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

BAKSA DISTRICT, ASSAM

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

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केंद्रीयभूमिजलबोर्ड
Ministry Of Water Resources, River Development & Ganga Rejuvenation
जलसंसाधन, नदीविकासऔरगंगासंरक्षणमंत्रालय
GOVERNMENT OF INDIA
भारतसरकार

AQUIFER MAPPING AND MANAGEMENT PLAN OF BAKSA DISTRICT, ASSAM

ANNUAL ACTION PLAN, 2019-20

NORTH EASTERN REGION
उत्तरपूर्वीक्षेत्र
GUWAHATI
गुवाहाटी
December, 2021

CONTENTS

CHAPTER -1

1.0 Introduction

Central Ground Water Board, North Eastern Region has carried out Aquifer mapping and management plan in Baksa district, Assam during AAP 2019-20 covering **2449 sq.km** out of total geographical area of **2457** sq.km. Under National Aquifer Mapping and Management (NAQUIM) program, combination of geologic, geophysical, hydrologic and hydro chemical information is applied to characterize the quantity, quality and sustainability of ground water aquifers. Systematic aquifer mapping will improve our understanding of the geologic framework of aquifers, their hydrogeologic characteristics, quality and also quantifying the available ground water resources potential and proposing plans appropriate to the scale of demand and the institutional arrangements for management. Aquifer mapping at the appropriate scale can help 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 approachon 1:50,000 scale and finally formulate a complete, sustainable and effective management plan for ground water development.

1.2 Scope of the Study

The activities of the Aquifer Mapping and Management Program can be envisaged as follows:

a. Data Compilation & Data Gap Analysis: One of the important aspect of the aquifer mapping programme 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.

b. Data Generation: There was also a strong need for generating additional data to fill the data gaps to achieve the task of aquifer mapping. This was achieved by multiple activities such as exploratory drilling, geophysical techniques, 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.

c. Aquifer Map Preparation: On the basis of integration of data generated from various studies of hydrogeology & geophysics, 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 aquifer extremities, quality, water level, potential and vulnerability (quality & quantity).

d. Aquifer Management Plan Formulation: Aquifer Maps and ground water regime scenario will be 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 tube wells tapping various groups of aquifers,

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

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

(v) Collection of various relevant technical data from the field in Baksadistrict 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.

1.4 Area Details

Aquifer mapping and management programme has been taken up during Annual Action Plan 2019–20 in Baksa District covering Baska, Tihu-Barama, Dhamdhama, Jalah, Tamulpur, Goreshwar, Nagrijuli and Gobardhana administrative blocks in order to delineate the available aquifers. The district headquarter of Baksadistrict is Mushalpur. The district covers an area of 2008 Square Kilometer. As per Census 2011, the Baksa district is having a total population of 9,53,773 dominated by ST.

The district lies in the northern bank of the River Brahmaputra. It has the international and state boundaries with Bhutan on north. It is bounded by Chirang district in the west, Nalbari, Barpeta and Kamrup (Rural) district on the south and Udalguri district on the east and is confined within North Latitudes 26°32′ and 26°40′ and East Longitudes of 90°56′ and 91°43′. The area is falling mainly and partly in 47 Quadrants in the Survey of India Toposheets bearing nos. 78 J/13,78 N/1, 78 N/5, 78 N/9, 78 N/14, 78 N/2, 78 N/6, 78 N/10, 78 J/15, 78 N/3, 78 N/7, 78 N/11Fig-1 depicts the base map of the NAQUIM area. The district is well connected with rail, road and air. Guwahati airport is the nearest airport which is 107 KM away from its district head quarter at Mushalpur. National Highway 127 E passes through the district. It is a spur road of National Highway 27. It passes through Barama, Baska, Subankhata, Indo/Bhutan border near Chowki

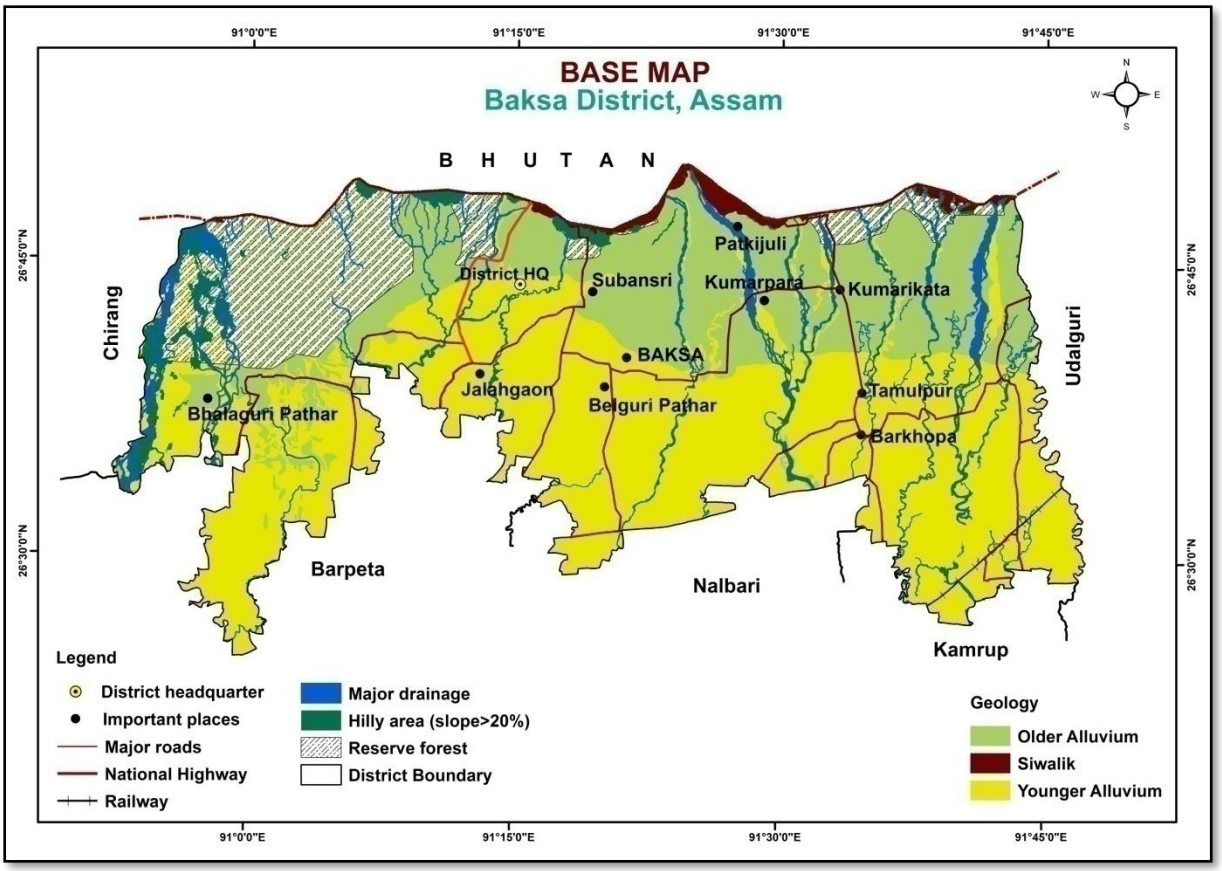

Fig 1: Base Map of Baksa District, Assam

1.5 Data Availability & Data Adequacy before conducting Aquifer Mapping

After plotting the available data on the map prepared by Mapinfo it was found that there is a huge data gap in the district. As the available data is very less there is a huge need of data generation in the said area. Hydrogeological, geophysical and ground water exploration data available in the district are as follows:

- **Exploration Data**: CGWB has constructed 2 (Two exploratory wells and one) Slim Hole in the Baksa district. Details of drilling operation, aquifer parameters are furnished in Annexure – 4. State govt. has also drilled several wells.

- **Geophysical Survey (VES) Data**: Neither CGWB nor the State Govt. Departments have conducted any VES survey in this district till date.

Ground Water Level Monitoring Data : CGWB has 17 (Seventeen) NHNS wells at Jhargaon, Tamulpur, Darkuchi, Dumnibazar, Goraimari, Hudukata, Simla, Borghuli, Goreswar, Hengulapara, Nagrijuli, Naokata, PanitemaOW, Aithabari, Hazaregaon, Mithabari, W.sigrapara where water levels are measured 4 times in a year. But most of these wells are abandoned. State ground water user departments like PHED, Irrigation department etc. do not have any ground water monitoring station.

- **Ground Water Quality Monitoring Data**: As the 17 Ground Water Monitoring Stations were abandoned. Chemical quality monitoring was also not carried out for the said wells.

1.6 DataGap Analysis & Data Generation

- **Exploration Data Gap: CGWB**, NER has constructed 2 (Two) exploratory wells and 1(One) Slim Hole in the district. Based on this drilling work, hydrogeological data have been gathered.

- **VES and Profiling Data Gap**

Data gap related to Resistivity Surveys i.e., VES and Profiling was never carried out by CGWB or by any State Govt. Departments in any parts of the District.

- **Ground Water Level Monitoring Data Gap**

Only 17 (Twenty Two) GWM wells at Simla, Mithabari, Aithabari, Goraimari, Hudukata, Panitema, Dumnibazar, W. Singrapara, Hazargaon, Nagrijuli, Tamulpur, Jhargaon, Darkuchi, Borguli, Naokata, Goreswar and Hengulpara. Most of them are abandoned. As such establishment of new key well has been proposed.

- **Ground Water Quality Monitoring Data Gap**

As most of the GWMS are abandoned, there is a huge data gap in the district in terms of Chemical quality. Collection of water samples from new key wells and analysis of the same has been proposed.

The Data Gap is shown in Fig.1.2 and Data Requirement, Data Availability and Data Gap Analysis are presented in table 1.1

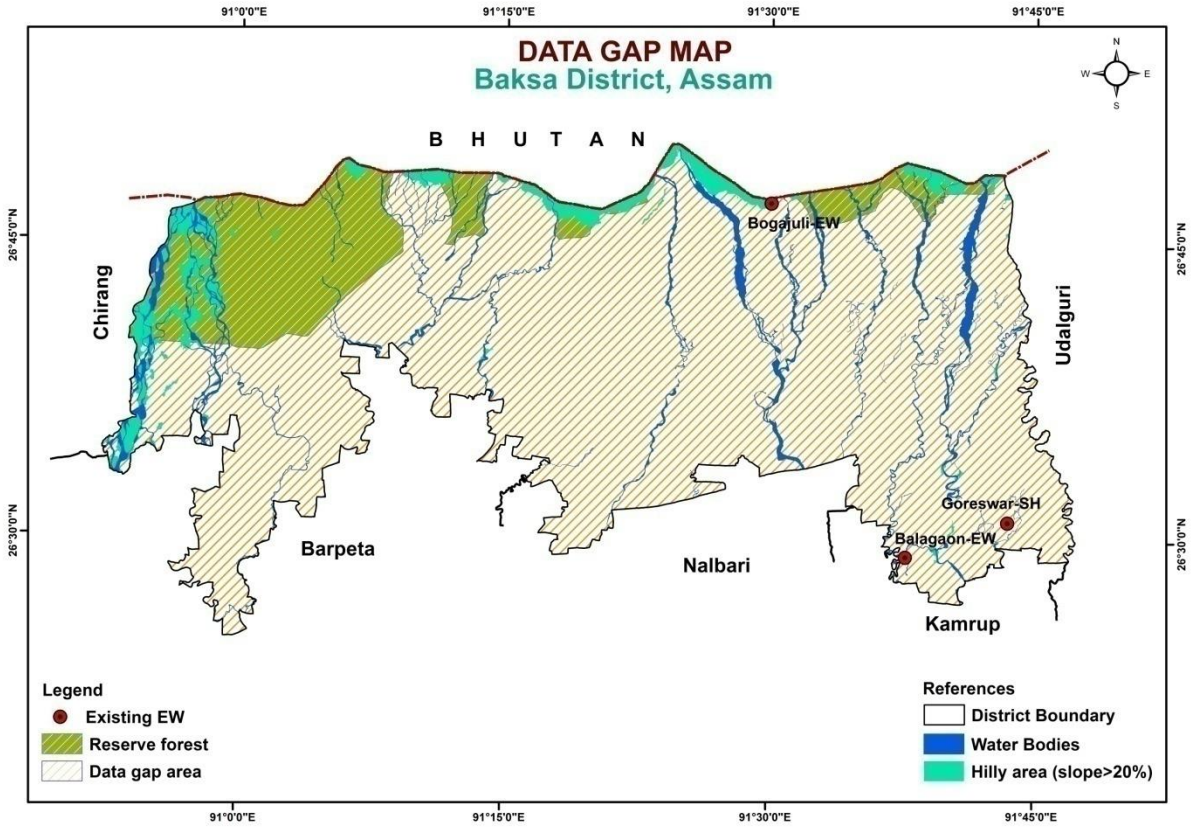

Fig 1.2: Data gap and Availability Map of Baksa District

1.6 Rainfall and Climate

The district enjoys a sub-tropical humid climate with a hot summer and moderate winter. January is the coldest month and July/August is the warmest month. The winter temperature drops to 10°C and summer temperature goes up to 35°C. South-West monsoon activates from June and continues up to September-October. Nearly 70% of rainfall occurs during monsoon season. The average annual rainfall of the district is 2,971.6 mm.

Table1.3 Rainfall Data of Last Five Years

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	0	23	21	64.8	309.2	344.1	198	547.6	325.8	2.5	0	0
2015	11.7	14.8	12.1	229.1	444.8	723.6	235.5	621.5	218.2	55.9	8	17.4
2016	37	2.5	77.1	247.5	349.5	367.6	511.1	108.8	187.5	86.1	0	11.6
2017	2.7	56.5	60	217.2	219.9	484.8	207.6	406	318.4	61.8	1.6	0
2018	0	21.5	87.2	73.1	355.4	314.8	373.5	200.8	515.6	26.1	31.1	19.2

Note :(1) The District Rainfall in millimeters shown above are the arithmetic averages of Rainfall of Stations under the District. (Source : India Metrological Department)

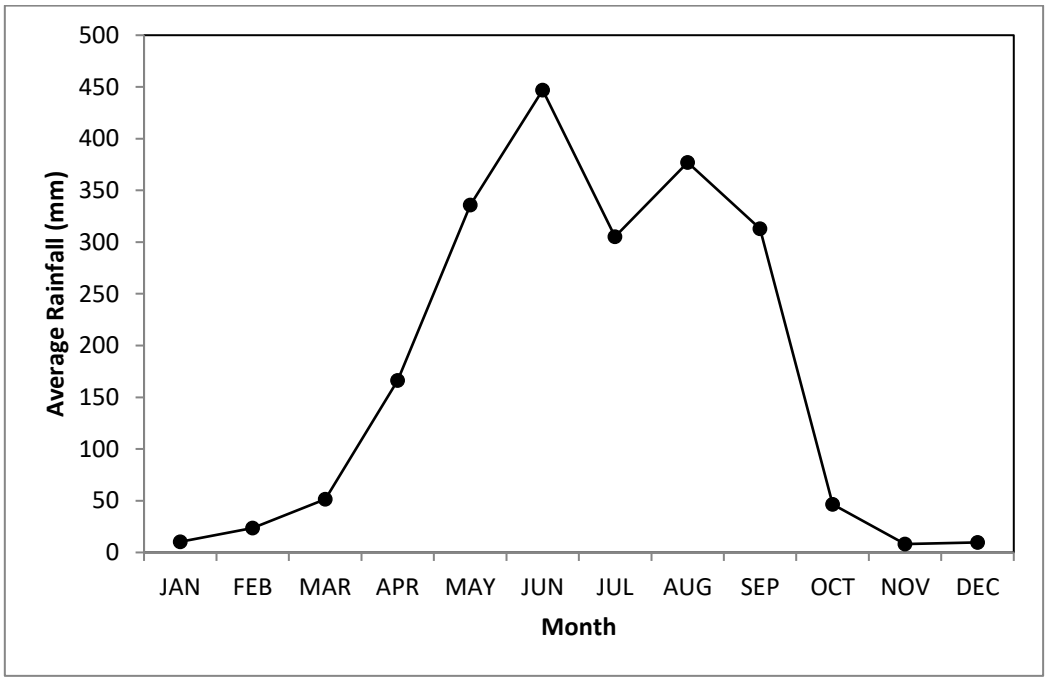

Fig 1.3: Rainfall Hydrograph of Baksa District

Portion of the graph showing June to September represents monsoon season, January to May represents pre-monsoon season and September to December represents post monsoon season. Nearly 80% of the rainfall occurs during monsoon period.

A bar diagram showing average annual rainfall in last 5 years has been shown in the Fig 1.4 below.

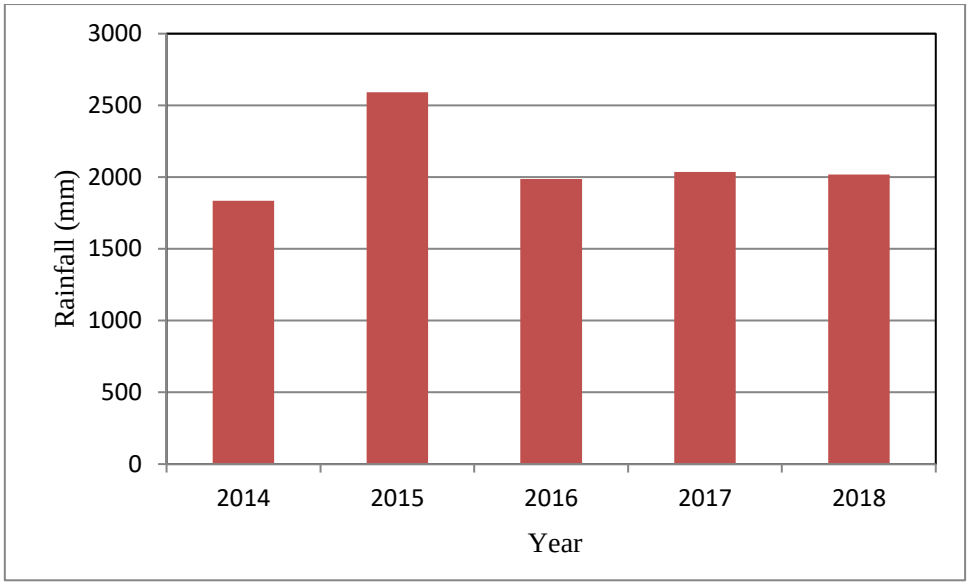

Fig 1.4: Average annual rainfall from 2014 to 2018

1.7 Physiography

The district shares the privilege of being the International Boundary with Bhutan in the North with a mixed topography of plains and foot hills. The gentle and gradual slopes can be seen stretching from the foot hill of Bhutan and reaching out to the southern tips of Barpeta, Nalbari and Kamrup district.

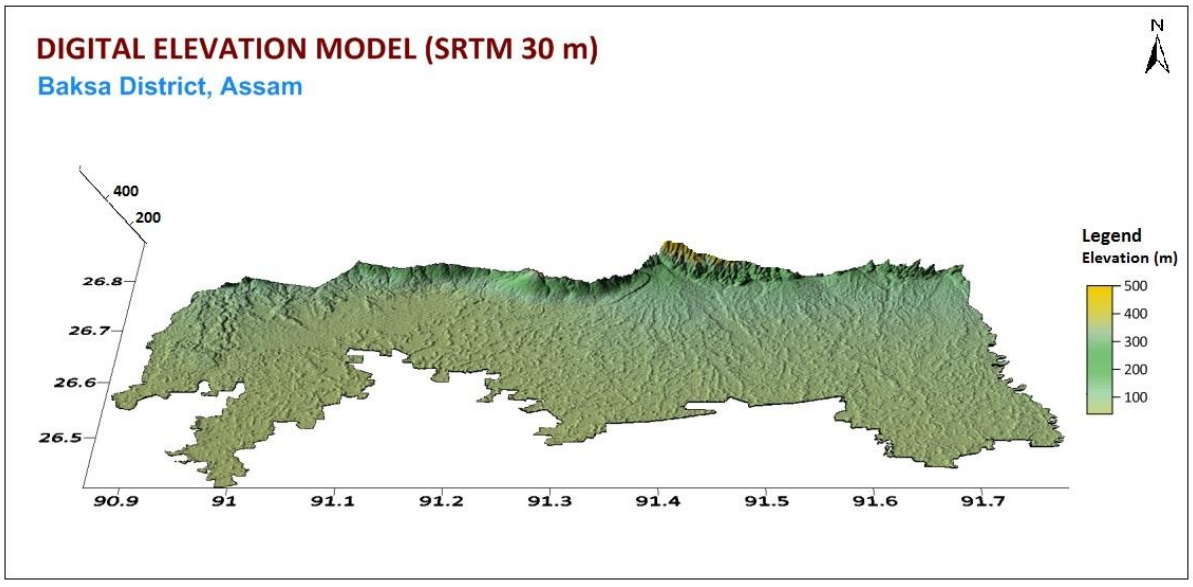

Fig 1.5: Digital Elevation Model of Baksa District

1.8 Geomorphology

Geomorphologically, it is characterized by the different land forms, viz., a) denudation structural hill and b) alluvial plain. The low mounds/hillocks are covered by a thick lateritic mantle and these are occupied by evergreen mixed forests. The alluvial plains comprise of Older and Newer alluvium. The Older alluvium occupies the piedmont zone towards the north of the district bordering Bhutan. The narrow zone at the Himalayan foothill is known as the Bhabar zone. To the south of the Bhabar zone and parallel to it, the flat

Teraizone lays where the ground remains damp and sometimes, spring oozes out. The Terai zone is covered by tall grass. The Newer alluvium includes sand, gravel, pebble with silt and clay.

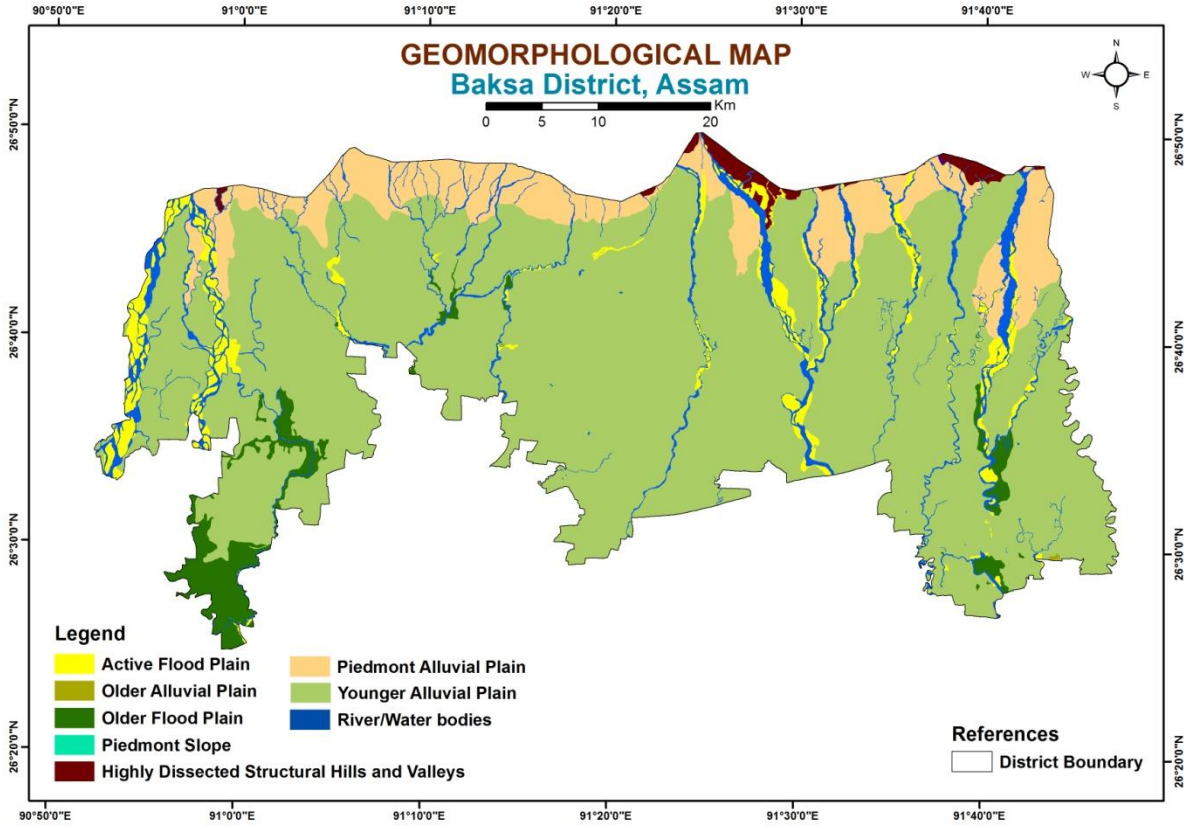

Fig 1.6 : Geomorphological Map of Baksa District

1.9 Land Use

Based on the land utilization, the total area is divided into various types of landforms such as forest, cultivable land, fallows lands, crop area etc. which in turn reflects the degree of development of agricultural activities and cultivation potential.

Table1.3: Land utilization of the Baksa District (as on 2019)

Geographicalarea	2346
Cultivablearea	1200
Forestarea	189
Landundernonagriculturaluse	123
Permanentpastures	4
Cultivable wasteland	59
Land under misc. tree cropsandgroves	10
Barren andun-cultivableland	222
Currentfallows	53
Otherfallows	4

1.10 Soil

Soil in greater parts of the district is sandy and silty loam, or clayey loam. The variation in composition is mainly due to the varying composition of the river bornematerials deposited at different times and under different conditions. The younger alluvial soil has a high phosphorous content whereas, in Older Alluvial soils, it is very low. In general, the soil is acidic to slightly alkaline in nature and is moderately permeable and characterized by the presence of low organic carbon and low soluble salts. Soils restricted to inselberg areas are more clayey, lateritic and less permeable and are highly acidic in nature. From agricultural point of view, the soils in major parts of the district are suitable for all sorts of crops.

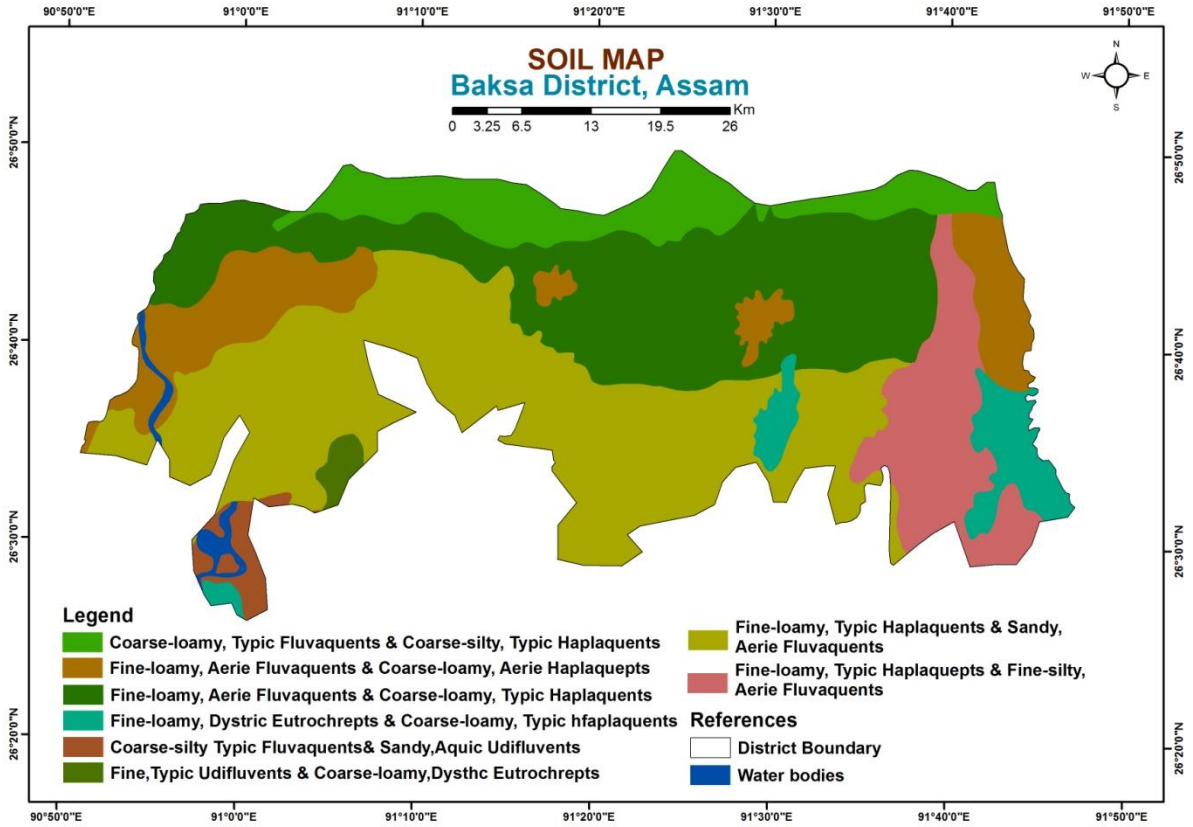

Fig 1.7: Soil Map of Baksa District

1.11.1 Ponds, Tanks and other Water Conservation Structures

There are thousands of small ponds available in the district. These ponds are used mainly for fish cultivation and also used for domestic purpose like washing, bathing, water for cattle's etc. There are almost 90 tanks which are used for irrigation purpose and almost 200 Ha area of cultivable land is irrigated through these tanks.

1.11.2Drainage

Number of perennial streams flow through the district from north to south and join the Brahmaputra River. The major streams that drain the area are Mara Manas, Palla, Po-Mara, Kaldia, Tihu, Mora Pagladia, Burhadia, Pagladia, Nona, Baralia and Puthimari River. The whole drainage of the district ultimately finds its way to all rivers and tributaries.

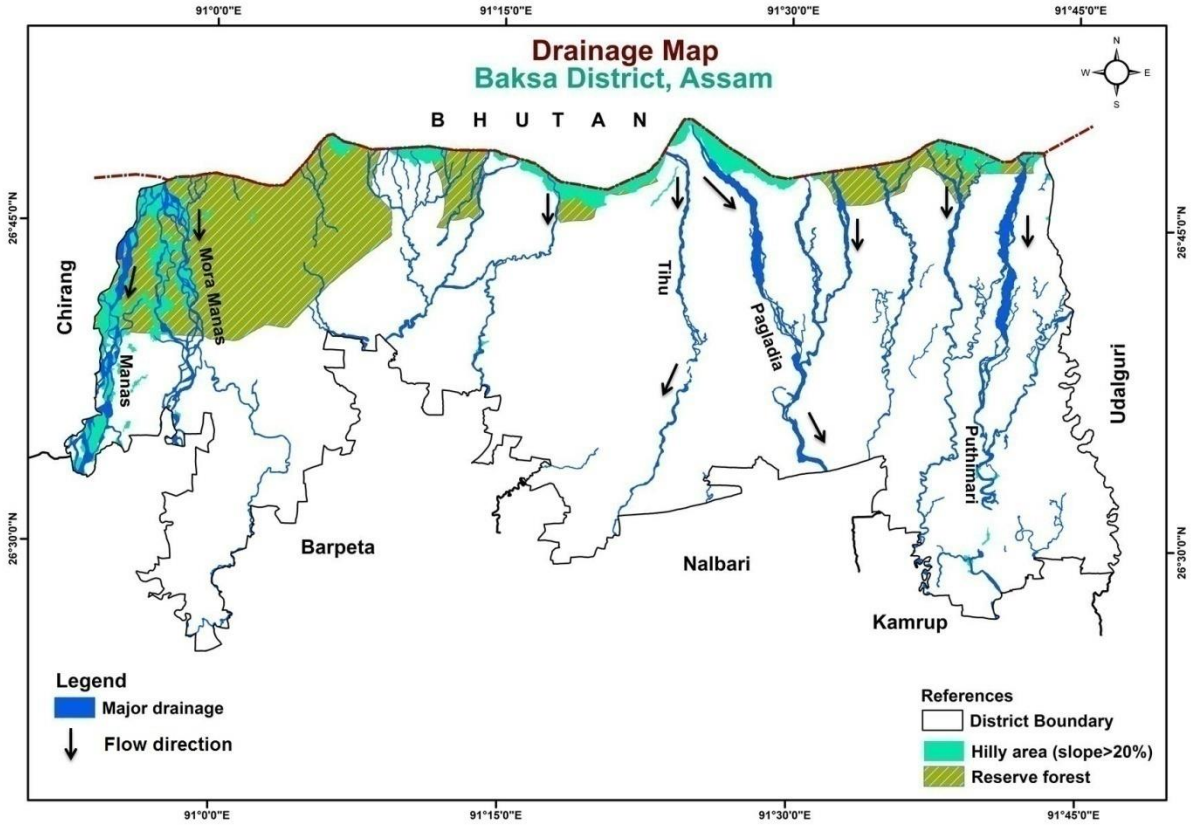

Fig 1.5: Drainage Map of Baksa District, Assam

1.13 Agriculture

Agriculture in Baksa district depends mainly on the timely monsoon. Fertile soils of the valleys and the abundant rainfall are very conducive to grow agricultural and horticultural crops. Net area under agriculture (net area sown) is **145872** ha (in 2019), which is **62.17373**% of total geographical area (**234620** ha).

Economy of the area is basically agrarian and about 70 % of the population is dependent on agriculture and allied activities for their livelihood as agricultural work is the single largest provider of employment to the rural people of Baksa district. Paddy is the main cereal crop of the District during Kharif and summer season while maize is grown in both Kharif and summer season. Pulse crops like arahar, black gram are grown as secondary crop during Kharifwhile pulse crops like pea and lentil and oil seed crops such as mustard, sesame and linseed are major Rabi crops of the District. Major area in the Baksa district is under rainfed condition. During summer some area is covered with summer paddy in irrigated condition. About 15,000 ha area are covered with horticultural crops like arecanut, coconut, banana, pine apple, ginger, orange, turmeric and vegetables.

Cropping Pattern

Paddy is the main cereal crop of the district during Kharif and summer season while maize is grown in both Kharif and summer season. Pulse crops like arahar, black gram are grown as secondary crop during Kharif while pulse crops like pea and lentil and oil seed crops such as mustard, sesame and linseed are major Rabi crops of the district. Major area in the Baksa district is under rainfed condition. During summer some area is covered with

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Table 1.4 :Production and Productivity of Major Crops

Sl. No.	Season	Crop Sown	Rainfed		Irrigated	
			Production (MT)	Productivity (Kg)	Production (MT)	Productivity (Kg)
1	Kharif	Paddy	196000	2800	43500	2900
		Maize	1140	3800		
		Black gram	415	830		
2	Rabi	Pea	1365	910		
		Lentil	1950	780		
		Maize			1520	3800
		Black gram	249	830		
		Mastard	8100	900	2375	950
3	Summer	Paddy			18600	3100
4	Kharif& Rabi	Horticu-ltural Crops	72900	8100	50400	8400

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		Mustard	8100	900	2375	950
3	Summer	Paddy			18600	3100
4	Kharif& Rabi	Horticu-ltural Crops	72900	8100	50400	8400

1.14 Irrigation

The district is primarily rainfed. Out of the gross cropped area of **164862** ha, the extent of irrigated land is only **22,043** ha, i.e. 13.37% of total cropped area. Considering the block-wise data, percentage of gross irrigated land to gross cropped area is maximum in Goreswar block, followed by Tamulpur block, i.e 21.0% and 20.8% respectively.

A total of **1,42,819**ha of area is under rainfed cultivation. While comparing the ratio of area under rainfed cultivation to gross cropped area in each block, Dhamdhama block comes at the top position with 90.35% (gross cropped area of 21146 ha) under rainfed irrigation, followed closely by Baska block with 90.34% area under rainfed cultivation (gross cropped area of 21085 ha) (Table 1.6.).

Table 1.6: Irrigated area in Baksa District

Block	Irrigated (Area in Ha)		Rainfed (Area in Ha)	
	Gross Irrigated Area	Net Irrigated Area	Partially Irrigated / Protective Irrigation	Un-Irrigated or Totally Rainfed
Baska	2,037.00	1,767.00	-	19,048.00
Tihu- Barama	2,096.00	1,812.00	-	19,066.00
Tamulpur	4,756.00	3,388.00	-	18,099.00
Nagrijuli	1,580.00	1,580.00	-	14,572.00
Goreswar	4848	3477	-	18,226.00
Jalah	2,065.00	1,843.00	-	18,728.00
Gobardhana	2,620.00	2,390.00	-	15,975.00
Dhamdhama	2,041.00	1,771.00	-	19,105.00
Total	**22,043.00**	**18,028.00**	**-**	**1,42,819.00**

1.17 General Geology

The base of the Baksa district is formed by Archaean geneisses. Except the Northern boundary at the foot hills of Himalaya, the entire district of Baksa is covered by alluvial deposits of recent and sub-recent origin. The older alluvium is being carried down by the Himalayan originated rivers and deposited along the original inundation area which has later been raised to its present condition. The new alluvium covering the major part of the district consists of loosely consolidated sands, clays.

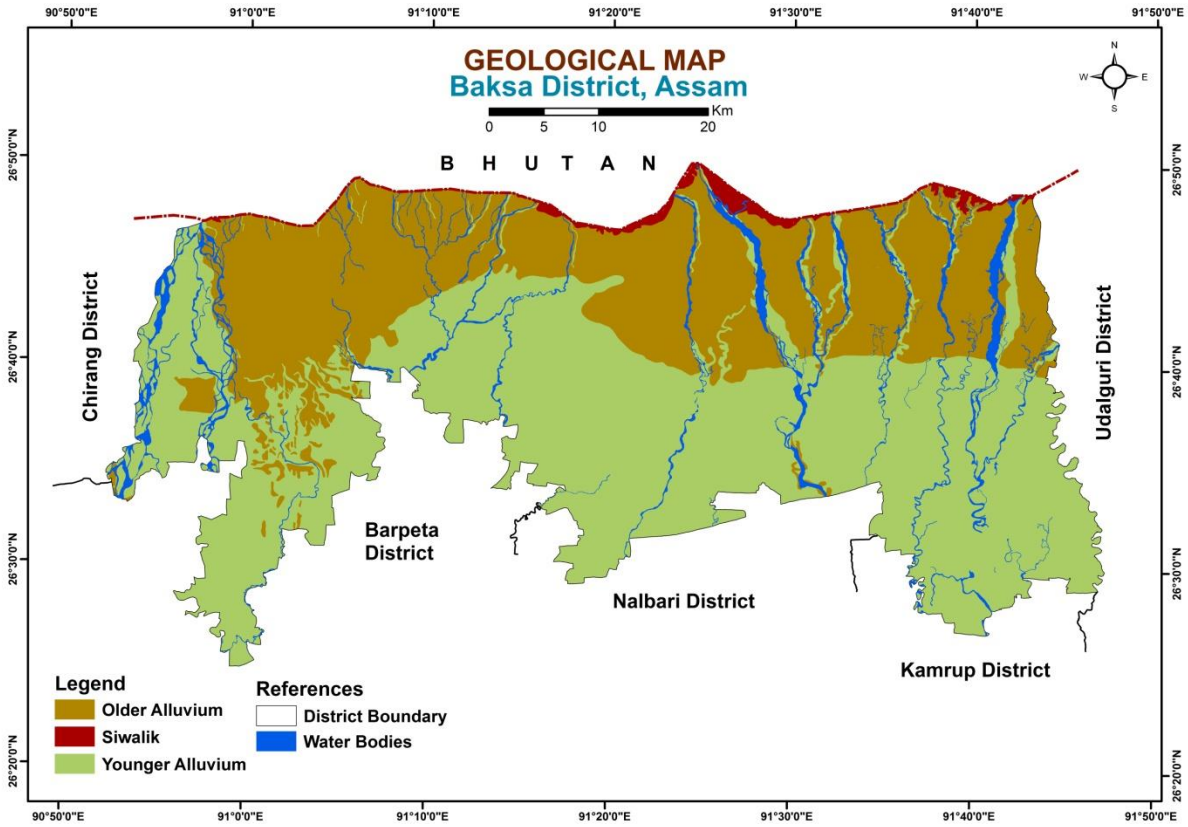

Fig 1.6 : Geological Map of Baksa District, Assam

CHAPTER -2

DATA COLLECTION & GENERATION

2.1 Data Collection

Exploration: Central Ground Water Board (CGWB), North Eastern Region had constructed 3 nos. of exploratory wells were constructed in the district (Table. 2.1).

Table 2.1: Details of earlier constructed wells in Baksa District.

Location	Latitude	Longitude	Depth Drilled (mbgl	Constr. Depth (mbgl)	Discharge (m^3/hr)	Draw Down (m)	Zones Encountered	T (m2/ day	Permeability (m/day)	Specific Capacity
Balagaon	26.4869	91.6289	301.69	143	3440.16	4.3	41-53 65-71 83-95 101-107 116-125 134- 140	13998.99	102.93	544.8
Goreswar-SH	26.5166	91.725	159.9							
Bogajuli	26.7852	91.5000	72	63	16.32	0.43	44-50 51-60	958		634.88

Geo-physical Survey: No VES survey was conducted in this district till date.

Water Level Monitoring Stations and Water Quality: CGWB has one water level monitoring station at Tamulpur in Baska district.

Table 2.2 : Details of NHNS in Baksa District.

Location	Latitude	Longitude	Depth of well (mbgl	Dia (m)	MP	RL	Pre-Monsson Water level (m)	Post Monsson Water Level (m)
Tamulpur	26.61	91.58	4.8	0.8	0.4	68.55	3.6	2.98

CGWB collects water samples from the only GWM well and carried out chemical analysis in its regional laboratory at Guwahati once in a year.

2.2 Data Generation

Exploration:

CGWB has constructed 11EWs down to a depth of 301 m. These exploratory wells were constructed through departmental rig and outsourcing (Table-2.1 and Fig.3.1).

Table 2.2 :Details of the Wells

Sl No.	Location	Block	Topo sheet No.	Latitude	Longitude	Depth Drilled/ Depth of Construction	Aquifer Tapped (Mbgl)	SWL (m bmp)	Discharge m^3 /hr	Draw Down	Transmitivity m^2/day	**Storativity**
1	Kachubari (In house)	Tamulpur	98N/14	26°38′9.16″	91°36′32″	18.50/18.50	9.00 -15.00	2.03	31.104	0.05		
2	Bengenahati (In house)	Goreswar	98N/14	26°31′18.3″	91°43′34.8″	91.60/91.60	47.50 -53.50 70.80 -82.80	0.25	29.88	0.25		
3	Barama (In house)	Barama	98N/10	26°33′44.38″	91°20′51.9″	129.15/43.80	31.00-40.00	0.23	13.68	0.30		
4	Barikadonga (Outsourced)	Dhamdhama	98N/10	26°42′18.93″	91°27′58.74″	305.50/228	101-104 129-132 152-158 169-175 197-203 218-224	4.70	101.74	5.34	829.11	$1.08x10^{-3}$
5	Bakuwa (Outsourced)	Jalah	98N/6	26°41′16.94″	91°14′33.52″	305.50/237	110-116 130-136 149-155 169-175 184-190 227-233	4.45	138.06	6.18	1959.84	$4.67x10^{-3}$
6	Bhabanipur B-Block (Outsourced)	Baksa	98N/10	26°42′16.13″	91°23′42.59″	305.50/	127 -133 164 -170 184 -190 197 -203 262 -268 278 -284	12.10	60.40	9.43	565.60	$1.75x10^{-6}$

Sl No.	Location	Block	Topo sheet No.	Latitude	Longitude	Depth Drilled/ Depth of Construction	Aquifer Tapped (Mbgl)	SWL (m bmp)	Discharge m^3 /hr	Draw Down	Transmitivity m^2/day	**Storativity**
7	BheblaBoropara (Outsourced)	Jalah	98N/6	26°38′51″	91°14′27.45″	305.50/269	106 -112 144 -150 175 -181 236 -242 259 -265	5.60	78.57	15.44	1933.60	$3.89x10^{-4}$
8	Charaimari (Outsourced)	Baska	98N/10	26°40′55.2″	91°17′55.25″	305.50/262	112-118 125-128 135 -141 173 -176 242 -245 255 -258	Auto Flow	29.52	9.43	79.69	
9	DakkhinDongargaon (Outsourced)	Nagrijuli	98N/14	26°40′34.4″	91°40′10.06″	297/291	145-151 167-173 233-239 258-264 281-287	2	138.06	5.42	2531.46	$3.06x10^{-3}$
10	Tangabari (Outsourced)	Jalah	98N/6	26°37′22.64″	91°5 ′57.84″	305.50/258	100 -106 118 -124 200 -206 220 -226 248 -254	3.90	151.68	3.53	4171.80	$2.01x10^{-3}$
11	Khusrabari (Outsourced)	Govardhana	98N/6	26°34′56″	91°1′30.6″	269.75	114-120 122-125 140-146 186-189 191-194 202-208					

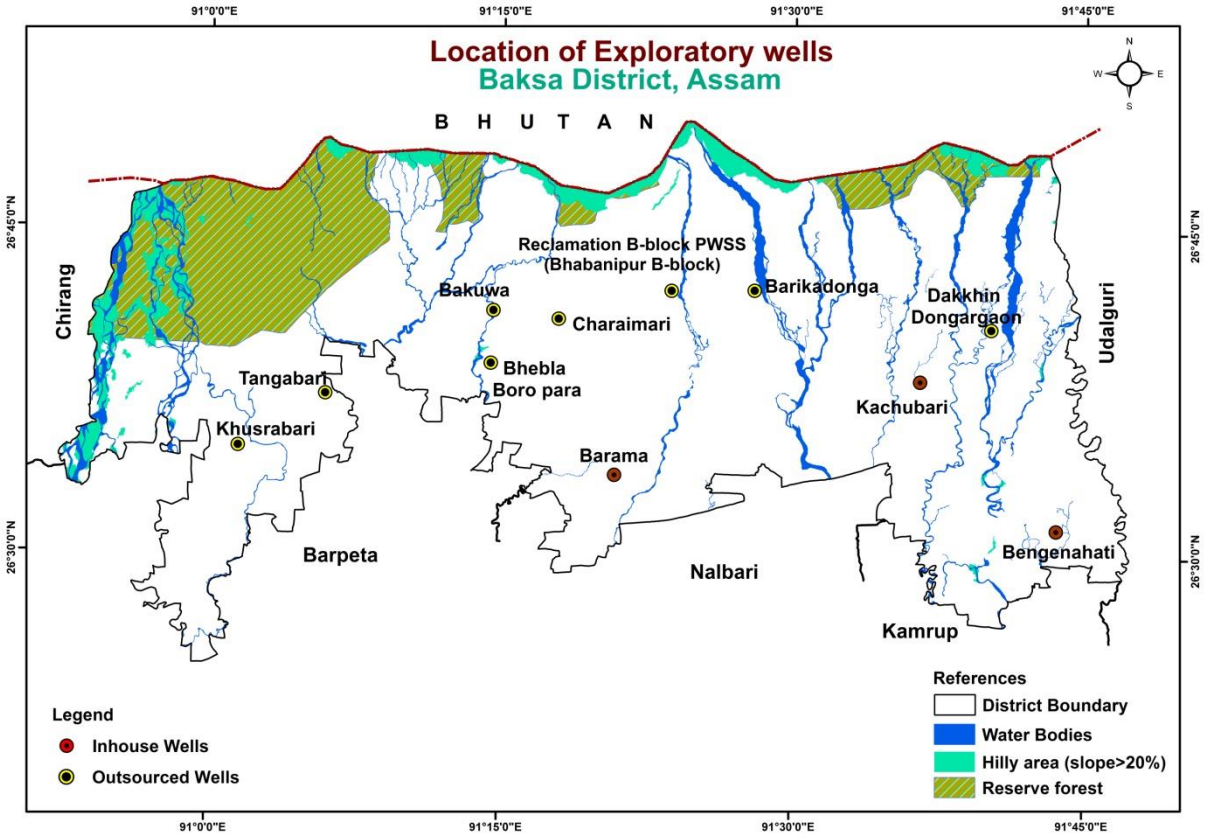

Fig 3.2.1: Map Showing Position of Deep tube Wells drilled by CGWB though In-house drilling and out sourced drilling.

Geo-physical Survey:

No Geophysical survey was conducted.

Water Level Monitoring Stations:

During aquifer mapping, 27 nos. of key wells were established to monitor ground water regime of the district (Fig 2.1)

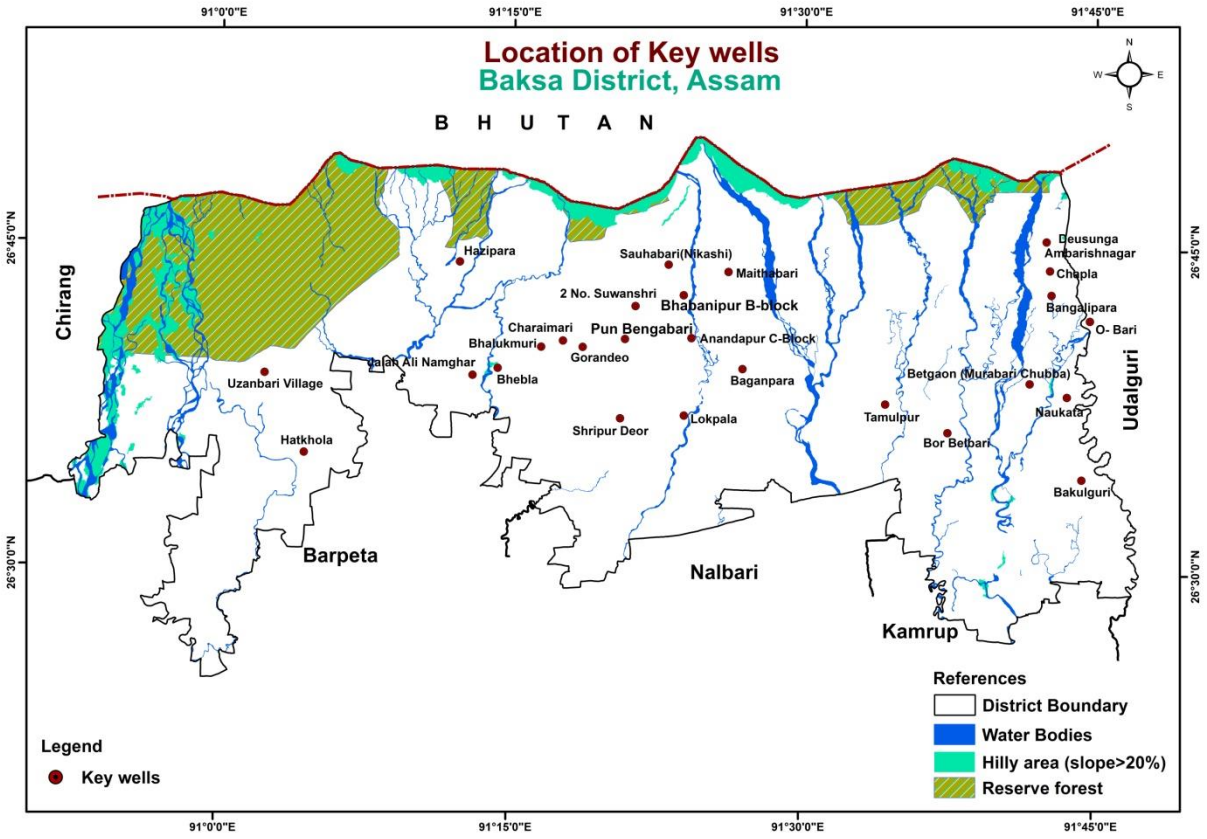

Fig 2.1: Key Well Location Map of Baksa District

Water Quality:

Groundwater samples were collected from shallow aquifers and also from exploratory wells. 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 4. GW samples collected from EWs (outsourced) were analyzed outside CGWB.

CHAPTER-3

DATA INTERPRETATION, INTEGRATION AND AQUIFERMAPPING

3.1.0 Data Interpretation

Central Ground Water Board, North Eastern Region, Guwahati has drilled elevenexploratory wells in the area. From the examination of this lithologs it is observed that down to a maximum explored depth of 305 m the sequence is dominated by gravel, sand, clay and boulders. The principal aquifer identified in the district is alluvium.

Table 3.1: Summary result of Litholog Study

Depth (mbgl)	Lithology
0 to 5	Top soil: clays with boulders of compact nature
5 to 50	Saturated formation : Sands, clays with pebbles etc.
50 to 305	Saturated formation: Pebbles with sands and clays occasionally with boulders

3.1.1 Aquifer Geometry

The district is located in the foothills of Bhutan Himalayas. The older alluvium is found in the piedmont or bhabar and is dominated by the boulders at shallow depth. The grain size of the aquifer material decreases towards the south.

The aquifer disposition in 2D is illustrated by two sections, viz., east –west section along the pieddmont and another is northwest-southeast section from piedmont to flood plain.

(i) East-West Section: The section is drawn along the piedmont zone from Dakkhin Dongargaon to Bakuwa (Fig. 3.1.1). The significant features of the section are:

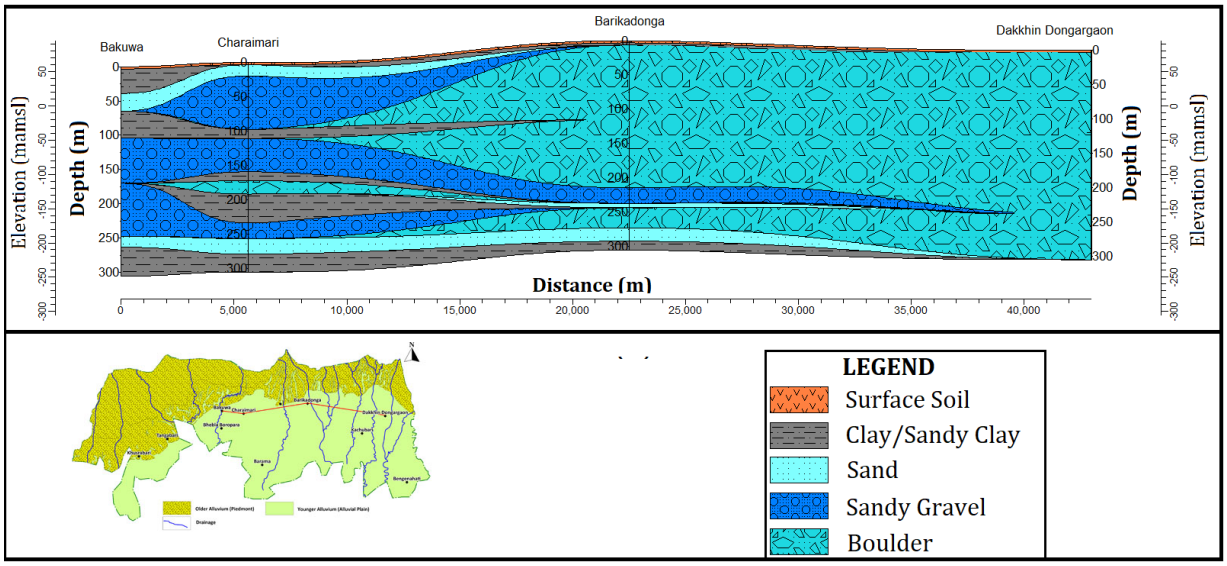

Fig 3.1.1: Section Diagram of Dakkhin Dongargaon- Bakuwa Section

A predominantly bouldery zone is encountered near the surface towards the eastern part of the district close to the piedmont at Bhabanipur B-Block, Barikadonga and Dakkhin Dongargaon.

The grain size of aquifer materials are decreasing towards the western part. Bouldery layer which is dominant in the eastern part is pinched out towards the eastern part. Gravel is dominant in the eastern part. Four numbers of sandy clay layers are observed in western part of the section. The top most layer extends from the surface down to a depth of 20 meters. The second sandy clay layer is encountered at a depth of 60 meters and extended up to a depth of 100 meters. Third sand clay layer is encountered at a depth of 260 meters and extended up to a depth of 305 meters. All these clay layers pinch out towards the eastern part. In general clay layers occur as lenses in this section.

(ii) Northwest-southeast section: The section is drawn from piedmont zone to alluvial plain i.e. Bhabanipur B-Block to Bengenahati (Fig. 3.1.2). The significant features of the section are :

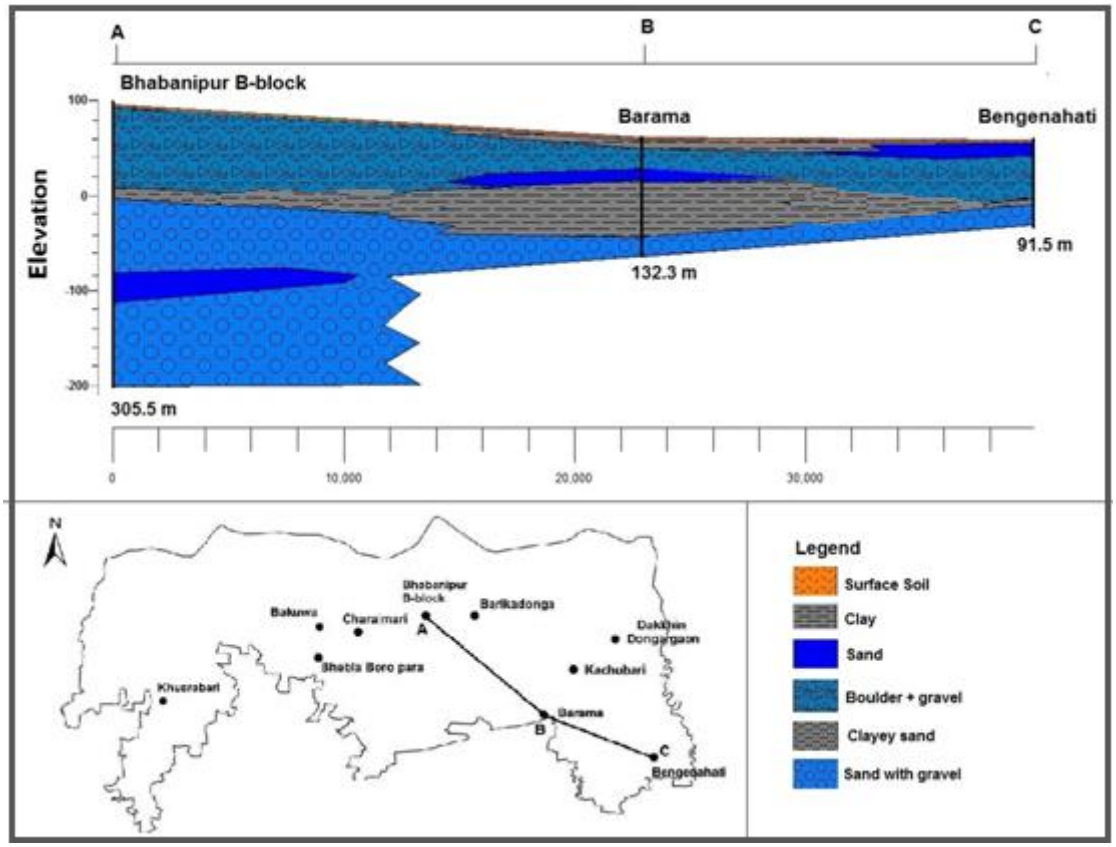

Fig 3.1.2: Section of Bhabanipur B-Block - Bengenahati Section

Boulder zone is detected near surface in the north-west and the zone is encountered within 20m depth towards the southeastern part of the district. Thickness of this zone ranges between 48 m to 90 m. Its thickness reduces towards the alluvial plain.

This boulder zone is separated from underlying thick gravelly zone by clay layer. The clay layer thickness reduces in both directions. The sandy clay layer attains a thickness of 34m at Barma and towards the northwestern part its thickness is 9m while towards Bengenahati the clay layer thickness reduces to 12m.

(iii) North West- South East section: The section is drawn from piedmont zone to alluvial plain i.e. Bakuwa to Barama (Fig. 3.1.3). The significant features of the section are :

A predominant Gravel zone is encountered up to a depth range of 300 meters from just below the surface. That very zone is uniformly extended from Bakuwa to Barama and is encountered at a depth of 12 m at Barama & 35 m at Bheblaboropara. Thickness of this zone ranges between 48m to152m. Its thickness reduces towards eastern part of the district.

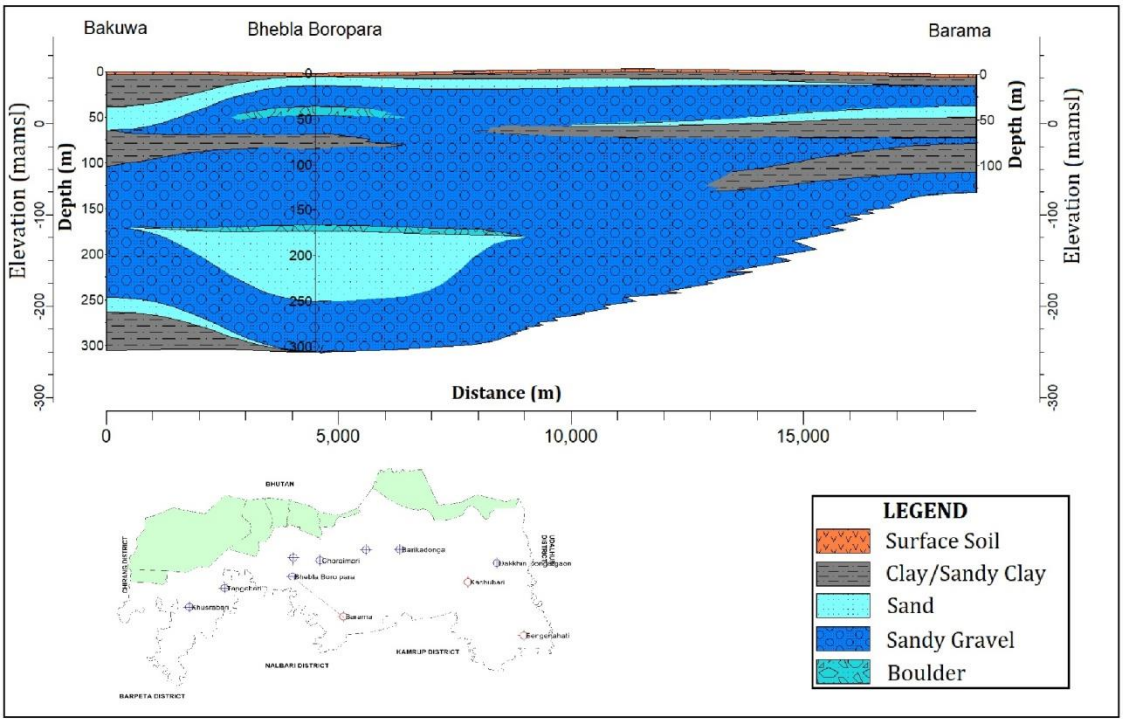

Fig 3.1.3 : Section of Khusrabari- Bengenahati Section

One uniformly distributed sand layer is found from Bakuwa to Barama. The thickness of this layer ranges between 10 m to 30 m . A thin clayey sand layer of thickness around 12 m is encountered at the surface in Barama area. Also a 34 m thick clayey sand layer of encountered at a depth of 46 metres at Barama area. A 12 m thick sand layer is found at a depth of 34 m at Barama and at Bengenahati 15m thick sand layer is encountered from the surface.

(iv) South West – North East section: The section is drawn from alluvial plain to piedmond zone i.e. Khusrabari to Bakuwa (Fig. 3.1.4). The significant features of the section are:

A predominant gravel zone is encountered up to a depth range of 270 meters from beneath the surface soil. That very zone is uniformly extended from Khusrabari to Tangabari and is encountered at a depth of 50 m at Bakuwa. Thickness of this zone ranges between 117 m to270 m. Its thickness reduces towards North eastern part of the district. This large thickness of gravel zone at Tangabari and Khusrabari may be attributed to the Mora Manas river which is flowing nearby.

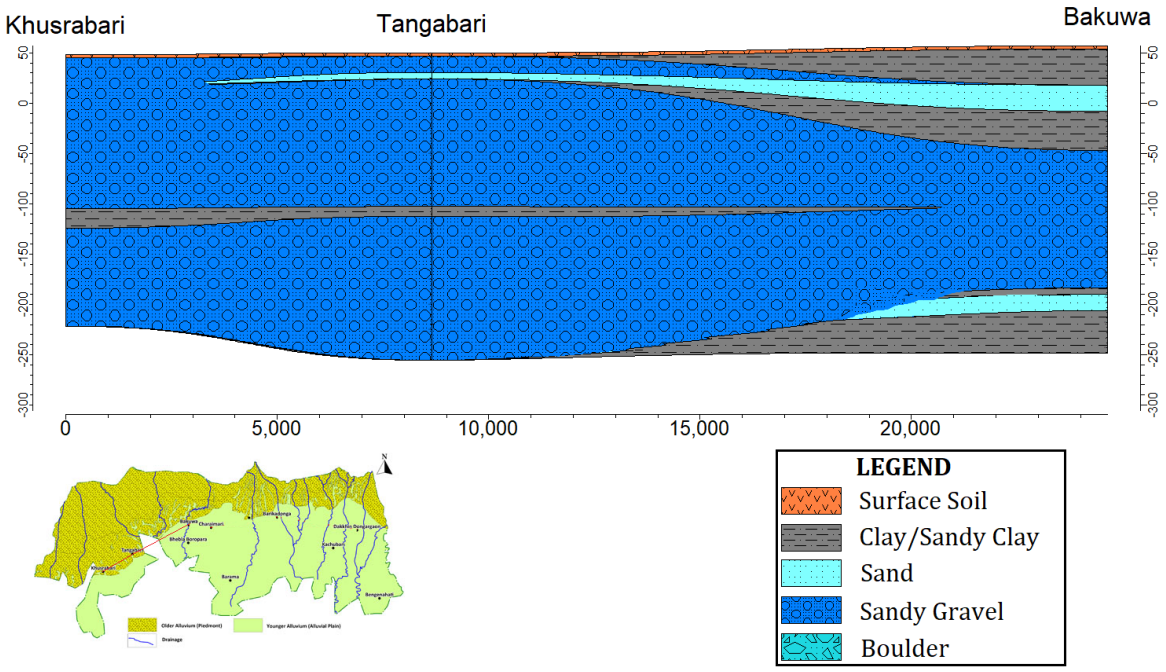

Fig 3.1.4 : Section of Khusrabari- Bakuwa Section

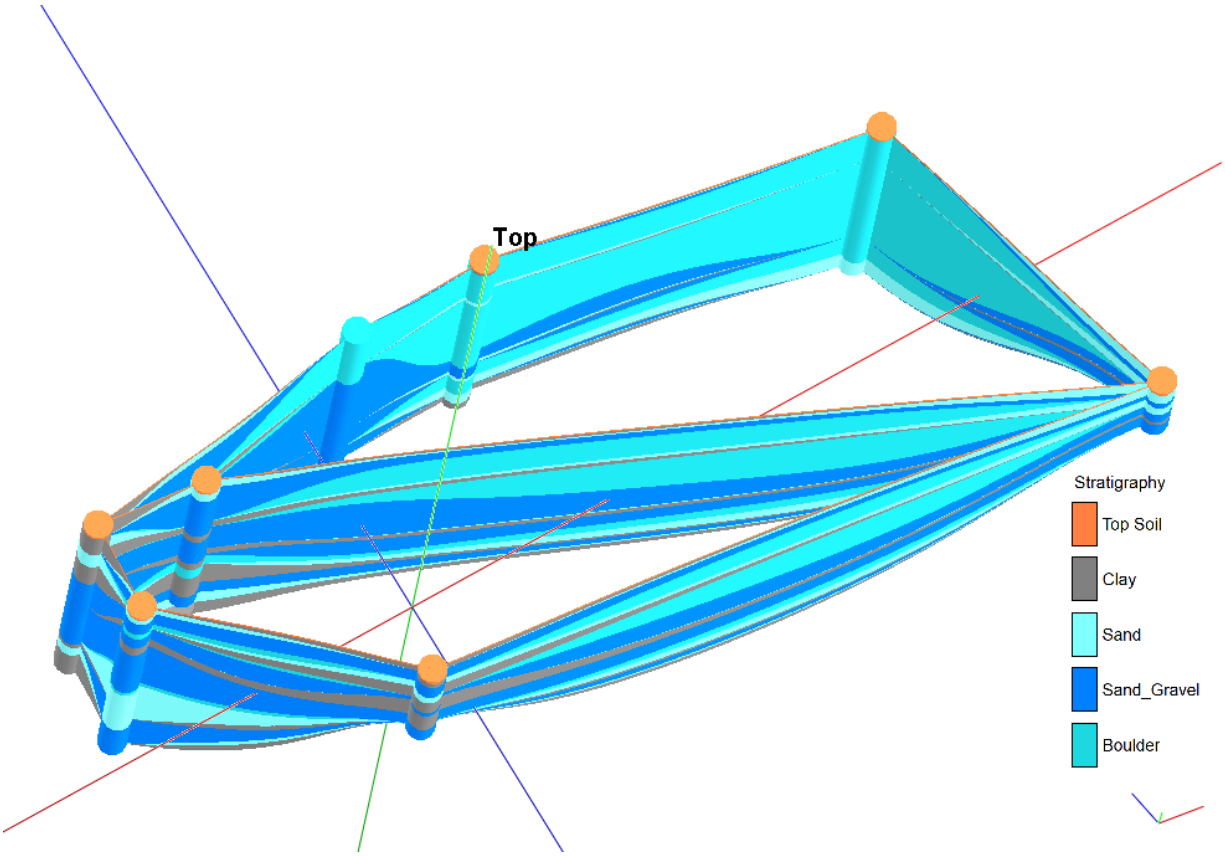

Fig 3.1.5 : 3D disposition of Aquifer of Baksa District

Aquifer Characterization: Unconsolidated alluvial aquifer consists of older and younger alluvium. Older alluvial aquifer is found towards north in the piedmont zone. The alluvial aquifer is characterized by coarse grained materials ranging in size from gravel to boulder. 2D disposition of aquifer clearly indicates that boulder zone is found in the sub-surface near the surface. The thickness of boulder zone is more in the piedmont and decreases towards the flood plain. Below the boulder zone, sand and gravel zone is found. Size of the aquifer materials generally decreases towards north. Broadly the aquifer in the district can be classified into two groups for ground water extraction purposes, viz., shallow aquifer and deeper aquifer. Shallow aquifer depth limit is 50m and below which deeper aquifer exists. The characteristic features of shallow and deeperaquifer zones are given in Table 3.2.

Table 3.3: Distribution and Characteristics of Aquifer System of Baksa District

Principal Aquifer Delineated	Zones Encountered (m bgl)	Zones Tapped (m bgl)	Discharge (m^3/hr)	Drawdown (m)	Transmitivity m^2/day	Storativity
Alluvium	**Shallow** 9-30 32-40 **Deeper** 69-76 106-123 165-191 227-240 243-270 273-292	**Shallow** 9-15 31-40 **Deeper** 70-75 110-116 227-233 242-265 282-285	**Shallow** 13.9-31 **Deeper** 16.3-151.6	**Shallow** 0.03-0.05 **Deeper** 0.25-9.43	**Deeper** 565.6-4171.8	**Deeper** $1.75x10^{-6}$ to $8.93x10^{-3}$

3.1.2: Depth to water level: Depth to water level monitored from dug wells (unconfined Aquifer) during November, 2019 ranges from 0.83 m to 10.98 mbgl while in March,2020 depth to water level ranges from 1.18 m to 11.19 m bgl. Depth to Water Level Map of Baksa District during pre- monsoon and Post-Most Monsoon is shown in the Fig 3.1.1 and Fig 3.1.2 respectively. Fluctuation of water level in the piedmont zone ranges from 0.13 to0.97 mbgl while in alluvial plain pre- and post monsoon water level difference ranges from 0.17 to 0.28 mbgl. In the piedmont slope, pre-monsoon water level is deeper and difference of pre and post monsoon water level is high. Fluctuation of water level in the piedmont zone ranges from 0.13 to0.97 mbgl while in alluvial plain pre- and post monsoon water level difference ranges from 0.17 to 0.28 mbgl.

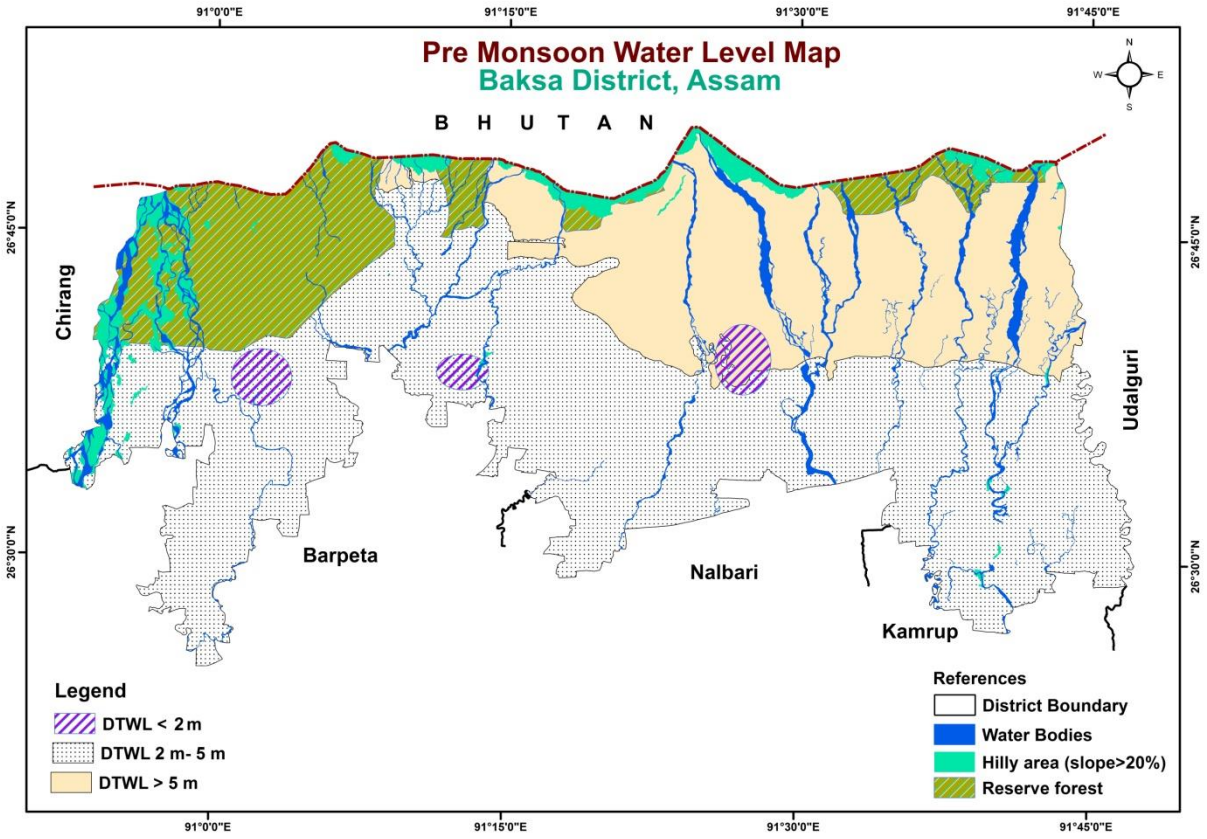

Fig 3.1.3: Pre Monsoon Water Level Map of Baksa District

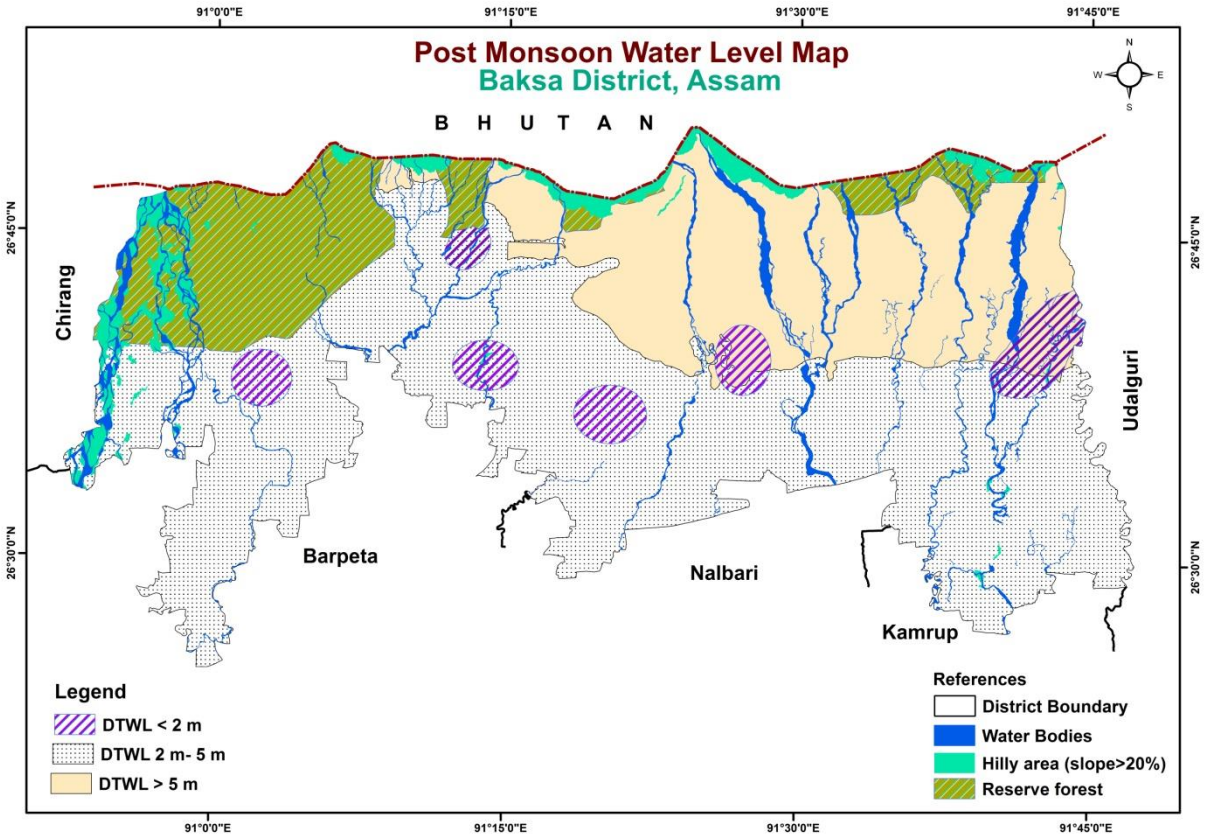

Fig 3.1.4: Post- Monsoon Water Level Map of Baksa District

Groundwater Movement: The recharge zone of the district lies towards the north, i.e., the piedmont zone. The groundwater flow is from northeast to southwest. The aquifer is contributing to the river (Fig.3.1.8).
Groundwater Movement: The recharge zone of the district lies towards the north, i.e., the piedmont zone. The groundwater flow is from northeast to southwest. The aquifer is contributing to the river (Fig.3.18).

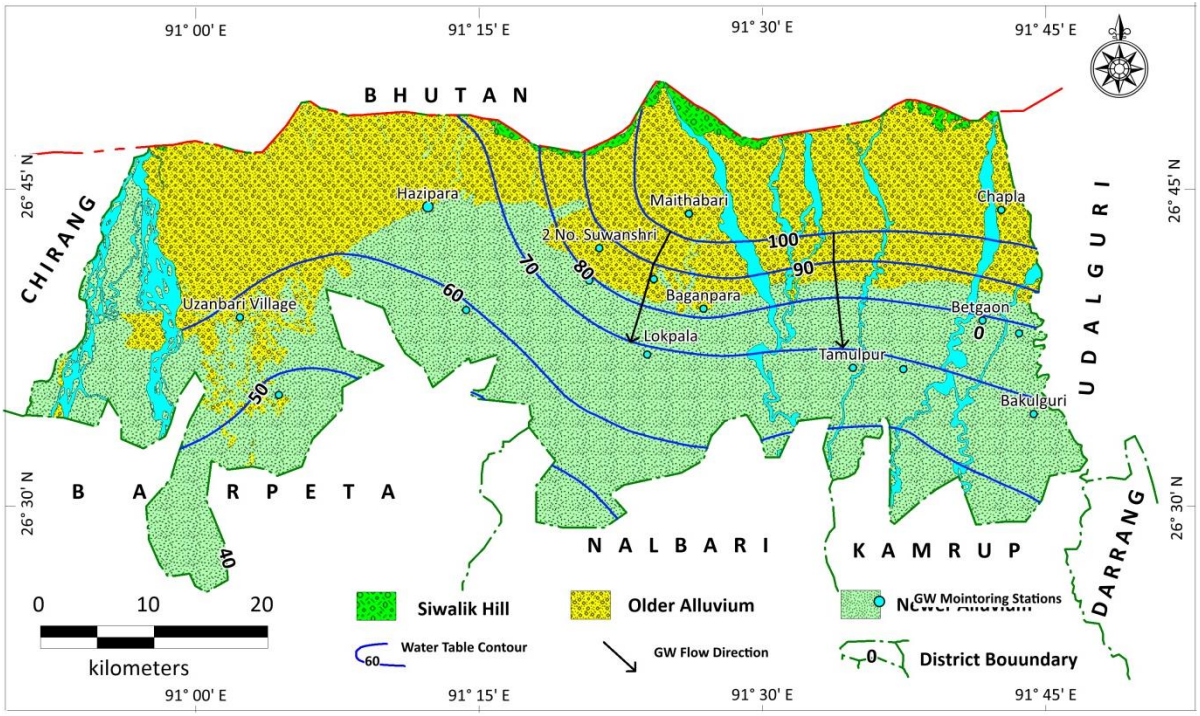

Fig 3.1.8: Water table contour map of Baksa District

The entire piedmont zone forms the recharge zone for the entire area. Ground water flow is from the higher elevation in northern towards the alluvial plain area. The highest water table is 100 m above mean sea level in the piedmont zone area while lowest contour is 50 m towards south.

3.1.3 Ground water quality

The pH value in ground water in dug wells ranges from 6.77 to 7.54, while the EC value and TDS concentration varies from 79.9 to 921.8 µmhos/cm and 52.7 to 608.3mg/l respectively. The concentration of Cl^- is from 14.18 to 81.53mg/l and that of SO_4 is 3.3 to12.68 mg/l. Ca and Mg concentration ranges from 6.80 to 32.32mg/l and 1.03 to 35.10mg/l respectively with a total hardness of 42.53 to 221.17mg/l. Chemical constituents of ground water of dug wells are within permissible limit of drinking, agricultural and industrial water standard set by BIS. However, iron (Fe) content beyond permissible limit has been observed in some places in the shallow aquifer zone.

The pH value of ground water in deeper aquifer zone ranges from 7.1 to 7.8, while the EC value and TDS concentration varies from 139 to 188 µmhos/cm and 83.4 to 122mg/l respectively. The concentration of SO_4 is 1.7 to 22.14 mg/l. Ca and Mg concentration ranges from 3 to 21 mg/l and 2.17 to 20.6 mg/l respectively with a total hardness of 25 to 225. Iron distribution in both shallow and deeper aquifersis shown in Fig 3.1.9.

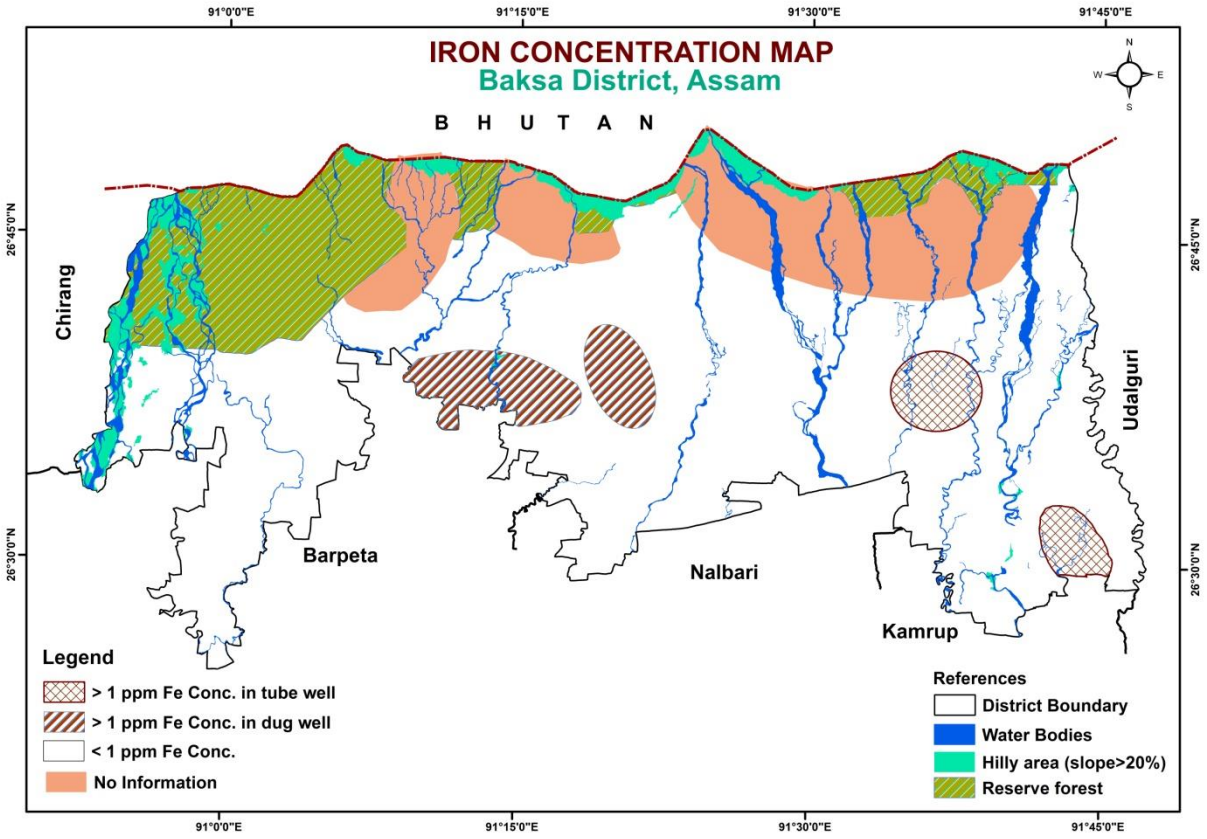

Fig 3.1.9: Iron Concentration map of Baksa District

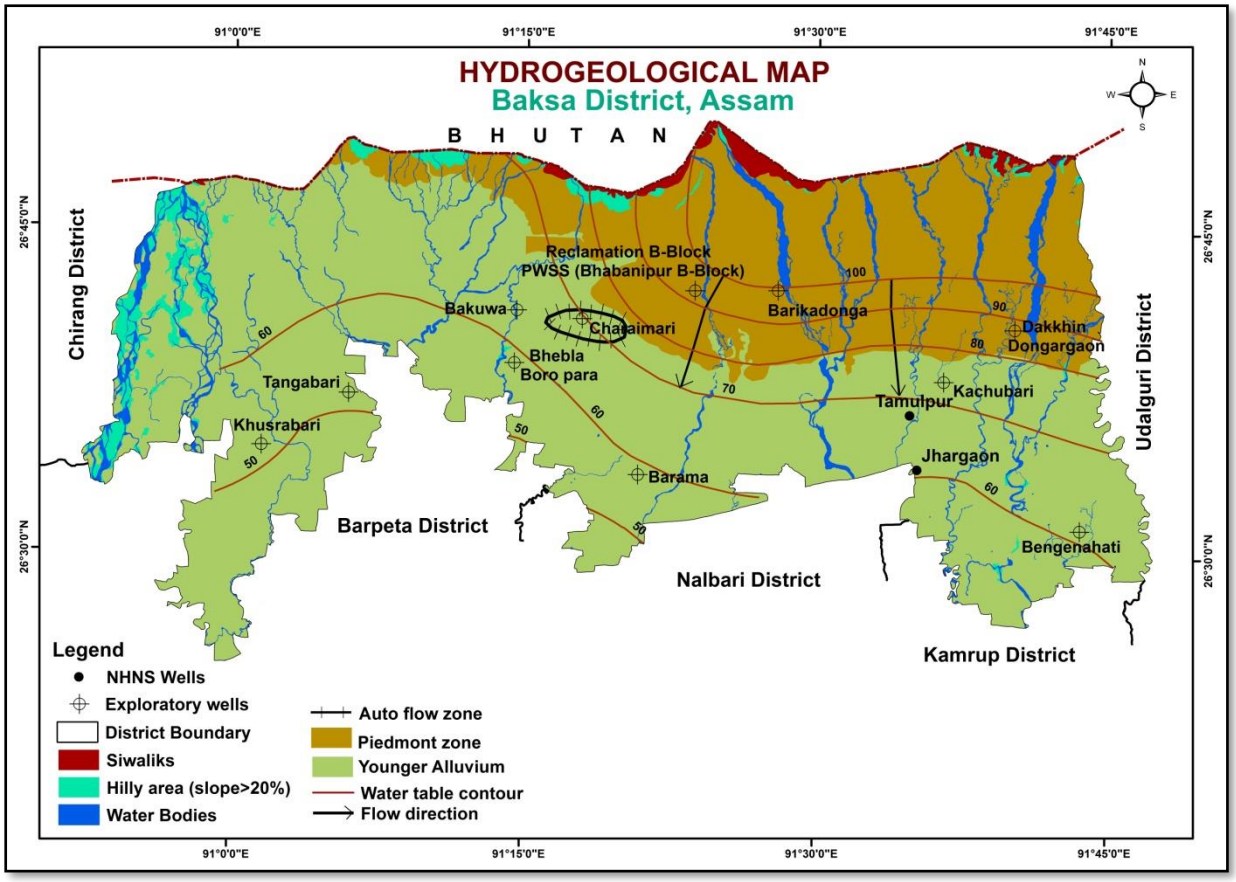

Fig 3.1: Hydrogeological Map of Baksa District

Based on the hydrogeomorphic set up, the area can broadly be classified into three zones. The characteristic feature of these zones are enumerated in the following table

Table 3.2:Division of study area based on geomorphology and its characteristic features

Zone	Geomorphology	Lithology	Chemical Quality	WL Condition
Zone-I	Alluvial plain	Sand, silt dominated with occasional gravel	High Fe in Some Areas	Shallow water level/ water logged
Zone-II	Piedmont	Gravel, pebbles, boulder with little sand and clay	Arsenic nil or within acceptable limit	Post monsoon water level is generally 3 to 4 mbgl
Zone-III	Piedmont slope and highly dissected structural hills	Gravel, pebbles, boulder with little sand and clay	As not reported and Fe is within acceptable limit	Deeper pre-monsoon WL, WL fluctuation is high

In the piedmont zone sediments deposited in high energy conditions as coarser grain materials are dominated in sub surface formation.

The aquifer disposition of the area in pannel diagram indicates existence of a single aquifer in the area. The confining layers are not continuous throughout the area. In piedmont zone boulders/gravels are encountered from around 12 meters whereas in alluvial plains it is encountered at around 20 maters making it difficult for drilling.

CHAPTER-4

GROUNDWATERRESOURCES

The computation of ground water resources available in the district has been carried out using GEC 2015 methodology. The assessment unit in the present assessment is district due to paucity of block-wise data. The summarised result is presented in Table 4.1.

Data and assumptions used in the assessment: Following data and assumptions are used in the assessment:

1) Rainfall recharge has been computed by RIF method. In RIF method, rainfall infiltration factor has been taken as 0.22 for major aquifer like valley fill.

2) Last ten years rainfall data is considered for groundwater resource calculation.

3) Water level data has been considered for 2019-20. Water level fluctuation based on data of March (Pre monsoon) and November (post monsoon) has been considered since deepest water levels are recorded during the month of March.

The average pre- and post-monsoon water level of Darrang district is 3.76mbgl and 3.44mbgl.

4) The population figures were collected from Census, 2011and projected to 2020. The per capita domestic requirement for the rural population has been considered as 60 lpcd and for urban population, it is 135 lpcd.

5) The dependency on ground water resource for domestic and industrial water supply in rural areas is considered as 91% and for urban areas, the dependency is 79%.

6) The command area of the district is 19627.07ha and the non-command area is 124459.1ha as per data provided by the Irrigation Department, Govt. of Assam.

7) In order to calculate the canal seepage, the data on length of the drainage channels are taken from the Irrigation Department, Govt. of Assam. The factor for return flow from surface water irrigation has been taken as 0.50 (paddy) and 0.30 (non-paddy) and for Ground water irrigation it has been taken as 0.45 (paddy) and 0.25 (non-paddy). Recharge from tanks and ponds are calculated based on the norms suggested in GEC'2015.

8) Recharge from water conservation structure has been taken as nil.

4.1 Recharge

The aquifers of the study area are recharged through a) infiltration of rainfall on the outcrop b) seepage from the tanks and ponds c) subsurface inflow across the up dip margin. The area experiences south-east monsoon. Monsoon rainfall contributes approximately 81 percent of total rainfall (May, June, July, August, September) while share of post and pre monsoon rainfall are approximately 13 and 6 percent each.

The rainfall recharge in the command area is 19,627.07ham while recharge from other sources is 1059.39ham. In the command area recharge from rainfall is 1,24,459.14 ham and recharge from other sources 1898.12 ham. Total ground water recharge is 147043.72ham.

4.2 Ground Water Extraction

The ground water extraction of unconsolidated aquifer is created by natural discharge like seepages and draft created by human interference, viz., (a) withdrawals for irrigation and industry and (b) public-supply wells.

In the district natural discharge is 14704.38ham of the total groundwater recharge, i.e., 147043.72 ham. Total irrigation extraction is 2,548.56ham, for industry 2.64ham and extraction for domestic uses is 2,078.68ham. Total groundwater extraction for all uses is only 4,629.88ham.

4.3 Allocation of resources up to 2025

The net ground water resource allocated for domestic sector is2,226.40ham while 1,22,371.23ham resource is available for future use.

4.4 Stage of Ground Water Extraction

The area has very little irrigation facilities. Similarly industrial development in the area is practically less. Groundwater is mainly utilized for domestic purposes. The stage of groundwater extraction in the district is 3.64%

Table 4.1: Dynamic GW resources of Baksa District, Assam

There is no major or medium canal irrigation scheme and thus the whole Baksa district has been considered as a non-command area.

Table 4.1: Net ground water availability (ham)

Monsoon recharge	Non-monsoon Recharge	Total annual ground water recharge	Environmental Flow (ham)	Annual Extractable GW Resources
117135.66	29908.06	147043.72	14704.38	127148.83

Table 4.2: Categorization of ground water resources (ham)

Annual Extractable GW Resources	Annual GW extraction				Allocation for Domestic use up to 2025	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Stage of ground water extraction (%)
	Irrigation	Domestic extraction	Industrial extraction	Total			
127148.83	2548.56	2.64	2078.68	4629.88	2226.4	122371.23	3.64

Groundwater Resources – Recharge for Various Seasons

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.

Recharge from All Sources: Total recharge to groundwater has several components, rainfall being the major one. The other components include seepage from canals, return flow from surface water irrigation, return flow from groundwater irrigation, seepage from tanks/ ponds

etc. Recharge from various sources has been calculated for monsoon as well as non-monsoon periods and details have been shown in table 4.3

Table 4.3: Recharge from various sources (ham).

District	Recharge from Rainfall during monsoon season	Recharge from rainfall during non-monsoon season	Recharge from other sources during non-monsoon Season	Total Annual Ground Water Recharge	Annual Extractable GW Resources
Baksa	49008	36833	4151	89992	85488

Recharge from rainfall in the district is 85841 hams. Comparison of monsoon & non-monsoon rainfall recharge shows that monsoon recharge accounts for 54 %. Recharge from other sources is 4151 ham. Comparison of recharge from rainfall, to recharge from sources other than rainfall shows that the later accounts for only about 0.04 % of the total recharge.

Groundwater Extraction for Various Purposes

Domestic Extraction

Groundwater extraction for domestic use has been estimated on projected population for 2025, based 2011 Census data of number of households using groundwater as “Main source of drinking water”. Groundwater extraction for irrigation is 2548 whereas for domestic and industrial supply it is 4437 ham in the district. Hence, groundwater extraction for all uses in the district is 6985 ham. Provision for domesticand industrial requirement supply to 2025 is 4611 ham.Net Ground Water Availability for future development in the district is 85488 ham.

Stage of Groundwater Development &Categorization of theBlocks

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 Baksa district is 3.64 %. Based on the stages and development and long-term water level trend analysis the district can be categorized under **safe** category.

CHAPTER-5

5.0 Groundwater Issues

Major groundwater issues in the district are:

a) Low stage of groundwater extraction
b) Water quality problem pertaining to high concentration of iron above permissible limit in some pockets

a) Low Stage of Ground Water Extraction

As per ground water resource estimation, the stage of ground water development is just 3.64 % and share of ground water in irrigation is very less. The irrigated area of the district is only 13.37% of the net cropped area.

Shallow tube well is not feasible in the piedmont zone due to presence of near surface boulder formation. One major obstacle in accelerating ground water irrigation is the presence of boulder pebble and cobble zone in the aquifer which creates difficulty in drilling operations.

b) Drilling Problems

The construction of tube wells is difficult due to encounter of boulder formation after certain depth. Towards the northern side, presence of Bhabar formation makes it difficult to drill tube wells.

c) Water Quality problems

Iron above permissible limit is detected in some shallow as well as deep wells in the younger alluvial plain. Except high iron content, the ground water of the district is suitable and safe for drinking and other uses.

In deeper aquifer it ranges from 0.19 to 3.86 ppm.

CHAPTER-6

6. GROUND WATER MANAGEMENT STRATEGY

As per dynamic ground water resource estimation of Baksa district for 2019-20, net ground water availability is 85488 ham and stage of extraction is only 3.64%. The district is having balance net ground water availability for future irrigation use in the tune of 78284 ham. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 46970 ham of groundwater resources is available in the district for the future irrigation uses. From this available resource,19570 nos. of shallow tube wells (considering a unit draft of 2.4 ham/year) can be constructed. Therefore, there is enough scope for future development of ground water in the district to bring more area under irrigation practice.

During Kharif season, land under cultivation (field crops only) in the district is 106940 ha (District Irrigation Plan, 2016-20). After kharif crops are over, whole of this cultivable area remains fallow during Rabi season. Gap between area cultivated during kharif season and rabi season is 106940 ha. The intention of this plan is to utilize this fallow land of about 106940 ha under assured irrigation during Rabi season which will help to increase gross cropped area to 213880 ha. This will help to increase gross cropped area and thereby increase cropping intensity up to 200%. Since stage of dynamic ground water is only 3.64%, this area of 106940 ha can easily be covered by constructing ground water based irrigation projects. 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 and is presented in Table 6.1

Table 6.1: Cropping Pattern Data of BaksaDistrict (*Source: CROPWAT)*

CROPPING PATTERN DATA

(File: C:\ProgramData\CROPWAT\data\sessions\Baksa_rice_crop plan.PAT)

Cropping pattern name: Baksa_Rice

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...Data\CROPWAT\data	Rice	05/06	02/10	20
2	...Data\CROPWAT\data	Rice	10/06	07/10	20
3	...Data\CROPWAT\data	Rice	20/06	17/10	20
4	...Data\CROPWAT\data	Rice	25/06	22/10	20
5	...Data\CROPWAT\data	Rice	30/06	27/10	10
6	...Data\CROPWAT\data	Rice	10/07	06/11	10

In rice fallow, potato, mustard, pulses and rabi vegetables can be grown with the support of irrigation. Present cropping pattern, proposed cropping pattern, targeted increase in cropping intensity were shown in table 6.2

Table 6.2: Proposed cropping pattern of Vegetables & Rice in Baksa district

Cropping pattern (s)				
Rice-Pulse-Potato	Present Cultivated area	Area to be cultivated	Area to be cultivated (**ha**)	Irrigation requirement (**ha m**)
Rice-Vegetables	(**ha**)	(**%**)		
Rice-Pulses				
Rice-Rapseed Mustard				
	1	2 (= % of 1)	3	4
Rice (main crop)	106940	100	106940	**17877.16**
Pulses		20	21388	3190.0202
Oilseed		20	21388	4702.1518
Winter vegetables		20	21388	3165.424
Summer vegetables		20	21388	991.3338
Potato		20	21388	4603.767
Net cultivated area	106940			**34529.86**
Gross cultivated area (Paddy/+Pulses+Millet)			**213880**	
Total irrigation requirement				**34529.86**
With 70% irrigation efficiency				**49328.37**
Cropping intensity			**200% (Intended)**	

Source: CROPWAT

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 6.4. Crop-wise and month-wise Irrigation water requirement in ham has been further calculated in Table 6.5.

The total area of rice cultivation is comprised of **106940** ha. 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 two to four stages during this period. It is planned to utilize rice fallow of **106940** ha for the cultivation of pulses, potato, mustard and vegetables. It is considered to cultivate the proposed crops 21388 ha each. The peak water requirement for irrigation for rice is in the months of May-June, for mustard and pulses it is in the month of January, for potato it is in the month of March and for vegetables it is during February.

Table 6.4: Crop-wise and month-wise precipitation deficit (mm) using CROPWAT 8 for BaksaDistrict.

Precipitation deficit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Rice	0	0	0	0	147.1	52.1	0	0	0	6.2	0	0
2. Rice	0	0	0	0	49.7	98	0	0	0	0	0	0
3. Rice	0	0	0	0	48.5	98	0	0	0	1.9	0	0
4. Rice	0	0	0	0	0	147.1	0	0	0	15.1	0	0
5. Rice	0	0	0	0	0.5	146.5	0	0	0	12.3	0	0
6. Rice	0	0	0	0	0	48.9	98	0	0	27.9	10.2	0
7. Small Vegetables	38.2	0	0	0	0	0	0	0	0	6.4	39	56.7
8. Small Vegetables	56.3	24.5	0	0	0	0	0	0	0	0	26.7	48.2
9. Mustard	49.7	51.8	58.2	7.1	0	2.9	0	0	0	0	13.6	44.5
10. Mustard	49.7	51.8	58.2	7.1	0	0	2.8	0	0	0	6.1	36.2
11. Potato	62.5	64.5	32	0	0	0	0	0	0	0	16.1	39.9
12. Potato	59.5	67	49.6	0	0	0	0	0	0	0	8.7	30.7
13. Pulses	16.2	51.8	81.5	11.8	0	0	0	0	0	0	0	0
14. Pulses	6.8	27.2	77.9	25.1	0	0	0	0	0	0	0	0
15. Small Vegetables	0	0	23.1	1.1	0	6.7	0	0	0	0	0	0
16. Small Vegetables	0	10.3	42	16.2	0	0	0	0	0	0	0	0

Crop	Area (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total IWR (Ham)
1. Rice	20	0	0	0	0	3146.175	1114.315	0	0	0	132.6056	0	0	4393.1
2. Rice	20	0	0	0	0	1062.984	2096.024	0	0	0	0	0	0	3159.01
3. Rice	20	0	0	0	0	1037.318	2096.024	0	0	0	40.6372	0	0	3173.98
4. Rice	20	0	0	0	0	0	3146.175	0	0	0	322.9588	0	0	3469.13
5. Rice	10	0	0	0	0	5.347	1566.671	0	0	0	131.5362	0	0	1703.55
6. Rice	10	0	0	0	0	0	522.9366	1048.012	0	0	298.3626	109.0788	0	1978.39
7.Winter Vegetables		408.5108	0	0	0	0	0	0	0	0	68.4416	417.066	606.3498	1500.368
8.Winter Vegetables		602.0722	262.003	0	0	0	0	0	0	0	0	285.5298	515.4508	1665.056
9.Oil seed		531.4918	553.9492	622.3908	75.9274	0	31.0126	0	0	0	0	145.4384	475.883	2436.093
10.Oil seed		531.4918	553.9492	622.3908	75.9274	0	0	29.9432	0	0	0	65.2334	387.1228	2266.059
11.Potato		668.375	689.763	342.208	0	0	0	0	0	0	0	172.1734	426.6906	2299.21
13. Potato		636.293	716.498	530.4224	0	0	0	0	0	0	0	93.0378	328.3058	2304.557
14. Pulses		173.2428	553.9492	871.561	126.1892	0	0	0	0	0	0	0	0	1724.942
15. Pulses		72.7192	290.8768	833.0626	268.4194	0	0	0	0	0	0	0	0	1465.078
16.Summer Vegetables		0	0	247.0314	11.7634	0	0	0	0	0	0	0	0	258.7948
17. Summer Vegetables		0	110.1482	449.148	173.2428	0	0	0	0	0	0	0	0	732.539
Total		**3624.2**	**3731.14**	**4518.22**	**731.47**	**5251.82**	**10573.16**	**1077.96**	**0**	**0**	**994.54**	**1287.56**	**2739.8**	**34529.86**

Under ground water exploration programme, of CGWB has drilled 10 nos. DTWs down to the depth of 305 m bgl and one shallow tube well. It is observed that tube wells constructed down to a depth from 305 m and tapping 41 – 36 m cumulative thickness of aquifer are capable to yield 16.32 to 3440 m^3/hr for a maximum drawdown up to 39 m. The transmissivity of the aquifer is calculated as 89.3 to 13999 m^2/day and permeability as 213 to 490 m/day and can be sustainably developed and use for irrigation purpose. Shallow tube wells within 40m depth can be constructed through 150/100mm diameter well assembly tapping 30–55m granular zones having 25m housing and 15-30 m slotted portion. The annular space between the borehole and the well assembly should be shrouded preferably with 100mm thick zone of pea gravels.

A shallow tube well in the district is expected to yield 30 m^3/hr. If such a tube well runs for 8 hrs/day for 120 days, then it will create a draft of 2.88ham.

Annual irrigation water requirement is **42191.49 ham**. However, proportionate dynamic groundwater resources available for future irrigation use in the district is 78284 ham. Therefore, this rice fallow area can be irrigated by constructing ground water abstraction structures and can bring under double cropped area. This amount of groundwater resources can be harnessed by constructing 14650 tube wells. It is also proposed to construct water harvesting structures at suitable places. As per available ground water resources (60% availability) 14650 nos. of tube wells can be constructed.

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

ANNEXURE 2: WATER LEVEL DATA OF KEY WELLS OF BAKSA(Nov, 2019)

S.N	District*	Block*	Village	Lat*	Long*	Well* Type	MP*	RL*	Depth*	Dia*	Water Level (m bmp) Nov-2019
STATE : ASSAM											
1	Baksa	Goreshwar	Bakulguri	91.7395	26.5735	DUG	0.69		5.19	0.78	2.08
2	Baksa	Mushalpur	ShripurDeor	91.3439	26.6176	DUG	0.90		5.36	0.78	1.96
3	Baksa	Mushalpur	Pub Bengabari	91.3473	26.6788	DUG	0.71		5.67	0.71	3.69
4	Baksa	Mushalpur	2 No. Suwanshri	91.3560	26.7042	DUG	1.06		4.96	0.90	2.16
5	Baksa	Mushalpur	Maithabari	91.4353	26.7314	DUG	1.00		28.95	1.51	9.97
6	Baksa	Goreshwar	Naukata	91.7264	26.6370	DUG	0.80		4.44	0.80	2.00
7	Baksa	Goreshwar	O- Bari	91.7456	26.6958	DUG	0.85		3.99	1.00	1.96
8	Baksa	Goreshwar	Bangalipara	91.7125	26.7155	DUG	0.60		6.40	0.74	2.80
9	Baksa	Goreshwar	DeusungaAmbarishnagar	91.7078	26.7566	DUG	0.92		29.00	0.92	10.98
10	Baksa	Goreshwar	Chapla	91.7109	26.7343	DUG	0.92		11.50	1.07	5.79
11	Baksa	Goreshwar	Betgaon (MurabariChubba)	91.6944	26.6472	DUG	1.17		4.70	0.93	1.98
12	Baksa		BorBelbari	91.6244	26.6090	DUG	0.88		7.10	1.06	2.14
13	Baksa	Borpetaroad	Uzanbari Village	91.0389	26.6497	DUG	0.60		2.83	0.62	0.97
14	Baksa	Borpetaroad	Hatkhola	91.0735	26.5887	DUG	0.78		5.58	1.10	2.79
15	Baksa	Mushalpur	Baganpara	91.4482	26.6567	DUG	0.95		4.62	1.00	0.95
16	Baksa	Mushalpur	Gorandeo	91.3111	26.6723	DUG	0.90		4.30	0.68	2.27
17	Baksa	Mushalpur	Charaimari	91.2942	26.6770	DUG	1.00		6.00	0.71	3.17
18	Baksa	Mushalpur	Bhalukmuri	91.2756	26.6720	DUG	0.40		4.86	0.87	2.70
19	Baksa	Jalah	Bhebla	91.2386	26.6554	DUG	0.60		4.50	0.71	1.81
20	Baksa	Mushalpur	Bhabanipur B-Block	91.3972	26.7129	DUG	0.69		11.45	1.09	4.34
21	Baksa	Mushalpur	Anandapur C-Block	91.4042	26.6800	DUG	1.06		6.85	1.14	4.71
22	Baksa	Mushalpur	Lokpala	91.3984	26.6203	DUG	0.93		4.83	0.65	2.08
23	Baksa	Jalah	Hazipara	91.2050	26.7368	DUG	0.54		4.92	0.80	1.83
24	Baksa	Jalah	Jalah Ali Namghar	91.2171	26.6497	DUG	0.76		5.22	0.76	0.83

ANNEXURE 3 : WATER LEVEL DATA OF KEY WELLS OF BAKSA (March, 2020)

S.N	District*	Block*	Village	Lat*	Long*	Well* Type	MP*	Depth*	Dia*	Water Level (m bmp)
STATE : ASSAM										
1	Baksa	Goreshwar	Bakulguri	91.7395	26.5735	DUG	0.69	5.19	0.78	2.36
2	Baksa	Mushalpur	ShripurDeor	91.3439	26.6176	DUG	0.90	5.36	0.78	2.17
3	Baksa	Mushalpur	Pub Bengabari	91.3473	26.6788	DUG	0.71	5.67	0.71	4.11
4	Baksa	Mushalpur	2 No. Suwanshri	91.3560	26.7042	DUG	1.06	4.96	0.90	2.52
5	Baksa	Mushalpur	Maithabari	91.4353	26.7314	DUG	1.00	28.95	1.51	10.08
6	Baksa	Goreshwar	Naukata	91.7264	26.6370	DUG	0.80	4.44	0.80	2.25
7	Baksa	Goreshwar	O- Bari	91.7456	26.6958	DUG	0.85	3.99	1.00	2.17
8	Baksa	Goreshwar	Bangalipara	91.7125	26.7155	DUG	0.60	6.40	0.74	3.02
9	Baksa	Goreshwar	DeusungaAmbarishnagar	91.7078	26.7566	DUG	0.92	29.00	0.92	11.19
10	Baksa	Goreshwar	Chapla	91.7109	26.7343	DUG	0.92	11.50	1.07	5.98
11	Baksa	Goreshwar	Betgaon (MurabariChubba)	91.6944	26.6472	DUG	1.17	4.70	0.93	2.11
12	Baksa		BorBelbari	91.6244	26.6090	DUG	0.88	7.10	1.06	2.31
13	Baksa	Borpetaroad	Uzanbari Village	91.0389	26.6497	DUG	0.60	2.83	0.62	1.22
14	Baksa	Borpetaroad	Hatkhola	91.0735	26.5887	DUG	0.78	5.58	1.10	3.04
15	Baksa	Mushalpur	Baganpara	91.4482	26.6567	DUG	0.95	4.62	1.00	1.18
16	Baksa	Mushalpur	Gorandeo	91.3111	26.6723	DUG	0.90	4.30	0.68	3.31
17	Baksa	Mushalpur	Charaimari	91.2942	26.6770	DUG	1.00	6.00	0.71	3.29
18	Baksa	Mushalpur	Bhalukmuri	91.2756	26.6720	DUG	0.40	4.86	0.87	2.84
19	Baksa	Jalah	Bhebla	91.2386	26.6554	DUG	0.60	4.50	0.71	2.43
20	Baksa	Mushalpur	Bhabanipur B-Block	91.3972	26.7129	DUG	0.69	11.45	1.09	4.79
21	Baksa	Mushalpur	Anandapur C-Block	91.4042	26.6800	DUG	1.06	6.85	1.14	4.86
22	Baksa	Mushalpur	Lokpala	91.3984	26.6203	DUG	0.93	4.83	0.65	2.39
23	Baksa	Jalah	Hazipara	91.2050	26.7368	DUG	0.54	4.92	0.80	2.28
24	Baksa	Jalah	Jalah Ali Namghar	91.2171	26.6497	DUG	0.76	5.22	0.76	1.19

Annexure 4:WATER QUALITY DATA OF SHALLOW AQUIFER ZONE, BAKSA DISTRCT

Sl. No.	Village/ Location	Type of well	p^H	EC (µS/cm)	TRBD (NTU)	TDS	CO_3	HCO_3	TA	Cl^-	SO_4^{-2}	NO_3^- 1	F^-	Ca^{+2}	Mg^{+2}	TH	Na^+	K^+	Fe
							(mg/lt)												
1.	Bakulguri	DW	8.18	247.70	BDL	146.70	BDL	170.14	170.14	14.18	10.61	BDL	0.44	26.02	20.62	150.00	14.37	2.06	BDL
2.	ShripurDeor	DW	7.69	164.50	BDL	97.15	BDL	75.06	75.06	31.91	19.02	BDL	0.24	20.02	9.70	90.00	12.20	5.38	3.050
3.	Pub Bengabari	DW	7.47	70.03	BDL	41.80	BDL	40.03	40.03	14.18	12.08	BDL	0.14	8.01	6.06	45.00	5.72	3.17	0.002
4.	2 No. Suwanshri	DW	8.02	237.90	BDL	141.70	BDL	140.11	140.11	17.73	21.65	BDL	0.23	32.03	15.76	145.00	6.38	6.39	BDL
5.	Naukata	DW	7.92	159.80	BDL	94.77	BDL	90.07	90.07	24.82	20.72	BDL	0.41	22.02	7.27	85.00	10.08	9.48	BDL
6.	O- Bari	DW	8.17	390.80	BDL	232.40	BDL	280.22	280.22	21.27	18.61	BDL	0.33	32.03	42.46	255.00	4.09	1.66	BDL
7.	Bangalipara	DW	8.01	340.00	BDL	201.90	BDL	215.17	215.17	14.18	26.08	BDL	0.25	40.03	31.53	230.00	4.80	3.62	BDL
8.	DeusungaAmbarishnagar	DW	8.17	403.30	BDL	239.60	BDL	250.20	250.20	14.18	31.50	BDL	0.21	46.04	32.74	250.00	4.87	2.22	BDL
9..	Chapla	DW	8.18	364.30	BDL	216.90	BDL	240.19	240.19	14.18	26.54	BDL	0.24	36.03	38.82	250.00	4.23	2.17	BDL
10.	Uzanbari Village	DW	7.62	322.80	BDL	187.40	BDL	175.14	175.14	31.91	19.60	BDL	0.10	30.02	24.26	175.00	15.85	8.19	0.53
11.	Hatkhola	DW	7.35	118.10	BDL	68.21	BDL	70.06	70.06	10.64	7.81	BDL	0.15	14.01	7.27	65.00	3.97	3.49	BDL
12.	Baganpara	DW	6.92	144.90	BDL	83.67	BDL	60.05	60.05	35.45	12.24	BDL	0.16	14.01	6.06	60.00	19.89	3.07	BDL
13.	Gorandeo	DW	7.26	127.10	BDL	73.84	BDL	75.06	75.06	17.73	10.70	BDL	0.14	18.01	3.63	60.00	9.49	7.27	1.24
	Charaimari	DW	7.31	270.80	BDL	156.80	BDL	95.08	95.08	53.18	21.97	BDL	0.22	22.02	6.06	80.00	38.44	16.76	0.331
	Bhalukmari	DW	7.08	124.40	BDL	72.16	BDL	65.05	65.05	21.27	9.16	BDL	0.14	14.01	6.06	60.00	11.79	3.93	BDL
	Bhebla	DW	7.29	289.10	BDL	167.30	BDL	110.09	110.09	49.63	29.80	BDL	0.17	22.02	9.70	95.00	41.51	15.19	0.524
	Bhabanipur B- Block	DW	7.54	176.90	BDL	102.30	BDL	105.08	105.08	21.27	12.04	BDL	0.13	26.02	12.12	115.00	6.86	2.48	BDL
	Anandapur C- Block	DW	7.39	165.10	BDL	95.68	BDL	80.06	80.06	21.27	19.39	BDL	0.13	22.02	4.84	75.00	11.97	4.72	BDL
	Lokpala	DW	7.55	160.20	0.20	92.68	BDL	90.07	90.07	14.18	11.72	BDL	0.20	26.02	6.06	90.00	7.59	5.37	BDL
	Hazipara	DW	7.24	243.40	BDL	141.40	BDL	120.10	120.10	28.36	14.49	BDL	0.21	24.02	7.27	90.00	16.04	22.20	BDL
	Jalah Ali Namghar	DW	6.93	104.00	BDL	60.51	BDL	60.05	60.05	14.18	2.92	BDL	0.25	20.02	3.63	65.00	1.99	2.10	1.652
	Sauhabari (Nikashi)	DW	7.45	166.20	BDL	96.62	BDL	90.07	90.07	7.09	13.27	7.84	0.15	20.02	10.91	95.00	7.11	2.69	BDL
	Kachubari	TW	7.98	158.60	BDL	79.54	BDL	97.68	97.68	7.09	21.10	0.00	0.29	24.97	6.06	60.00	9.65	3.80	3.44

Annexure 1 :WATER QUALITY DATA OF DEEPER AQUIFER IN BAKSA DISTRCT FOR THE YEAR 2020

Sl. No.	Village/ Location	Aquifer Type	p^H	EC (µS/cm)	TDS	CO_3	HCO_3	Cl^-	SO_4^{-2}	$NO_{3\ 1}^-$	F^-	Ca^{+2}	Mg^{+2}	TH	Na^+	K^+	Fe	As
2	Bengenahati		8.09	191.50	96.17	BDL	128.20	10.64	28.12	0.00	0.40	39.98	9.70	70.00	7.35	2.71	3.86	N/A
3	BheblaBoropara		7.5	160	96	0	6.1	7.2	5.37	4.6	0.2	3	2.17	25	3.46	0.59	0.37	0.0052
4	Charaimari		7.4	147	88.2	0	54.9	14.2	14.7	4.25	0.5	12	9.7	70	1.23	0.31	0.19	0.005
5	DakhinDongargaon		7.2	171	102.6	0	85.4	39	8.4	7.21	0.6	21	20.6	225	1.97	0.52	0.35	0.008
6	Khusrabari		7.8	191	114	0	61	21.3	16.2	5.25	0.6	25	2.1	65	11	6.16	0.19	0.01
8	Tangabari		7.1	163	97.8	0	73.2	5.7	22.14	3	0.5	20	6.1	75	1.8	0.84	0.25	0.006
9	Barikadonga		7.8	154	92.4	0	67.10	14.2	6.4	1.95	0	14.00	8.50	70.00	0.11	0.12	0.43	0.006
10	Bhabanipur B-Block		6.9	142	284	1.8	1.8	N/A	4.2	2.3	0.4	38.6	10.3	62.4	14.8	1.02	N/A	N/A

ANNEXURE 5: LITHOLOG

LITHOLOG OF KACHUBARI

Latitude : 26°38′9.16″NLongitude: 91°36′32″E

Depth	Formation
0-3	Topsoil , Brown in Colour
3-6	Fine clay mixed with sand, Grey in Colour
6-9	Fine sand mixed with pebble, Grey in Colour
9-12	Fragments of Pebble, Sand Ferruginous Sandstone (Medium), Grey in Colour
12-15	Coarse Fragments of Pebble, Sand Ferruginous Sandstone, Grey in Colour
15-18.5	Coarse Fragments of Pebble, Sand Ferruginous Sandstone, Grey in Colour

LITHOLOG OF BENGENAHATI

Latitude :26°31′18.3″N Longitude: 91°43′34.8″E

Depth	Formation
0-3.25	Topsoil, Brown in Colour
3.25-6.50	River Sand, Grey in Colour
6.50-15.95	Fine sand , Grey in Colour
15.95-22.25	Medium sized sand with Gravel, Grey in Colour
22.25-31.75	Sand Mixed with Gravel, Grey in Colour
31.75-47.50	Sand mixed with Clay, Grey in Colour
47.50-53.80	Sand mixed with Gravel,Grey in Colour
53.80-63.25	Sand mixed with Medium sized Gravel, Grey in Colour
63.25-69.55	Sandy Clay, Grey in Colour
69.55-85.30	Coarse sand mixed with Gravel, Grey in Colour
85.30-91.60	Medium sized sand mixed with Gravel, Grey in Colour

LITHOLOG OF BARAMA

Latitude : 26°33′44.38″NLongitude: 91°20′51.9″E

Depth	Formation
0-3.15	Topsoil mixed with Clay, Grey in Colour
3.15-12.6	Clay, Grey in Colour
12.6-34.65	**Subrounded Gravel, Grey in Colour**
34.65-47.25	**Sand, Grey in Colour**
47.25-69.30	Clay, Grey in Colour
69.30-75.60	**Subrounded Gravel, Grey in Colour**
75.60-107.10	Clay, Grey in colour
107.10-113.40	Sand mixed with clay,Grey in Colour
113.40-129.15	**Coarse grained sand ,Brownish Grey in colour**

LITHOLOGBAKUWA, BLOCK-JALAH, DISTRICT-BASKA
Latitude : 26.64713 N Longitude : 92.24089E

Depth	Formation
0.00-3.25	Fine grained sand mixed with surface soil, brownish color
3.25-19.50	Clay sticky, brownish color
19.50-26.00	Clay sticky, grey color and mixed with pieces of quarzitic gravel 2-5mm in size, greyish color
26.00-32.50	Clay sticky, grey color
32.50-39.00	Clay sticky, grey color and mixed with pieces of quarzitic gravel 2-6mm in size, greyish color
39.00-65.00	Angular to sub angular pieces of quarzitic gravel 2-5mm in size, greyish color
65.00-104.00	Clay sticky, grey color and mixed with pieces of quarzitic gravel 2-5mm in size, greyish color
104.00-123.50	Angular to sub angular pieces of quarzitic gravel, 2-5mm in size and mixed with fine sand, greyish color
123.50-130.00	Fine grained sand mixed with clay grey and kankar, grey color
130.00- 136.50	Fine grained sand mixed with quartz gravel andkankar, greyish color
136.50- 156.00	Fine grained sand mixed with quartz gravel andkankar, brownish color
156.00-169.00	Fine grained sand mixed with clay and kankar, brownish color
169.00-191.75	Fine grained sand mixed with quartz gravel and kankar, grey color
191.75-208.00	Fine grained sand mixed with kankar and little clay, grey color
208.00-221.00	Fine grained sand mixed with quartz gravel and kankar, grey color
221.00-227.50	Fine grained sand mixed with kankar and little clay, grey color
227.50-240.50	Fine grained sand mixed with quartz gravel and kankar, grey color
240.50-247.00	Clay mixed with fine grained sand, grey color
247.00-250.25	Fine grained sand, greyish color
250.25-260.00	Fine grained sand mixed with clay, grey color
260.00-263.25	Fine grained sand, greyish color
263.25-279.50	Clay sticky mixed with little amount of fine sand, grey color
279.50-305.50	Clay loose mixed with little amount of fine sand, grey color

LITHOLOGBARIKADONGA, BLOCK-JALAH, DISTRICT-BASKA
Latitude : 26.705219 N Longitude : 91.466292E

Depth	Formation
0.00- 3.25	Surface soil mixed with fine grained sand grey color
3.25-6.50	Clay grey color mixed with very fine sand
6.50-26.00	Crushed boulder in powder form and 1-3mm size, grey color
26.00-32.50	Pieces of boulder 2-6mm, brownish color
32.50-48.75	Crushed boulder in powder form and 1-3mm size, brownish color
48.75-68.25	Pieces of bolder 2-3mm mixed with fine to medium grained sand (90%+10%),brownish color
68.25-74.75	Medium grained sand, brownish color
74.75-117.00	Pieces of boulder 2-4mm gravel size, brownish color
117.00-178.75	Pieces of bolder 2-3mm mixed with medium grained sand (60%+40%),brownish color
178.75-195.00	Pieces of bolder 2-3mm mixed with medium grained sand (80%+20%),brownish color
195.00-214.50	Fine to medium grained sand, brownishcolor mixed with pieces of boulder
214.50-237.25	Medium grained sand, brownish color mixed with pieces of boulder small size and little clay
237.25-243.75	Fine to medium grainedgrained sand, brownish color mixed with little amount of clay
243.75-263.25	Medium to coarse grained sand, brownish color mixed with pieces of boulder
263.25-273.00	Medium grained sand, grey color mixed with pieces of boulder and little amount of clay
273.00-292.50	Fine to medium grained sand, brownish color
292.50-305.50	Fine to medium grained sand mixed with clay brownish color

LITHOLOGBHABANIPUR B-BLOCK,BLOCK-BASKA,
DISTRICT-BAKSA

Latitude : 26.704652 NLongitude : 91.394764E

Depth	Formation
0.00- 91.00	Angular to sub angular quarzitic gravel, brownish color and greyish color
91.00-100.75	Fine grained sand mixed with quarzitic gravel and little amount of clay, brownish color
100.75-133.25	Angular to sub angular quarzitic gravel mixed with fine grained sand, brownish color
133.25-146.25	Fine grained sand mixed with quartz gravel andkankar, brownish color
146.25-156.00	Fine grained sand mixed with quartz gravel and little amount of clay, brownish color
156.00-188.50	Fine grained sand mixed with quartz gravel andkankar, brownish color
188.50-214.50	Fine to medium grained sand mixed with quartz gravel andkankar, brownish color
214.50-237.25	Fine to medium grained sand mixed with little kankar, brownish color
237.25-247.00	Fine to medium grained sand mixed with little clay andkankar, brownish color
247.00-253.50	Fine to medium grained sand mixed with little kankar, brownish color
253.50-269.75	Fine grained sand mixed with quarzitic gravel and kankar, greyish color
269.75-305.50	Fine to medium grained sand mixed with little kankar, brownish color

LITHOLOG OFBHEBLA BOROPARA, BLOCK-JALAH,DISTRICT-BASKALatitude : 26.64713 NLongitude : 92.24089E

Depth	Formation
0.00-3.25	Fine grained sand mixed with surface soil, blackish color
3.25-13.00	Fine grained sand, dark grey color
13.00-35.75	Angular to sub angular pieces of quarzitic gravel 2-6mm in size, greyish color
35.75-45.50	Boulder crushed in powdery form and 1-3mm in size, greyish color and mixed with little clay, greyish color
45.50-65.00	Angular to sub angular pieces of quarzitic gravel, 2-6mm in size and mixed with little clay, greyish color
65.00-81.25	Fine grained sand mixed with clay, grey color
81.25-100.75	Fine grained sand mixed with pieces of quarzitic gravel and little clay, greyish color
100.75-104.00	Fine grained sand mixed with pieces of quarzitic gravel, greyish color
104.00-107.25	Fine grained sand mixed with pieces of quarzitic gravel and little clay, greyish color
107.25-113.75	Angular to sub angular pieces of quarzitic gravel mixed with little amount of fine grained sand, greyish color
113.75-120.25	Fine grained sand mixed with pieces of quarzitic gravel(60%+40%), greyish color
120.25-126.75	Fine grained sand mixed with pieces of quarzitic gravel (60%+40%) and little amount of sand, greyish color
126.75-165.75	Fine grained sand mixed with pieces of quarzitic gravel(80%+20%), greyish color
165.75-172.25	Boulder crushed in powdery form ,greyish color
172.25-182.00	Fine to very fine grained, sand greyish color
182.00-204.75	Fine grained sand mixed with clay, grey color
204.75-211.25	Fine grained sand mixed with pieces of quarzitic gravel (30%+70%), greyish color
211.25-221.00	Fine grained sand mixed with clay, greyish color
221.00-250.25	Fine grained sand, greyish color
250.25-260.00	Fine grained sand mixed with pieces of quarzitic gravel (50%+50%), greyish color
260.00-273.00	Fine grained sand mixed with pieces of quarzitic gravel (50%+50%), greyish color
273.00-279.50	Fine grained sand mixed with pieces of quarzitic gravel (50%+50%) mixed with little amount of clay, greyish color
279.50-289.25	Fine grained sand mixed with pieces of quarzitic gravel (50%+50%), greyish color
289.25-295.75	Fine grained sand mixed with pieces of quarzitic gravel (50%+50%) mixed with little amount of clay, greyish color
295.75-305.50	Fine grained sand mixed with pieces of quarzitic gravel (50%+50%), greyish color

LITHOLOG OF CHARAIMARI, BLOCK-CHARAIMARI, DISTRICT-BASKA
Latitude : 26.682159 NLongitude: 92.298407E

Depth	Formation
0.00-3.25	Surface soil brownish color
3.25-19.50	Fine grained sand, grey color
19.50-48.75	Angular to sub angular pieces of quarzitic gravel, greyish color
48.75-61.75	Angular to sub angular pieces of quarzitic gravel, greyish color mixed with clay, grey color
61.75-71.50	Angular to sub angular pieces of quarzitic gravel, greyish color
71.50-81.25	Angular to sub angular pieces of quarzitic gravel, greyish color mixed with clay, grey color
81.25-97.50	Angular to sub angular pieces of quarzitic gravel, greyish color
97.50-104.00	Clay sticky, grey color
104.00-110.50	Clay sticky, grey color mixed with pieces of quarzitic gravel
110.50-120.25	Fine to medium grained sand mixed with angular to sub angular pieces of quarzitic gravel, greyish color (50%+50%)
120.25-133.25	Fine to medium grained sand mixed with angular to sub angular pieces of quarzitic gravel, greyish color (40%+60%)
133.25-139.75	Angular to sub angular pieces of quarzitic gravel, reddish brown color
139.75-159.25	Angular to sub angular pieces of quarzitic gravel, reddish brown color mixed with little amount of fine grained sand reddish brown color
159.25-165.75	Clay sticky, dark grey color
165.75-172.25	Loose clay, grey color mixed with fine sand and kankar
172.25-191.75	Fine to medium grained sand mixed with boulder crushed in powdery form and gravel size 1-2mm, greyish color (60+40%)
191.75-211.25	Loose clay, grey color
211.25-234.00	Clay, dark grey color mixed with fine sand
234.00-247.00	Angular to sub angular Quartzitic gravel, brownish color mixed with clay, grey color
247.00-256.75	Fine grained sand mixed withkankar
256.75-263.25	Loose clay, grey color mixed with kankar
263.25-279.50	Fine grained sand mixed with clay, grey color
279.50-305.50	Sandy clay, grey color

LITHOLOG OF DAKHIN DONGARGAON, BLOCK-NAGRIJULI, DISTRICT-BAKSA, ASSAM

Latitude : 26.676376 NLongitude : 91.669804E

Depth	Formation
0.00-3.25	Surface soil mixed with pieces of bolder 6-8mm 90%
3.25-9.75	Pieces of bolder 6-8mm, greyish color
9.75-22.75	Crushed boulder in powder form and 1-3mm size
22.75-39.00	Pieces of boulder 6-8mm, brownish color
39.00-55.25	Pieces of bolder 2-3mm mixed with fine to medium grained sand (80%+20%),brownish color
55.25-74.75	Pieces of boulder 6-8mm, brownish color
74.75-94.25	Pieces of boulder 3-6mm, brownish color
94.25-110.50	Coarse to medium grained sand 60%, brownish color, mixed with pieces of boulder
110.50-156.00	Pieces of bolder 3-5mm mixed with fine to medium grained sand (80%+20%),brownish color
156.00-191.75	Medium to coarse grained sand, brownish colormixed with pieces of boulder
191.75-201.50	Coarse to mediumgrained sand, greycolor mixed with pieces of boulder and little amount of clay
201.50-240.50	Coarse to medium grained sand, brownishcolor mixed with pieces of boulder
240.50-260.00	Coarse to medium grained sand, brownish color mixed with pieces of boulder
260.00-276.25	Mediumgrained sand, greycolor mixed with pieces of boulder
276.25-279.50	Medium grained sand, grey color mixed with little amount of clay
279.50-305.50	Medium grained sand, grey color

LITHOLOG OF KHUSRABARI, BLOCK-GOVARDHANA, DISTRICT-BASKA
Latitude : 26.582404 NLongitude : 91.024654E

Depth	Formation
0.00-3.25	Surface soil grey color
3.25-19.50	Quarzitic gravels sub angular to sub rounded 3-6mm, grey color
19.50-26.00	Fine to medium grained sand, grey color
26.00-35.75	Quarzitic gravels angular to sub angular 2-8mm, grey color
35.75-152.75	Quarzitic gravels angular to sub angular 2-4mm, yellowish brown color
152.75-172.25	Sandy clay mixed with quarzitic gravels, angular to sub angular, grey color
172.25-208.00	Quarzitic gravels angular to sub angular 2-4mm mixed with fine grained sand, yellowish brown and grey color
208.00-253.50	Quarzitic gravels angular to sub angular 2-4mm mixed with fine grained sand and clay, grey color
253.50-269.75	Quarzitic gravels angular to sub angular 2-4mm, yellowish brown color

LITHOLOG OF TANGABARI M.E. SCHOOL, BLOCK-SALBARI, DISTRICT-BASKA
Latitude : 26.622957 N Longitude : 91.099409E

Depth	Formation
0.00-3.25	Surface soil grey color
3.25-6.50	Quarzitic gravels sub angular to sub rounded 3-8mm mixed with clay, grey color
6.50-13.00	Quarzitic gravels angular to sub angular 2-3mm, grey color
13.00-19.50	Quarzitic gravels angular to sub angular 2-4mm, grey color
19.50-26.00	Fine to medium grained sand, grey color
26.00-39.00	Quarzitic gravels angular to sub angular 2-3mm, grey color
39.00-48.75	Quarzitic gravels angular to sub angular 2-5mm, grey color
48.75-71.50	Quarzitic gravels angular to sub angular 2-5mm,yellowish brown and grey color
71.50-78.00	Quarzitic gravels angular to sub angular 2-3mm, yellowish brown and grey color
78.00-84.50	Quarzitic gravels angular to sub angular 2-5mm, yellowish brown and grey color
84.50-91.00	Quarzitic gravels angular to sub angular 2-3mm mixed with fine sand, yellowish brown and grey color
91.00-130.00	Quarzitic gravels angular to sub angular 2-3mm, yellowish brown and grey color
130.00-139.75	Quarzitic gravels angular to sub angular 2-5mm mixed with little amount of clay, yellowish brown and grey color
139.75-152.75	Quarzitic gravels angular to sub angular 2-5mm, yellowish brown and grey color
152.75-162.50	Clay mixed with quarzitic gravels angular to sub angular, grey color

162.50-172.25	Quarzitic gravels angular to sub angular 2-5mm mixed with fine to medium grained sand, yellowish brown and grey color
172.25-182.00	Quarzitic gravels angular to sub angular 2-5mm mixed with fine sand and little amount of clay, yellowish brown and grey color
182.00-191.75	Quarzitic gravels angular to sub angular 2-4mm mixed with fine grained sand, yellowish brown and grey color
191.75-198.25	Fine grained sand mixed with quarzitic gravels crushed in powdery form , yellowish brown and grey color
198.25-211.25	Quarzitic gravels angular to sub angular 2-4mm, yellowish brown and grey color
211.25-230.75	Quarzitic gravels angular to sub angular 2-4mm mixed with fine to medium grained sand, yellowish brown and grey color
230.75-247.00	Fine to medium grained sand mixed with quarzitic gravel and little amount of clay, yellowish brown color
247.00-273.00	Medium to coarse grained sand mixed with quarzitic gravel, yellowish brown color
273.00-282.75	Fine to medium grained sand mixed with quarzitic gravel and little amount of clay, yellowish brown color
282.75-305.50	Fine to mediumgrained sand, yellowish brown color

FIELD PHOTOGRAPHS

Plate: Pump Test at KharuajanBaksa

Plate: Volumetric Discharge Calculation

Plate: Drill Cut Samples of Kachubari

Plate: TierIII Training Programme at Barama, Baksa

Plate: Large Boulders at Subankhata

Plate: Tier III Training Programme at Borpetaroad, Baksa

Plate: Manas River at Piedmond Zone

Plate: Drilling Operation at Barama

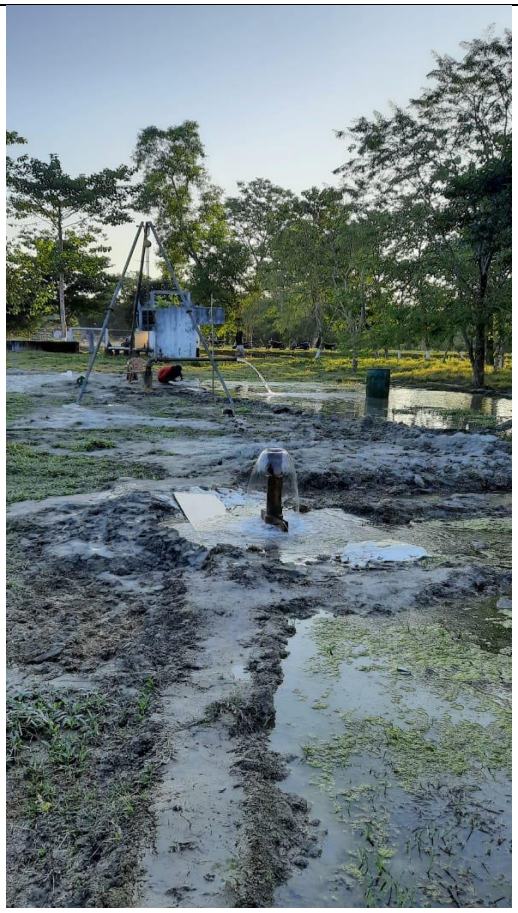

Plate: Artesian Well at Charaimari

Plate: PIP in Nizbetna Village

Plate: PIP at Maharipara