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

NAGAON DISTRICT, ASSAM

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION
केंद्रीय भूजल बोर्ड
CENTRAL GROUND WATER BOARD

REPORT
ON
"AQUIFER MAPPING AND MANAGEMENT PLAN OF NAGAON DISTRICT, ASSAM"
(AAP 2022-23)

By
Ms. Anenuo Pienyu
Scientist-C (Hydrogeology)
&
Ms. Rinku Rani Das
Scientist-B (Hydrogeology)

Central Ground Water Board
State Unit Office
Shillong
Meghalaya
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ABBREVIATION

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

EXECUTIVE SUMMARY

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

The total coverage area of aquifer mapping and management plan is 3773 sq.km out of total geographical area of 3972 sq.km of the district. The district is underlain by unconsolidated recent alluvium, consolidated Banded Gneissic complex, Quartzite and semi-consolidated formation of Tertiary age.

The geological formation ranges from Pre Cambrian Group of rocks, semi-consolidated formation of Tertiary age and unconsolidated alluvium of Quaternary age. The alluvium occurring in the district is of recent alluvium.

Occurrence of ground water in the study area is within the saturated intergranular pore spaces of unconsolidated Brahmaputra alluvium and weathered and fractured consolidated and semi-consolidated rocks. The different hydrogeological data are generated through intensive field data collection and testing. Two distinct hydrogeological set ups prevail in the district. The first set up is the newer alluvium and occupies about 90 % of the total geographical area of the district. The second set up is the consolidated and semi-concolidated formation which covers about 10% of the district. Central Ground Water Board had explored the area down to the depth of 305 m which reveals the existence of several good aquifer zones with yielding capacity of maximum 268.74 m^3/hr.

Ground water exploration has been carried out in different parts of the district to delineate the potential aquifers and their geometry and to determine the hydrogeological parameters of the aquifer systems.

Study of water level trend and its behaviour in phreatic aquifer were carried out in the aquifer mapping area.

In order to study the chemical quality of ground water in the district, water samples from first aquifer (dug) and shallow tube wells were collected during the course of field work. The samples were analyzed and found that there is a moderately high concentration of iron in some samples and needs to be treated before consumption.

Dynamic Groundwater Resources of the study area has been estimated based on the methodology recommended by Groundwater Estimation Committee (GEC'2015). The net ground water availability is 77063.82 ham and the stage of ground water extraction is 28.86% which comes under safe category.

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

1. INTRODUCTION

Central Ground Water Board, North Eastern Region has carried out Aquifer mapping and management plan in Nagaon district, Assam during AAP 2022-23 covering an area of 3773 sq.km (total district area is 3972 sq.km). Under National Aquifer Mapping and Management (NAQUIM) program, combination of geologic, geophysical, hydrologic and hydrochemical 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 resource development.

1.1 Objectives

The objectives of this project are to understand the aquifer systems up to 200 m depth, to define the aquifer geometry, type of aquifers, ground water regime behaviors, hydraulic characteristics and to establish groundwater quantity, quality, and sustainability, and to estimate the dynamic and static resources accurately through multidisciplinary scientific approach on 1:50000 scale and finally formulate a complete, sustainable and effective management plan for ground water development.

1.2 Scope of the Study

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

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

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

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

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

1.2.4. Aquifer Management Plan Formulation: Aquifer Maps and ground water regime scenario are being 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) Exploratory drilling and construction of bore wells tapping various groups of aquifers.

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

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

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

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

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

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

1.4 Area details

Nagaon district lies between E 92˚15’30” to E 93˚20’00” Longitude and N 25˚40’00” to N 26˚10’00” Latitude. The district is having an area of 3972 sq.km. Out of this, 3773 sq.km of mappable area was covered under NAQUIM program during AAP 2022-23. The district lies in

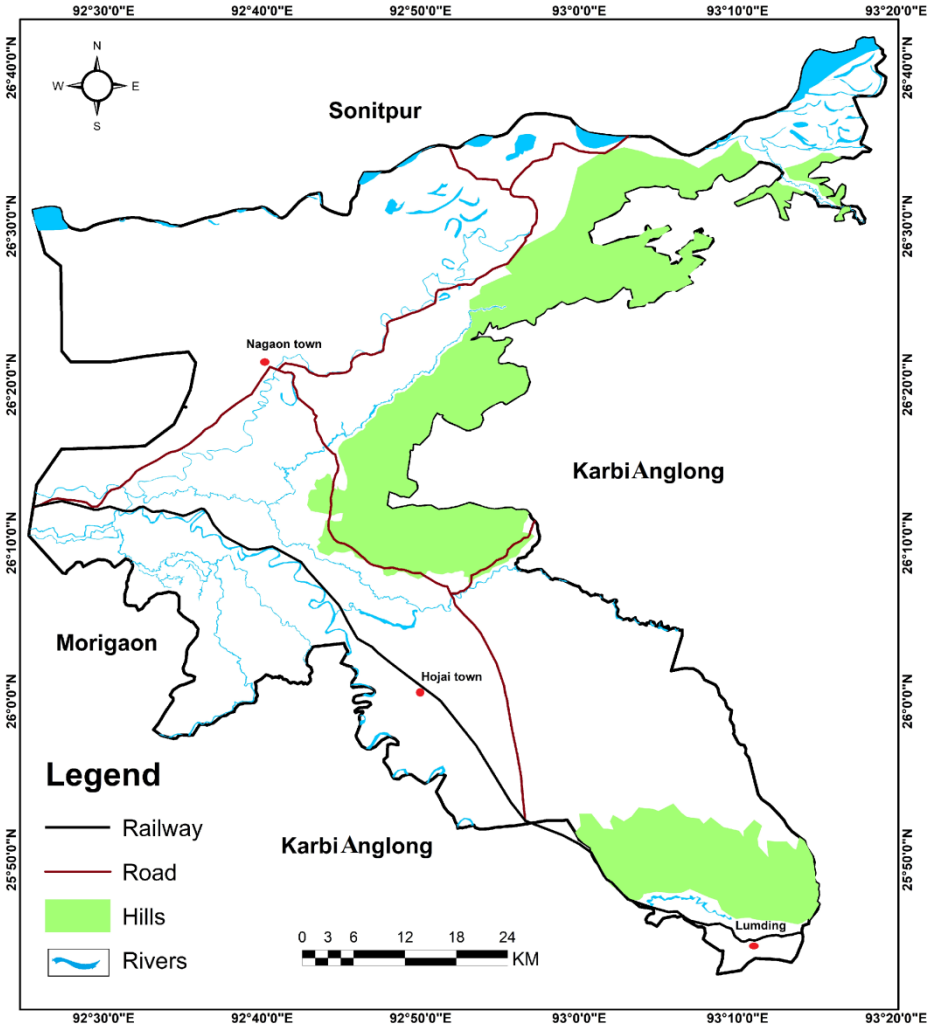
the central part of Assam on the southern bank of the Brahmaputra River. The district is represented by vast plain land with small hills in Northeastern, western and southern part. The district is bounded by Brahmaputra & Sonitpur district on the north, towards south lies West Karbi Anglong and North Cachar Hills, towards its east lies the districts of East Karbi Anglong and Golaghat. The district occupies part of the Brahmaputra valley and the mighty river Brahmaputra flows on westerly direction along its northern boundary. The district is drained by several perennial rivers namely Kalong, Kopili and Sonai.

The district comprises 10 numbers of circle/sub-district. They are – Kaliabor, Samaguri, Rupahi, Dhing, Nagaon, Raha, kampur, Hojai, Doboka, Lanka

The total population as per 2011 Census is 2823768.

This area falls partly or fully in the quadrants of Survey of India Toposheets bearing nos. 83 B/6, 83B/7, 83B/8, 83B/10, 83B/11, 83 B/12, 83B/14, 83B/15, 83B/16, 83C/9, 83C/13, 83F/2, 83F/3, 83F/4, 83F/6, 83G/1, 83G/2. The base map of the study area is shown in fig.1.1.

Fig 1.1 Base Map of Nagaon District



1.5 Data availability, data adequacy and data gap analysis:

Aquifer mapping and management plan is carried out through collaborative study of different data. The required data on various attributes of the study are collected from the available literatures of Central Ground Water Board and various Central and State Government agencies. The Data Requirement, Data Availability and Data Gap Analysis are presented in table 1.1 and data availability and gap is shown in Fig 1.2, 1.3 & 1.4.

Fig 1.2 Data Gap map of Exploratory well

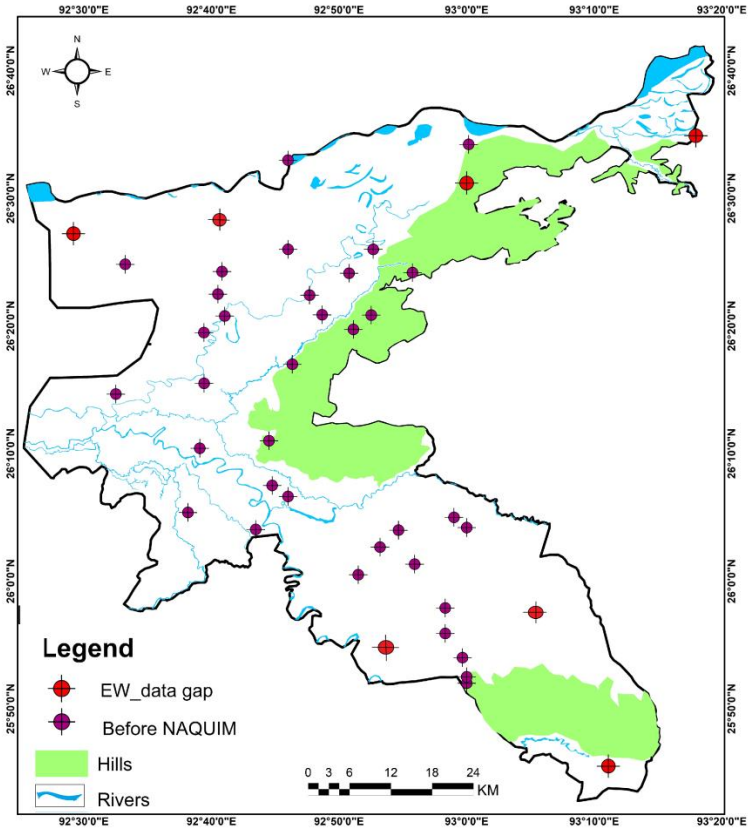


Fig 1.3 Data Gap map of Key Wells

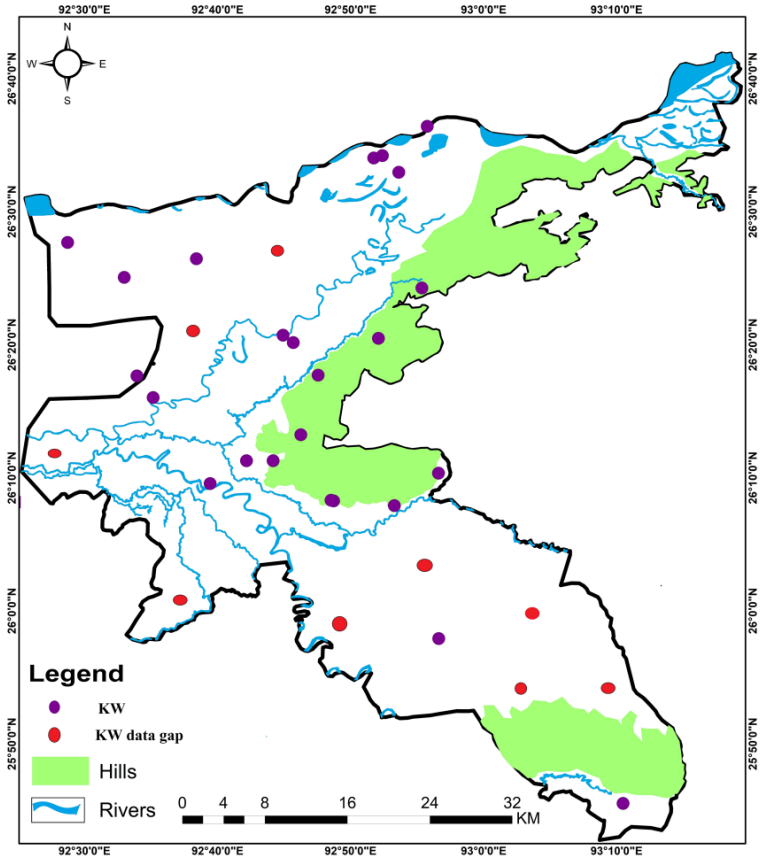


Fig 1.4 Data Gap map of Geophysical exploration

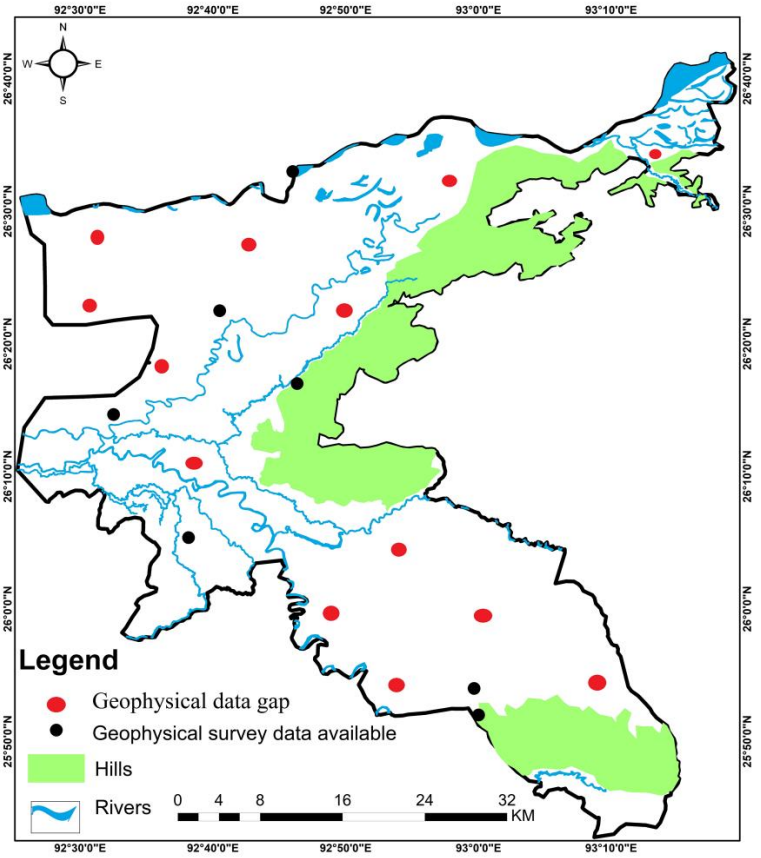


Table1.1 Data Availability and Data Gap Analysis in Aquifer Mapping Studies

Sl. No.	Items	Data Requirement	Data Availability	Data Gap
1	Ground Water Exploration Data	Both first aquifer and second aquifer	32 EW 13 OW 5 Pz 2 SH	3 nos. of EW &3 nos. of Pz.
2	Geophysics	Geophysical data of the Study area	7 Nos.	13 Nos.
3	Ground Water Monitoring Regime	Representative Monitoring Wells well distributed over the Study Area for both first and second aquifers.	27 NHNS	Aquifer : 10 nos.
4	Ground Water Quality	Representative well distributed Monitoring Wells over the study area for both first and second aquifers.	27 nos.	Entire study area
5	Climate	Season-wise Rainfall pattern	Nil	Monthly rainfall data for the past 10 years.
6	Soil	Soil map and Soil Infiltration Rate	Soil map	Soil Infiltration studies covering the entire study area
8	Land use	Latest Land Use pattern	Latest Land Use pattern	NA
9	Geomorphology	Detailed Information on Geomorphology of the area	District level information	NA
10	Recharge Parameters	Recharge parameters for different soil and aquifer types based on field studies	Recharge parameters given in Ground Water Resources Estimation	Entire study area

1.6 Demography

The total population of Nagaon district are as per 2011 Census is 2823768.

Nagaon District	Rural	Urban	Total
Total population	2454234	369534	2823768

1.7 Communication

The district is well connected by rail and road. Nagaon, the district headquarter is about 120 Kms from state capital Guwahati. National highway 37 runs along Northeast direction through the district. National highway 36 starts from Nagaon and runs through Doboka connecting the south-eastern part of the district. Another state road runs from Doboka to Lumding through Lanka with sub-ways connecting Hojai. The main railway line of NorthEast Frontier railway runs from Guwahati via Chaparmukh to Lumding and further Northeast connecting the major cities of NorthEast.

1.8 Climate

The area experiences hot sub tropical humid climate. A hot and humid pre-monsoon from March to mid May, a prolonged southwest monsoon or rainy season from mid May to

September, a pleasant post-monsoon or retreating monsoon from October to November and a cold pleasant winter from December to February are the characteristics of the general climate. Summer runs concurrently with the later part of the pre-monsoon season and continues throughout the monsoon season.

The four climatic seasons viz pre-monsoon, monsoon, post-monsoon and winter could be considered as comprising of the following months:

i. Pre-monsoon: March, April and May
ii. Monsoon: June, July, August and September
iii. Post-monsoon: October and November
iv. Winter: December, January and February

Sometimes, the monsoon commences in mid-May and ends in mid-September. Therefore, the boundaries between the seasons are not very rigid.

The mean daily maximum temperature during winter is about 25°C and minimum is 11°C. The mean daily maximum temperature during summer is 34°C and the minimum is 24° C. The relative humidity varies from month to month and increases from 76% to 84% during the South west monsoon and is about 77% during the rest of the year. The humidity varies throughout the year but seldom drops down below 67%. The average annual rainfall is 1541 mm. Rainfall is confined mainly during the monsoon season with occasional winter showers.

1.9 Land use

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

Table 1.2: Land use statistic in Nagaon district 2021-22

Sl.No.	Particulars	Area in Hectares
1	Total reporting area under land utilisation	240153
2	Total uncultivated land	7994
3	Other uncultivable land excluding fallow land	7994
4	Current Fallow land	1270
5	Net area sown	230890
6	Area sown more than once	19399
7	Gross cropped area	250289
8	Cropping intensity	108 %

Source: Agricultural Census of Assam, Ministry of Agriculture and Farmers Welfare, Govt. of India

1.10 Soil

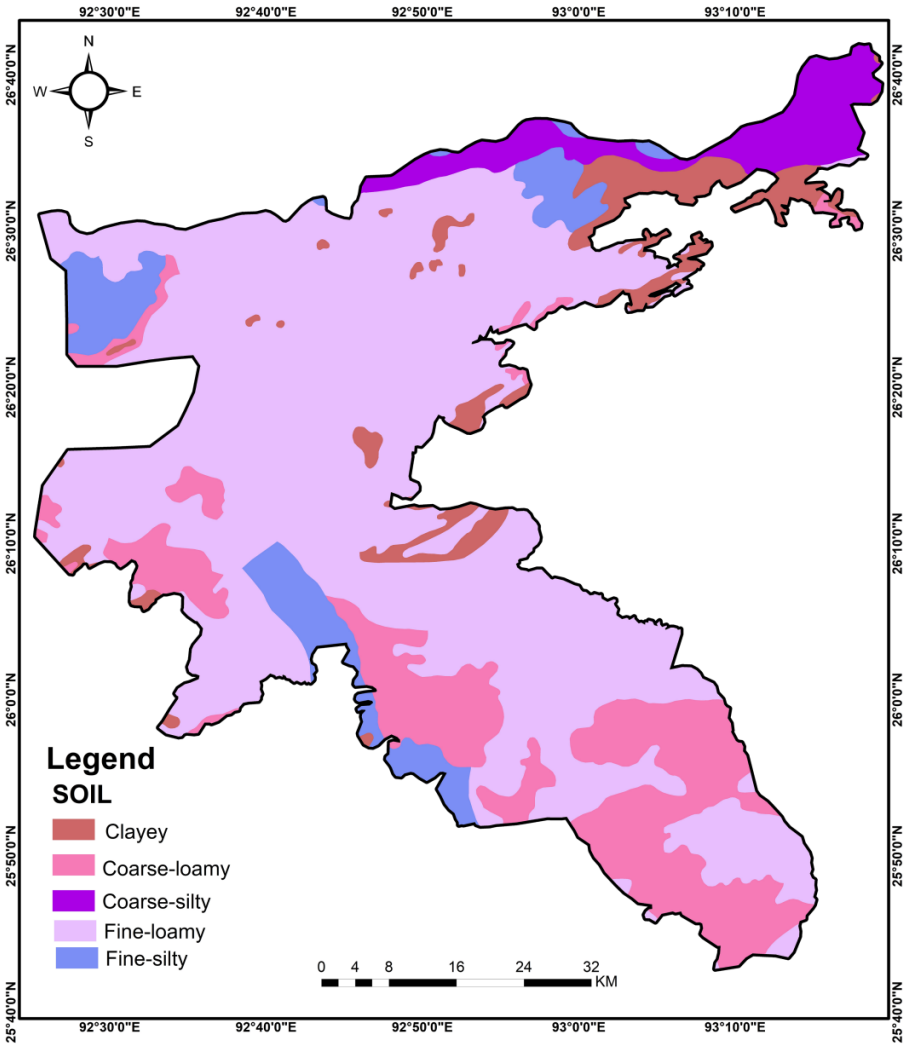
The district represents various soil type depending upon the composition of the parent materials, palaeogeographical and climatic conditions prevailing at the time of its formation. The variation of soil type is described as follows:

a. The flood plain of the district has mostly soils of loamy nature which varies from silty loam o clayey loam or loamy clay. The soil as a whole is moderately permeable (highly permeable in recent sediments along river coarses). It is less acidic and suitable for paddy cultivation.
b. High level alluvial soils are found in relatively high land in comparison to the recent flood plain and around the inselbergs. The high level alluvial soil is sandy in nature with percentage of clayey materials while that in the inselberg zone, the soil is reddish with high acid content.

The land suited best for growth of rice is a clayey loam variety , the most fertile variety of which is locally called “Berbherial” and is particularly deep and soft. This type of soil is found in the lowest part of the rice basin which constitute the area from Silghat in the Northeast to further south. The soils are highly fertile.

The alluvial soil is mostly loamy and consists of a mixture of clay and sand in varying proportions, ranging from pure sand on the banks of the Brahmaputra to sticky clay which is considered unfit for cultivation. Marshy soil is chiefly found in the low lying areas. These are black in colour. The red soil generally occupies the hill slopes and foot hills. Occasionally lateritic soil is also found near Lumding. The plain areas bordering Brahmaputra River are occupied by alluvial sediments belonging to Quaternary age. Soil map of the district is given in Fig.1.5.

Fig 1.5 Soil Map of Nagaon District



Soil Infiltration Test

The soil infiltration rates are useful in determination of recharge parameters and demarcation of areas feasible for artificial recharge. The experiments are conducted at 3 sites in Nagaon District in 2022-23. Soil infiltration tests were conducted by using Double Ring Infiltrometer. A Double-ring Infiltrometer consists of two concentric metal rings. The rings are driven into the ground and filled with water. The outer ring helps to prevent divergent flow. The drop in water level or volume in the inner ring is used to calculate the infiltration rate. The infiltration rate is determined as the amount of water per surface area and time unit that penetrates the soils. The final infiltration rate at which the rate of infiltration becomes constant in time scale is taken as the infiltration rate. The details of the soil infiltration tests results are given in table below.

Table 1.3: Soil infiltration test results in the study area

Sl.	Location	Co-ordinates	Soil Type	Season	Infiltration Rate

No.		Longitude	Latitude			(cm/hr) in %
1	Beldonga	92.812768	26.142521	Clayey	Pre Monsoon 2023	0.64
2	Lumding	93.155583	25.763947	Coarse loamy	Pre Monsoon 2023	2.5
3	Dhing	92.473599	26.469026	Fine silty	Pre Monsoon 2021	2.5

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

1.11 Agriculture

Agriculture plays an important role in the economy of the district and the rural population directly depends on agriculture for their livelihood. The district has a high cropping intensity and more intensive farming systems in comparison to other district. Paddy is the most important food crop that is grown in the district. The soil of the district is very suitable for production of all seasonal paddy and other Rabi and Horticultural crops. Among the crops, various other crops like pulses, rape seed, mustard, jute, sugarcane, etc and almost all types of vegetables are cultivated in the district. Both Kharif and Rabi rice is cultivated thoughout the district. Kharif cultivation depends mainly on monsoon rainfall. The district is endowed with diversified climatic condition thereby offering good scope for cultivation of temperate and subtropical crops.

1.12 Irrigation

Agriculture is mainly rainfed. However, a number of irrigation schemes based on surface water sources and groundwater irrigation exists in the district. The State Government has provided irrigation facilities to the farmers by means of lift, flow irrigation schemes and by installation of deep and shallow tube wells. Irrigation schemes under PMKSY-HKKP-GW scheme under Ministry of Jal Shakti are also operational in the district. Apart from these, various private organisations and individuals have constructed shallow/deep tubewells for irrigation to their own land.

1.13 Industries

The district of Nagaon has various natural resources like minerals, forest wealth besides adequate water from many rivers covering major part of the district. Based on these resources,

productive units have been established.. Agro-processing units like rice mills, flourmills and mustard oil extraction mills are also available in Nagaon. Apart from these various Industries both big and small are available in the district.

1.14 Forest

The District is very rich in natural resources. The district is blessed with huge forest cover. A part of the Kaziranga National park is located within the district.

1.15 Geomorphology

The major geomorphic units in the district are - i. Denudational hills, ii. Piedmont zone, iii. Flood plain deposits with Charland and Swampy areas.

i. Denudational Hills: It occupies eastern and southern part of the district comprising parts of Karbi angling hills and N.C.hills. They are NE-SW trending rugged topographic highs standing out due to differentiated erosion. The hilly terrain is covered by thick mantle of lateritic deposit and is densely forested.

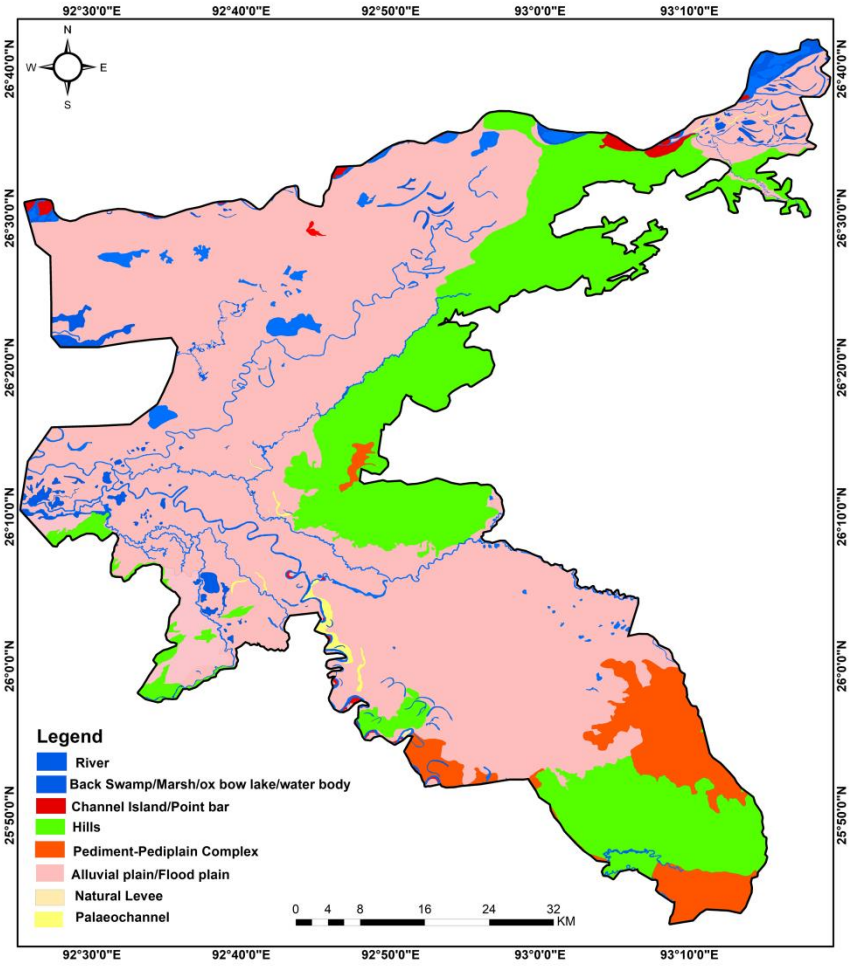
ii. Piedmont Zones: These zones occur at the contact of the denudational hills and plains. They are high land forms deposited adjacent to hill slopes by fluvial action. They consist of assorted admixture of cobbles, pebbles, sand and a matrix of clay.

iii. Flood Pain deposits: Flood Plain deposit occupy a major part of the district with huge thickness of unconsolidated alluvial sediment deposited by the mighty Brahmaputra and its tributaries. The Kopili River on the south and the Kalong River on the north-east have deposited the sediment during floods

iv. Charland: Charland is relatively low lying area along the river Brahmaputra within the recent flood plain. The area is characterized by fertile land with sandy and silty loam. The Charland is formed due to oscillation of the river water which is either washed away by subsequent floods or strengthened by further deposition.

v. Swampy areas: Swampy areas are low lying areas or the natural depressions created due to change of river courses as abandoned channels or meander lakes. They are locally known as beels and are found abundantly in the district.

Fig 1.6 Geomorphology Map of Nagaon District



1.16 Drainage

The main river is the Brahmaputra flowing on the northern part of the district from east to west with its tributaries Kopili, Kalong and Sonai rivers. Among these, Kopili is the major river originating in the hills of Karbi Anglong to the south and flows on north-westerly direction and meet with Diyang River near Dhing. It follows north-westerly direction from Dhing to the same north-westerly trend up to Kampur and deflects towards west. Kalong, the tributary of Kopili joins the later near Jagiroad.

Apart from the above main rivers small streams and nalas attribute to the main rivers. The main river systems of the district is described below:

Kalong : The along takes off from Brahmaputra about 13 Km NE of Silghat and after flowing a meandering course through middle of the district, rejoins the parent river at kajalimukh about 24 Km upstream of Guwahati. In its upper reaches, the kalong is joined by Diju and Missa which drain the NW slopes of the Mikir Hills.

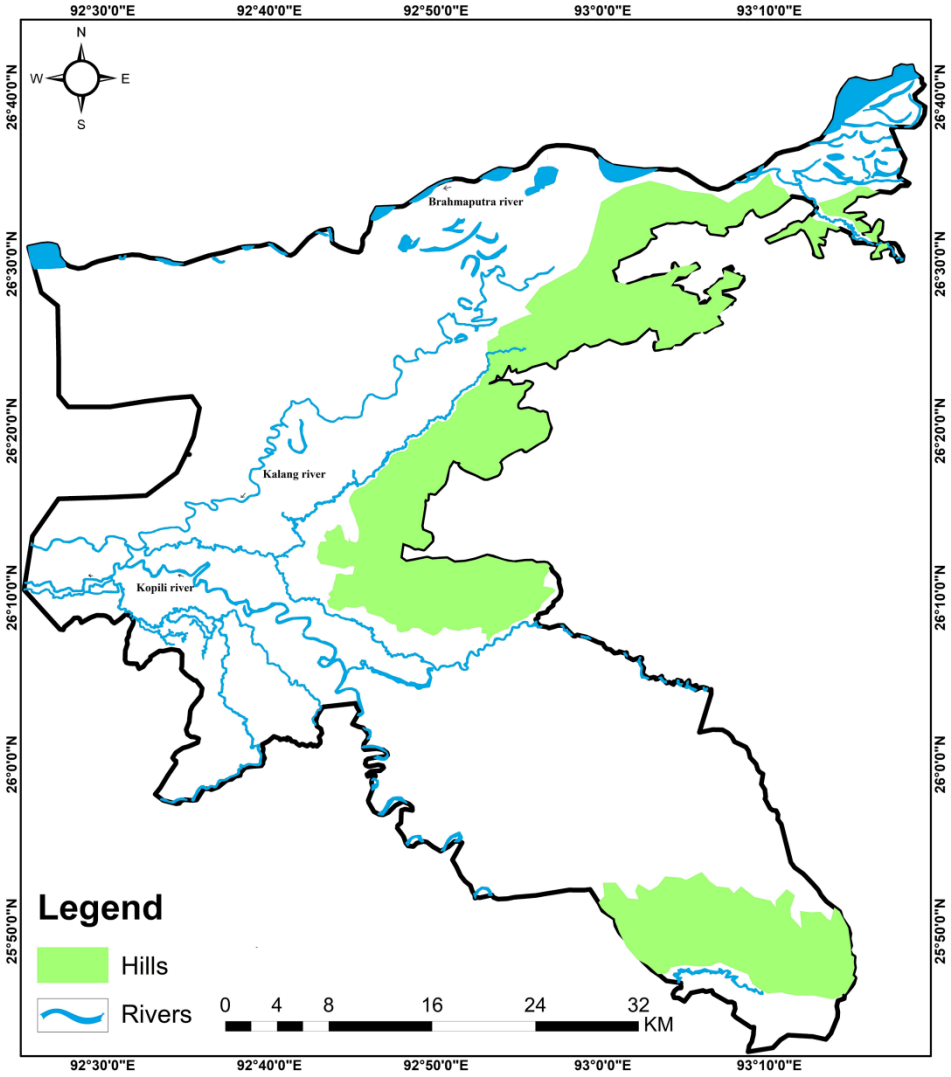
The region between kalong and Brahmaputra is drained by a large number of water coarses and forms bils. The river Kalong forms an important role during flood period with water and submerging the entire water courses.

Kopili : The Kopili river which rises in the Jaintia Hills flows through North Cachar Hills , Mikir Hills and Nagaon district. Coming down the hills it flows in a NW direction and meets the eastern tributary Jamuna at Jamunamukh further west of Nagaon district. It finally merges into Kalong near Jagiroad after a course of 262 Km (102 Km in Nagaon district) . The Kopili basin comprises an area of about 1300 sq. Km and is rich in rice cultivation.

Jamuna : The Jamuna is the main tributary of Kopili and originate from the Mikir hills. After flowing for about 120 Km from east to west, it falls in Kopili at Jamunamukh.

The drainage map is shown in Fig 1.7

Fig 1.7 Drainage Map of Nagaon District



2 DATA COLLECTION AND GENERATION

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

2.1 Hydrogeological

Occurrence of ground water in the study area is mainly of newer alluvium and consolidated Banded Gneissic complex, Quartzite and semi-consolidated formation of Tertiary age. The different hydrogeological data are generated through intensive field data collection and testing.

2.1.1 Water level monitoring : In the study area, 39 dug wells were established as key wells to study the water level and water quality. The district is covered by regular monitoring of existing 27 GWMS (NHNS) and another 12 key wells have been established. All these wells are monitored periodically to know the water level trend and its behavior. Table 2.1 shows the details of the Key wells established in Nagaon district in AAP 2022-23.

Table 2.1 Details of the Key wells established in Nagaon district in AAP 2022-23

Location	Latitute	Longitiute	RL (m)	Dia (m)	Depth	MP	WL pre monsoon	WL post monsoon
Amsoi	26.13611	92.42167	46	1.05	9.60	0.77	3.2	3.12
Bamuni Tinali	26.29528	92.7925	45.09	0.90	11.00	1.41	2.12	0.46
Bordowa	26.41774	92.54953	64	64	9.00	0.85	2.12	1.37
Dakhinpath	25.6375	92.46056	72.01	72.01	8.60	0.20	4.8	4.01
Dalapani	26.56722	92.86222	77.25	0.95	7.20	0.9	2.39	-
Dhing	26.461485	92.47859	62	0.85	9.30	0.49	3.81	2.32
Doboka	26.13194	92.88806	74.51	0.75	8.30	0.8	3.46	1.9
Ghasibasti/Chapanala	26.34139	92.86806	52.72	0.85	11.20	0.4	3.6	3.1
Gomotha	26.34528	92.74861		0.55	8.40	0.85	2.55	2.85
Gosaibari Namghar/Gokhaibari	26.29429	92.5655	74.18	74.18	8.50	0.90	2.54	1.56
Haldiati Sub Bt	26.1725	92.94333	79.57	0.65	6.50	0.89	2.78	2
Hatenibatha	26.33611	92.76139	91	0.50	6.50	0.68	2.22	1.85
Jurapukhuri	25.96528	92.94361	107	0.55	8.90	0.84	5.81	5.01
Kampur	26.15944	92.65722	89	0.01	3.00	0.83	3.2	0.01
Kathiatoli	26.18806	92.70278	94	0.65	6.50	0.94	2.34	0.32
Kondoli	26.22056	92.77083	60.34	1.00	10.30	0.99	2.26	0.27
Lanka	26.18806	92.73611		0.75	11.00	0.72	6.15	4.97
Lumding	25.758808	93.17457	154.9	0.85	18.00	0.7	4.77	2.47

Rangamati	26.40444	92.9225	60	1.00	7.00	0.8	5.85	5.8
Silghat	26.60694	92.92917	73.95	0.80	8.60	0.96	7.24	1.05
Sulung PO	26.57028	92.87306	63	0.85	7.00	0.74	4.45	2.2
Telia bebejia	26.44111	92.64	57.73	1.25	9.36	0.5	3.68	2.81
Beldonga Shiv mandir	26.13778	92.81194	78.19	1.70	10.00	0.85	5.29	4.48
Zebra Khua	26.13861	92.80861	82.25	2.3	21.00	1.1	2.05	2.58
Lankajan Notun Basti	25.74261	93.49789	98	1.0	5.75	0.80	4.35	1.41
Bagori	26.71744	93.15861	68	1.20	10.35	1.10	6.18	4.77
Saitali	26.29613	92.59661	73	0.69	5.29	0.7	3.28	1.84
Nagaon	26.32088	92.70286	58	0.82	6.34	0.7	4.86	2.42
Hojai	25.99944	92.82491	98	1.36	10.54	0.61	6.19	9.18
Lawkhowa	26.53539	92.80936	94	0.75	5.6	0.95	3.86	2.3
Jakhalabandha	26.58435	92.98873	95	0.94	9	0.58	2.66	2
Chatia	26.5618	92.94734	96	1.1	6.29	0.98	2.24	1.15
Saporigaon	26.0604	92.93676	101	0.94	10.67	0.76	3.54	1.28
Raja Ali	26.07338	92.62979	85	1.3	5.21	0.43	4.41	2.47
Samaguri	26.39362	92.79898	95	0.61	20.16	0.78	5.2	4.24
Missa	26.49499	92.9483	93	1.06	7.8	0.98	3.53	2.1
Buryapahar	26.57552	93.08558	100	1.08	10.89	0.91	3.46	3.38
Bichamari	26.40139	92.46	64	0.95	11	0.87	2.49	2.65
Balijuri	26.32611	92.84972	76	0.85	45	0.8	2.34	3.57

2.2 Hydrochemistry

The quality of ground water is as important as that of the quantity. To understand the chemical quality of groundwater in the study area and its suitability for domestic, drinking and agricultural utilization, pre monsoon and post monsoon water samples was collected and analysed at Regional Chemical Laboratory, CGWB NER Guwahati. The samples were analyzed for parameters like pH, EC, Turbidity, TDS, CO3, Cl, SO4, Na, K, HCO3, NO3, F, Ca, Mg, TH, U, As and Fe.

2.3 Ground water exploration studies

Ground water exploration has been carried out in different parts of the district to delineate the potential aquifers and their geometry and to determine the hydrogeological parameters of the aquifer systems. Before NAQUIM programme started in the district, 32 EWs, 13 OW, 5 Piezometer and 2 Slim holes were constructed. Details of the exploratory wells are presented below in the table 2.2. Hydrogeological details of bore wells constructed by CGWB in Aquifer mapping area is given in Annexure I.

Table 2.2 Exploratory wells constructed in Nagaon district

Sl. No	Village/ Location	Longitude	Latitude	Type of well	Drilled Depth (m bgl)
1	Nagaonpam-EW	92.7458	26.125	EW	302.00
2	Nagaonpam-OW	92.7444	26.124	OW	171.40
3	Kathiatoli-EW	92.7417	26.183	EW	300.00
4	Nilbagan-EW	92.9083	26.067	EW	304.22
5	Peepal Pukhuri-EW	92.9944	25.900	EW	255.60
6	Nilbagan-OW	92.9000	26.067	OW	169.02
7	Nagaon Town-EW	92.684	26.346	EW	215.33
8	Puranigudam-EW	92.795	26.374	EW	105.22
9	Jakhalabandha-EW	93.003	26.571	EW	147.97
10	Rupahitoli-EW	92.5417	26.244	EW	300.70
11	Vartak office campus , (Tezpur) G mine well - EW	92.7903	26.6333	EW	73.81
12	Itapara-EW	92.6750	26.375	EW	300.00
13	Chalchali-PZ	92.8111	26.348	PZ	37.00
14	Pachim Singimari-EW	92.7667	26.525	EW	268.74
15	Pachim Singimari- OW	92.7667	26.519	OW	169.00
16	Itapara-OW -I	92.6750	26.374	OW	300.00
17	Itapara-OW	92.6750	26.371	OW	54.95
18	Bordowa-EW	92.5539	26.416	EW	37.50
19	Majputoni-EW	92.772	26.283	EW	300.10
20	Bordhowa-PZ	92.5539	26.416	PZ	37.50
21	Kunwarital-PZ	92.7244	26.068	PZ	75.65
22	Hojai-EW	92.8583	26.008	EW	228.90
23	Hojai-PZ	92.8583	26.008	PZ	42.75
24	Gajiapam-SH	92.7667	26.433	SH	305.00
25	Bandermela-SH	93.0000	26.070	SH	301.00
26	Rangagora-EW	92.8778	26.433	EW	251.40
27	Rangagora-OW	92.8722	26.433	OW	164.00
28	Tapatjuri-EW	92.6803	26.404	EW	165.32
29	Hirabasti-EW	92.932	26.022	EW	125.20
30	Doboka-EW	92.7667	26.111	EW	229.70
31	Doboka-PZ	92.7667	26.111	PZ	159.10
32	Ram Nagar-II-EW	92.9719	25.932	EW	201.80
33	Ramnagar (Rangagura)-EW	92.972	25.965	EW	201.90
34	Ramnagar (Rangagura)-OW	92.972	25.965	OW	201.90
35	Jugijan-EW	92.8119	26.049	EW	197.80
36	Islam Nagar-EW	92.8867	26.044	EW	201.80
37	Debasthan-EW	92.9833	26.083	EW	201.80
38	Kaki-EW	93.0000	25.875	EW	102.00
39	Phakoli-EW	92.636	26.090	EW	177.00
40	Phakoli-OW	92.636	26.090	OW	181.00

41	Lankajan-EW	92.6358	26.090	EW	206.00
42	Balijuri Karbi gaon-EW	92.8519	26.329	EW	200.70
43	Balijuri Karbi gaon-OW	92.8506	26.328	OW	125.00
44	Senchowa-EW	92.6567	26.325	EW	201.65
45	Dakhinpat-OW	92.651	26.174	OW	200.00
46	Dakhinpat Satra-EW	92.6569	26.258	EW	200.00
47	Dakhinpat Satra-OW	92.6556	26.258	OW	200.00
48	Gashibasti Chhapanala-EW	92.8753	26.348	EW	71.45
49	Gashibasti Chhapanala-OW	92.8742	26.347	OW	62.25
50	Rangamati-OW	92.9292	26.403	OW	150.00
51	Rangamati-EW	92.9289	26.403	EW	125.00
52	Gendhali Kachharigaon-EW	92.8464	26.402	EW	156.75
53	Lumding Pz	93.18	25.75	Pz	102.00
54	Bagori Pz	93.2994	26.582	Pz	66.00
55	Bagori EW	93.2994	26.582	EW	72.50
56	Hatigaon Pz	90.0062	26.521	Pz	104.00
57	Hatigaon EW	90.0062	26.521	EW	100.90
58	Dhing EW	92.486	26.454	EW	100.90

3 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 General hydrogeology and occurrence of ground water

The Quaternary Group of sediments represented by unconsolidated alluvium covers large part of the district. These deposits comprise sands of various grades with minor silt and clay. The older alluvium comprising sand, silt and clay occurs in the present day channel of rivers Kalang and Kopili. The Newer alluvium is confined broadly to the area north of Kalang River and comprises medium to very coarse sand with gravel.

A large area near Lumding is occupied by the transgressive Surma Series which dip at very low but variable angles. The Surmas are predominantly argillaceous and as such clay and shale dominate over sandstone and siltstone. The northern and central parts of the district are mostly covered by alluvium of the Brahmaputra river system.

A critical appraisal of aquifer zones encountered in the boreholes reveal that in the flood plain areas in the Kalang sub-basin the aquifers are not only extensive but thick and prolific. Clay predominance increases in the south and fine to medium grained sands occur in relatively very thin lenses indicating that the formations possibly belong to arenaceous facies of Tipam Group or Dupitila Group of Tertiary age.

Hydrogeologically the district is proved to be potential. Ground water in Nagaon district occurs in the semi consolidated and unconsolidated formations of Tertiary and Quaternary age respectively and in secondary porosity like fractures, fissures of Precambrian rocks. While the greater part of the district falls in Kalang sub-basin, in the Kalang sub-basin the alluvial formations show two characteristic features. In the northern part of the district particularly north of Sonai river, the alluvium comprising medium to coarse sand with gravel and pebbles form a single aquifer system of massive thickness, but in the south central and southern parts, which is broadly underlain by older alluvium, the clay proportion increases markedly. The clay beds act as confining layers. Thus ground water occurs both under confined, semi-confined and unconfined conditions.

In the Jammu Command area (Kopili sub-basin) three to four good aquifer horizons are encountered within the depth of 300 m with a cumulative thickness of aquifers actually occur within 200 m depth. The dispositions of aquifers are such that both shallow and deep tube wells can be constructed to develop ground water resource.

Water table generally rests within 4 to 6m of land surface in the greater part of the district. The depth to piezometric surface more or less coincides with the water table in the Kalang sub-basin and is thus generally within 6m from ground surface. However, in the Kopili sub-basin i.e , in the southern part of the district it is variable from 0.5 to 14.0 m below ground surface. and in certain localized areas around Hojai- Doboka and Nilbagan artesian conditions prevail indicating thereby that the piezometric surface lies above land surface.

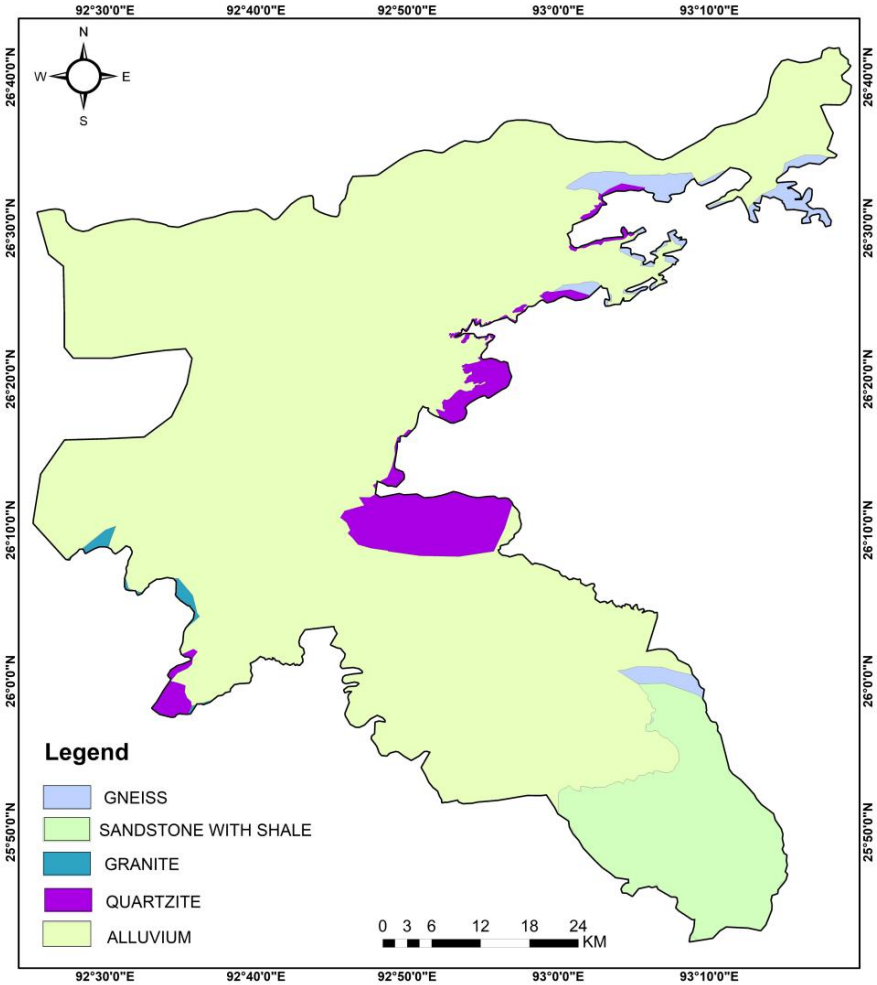
Large numbers of shallow and deep tube wells have been constructed in the district which provides us with valuable information regarding aquifer characteristics. Tube wells 20 to 40 m deep and fitted with hand pump normally yield 3 to 6 m^3/hr which is considered

sufficient for domestic supplies. Low-duty irrigation tube wells of 10 to 15 cm diameters and 30 to 40 m deep generally tapping 10 to 20 m of saturated sand may yield 15 to 35 m^3/hr.

In kalang sub-basin deep tube wells, 120 to 230 m deep tapping about 60 m of saturated zone, yield 175 to 200 m^3/hr for drawdown of 5.5 9.7 m. But in Kopili sub-basin i.e. (Jammu Command area) yields of deep tube wells is within one cusec (100 m^3/hr) for a drawdown of up to 12 m.

The principal aquifer of the district is shown in fig 3.1.

Fig 3.1 Principle Aquifer of Nagaon District



3.1.1 Occurrence of ground water: Groundwater occurs within the saturated intergranular pore spaces in unconsolidated alluvium and in the secondary pores in fractured and jointed gneissic and quartzite formations. In the newer alluvium, groundwater occurs under phreatic condition in shallow horizon and under semi-confined conditions in deeper aquifer.

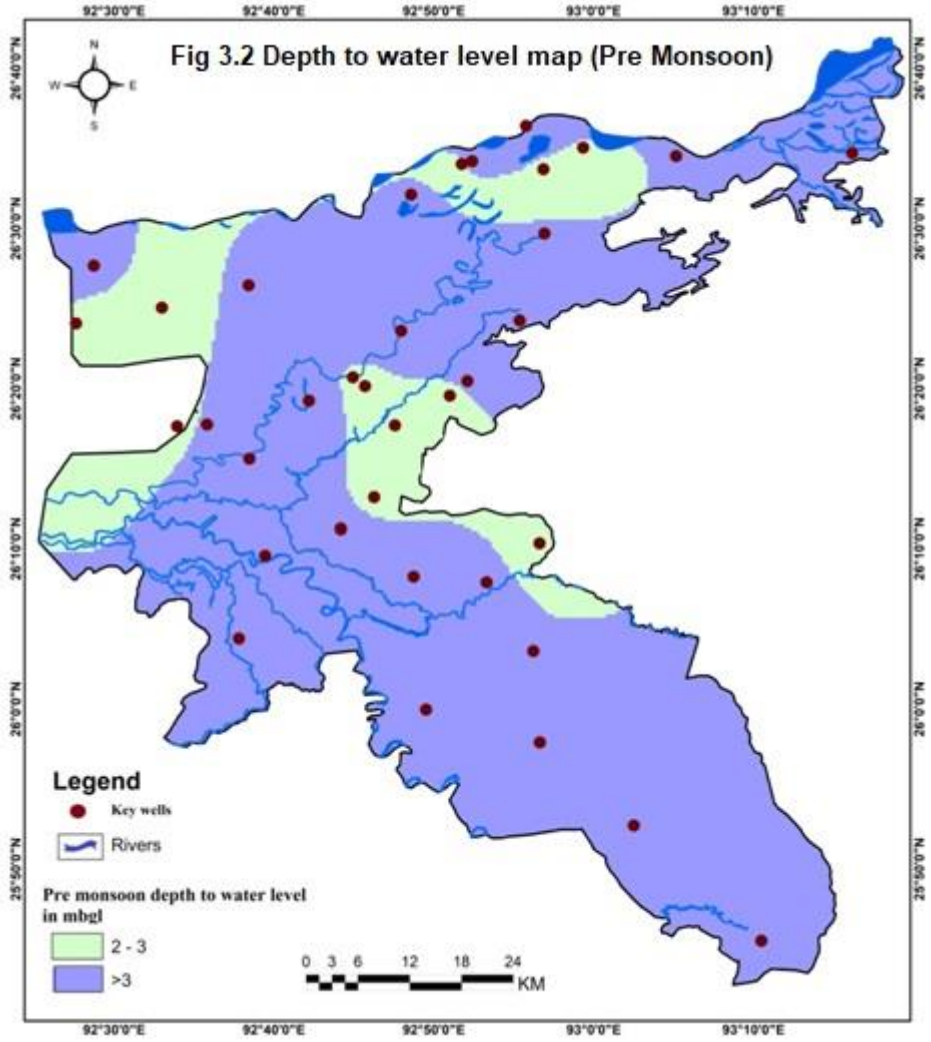
Generally the groundwater table has configuration synonymous to ground surface. However , depth to groundwater level is deeper in upland areas than in valley bottoms.

3.2 Depth to Water Level:

Study of water level and its behaviour were carried out in the aquifer mapping area. A total of 39 dug wells were established as key well for periodical monitoring to know the water level trend and its behavior in phreatic condition. During pre monsoon the highest water level is 7.24 mbgl at Silghat monitoring station and the lowest water level is 2.12 mbgl at Bordowa monitoring station. During post monsoon the highest water level is 9.18 mbgl at Hojai monitoring station and the lowest water level is 0.01 mbgl at Kampur monitoring station and the average water level fluctuation is 1.41 m.

To depth to water level in exploratory wells drilled in Nagaon district varies from 0.0 mbgl to 14.68 mbgl.

Depth to water level map during Pre Monsoon and Post Monsoon is given in fig. 3.2 and 3.3 respectively. Water level fluctuation map is given in fig. 3.4. Depth to water level for Pre Monsoon and Post Monsoon in Nagaon District is given in Annexure II.



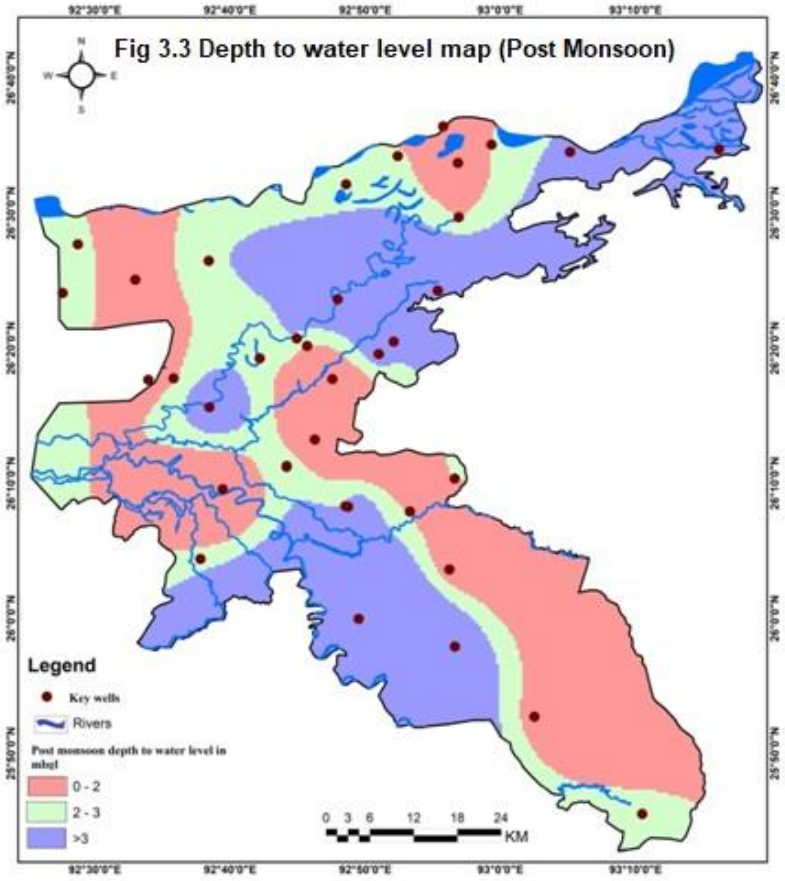


Fig 3.3 Depth to water level map (Post Monsoon)
92°30'0"E
92°40'0"E
92°50'0"E
93°0'0"E
93°10'0"E
Legend
Key wells
Rivers
Post monsoon depth to water level in mbgl
0 - 2
2 - 3
>3
0 3 6 12 18 24
KM

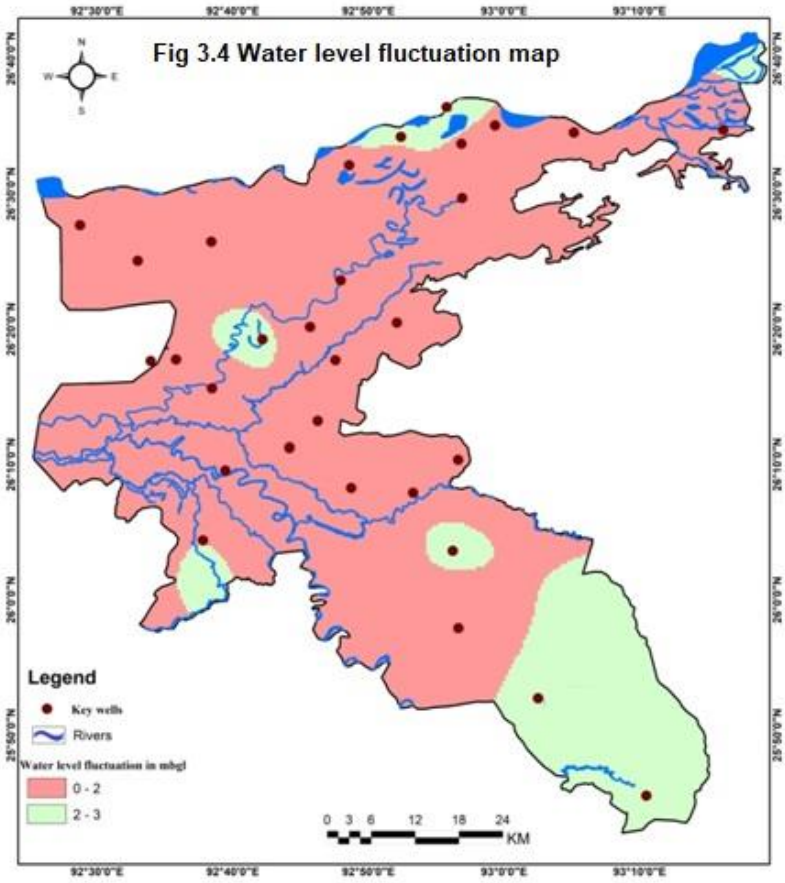


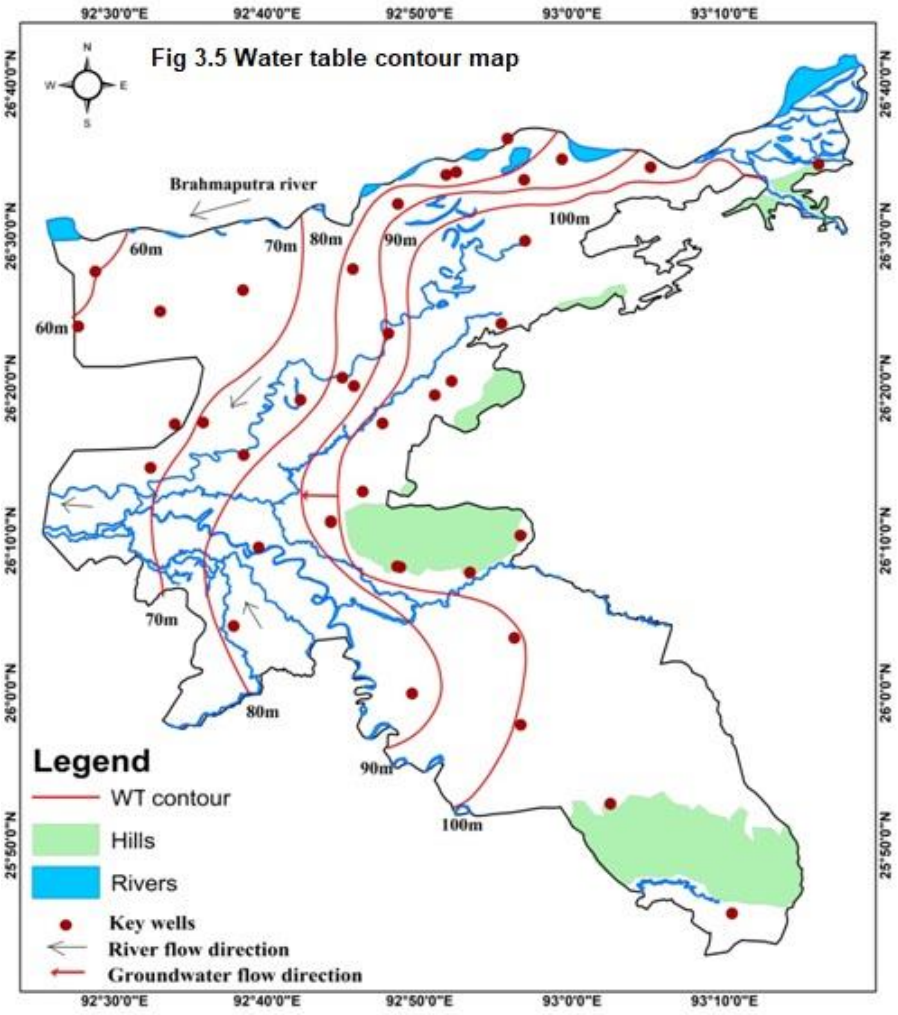
Fig 3.4 Water level fluctuation map
92°30'0"E
92°40'0"E
92°50'0"E
93°0'0"E
93°10'0"E
Legend
Key wells
Rivers
Water level fluctuation in mbgl
0 - 2
2 - 3
0 3 6 12 18 24
KM

In the water level fluctuation map of the district, it can be seen that the water level during postmonsoon and premonsoon fluctuates within 0-2m in the most part of the district. However water level fluctuates within 2-3m between post monsoon and pre monsoon water level in the southern part of the district. Water level fluctuation more than 3m is not observed in any key wells in the district.

3.3 Ground Water Movement

Ground water movement is to the north west towards Brahmaputra River. The hydraulic gradient vary considerably from place to place. In the northern and northeastern parts, the gradient is very gentle and in the foot hill areas the gradient is much steeper.

From the water table contour map Ground water recharge area can be identified in the eastern pediment complexes. The groundwater flow direction is towards the north western part of the district. The hydraulic gradient varies from 13m/km to 25m/km. The shape of water table contour also indicates that the Kopili and Kalang rivers are effluent rivers which are recharged by the aquifer. The depth to water table contour map is shown in the fig 3.5.



3.4 Aquifer System

Based on the behaviour and occurrence of groundwater, the regional groundwater flow system of the district has been described under two distinct categories –

a. Shallow aquifer group upto a depth of 50 mbgl
b. Deeper aquifer group upto the drilled depth of 305 mbgl

Shallow Aquifer Group : The shallow aquifer group occurring within the depth range of 50 m bgl comprise a mixture of sand, clay, silt with occasional gravel. The thickness of the aquifer material varies from 20-40 m. This aquifer is capable of yielding only limited quantities (3 to 6 cum/hr) of groundwater through handpump. Groundwater in this aquifer generally occurs under water table to semi-confined conditions and open wells and dug wells are used for extraction of ground water from this zone.

Based on the water level data of the hydrographic networks stations, considering the pre-monsoon data, the depth to water level ranges from 2.12 to 7.24 mbgl.

Periodical monitoring of water level during different seasons (4 times a year) in the shallow zone indicats that the general fluctuation of water table during pre monsoon and post monsoon period is of the order of 0-2m as a whole and increases along the northern part. The major part of the actual rise of water level during the period from April to August dissipates quickly and only about 60-70 % of actual rise is available for the longer period upto April.

Deeper Aquifer Group : The aquifer occurring in the depth range of 50 – 200 m below ground level and beyond are grouped in this deeper aquifer category. The aquifer consist of medium to coarse grained sands with intercalations of clay bands. The depth and thickness of these granular zones vary widely and the groundwater occurs under confined conditions especially in the southern part of the district.

The piezometric surface in the major part of the district is below land surface except around Hojai area flowing conditions existed during construction of piezometer. The piezometric head shows that the gradient is towards north.

3.5 Aquifer geometry: The aquifer system in this district can be categorised into two aquifer system. The first aquifer or shallow aquifer where ground water occurs under water table condition and is mainly developed by construction of dug wells or shallow tubewells as handpump or deep tube wells and the second aquifer or deeper aquifer found in the south western and northeastern part of the district and is underlain by Pre Cambrian Group of rocks where groundwater occurs in secondary pores of fractured gneiss and quartzite as deciphered from explorations carried out in the district. In the southern part of the district groundwater occurs in semi-confined to confined conditions. The area towards Lumding shows increasing

proportion of clay. The aquifer zones are often observed to be pinching against the clay beds and there is very little limited potential of groundwater development in these part. The sediments are mostly deposited by Kopili river flowing northward as a tributary of Brahmaputra. The greater proportion of clayey substances in the sediment may be due to the prevailing shaly nature of the catchment on the southern hilly part.

Central Ground Water Board has been carrying out exploratory drilling activities in various hydrogeological set ups by deploying appropriate drilling rigs in Nagaon district, Assam. The Board has constructed thirty two (32) exploratory tube wells in the district since its inception. In addition to this thirteen (13) observation wells, five (5) piezometers and two(2) slim holes have already been constructed in the district during the different groundwater exploration programmes of CGWB, NER, Guwahati. List of the exploratory wells are given in table 2.2.

Large numbers of shallow and deep tube wells have been constructed in the district which provides us with valuable information regarding aquifer characteristics.

Based on the litholog of the exploratory wells, three sections have been prepared to show the 2D disposition of the aquifers along the North-South direction (Figure 3.6), East-West direction (Figure 3.7), and Northwest- Southeast direction(Fig 3.8). From the sections prepared it is found that the sand content decreases from North to South direction of the district. In East-West direction, the sand content is more in comparison to clay.

A panel diagram is prepared based on the subsurface data available for the district. The diagram shows the distribution of the aquifer materials throughout the district. It is clear from the diagram that the northern part of the district along the bank of the river Brahmaputra from Jakhalabanda to Rupahitoli has a good thickness of aquifer (sand) throughout with small lenses of intervening clay bands. The sediments in this part are mostly derived from river Brahmaputra and its tributaries. The southern part of the district covering Kathiatoli to Nilbagan and further south shows shows altercation of clayey materials. The sand/clay proportion is about 30:70 in the southern part and the groundwater occurs mostly under semi-confined to confined condition. The aquifer zones are often observed to be pinching against the clay beds and there is very limited potential of groundwater development in the area. The sediments are mostly deposited by the Kopili river flowing northward as a tributary of Brahmaputra. The greater proportion of clayey substances in the sediment may be due to the prevailing shaly nature of the catchment on the southern hilly part.

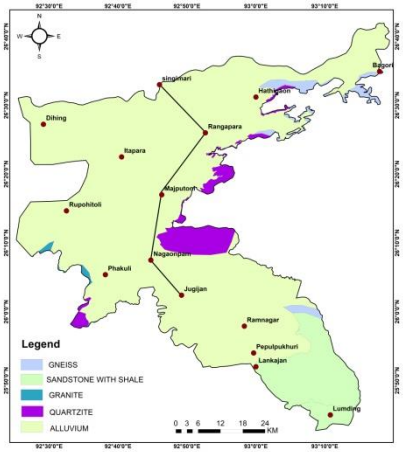
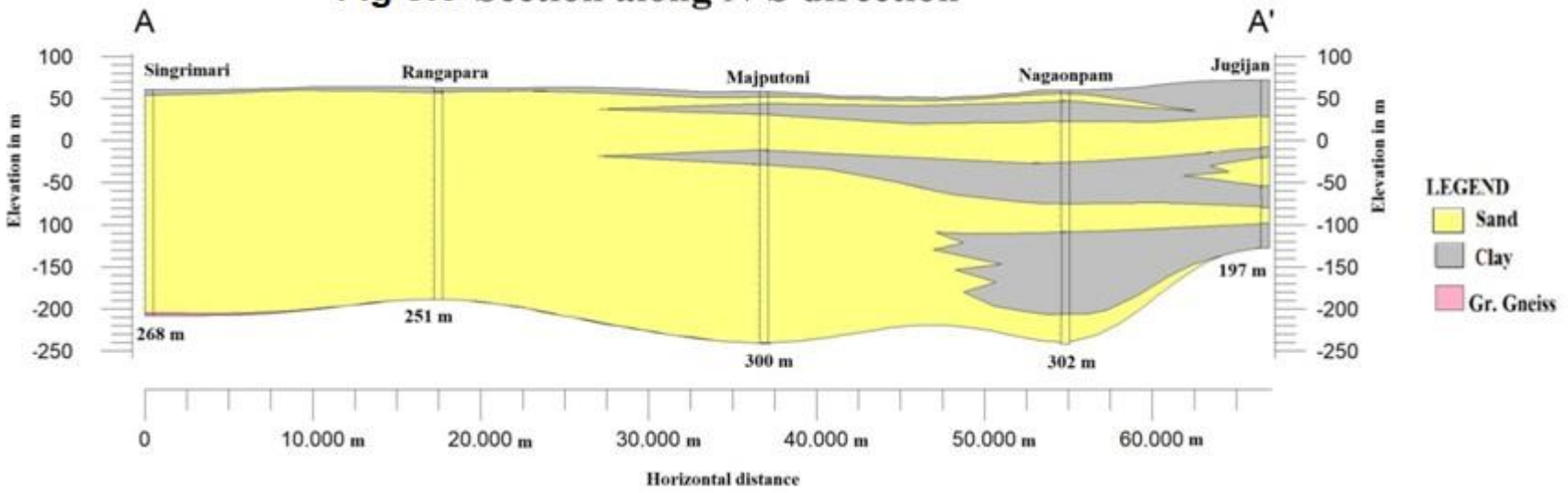


Fig 3.6 Section along N-S direction



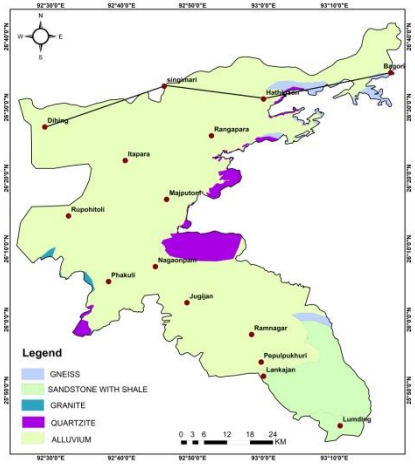
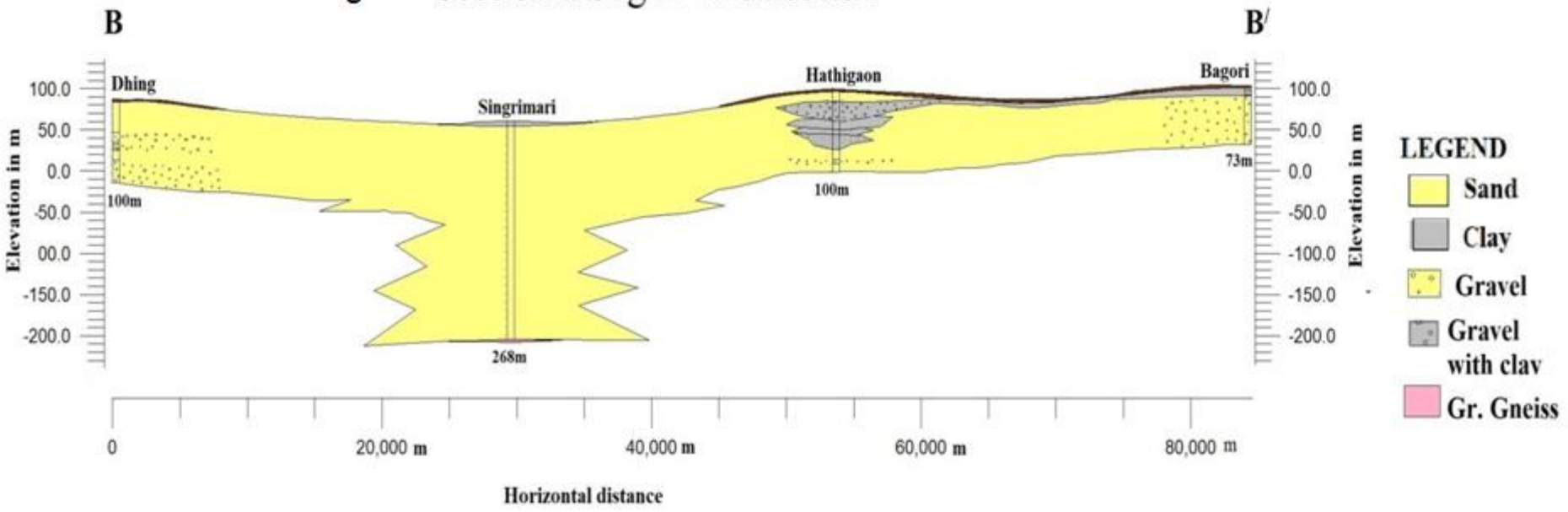


Fig 3.7 Section along E-W direction



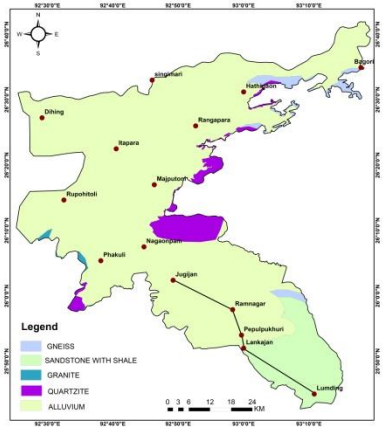
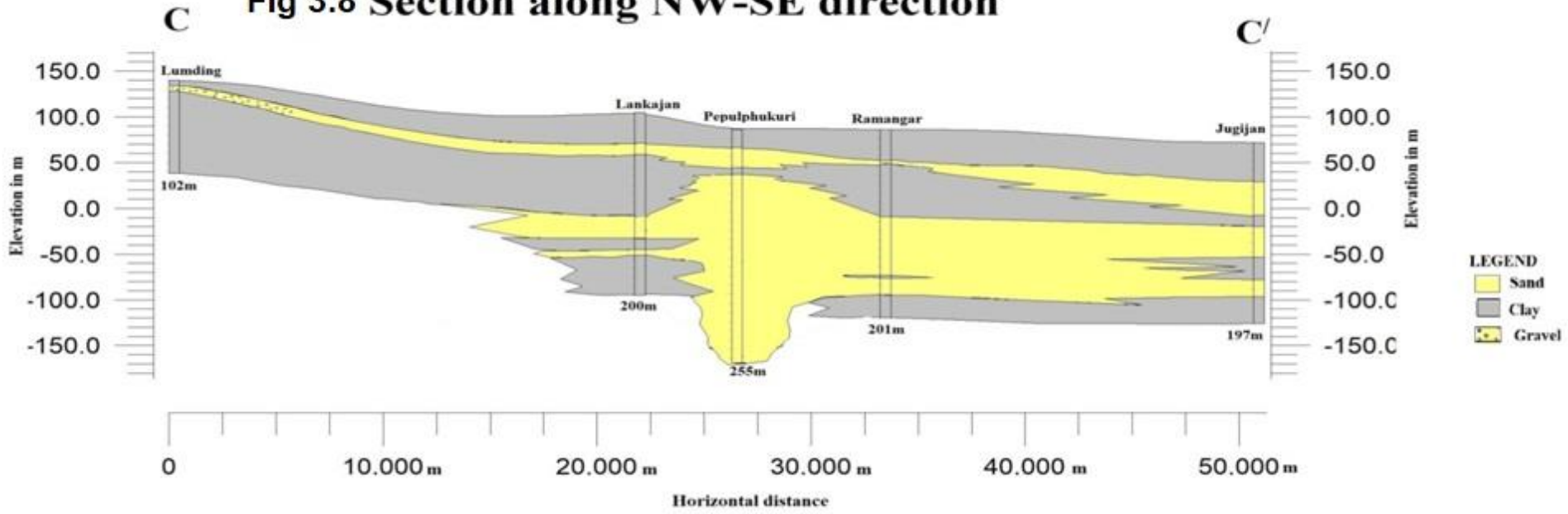
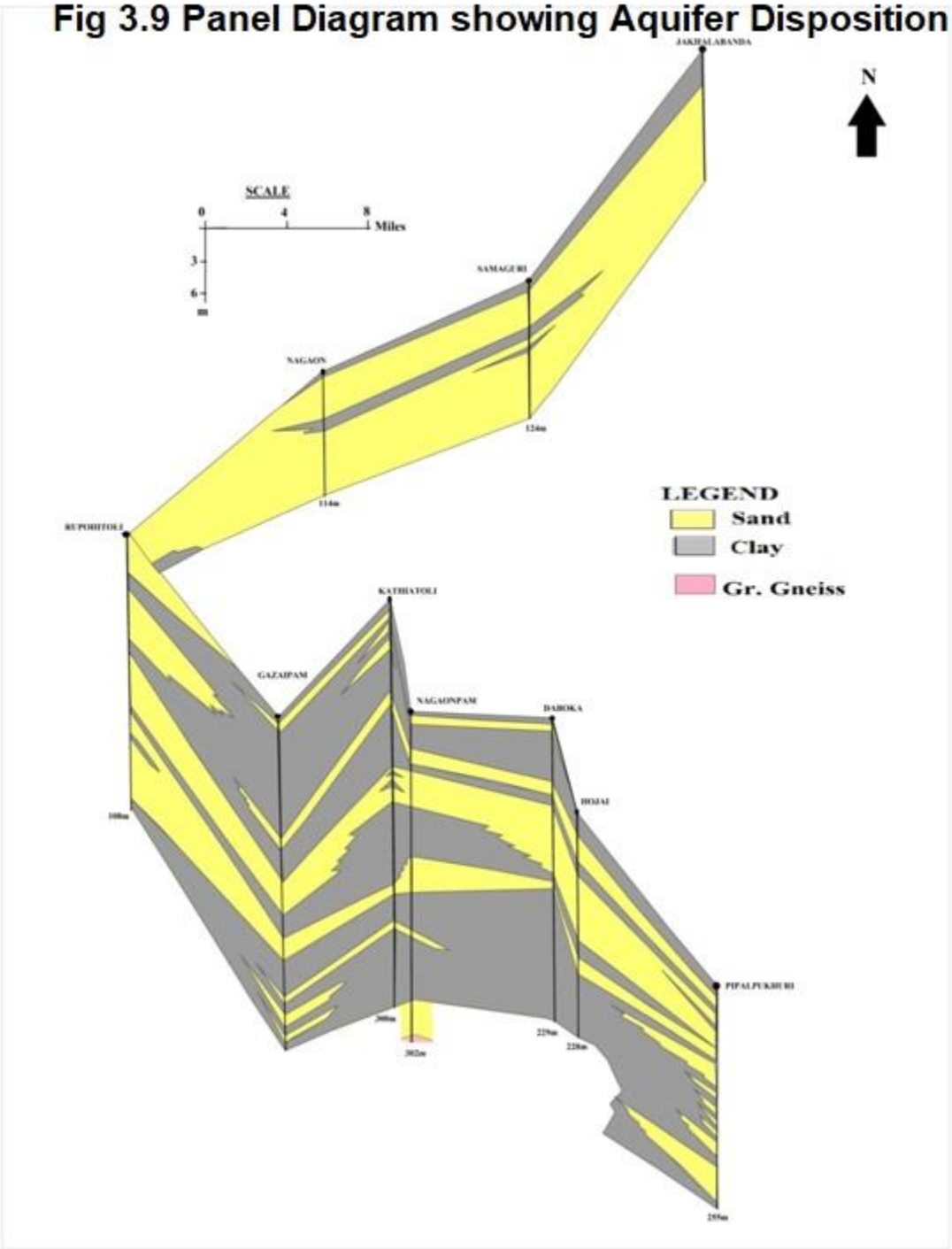


Fig 3.8 Section along NW-SE direction



A panel diagram (Fig 3.9) is prepared based on the subsurface data available for the district. The diagram shows the distribution of the aquifer materials throughout the district. It is clear from the diagram that the northern part of the district along the bank of the river Brahmaputra from Jakhalabanda to Rupahitoli has a good thickness of aquifer (sand) throughout with small lenses of intervening clay bands. The sediments in this part are mostly derived from river Brahmaputra and its tributaries. The southern part of the district covering Kathiatoli to Nilbagan and further south shows shows altercation of clayey materials. The sand/clay proportion is about 30:70 in the southern part and the groundwater occurs mostly under semi-confined to confined condition. The aquifer zones are often observed to be pinching against the clay beds and there is very limited potential of groundwater development in the area. The sediments are mostly deposited by the Kopili river flowing northward as a tributary of Brahmaputra. The greater proportion of clayey substances in the sediment may be due to the prevailing shaly nature of the catchment on the southern hilly part.

Fig 3.9 Panel Diagram showing Aquifer Disposition



3.6 Aquifer parameters

The yield of the aquifer ranges from 3.30 cubic meter/hour to 251.04 cubic meter/ hour at a drilled depth of 102 m and 300.7 m respectively.

Transmissivity of the aquifer ranges from 53.43 – 5894 m2/day, the lowest in Kaki EW and the highest in Itapara EW. The specific capacity ranges from 27.23 litre per minute /m at Kaki EW to 910.11 litre per minute /m at Itapara EW.

3.7 Hydrochemistry:

The quality of ground water is as important as that of the quantity. In order to study the chemical quality of ground water in the district, a total of 37 numbers of ground water samples were collected and analyzed during pre monsoon and 34 numbers of samples were collected during post monsoon. The samples were analyzed for parameters like pH, EC, Turbidity, TDS, CO3, Cl, SO4, Na, K, HCO3, NO3, F, Ca, Mg, TH, U, As and Fe. Table 3.2 and 3.3 summarizes the results of chemical analysis of groundwater samples from Nagaon district during pre-monsoon and post-monsoon season and the details of chemical analysis are given in the Annexure IV and V. Chemical quality of ground water in the district is being monitored every year in the month of November (post monsoon) and March (premonsoon) for temporal and spatial changes. In general, the quality of ground water in the district is suitable both for drinking and irrigation purposes except high concentration of iron (Fe) which exceeds permissible limit in certain areas.

Table 3.1: Chemical quality of water samples from dug well in Nagaon district during pre-monsoon

Sl. No.	Chemical constituents (Concentrations in mg/l except pH, EC, U and As)	Dug Well	
		Range	
1	pH	5.66	7.87
2	EC (µs/cm) 25°C	114.4	985.8
3	Turbidity (NTU)	BDL	0.85
4	TDS	75.50	650.63
5	CO_3^{-2}	0	0
6	HCO_3^{-1}	42.734	457.87
7	TA (as $CaCO_3$)	42.734	457.87
8	Cl^-	7.09	155.98
9	SO_4^{-2}	0	58.47
10	NO_3^{-1}	0.12	34.96
11	F^-	0.02	0.41
12	Ca^{+2}	4.003	110.09
13	Mg^{+2}	1.20	63.09
14	TH (as $CaCO_3$)	35	445
15	Na	3.89	99.79
16	K	0.75	38.42
17	U from Fluorometer	BDL	6.07

Table 3.2: Chemical quality of water samples from dug well and springs in Nagaon district during post-monsoon

Sl. No.	Chemical constituents (Concentrations in mg/l except pH, EC, U and As)	Dug Well	
		Range	
1	pH	6.549	8.31
2	EC (µs/cm) 25°C	65.88	991.7
3	Turbidity (NTU)	BDL	2.2

4	TDS	43.48	654.52
5	CO_3^{-2}	0	18
6	HCO_3^{-1}	12.21	616.59
7	TA (as $CaCO_3$)	12.21	616.59
8	Cl^-	10.635	205.61
9	SO_4^{-2}	0.16	18.92
10	NO_3^{-1}	0	38.15
11	F^-	0.03	1.1
12	Ca^{+2}	4.00	186.15
13	Mg^{+2}	1.20	35.15
14	TH (as $CaCO_3$)	50	585
15	Na	5.62	107.62
16	K	1.02	58.46
17	Fe	0.046	6.67
18	U from Fluorometer	0.0027	7.32

It is deciphered from table 3.2 and 3.3 that except Iron (Fe), the other chemical parameters are within permissible limit. The concentration of Iron beyond permissible limit is found in 8 dug wells during post-monsoon.

3.6.1 Assessment of ground water quality with various graphical diagram

Each ground water system in an area is known to have a unique chemistry, which depends on several factors such as soil-water interaction, dissolution of mineral species, duration of solid-water interaction and anthropogenic sources. Graphical approach was used to assess the quality of groundwater to recognise the various hydro-chemical types in a groundwater system. It further helps in evaluation of the suitability of groundwater for irrigation purpose. Ground water quality has been assessed with the help of various diagram such as Piper diagram and Stiff diagram prepared with the help of Aquachem 9 software.

Piper diagram

A Piper diagram is a graphical representation of the chemistry of a water sample. The cations and anions are shown by separate ternary plots. The apexes of the cation plot are calcium, magnesium and sodium plus potassium cations. The apexes of the anion plot are sulphate, chloride and carbonate plus hydrogen carbonate anions. The two ternary plots are then projected onto a diamond. The diamond is a matrix transformation of a graph of the anions (sulfate + chloride / total anions) and cations (sodium + potassium /total cations). In order to understand water composition and chemical relationship between dissolved ions, Pipers trilinear diagram for graphical analysis (Fig. 3.9 & 3.10) is used. This diagram reveals similarities and differences among water samples. Most of the water samples analysed fall in magnesium bicarbonate type for both pre monsoon and post monsoon. The cations plotted in the diagram

fall in no dominant type and calcium type in majority of the samples both for pre monsoon and post monsoon. In case of anions, most of the samples are under bicarbonate type. These trends are reflected in the central diamond of the diagram where most of the samples fall under the category of magnesium bicarbonate type. The results suggest that magnesium bicarbonate type are the dominant hydro chemical facies for the studied groundwater samples.

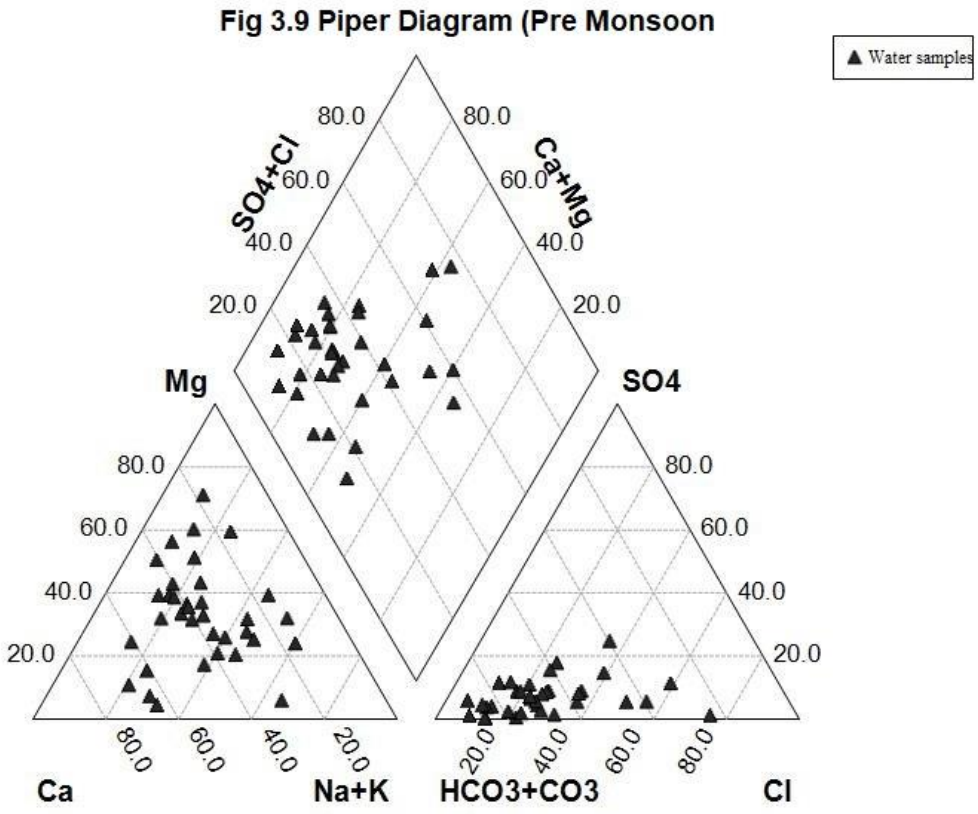
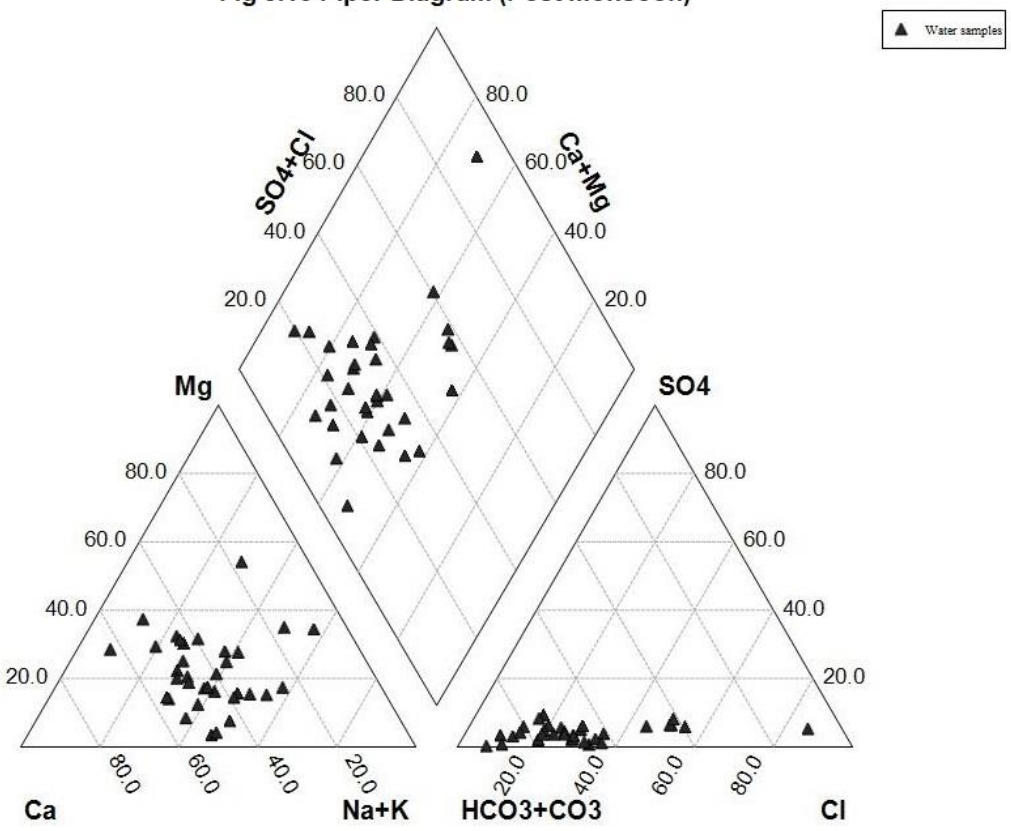


Fig 3.10 Piper Diagram (Post Monsoon)



Stiff Diagram

Stiff diagram is a graphical representation of chemical analyses. Stiff diagrams are created by plotting the equivalent concentration of the cations to the left of the center axis and anions to the right. The points are connected to form the figure. The graphical representation of Stiff diagram for water samples from Pre Monsoon and Post monsoon is shown in fig. 3.11 and 3.12 respectively. From the diagram it is concluded that the groundwater samples fall in Magnesium bicarbonate type both for pre monsoon and post monsoon.

Fig 3.11 Stiff diagram (Pre Monsoon)

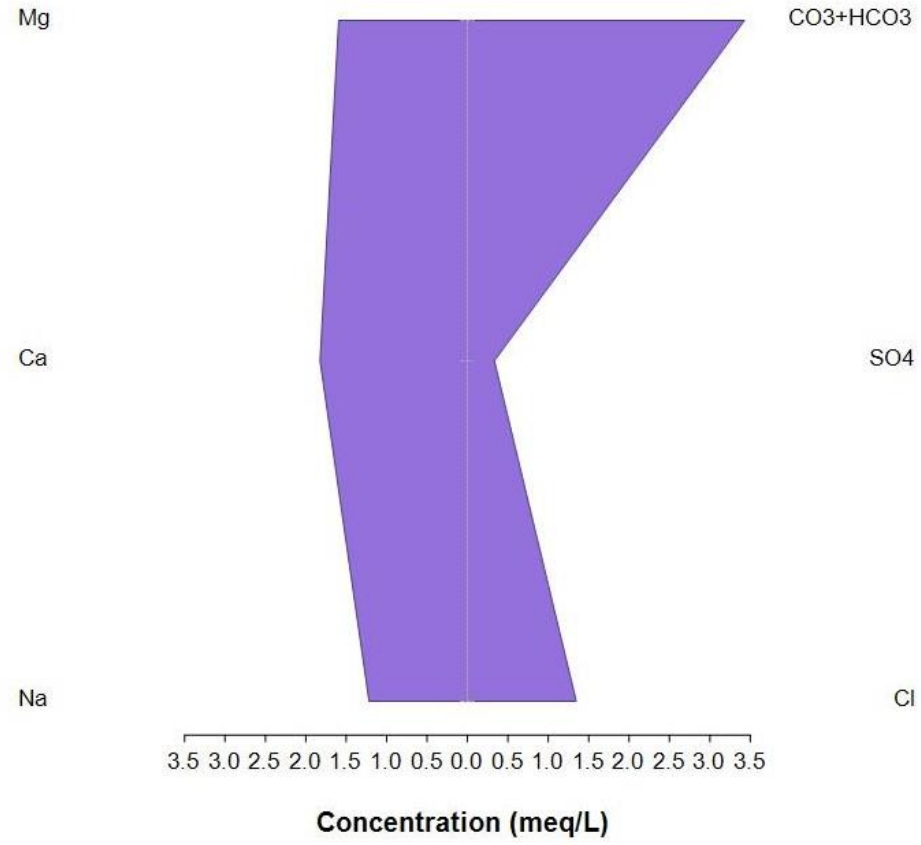
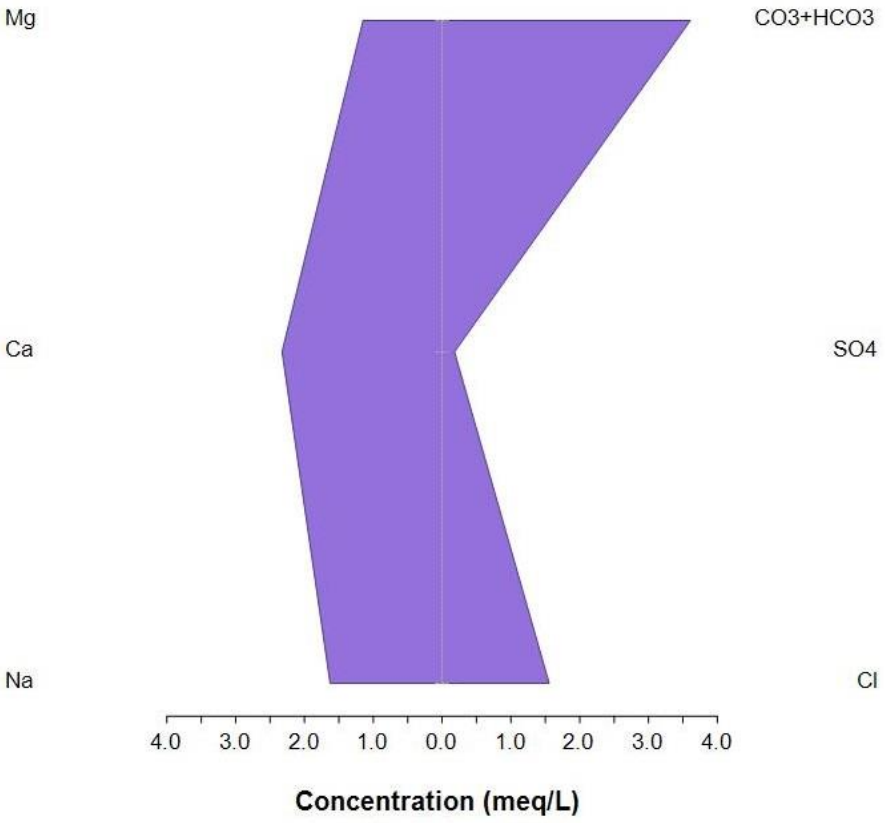


Fig 3.12 Stiff Diagram (Post Monsoon)



4 GROUNDWATER RESOURCES

Dynamic Groundwater Resources of Nagaon district has been estimated based on the methodology recommended by Groundwater Estimation Committee (GEC'2015). The present methodology used for resource assessment is known as Ground Water Resource Estimation Methodology – 2015 (GEC'2015). GEC 2015 recommends estimation of replenishable and in-storage ground water resources for both unconfined and confined aquifers. In GEC'2015, two approaches are recommended – water level fluctuation method and norms of rainfall infiltration method. The resources computed for groundwater year 2021-22. The following sub-units are recommended for the computation of various figures in the methodology and these are considered in details below:

Hilly Area: Area with more than 20% slope has been excluded for the recharge computation. Total recharge worthy area in the district is 140966 Ha.

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

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

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

Table 4.1: Groundwater recharge from various sources (ham).

Assessment Unit/ District	Command/ Non-Command/ Total	Recharge from rainfall during monsoon season	Recharge from other sources during monsoon season	Recharge from rainfall during non-monsoon season	Recharge from other sources during non-monsoon season	Total Annual Ground Water Recharge	Total Natural Discharges	Annual Extractable Ground Water
Nagaon District		85908.45	9996.22	21452.74	9941.96	127299.38	12729.94	108901.86

4.1 Groundwater extraction for Various Purposes: Groundwater extraction for domestic use has been estimated based on number of households using groundwater (Census 2011 data). Groundwater draft for irrigation is 27157.20 Ham and groundwater draft for all uses in the district is 31428.34 ham.

4.2 Stage of Groundwater extraction & categorization of the Blocks: The district falls under "**SAFE"** category. The stage of GW extraction is 28.86%. Summary of groundwater resources, stages of development and categorization are given in annexure III.

4.3 Summarized results of dynamic ground water resources of Nagaon district as on 2022:

The summarized results of dynamic ground water resources estimation of Nagaon district as on March 2022 is shown in table 4.2

Table 4.2: Summarized results of dynamic ground water resources of Nagaon district as on March 2022

Sl. No.	**ITEM**	**Year 2022**
	Methodology	**GEC 2015 (in ham)**
1	Total Annual Ground Water Recharge	127299.38
2	Total Natural Discharges	12729.94
3	Annual Extractable Ground Water Resource	108901.86
4	Total annual Ground water extraction	31428.34
5	Annual GW Allocation for Domestic Use as on 2025	4637.48
6	Net Ground Water Availability for future use	77063.82
7	Stage of GW Development (%)	28.86

5 GROUND WATER RELATED ISSUES

The main groundwater issues in this area are its vulnerability issue and low potential of groundwater in the southern part of the district. These include areas vulnerable to high Iron concentration in ground water above the permissible limit.

Low potential of groundwater development.

Central Ground Water Board has been carrying out exploratory drilling activities in various hydrogeological set ups by deploying appropriate drilling rigs in Nagaon district, Assam. It has been deciphered from these exploration studies that in the southern part of the district, towards Lumding groundwater occurs in semi-confined to confined conditions. The area shows increasing proportion of clay. The aquifer zones are often observed to be pinching against the clay beds and there is very little limited potential of groundwater development in these part. The sediments are mostly deposited by Kopili river flowing northward as a tributary of Brahmaputra. The greater proportion of clayey substances in the sediment may be due to the prevailing shaly nature of the catchment on the southern hilly part. Clay predominance increases in the south and fine to medium grained sands occur in relatively very thin lenses indicating that the formations possibly belong to arenaceous facies of Tipam Group or Dupitila Group of Tertiary age. Hence there is low potential of groundwater development in these area.

High Iron concentration

In the study area, high concentration of Iron (Fe) has been observed in some monitoring stations where Fe concentration in ground water have been found to be beyond the permissible limit of 1.0 mg/ltr.

6. MANAGEMENT STRATEGIES

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

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

As per dynamic ground water resource of Nagaon District for 2022, annual extractable groundwater resource is 108901.86 ham and stage of development is 28.86%. The district is having balance net ground water availability for future development in the tune of 77063.82 ham. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 46238.29 ham of groundwater resources is available in the district for future irrigation uses. Hence, there is ample scope for ground water development for irrigation purpose which will help the district in achieving self-reliance on food grain.

In Nagaon district , net sown area is 230890 ha, area sown more than once is 250289 ha and cropping intensity is about 108%. The net sown area includes field crops as well as horticulture and plantation crops on slopes and hills. Cropping intensity is calculated generally from field crops, which are of short duration whereas horticulture (like citrus, banana, pineapple) and plantation crops like spices are long duration crops. Moreover, crops like turmeric and ginger are having negligible or nil irrigation requirements.

As per agricultural census, the unirrigated area in the district is 211097 Ha. The intention is to bring this fallow land of 211097 Ha under assured irrigation during rabi season so as to increase gross cropped area to 422194 Ha and thereby increase cropping intensity up to 200%. In rice fallow, pulses, potato, maize and small vegetables can be grown with the support of irrigation.

To use groundwater for irrigation purpose a cropping plan has been designed for the

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

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

Cropping pattern name: Nagaon District

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...Data\CROPWAT\data	Rice	04/06	01/10	15
2	...Data\CROPWAT\data	Rice	11/06	08/10	15
3	...Data\CROPWAT\data	Rice	18/06	15/10	10
4	...Data\CROPWAT\data	Rice	25/06	22/10	10
5	...\CROPWAT\data\cro	Potato	15/10	21/02	10
6	...\CROPWAT\data\cro	Potato	15/11	24/03	10
7	...a\CROPWAT\data\cr	Pulses	25/10	11/02	10
8	...CROPWAT\data\crop	Small Vegetables	15/10	17/01	10
9	...CROPWAT\data\crop	Small Vegetables	07/11	09/02	5
10	...ata\CROPWAT\data\	MAIZE (Grain)	20/10	21/02	5

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

Cropping pattern (s)				
Rice based cropping pattern				
Rice-Mustard	Present Cultivated area	Area to be cultivated	Area to be cultivated (ha)	Irrigation requirement (ha m)
Rice-Vegetables	(ha)	(%)		
Rice-Pulses				
Rice-Millet				
	1	2 (= % of 1)	3	4
Rice (main crop)	211097		211097	
Potato	0	20	42219	899.8
Potato	0	20	42219	1010.8
Pulses	0	20	42219	710.4
Small vegetables	0	20	42219	639.8
Small vegetables	0	15	31665	723.5
Maize (Grain)	0	05	10556	800.9
Net cultivated area (Paddy)	211097	100	211097	

Gross cultivated area	211097		422194	
Cropping intensity	100% (Present)		200% (Intended)	

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

Crop	Growing period (Months)	Periods/months of water deficit	Irrigation requirement (ham)	Peak water requirement for Irrigation
Rice	4	1 – 2	4347.1	June
Potato	4	4	899.8	December
Potato	4	4	1010.8	May
Pulses	4	4	710.4	December
Small Vegetables	3	3	639.8	March
Small Vegetables	3	3	723.5	March
Maize	4	4	800.9	March

During kharif season, rice is cultivated from June to mid-July. Since this huge area cannot be cultivated in a single day (one planting date), so it is considered/ planned to cultivate rice in four stages during this period. It is planned to utilize rice fallow of 211097 ha for the cultivation of potato, pulses, small vegetables and maize. It is considered to cultivate potato in 84438 ha, pulses in 42219 ha, , Small vegetables in 73884 ha and maize in 10556 ha, including present cultivation area for these crops. Area under potato and vegetable cultivation is considered/ planned to cultivate in two stages during this period.

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Rice	0	0	0	0	147.2	50.9	0	0	0	3.1	0	0
2. Rice	0	0	0	0	49.6	98	0	0	0	0	0	0
3. Rice	0	0	0	0	49.7	150.1	0	0	0	5.7	0	0
4. Rice	0	0	0	0	0	147.1	0	0	0	17	0	0
5. Potato	59.8	34.9	0	0	0	0	0	0	0	0	29.1	61
6. Potato	60.1	64.4	36.3	0	0	0	0	0	0	0	12.4	34.4
7. Pulses	58.1	10.4	0	0	0	0	0	0	0	0	18.5	58.9
8. Small Vegetables	27.1	0	0	0	0	0	0	0	0	5.1	42.2	57
9. Small Vegetables	55.6	16.3	0	0	0	0	0	0	0	0	26.8	49.9
10. Maize (Grain)	60.5	23.5	0	0	0	0	0	0	0	1	19.3	60.2

Table 6.5: Irrigation Water Requirement (in ham), Nagaon District

Crop	Area %	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total IWR
1. Rice	15	0.0	0.0	0.0	0.0	1075.1	371.8	0.0	0.0	0.0	22.6	0.0	0.0	1469.5
2. Rice	15	0.0	0.0	0.0	0.0	362.3	715.8	0.0	0.0	0.0	0.0	0.0	0.0	1078.0
3. Rice	10	0.0	0.0	0.0	0.0	242.0	730.9	0.0	0.0	0.0	27.8	0.0	0.0	1000.6
4. Rice	10	0.0	0.0	0.0	0.0	0.0	716.2	0.0	0.0	0.0	82.8	0.0	0.0	799.0
5.Potato	10	291.2	169.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	141.7	297.0	899.8
6. Potato	10	292.6	313.6	176.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.4	167.5	1010.8
7. Pulses	10	282.9	50.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.1	286.8	710.4

8. Small Vegetables	10	132.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.8	205.5	277.5	639.8
9. Small Vegetables	5	270.7	79.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	130.5	243.0	723.5
10. Maize	5	294.6	114.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	94.0	293.1	801.0
Total	100	1563.95	727.93	176.748	0	1679.35	2534.61	0	0	0	162.871	722.088	1564.93	9132.48

As majority of the area is underlain by alluvial plains, there is scope for development of ground water. Ground water development is being done through dug well and tube well/ bore well. The peneplained surfaces, buried pediments and valley fills are the most favourable localities for development of ground water. The weathered mantle holds good prospect for dugwell within the depth range of 4 to 10 m depending on the topographical setting. Large diameter dug wells can sustain moderately higher yield. Dug wells need to be properly lined with cement rings to avoid collapse of weathered zone. As very good quantity of dynamic ground water resources is available, dug wells are the preferred structures as of now in low-lying areas and valleys. The shallow water level condition gives scope to maintain sufficient water column in the dug wells. In future, if there are water crises, tube well within the depth of 100 m can be constructed.

Under ground water exploration programme, CGWB has constructed 4 nos. of shallow tube wells in the district and has established that the aquifer is having average discharge of 30 cubic m/hour, considering the discharge of wells in the neighbouring districts aswell. In these areas tubewells can be sustainably developed for irrigation purpose. Tube wells can be designed within a depth of 50-100 m, expected to encounter good yield.

The ground water potentiality in the district is moderate to high which are feasible for sustainable ground water development. Therefore, those areas can be brought under irrigation by developing ground water through construction of tubewells.

A tubewell in the area is expected to yield 30 m^3/hr. If such a tube well runs for 10 hrs/day for 120 days, then it will create a draft of 3.6 ham. Tube wells can be designed within a depth of 100m, expected to encounter 1 to 2 zones. Tube wells can be constructed by using $8^{//}$ dia.

In considered unirrigated of 211097 Ha, 1366 nos. of shallow tube wells can be constructed (considering 200m distance between any two shallow bore well).

Annual irrigation water requirement is 9132.48 ham while irrigation water requirement during dry season spanning from October to March is 4918.52 ham. Again proportionate dynamic groundwater resources available for future use in the considered area is 46238.29 ham, considering 60% of the available groundwater resources available for future use. Hence, this area can be brought under assured irrigation from groundwater sources. The demand of 4918.52 ham can be harnessed by constructing 1366 nos. of shallow tube wells. At possible places rainwater harvesting methods should be employed. If more bore wells are constructed, then the stage of groundwater development will increase leading to room for addressing the water logging issues by lowering the water levels.

When managing a precious and scarce resource such as groundwater, it is essential that the resource is not subjected to pollution.

The chemical quality of ground water indicates that groundwater in major part of the area is good for domestic, irrigation and industrial use. However, iron content in some wells are found to be beyond the permissible limit, which warrant proper treatment before use. Removal of the iron is best effected by aeration process followed by sedimentation and filtration. Potassium permanganate or chlorine/chloride may be employed to oxidize the iron, which is then filtered from the waters. The process is applicable very much when bacteria is present in the water. Iron can also be removed by addition of a mixture of sodium carbonate and sodium phosphate to precipitate iron as insoluble, followed by settling and filtration.

Ground Water Development : In view of ground water development, the district shows occurrence of enough ground water resources for domestic and irrigation purposes. Method of making ground water abstraction structure, type, design, depth of wells, number and spacing between two wells depends on size of aquifer material, depth range & hydraulic parameters of aquifer zones, differ from place to place. As per earlier reports and present study, following design criteria is recommended.

a) Shallow Domestic Wells - Open wells and filter point wells are feasible in all area of the district. In unconsolidated sediments ring well may be constructed by excavating down to the saturated horizon. Cement or earthen rings from 0.80 to 1.20 placed one above another with weep holes in the bottom rings are likely to hold sufficient quantity of water. Depth may be range from 9 to 22 m depending upon the topographic elevation. Expected discharge will be 4 to 6 cubic meters per day. In the iron contaminated areas of the district it is important to install Filter Point Wells with a total depth of 10 to 25 mbgl by providing galvanized iron or mild steel pipe and at bottom slotted pipe against aquifer zone either made from bamboo or MS pipe or P.V.C pipe are suitable. Bamboo as pipe and screen are very much within the reach of small and marginal farmers, as bamboo is locally available in the district. This type of well will be low cost and long lasting. Expected discharge will be 10 to 20 cubic meters per day.

b) Deep Tube Well for Irrigation Purpose - Nagaon is feasible for construction of deep tube wells for irrigation purposes by tapping the granular zones occurring beyond 35-50 mbgl. Diameter of casing pipe, when used as housing pipe, need to be decided based on the anticipated discharge. Housing pipe should be large enough to accommodate the pump. Based on the static water level, maximum draw down and

seasonal fluctuation length of housing pipe should be range from 30 to 40 mbgl. Along foothill region of inselbergs and towards southeastern part bordering to Mikir Hills, it should be range from 20 to 30 mbgl. For avoiding corrosion and clogging of well screen, the entrance velocity should be less than 2 cm/sec.

Low potential of groundwater development can be addressed by water conservation and artificial recharge methods. Rainwater harvesting structures is recommended to be constructed.

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

Longitude	Latitude	District	Location	Tpye of well	Topo sheet	year of construction	Depth of Drilled (mbgl)	Depth of constr. (mbgl)	Zones upto 50 m.bgl	Zones upto 100 m.bgl	Zones / Fractured upto 200 m.bgl	Zones / Fractured upto 300 m.bgl	Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Permeability (m/day)	Specific Capacity(lpm/m)	Storage co-efficient (S) (lpm/m)	Formation
92.7458	26.125	Nagaon	Nagaonpam-EW	EW	**83B/12**	Nov-78	302.00	165.00	38.5-49.50	56-58, 74-85	135- 147, 153-156, 159.5-162		1.03	53.352	11.11	1900		334	0.61*10-3	Alluvium
92.7444	26.124	Nagaon	Nagaonpam-OW	OW	**83B/12**	Nov-78	171.40	165.00	38.5-49.50	56-58, 74-85	135- 147, 153-156, 159.5-162		1.476		1.962					Tertiary-Alluvium and Gravel
92.7417	26.183	Nagaon	Kathiatoli-EW	EW	**83B/12**	Dec-78	300.00	187.00	35-45	73.5-75.5, 80.5-85.5	152.5-156, 159.5-163, 175.5-184		14.68	130.8	9.52	363		229.5	2.29*10-2	Alluvium
92.9083	26.067	Nagaon	Nilbagan-EW	EW	**83B/16**	Jan-79	304.22	158.00	33.5-37.5	56.58.5, 61.5-79, 90.5-97	101-103, 128.5-131.5, 134.5-137, 150-155		1.31	91.08	11.29	409.5	9.4	134.41	8*10-5	Alluvium
92.9944	25.900	Nagaon	Peepal Pukhuri-EW	EW	**83C/13**	Feb-79	255.60	146.50		50-59, 65-70, 76.5-97	100.5-110, 115.-121.5, 125.5-132, 136-142		14.69	78.6	9.03	161		144.27		Alluvium. Hard rock at 255
92.9000	26.067	Nagaon	Nilbagan-OW	OW	**83B/16**	Mar-79	169.02	158.00	33.5-37.5	56.58.5, 61.5-79, 90.5-97	101-103, 128.5-131.5, 134.5-137, 150-155		2.03		4.408					Alluvium
92.684	26.346	Nagaon	Nagaon Town-EW	EW	**83B/11**	Oct-79	215.33						3.39	0.00	2.89					Alluvium
92.795	26.374	Nagaon	Puranigudam-EW	EW	**83B/15**	Nov-79	105.22						3.53	43.79	2.31					Alluvium
93.003	26.571	Nagaon	Jakhalabandha-EW	EW	**83B/13**	Dec-79	147.97						0.00	0.00	0.00					Alluvium
92.5417	26.244	Nagaon	Rupahitoli-EW	EW	**83B/12**	Jan-80	300.70	138.00		55-70, 80-95,	110-120, 125-135		2.34	251.04	5.6	3430		355.82		Alluvium. Hard rock at 256
92.7903	26.6333	Nagaon	Vartak office campus , (Tezpur) G mine well -EW	EW	**83B/15**	Jun-81	73.81	60.30	30.5 - 54.1				3.785	9.349	1.025	1244.62	52.8	699.93		Alluvium
92.6750	26.375	Nagaon	Itapara-EW	EW	**83B/11**	Feb-82	300.00	231.00	41-50	50-94.04	155.13-162.25, 179.81-186, 194.16 -200	200-215.75-218.71-228.08	1.52	179.40	9.103	5894	84		6.44*10-2	Alluvium
92.8111	26.348	Nagaon	Chalchali-PZ	PZ	**83B/15**	Feb-82	37.00	34.43	31.53-33.03											Alluvium
92.7667	26.525	Nagaon	Pachim Singimari-EW	EW	**83B/8**	Feb-82	268.74	169.00	43-50	50-52, 65-86, 96-100	100-117, 154-166		0.287	268.74	9.671	4886	29.43	100	1.5*10-3	Alluvium. Hard rock at 265 m
92.7667	26.519	Nagaon	Pachim Singimari- OW	OW	**83B/8**	Feb-82	169.00	169.00	43-50	50-52, 65-86, 96-100	100-117, 154-167		0.59		0.25					Alluvium. Hard rock at 265 m
92.6750	26.374	Nagaon	Itapara-OW -I	OW	**83B/11**	Mar-82	300.00	231.00	41-50	50-94.04	155.13-162.25, 179.81-186, 194.16 -200	200-215.75-218.71-228.08	1.51		0.97					Alluvium
92.6750	26.371	Nagaon	Itapara-OW	OW	**83B/11**	Mar-82	54.95	48.00	30-45				1.37		0.633			910.11		Alluvium
92.5539	26.416	Nagaon	Bordowa-EW	EW	**83B/11**	Mar-82	37.50	35.05	33.03 - 34.03											Alluvium
92.772	26.283	Nagaon	Majputoni-EW	EW	**83B/15**	May-82	300.10	228.00		55-61, 76.5-	110-116, 119-128, 131-137,	206-212, 219-225	1.77	194.64	10.67	1426.00	27.95	303.97		Alluvium. Hard rock at

										82.5,	174-185									255 m
92.5539	26.416	Nagaon	Bordhowa-PZ	PZ	**83B/11**	Jun-82	37.50	35.05	33.03-34.03											Alluvium.Hard rock at 255 m
92.7244	26.068	Nagaon	Kunwarital-PZ	PZ	**83B/12**	Jun-82	75.65	37.00	34-35											Alluvium.Hard rock at 255 m
92.8583	26.008	Nagaon	Hojai-EW	EW	**83C/13**	Jul-82	228.90	164.19		63.49-87.25, 92.85-99	123.60-135.37, 143.63-161.14		1.525 m agl	74.00	10.04	2800.00		440.0		Alluvium
92.8583	26.008	Nagaon	Hojai-PZ	PZ	**83C/13**	Jul-82	42.75	41.00	40-41											Alluvium
92.7667	26.433	Nagaon	Gajiapam-SH	SH	**83B/15**	Aug-82	305.00													Alluvium. Hard rock at 255 m
93.0000	26.070	Nagaon	Bandermela-SH	SH	**83B/16**	Sep-82	301.00													Alluvium.Hard rock at 255 m
92.8778	26.433	Nagaon	Rangagora-EW	EW	**83B/15**	Oct-82	251.40	161.07		59.74-66, 81.57-94.05	109.54-122.03, 128.3-140.69, 145.88-158.07		4.00	3.96	6.93	5780.85	21.9	396.82	1.4*10-3	Alluvium. Hard rock at 255 m
92.8722	26.433	Nagaon	Rangagora-OW	OW	**83B/15**	Oct-82	164.00	158.00		62-64,87-89,	115-117,135-136,150-153		3.86		4.95					Alluvium
92.6803	26.404	Nagaon	Tapatjuri-EW	EW	**83B/11**	Oct-82	165.32	160.78	22.09 - 38.18	55.08 - 59.45, 92.	92 - 110.55, 139.04 - 159.55		2.11	122.91	16.33	0.00				Alluvium
92.932	26.022	Nagaon	Hirabasti-EW	EW	**83C/13**	Sep-87	125.20	49.88	20.00 - 47.20				2.17	43.54	0.00	0.00				Alluvium
92.7667	26.111	Nagaon	Doboka-EW	EW	**83B/16**	Mar-93	229.70	128.94		60-72	85.15-126		0.85 m agl	71.83	10.16	660.00		424.20		Alluvium.Hard rock at 255 m
92.7667	26.111	Nagaon	Doboka-PZ	PZ	**83B/17**	Mar-93	159.10	63.00		57-60			2.27	4.43						Alluvium.Hard rock at 255 m
92.9719	25.932	Nagaon	Ram Nagar-II-EW	EW	**83C/13**	Mar-94	201.80	155.00			102-108, 126-153		6.96	60.84	10.66	545.66		95.11	1.704*10-4	Alluvium.Hard rock at 255 m
92.972	25.965	Nagaon	Ramnagar (Rangagura)-EW	EW	**83C/13**	May-94	201.90	156.00					7.66	60.83	10.66	545.06	8.134	100.52	1.794*10-4	Alluvium
92.972	25.965	Nagaon	Ramnagar (Rangagura)-OW	OW	**83C/14**	May-94	201.90	154.00					7.16		1.87					Alluvium
92.8119	26.049	Nagaon	Jugijan-EW	EW	**83B/16**	Dec-94	197.80	65.00		56-62			10.83	5.34						Alluvium. Hard rock at 255 m
92.8867	26.044	Nagaon	Islam Nagar-EW	EW	**83B/16**	Jan-95	201.80	113.00		55-60			3.20	8.40						Alluvium. Hard rock at 255 m
92.9833	26.083	Nagaon	Debasthan-EW	EW	**83B/16**	Feb-95	201.80	166.00		62-80, 95-100	100-101, 139-148, 157-163		4.26	55.00						Alluvium. Hard rock at 255 m
93.0000	25.875	Nagaon	Kaki-EW	EW	**83G/1**	Nov-99	102.00	101.00		64-70, 76-88, 95-98			10.68	3.30	2.02	53.43		27.23	1.88*10-3	Alluvium.Hard rock at102 m
92.636	26.090	Nagaon	Phakoli-EW	EW	**83B/12**	Nov-99	177.00	177.00		96-100	100-102, 114-120, 154-166, 170-174		1.30	28.20	0.96	1504.50	32.01	546.51		Alluvium
92.636	26.090	Nagaon	Phakoli-OW	OW	**83B/13**	Jan-00	181.00	177.00		96-100	100-102, 114-120, 154-166, 170-175		1.30		6.00					Alluvium
92.6358	26.090	Nagaon	Lankajan-EW	EW	**83B/12**	Feb-00	206.00	159.00	35-38,41-47		117-123, 130-136, 150-156		10.45	9.66	2.45	131.85		65.72	3.92*10-4	Alluvium.Hard rock at102 m

92.8519	26.329	Nagaon	Balijuri Karbi gaon-EW	EW	**83B/15**	Sep-07	200.70	121.00	26-29, 45-47	83-89, 97-100	115-121		2.85	22.70	5.55					Alluvium. Hard rock at 255 m
92.8506	26.328	Nagaon	Balijuri Karbi gaon-OW	OW	**83B/15**	Oct-07	125.00	119.00	27-28, 46-47	85-87, 98-99	117-119									Alluvium.Hard rock at 255 m
92.6567	26.325	Nagaon	Senchowa-EW	EW	**83B/11**	Nov-07	201.65	120.00	42-50	50-54, 78-90	102-120		2.10	53.00	3.34	4341.00		265.27	6.05*10-4	Alluvium. Hard rock at 255 m
92.651	26.174	Nagaon	Dakhinpat-OW	OW	**83B/11**	Feb-08	200.00	130.00	41-44	58-64	124-127		3.31							
92.6569	26.258	Nagaon	Dakhinpat Satra-EW	EW	**83B/11**	Apr-08	200.00	129.00	38-48	55-67	123-129		3.24	53.00	6.41					Alluvium. Hard rock at 255 m
92.6556	26.258	Nagaon	Dakhinpat Satra-OW	OW	**83B/11**	May-08	200.00	127.00	41-44	58-64	124-127		3.31							Alluvium.Hard rock at 255 m
92.8753	26.348	Nagaon	Gashibasti Chhapanala-EW	EW	**83B/15**	Aug-11	71.45	68.00	47-50	50-65				24.24						Alluvium
92.8742	26.347	Nagaon	Gashibasti Chhapanala-OW	OW	**83B/15**	Aug-11	62.25	61.00		50-58				15.30						Alluvium
92.9292	26.403	Nagaon	Rangamati-OW	OW	**83B/15**	Dec-11	150.00	147.00			136-145			15.36						Alluvium
92.9289	26.403	Nagaon	Rangamati-EW	EW	**83B/15**	Feb-12	125.00	123.50			116-122			8.82						Alluvium
92.8464	26.402	Nagaon	Gendhali Kachharigaon-EW	EW	**83B/15**	Mar-12	156.75	137.00		50-52, 62-68, 100-112	100-112, 128-134			35.64						Alluvium
25.75	93.18	Nagaon	Lumding Pz	Pz		Dec-22	102.00	15.00	6 12			1.48			0.89					Alluvium
26.582	93.2994	Nagaon	Bagori Pz	Pz			66.00	61.00	3 50	50 58		7.7	16.524	8.7	136.04					Alluvium
26.582	93.2994	Nagaon	Bagori EW	EW			72.50	65.00	12 15 , 15 24 , 24 57	57 69		6.4	10.62	13.85	155.58					Alluvium
26.521	90.0062	Nagaon	Hatigaon Pz	Pz			104.00	95.00		85.7 90.7										Alluvium
26.521	90.0062	Nagaon	Hatigaon EW	EW			100.90	100.00	6.4 15.5, 24.7 27.7	58.2 61.3, 79.6 85.7, 88.7 91.8		14.25	4.32	36.97	1.52					Alluvium

Annexure II : Depth to water level for Pre Monsoon and Post Monsoon in Nagaon District.

Location	Latitute	Longitiute	RL (m)	Dia (m)	Depth	MP	WL pre monsoon	WL post monsoon
Amsoi	26.13611	92.42167	46	1.05	9.60	0.77	3.2	3.12
Bamuni Tinali	26.29528	92.7925	45.09	0.90	11.00	1.41	2.12	0.46
Bordowa	26.41774	92.54953	64	64	9.00	0.85	2.12	1.37
Dakhinpath	25.6375	92.46056	72.01	72.01	8.60	0.20	4.8	4.01
Dalapani	26.56722	92.86222	77.25	0.95	7.20	0.9	2.39	-
Dhing	26.461485	92.47859	62	0.85	9.30	0.49	3.81	2.32
Doboka	26.13194	92.88806	74.51	0.75	8.30	0.8	3.46	1.9
Ghasibasti/Chapanala	26.34139	92.86806	52.72	0.85	11.20	0.4	3.6	3.1
Gomotha	26.34528	92.74861		0.55	8.40	0.85	2.55	2.85
Gosaibari Namghar/Gokhaibari	26.29429	92.5655	74.18	74.18	8.50	0.90	2.54	1.56
Haldiati Sub Bt	26.1725	92.94333	79.57	0.65	6.50	0.89	2.78	2
Hatenibatha	26.33611	92.76139	91	0.50	6.50	0.68	2.22	1.85
Jurapukhuri	25.96528	92.94361	107	0.55	8.90	0.84	5.81	5.01
Kampur	26.15944	92.65722	89	0.01	3.00	0.83	3.2	0.01
Kathiatoli	26.18806	92.70278	94	0.65	6.50	0.94	2.34	0.32
Kondoli	26.22056	92.77083	60.34	1.00	10.30	0.99	2.26	0.27
Lanka	26.18806	92.73611		0.75	11.00	0.72	6.15	4.97
Lumding	25.758808	93.17457	154.9	0.85	18.00	0.7	4.77	2.47
Rangamati	26.40444	92.9225	60	1.00	7.00	0.8	5.85	5.8
Silghat	26.60694	92.92917	73.95	0.80	8.60	0.96	7.24	1.05
Sulung PO	26.57028	92.87306	63	0.85	7.00	0.74	4.45	2.2
Telia bebejia	26.44111	92.64	57.73	1.25	9.36	0.5	3.68	2.81
Beldonga Shiv mandir	26.13778	92.81194	78.19	1.70	10.00	0.85	5.29	4.48
Zebra Khua	26.13861	92.80861	82.25	2.3	21.00	1.1	2.05	2.58
Lankajan Notun Basti	25.74261	93.49789	98	1.0	5.75	0.80	4.35	1.41
Bagori	26.71744	93.15861	68	1.20	10.35	1.10	6.18	4.77
Saitali	26.29613	92.59661	73	0.69	5.29	0.7	3.28	1.84
Nagaon	26.32088	92.70286	58	0.82	6.34	0.7	4.86	2.42
Hojai	25.99944	92.82491	98	1.36	10.54	0.61	6.19	9.18
Lawkhowa	26.53539	92.80936	94	0.75	5.6	0.95	3.86	2.3
Jakhalabandha	26.58435	92.98873	95	0.94	9	0.58	2.66	2
Chatia	26.5618	92.94734	96	1.1	6.29	0.98	2.24	1.15
Saporigaon	26.0604	92.93676	101	0.94	10.67	0.76	3.54	1.28
Raja Ali	26.07338	92.62979	85	1.3	5.21	0.43	4.41	2.47
Samaguri	26.39362	92.79898	95	0.61	20.16	0.78	5.2	4.24
Missa	26.49499	92.9483	93	1.06	7.8	0.98	3.53	2.1
Buryapahar	26.57552	93.08558	100	1.08	10.89	0.91	3.46	3.38
Bichamari	26.40139	92.46	64	0.95	11	0.87	2.49	2.65
Balijuri	26.32611	92.84972	76	0.85	45	0.8	2.34	3.57

Annexure III: Ground water resource

a) General Description of Ground Water Assessment in Nagaon district for 2022 (area in ha)

Name of Ground Water Assessment Unit	Nagaon
Type of Ground Water Assessment Unit	District
Type of rock formation	Younger Alluvium, Quartzite, Gneiss, Sandstone
Total area of Groundwater Assessment Unit	397300 Ha
Recharge worthy Area	377341 Ha
Poor ground water quality area	Nil
Total Annual Groundwater Recharge	127299.38 Ha

b) Ground Water Resource Potential in Morigaon district during 2022

Assessment Unit / District	Nagaon
Command/ Non-Command/ Total	Total
Recharge from rainfall during monsoon season	85908.45 Ham
Recharge from other sources during monsoon season	9996.22 Ham
Recharge from rainfall during non-monsoon season	21452.74 Ham
Recharge from other sources during non-monsoon season	9941.96 Ham
Total Ground Water Recharge	127299.38 Ham
Annual extractable Ground Water	108901.86 Ham

c) Ground Water extraction for All Uses in Nagaon district

District	Nagaon
Total extraction for domestic	4227.78 Ham
Total extraction for industrial	43.36 Ham
Total extraction for irrigation	27157.20 Ham
Total groundwater extraction	31428.34 Ham

d) Balance Ground Water Resources Available and Stage of Groundwater extraction in the Study Area as On 31st March 2022

Assessment Unit / District	Nagaon
Command/ Non-Command/ Total	Total
Net Annual Ground Water Availability	77063.82 Ham
Provision for domestic, and industrial requirement supply to 2025	4637.48 Ham
Net Annual Ground Water Availability for future development	77063.82 Ham
Stage of ground water extraction	28.86 %

e) Categorization for Ground Water Development of Nagaon district during 2022

Assessment/ Administrative Uint	**Stage of Ground Water extraction %**	**Quantity Categorization (Safe/Semi-Critical/ Critical/ Over Exploited)**	**Quality Tagging**
Nagaon	28.86	Safe	Fresh

Annexure IV Quality of groundwater in Nagaon District during Pre Monsoon

Location	Lat DMS	Long DMS	Type of sa	TempºC	Salinity (p	ORP (mV)	pH	EC (µs/cm	Turbidity (	TDS	CO3-2	HCO3-1	TA (as CaC	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaC	Na	K	U from Fluorimeter)
Raha	26.25	92.54	TW	25	0.284	83	6.862	337.8	0.23	222.95	0	183.1464	183.1464	17.725	6.625	0.7144	0.17	20.016	20.62136	135	9.89	7.81	0.1534
Saitali	26.3	92.6	DW	22.7	0.301	158	7.548	430.7	0.14	284.26	0	164.8318	164.8318	38.995	16.7469	2.3479	0.19	32.0256	20.61553	165	14.1	2.71	0.4235
Nagaon	26.32	92.7	DW	23.9	0.672	144	7.46	979.5	0.8	646.47	0	372.3977	372.3977	77.99	22.8039	13.068	0.2	56.0448	25.45825	245	59.84	25.93	1.5491
Lankajan M	25.88	93.04	DW	24.4	0.307	213	5.663	413	0.09	272.58	0	42.73416	42.73416	77.99	1.3316	34.957	0.02	16.0128	12.12816	90	27.28	7.17	BDL
Lumding	25.76	93.17	DW	24.2	0.608	203	7.022	851.7	0.1	562.12	0	293.0342	293.0342	67.355	58.4654	7.694	0.15	54.0432	29.1	255	45.42	10.45	0.4546
Lanka	25.92	92.95	DW	25.6	0.666	183	6.923	985.8	0.17	650.63	0	378.5026	378.5026	106.35	5.2555	0.6433	0.2	86.0688	33.93883	355	38.85	0.75	1.7039
Jurapukhu	25º 57′ 55′	92º 56′ 3″	DW	26.7	0.352	135	6.895	484.4	0.1	319.70	0	268.6147	268.6147	24.815	0	0.2638	0.25	64.0512	6.036893	185	19.49	5.58	0.3969
Hojai	25.98	92.93	DW	26.1	0.825	175	6.846	119.2	0.2	78.67	0	457.866	457.866	113.44	27.5103	1.9607	0.25	110.088	27.85922	390	63.61	1.88	2.6981
Singimari	26.46	92.76	DW	23.8	0.327	118	6.773	382.4	0.33	252.38	0	146.5171	146.5171	35.45	15.8371	0.7296	0.12	18.0144	25.4767	150	9.95	2.53	BDL
Lawkhowa	26.54	92.81	DW	23.5	0.6	152	7.326	832.4	0.14	549.38	0	341.8733	341.8733	63.81	26.7754	1.9485	0.14	64.0512	30.30874	285	38.3	5.97	5.0551
Sulung PO	26º 34′ 13′	92º 52′ 23″	DW	24.6	0.486	145	7.013	667.1	0.24	440.29	0	280.8245	280.8245	53.175	19.4813	3.0298	0.12	42.0336	26.67864	215	35.62	4.66	2.4928
Silghat	26.61	92.93	DW	25.6	0.409	168	6.996	603.8	0.09	398.51	0	274.7196	274.7196	42.54	25.5922	1.6518	0.12	54.0432	27.88641	250	18.5	3.09	0.4469
Jakhalaba	25.58	93	DW	25.6	0.1857	159	6.22	243.6	0.67	160.78	0	79.36344	79.36344	38.995	19.4864	3.0707	0.04	8.0064	10.91845	65	26.6	14.42	BDL
Chatia Bas	26.56	92.95	DW	24.4	0.89	136	7.404	141.6	0.85	93.46	0	427.3416	427.3416	155.98	47.1919	11.4255	0.13	94.0752	50.92524	445	45.94	38.42	2.4449
Soporigao	26.06	92.94	DW	23.6	0.612	168	7.186	848.2	0.45	559.81	0	402.9221	402.9221	56.72	9.0579	4.3582	0.41	54.0432	19.39126	215	74.91	13.62	0.8192
Doboka	26.13	92.89	DW	25.2	0.108	214	6.213	138.7	0.1	91.54	0	85.46832	85.46832	14.18	0.284	1.6191	0.08	6.0048	14.56019	75	3.89	0.9	BDL
Haldiati	26.17	92.94	DW	24.6	0.234	205	6.3	319.1	0.15	210.61	0	73.25856	73.25856	60.265	7.8174	0.6855	0.07	16.0128	9.700971	80	28.1	3.58	BDL
Beldonga	26.14	92.81	DW	23.5	0.1773	70	6.625	249.1	0.19	164.41	0	122.0976	122.0976	28.36	3.3966	0.1201	0.06	32.0256	4.838835	100	13.72	1.03	0.0611
Kampur	26.16	92.66	DW	25.9	0.424	-66	7.865	577.1	0.08	380.89	0	341.8733	341.8733	31.905	0.3279	1.5074	0.15	32.0256	18.18835	155	58.72	12.96	0.2079
RajaAli	26.07	92.63	DW	25	0.268	188	6.115	397.6	0.38	262.42	0	54.94392	54.94392	63.81	16.3285	10.2892	0.08	26.0208	6.05534	90	21.37	7.86	0.1209
Samaguri	26.39	92.8	DW	25.2	0.5	165	7.129	733.2	0.21	483.91	0	225.8806	225.8806	85.08	28.0942	10.7851	0.15	50.04	27.88835	240	28.17	11.89	0.3167
Missa	26.49	92.95	DW	26.6	0.1979	132	7.014	321.8	0.01	212.39	0	164.8318	164.8318	14.18	5.5041	1.7446	0.14	22.0176	9.698058	95	22.53	3.82	0.161
Buryapaha	26.58	93.09	DW	24.3	0.316	136	7.749	452.8	0.03	298.85	0	262.5098	262.5098	10.635	13.3016	3.3202	0.17	60.048	2.398058	160	30.11	7.74	1.1665
Bagori	26.58	93.27	DW	28.6	0.00974	121	6.491	124.4	0.04	82.10	0	61.0488	61.0488	10.635	7.5033	1.1667	0.02	18.0144	1.204854	50	8.31	1.51	0.2955
Hatenibat	26.34	92.76	DW	24.1	0.317	170	7.769	460.2	0	303.73	0	195.3562	195.3562	17.725	22.6367	4.2007	0.2	30.024	24.25728	175	20.88	9.05	1.7365
Kathiatoli	26.19	92.7	DW	24.8	0.583	139	7.287	836	0.21	551.76	0	207.5659	207.5659	134.71	19.0963	5.0153	0.14	40.032	4.834951	120	99.79	8.62	1.0049
Kondoli	26.22	92.77	DW	22.7	0.1995	122	6.579	309.5	0	204.27	0	61.0488	61.0488	31.905	29.6892	2.5207	0.03	8.0064	7.27767	50	18.19	28.27	0.4089
Bamuni Ti	26.3	92.79	DW	23.8	0.26	160	7.117	380.7	0.04	251.26	0	128.2025	128.2025	31.905	30.8508	5.742	0.16	30.024	9.694175	115	16.13	33.62	0.8099
Balijuri	26.33	92.85	TW	22.2	0.0705	181	6.407	114.4	0.02	75.50	0	48.83904	48.83904	17.725	3.4747	1.2767	0.02	4.0032	6.066019	35	10.06	5.45	0.0843
Telia Bebe	26.44	92.64	DW	23.7	0.1834	56	6.664	256.9	0.1	169.55	0	122.0976	122.0976	17.725	11.154	0.5784	0.07	22.0176	12.12524	105	8.63	3.3	0.6698
Dakhinpat	26.26	92.64	TW	22.1	0.316	-10	7.062	453.5	0.05	299.31	0	238.0903	238.0903	17.725	9.4399	0.7147	0.17	34.0272	25.46893	190	6.87	2.83	6.069
Bordua	26.41	92.54	DW	23.7	0.504	160	6.954	731.1	0.72	482.53	0	293.0342	293.0342	70.9	0.3916	7.3204	0.09	46.0368	33.95825	255	38.94	5.41	0.5882
Dhing	26.46	92.48	DW	24.4	0.393	186	7.223	587.7	0.6	387.88	0	238.0903	238.0903	28.36	29.3186	8.1625	0.11	44.0352	20.60971	195	30.11	8.55	0.4068
Bichamari	26.4	92.46	DW	24.5	0.398	272	6.918	585.8	0.06	386.63	0	238.0903	238.0903	53.175	21.6107	17.6001	0.09	48.0384	26.67573	230	23.63	3.73	0.5573

Annexure V Quality of groundwater in Nagaon District during Post Monsoon

Location	Lat DMS	Long DMS	Type of sar	TempºC	Salinity (pp	ORP (mV)	pH	EC (µs/cm)	Turbidity (I	TDS	CO3-2	HCO3-1	TA (as CaC	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaC	Na	K	Fe	uorimeter)
Raha	26.24661	92.53898	TW	29.5	0.18	56	7.587	218.2	BDL	144.01	0	140.4122	140.41	14.18	7.8654	0.0832	0.24	40.032	10.90291	145	5.62	1.09	0.13	0.1828
Saitali	26.29613	92.59661	DW	28.5	0.17	65	7.459	255.4	BDL	168.56	0	164.8318	164.83	21.27	13.9978	22.2648	0.05	48.0384	7.258252	150	11.87	31.55	0.063	0.0339
Nagaon	26.32088	92.70286	DW	28.4	0.29	28	8.167	449.8	0.04	296.87	9	244.1952	253.20	67.355	18.9151	3.9092	0.17	58.0464	6.039806	170	60.22	26.47	0.096	0.5698
Lankajan N	25.8788	93.04162	DW	27.9	0.36	51	7.231	563.4	BDL	371.84	0	140.4122	140.41	113.44	15.8746	6.3252	0.07	58.0464	13.32136	200	26.23	51.25	0.505	0.2786
Lumding	25.75881	93.17457	DW	28.9	0.4	115	8.171	605.8	BDL	399.83	0	134.3074	134.31	92.17	15.3806	38.1541	0.19	20.016	26.68932	160	53.72	30.45	0.046	0.561
Lanka	25.92143	92.95062	DW	28.2	0.4	167	7.419	638.7	BDL	421.54	0	415.1318	415.13	113.44	5.8013	1.0976	0.36	82.0656	35.15437	350	52.5	1.02	0.333	1.6615
Jurapukhur	25.96528	92.94361	DW	27.7	0.18	195	7.636	298.6	BDL	197.08	0	305.244	305.24	14.18	0.1617	0	0.52	48.0384	2.403883	130	51.09	5.24	0.299	BDL
Hojai	25.97969	92.93213	DW	28.6	0.29	188	7.818	447.9	0.01	295.61	0	274.7196	274.72	56.72	12.9101	27.9874	0.39	40.032	12.1165	150	65.79	30.02	0.385	BDL
Singimari	26.46413	92.76022	DW	29.5	0.15	34	7.289	237.2	BDL	156.55	0	164.8318	164.83	31.905	9.9107	1.6517	0.17	12.0096	23.05243	125	21.26	3.7	0.436	BDL
Lawkhowa	26.53539	92.80936	DW	28.6	0.4	112	7.669	637.7	BDL	420.88	0	421.2367	421.24	99.26	10.0181	2.7416	0.21	66.0528	27.88058	280	79.29	9.76	0.436	7.3221
Sulung PO	26.57028	92.87306	DW	29.3	0.22	113	7.462	338.9	BDL	223.67	0	238.0903	238.09	60.265	13.5739	5.9487	0.15	34.0272	18.18738	160	47.67	7.1	0.419	0.7753
Silaghat	26.60694	92.92917	DW	29.4	0.22	183	7.152	346.6	BDL	228.76	0	103.783	103.78	14.18	10.1532	1.4354	0.13	26.0208	2.414563	75	18.21	4.54	0.299	0.1517
Jakhalaban	25.58054	92.99683	DW	29.7	0.11	265	6.549	182.4	BDL	120.38	0	73.25856	73.26	38.995	6.8133	0.7968	0.04	4.0032	9.706796	50	11.49	32.46	0.113	BDL
Chatia Bast	26.5618	92.94734	DW	27.5	0.58	1855	7.377	916.6	BDL	604.96	0	482.2855	482.29	148.89	12.6689	21.6178	0.12	134.1072	31.48835	465	72.25	58.46	1.521	3.1428
Soporigaon	26.0604	92.93676	DW	27.8	0.27	113	7.441	420.3	BDL	277.40	0	244.1952	244.20	70.9	1.4679	18.8973	1.1	32.0256	13.33398	135	75.67	15.59	2.158	0.5729
Doboka	26.13194	92.88806	DW	28.2	0.04	667	6.801	65.88	0	43.48	0	97.67808	97.68	14.18	1.4485	1.1616	0.03	16.0128	3.63301	55	13.62	6.84	0.907	BDL
Haldiati	26.1725	92.94333	DW	28.8	0.13	936	6.78	219.5	BDL	144.87	0	12.20976	12.21	70.9	5.6553	0.1099	0.07	20.016	9.699029	90	13.26	6.45	0.079	BDL
Beldonga	26.13861	92.80861	DW	28.6	0.09	273	6.856	144.5	BDL	95.37	0	122.0976	122.10	28.36	2.6908	3.4101	0.03	26.0208	8.482524	100	17.89	1.02	0.164	BDL
Kampur			DW	29	0.42	164	7.42	631.9	0.02	417.05	0	390.7123	390.71	81.535	15.2006	24.597	0.34	76.0608	16.9534	260	89.24	27.57	4.654	2.0409
RajaAli	26.07338	92.62679	DW	28.7	0.14	280	6.58	241.2	0.02	159.19	0	79.36344	79.36	56.72	12.0374	22.7451	0.17	24.0192	6.056311	85	29.73	8.75	0.299	0.0807
Samaguri	26.39362	92.79898	DW	29.3	0.31	2190	7.36	495.5	BDL	327.03	0	274.7196	274.72	92.17	12.8761	9.7382	0.21	76.0608	18.16699	265	40.24	18.9	0.096	0.3533
Missa	26.49199	92.9483	DW	29	0.1	205	7.325	172.4	BDL	113.78	0	170.9366	170.94	10.635	4.9074	0.9152	0.14	26.0208	10.90971	110	17.39	1.02	0.819	0.028
Buryapahai	26.57552	93.08558	DW	29	0.19	-158	7.786	286.4	0.15	189.02	15	262.5098	277.51	21.27	1.4034	8.3136	0.29	42.0336	20.61068	190	51.98	1.98	2.063	0.4497
Bagori	26.57872	93.26921	DW	28.3	0.05	106	6.633	82.92	0.16	54.73	0	79.36344	79.36	14.18	2.947	1.0566	0.04	16.0128	2.419417	50	13.51	1.8	1.799	0.0606
Hatenibath	26.33611	92.76139	DW	27.7	0.64	16	7.733	991.7	0.06	654.52	0	616.5929	616.59	205.61	7.3531	5.9734	0.36	186.1488	29.03592	585	107.62	11.69	4.547	4.5902
Kathiatoli	26.18806	92.70278	DW	27.7	0.29	175	7.74	447.7	0.05	295.48	0	286.9294	286.93	67.355	10.0893	3.4616	0.19	66.0528	15.74466	230	53.27	22.89	0.505	BDL
Kondoli	26.22056	92.77083	DW	27.5	0.14	283	6.956	208.8	0.03	137.81	0	61.0488	61.05	42.54	6.9296	2.2743	0.04	18.0144	4.845631	65	17.51	21.9	0.164	0.0249
Bamuni Tin	26.29528	92.7925	DW	27.9	0.12	243	7.631	198.4	0.15	130.94	0	140.4122	140.41	21.27	6.6388	2.6355	0.18	30.024	1.199029	80	13.46	31.82	0.35	0.3144
Balijuri	26.32619	92.84978	TW	27.6	0.09	-39	7.33	129.6	2.2	85.54	0	122.0976	122.10	17.725	2.3993	0.4665	0.16	22.0176	9.698058	95	11.73	2.74	6.67	0.0027
Telia Bebej	26.44111	92.64	DW	28.3	0.1	35	7.885	159.3	0.1	105.14	0	134.3074	134.31	21.27	8.6969	0.9436	0.18	28.0224	9.695146	110	10.41	3.3	3.583	0.177
Dakhinpath	26.26056	92.64083	TW	27.9	0.17	178	8.31	262.5	0.02	173.25	9	225.8806	234.88	21.27	6.7295	0.6462	0.38	42.0336	10.90194	150	31.93	1.06	0.113	0.3186
Bordua	26.40556	92.54167	DW	29.3	0.3	164	8.252	410.6	0.01	271.00	18	280.8245	298.82	74.445	11.3374	11.9602	0.2	60.048	19.38835	230	40.73	45.6	0.113	0.9518
Dhing	26.46149	92.47859	DW	29.7	0.24		8.163	361.4	0.02	238.52	15	256.405	271.40	28.36	11.0109	10.9728	0.23	62.0496	16.96019	225	35.15	10.59	0.18	0.4779
Bichamari	26.40139	92.46	DW	28.9	0.18		7.997	279.4	0.01	184.40	6	177.0415	183.04	28.36	6.7213	8.0673	0.27	46.0368	20.60874	200	11.12	3.27	0.096	BDL

Field Photographs

Monitoring of Water Level

On spot water quality analysis

	
Soil infiltration studies	**Groundwater exploration**

	
Granite outcrop near Lanka	**Outcrop at Lumding road**