



केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga

Rejuvenation

Government of India

Report

on

AQUIFER MAP AND MANAGEMENT PLAN

Sivsagar District, Assam

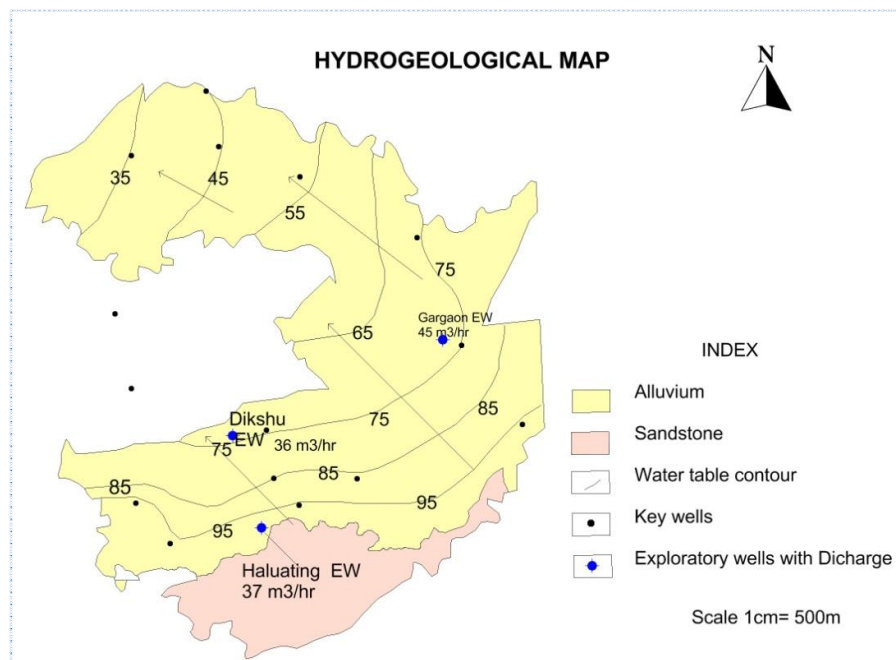
उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati



GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT &
GANGA REJUVENATION

CENTRAL GROUND WATER BOARD
NER GUWAHATI



REPORT ON
AQUIFER MAPPING AND MANAGEMENT PLAN OF
AMGURI, SIVSAGAR AND NAZIRA BLOCKS,
SIVSAGAR DISTRICT
ASSAM
(AAP 2016-17)

Preface

Under National Aquifer Mapping and Management Plan (NAQUIM) programme, Central Ground Water Board, CGWB NER has carried out aquifer mapping and management plan in Amguri, Sivsagar and Nazira Blocks, Sivsagar district of Assam. The objective was to understand the aquifer system down to the depth of 200 meters, decipher the aquifer geometry, its characteristics, quantity, quality and formulate a complete sustainable and effective management plan for ground water development in the study area.

A multi disciplinary approach of geology, geophysics, hydrology and chemistry was adopted to achieve the objectives of the study. And also with the help of Agricultural Scientists, a management plan was made.

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

The groundwater management plan was made with an emphasis in providing irrigation facilities through ground water development as agriculture is the main means of livelihood of the people in the district which covers about 60% of the total population. To use the groundwater for irrigation purpose, a cropping plan has been designed for the district by using CROPWAT model developed by FAO. All the necessary input to design a cropping plan was made with the help Agricultural Engineer of Assam Agricultural University, Jorhat.

The study of this Aquifer mapping and management plan of Amguri, Sivsagar and Nazira Blocks, Sivsagar district of Assam was carried out under the supervision of Dr. Utpal Gogoi, Shri Tapan Chakraborty-Senior Hydrogeologist (Sc-D), Nodal officer of NAQUIM, NER, Shri Biplab Ray- Senior Hydrogeologist (Sc-D) who has helped in all the aspects of field work, technical inputs, report preparation and management plan.

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

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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
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
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

1. INTRODUCTION

Central Ground Water Board, North Eastern Region has carried out Aquifer mapping and prepared management plan in Amguri, Sivasagar and Nazira Blocks of Sivasagar District, Assam during AAP 2016-17, covering an area of 700 sq.km. Under National Aquifer Mapping and Management (NAQUIM) program, combination of geologic, geophysical, hydrologic and hydro-chemical information is applied to characterize the quantity, quality and sustainability of 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 and proposing plans appropriate to the scale of demand and the institutional arrangements for management. Aquifer mapping in appropriate scale can help to prepare, implement and monitor the efficacy of various management interventions aimed for long-term sustainability of precious ground water resources. It will, in turn, help to achieve drinking water security, improved irrigation facilities and sustainability in development of water resources.

1.1 Objectives: During AAP 2016-17, as part of National Aquifer Mapping Programme, parts of the Tertiary aquifer and the unconsolidated alluvial aquifer of Sivasagar district covering an area of 700 sq.km was taken for study.

The objective of the study can be defined as follows:

- a) to define the aquifer geometry, type of aquifers, ground water regime behaviours, hydraulic characteristics and geochemistry of aquifer systems in 1:50,000 scale and
- b) Existing scenario of groundwater regime in shallow/deep aquifer
- c) To work out a management plan for sustainable development of ground water.

1.2. Approach and methodology: The approach is to identify the principal aquifers and to conceptualize the aquifer system. This will help to formulate an aquifer management plan. Finally the scientific knowledge will be disseminated to farmers, State government and stake holders.

The methodology can be illustrated as follows:

Data compilation and data gap analysis: The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB and State Groundwater

Departments. All data were plotted in the base map on GIS Platform (MapInfo-6.5) using Projection category latitude/ longitude (Indian for Pakistan, India, Bangladesh, Nepal projection). On the basis of available data, data gaps were identified.

1.2.1 Data Generation: Efforts were made to fill the data gaps by multiple activities such as exploratory drilling, geophysical techniques, hydro-geochemical analysis, water level monitoring, yield tests and soil infiltration studies.

1.2.2 Aquifer Map Preparation: Based on integration of data generated from aforesaid studies, 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) with reference to aquifer extremities, quality, water level, potential and vulnerability (quality & quantity).

Aquifer Management Plan Formulation: Based on aquifer map and analysis of present requirement and future demand, a sustainable development plan of the aquifer is formulated.

1.3 Area Details: The area chosen for aquifer mapping is bounded by $94^{\circ}30'E$ to $94^{\circ}60'E$ longitude and $26^{\circ}45'N$ to $27^{\circ}00'N$ latitude. The area is included in Survey of India topo sheet numbers 83G/5,9 and 83F/8.

Table 1: Administrative area

S. N.	Toposheet number	District	CD Block	No. of villages
1	83G/5 &G/9	Sivasagar	Sivasagar	129
2	83G/9 &F/8		Nazira	34
3	83F/8		Amguri	17

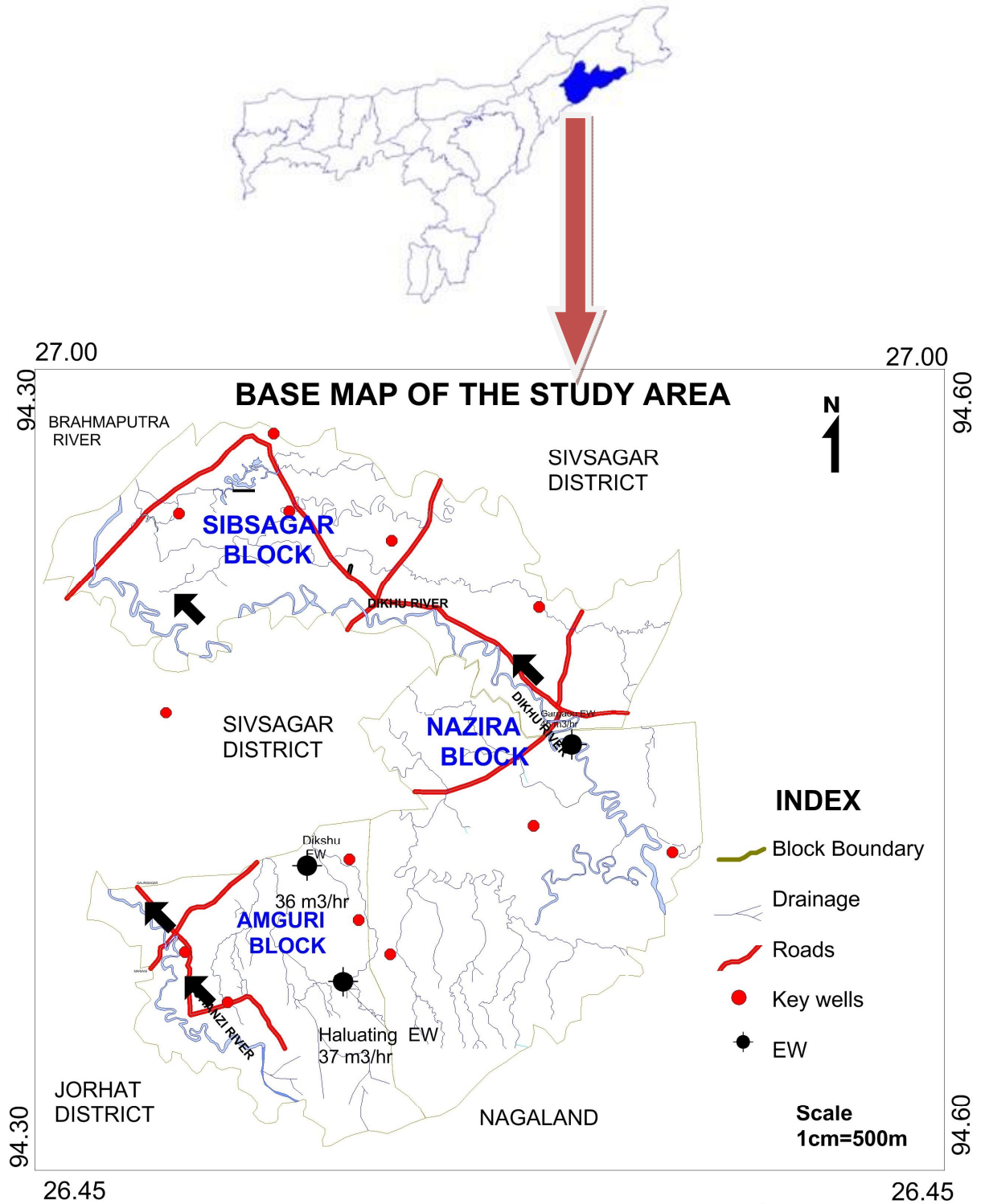


Fig 1: Base map of the study area

The district of Sivasagar covers an area of 2,668 sq km. The total population of the district, as per 2011 Census is 11,50,253 with 5,89,454 male and 5,60,799 females.

The study area is bounded on the north by the Brahmaputra river and the Naga-Patkai ranges towards the south. The area can be divided into two broad divisions i.e., the low lying areas characterised by marshy places as "Char" and "Beel" area which generally get flooded every year. Being a high rainfall area, the district is characterised by thick and luxurious growth of vegetation. The "Char" areas are cultivated during the "Rabi" season. The other parts of the district consist of plain areas. Important crops grown are paddy, pulses, sugarcane, mustard and wheat. The soils are generally sandy loam in the northern flood plain and silty to clayey loam in the southern part. These soils are characteristically different in colours, being grey in case of sandy loam and yellowish brown in case of silty and clayey type.

1.4 Drainage:

The Brahmaputra forms the principal drainage system along with its tributaries mainly Dikhu and Jhanzi originating in the Naga Patkai range and drain the district. The two rivers are having numerous streams in the southern part. The rivers have a highly meandering course. These meandering rivers with abandoned channels form beels and ox-bow lakes along their courses. The rivers of the area represent dendritic and trellis to sub-parallel drainage pattern. A number of physiographic features like oxbow lakes, cut off chutes, meander scrolls, point bars etc. occur in the area. The general slope of the area is from southeast to northwest to which the drainage pattern also conforms. The general elevation of the plain area varies from 85 to 100m above mean sea level and gradually rises to 128 to 150 m towards south and southeast.

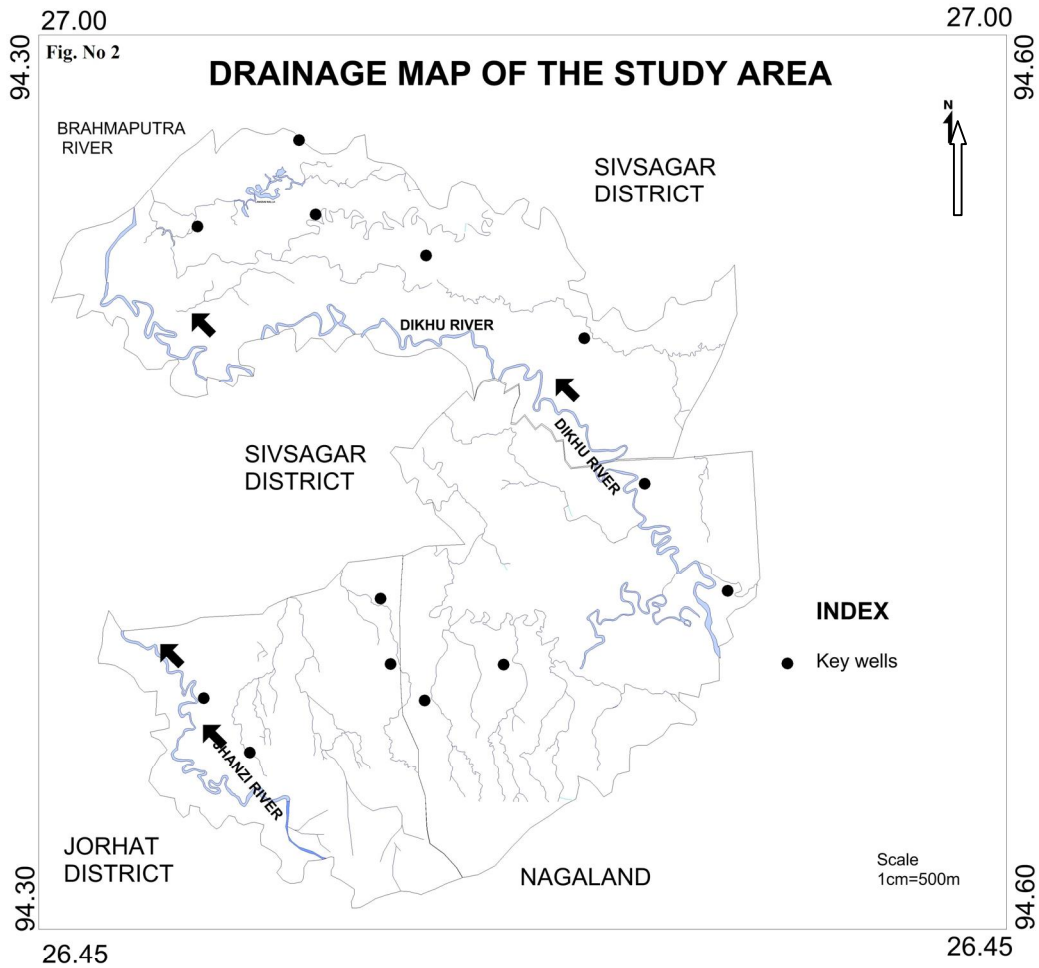


Figure 2: Drainage map of the study area

1.5 Rainfall-spatial, temporal and secular distribution:

The average annual rainfall in Sivasagar District, Assam is 1400 to 2400 mm. Most of the rainfall is received under the influence of SW monsoon which starts in May and lasts till September to mid-October. Maximum rainfall is recorded in the month of July and minimum in the month of January. Rainfall variations in the district is graphically illustrated in Fig. 3.

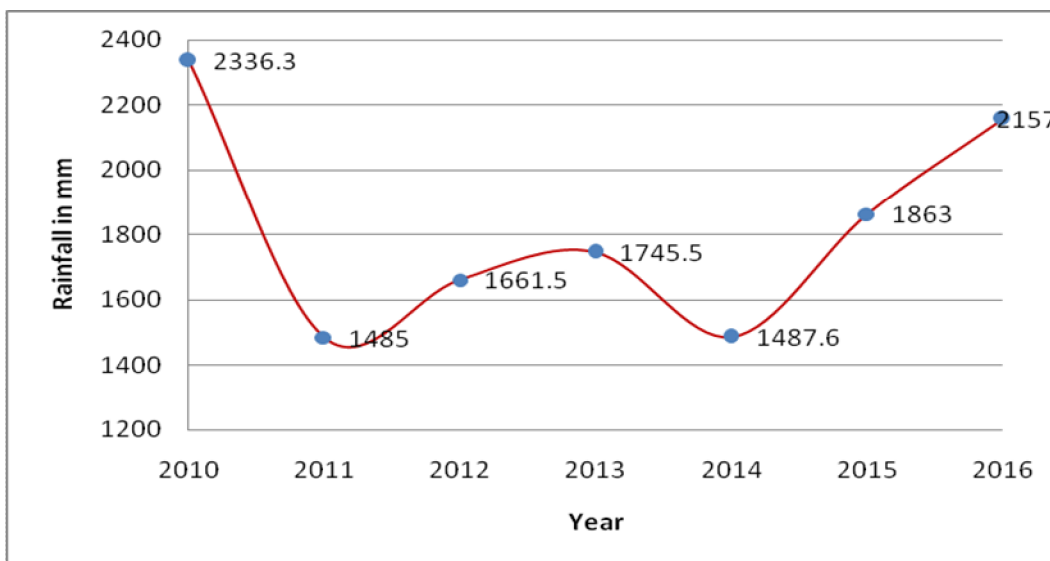
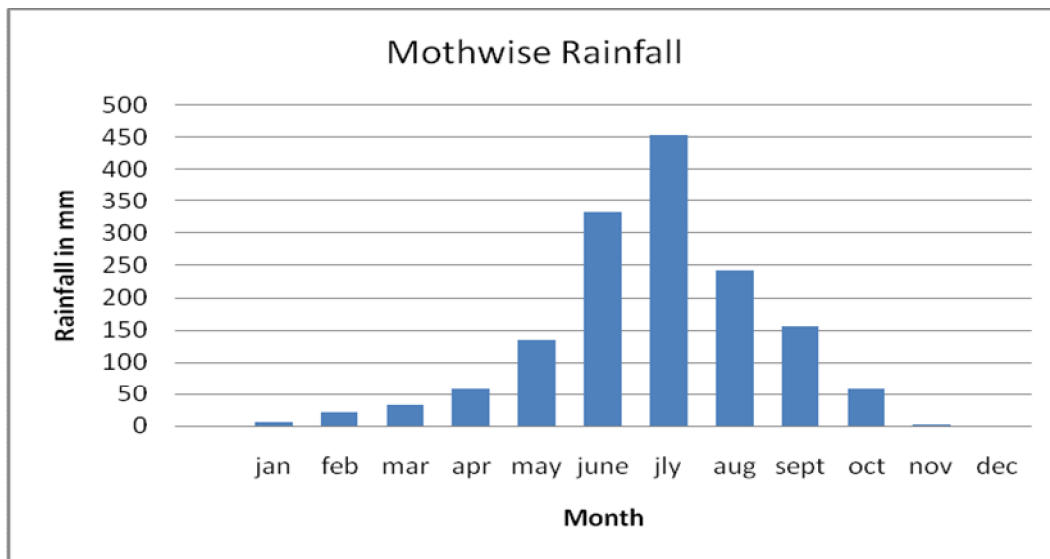
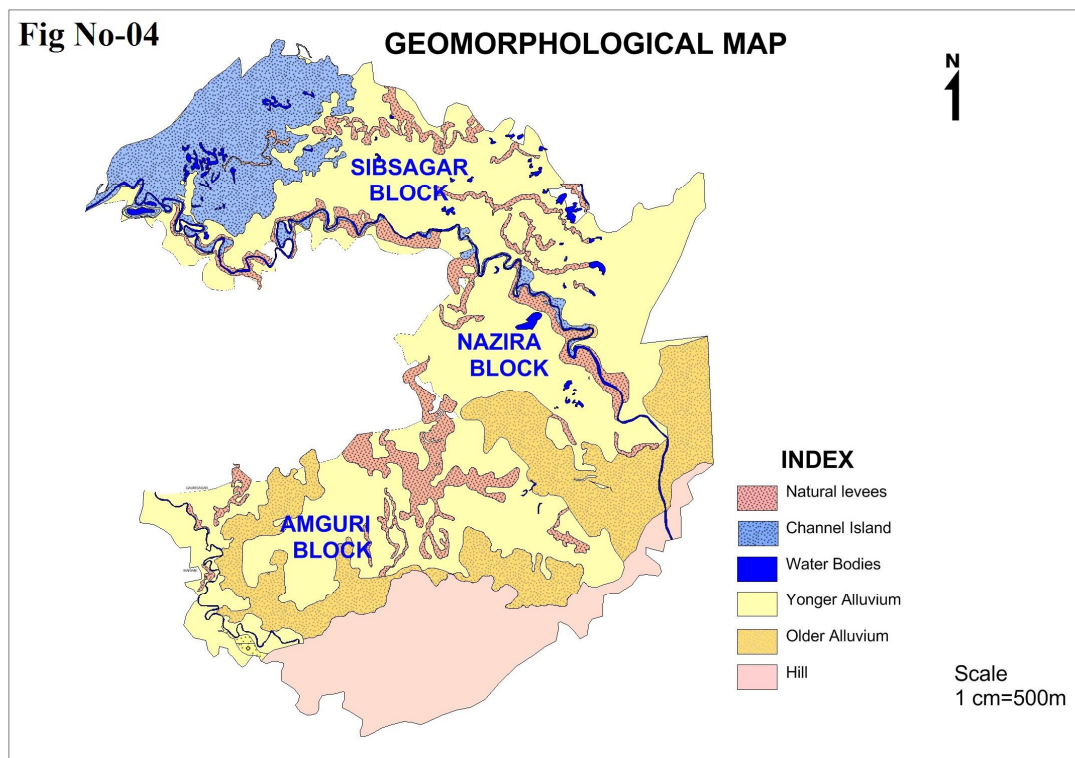


Fig 3 : Average monthly rainfall and yearly rainfall variations in and around the study area

1.6 Soil:- The soils of this district can be broadly classified into three types viz., the foothill/piedmont zone soils, active flood plain soils near the river Brahmaputra and the low-lying marshy land soils.

Commonly foothill/Piedmont zone soil is highly acidic. However, new alluvial soils formed due to inundation of land by river contain more percentages of fine sand and fine silt and are less acidic. Such soils are often neutral and even alkaline in character. The rest large expanse of low-lying land is characterized by heavy clay soil, which shows high percentage of nitrogen. This clay rich soil is very fertile and good for rice cultivation.

1.7 Geomorphology: - Geomorphologically the area can be classified mainly into four divisions: natural levees, channel island, younger and older alluvial plain, piedmont zone. Southern part of the study area is covered by Piedmont zone. The piedmont zone is gravel dominated while alluvial plain and the flood plain area are comprised of mixture of sand and silt in varying proportions. The alluvial flood plain consists of younger and older alluvial deposits. It represents various sub-features, viz., palaeochannel, swampy/marshy land, river terraces, flood plains, point bars, channel island and river channel (Fig: 4).



1.8 Landuse pattern:-

Land utilization statistics provide detailed information of the land use pattern in the area. Based on the land utilization, the total area divided into various types of landforms such as forest, cultivable land, fallow land, crop area etc. which in turn reflects the degree of development of agricultural activities and cultivation potential. The land utilization statistics of the Sivsagar district is presented in Table-2.

Table 2: Land use Pattern in Sivasagar District, (2011-12)

SI. No	Land put to different uses	Area in ha
1	Total Geographical area	260290
2	Forest area	30465
3	Land not available for cultivation	56151
	a. Land put to non-agricultural uses	48815
	b. Barren and un-cultural land	7336
4	Other non-cultivated land excluding fallow land	29211
5	Fallow land	7641
6	Net sown area	136822
7	Total cropped area	146734
8	Area sown more than once	9912

Source: District Census Handbook Sivasagar, Govt. of Assam.

1.9 Irrigation: Cultivators of the district are mainly dependent on rainfall but rainfall being unevenly distributed, they also resort to indigenous methods of irrigation such as lifting of water by means of swing bucket .To meet the demands of the agriculturists for a regular supply of water some irrigation schemes are undertaken by the government.

The district receives sufficient amount of rain during monsoon season but the major crops like paddy, jute, sugarcane etc. have to depend on some other sources of water during the major part of the year. The system of Jan or dong (a canal) to irrigate paddy field by constructing small canals is still in practice in some part of the district. Some minor irrigation projects like construction of bunds across the streams and rivulets, drainage channels and silt channels etc. are implemented in the district by the Government. Lift irrigation with electric pump-sets has also been operated in some parts of the district. The diesel generators are also used to lift water and water the paddy fields.

1.10 Crops: Tea, Paddy, Sugar cane, vegetables and to some extent fruits are the main crops, grown in old alluvial soils of the district as the soil conditions being suitable for these crops. Rice is the principal food crop of the district. Crop wise area and its production in the district, yield etc. during 2011-2012 are presented in **Table No3**.

Table 3: Area and Production of important crops in Sivasagar district for the year 2011-2012

	Types of Crop	Area under cultivation (hectare)	Production (Tones)
A ó Cereals			
1	Autumn Paddy	62	90
	Winter Paddy	96696	328063
	Summer Paddy	336	1475
	Wheat	18	22
B-Miscellaneous			
	Matikalai	239	134
	Jute	43	398
	Rape & Mustard	1455	437
	Potato	1059	6633
		96	3597

Source: District Census Hand book Sivsagar, Govt. of Assam.

2. Data Collection and Generation

The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB and State Groundwater Departments. All data were plotted in base map on GIS Platform (MapInfo-6.5 using Projection category longitude/latitude (Indian for Pakistan, India, Bangladesh, Nepal projection)).

2.1 Depth to Water Level:

Study of water level and its behavior both in phreatic and confined conditions were carried out in the aquifer mapping area. Sixteen Dug wells were established as key wells for periodical monitoring to know the water level trend and its behaviour in phreatic condition. The depth to water level in these dug wells ranges from 0.93 to 6.5 m bgl during pre-monsoon and 0.54 to 3.5 m bgl during post-monsoon season and the average water level fluctuation is 0.60 m.(Fig. No. 5 & 6)

2.2 Ground Water Exploration:-

Ground water exploration has been carried out in parts of Amguri, Sivsagar and Nazira Blocks of Sivsagar district to delineate the potential aquifers and their geometry and to determine the hydrogeological parameters of the aquifer systems. Maximum discharge of 45 m³/hr has been found at IIT Gargaon Exploratory well and minimum discharge of 36m³/hr has been found at Haluating Exploratory well (EW). Details of the exploratory wells are given in Annexure **No-02** and location of the EW are presented in **Fig. No. 7**.

2.3 Geophysical studies:-

Surface Geophysical studies in the study area were carried out during AAP -2016-17 to delineate the subsurface geology as well as supplement the data gap under the assignment of Aquifer Mapping.VES of 43 Nos. were conducted with maximum available electrode spread (AB) of 600 m as part of electrical prospecting. The detail results are given in **Annexures-3 to 7**. The locations of the VES carried out are given in **Table No.4**.

Table No. 4: Locations of V.E.S Points in Sibsagar District, Assam

VES NO	Location/ Village	Depth (m)	Hard rock/ Soft Rock	Latitude (N)	Longitude (E)	Remarks
1	Betbari	281.6	Soft rock	27.02	94.65	Unconsolidated formation encountered upto a depth of 321 m
2	Betbari	117.3	Soft rock	27.02	94.65	
3	Gohaingaon	274.2	Soft rock	27.02	94.64	
4	Demowmukh Gaon	263	Soft rock	27.06	94.61	
5	Panbecha	14.36	Soft rock	27.02	94.60	
6	Panbechagaon	129	Soft rock	27.04	94.60	
7	Kunworgaon	162	Soft rock	27.00	94.60	
8	Kunworpur tepatola Gohaingaon	250	Soft rock	27.00	94.56	
9	Panbecha laopochagaon	80.1	Soft rock	27.02	94.54	
10	Metongnagdali	102	Soft rock	26.95	94.52	
11	Dulia	121	Soft rock	26.96	94.48	
12	ThekeraTal	204	Soft rock	26.97	94.47	
13	Hatighuli Silpukhuri	255	Soft rock	26.93	94.49	
14	Bejgaon	142	Soft rock	26.93	94.54	
15	Rudrasagar	255	Soft rock	26.96	94.60	
16	Mograghatchangmari	117	Soft rock	26.94	94.59	
17	Mograhatnamtial	251	Soft rock	26.90	94.64	
18	Namti Charali	160	Soft rock	26.86	94.58	
19	Hatimurigaon	92	Soft rock	26.99	94.68	
20	Bhadhorgaon	225	Soft rock	27.00	94.70	
21	Kalugaon	48.7	Soft rock	26.60	94.63	
22	Kulakotiagaon	194.8	Soft rock	26.97	94.66	
23	Lahongaon	194.8	Soft rock	26.92	94.66	
24	Mathiyasiga	255	Soft rock	26.93	94.69	
25	Metekaborali	84	Soft rock	26.96	94.66	
26	Kohiyagaon	161	Soft rock	26.87	94.67	
27	Bogisaparigaon	161	Soft rock	26.84	94.70	
28	Namati	218	Soft rock	26.93	94.72	
29	Mangaon	149	Soft rock	26.97	94.72	
30	Manipurigaon	12	Soft rock	26.96	94.69	
31	Vedbari2 no. daogaon	152	Soft rock	27.03	94.71	
32	Bogtakhamu	211	Soft rock	27.04	94.74	
33	Athabarihilodarigaon	172	Soft rock	27.09	94.74	
34	Pahelilanka	81.4	Soft rock	26.95	94.74	
35	Vedbari 2 no. kunworgaon	214	Soft rock	27.02	94.68	
36	Babjan	154	Soft rock	26.95	94.55	
37	Badabamchetiyagaon	158	Soft rock	26.77	94.53	
38	Bhunyahat	228	Soft rock	26.83	94.52	
39	Diksumoutgaon	225	Soft rock	26.87	94.61	
40	Badabam	125	Soft rock	26.83	94.69	
41	Hatighuligaon	228	Soft rock	26.94	94.50	
42	Hatighuligaon 2 no.	259	Soft rock	26.93	94.48	
43	Tipomiyagaon	321.1	Soft rock	26.94	94.45	

2.4 Ground water quality:-

To know the water quality of the study area, water sampling was done from shallow aquifers. Water samples were collected from the key wells that were established during 2016-17. A total of 15 water samples were collected from dug wells during pre monsoon and 13 samples were collected during post monsoon period. The samples were analyzed for the different chemical constituents in the Regional chemical laboratory of CGWB, NER Guwahati.

3. Data Interpretation, Integration and Aquifer Mapping-

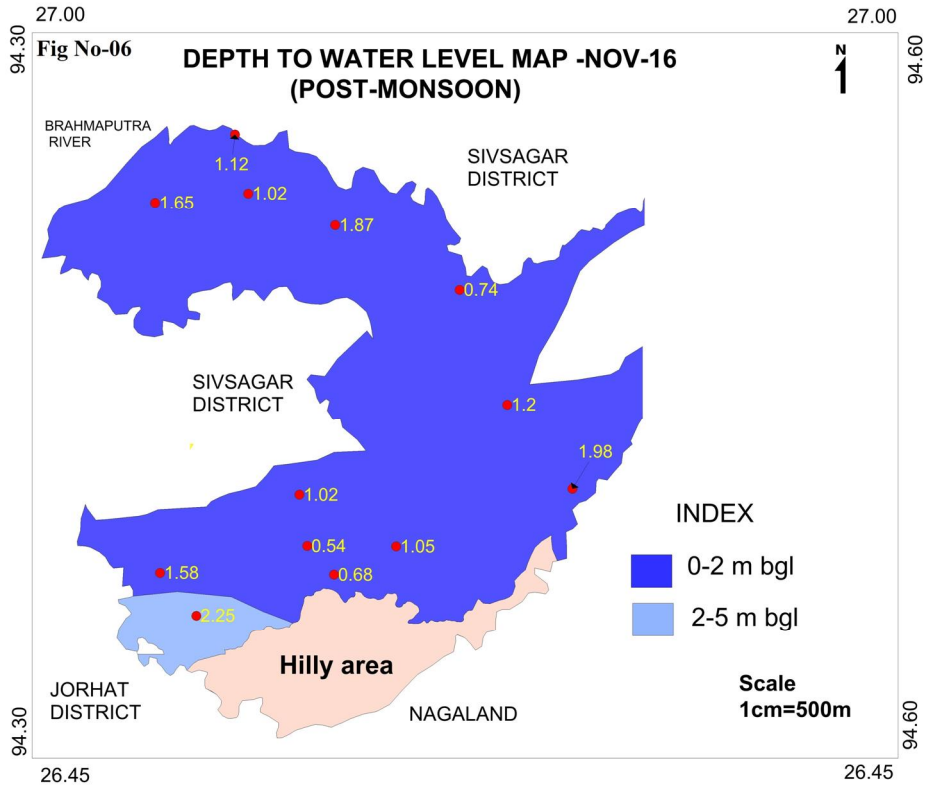
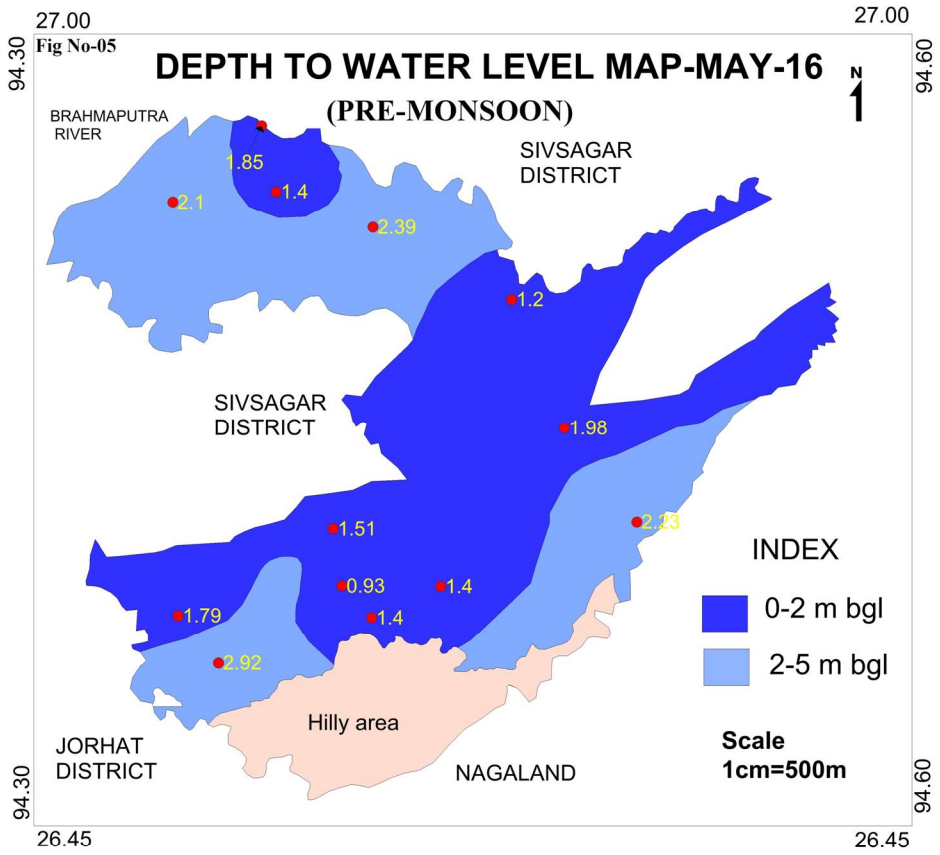
3.1 Depth to Water Level -

To study about the ground water regime, depth to water level from 15 key wells have been measured seasonally. During post-monsoon water levels (W.L.) have been found in the range of 0.32 to 1.98 m bgl and during pre-monsoon water level ranged from 0.31 to 2.06 m bgl. Maximum seasonal fluctuation of **1.79 m** has been observed at Dikhumukh. Depth to water level Contour Maps of **most** of the key wells have been prepared for pre-monsoon and post-monsoon period. The depth to water level has been found to vary from 2 to 5 m bgl in the study area except in inselbergs. The details of the key wells and depth to water level in pre and post monsoon period of 2016, have been given in **Table No. 5**.

Table No. 5- Details of Key wells of Sivasagar District with Depth to Water Level during 2016

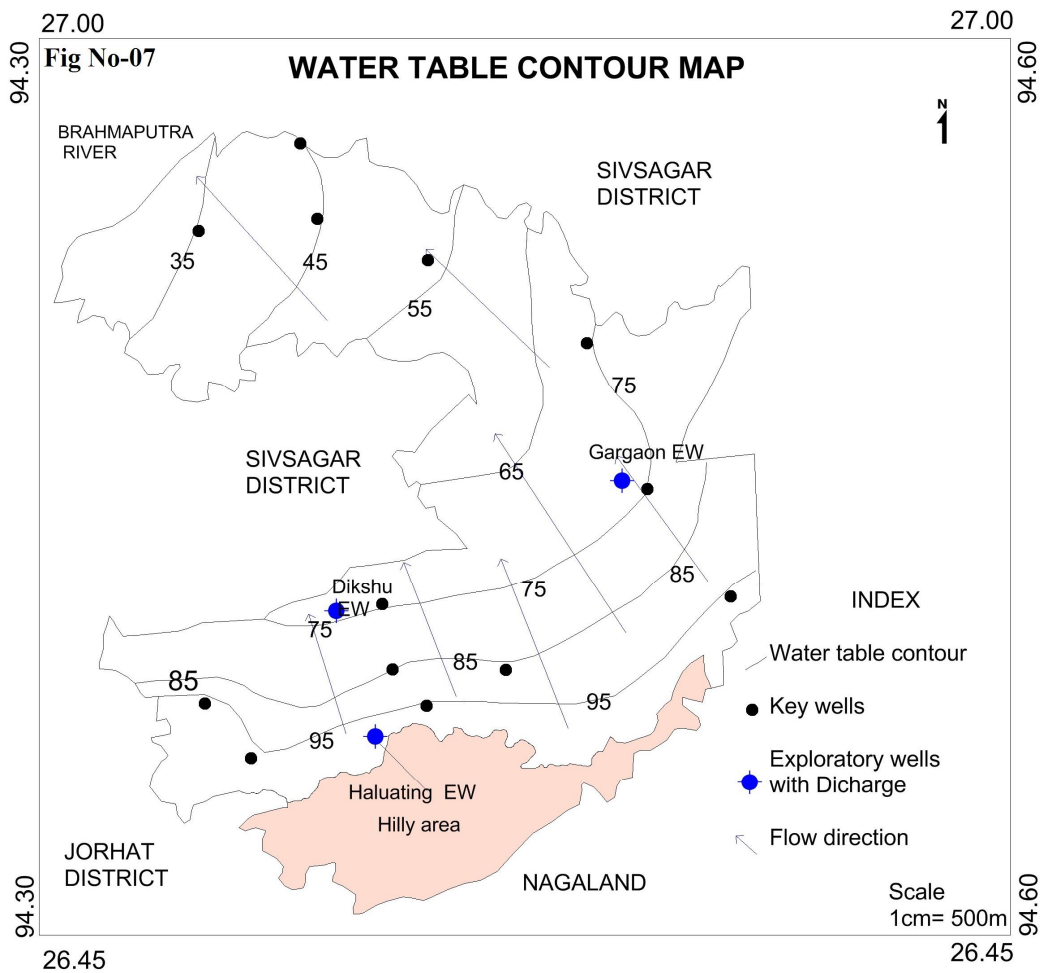
SI. No	Location	Type of structure	Latitude (N)	Longitude (E)	DTWL	DTWL	Fluctuation (in m)
					in mbgl	in mbgl	
					(May 2016)	(Nov 2016)	
1	Amguri	DW	26.7994	94.5319	1.79	0.84	0.95
2	Haluating	DW	26.7736	94.5564	2.92	1.98	0.94
3	Bihubar	DW	26.8500	94.8100	2.23	1.22	1.01
4	Namti	DW	26.8464	94.6258	1.51	0.55	0.96
5	Potuasala	DW	26.9211	94.5169	1.96	0.83	1.13
6	Charugua	DW	26.9700	94.7340	1.2	0.42	0.78
7	Panbecha	DW	27.0283	94.5914	1.4	0.74	0.66
8	Amkutia Chuk	DW	26.8639	94.0139	1.18	0.04	1.14
9	Deopani Basti	DW	26.7983	94.6492	1.4	0.7	0.7
10	Notun Lunpuria	DW	26.8156	94.6311	0.93	0.92	0.01
11	Jailgaon	DW	27.0639	94.5825	1.85	0.5	1.35
12	Dikhumukh	DW	27.0090	94.6500	2.39	0.6	1.79
13	Geleky Nogaon	DW	26.8153	94.6911	1.4	0.38	1.02
14	Kathpua	DW	27.0227	94.5286	2.1	0.9	1.2
15	Jamuguri	DW	26.8731	94.5286	1.16	0.32	0.84
16	Simaliguri	DW	26.9009	94.7660	1.98	1.2	0.78

Depths to water level for pre-monsoon and post-monsoon periods are presented in **Fig. No. 5 and 6** respectively. Seasonal fluctuation of water level has been found to vary from 0.70 to 1.79.



Ground Water Movement

The water table contour has been prepared based on water level and mean sea level of the study area (MSL) of ground water monitoring stations. The regional ground water flow direction is from south, southeastern towards northwest of the Brahmaputra River. The highest water table is 110 m above mean sea level in the piedmont zone area towards south while lowest contour is 35 m towards northwest in the flood plain. In general, the gradient of flow is high towards north than the other part. The entire piedmont zone forms the recharge zone for the entire area. Water table contour map for shallow aquifers is presented in **Fig. No. 7.**



Water table contour map

3.2 Ground Water Exploration:-

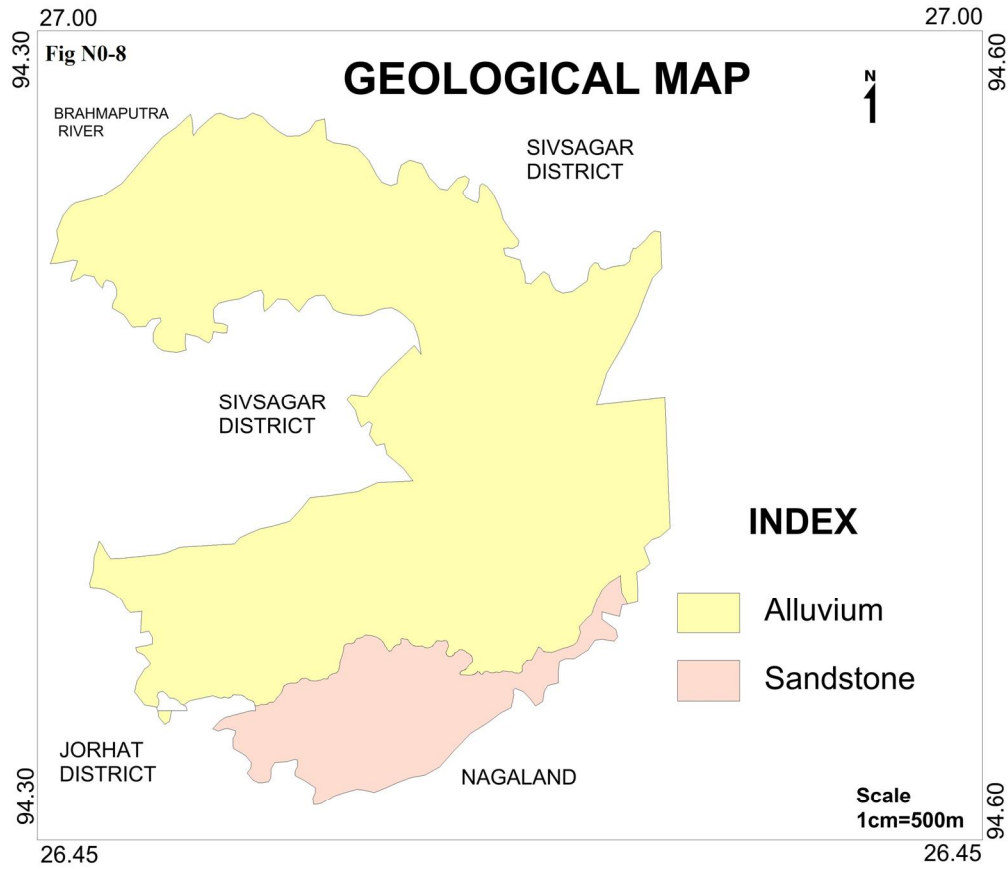
From the lithology of different exploratory wells drilled by C.G.W.B. that EW it can be deciphered that in regional scale mono aquifer system occur in the area. The aquifer is comprised mainly of medium to coarse sand. This sandy aquifer is having gravel and clay intercalations in places. In some places due to the presence of clay intercalations, 2 to 3 granular zones occur in the study area. Separations of two or more granular zones by clay beds often misguide to classify the aquifers into a multiple aquifer system. However, these clay beds are mostly in lensoid shape and they pinch out within a short distance. Thickness of the saturated zone varies from 50 to 100 m within a depth of 133.m. The existing deep tube wells constructed by CGWB show yield of 37 to 85 m³/hr for a drawdown of 1.82 to 7.70 m (maximum drawdown observed near Inselbergs). Details of aquifer parameters are given in Annexure No.2 and locations of Exploratory wells are presented in Fig. No.7.

3.3 Hydrogeology and Occurrences of Ground Water

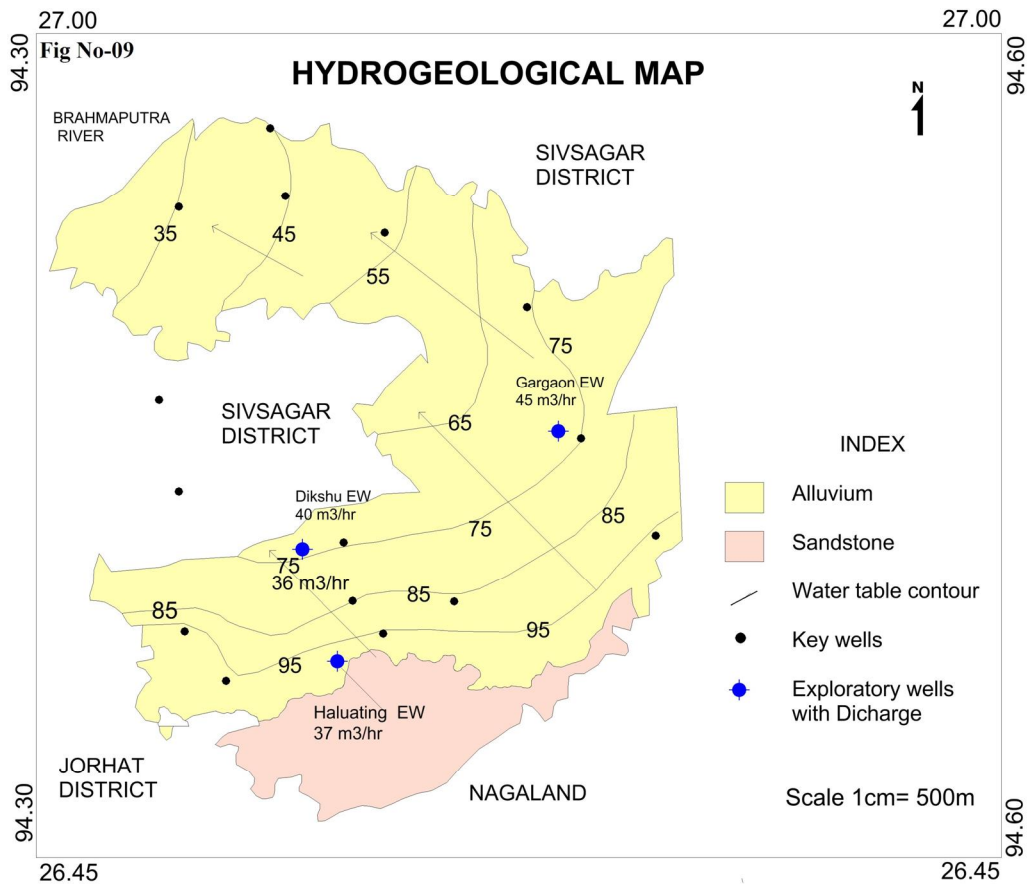
The main hydrogeological formation of the aquifer mapping area is Quaternary to Tertiary semi-consolidated formations, more specifically Recent Alluvium of Quaternary age. The ground water in this aquifer mapping area occurs under unconfined, semi-confined and confined conditions. Study of dug wells, shallow tube wells and deep exploration data of CGWB reveals the presence of phreatic, shallow and deeper aquifers in the area. Most of the study area is having shallow water level but towards south water levels become deep due presence of hard rock. Geology and Hydrogeology of the study area are shown in Fig.8 and 9 respectively.

3.3a Occurrences of Ground Water in Shallow Aquifers: Shallow aquifers generally occur within the depth range of 5 to 30 m. In shallow aquifer, ground water generally occurs under unconfined condition. In major part of the area, ground water in shallow depths occurs under unconfined condition.

3.3b Occurrences of Ground Water in Deeper Aquifers: In deeper aquifers, ground water occurs under semi-confined to confined conditions. A total of 5 exploratory wells have been constructed by CGWB, NER in the area and data on aquifer parameters are available. State Govt. departments have also constructed a good numbers of tube wells in the area, however, apart from discharge data no other set of data are available with them and the discharge varies from 37 to 70 m³/hr.



Geological Map

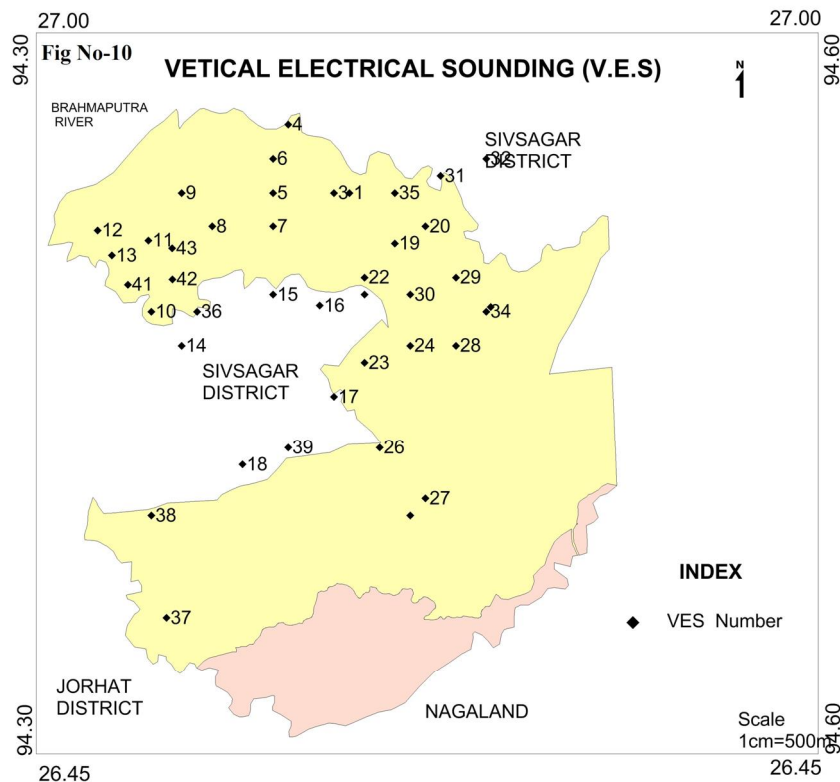


3.3 Geophysical studies:-

Forty three Vertical Electrical Sounding (V.E.S.) under surface geophysical studies have been conducted during AAP, 2016-17. According to the results of interpretation of V.E.S curves, correlation of the data with hydrogeological details of exploratory boreholes and taking the apparent resistivity into account, following conclusions have been drawn in respect of parts of Sivasagar district. Locations of VES are presented in **Fig.10**.

1. The top soil with resistivity in the range of 18.3 and 201 Ohm with thickness within 10m comprises top soil with clays / hard clays etc.
2. The underlying layers below the top soil show resistivity varying within 100 Ohm m in general and is indicative of sandy formation intercalated with clays / hard clays etc.
3. The inferences for bottom portion are drawn on the basis of interpreted results of surface resistivity surveys, apparent resistivity pertaining to extreme portion of VES curves and hydrogeological data.

The VES locations are shown in Map No-05. During the survey H,K, KHK, KAHK, AKQ, KH, KQ, KQKH, AK, HKH, HAK, AHA, QHA, HK, HA type VES curves were obtained.



3.4 Aquifer Geometry:-

The main objective of the study is to delineate the horizontal and vertical disposition of aquifer as well as to study the aquifer character. In this connection 15 key wells were monitored in different season. Locations of exploratory wells showing aquifer disposition have been shown in **Fig. 11 & 12**. To know the aquifer disposition in the study area, exploratory wells data, V.E.S. data available with CGWB and some data of state departments, Govt. of Assam were utilized.

CGWB has drilled two exploratory wells within a depth range of 129 to 133 m during 2016-17. A thin layer of discontinuous clay bed occur at surface all over the alluvial deposit ranging in thickness from 5 to 10 m. The tube wells drilled in alluvial deposits show alternate thick beds of sand, gravel and thin beds of clay.

From the lithologs of different exploratory wells drilled by C.G.W.B. it can be deciphered that in regional scale mono aquifer system occurs in the area. The aquifer is comprised mainly of medium to coarse sand. This sandy aquifer is having gravel and clay intercalations in place to place. In some places due to the presence of clay intercalations 2 to 3 granular zones occur in the study area. Separations of two or more granular zones by clay beds often misguide to classify the aquifers into a multiple aquifer system. However, these clay beds are mostly in lensoid shape and they pinches out within a short distance. Thickness of the saturated zone varies from 50 to 80 m within a depth range of 130 m. The existing deep tube wells constructed by C.G.W.B. show yield of 70 to 177 m³/hr for a drawdown of 1.82 to 7.70 m (maximum drawdown observed near inselbergs).

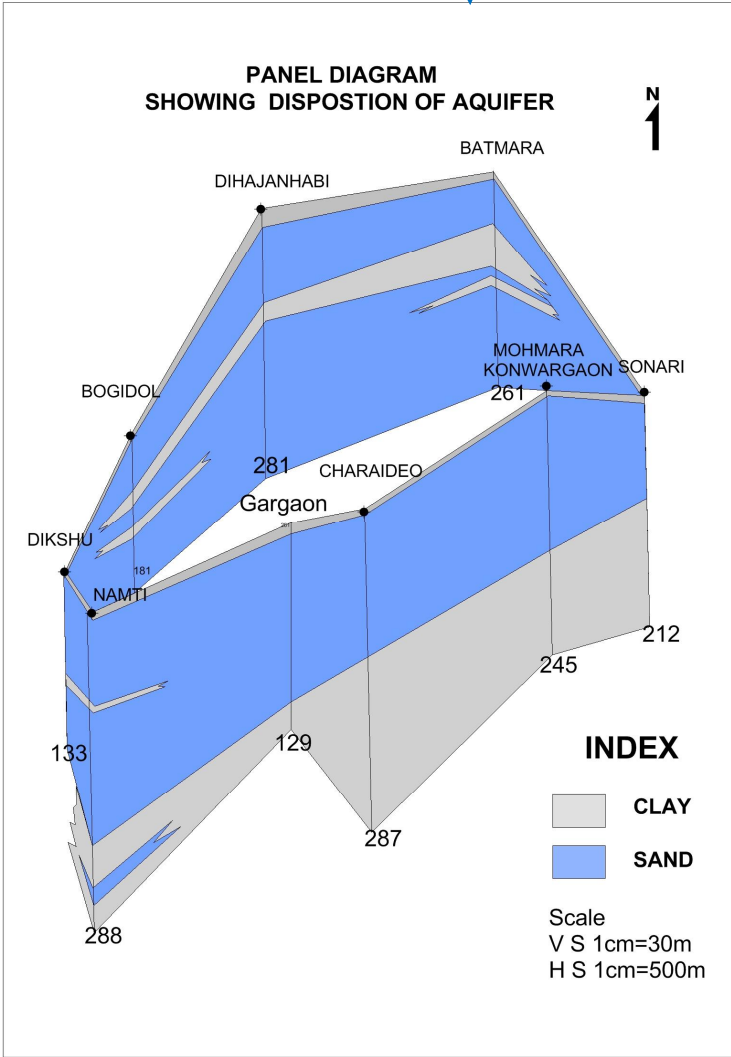
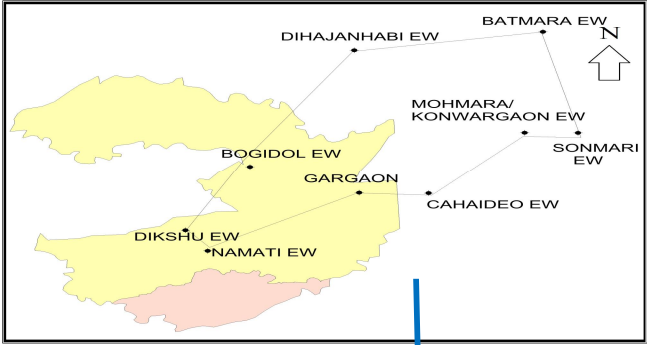


Fig 11- Panel Diagram

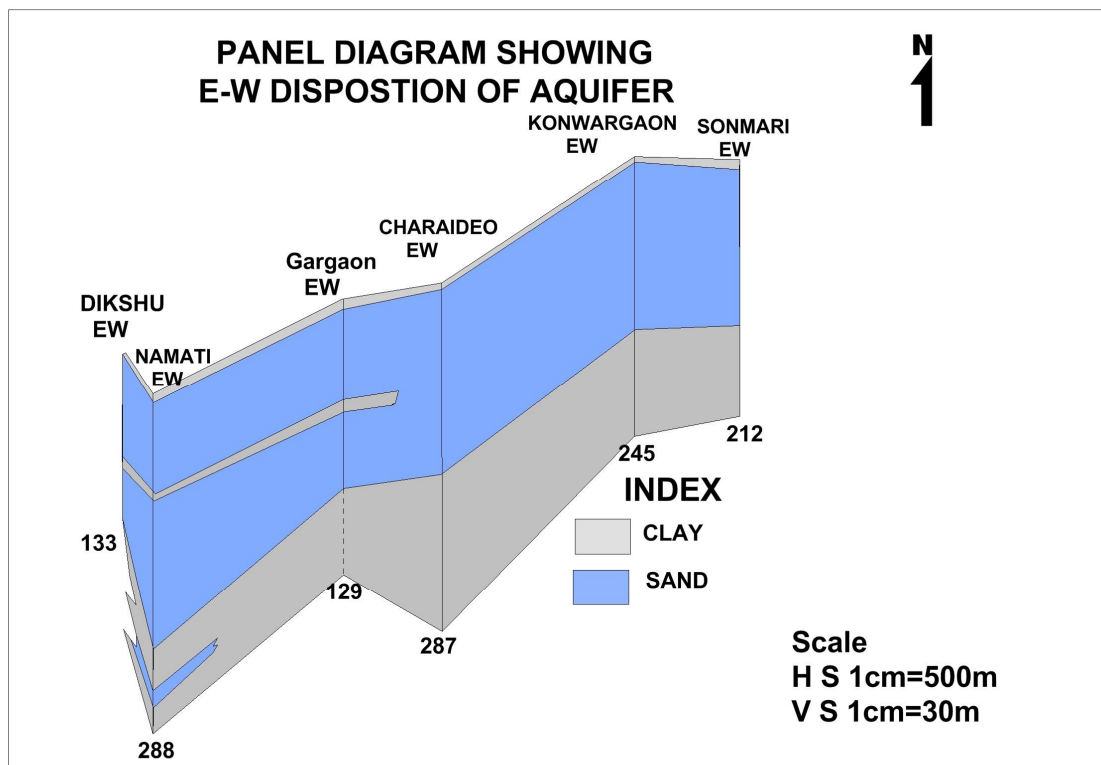
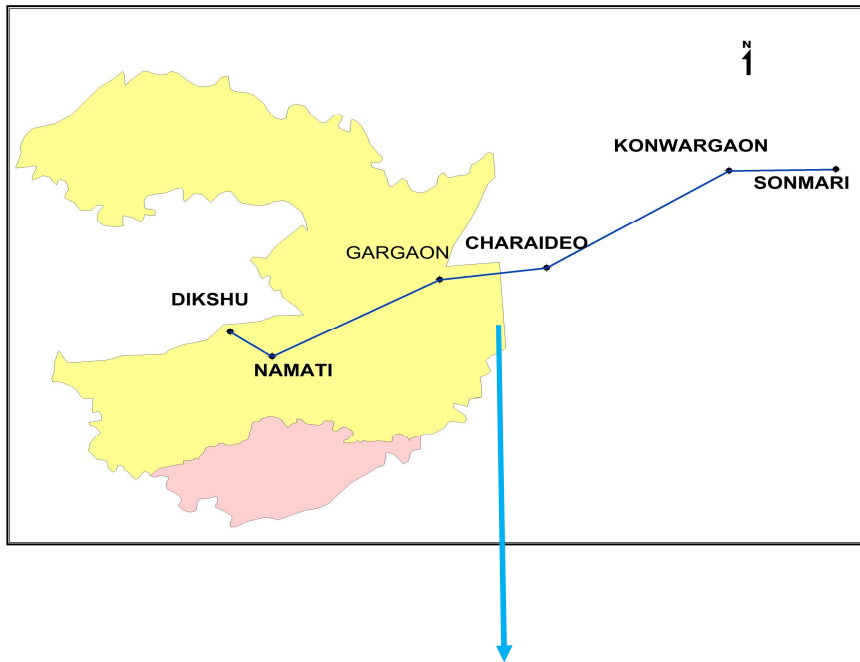


Fig 12: Aquifer disposition along E-W –SW direction

3.5 Ground Water Quality

To find out the different chemical parameters water samples were collected from 15 dug wells and analysed in the Regional Chemical Laboratory of CGWB, NER. The samples were tested for 16 physico-chemical parameters like pH, total dissolved solids (TDS), Electrical conductivity (EC), sodium, potassium, chloride, fluoride, nitrate, sulphate, total hardness, calcium, magnesium, carbonate, bicarbonate and iron. pH was measured by 1, 10 Phenantroline method using a visible spectrometer (DR-2700, Hach, USA) at 510 nm. Fluoride in water was determined by SPADNS method (colorimetric) by using a visible spectrometer (DR-2700, Hach, USA) at 570 nm.

The results after analysis show that there is no general variation in the constituents of chemical radicals and all the major anions and cations are within the permissible limit (as per Bureau of Indian Standards) except that of iron. The pH of the Ground water varies from 6 to 8 indicating slightly basic character of the water. The value of EC during pre monsoon varies from 99.4 to 477.9 $\mu\text{s}/\text{cm}$ at 25⁰ C and during post monsoon varies from 116.9 to 554.6 $\mu\text{s}/\text{cm}$ at 25⁰ C. The fluoride content of water samples is within permissible limit and varies from 0.2 to 1.04 mg/l during pre monsoon and 0.01 to 0.22 mg/l during post monsoon.

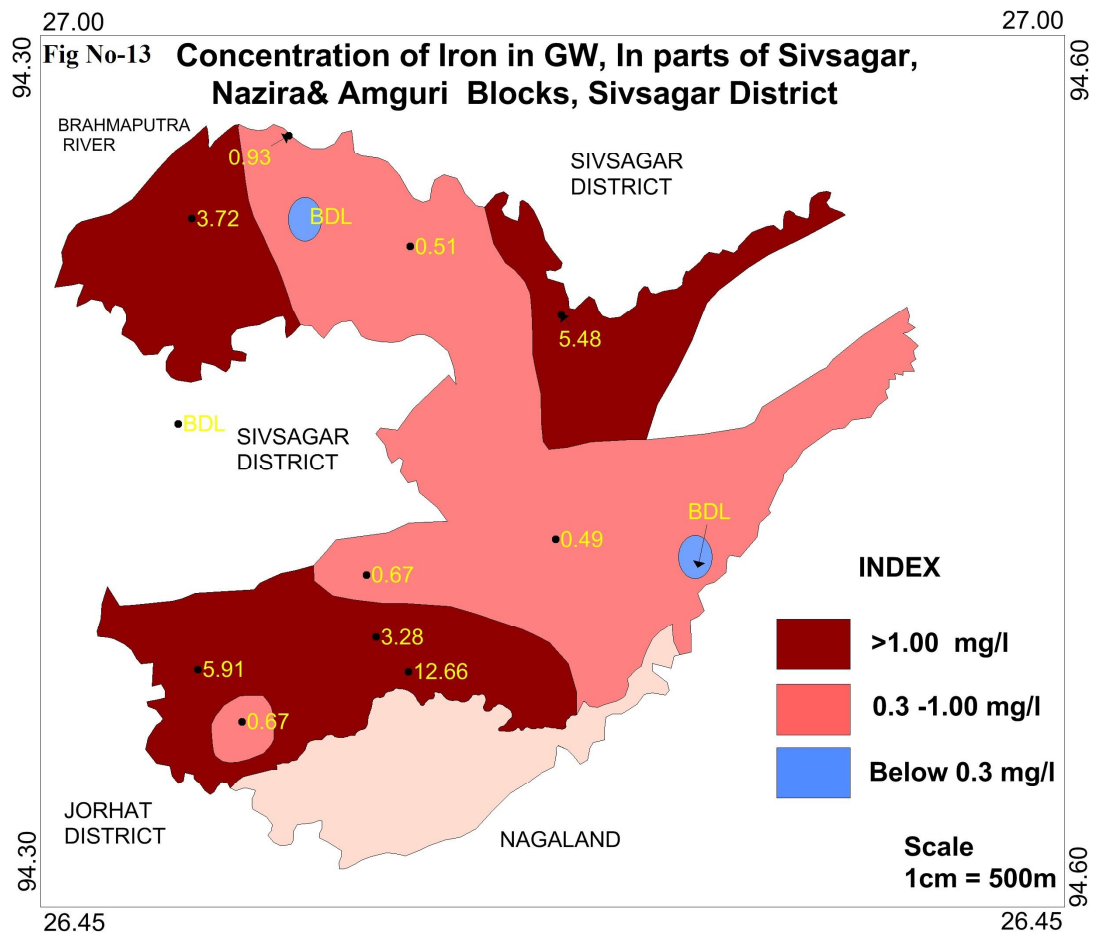
In general, ground water of the area is characterized by high iron content which ranges from 0.22 to 12.66 mg/l. The concentration of iron in ground water is generally much beyond the prescribed desirable limit of 0.3 ppm and maximum permissible limit of 1 ppm. It has been found that all the water samples analysed show content of iron more than the permissible limit except in two stations during premonsoon and three stations during post monsoon. The iron content has been found ranging from 0.22 to 8.99 mg/l during May 2016 and 0.49 to 12.66 mg/l during the month of November 2016. The maximum concentration of iron with a value of 8.99 mg/l and 12.66 mg/l was detected at Bihubar during pre-monsoon and post-monsoon respectively. The iron values are shown in **Fig 13** and summarized chemical analysis data for May, 2016 and November, 2016 are presented in **Table.6 and 7** respectively.

Table-6: Summary of chemical analysis data showing concentration of Iron (Fe) in Sivasagar District, for May 2016

Result of Chemical Analysis of Water samples from Dug Wells			
Sl. No	Fe (mg/l)	No. of samples	% of samples
01	BDL	2	13
02	0.3-1.00	4	27
03	1.00-5.00	8	53
04	>5.00	1	7

Table: 7 Summary of chemical analysis data showing concentration of Iron (Fe) in Sivasagar District, for November 2016

Result of Chemical Analysis of Water samples from Dug Wells			
SI. No	Fe (mg/l)	No. of samples	% of samples
01	BDL	3	23
02	0.3-1.00	5	38
03	1.00-5.00	2	16
04	>5.00	3	23



3.7 Soil Infiltration studies-

Infiltration test: Salient features of the test sites are provided in **Table.8**. A perusal of the table shows that the tests have been conducted and the soil types encountered in the sites are clay loam to sandy soil (as per infiltration classification). In general, infiltration test was conducted for a duration of 150 minutes. Soil infiltration studies locations are shown **Fig.14**.

Table 8: Salient features of Soil Infiltration Test

SI No	Location	Latitude (N)	Longitude (E)	Infiltration Rate (mm/hour)	Soil Type
1	Lunpuria	26°48'46"	94°35'43.3"	120	Sand
2	Disangmukh	26°03'50	94°34'57"	48	Sand
3	Namti	26°01'15"	90°56'42"	63	Sand
4	Bogidol Forest Beat Office	26°57'21.3"	94°39'48.8"	9	Clay loam
5	Joirapar, Near Dhaiali, Sivsagar	27°02'12.0"	94°37'54.9"	36	Sand
6	Borkula Nagar	26°55'47.7"	94°44'39.9"	72	Sand
7	Haluating	26°46'15"	94°33'23"	12	Loam
8	Chargua	27°05'26	94°39'05"	69	Sand
9	Mezinga	26°51'41.04"	94°36'11.52"	32	Sand
10	Noajan	27° 0' 13.68"	94° 39' 7.2"	24	Sandy loam
11	Tekela chuk	26°55'21.07"	94° 46' 28.13"	34	Sand
12	Mechhagarh	26° 56'41.64"	94° 43' 7.68"	78	Sand
13	Chetiagaon	27° 0' 57.6"	94° 38' 39.48"	28	Sandy loam
14	Kathpua	27° 1' 7.68"	94° 37' 6.6"	15	Loam
15	Nagaon Gelekey	26°41'48"	94°41'20"	52	Sand

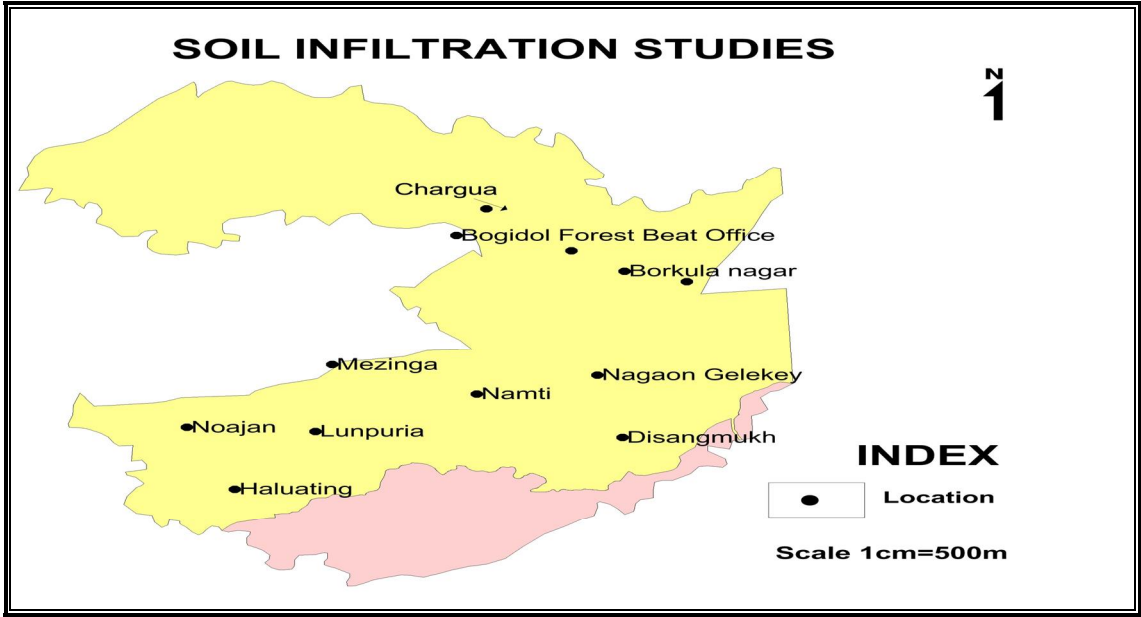


Fig 14: Soil Infiltration Studies

4. Ground Water Resources:-

As per the report on dynamic groundwater resources of Assam, 2011 the study area is having a net groundwater availability of 312 mcm for future irrigation and stage of development is 7% . Detail of ground water resources of Sivasagar district are given in **Table.9 &10** respectively

Based on available resource-

Table-9: Dynamic Groundwater Resources, 2013 in the Study Area in mcm

Assessment Unit/ District	Non-Command (Ha)	Net Annual Ground Water Availability (mcm)	Provision for domestic, and industrial requirement supply to 2025 (mcm)	Net GW Availability for future irrigation development (mcm)	Stage of Ground Water Development {(13/10) * 100}(%)
Sivsagar	266800	1288.13	25.95	1190.54	7

Table-10: Dynamic Groundwater Resources, 2013 in the Study Area in mcm

Block	Area (sq.km)	Net Annual GW availability (mcm)	Provision for domestic and industrial requirement supply to 2025 (mcm)	Net GW availability for future irrigation development (mcm)	60% of resource to be utilised for irrigation (mcm)
Sivsagar	196	95	1.91	87.46	52.48
Nazira	187	90	1.82	83.45	50.07
Amguri	92	45	0.9	41	24.60
Total	475	230	4.63	212	127.15

5. Ground Water related Issues

Following are the issues related to ground water:

1. Low stage of ground water development.
2. High iron content both in shallow and deeper zones

Ground Water Development: As per ground water resource estimation 2013, the stage of ground water development is just 5.5 %. The aforesaid data it indicates that the study area is having meager irrigation facility while having a huge ground water resource for utilisation. Infrastructure for irrigation in the study area is very meager and other issues related to ground water development are-

I. Majority of farmers are marginal and poor.

II. Irregular / no power supply

6. MANAGEMENT STRATEGIES

The dynamic resource estimation presented here is taken from 2013 dynamic groundwater resources of Assam where resource was estimated district wise due to paucity of block-wise data. In the present report the same calculation is used and the resource is proportionately divided among blocks based on their geographical areas.

Table No-11.1 Salient features of GW resource of the district is given below-

Assessment Unit/ District	Non-Command (Ha)	Net Annual Ground Water Availability (mcm)	Provision for domestic, and industrial requirement supply to 2025 (mcm)	Net GW Availability for future irrigation development (mcm)	Stage of Ground Water Development {(13/10) * 100} (%)
Sivsagar	266800	994.72	27.67	937.02	5.5

Table 11.2 Block wise Resource, Resource allocation up to 2025

Block	Area (sq.km)	Net Annual GW availability (mcm)	Provision for domestic and industrial requirement supply to 2025 (mcm)	Net GW availability for future irrigation development (mcm)	60% of resource to be utilised for irrigation (mcm)
Sivsagar	196	95	1.91	87.46	52.48
Nazira	187	90	1.82	83.45	50.07
Amguri	92	45	0.9	41	24.60
Total	475	230	4.63	212	127.15

As per dynamic ground water resource estimation (2012-13) of the study area, net ground water availability is 230 mcm and stage of development is only 7% (Table No 6.1 & 6.2). The area is having balance net ground water availability for future irrigation use in the tune of 212 mcm. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 127 mcm of groundwater resources will be available in the study area for the future irrigation uses.

As per agriculture census data 2010-11 net sown area in the study area is 47500 ha and cropping intensity is 103%; but this data on net sown area included field crops as well as horticulture (like Papaya, Banana and Pineapple). It was found that area under field crops (mainly Kharif paddy) is 37000 ha. During Kharif season, paddy is cultivated in 37000 ha land and after Kharif season is over, this area remains fallow during the Rabi season. A management plan has been envisaged to use this vast fallow land for double

cropping by utilizing the huge available groundwater resources. Basic aim is to increase the gross cropped area from 37000 ha to 74000 ha and thereby increase in cropping intensity up to 200%. To use the groundwater for irrigation purpose a cropping plan has been designed for the district by using CROPWAT model developed by FAO. A suitable cropping plan for the district was prepared in consultation with scientists of Assam Agricultural University, Jorhat. Cropping pattern data for the district is presented in Table 6.3 .Present cropping pattern, proposed cropping pattern, targeted increase in cropping intensity were shown in Table 6.4 and 6.5.

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

Table 6.3. Cropping pattern Amguri, Nazira&Sivsagar Blocks

CROPPING PATTERN DATA (File: untitled)					
Cropping pattern name: sival7					
No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...Data\CROPWAT\data	Rice	10/06	07/10	13
2	...Data\CROPWAT\data	Rice	20/06	17/10	12
3	...Data\CROPWAT\data	Rice	10/07	06/11	13
4	...Data\CROPWAT\data	Rice	20/07	16/11	12
5	...CROPWAT\data\crop	Small Vegetables	15/11	17/02	8
6	...CROPWAT\data\crop	Small Vegetables	20/12	24/03	8
7	...\CROPWAT\data\cro	Potato	30/12	08/05	6
8	...\CROPWAT\data\cro	Potato	15/01	24/05	6
9	...a\CROPWAT\data\cr	Pulses	30/01	19/05	6
10	...\CROPWAT\data\cro	Potato	10/02	19/06	6
11	...\data\crops\Sibsa	Rape & mustard	15/02	24/06	5
12	...\data\crops\Sibsa	Rape & mustard	20/02	29/06	5

Source: CROPWAT

Table 6.4 Cropping pattern, proposed cropping pattern, intended cropping intensity Amguri, Nazira & Sivasgar Blocks

Cropping pattern (s)				
Rice based cropping pattern				
1. Rice-Potato 2. Rice-Mustard 3. Rice-Vegetables	Present Cultivated area (ha)	Area to be cultivated (%)	Area to be cultivated (ha)	Irrigation requirement (ha m)
	1	2	3(= % of 1)	4
Rice (main crop)	37000	37000		5741
Potato	540	8880	24	277
Rape & Mustard	170	7400	20	3
Pulses	80	8880	24	121
Vegetables	280	11840	32	2636
Net cultivated area	37000	37000		
Gross cultivated area (1+potato/+mustard/+Veg+pulses)	38110	74000		
Total irrigation requirement				8778
Cropping intensity	103% (Present)	200% (Intended)		

Table 6.5. Proposed cropping pattern with water deficit months and IWR

Study area

Rice based cropping pattern			
Crop	Growing period (Months)	Periods/months of water deficit	Irrigation requirement (ha m)
Rice	4	2	5741
Potato	5	3	277
Rape & Mustard	4	1	2.96
Vegetables	3	2-3	2636
Pulses	4	2	121

The total area of rice cultivation is comprised of (37000 ha) 50% of the targeted cultivated area of (74000 ha). During kharif season, rice is cultivated from June to 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 37000 ha for the cultivation of potato, rape & mustard, pulses and vegetables. It is considered to cultivate potato and pulses in 8880 ha each, rape & mustard in 7400 ha and vegetable in 11840 ha, including present cultivation area for these crops.

The peak water requirement for irrigation for rice is in the month of June, for potato it is in the month of March, for rape & mustard it is in the month of December, for pulses it is in the month of March, for sugarcane it is in the month of November and December and for vegetables it is during Jan.

**Table 5: Crop-wise and month and year wise precipitation deficit (mm) using CROPWAT 8
for Amguri, Sivsagar & Nazira Block.**

Precipitation deficit	% of total areaof 74000 ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Rice	13	0	0	0	0	49.4	98	0	0	0	0	0	0	147.4
2. Rice	12	0	0	0	0	48.4	98	0	0	0	0	0	0	146.4
3. Rice	13	0	0	0	0	0	48.9	98	0	0	2.4	10	0	159.3
4. Rice	12	0	0	0	0	0	48.7	98	0	0	3	18.1	0	167.8
5. Small Vegetables	8	23.5	7.9	0	0	0	0	0	0	0	0	13.5	24	68.9
6. Small Vegetables	8	13.1	17.6	9.2	0	0	0	0	0	0	0	0	7	46.9
7. Potato	6	0.3	14.3	21	0	0	0	0	0	0	0	0	1.7	37.3
8. Potato	6	0.3	0.8	18.6	0	0	0	0	0	0	0	0	0	19.7
9. Pulses	6	1.5	0	10.1	0	0	0	0	0	0	0	0	0	11.6
10. Pulses	6	0	0.8	1.4	0	0	0	0	0	0	0	0	0	2.2
11. Rape & mustard	5	0	0	0	0	0	0	0	0	0	0	0	0	0
12. Rape & mustard	5	0	0.8	0	0	0	0	0	0	0	0	0	0	0.8
Total	100	38.7	42.2	60.3	0	97.8	294	196	0	0	5.4	41.6	32.7	808.3

Table 6: Irrigation water requirement (ham) for Amguri, Sivsagar & Nazira Block of Sivsagar district

Precipitation deficit	crop wise area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Rice	9620	0	0	0	0	475	943	0	0	0	0	0	0	1417
2. Rice	8880	0	0	0	0	430	870	0	0	0	0	0	0	1300
3. Rice	9620	0	0	0	0	0	470	943	0	0	23	96.2	0	1532.5
4. Rice	8880	0	0	0	0	0	432	870	0	0	27	161	0	1490
5. Small Vegetables	5920	1391	46.8	0	0	0	0	0	0	0	0	79.9	142.08	1659.9
6. Small Vegetables	5920	776	104	54.5	0	0	0	0	0	0	0	0	41.44	975.6
7. Potato	4440	13.3	63.5	93.2	0	0	0	0	0	0	0	0	7.548	177.6
8. Potato	4440	13.3	3.55	82.6	0	0	0	0	0	0	0	0	0	99.4
9. Pulses	4440	66.6	0	44.8	0	0	0	0	0	0	0	0	0	111.4
10. Pulses	4440	0	3.55	6.22	0	0	0	0	0	0	0	0	0	9.8
11. Rape & mustard	3700	0	0	0	0	0	0	0	0	0	0	0	0	0
12. Rape & mustard	3700	0	2.96	0	0	0	0	0	0	0	0	0	0	2.9
Total	74000	2260	225	281	0	905	2716	1813	0	0	50	337	191.07	8777.4

Under ground water exploration programme, CGWB has constructed 8 bore wells in Amguri, Nazira and Sivsagar blocks and has established that the aquifer in most part of the district is having good potential, having an average discharge of about 45 m³/hr. but can be sustainably developed and use for irrigation purpose.

As per dynamic ground water resource estimation 2013, the stage of ground water development is just 7 %. The study area is having meager irrigation facility, mostly single cropped area and in contrast to it is having groundwater resources of 127 mcm which can be withdraw safely for irrigation-

The gross irrigation requirement, calculated using 'CROPWAT' software, of the study area with the recommended cropping plan calculated as 88 **MCM**. As available groundwater resource is **127 MCM** therefore, above-mentioned cropping plan can be safely implemented for the area.

Table 6.4: Crop-wise and month and year wise precipitation deficit (mm) using CROPWAT 8 for Amguri, Sivsagar & Nazira Block.

Precipitation deficit	% of total areaof 74000 ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Rice	13	0.00	0.00	0.00	0.00	48.90	98.00	0.00	0.00	0.00	5.70	0.00	0.00	165.6
2. Rice	12	0.00	0.00	0.00	0.00	48.40	98.00	0.00	0.00	0.00	0.00	0.00	0.00	158.4
3. Rice	13	0.00	0.00	0.00	0.00	0.00	48.90	98.00	0.00	0.00	3.00	10.60	0.00	173.5
4. Rice	12	0.00	0.00	0.00	0.00	0.00	48.70	98.00	0.00	0.00	3.70	19.00	0.00	181.4
5. Small Vegetables	7	24.40	8.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.60	24.30	53.6
6. Small Vegetables	7	13.30	18.50	10.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.10	49
7. Potato	5	0.30	15.40	23.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.70	43.9
8. Potato	5	0.30	0.90	20.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.9
9. Pulses	5	1.50	0.00	11.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.7
10. Pulses	5	0.00	0.80	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.7
11. Rape & mustard	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5
12. Rape & mustard	5	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.8
13. Sugarcane (Ratoon)	3	25.00	11.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	48.40	42.80	93.5
14. Sugarcane (Ratoon)	3	16.40	4.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	47.90	35.90	77.5
Total	100	81.20	60.30	67.20	0.00	97.30	293.60	196.00	0.00	0.00	24.40	139.50	111.80	1071.3

Table 6.5: Irrigation water requirement (ham) for Amguri, Sivsagar & Nazira Block of Sivsagar district

Precipitation deficit	% of total area of 74000 ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Rice	13	0.00	0.00	0.00	0.00	470.42	942.76	0.00	0.00	0.00	54.83	0.00	0.00	1468.01
2. Rice	12	0.00	0.00	0.00	0.00	429.79	870.24	0.00	0.00	0.00	0.00	0.00	0.00	1300.03
3. Rice	13	0.00	0.00	0.00	0.00	0.00	470.42	942.76	0.00	0.00	28.86	101.97	0.00	1544.01
4. Rice	12	0.00	0.00	0.00	0.00	0.00	432.46	870.24	0.00	0.00	32.86	168.72	0.00	1504.27
5. Small Vegetables	7	126.39	44.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.45	125.87	367.262
6. Small Vegetables	7	68.89	95.83	52.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.78	254.338
7. Potato	5	1.11	56.98	85.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.29	150.22
8. Potato	5	1.11	3.33	76.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	81.03
9. Pulses	5	5.55	0.00	41.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46.99
10. Pulses	5	0.00	2.96	7.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.99
11. Rape & mustard	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
12. Rape & mustard	5	0.00	2.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.96
13. Sugarcane (Ratoon)	3	55.50	24.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.32	107.45	95.02	295.926
14. Sugarcane (Ratoon)	3	36.41	9.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.32	106.34	79.70	245.088
Totoal	100	294.96	240.57	263.74	0.00	900.21	2715.87	1813.00	0.00	0.00	143.19	554.93	343.66	7270.13

Cultivators of the district are mainly depend on rainfall. But rainfall being unevenly distributed, they also resort to indigenous methods of irrigation such as lifting of water by means swing buckets. The districts receives sufficient amount of rain during monsoon season but the major crops like paddy and sugarcane etc. have to demand some other sources of water during the major part of the year. Some minor irrigation project like construction of buds across the stream is implemented in district and lift irrigation with electric pump set has also been operated in some part of the district system and during monsoon season most of the part

Under ground water exploration programme, CGWB has constructed 8 bore wells in Amguri, Nazira and Sivsagar blocks and has established that the aquifer in most part of the district is having good potential, having an average discharge of about 45 m³/hr. but can be sustainably developed and use for irrigation purpose.

CGWB's exploration has established that the aquifer of the district is medium to high yielding. A tube well of 50 m depth tapping 20 m saturated thickness of aquifer can yield 45m³/hr. If the well is allowed to run for 8 hrs for 100 days, it will create a draft of 0.036MCM. Considering 200 m safe distance between two tube wells, 9250 numbers of TW can be constructed in the area. But, as per requirement, i.e., to meet the planned irrigation demand of 88 MCM, 2444 numbers of [tube wells](#) will be sufficient for construction.

Groundwater in the area is infested with iron, therefore before consumption aeration/ filtering/ installation of Iron Removal Plant is necessary.

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REFERENCES

- 1 **Central Ground Water Board, Ministry of Water Resources, New Delhi** Dynamic Groundwater Resources of India (as on march 2011).
- 2 **Central Ground Water Board, Ministry of Water Resources, NER, Guwahati** Dynamic Groundwater resources of Meghalaya State (as on march 2013)
- 3 **Central Groundwater Board, Ministry of Water Resources, New Delhi** Ground Water Information Booklet of Sivsagar District, Assam (2011-12)
- 4 **Central Groundwater Board, Ministry of Water Resources, New Delhi** Manual on Aquifer Mapping
- 5 **Directorate of Economics and Statistics, Government of Assam.**Statistical Hand Book of Assam, 2013
- 6 **District Census Hand Boob of Sivsagar District-2011.**
- 7 **Todd, D. K. (1959)** Groundwater hydrology; 4th Ed.; John Willy and Sons Inc.; N.Y.; 535 P

Annexure

No-1

RESULT OF CHEMICAL ANALYSIS OF WATER SAMPLES (MAY 2016) (in ppm)

State	Location	District	Type of sample	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO ₃ ⁻²	HCO ₃ ⁻¹	Cl ⁻	SO ₄ ⁻²	NO ₃ ⁻¹	F ⁻	Ca ⁺² (as Ca)	Mg ⁺² (as Mg)	TH (as CaCO ₃)	Na	K	Fe
Assam	Amguri	Sivasagar	DUG	6.02	99.4	0.8	48.4	0	40	20.0	3.0	BDL	0.87	10	2.4	35	7.75	1.44	0.99
Assam	Haluating	Sivasagar	DUG	6.45	247.1	0.8	115	0	40	42.5	5.2	BDL	0.15	10	1.2	30	28.6	1.79	2.03
Assam	Bihubar	Sivasagar	DUG	6.63	110	0.6	51.8	0	50	15.0	5.7	BDL	0.32	8	9.7	60	3.41	1.75	8.99
Assam	Namti	Sivasagar	DUG	7.57	115.1	0.9	54.7	0	25	15.0	4.6	0.6	0.4	10	7.3	55	5.61	2.9	0.87
Assam	Potuasala	Sivasagar	DUG	6.93	135.2	0.4	64.6	0	15	15.0	6.2	0.2	0.48	14	6.1	60	5.33	1.81	BDL
Assam	Charugua	Sivasagar	DUG	7.24	143.8	0.4	67.5	0	115	12.5	3.7	0.5	0.62	10	8.5	60	10.8	0.54	1.34
Assam	Panbecha	Sivasagar	DUG	8.43	233.9	0.3	112	20	20	20.0	12.7	0.4	0.58	12	13.3	85	14.5	0.62	BDL
Assam	Amkutia Chuk	Sivasagar	DUG	7.41	122.8	0.5	58.4	0	55	17.5	3.7	0.4	0.28	12	10.9	75	4.02	2.61	1.36
Assam	Deopani Basti	Sivasagar	DUG	7.87	260.2	0.6	125	0	70	22.5	7.0	BDL	0.3	26	7.3	95	13.6	7.86	0.22
Assam	Notun Lunnoria	Sivasagar	DUG	8.02	40.56	0.5	18.2	0	20	10.0	3.5	BDL	0.12	4	2.4	20	3.25	1.05	1.57
Assam	Jaligaon	Sivasagar	DUG	8.31	477.9	0.3	229	40	95	22.5	11.3	BDL	0.57	38	30.3	220	12.6	10.1	1.83
Assam	Dikhumukh	Sivasagar	DUG	7.99	162.5	0.4	76.8	0	70	10.0	5.0	0.4	0.45	18	6.1	70	3.02	1.93	1.04
Assam	Geleki Nogaon	Sivasagar	DUG	8.43	371.9	0.4	180	30	105	17.5	8.8	BDL	0.59	40	12.1	150	12.3	11.64	1.4
Assam	Kathpua	Sivasagar	DUG	8.02	130.3	1.6	61.6	0	55	12.5	3.5	1.4	0.84	4	6.1	35	6.01	8.19	1.32

Assam	Jamuguri Khatowal	Sivasagar	DUG	7.52	120.1	0.5	57.8	0	65	17.5	6.5	BDL	1.04	8	7.3	50	5.38	4.85	0.79
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Annexure No-2

RESULT OF CHEMICAL ANALYSIS OF WATER SAMPLES (NOVEMBER 2016 (in ppm))

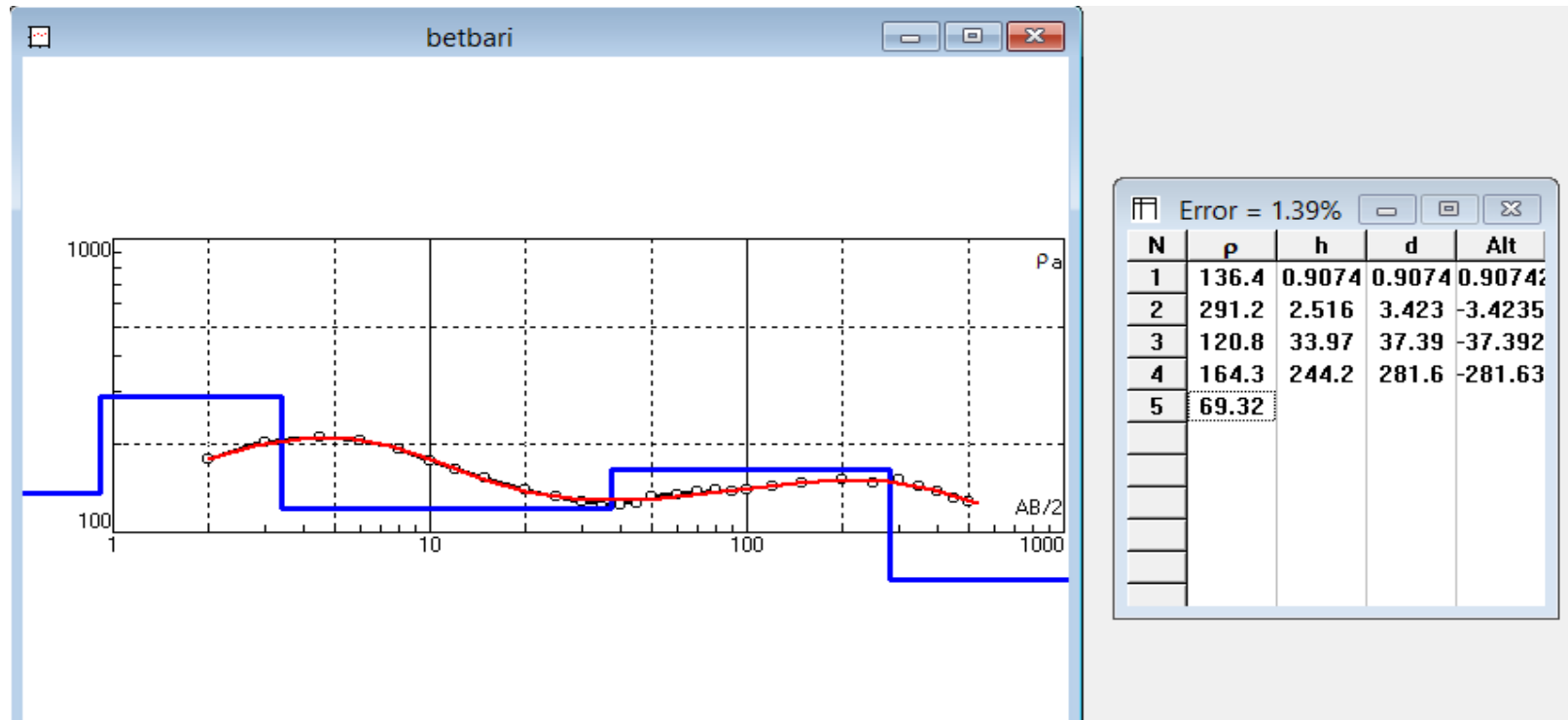
State	Location	District	Type of sample	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO3-2	HCO3-1	Cl-	SO4-2	NO3-1	F-	Ca+2 (as Ca)	Mg+2 (as Mg)	TH (as CaCO3)	Na	K	Fe
Assam	Amguri	Sivasagar	DUG	5.97	173.3	BDL	100.4	0	61	42.54	1.90	0.3	BDL	18	10.92	90	10.8	1.73	5.91
Assam	Haluating	Sivasagar	DUG	6.47	194.1	2.1	112.5	0	61	24.815	3.29	BDL	BDL	22	10.92	100	11.65	2.32	0.67
Assam	Bihubar	Sivasagar	DUG	6.93	184.8	2	107.2	0	134.2	21.27	7.48	BDL	BDL	28	9.71	110	3.76	3.27	12.66
Assam	Namti	Sivasagar	DUG	6.95	281.7	1.8	164.3	0	140.3	31.905	3.95	0.5	BDL	44	12.14	160	7.98	4.95	0.67
Assam	Potuasala	Sivasagar	DUG	7.02	155.8	1.7	89.67	0	85.4	17.725	4.72	BDL	0.07	24	12.14	110	3.62	1.68	BDL
Assam	Charugua	Sivasagar	DUG	6.49	143.2	1.9	83	0	79.3	24.815	2.04	BDL	BDL	8	15.78	85	10.49	0.7	5.48
Assam	Panbecha	Sivasagar	DUG	6.56	224.2	1.8	128.9	0	109.8	31.905	2.71	BDL	BDL	14	20.63	120	13.7	0.71	BDL
Assam	Amkutia Chuk	Sivasagar	DUG	6.90	233.4	1.8	134.6	0	97.6	28.36	8.42	0.1	BDL	30	13.35	130	6.12	5.08	0.49
Assam	Deopani Basti	Sivasagar	DUG	6.49	340.8	2	197.6	0	189.1	21.27	1.71	12.7	0.11	42	16.99	175	15.4	3.9	BDL
Assam	Notun Lunpuria	Sivasagar	DUG	5.51	116.9	1.7	66.74	0	18.3	31.905	2.18	1.5	BDL	6	4.85	35	2.62	1.28	3.28
Assam	Jaligaon	Sivasagar	DUG	8.36	554.6	1.8	324	60	201.3	31.905	21.53	BDL	0.22	78	25.49	300	10.87	16.53	0.93
Assam	Dikhumukh	Sivasagar	DUG	7.12	298.6	1.8	165.1	0	158.6	17.725	3.17	BDL	0.01	44	14.56	170	2.42	3.24	0.51
Assam	Kathpua	Sivasagar	DUG	7.02	250.3	1.8	143.7	0	134.2	21.27	4.04	BDL	0.08	24	14.56	120	7.58	13.83	3.72

Annexure No-3

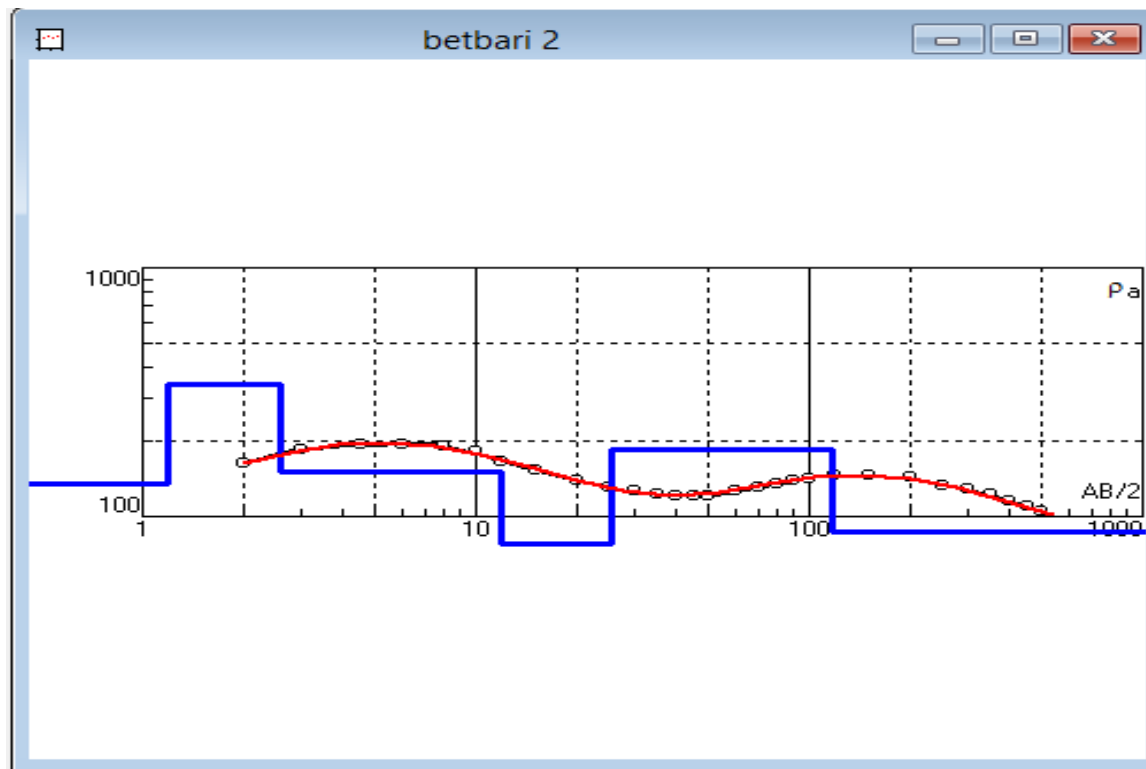
DETAILS OF EXPLORATORY DRILLING CARRIED OUT IN THE REGION DURING XII PLAN

S. No	State	Dist	Block	Location	EW/OW/ PZ	Hard rock/ Soft Rock	Constru cted during AAP- 2016-17	Long	Lat	Tot al dep th (m)	Granula r zone/ fracture	Aquifer tapped (I/II/III/ combin ed)	Q (lps)	Remarks
1	ASSAM	Sivasagar	Amguri	Dikshu	EW	Soft rock	2016-17	94.53	26.74	133	Granula r zone	I	10	Semi confined to Confined
2			Amguri	Dikshu	OW	Soft rock	2016-17	94.56	26.72	133	Granula r zone	I	8	Semi confined to Confined
3			Nazira	IIT Gargaon	EW	Soft rock	2016-17	94.76	26.99	129	Granula r zone	I	12	Semi confined to
4			Nazira	IIT Gargaon	OW	Soft rock	2016-17	94.78	26.97	129	Granula r zone	I	10	Semi confined to

VES NO-01



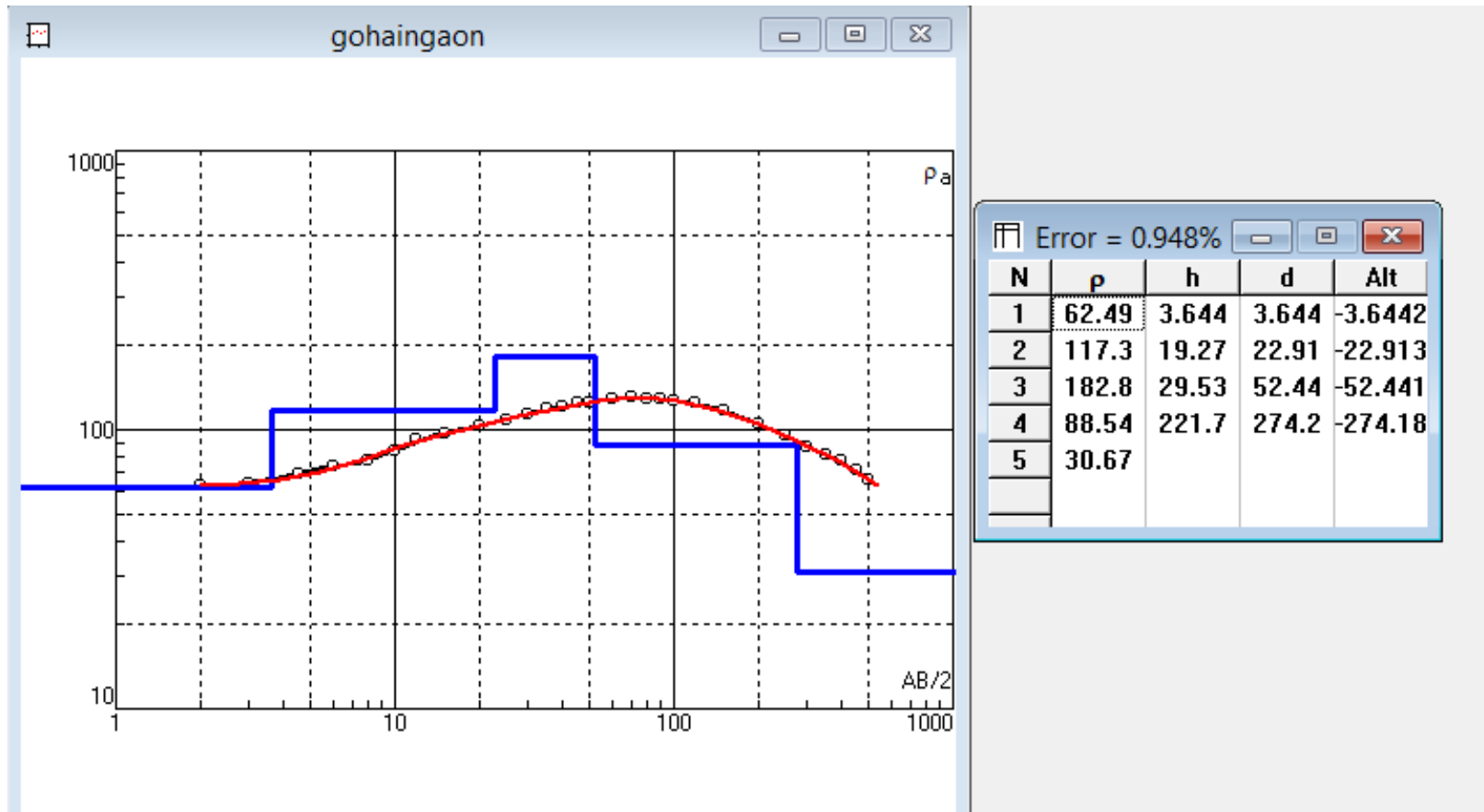
VES NO-02



Error = 1.04%

N	p	h	d	Alt
1	135.8	1.2	1.2	-1.2
2	338.5	1.373	2.573	-2.573
3	152	9.297	11.87	-11.87
4	77.38	13.53	25.4	-25.404
5	185.2	91.88	117.3	-117.29
6	87.12			

VES NO-03



VES NO-04

