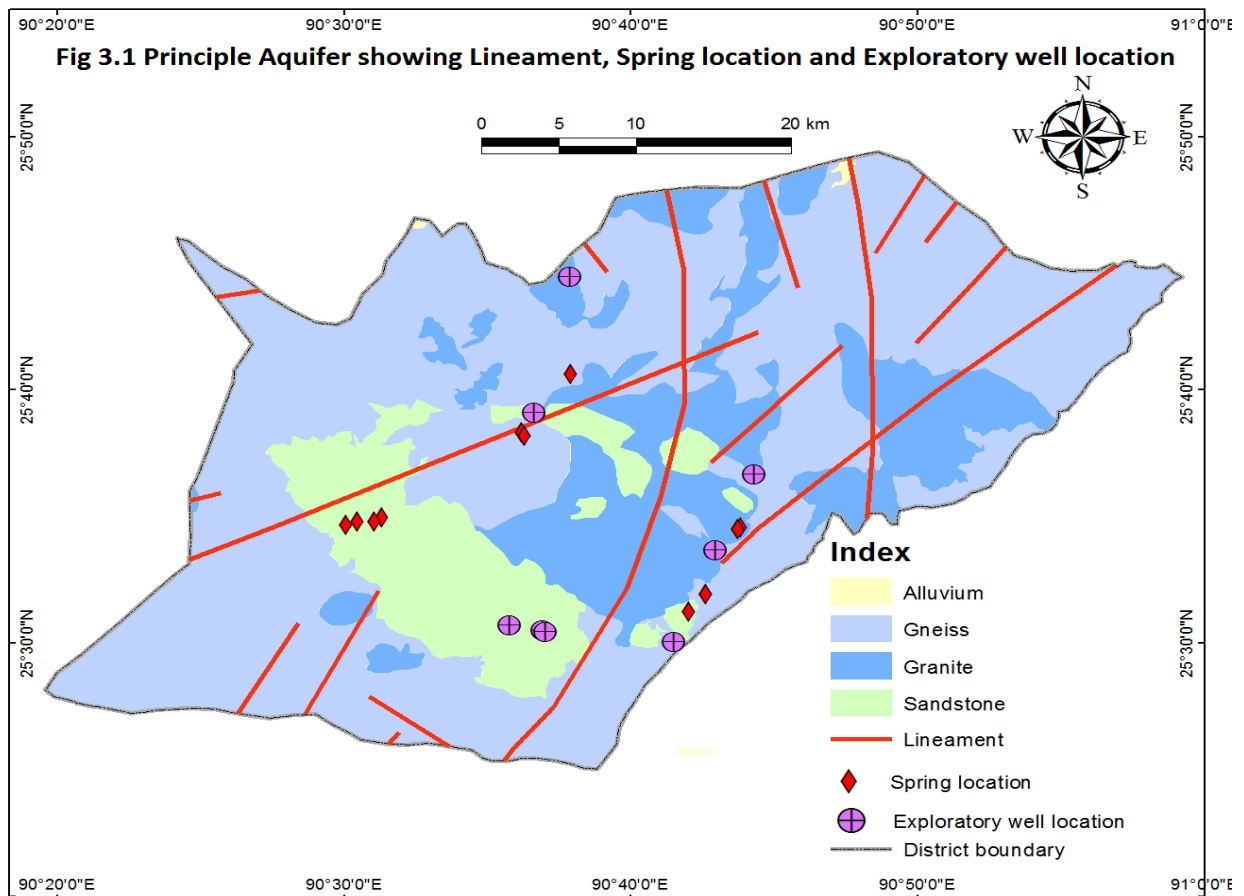
Village/ Location	Drilled Depth	Main Yielding Zones in m bgl	Depth to water level (mbgl)	Drilling Discharge (lit/sec)	Draw down (m)	T (m ² /day)	Specific Capacity (lpm/m of dd)
Songsak	196.2	48.0 – 56.0 (4) 190.0 – 196.0 (6)	11.38	6	11.02	10	16.34
Chidmit	170.85	93.0 – 102.0 (0.5) 161.0 – 170.0 (12)	8.11	12.0	10.88	115	19.31
Narringre	113.8	33.0 – 35.0 (3) 65.0 – 71.0 (11) 111.0 – 113.8(15)	4.53	15.0	4.19	45	70.03
Dobu- Rinding	202.3	62.0 – 65.0 (0.5) 93.0 – 95.0 (1)	15.20	1.0	33.42	2	1.79
Nengkhra	141.3	22.0 – 23.0 (2) 129.0 – 141.0 (16)	5.07	16.0	22.8	5	5.89
Nokilawe	119.9	25.0 – 26.0 (4) 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: Williamna gar	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.



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.

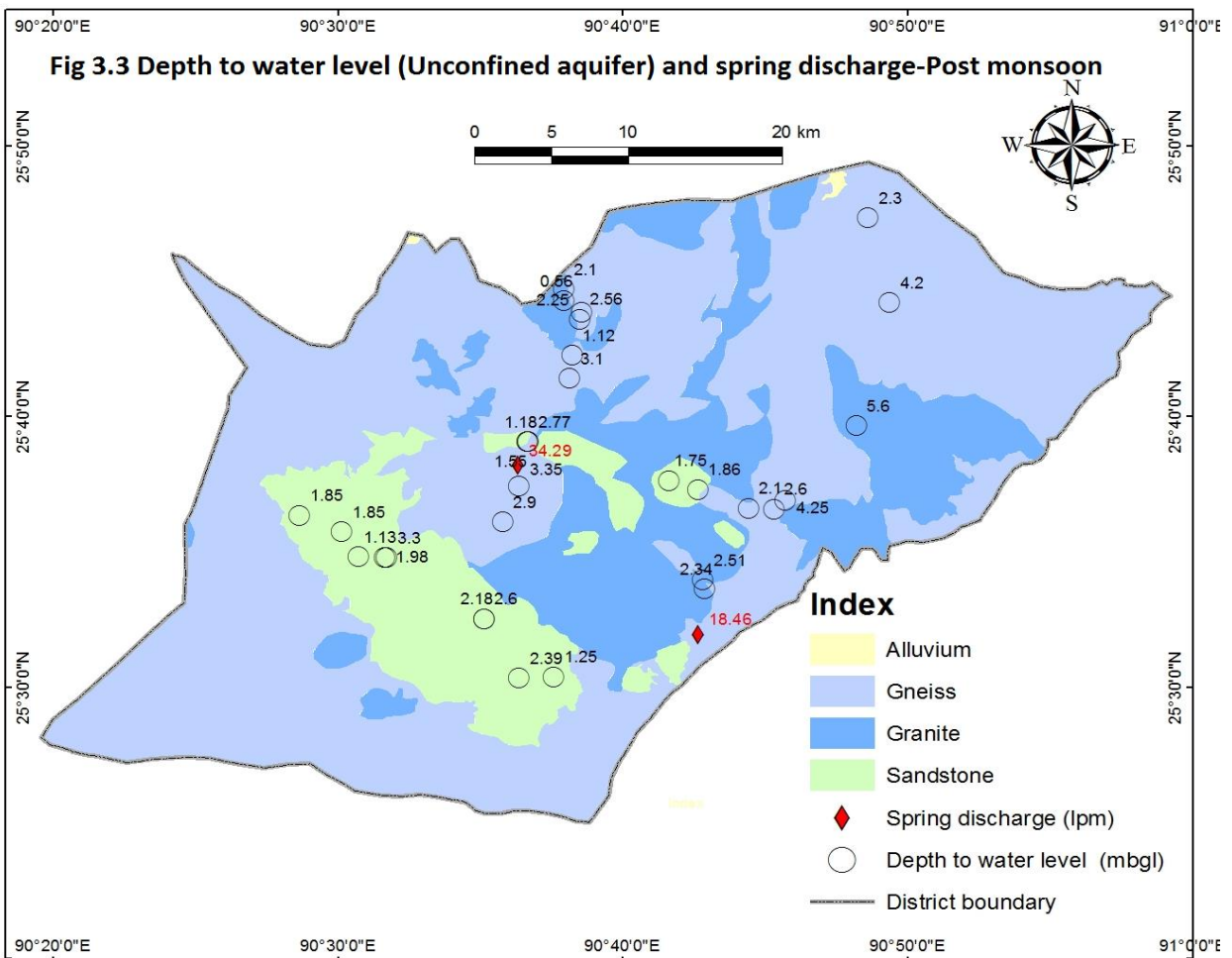
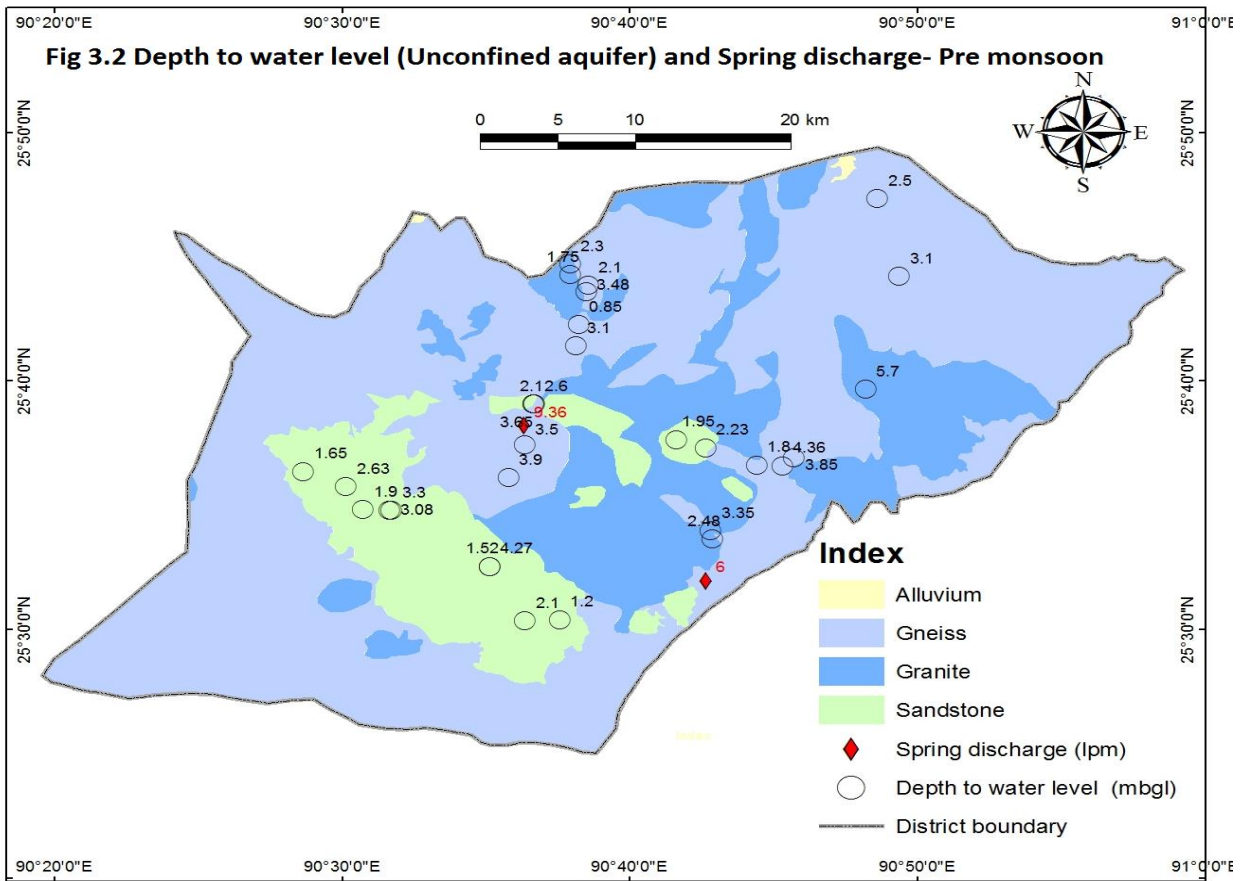
3.1.2 Occurrence of ground water in deeper aquifers: The deeper aquifer occurs as semi-confined to confined condition where ground water occurs in the fractured zone of consolidated sandstone, granite and Archaean gneissic rock. The drilled depth of exploratory wells tapping this aquifer ranges from 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 34.29 litre/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 2019-20 as 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 mbgl and 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.



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 abandoned, 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

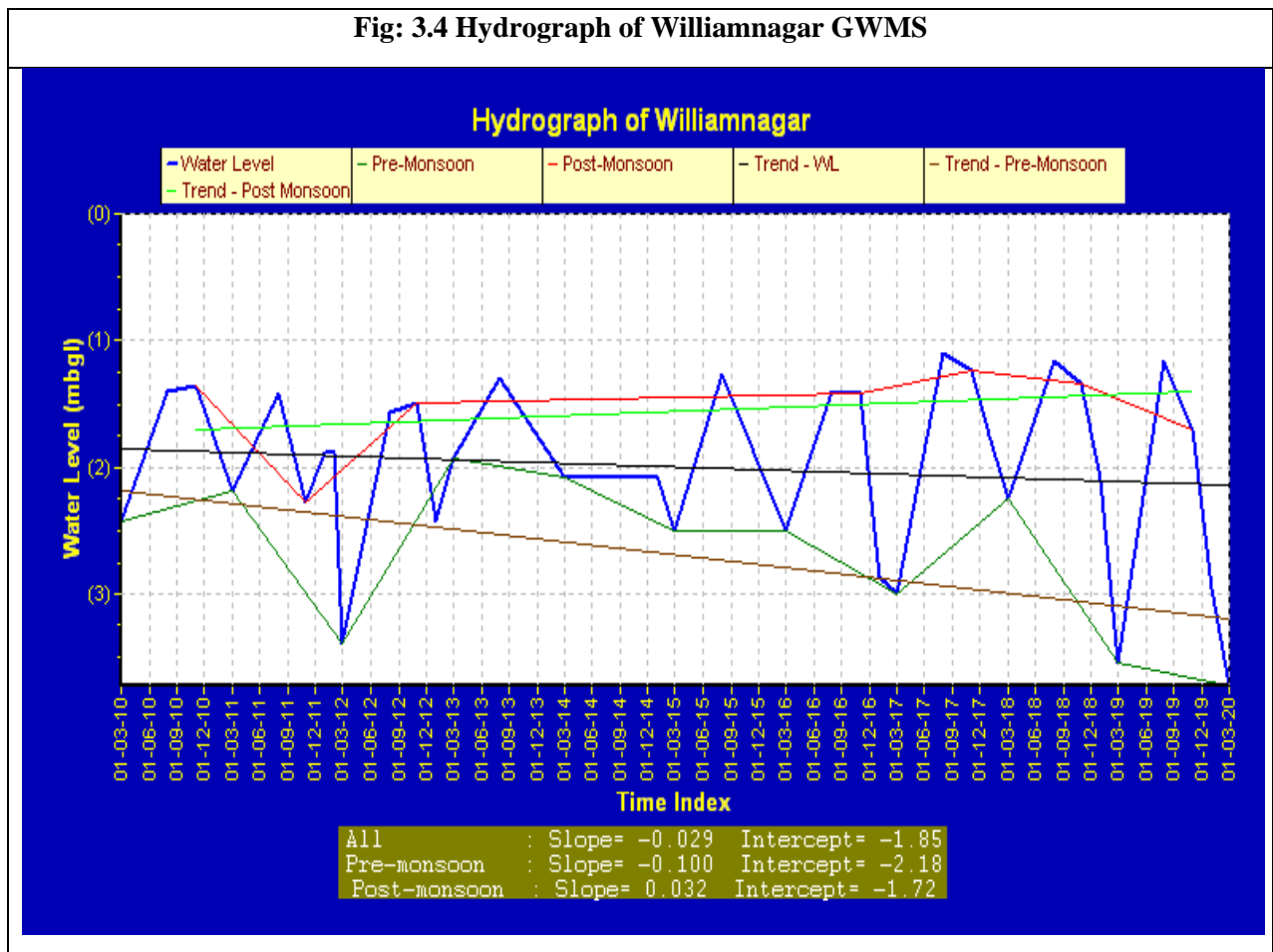
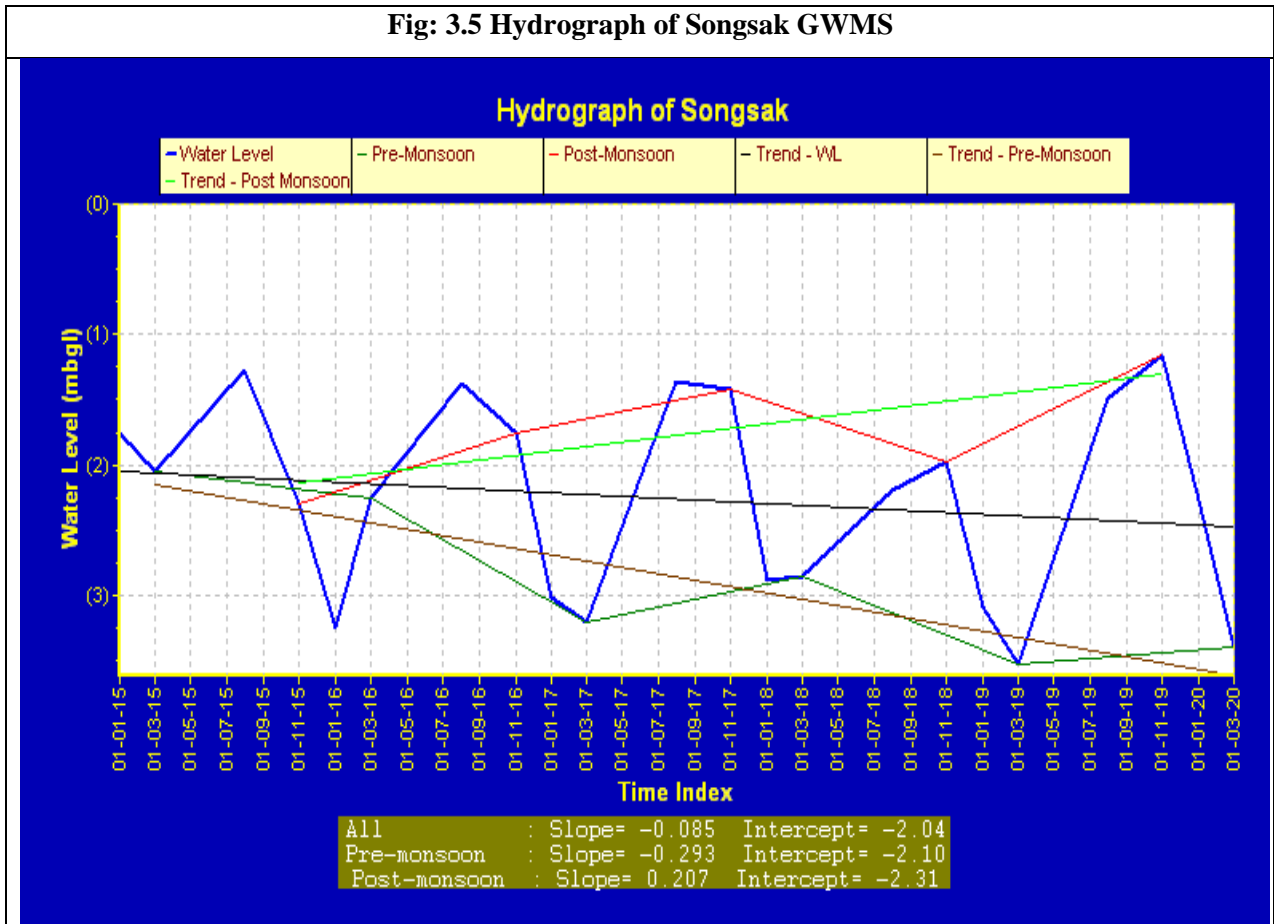


Fig: 3.5 Hydrograph of Songsak GWMS

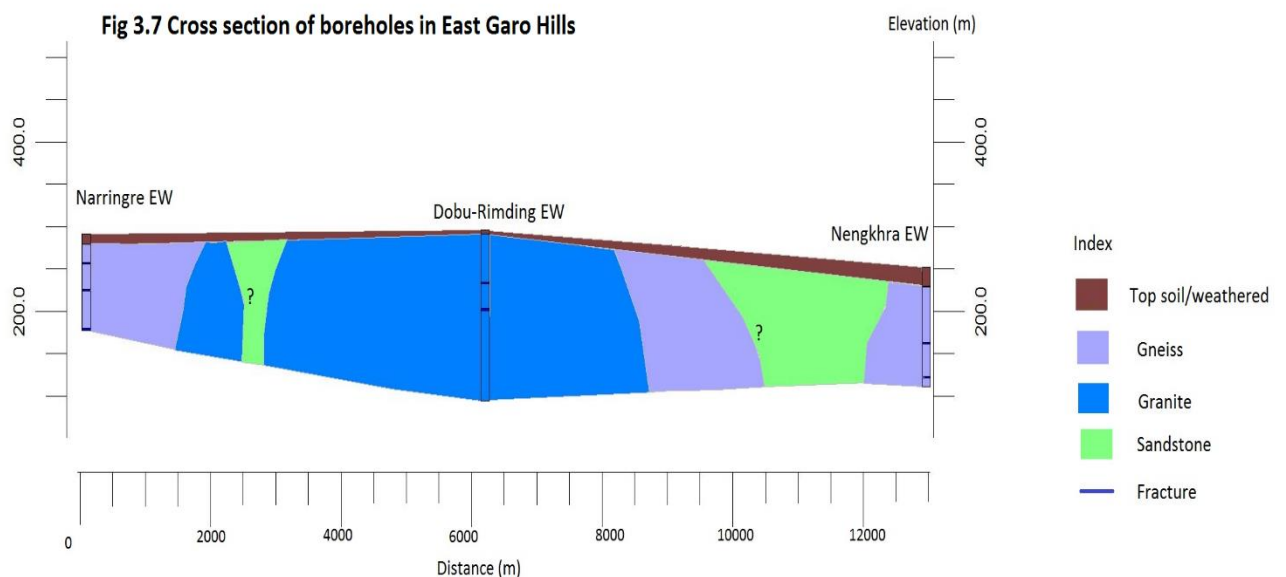


3.3 Aquifer System

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.

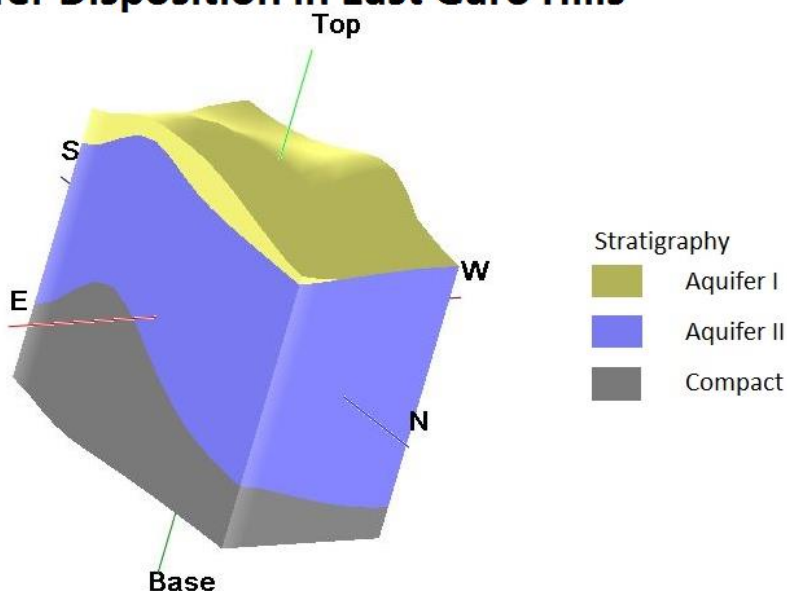


3.4 Aquifer Geometry

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 (m ² /day)
Aquifer - I	G.L. to 30	4 to 10	0.5 to 1	-
Aquifer– II: Hard rock /Tertiary Sediments	12 to 114 61 to 92	1 to 10 5 to 30	0.43 to 12 0.8 to 10	2 to 45 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, CO₃, Cl, SO₄, Na, K, HCO₃, NO₃, 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 18 ground water samples from dug well were collected during pre-monsoon and post-monsoon studies and the range 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 the range of concentration of different chemical constituents present in the spring samples is shown in table 3.1.

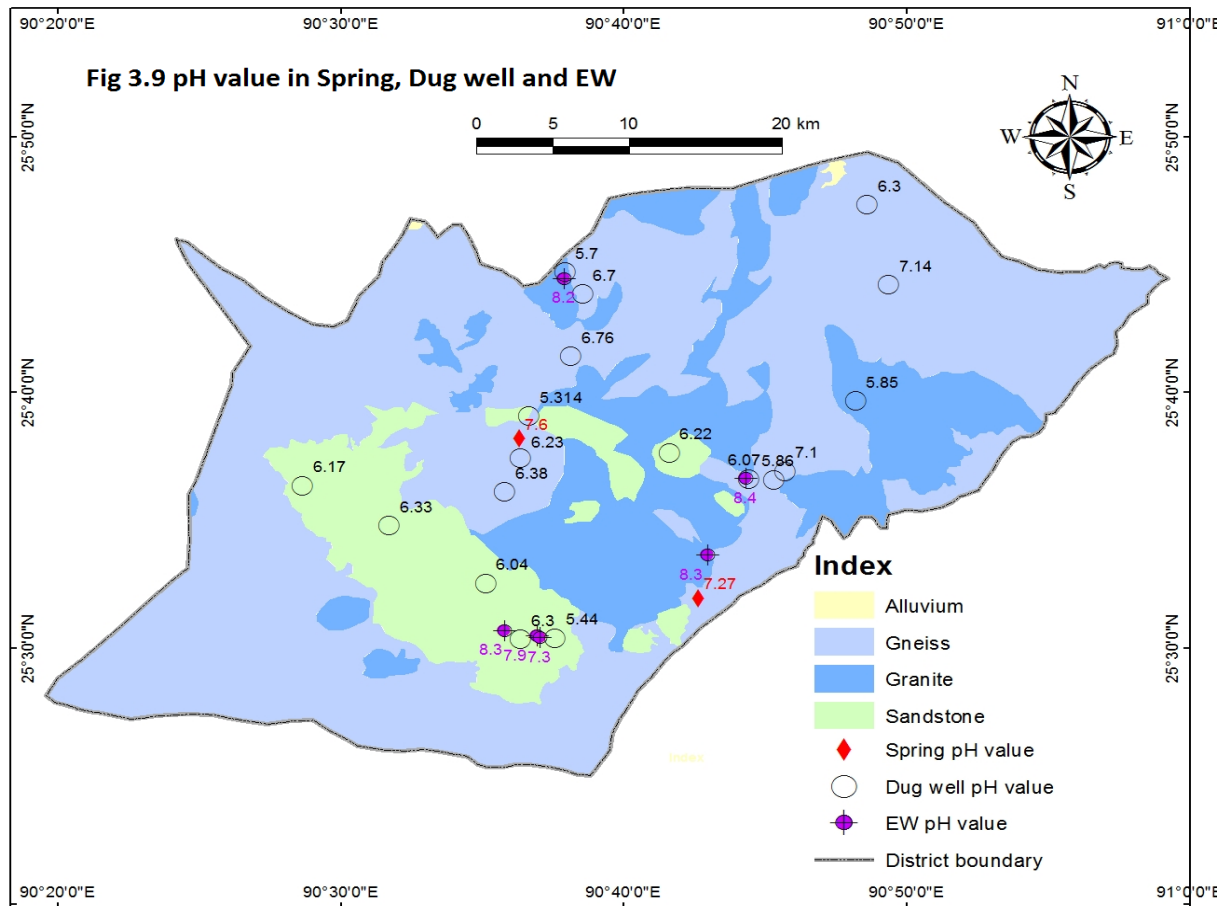
3.6.3. Ground water quality in deeper aquifer: A total of 6 number of water samples were collected during exploratory drilling of CGWB in the district. Based on chemical analysis data the range of concentration of different chemical constituent present in the deeper aquifer are given in table 3.2.

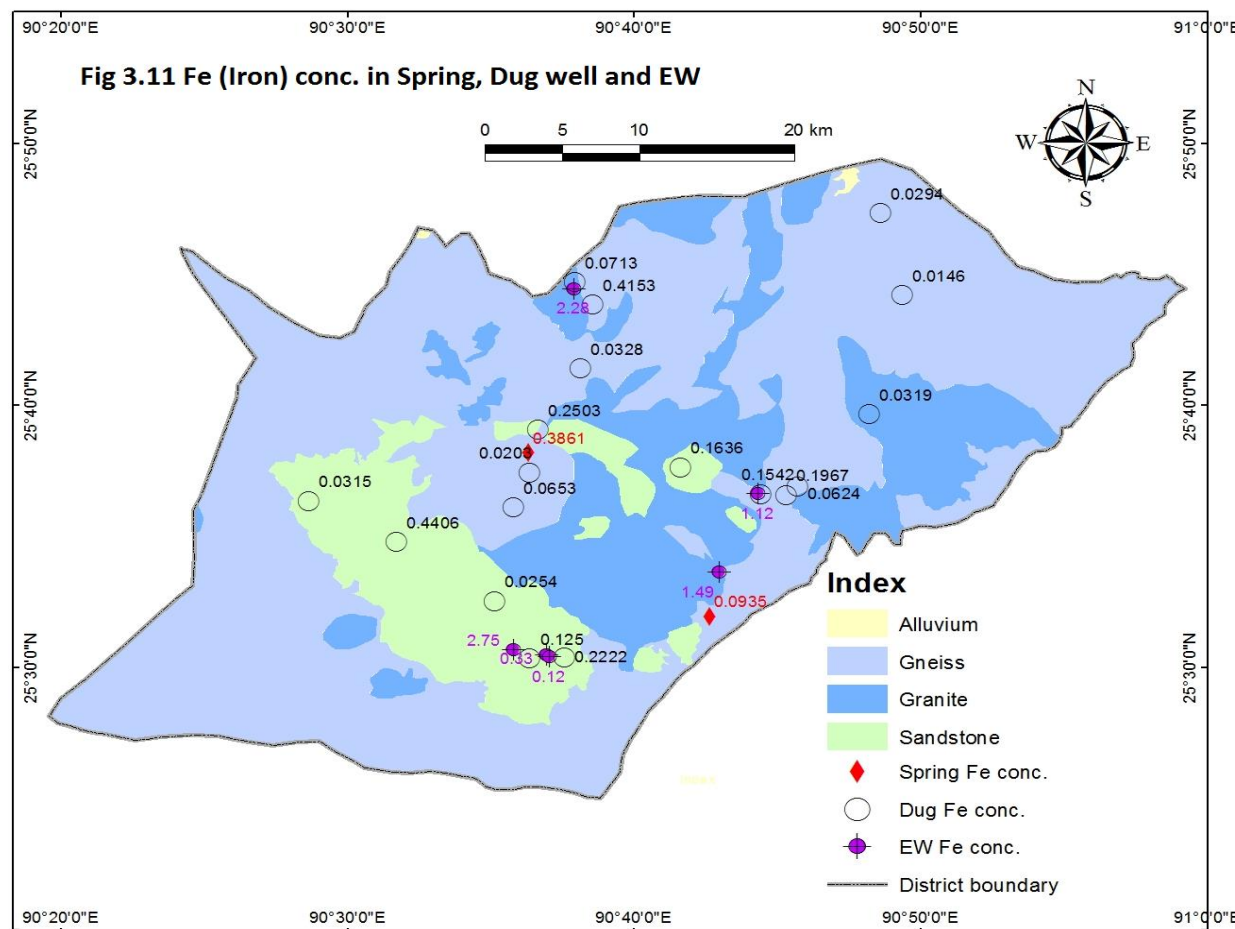
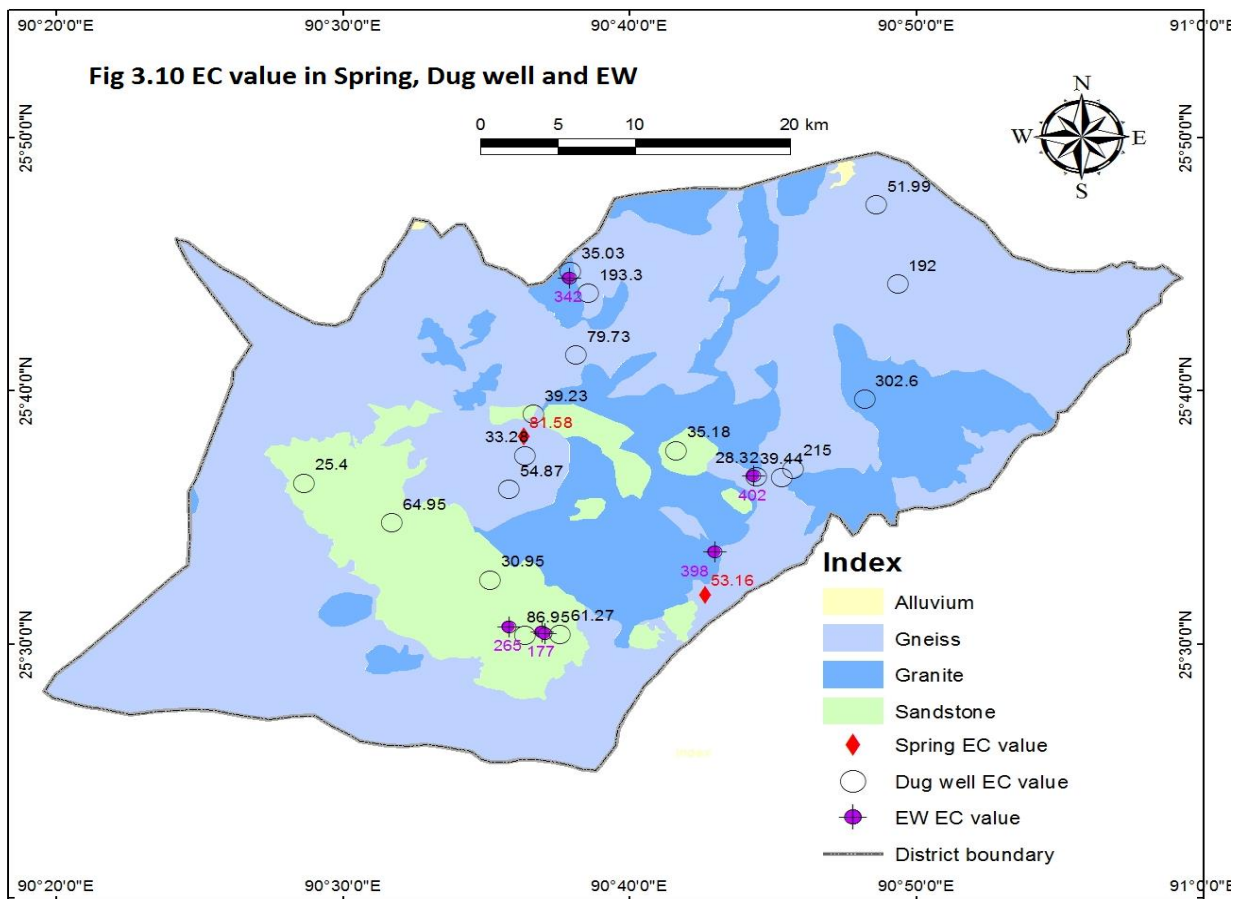
Table 3.2: Chemical Quality of water samples from Dug wells, Springs and Borewell

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 <i>micro seimens/cm at 25°C</i>	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.





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)

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

Table 4.2: Categorization of Ground Water Resources (ham)

<i>Net Ground water availability</i>	<i>Annual GW draft</i>			<i>Domestic and industrial uses upto 2025</i>	<i>Ground water availability for future development</i>	<i>Stage of ground water development (%)</i>	<i>Categorization</i>
	<i>Irrigation</i>	<i>Domestic and industrial uses</i>	<i>Total</i>				
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).

<i>District</i>	<i>Recharge from Rainfall during monsoon season</i>	<i>Recharge from other sources during monsoon season</i>	<i>Recharge from rainfall during non-monsoon season</i>	<i>Recharge from other sources during non-monsoon season</i>	<i>Total Annual Ground Water Recharge</i>	<i>Provision for Natural Discharges</i>	<i>Annual Extractable Ground Water</i>
<i>East Garo Hills</i>	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

No.	Crop file	Crop name	Planting date	Harvest date	Area %
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	Peak water requirement for Irrigation
			(ham)	
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 m³/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 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.

7.2 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	BaizaRongren g	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	<u>Samanda</u>	25°31'57"	90°42'37.2"	321	36
4	Nengkhra	<u>Samanda</u>	25°31'14"	90°42'01"	265	06
5	Rangnalgri	<u>Samanda</u>	25°34'58"	90°31'19.6"	298	02
6	Rongsak	<u>Samanda</u>	25°34'48"	90°31'03"	327	01
7	Songkalwari	<u>Samanda</u>	25°34'48"	90°30'27"	349	01
8	Rongwagri	<u>Samanda</u>	25°34'40"	90°30'03.6"	459	01
9	Songkhama	<u>Songsak</u>	25°40'38.9"	90°37'54.8"	226	11
10	Songsak I	<u>Songsak</u>	25°38'20.2"	90°36'11.7"	407	1.5
11	Songsak II	<u>Songsak</u>	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	Narringgr e	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	DarugreN engphachi	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	Samanda Megapgr e	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	Wagopgr e	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	SaminSogkama	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	Koksinen gsai	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	Ronguguhan 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

Uniqu e ID	Village/ Location	Taluka/Bloc k	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
MEG-78 K10-02	Chidmit	Songsak	Granitic gneiss	170.85	8.2	342	BDL	163	116	33.2	8	19.1	3.81	BDL	176	1.93	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	2.63	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	4.62	24	156	9.61	BDL	1.49

MEG-78 K10-06	Nokilawe	Samanda	Sandstone	119.9	8.3	265	BDL	125	110	38	3.64	1.14	3.58	16	92	11.0 2	0.7	2.75
MEG-78 K10-07	Somgong	Samanda	Sandstone	75.35	7.9	177	BDL	84.4	31	9.2	1.94	19.6	2.85	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	5.09	0.58	2.72	BDL	40	11.8	BDL	0.12

Annexure 5: Ground water resource

a) General Description of Ground Water Assessment East Garo Hills district 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				
		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°39'04.86''N
Longitude	90°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°44'27.7''N
Longitude	90°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°36'38.8''N
Longitude	90°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°33'38.6''N
Longitude	90°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°30'02.4''N
Longitude	90°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°30'28.8''N
Longitude	90°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°30'25''N
Longitude	90°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 heet No.	Lat	Long	Type of well	Depth	Di a	Date of pumping Test	Drawdown (m)	Transmissivity (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°36'38.8''N
Longitudes	90°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	25°36'38" N
Longitudes	90°44'19" 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	25°30'04" N
Longitudes	90°41'29"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	25°33'39" N
Longitudes	90°42'57" 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	25°30'42"N
Longitudes	90°35'46" 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	25°31'42" N
Longitudes	90°37'00"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	25°30'55"N
Longitudes	90°36'54"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



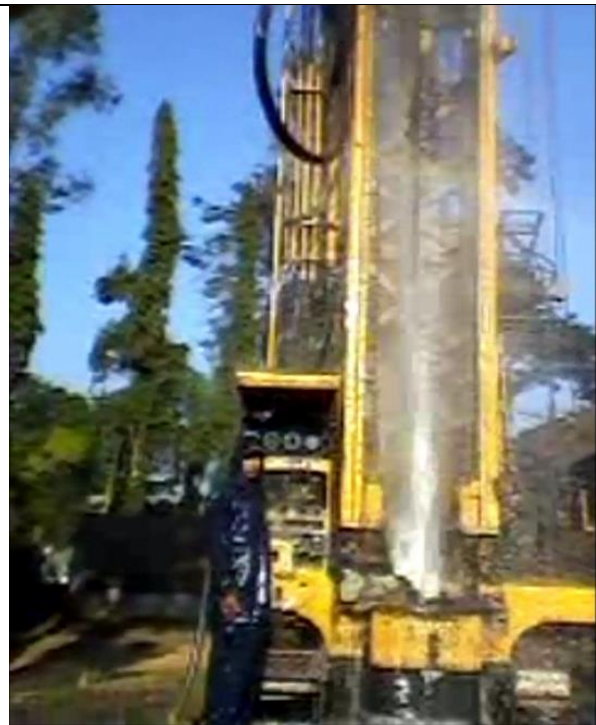
SPRING AT DOBU



SPRING AT SONGKHAMA



GROUND WATER EXPLORATION AT CHIDMIT



GROUND WATER EXPLORATION AT NOKILawe



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