केन्द्रीय 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

MORIGAON DISTRICT
ASSAM

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

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केंद्रीय भूमि जल बोर्ड
Department of Water Resources, River Development & Ganga Rejuvenation
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GOVERNMENT OF INDIA
भारत सरकार

AQUIFER MAPPING AND MANAGEMENT PLAN OF MORIGAON DISTRICT, ASSAM

पर प्रतिवेदन मोरीगांव जिला, असम की जलभृत मानचित्रण और प्रबंधन योजना

(AAP 2021-22)

NORTH EASTERN REGION
उत्तर पूर्वी क्षेत्र
GUWAHATI
गुवाहाटी
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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 MORIGAON DISTRICT, ASSAM"
(AAP 2021-22)

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ABBREVIATION

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

EXECUTIVE SUMMARY

Aquifer Mapping Studies and Management Plan has been carried out in Morigaon 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 1491 sq.km out of total geographical area of 1551 sq.km of the district. The district is underlain by unconsolidated older alluvium, newer alluvium and consolidated Granitic Gneiss and Quatzite.

The ge ological formation ranges from Archaean to unconsolidated alluvium of Quaternary age. The alluvium occurring in the district is divided into older and newer alluvium.

Occurrence of ground water in the study area is within the saturated intergranular pore spaces of unconsolidated Brahmaputra alluvium. The granitic gneissic rocks forms the basement. 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 older alluvium surrounding Inselberg and occurs also along the foothill regions in the southern part which borders the Mikir Hills of Karbi Anglong district. It comprises of clay, silt and sand. The clay component of these formation is comparatively more than sand which is fine grained in nature. The second set up is younger alluvium which covers major part of the district and consists of sand, find to coarse grained in texture, with intermixed gravels and pebbles along with clay and silt. Central Ground Water Board had explored the area down to the depth of 300.7 m and reveals the existence of several good aquifer zones with yielding capacity of maximum 200 m^3/hr. More or less, the sub-surface strata represent mono-aquifer system at Bhuragaon area on north and the intercalation of clay beds are observed towards south on the older alluvial.

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. Soil infiltration studies were also carried out to know the infiltration rate in the area.

In order to study the chemical quality of ground water in the district, water samples from first aquifer (dug) 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 from dug wells 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 30224.62 ham and the stage of ground water extraction is 29.87% 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.

Chapter 1.0
INTRODUCTION

Central Ground Water Board, North Eastern Region has carried out Aquifer mapping and management plan in Morigaon district, Assam during AAP 2021-22 covering an area of 1491 sq.km (total district area is 1551 sq.km). Under National Aquifer Mapping and Management (NAQUIM) program, combination of geologic, geophysical, hydrologic and hydro-chemical information is applied to characterize the quantity, quality and sustainability of aquifers. Systematic aquifer mapping will improve our understanding of the geologic framework of aquifers, their hydrogeologic characteristics, quality and also quantifying the available ground water resources potential and proposing plans appropriate to the scale of demand and the institutional arrangements for management. Aquifer mapping at the appropriate scale can help prepare, implement and monitor the efficacy of various management interventions aimed at long-term sustainability of our precious ground water resources, which, in turn, will help achieve drinking water security, improved irrigation facilities and sustainability in water resources development.

1.1. Objectives

The objectives of this study are to understand the aquifer systems, 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 through multidisciplinary scientific approach on 1:50000 scale and finally formulate a sustainable and effective management plan for ground water use.

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

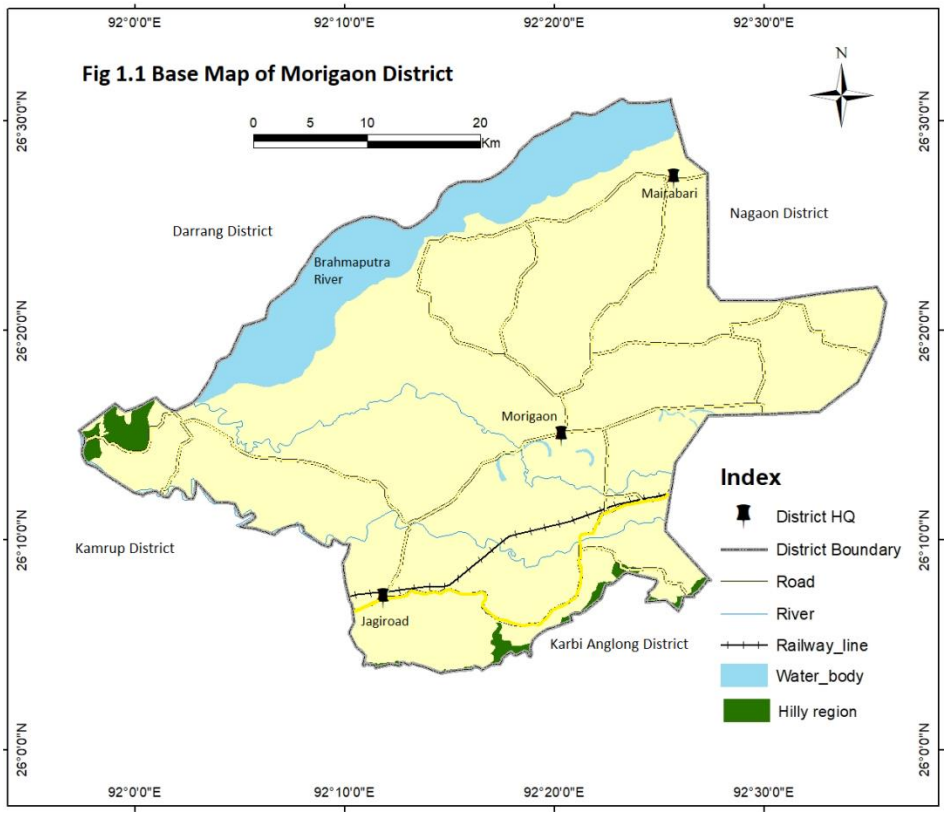
Morigaon district lies between E 91˚58’30” to E 92˚34’00” Longitude and N 26˚03’00” to N 26˚30’00” Latitude. The district is having an area of 1551 sq.km. Out of this, 1491 sq.km of mappable area was covered under NAQUIM program during AAP 2021-22. The district lies in the central part of Assam on the southern bank of the Brahmaputra River. It is bounded by Karbi Anglong and Ri-Bhoi districts in the South, Nagaon district on the east, Kamrup district on the West and Darrang district in the North.

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 flowing from south to north. Rivers Kalong and Kopili are two major rivers.

The district comprises 5 numbers of C.D. blocks. They are – Moirabari, Bhurbandha, Kapili, Lahorighat, Mayang and Dolong-ghat (part) / batadraba (part) block with 94 Gaon Panchayats .

The total population as per 2011 Census is 95742 and the density of population is 618/sq. km.

This area falls partly or fully in the quadrants of Survey of India Topo-sheets bearing nos.78 N/15, 78N/16, 83 B/3, 83 B/4, 83 B/6, 83 B/7, 83 B/8 . The base map of the study area is shown in fig.1.1.



1.5. Data availability, data adequacy and data gap analysis:

The required data for aquifer mapping and management plan 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 Fig1.2 and Table 1.1.

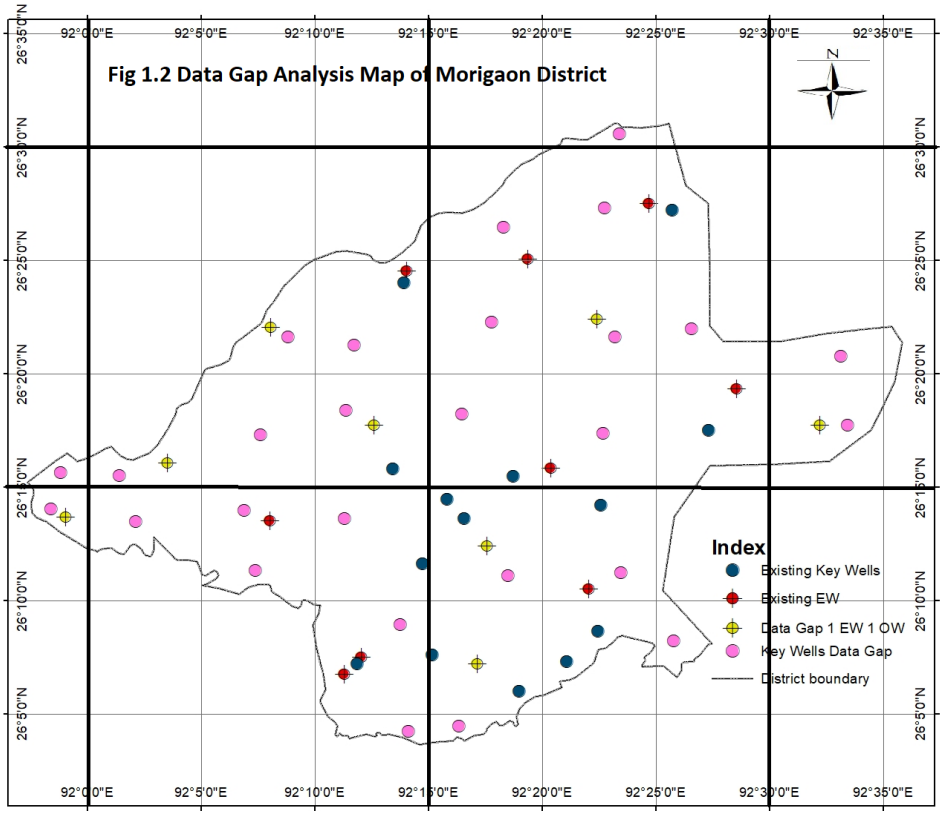


Table1.1 Data Availability and Data Gap Analysis in Aquifer Mapping Studies

Sl. No.	Items	Data Availability	Data Gap	Data Generation	Total
1	Ground Water Exploration Data	9 EW	8 nos. of EW &8 nos. of OW.	Nil	9 EW
2	Geophysics	Nil	Entire study area	Nil	Nil
3	Ground Water Monitoring Regime	15 NHNS	27nos.	27 nos.	42 Nos.
4	Ground Water Quality	15 nos.	Entire study area	34 nos.	49 Nos.

1.6. Demography

The total population of Morigaon district are as per 2011 Census is 957853 with 485328 males and 472525 females.

Morigaon District	Rural	Urban	Total
Total population	884125	73298	957423

The revenue circle wise population of the community and number of villages of Morigaon District as per the 2011 census is as below: -

Name of Revenue Circle	No. of villages	Population
Mayong	177	242718
Bhuragaon	121	123469
Laharighat	102	253582
Marigaon	167	200441
Mikirbheta	65	137213

1.7. Communication

The district is well connected by rail and road. It is accessible through air via Guwahati which is about 94 Kms away from Morigaon district. This physical proximity makes it accessible to visitors from various parts of India through Guwahati. The nearest railway station to Morigaon is Jagiroad Railway Station. It serves as the main railhead for the whole district. Morigaon is connected to its neighbouring cities and other cities of state via a well-maintained network of roads.

1.8. Climate

The climate in the area is characterized by tropical and humid type. Based on the monthly mean temperature efficiency ratio (Thermal efficiency ratio) Koppen and Geiger 1930). The thermal efficiency ratio for Morigaon district is 133.90. Since this value is more than 128, the climate is classified as tropical (Koppen & Geiger).

The district receives rainfall mainly from the southwest monsoon which commences in the month of June and lasts till October, while the maximum rainfall occurs during the month of July while October and November forms the hot monsoon period. The average annual rainfall is 1770 mm. More than 93 % of annual rainfall occurs between April to September. The winter rains account only 7% of annual precipitation. The rainfall in general decreases from south to north. The district has sub-tropical and humid type of climate. The humidity data reveal that the air is humid throughout the year. It has the value of 67 to 79 % during dry period. The cold season is found from December to February followed by the pre monsoon season of thunder storm from March to May. The months of March, April and May are the period of Pre-monsoon season. The temperature begins to rise from the month of March. The frequency of storms also increases during these months. During the monsoon period, due to heavy rainfall, the weather is suitable for crop plantation especially paddy.

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 net sown area in the district is 74.5 % of total geographical area. The land utilization statistics of Morigaon district is shown in the following Table1.3.

Table 1.3: Land use statistic in Morigaon district 2020-21

Sl.No.	Particulars	Area in Hectares
1	Total reporting area under land utilisation	155100
2	Forest land	6611
3	Not available for cultivation	48304
4	Other cultivated land	NA
5	Fallow land	4976
6	Net area sown	115574
7	Area sown more than once	84958
8	Gross cropped area	214921
9	Cropping intensity	173.5 %

Source: District Agricultural Office, Morigaon, Govt. of Assam

1.10. Soil

The major soils in the district indicate-that the alluvial floodplains are mostly dominated by very deep soils many of which have poor drainage. Soils on the upland are also deep and possess the characters of typical Ultisols. However upland soils are on few occasions characterized by poor drainage mostly because of local depressions and the road cutting along the National Highway. The soils on the hills are also deep except the Buramayang soils which have lithic contact within 50 cm. In the hills the excessive rainfall had led to deep weathering, and subsequently deep soils, where excessive relief did not lead to severe soil loss probably because of luxuriant vegetation hindering soil erosion. Part of the hilly tracts in the western part and sane hummocks have somewhat shallow soils due to less. Low-lying areas in the south bank of Brahmaputra river are often subject to annual and/or perennial water logging which is further aggravated by annual flooding by the Brahmaputra and its tributaries. The soil control section remains saturated with moisture due to topographical variations as well as the proximity of river and a reducing regime virtually free of dissolved oxygen is developed with characteristic redoximorphic features viz. gleying and mottles. Since these soils are saturated with water in one or more layers within, 200 cm (in other words one or more layers remain unsaturated within that depth) this is termed as episaturation (Soil Survey Staff, 1992). Presence or absence of the well-developed structural horizon indicates these soils to be grouped under epiaquepts or epiaquents. Irregular patterns of organic carbon suggest fluventic characters of few soils. Few soils were identified in the back swamps with deep and wide cracks with high clay content which is in conformity of the characteristics of back swamp soils.

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 Morigaon District in 2021-22. Soil infiltration tests were conducted by using Double Ring

Infiltro-meter. A Double-ring Infiltro-meter 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 1.4: Soil infiltration test results in the study area

Sl. No	Location	Co-ordinates		Soil Type	Season	Infiltration Rate (cm/hr)
		Longitude	Latitude			
1	CHC Morigaon	92.4931	26.3261	Loamy	Pre Monsoon 2021-22	30.00
2	Manasa mandir, Mayang, Morigaon	92.9969	26.2371	Loamy	Pre Monsoon 2021	06.00
3	Amsoi Police outpost, Morigaon	92.4209	26.1357	Loamy	Pre Monsoon 2021	02.00

A perusal of the above table would indicate that the soils have wide range of Infiltration rate from 02 cm/hr to 30 cm/hr depending on whether the top soil is compact because of hard pans or carbonate deposits. From the study, it is observed that infiltration rate is affected by different soil conditions. It provides increased understanding of the local soil infiltration and its variability. It was found that the result obtained from the test 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 food crops, fibre crops, pulse, oil seeds, spices, horticultural crops and almost all types of vegetables are cultivated in 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. Present area under different crops and their productivity is shown in table 1.5.

Table 1.5: Area under different crops and their productivity and yield in Morigaon district (2020-21).

Sl No.	Types of Crops	TOTAL		
		Area (Hectare)	Production (Metric tonnes)	Yield (MT/Ha)
(2020-21)				
1	Sali paddy	50162	184746	3.68
2	Jute	7506	26271	3.5
3	Sugarcane	1200	1440	1.2
4	Kharif veg	6100	16354	2.68
2021-22				
1	Sali paddy	51102	163526	3.2
2	Jute	7556	26446	3.5
3	Sugarcane	1180	1400	1.18
4	Kharif veg	6225	16745	2.69
	Rabi			
5	Mustard	16945	17792	1.04
6	Groundnut	1760	4576	2.6
7	Maize	4862	29658	6.09
8	Potato	4810	36075	7.5
9	Pea	1011	1516	1.49
10	Rabi veg	16888	491440	29.09
11	Summer paddy	51241	286949	5.59

Source: District Agriculture Department, Morigaon district, Govt. of Assam

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. As per Irrigation Department, Government of Assam, an area of 6645 Ha of command area is under surface irrigation schemes and 2130 Ha command area is under ground water irrigation schemes. Irrigation statistics in Morigaon district are given in Annexure VI.

1.13. Industries

The district of Morigaon 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. One such sector is the dry fish market, for which Morigaon acts as the supplier of the entire North Eastern Region. Agro-processing units like rice mills, flourmills and mustard oil extraction mills are also available in Morigaon

1.14. Forest

The District is very rich in natural resources. There are three Reserved Forest constituted under Assam Forest Regulation Act, 1891. These are Sunaikuchi, Khulahat, and Bura

Mayong. There is also one wildlife Sanctuary, named Pabitara, which is famous for the Indian one horned Rhinoceros.

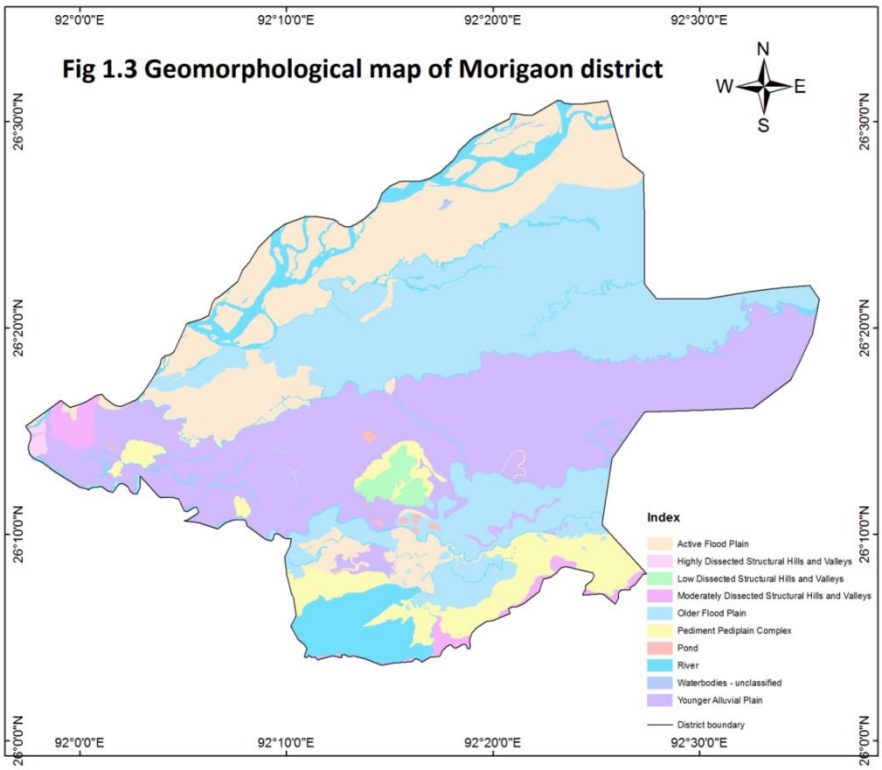
1.15. Geomorphology

Geomorphologically the district can be differentiated into three following geomorphic units,

i) Isolated hillocks / Inselbergs of various shapes and sizes, consisting of granite, gneiss and quartzite. These are found jutting out from the alluvial plains at Hatimara Parbat, teliasur, Baha, Bara, mayang and Mayang Parbat from south central to western part of the district. These Inselbergs rise to heights of 180 to 435 meters above the plains and are highly fractured and jointed.

ii) A belt of shallow weathered piedmonds in the foothill zones of Inselbergs at Sonaikuchi and Khellhat covered by reserved forests in the southern part of the district.

iii) Alluvial plains north of the piedmont zone extend upto Brahmaputra River. It is a thick pile of sediments which form the flood plains of the Brahmaputra river system. Within the flood plains, the older alluvial plains are found around Kapili river. The alluvial sediments rest on tectonically disturbed and fractured basement. The rejuvenated rivers exhibit features like levees, oxbow lake, abandoned channels, cut-off meanders and back-swamps at Udar-Chilathal-Khanagharia-Grajan Bil, Bhelapura, Makhanada, Saran and Maralalang Bil.



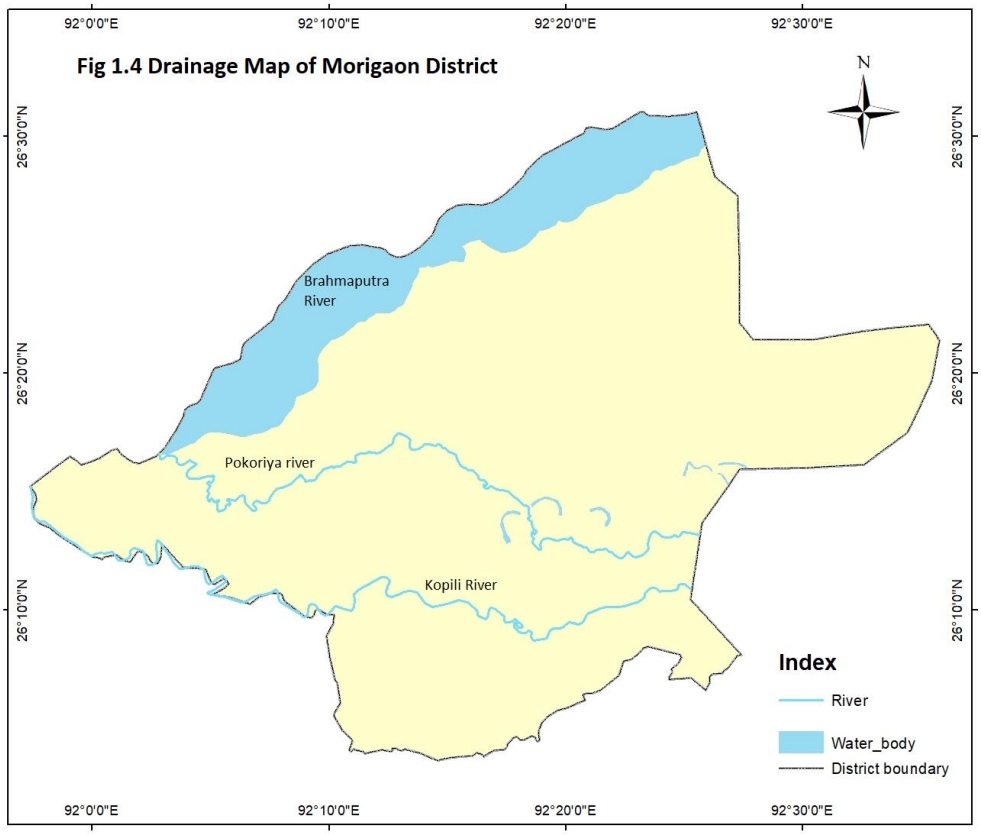
The younger flood plains are formed in the area lying north of Sonai river upto Brahmaputra river. The master slope of the area is from south towards north. The highest peak is 644.36 (triangular point) in Khola Parbat in the southern part and the lowest point is 52.50 m amsl north

of Berhampur, in the northwestern portion of the district. The geomorpological map of the district is given in fig 1.3

1.16. Drainage

The mighty Brahmaputra flows along with the northern boundary of the district. The district is drained by Kapili, Kalang, Kiling and Sonai rivers. The Kapili and Sonai rivers are tributaries to Brahmaputra River. There are a number of *Beels* which are remnants of old channels of these rivers. They are *Arum, Kiling, Sikhora and Bar Jalah Beels* in the vicinity of Kiling river ; Sholmari, Dandua, Marakalang, Sara, Sarumanaha, Dekhal, Baral, Habari, Nakara-Maudubi, Goranga, Taranga, Donga, Jan, Khar, Udmari Bils along the Kapili river and Garajan-Khanagharia-Srikanda, Chilpi-Bhangamur-Goroimari-Goranga Bils adjacent to Sonai river. These are the indications of tectonic disturbances the area has undergone.

The Kiling river joins Kapili, west of Dharamtul and which in turn joins Kalang NNE of Jagiroad. The Kapili drains the southern part of the district and the Kiling, Mikir Hills. The northern part of the district is drained by Sonai river. The drainage map is shown in Fig 1.4.



Chapter 2.0
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 database. 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 older and newer alluvium and fractured Granitic Gneiss. The different hydrogeological data are generated through intensive field data collection and testing.

2.1.1. Water level monitoring

In the study area, 42 dug wells were established as key wells to study the water level and water quality. There are 15 Ground Water Monitoring Stations in the district and another 27 Key wells have been established to fill the data gap. 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 Morigaon district in AAP 2021-2022.

During pre monsoon the highest water level is 13.44 mbgl at Jagiroad monitoring station and the lowest water level is 0.25 mbgl at Borbori monitoring station. During post monsoon the highest water level is 6.9 mbgl at Kathargaon monitoring station and the lowest water level is 0.09 mbgl at Rajabari monitoring station. The key observation wells details are presented in Annexure 2 and the pre-monsoon and post- monsoon water level contour map is shown in Fig 3.2 and 3.3.

Table 2.1 Details of the Key wells established in Morigaon district in AAP 2021-2022

Location	Latitude	Longitude	RL (m)	Dia (m)	Depth	MP	Depth-to-Water	
							pre monsoon	post monsoon
Jagiroad	26.12	92.197	61.39	0.75	8.00	0.62	13.44	2.03
Deosal	26.126	92.252	40	0.85	10.40	0.94	3.62	3.99
New Nellie	26.099	92.316	59.9	0.98	12.30	0.8	6.8	3.48
Silsang Namghar	26.122	92.351	52.07	0.90	7.50	0.94	3.4	0.59
Daponibari N	26.144	92.374	61.76	0.95	8.00	0.76	3.83	1.27
Mairabari/ Moirabari	26.454	92.428	94.58	1.50	10.20	0.9	5.5	2.9
Bichamari	26.401	92.46	63.66	0.95	11.00	0.87	2.27	2.01
Solmari	26.236	92.376	66.03	0.45	12.30	0.72	1.02	1.42
Charibahi	26.292	92.455	69.29	0.40	8.90	0.55	3.15	2.15
Basanaghat	26.258	92.312	52	0.90	13.05	0.85	3.45	1.09
Baghara	26.227	92.276	39	1.10	11.20	0.92	3.36	0.23
Pamibaghara	26.241	92.264	64.33	0.90	6.50	0.92	4.08	1.28

Location	Latitude	Longitude	RL (m)	Dia (m)	Depth	MP	Depth-to-Water	
							pre monsoon	post monsoon
Kumoi	26.194	92.245	45	0.60	12.00	0.85	1.28	1.03
Garmari Gaon	26.263	92.224	38	0.92	9.00	1	4.7	1.65
Barukati	26.4	92.232	41	0.4	9.32	0.7	4.07	2.33
Karmarpur	26.217	92.030	85	1.2	15.15	0.9	6.9	6.23
Mayang Police Station	26.262	92.036	52	0.94	5.6	0.85	1.93	1.83
Kathargaon	26.247	91.976	60	0.86	13.23	0.81	11.25	6.9
Buraburi bazaar	26.230	92.114	52	0.89	1.8	0.95	5.65	3.75
Manaha Kacharigaon	26.217	92.167	59	1.34	9	0.48	2.62	2.79
Jajuli Barmanipur (Hajukuti)	26.325	92.545	56	1	4.26	2.6	0.97	0.89
Naruloboi TW	26.342	92.498	63	0.203	15		3.3	1.22
Himuliguri	26.326	92.459	49	0.73	3.76	0.49	1.91	0.99
Sohuriapam	26.388	92.415	61	0.79	4.13	0.55	1.69	0.78
Datiaburi	26.425	92.361	56	0.74	7	0.61	4.68	4.16
Tinisukia Mohomari	26.413	92.297	62	1.04	12.12	1.02	0.6	0.7
Bogolibar	26.411	92.315	74	1.08	8	0.91	7.09	1.74
Dighalbari Pagai	26.315	92.298	56	1.03	16	1.06	3.44	2.64
Rajabari	26.349	92.231	48	0.8	14	2.8	1.5	0.09
Borongabari	26.285	92.343	29	0.76	4.4	0.41	1.39	2.75
Goroimari	26.335	92.363	57	1.1	6.13	1.04	4.39	2.17
Hukdol Borbori	26.323	92.391	69	0.79	4.49	1.94	1.46	0.5
Sabhokdhara	26.320	92.496	65	0.9	5.32	1.01	1.25	1.4
Niskapahara	26.291	92.498	45	1	10	1.09	2.11	0.93
Tokanabari	26.281	92.423	59	0.7	4.14	0.54	2.46	1.48
Betoni Rajasuk	26.206	92.332	54	0.92	7.14	0.78	1.86	2.73
Borbori	26.162	92.408	47	1.05	35	0.86	0.25	0.38
Telahi Bhatgaon	26.202	92.368	59	0.9	10.66	0.52	4.38	6.21
Amsoi	26.133	92.422		0.93	3.75	0.69	2.51	2.22
Sat Kendra Dharamtul	26.158	92.353	47	1.02	8.2	0.54	1.76	1.46
Polaguri	26.108	92.282	51	0.87	8.17	0.83	5.69	4.56
Datiaburi	26.425	92.361	56	0.84	7	0.61	4.68	2.28

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 were collected from 34 key wells during pre monsoon and and 32 key wells during post monsoon. The samples collected were analyzed for basic, iron, heavy metals and arsenic. Ground water samples were

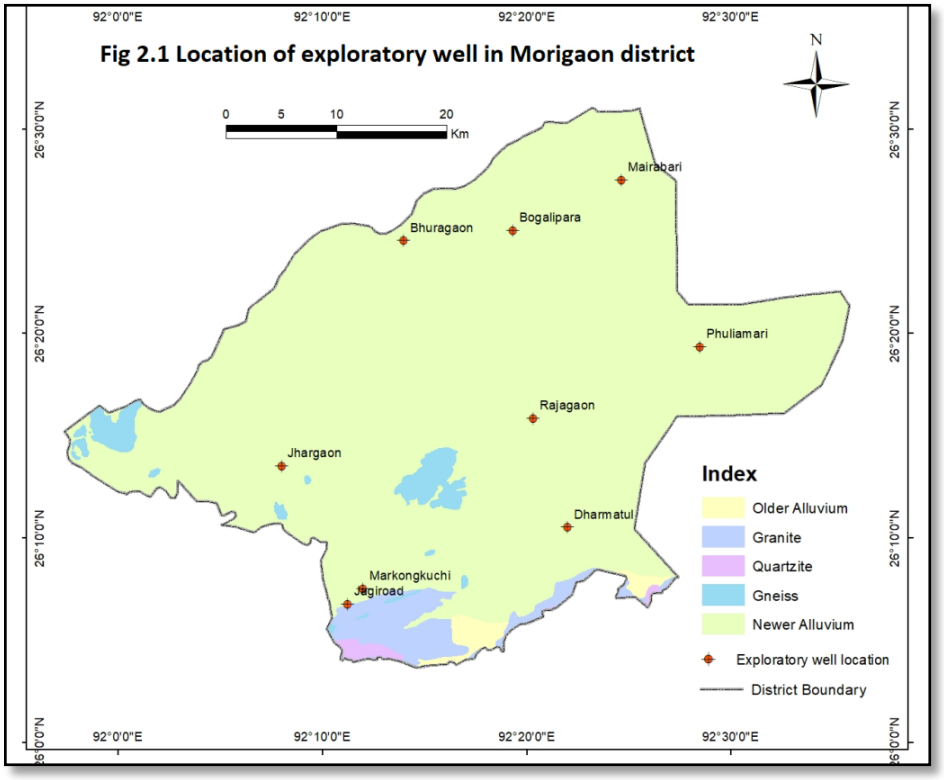
analysed in the regional chemical laboratory, Central Ground Water Board, North Eastern Region, Guwahati for 16 parameters. The analytical data are given in Annexure IV and V.

2.3. Ground water exploration studies

During previous Annual Action Plan, Central Ground Water Board has carried out Ground water exploration 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, 8 exploratory wells were constructed and 1 EW was constructed in 2015 during NAQUIM. Details of the exploratory wells are presented below in the table 2.2. Location of wells is shown in fig 2.1.

Table 2.2 Exploratory wells constructed in Morigaon district

Sl. No.	Village/ Location	Taluka/ Block	Longitude	Latitude	Type of well	Drilled Depth (m bgl)
1	Dharamtul	Mayang	92.367	26.175	EW	239.75
2	Jagiroad	Mayang	92.187	26.112	EW	95
3	Mairabari	Laharighat	92.411	26.458	EW	300.7
4	Phaliamari	Bhurbanda	92.475	26.322	EW	300.7
5	Rajagaon	Bhurbanda	92.339	26.264	EW	254
6	Markongkuchi	Mayang	92.2	26.125	EW	67.58
7	Jhargaon	Mayang	92.133	26.225	EW	108
8	Bogalipara	Laharighat	92.322	26.417	EW	200.2
9	Bhuragaon	Laharighat	92.233	26.409	EW	300
10	Santipur	Mayang	92.358	26.15	Piezometer	45.75



Chapter 3.0

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1. General hydrogeology and occurrence of ground water

Two distinct hydrogeological set ups prevail in the district. The first set up is the older alluvium surrounding Inselberg and occurs along the foothill regions in the southern part bordering Karbi Anglong district. It comprises of clay, silt and sand. The clay component of this formation is comparatively more than sand, which is fine grained in nature. The second set up is younger alluvium which covers major part of the district and consists of sand, find to coarse grained in texture, with intermixed gravels and pebbles along with clay and silt. The slope of the basin gradually deepens from south to north which is proved by the fact that basement encountered at 95 m at Jagiroad, 239.75 at Dharamtul and 254 m at Rajagaon, through exploratory wells drilled in the district.

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

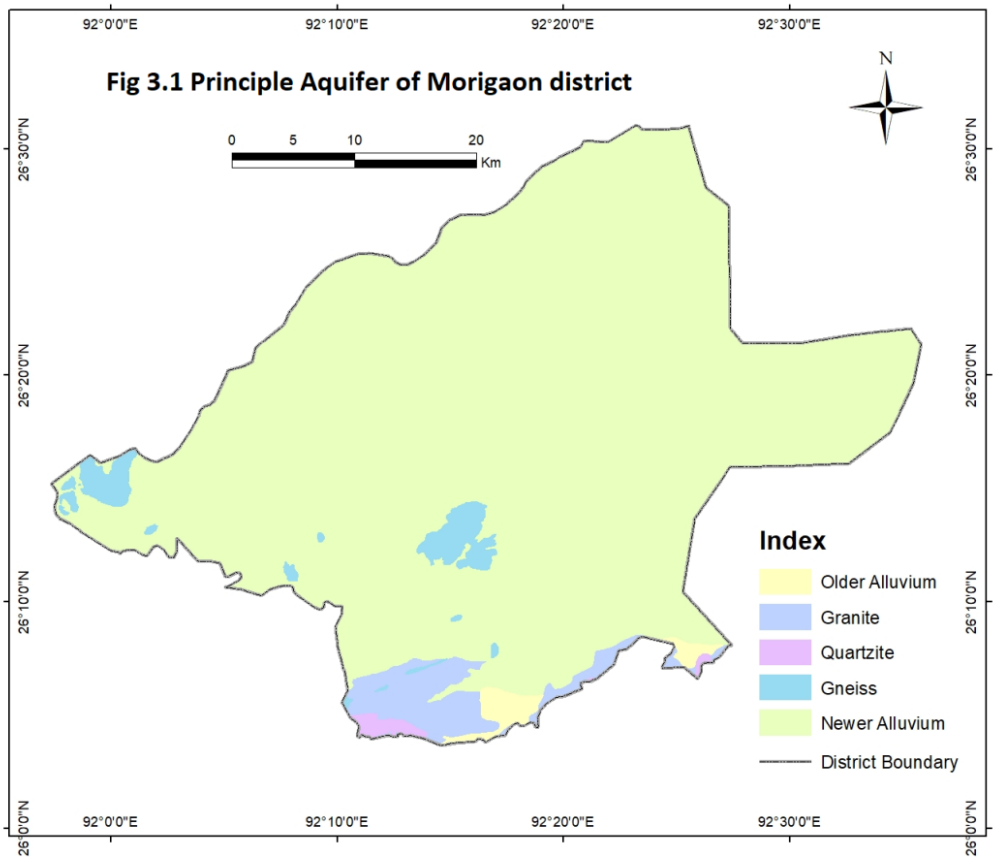


Fig 3.1 Principle Aquifer of Morigaon district

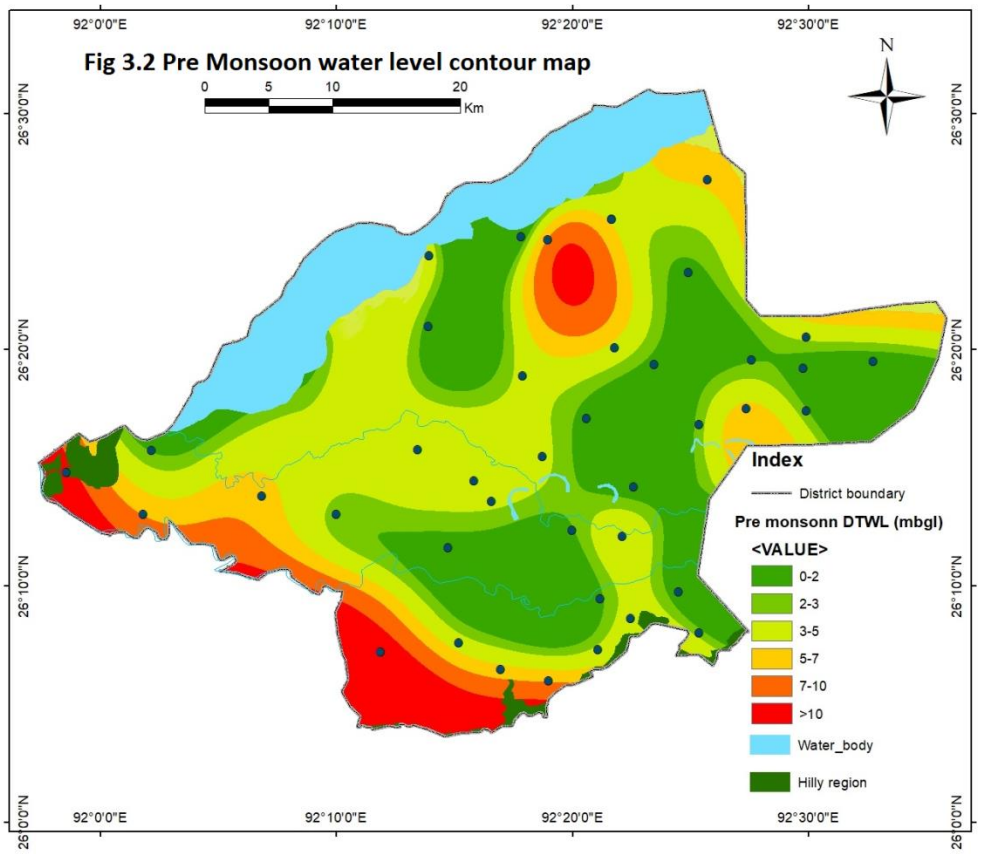
3.1.1. Occurrence of ground water

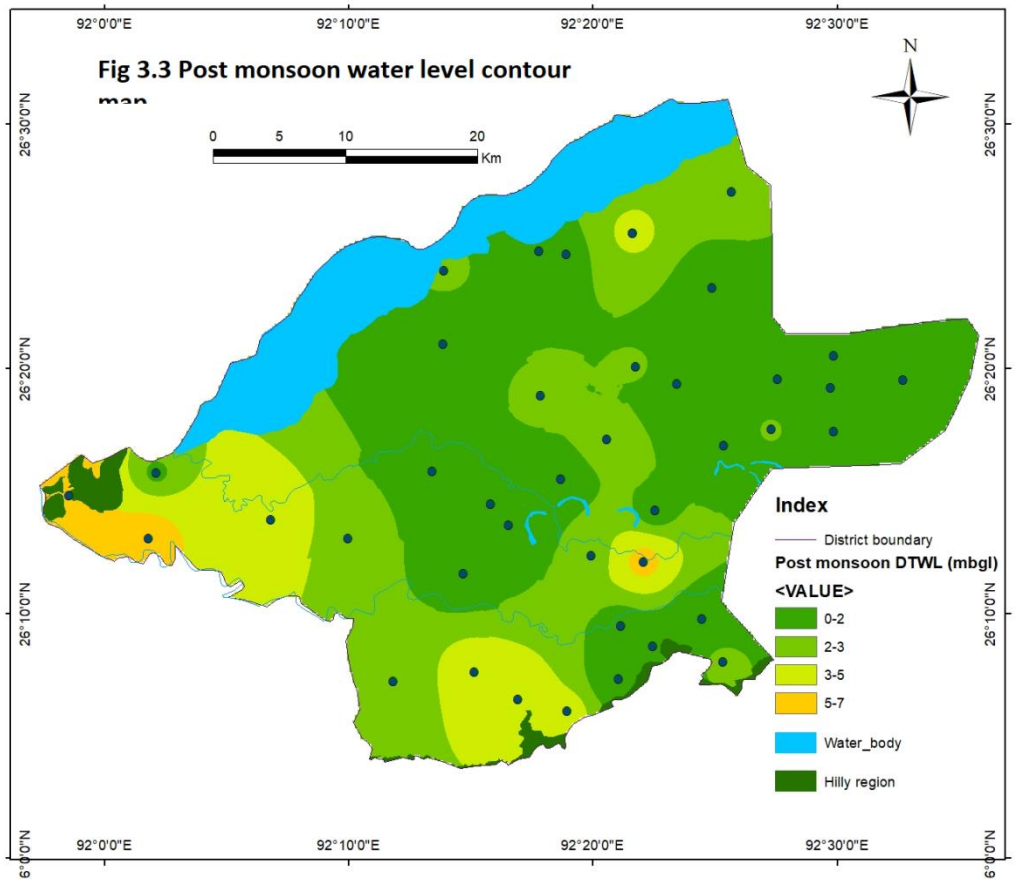
Groundwater occurs within the saturated intergranular pore spaces in unconsolidated alluvium and in the secondary pores in fractured and jointed granitic and gneissic formations in the Inselberg and Shillong Group of rocks of Archaean Age in the southern part of the district. In the newer alluvium, groundwater occurs under phreatic condition in shallow horizon and under semi-confined conditions in deeper aquifer.

3.2. Depth to Water Level

Forty-two (42) dug well were periodically monitored to know the water level trend and its behavior in phreatic condition. During pre monsoon the deepest water level is 13.44 mbgl at Jagiroad monitoring station and the lowest water level is 0.25 mbgl at Borbori monitoring station. During post monsoon the highest water level is 6.9 mbgl at Kathargaon monitoring station and the lowest water level is 0.09 mbgl at Rajabari monitoring station and the average water level fluctuation is 2.70 m. Water level contour map is shown in fig 3.2 and fig. 3.3

To depth to water level in exploratory wells drilled in Morigaon district varies from 1.369 mbgl to 4.665 mbgl.





3.3. Ground Water Movement

The water table contour has been prepared based on the water level of ground water monitoring stations. Regionally the ground water flow direction is from the higher elevation on southern sides towards the Brahmaputra river in the northwest. (Fig 3.4).

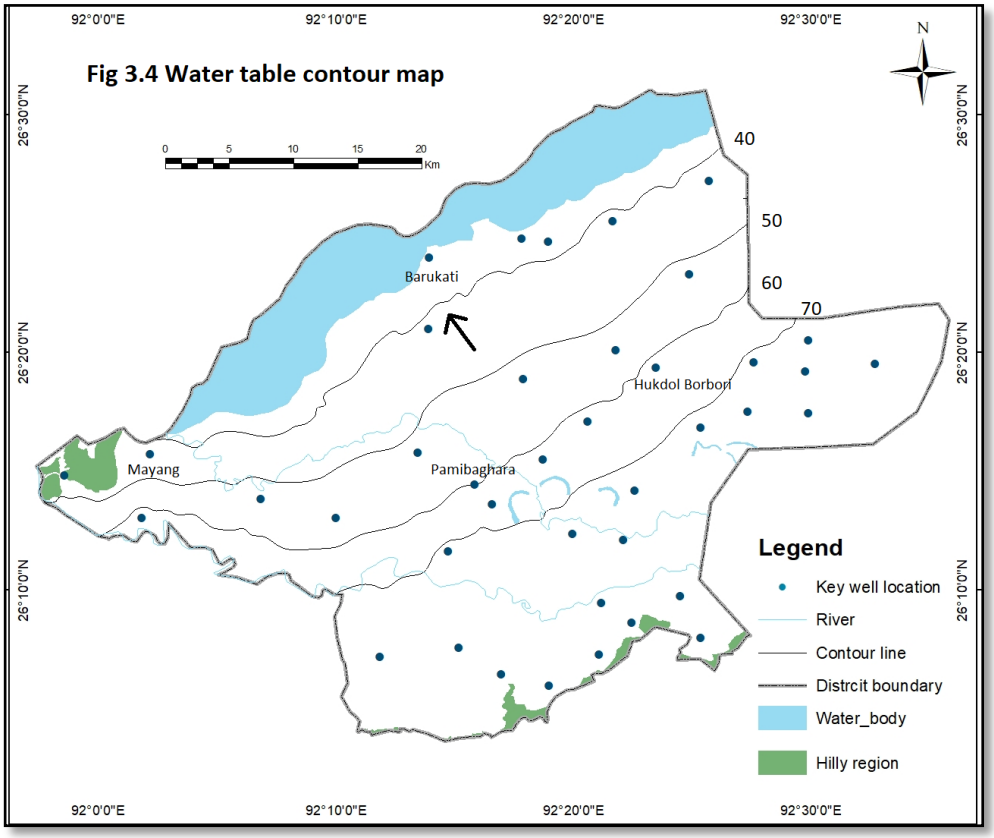
3.4. Aquifer System

The unconsolidated formation of the district is underlain by consolidated formation of granitic gneiss of Archaean age. The unconsolidated formation is composed of older and newer alluvium. Accordingly, two principal aquifers can be identified in the district, viz., (i) alluvial aquifer and (ii) granitic aquifer. The alluvial aquifer is mainly composed of younger alluvium (AL 01). The granitic gneissic aquifer is composed of biotite-hornblende gneiss, granulite schists and intrusive granite with pegmatite can be included under banded gneissic complex (BG 01).

Younger alluvium (AL 01)- The alluvial aquifer consists of sand , silt, gravel and clay. The sub-surface strata represent mono-aquifer system with intercalation of clay beds are observed towards south on the older alluvial formation.

Banded gneissic complex (BG 01)- CGWB's exploration has encountered this aquifer within 100m towards south of the district and below 250m towards south east of the district. However, in none of the EW of CGWB had penetrated this aquifer. Considering the GW potentiality of

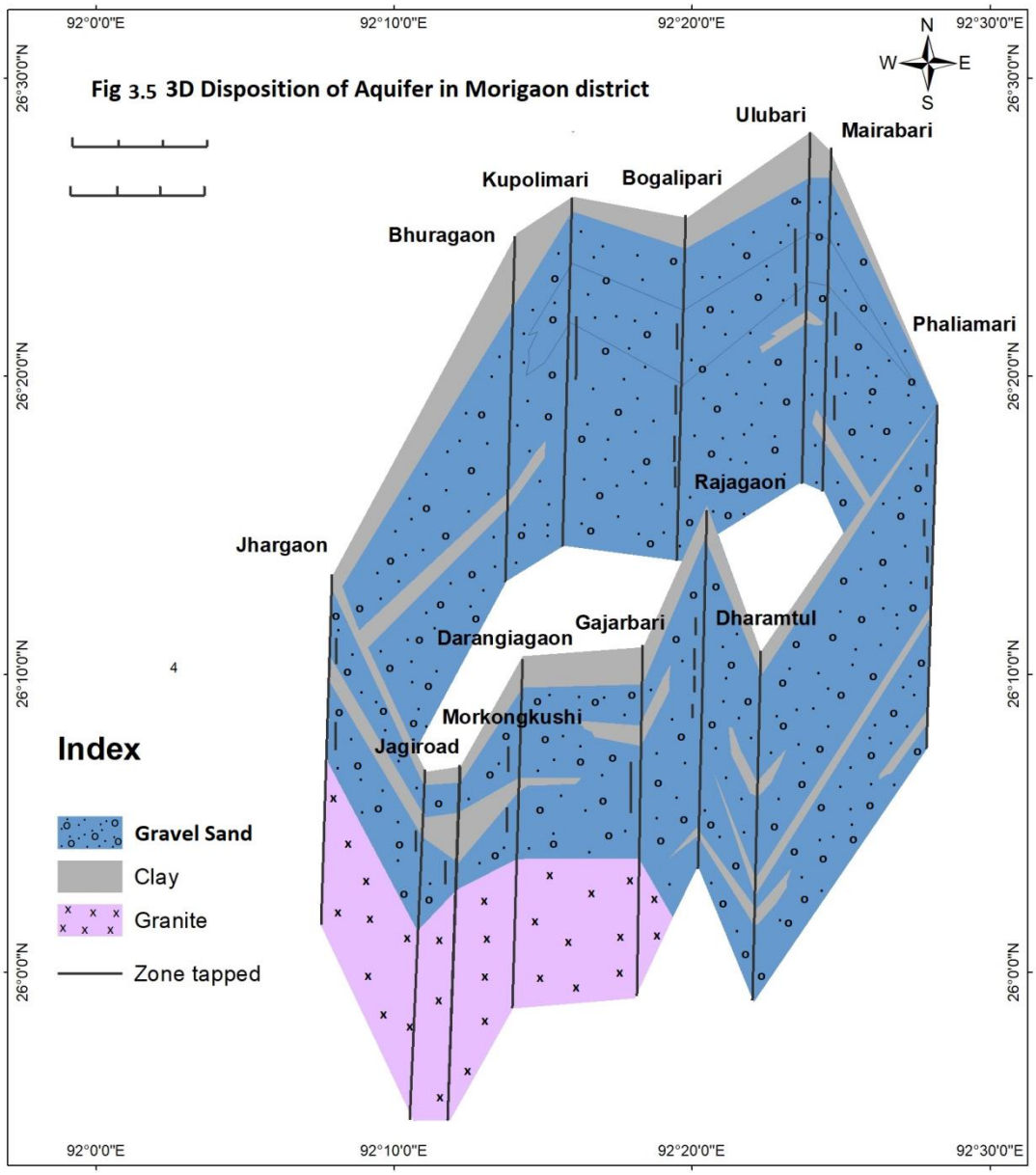
deep fractures in the adjacent Kamrup (metro) district, possibility of encountering potential fractures in this aquifer in Morigaon district cannot be ruled out.



3.5. Aquifer geometry

The alluvial aquifer of the district can be categorised as mono aquifer where ground water occurs under water table condition. Archaean group of rocks underlies alluvial aquifer in the southern part of the district.

Based on the litholog of the exploratory wells, a panel diagram have been prepared to show the 3D disposition of the aquifers as shown in figure 3.5. From the panel diagram it is observed that the alluvial aquifer thickness increases from southwest to northeast and whereas the T and Permeability is from SW to NE



Based on the litholog of the exploratory wells drilled by Central Ground Water Board and Irrigation Dept, Govt. Of Assam, two sections have been prepared to show the 2D disposition of the aquifers along the East-West direction (Figure 3.6), North-South direction (Figure 3.7). From the litholog and section prepared it has been observed that the aquifer thickness increases from south to north and west to east. Details of exploratory well drilled is given in Annexure I.

Fig 3.6 Cross section of boreholes in Morigaon District

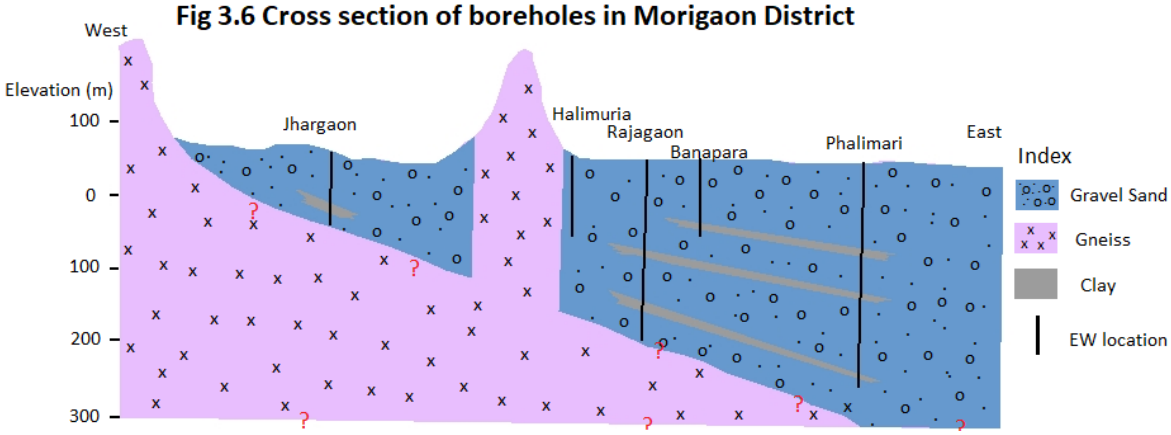
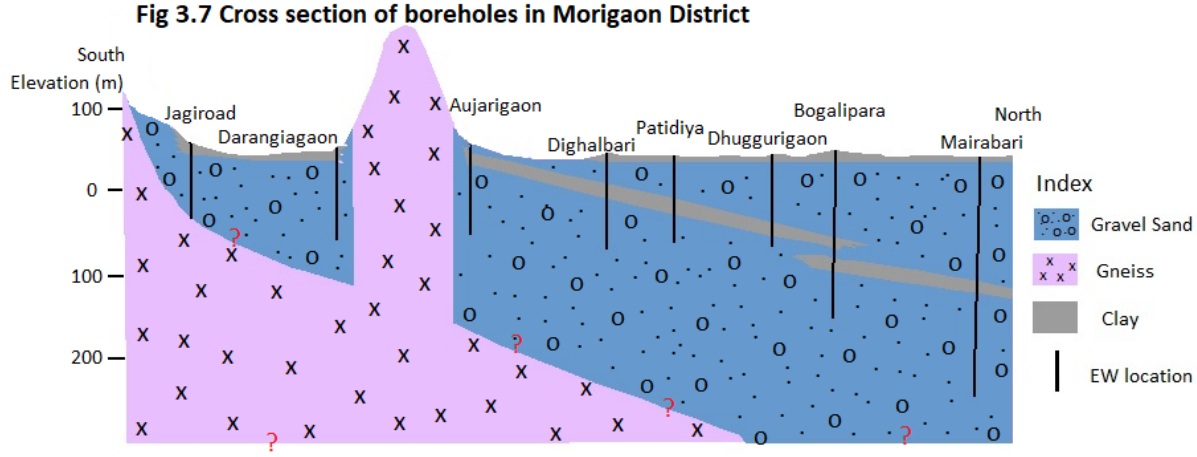
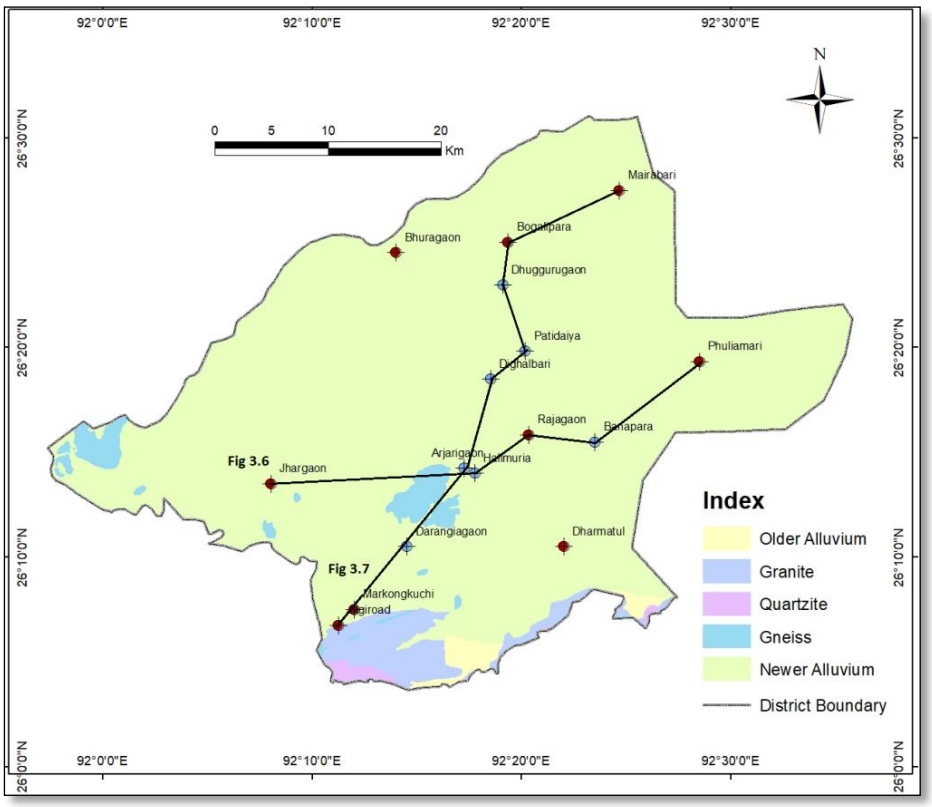


Fig 3.7 Cross section of boreholes in Morigaon District





3.6. Aquifer parameters

The yields of the aquifer are more than 200 cubic meter in major northern part, 100-200 cubic meter/hour in central part, 50-100 cubic meter / hour in southern part and less than 1 cubic meter/hour in the regions of Inselbergs and Hills of the district.

Transmissivity of the alluvial aquifer ranges from 500 – 6000 m2/day, the lowest in Jagiroad and the highest in Phaliamari – Mariabari areas. The storativity values of the aquifer ranges from 3.27 - 3.39 * 10^{-3} as observed in Phaliamari – Mairabari area which indicate the aquifer is in semi-confined condition. The transmissivity and permeability values are increasing from south-west to northeast. But piezometric surface increases from NE to SW, The details of aquifer parameters are given in Annexure I.

Computation of specific yield of the aquifers based on grain size parameter

The specific yield of the aquifers within the depth range of 100 meters was computed following the procedure using grain size parameters developed by Nautiyal (1991). The specific yield computed is 26% for the district. The productivity values of alluvial aquifers are in the range of 0..19 – 3.80 cubic meter/hour of the aquifer.

The sieve analysis data are plotted in the semi-log paper, the particle size in the logarithmic scale and the cumulative percent finer on the natural scale. From this curve percentage of particle sizes of gravel (4,75 – 20.00 mm), coarse sand (2.0 – 4.75 mm), medium sand (0.425 – 2,0 mm) , fine sand (0.075 – 0.425 mm), silt (0.002 – 0.075 mm) and clay (0.002 mm) are read. For each particle sizes a specific yield are adopted and they are gravel (0.26), coarse sand (0.28), medium sand (0.27), fine sand (0.23), silt (0.09) and clay (0.02).

This method was applied to the aquifers encountered in the exploratory drilling done by Central Ground Water Board at Mairabari, Philiamari, Rajagaon and Santipur where sieve analysis was done and specific yields were computed and given in table 3.1

Table 3.1 Specific yield estimation of Aquifer Samples in Morigaon district

S. N	Location	Depth range (m)	Grain size distribution in percentage					Specific yield (%)
			Gravel	Coarse sand	Medium sand	Fine sand	Silt	
1	Mairabari	20.98 – 31.31 74.18 – 97.49	7.20 81.20	37.60 16.60	52.40 1.80	2.60 0.30	0.30 0.10	27.15 26.32
2	Phaliamari	4.00 – 14.00 42.00 – 48.00 54.00 – 66.00	0.20 23.65 1.40	5.60 6.79 11.80	72.60 41.58 70.40	21.40 27.18 16.00	0.20 0.80 0.40	26.16 25.60 26.39
3	Rajagaon	12.80 – 21.80 21.80 – 24.80 60.80 – 120.80	9.00 49.68 13.50	9.61 26.46 13.90	52.49 15.48 36.60	27.50 7.74 33.00	1.40 0.64 3.00	25.65 26.34 25.14
4	Santipur	39.50 – 42.75	6.45	38.80	38.80	13.25	1.50	26.50

District average 26.34

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 32 numbers of ground water samples were collected and analyzed during the course of study. The samples were analyzed for parameters like pH, EC, Turbidity, TDS, CO_3, Cl, SO_4, Na, K, HCO_3, NO_3, F, Ca, Mg, TH, U, As and Fe. Table 3.2 and 3.3 summarizes the results of chemical analysis of groundwater samples from Morigaon district during pre-monsoon and post-monsoon season and the details of chemical analysis are given in the Annexure 4 and 5.

Table 3.2: Chemical quality of water samples from dug well in Morigaon district during pre-monsoon

Sl. No.	Chemical constituents (Concentrations in mg/l except pH, EC, U and As)	Dug Well	
		Range	
1	pH	7.65	8.45
2	EC (µs/cm) 25°C	143.7	1186.0
3	Turbidity (NTU)	BDL	0.10
4	TDS	94.842	782.76
5	CO_3^{-2}	BDL	12.0
6	HCO_3^{-1}	61.049	567.75
7	TA (as $CaCO_3$)	61.049	567.75
8	Cl^-	17.725	184.34
9	SO_4^{-2}	BDL	74.62
10	NO_3^{-1}	BDL	43.92
11	F^-	0.03	0.74
12	Ca^{+2}	8.0064	138.14
13	Mg^{+2}	2.3971	60.671
14	TH (as $CaCO_3$)	70	460
15	Na	7.54	131.8
16	K	1.97	118.4
17	Fe	0.00	4.49
19	As (µg/L)	BDL	11.528

Table 3.3: Chemical quality of water samples from dug well and springs in Morigaon district during post-monsoon

Sl. No.	Chemical constituents (Concentrations in mg/l except pH, EC, U and As)	Dug Well	
		Range	
1	pH	7.36	8.66
2	EC (µs/cm) 25°C	103.0	2181.0
3	Turbidity (NTU)	BDL	0.30
4	TDS	58.30	1262.0
5	CO_3^{-2}		18

Sl. No.	Chemical constituents (Concentrations in mg/l except pH, EC, U and As)	Dug Well	
		Range	
6	HCO_3^{-1}	42.73	616.59
7	TA (as $CaCO_3$)	42.73	616.59
8	Cl^-	14.18	336.78
9	SO_4^{-2}	0.17	63
10	NO_3^{-1}		39.61
11	F^-	0.30	1.40
12	Ca^{+2}	8.01	114.09
13	Mg^{+2}	7.27	109.17
14	TH (as $CaCO_3$)	70	735
15	Na	2.41	172.32
16	K	0.30	69.20
17	Fe	0.16	16.16

Table 3.4: Concentration of Fe and As value in ground water during pre-monsoon

Type of Structure	No. of Sample analysed	Conc. of Iron (mg/l)			As (ppb)	
		<0.3	0.3 to 1	>1	<10	>10
Dug well	34	20	9	5	33	1 (Jagiroad station)

Table 3.5: Concentration of Fe and As value in ground water during post-monsoon

Type of Structure	No. of Sample analysed	Conc. of Iron (mg/l)			As (ppb)	
		<0.3	0.3 to 1	>1	<10	>10
Dug well	32	13	12	7	31	1 (Datiaburi station)

3.7.1. Ground water quality of alluvia aquifer

A total of 34 ground water samples from dug well were collected during pre-monsoon and a total of 32 ground water samples were collected during post-monsoon. The range of concentrations of different chemical constituents present in the ground water samples are given in table 3.2 and 3.3.

It is deciphered from table 3.2 and 3.3 that except Iron (Fe) and Arsenic (As), the other chemical parameters are within permissible limit. From table 3.3 and 3.4, the concentration of Iron beyond permissible limit is found in 5 dug wells during pre-monsoon and 7 dug wells during post-monsoon. The Arsenic content beyond the permissible limit is found in 1 dug well during pre-monsoon. The Fe conc. during pre-monsoon and post-monsoon are shown in fig 3.8 and fig 3.9 respectively.

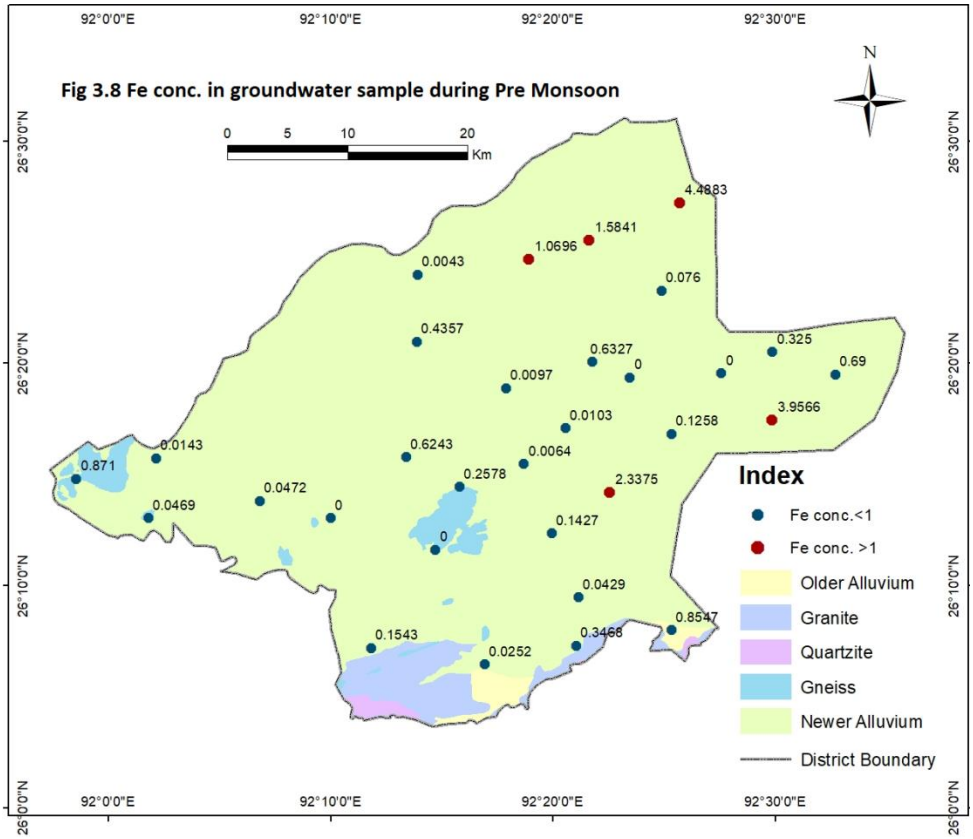


Fig 3.8 Fe conc. in groundwater sample during Pre Monsoon
92°0'0"E
92°10'0"E
92°20'0"E
92°30'0"E
26°30'0"N
26°20'0"N
26°10'0"N
26°0'0"N
N
0 5 10 20
Km
4.4883
1.5841
1.0696
0.0043
0.076
0.4357
0.6327
0
0
0.325
0.69
0.0097
0.0103
0.1258
3.9566
0.0143
0.6243
0.0064
0.871
0.2578
2.3375
0.0472
0.0469
0
0
0.1427
0.0429
0.8547
0.1543
0.3468
0.0252
Index
Fe conc.<1
Fe conc. >1
Older Alluvium
Granite
Quartzite
Gneiss
Newer Alluvium
District Boundary

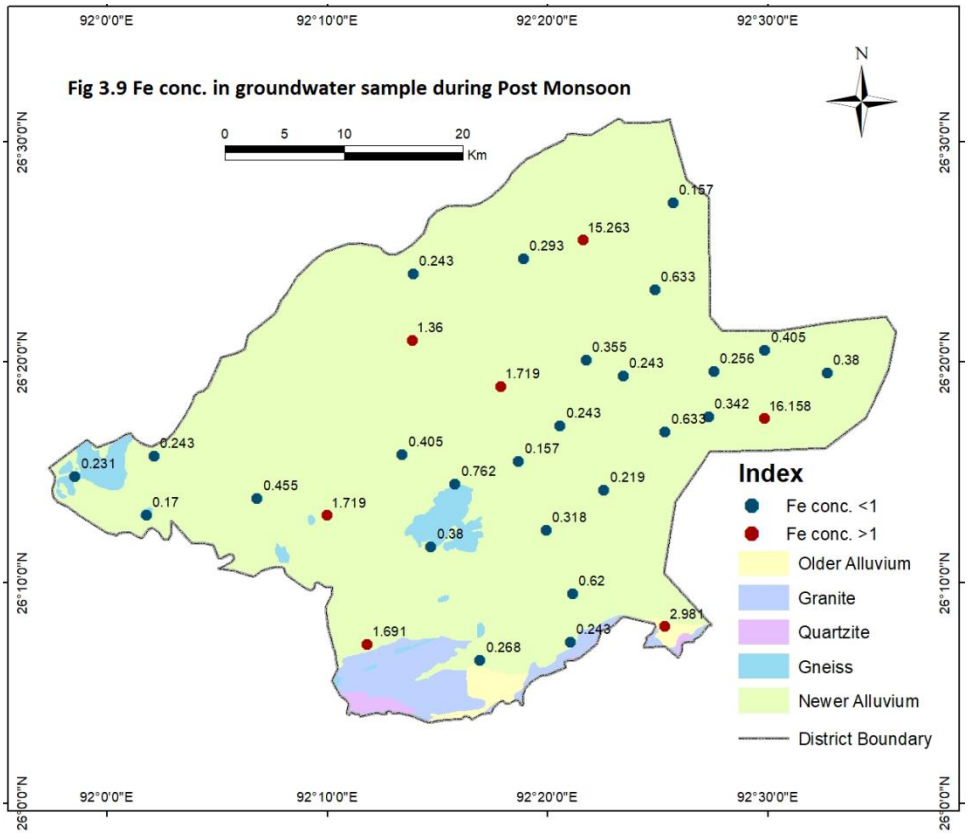


Fig 3.9 Fe conc. in groundwater sample during Post Monsoon
92°0'0"E
92°10'0"E
92°20'0"E
92°30'0"E
26°30'0"N
26°20'0"N
26°10'0"N
26°0'0"N
N
0 5 10 20
Km
0.157
15.263
0.293
0.243
0.633
1.36
0.405
0.355
0.256
0.38
0.243
1.719
0.342
16.158
0.243
0.633
0.243
0.405
0.157
0.231
0.762
0.219
0.455
1.719
0.17
0.318
0.38
0.62
2.981
1.691
0.268
0.243
Index
Fe conc. <1
Fe conc. >1
Older Alluvium
Granite
Quartzite
Gneiss
Newer Alluvium
District Boundary

3.7.2. 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, Wilcox 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. 3.10 & 3.11) 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 Magnesium 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.

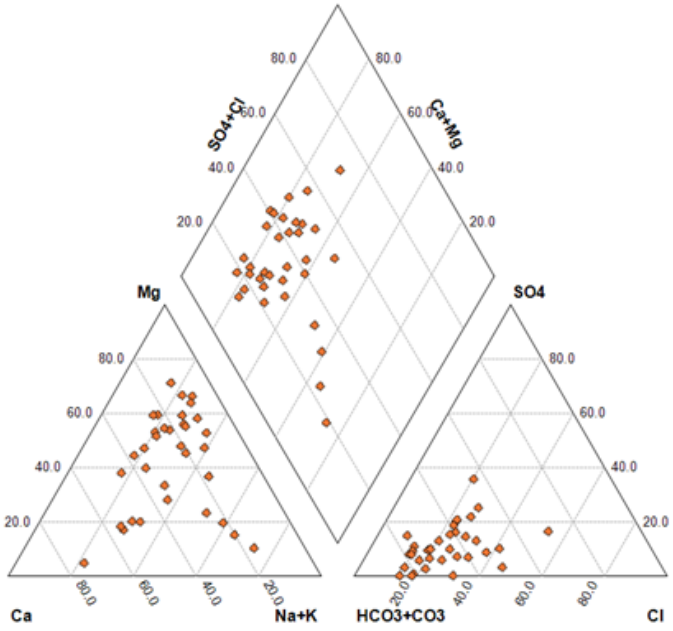


Fig 3.10 Piper Diagram for Morigaon District (Pre Monsoon)

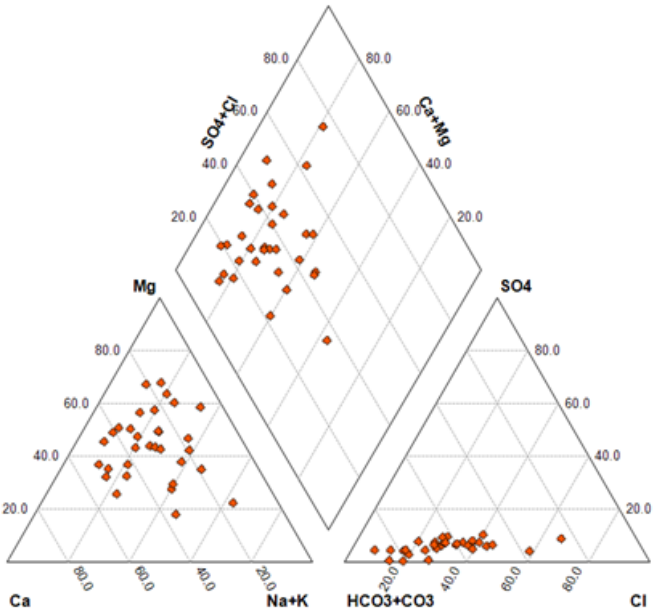


Fig 3.11 Piper Diagram for Morigaon District (Post Monsoon)

Wilcox diagram

Percentage of Sodium (Na+) is widely used for assessing the suitability of water for irrigation purposes. The sodium percentage is computed with respect to relative proportion of cations present in water. According to Wilcox diagram (US Salinity Laboratory's diagram) in Fig.3.12 for pre monsoon samples, 12% of the samples analyzed falls in C1–S1 which indicates low sodium and salinity hazard, 77 % of the samples fall in C2–S1 which indicates low sodium hazard and medium salinity hazard and 11 % of the samples fall in C3–S1 which indicates low sodium hazard and high salinity hazard C3-S1. During post monsoon in figure 3.13, 16% of the samples analyzed falls in C1–S1 which indicates low sodium and salinity hazard, 71 % of the samples fall in C2–S1 which indicates low sodium hazard and medium salinity hazard and 13 % of the samples fall in C3–S1 which indicates low sodium hazard and high salinity hazard C3-S1. The results indicate that water can be used directly for irrigation purpose. However, water samples falling in C3-S1 which falls under "doubtful to unsuitable" category should be treated before using for irrigation purposes.

Fig 3.12 Wilcox Diagram for Morigaon District (Pre Monsoon)

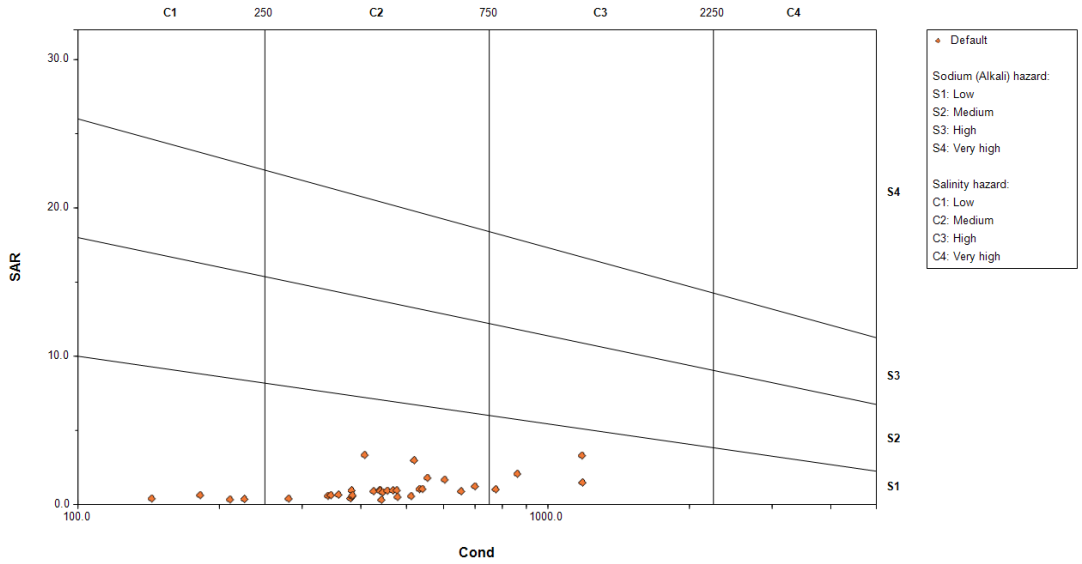
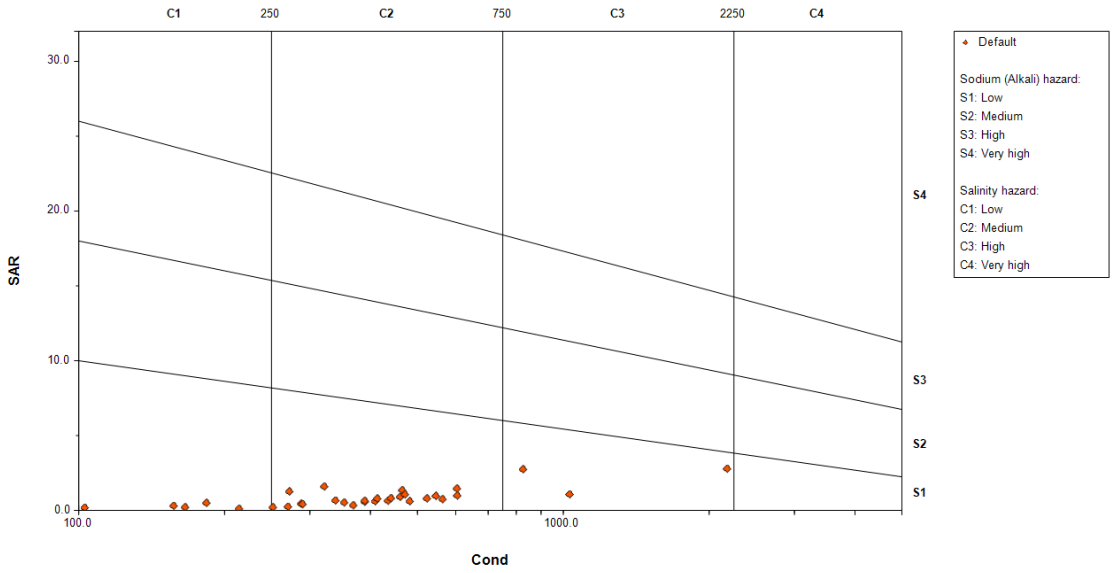


Fig 3.13 Wilcox **Diagram for Morigaon District (Post Monsoon)**



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. 3.14 and 3.15 respectively. From the diagram it is concluded that the groundwater samples fall in Magnesium bicarbonate type both for pre monsoon and post monsoon.

Fig 3.14 Stiff Diagram for Morigaon District (Pre Monsoon)

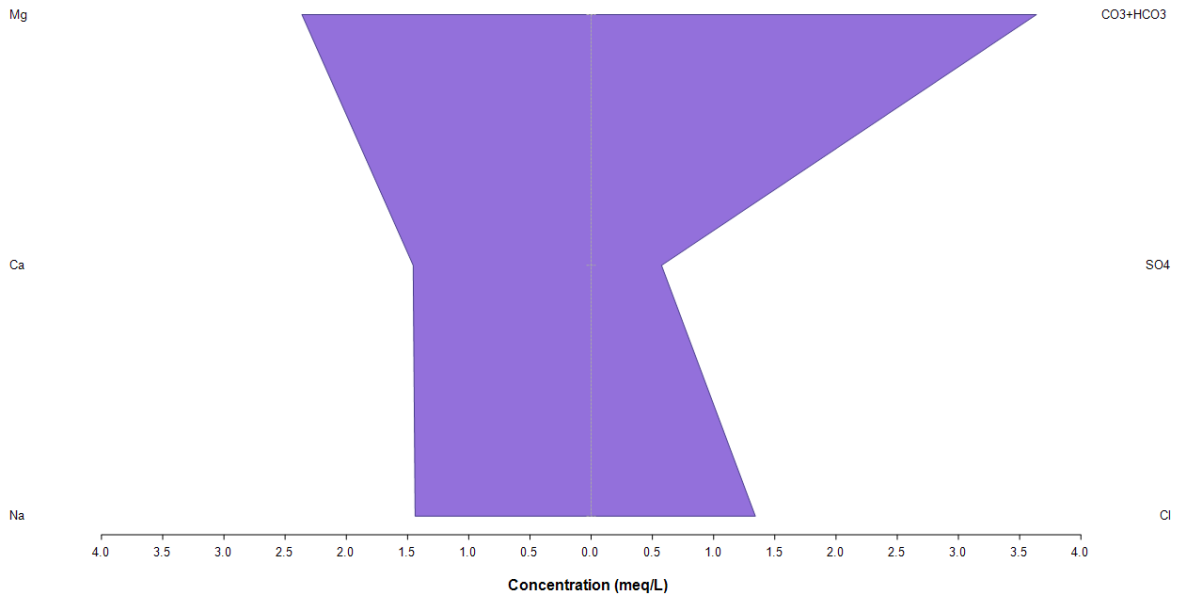
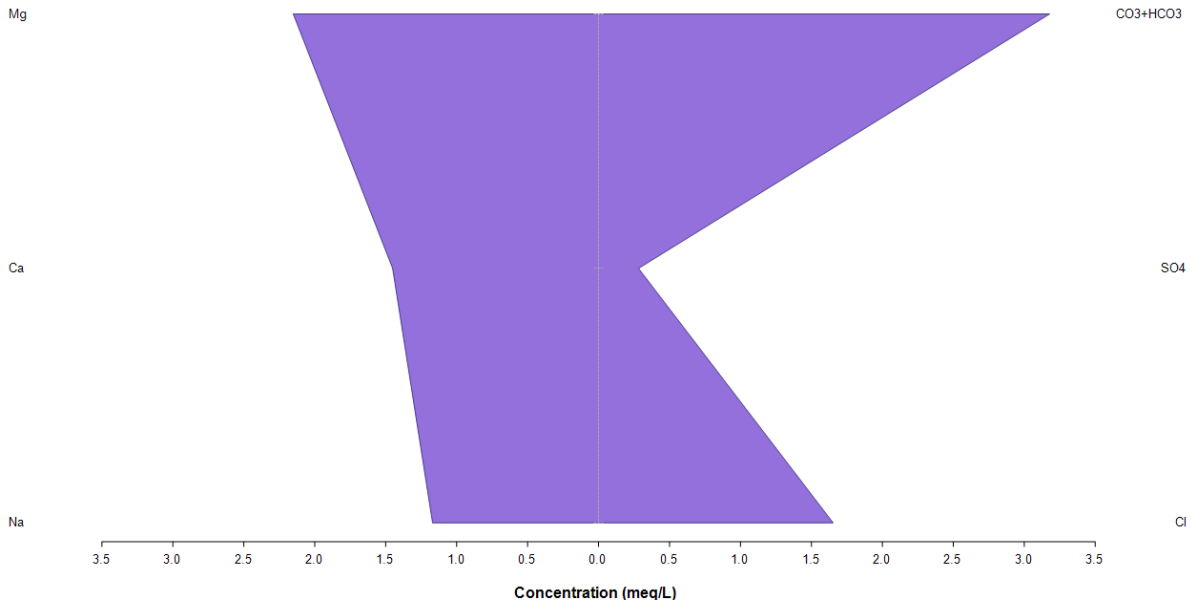


Fig 3.15 Stiff Diagram for Morigaon District (Post Monsoon)



Aquifer Map of the district: Two aquifers are identified in the district, viz., younger alluvium (AL01) and banded gneissioc complex (BG 01). Aquifer properties of 2nd aquifer, i.e., banded gneissioc complex (BG 01) are not known, The alluvial aquifer thickness is more towards north eastern side of the district. The alluvial aquifer is prolific and generally good for domestic and irrigation purposes. However, occurrence of arsenic in scattered locations at shallow depth is to be considered as major quality issue. The aquifer map of the district is shown in Fig. 3.16.

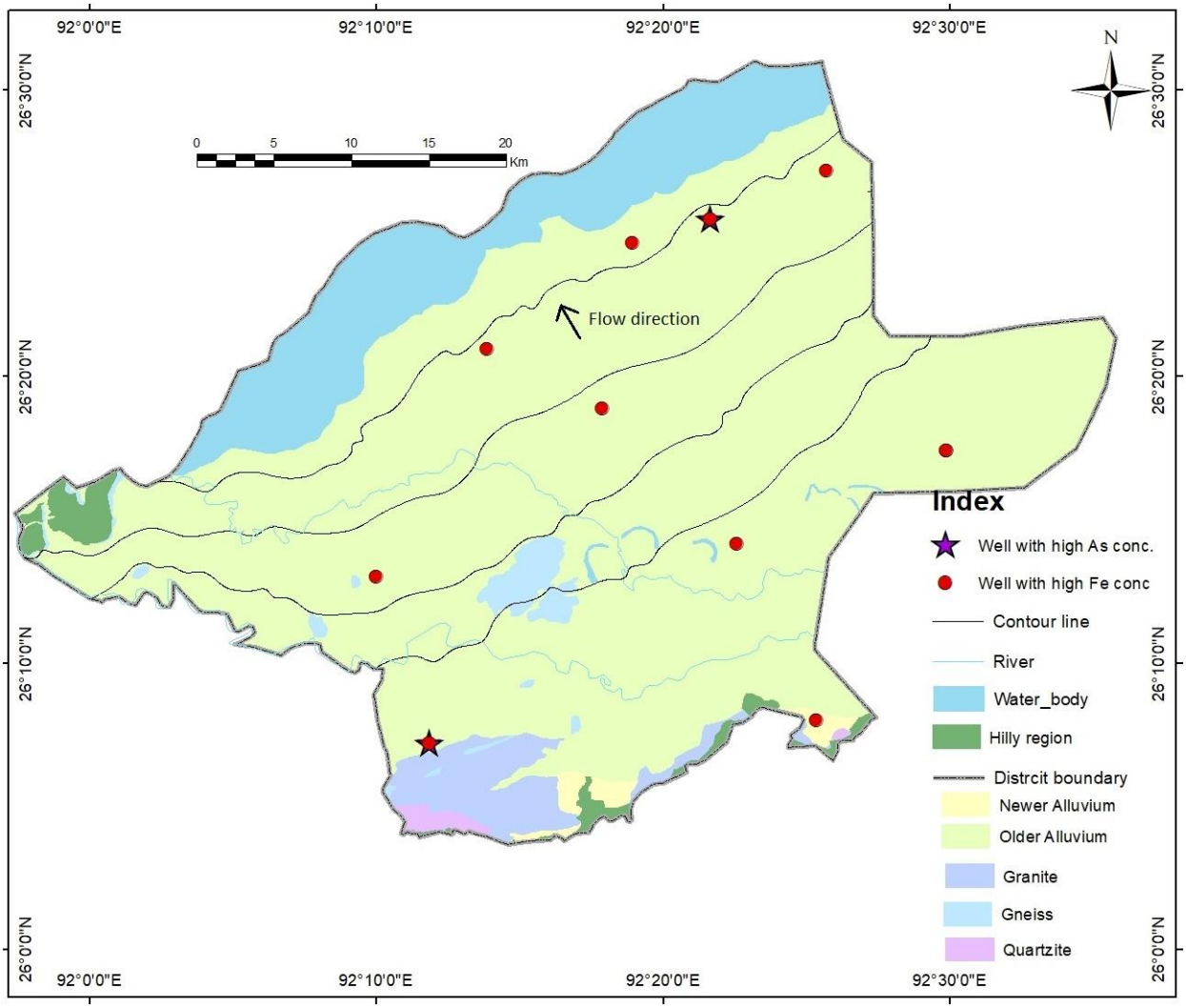


Fig.3.16: Aquifer map of Morigaon district, Assam

Chapter 4.0
GROUNDWATER RESOURCES

Dynamic Groundwater Resources of Morigaon 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 2019-20. 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
Morigaon District	Non-command	27315.21	6949.67	11597.78	3536.89	49399.56	4939.96	43590.37
	Total	27315.21	6949.67	11597.78	3536.89	49399.56	4939.96	43590.37

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 10777.20 Ham and groundwater draft for all uses in the district is 13021.52 ham.

4.2. Stage of Groundwater extraction & categorization of the Blocks

The district falls under "**SAFE"** category. The stage of GW extraction is 29.87%. Summary of groundwater resources, stages of development and categorization are given in annexure III.

4.3. Summarized results of dynamic ground water resources of Morigaon district as on March 2020

The summarized results of dynamic ground water resources estimation of Morigaon district as on March 2020 is shown in the table below,

Table 4.2: Summarized results of dynamic ground water resources of Morigaon district as on March 2020

Sl. No.	**ITEM**	**Year, 2019-20**
	Methodology	**GEC 2015 (in ham)**
1	Total Annual Ground Water Recharge	49399.56
2	Total Natural Discharges	4939.96
3	Annual Extractable Ground Water Resource	43590.37
4	Total annual Ground water extraction	13021.52
5	Annual GW Allocation for Domestic Use as on 2025	2583.67
6	Net Ground Water Availability for future use	30224.62
7	Stage of GW Development (%)	29.87

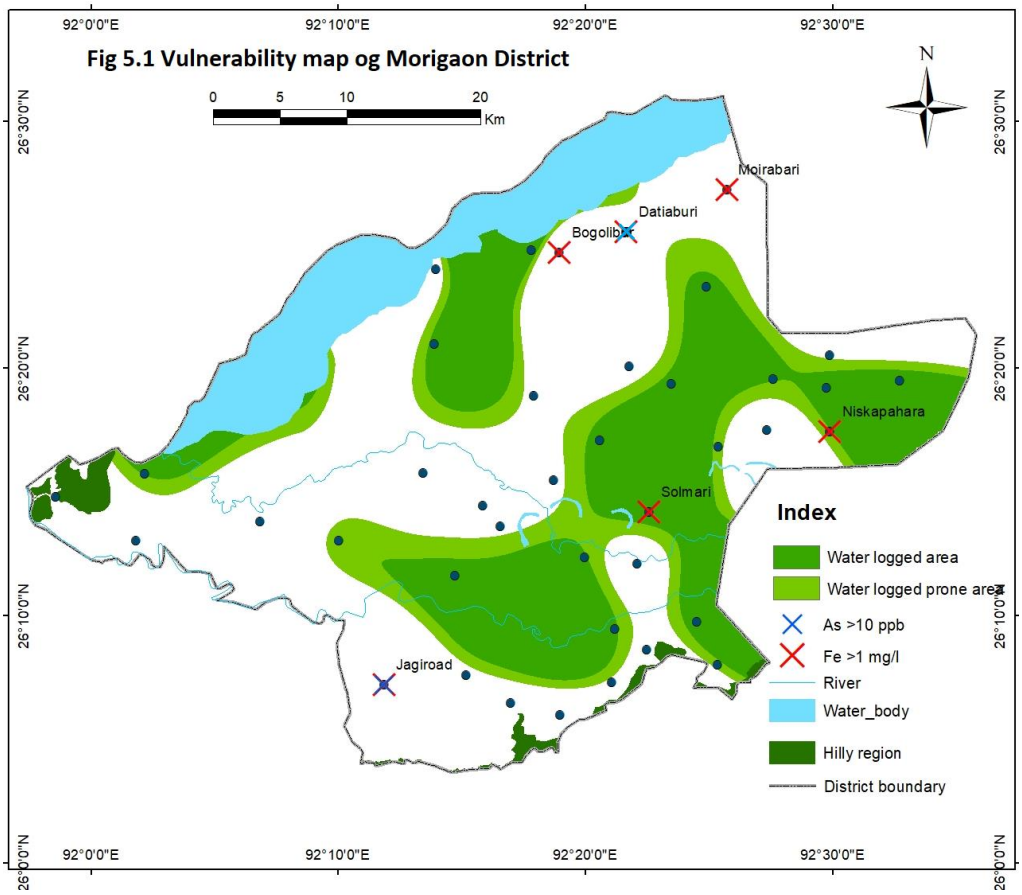
Chapter 5.0

GROUND WATER ISSUES

The main groundwater issues in this area are its vulnerability issue. These include areas vulnerable to water logging as well as prone to water logging conditions along with Iron concentration in ground water above the permissible limit.

Water logging

It is seen from the pre monsoon water level data that major part of the study area is perennially in water logged or prone to water logged condition. In Figure 3.2, it can be seen that water logged area is spread over the South Eastern and North Western part of the district. 33 % of the monitoring stations recorded water level of 0-2 mbgl during pre monsoon. The groundwater flow gradient from south to north is very sluggish. With high rainfall and slow movement of ground water along with poor drainage facility in the area causes water logging condition.



Quality Issues

High Iron concentration : In the study area, high concentration of Iron (Fe) has been observed. In Figure 3.8 & 3.9, the red points show the GWMS where Fe concentration in ground water have been found above the permissible limit of 1.0 mg/ltr.

High Arsenic concentration : As per water quality analysis data, water sample collected from Jagiroad monitoring station during pre monsoon shows high concentration of Arsenic (i.e.,>10ppb), which is beyond the permissible limit.

Chapter 6.0
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 Morigaon District for 2020, annual extractable groundwater resource is 43590.37 ham and stage of development is 29.87%. The district is having balance net ground water availability for future development in the tune of 30224.62 ham. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 18135 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 Morigaon District , net sown area is 115574 ha, area sown more than once is 84958 ha and cropping intensity is about 173.5%. 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.

During kharif season, paddy is cultivated in 51102 ha. After deducting irrigated area for maize, vegetables and Sali paddy (i.e 2411 Ha) as per data received from Irrigation Department, Government of Assam, a total of 48691 Ha of Kharif paddy land remains fallow during Rabi season. The intention is to bring this fallow land of 48691 Ha under assured irrigation during rabi season so as to increase gross cropped area to 97382 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 proposed for Morigaon district, Assam

Cropping pattern name: Cropping Pattern

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	...a\CROPWAT\data\cr	Pulses	25/10	11/02	10
6	...\CROPWAT\data\cro	Potato	15/10	21/02	10
7	...\CROPWAT\data\cro	Potato	15/11	24/03	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)	48691		48691	
Pulses	0	20	8115	685.6
Potato	0	20	8115	871.6
Potato	0	20	8115	977.7
Small vegetables	0	20	8115	616.9
Small vegetables	0	15	8115	700.7
Maize	0	5	8116	761.0
Net cultivated area (Paddy)	48691	100	48691	
Gross cultivated area	48691		97382	
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	4214.0	June
Pulses	4	4	685.6	December
Potato	4	4	8716	December
Potato	4	4	977.7	May
Small Vegetables	3	3	616.9	March
Small Vegetables	3	3	700.7	March
Maize	4	4	761.0	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 48691 ha for the cultivation of pulses, potato, small vegetables and maize. It is considered to cultivate pulses in 8115 Ha, potato in 16320 Ha, Small vegetables in 16320 ha and maize in 8116 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 Morigaon 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	4.6	0	0
4. Rice	0	0	0	0	0	147.1	0	0	0	15.1	0	0
5. Pulses	55.8	10.1	0	0	0	0	0	0	0	0	18.1	56.8
6. Potato	57.6	34.2	0	0	0	0	0	0	0	0	28.4	58.8
7. Potato	57.8	61.8	35	0	0	0	0	0	0	0	12.4	33.8
8. Small Vegetables	26	0	0	0	0	0	0	0	0	5.1	41	54.6
9. Small Vegetables	53.2	15.7	0	0	0	0	0	0	0	0	26.7	48.3
10. MAIZE (Grain)	57.3	22.6	0	0	0	0	0	0	0	1	18.4	57

Table 6.5: Irrigation Water Requirement (in ham), Morigaon 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	22.4	0.0	0.0	995.2
4. Rice	10	0.0	0.0	0.0	0.0	0.0	716.2	0.0	0.0	0.0	73.5	0.0	0.0	789.8
5. Pulses	10	271.7	49.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	88.1	276.6	685.6
6. Potato	10	280.5	166.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	138.3	286.3	871.6
7. Potato	10	281.4	300.9	170.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.4	164.6	977.7
8. Small Vegetables	10	126.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.8	199.6	265.9	616.9
9. Small Vegetables	5	259.0	76.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	130.0	235.2	700.7
10. Maize	5	279.0	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	89.6	277.5	761.0
Total	100	1498.22	703.098	170.419	0	1679.35	2534.61	0	0	0	148.264	706.02	1506.01	8946

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, bore well within the depth of 100 m can be constructed.

Under ground water exploration programme, CGWB has constructed 9 deep tube wells in this district and has established that the aquifer is having discharge of 31.4 to 205 cum/hour. 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 fractures. Tube wells can be constructed by using $8^{//}$ dia.

In considered net sown area of 48691 Ha, 1314 nos. of shallow tube wells can be constructed (considering 200m distance between any two shallow bore well).

Annual irrigation water requirement is 8946 ham while irrigation water requirement during dry season spanning from October to March is 4732 ham. Again proportionate dynamic groundwater resources available for future use in the considered area is 18135 ham. Hence, this area can be brought under assured irrigation from groundwater sources. The demand of 4732 ham can be harnessed by constructing 1314 nos. bore wells. At possible places rainwater harvesting methods should be employed.

When managing a precious and scarce resource such as groundwater, it is essential that the resource is not subjected to pollution. The chemical quality of ground water indicates that groundwater in 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. Acidity of water should be treated before consumption. Arsenic is found beyond permissible limit of 10 ppb in a dug well in Jagiroad

monitoring station during pre monsoon and in Datiaburi monitoring station during post monsoon which warrant proper treatment before use. The most cost-effective method for removing arsenic from a private water supply appears to be reverse osmosis, commonly called RO.

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iv. **Central Ground Water Board, Ministry of Water Resources, NER, Guwahati** Dynamic Groundwater resources of Assam (as on march 2020)

v. **Central Ground Water Board, Ministry of Water Resources, New Delhi,** Report of the Groundwater resources estimation committee(GEC-2015) Methodology, October 2017.

vi. **Central Groundwater Board, Ministry of Water Resources, New Delhi** Manual on Aquifer Mapping

vii. **Directorate of Economics and Statistics, Government of Assam,** Statistical Hand Book of Morigaon 2021.

viii. **David Keith Todd, Larry W. Mays,** 2005, third edition, Groundwater Hydrogeology, John Wiley & Sons, Inc.

ix. **Directorate of Census Operation, Assam** District Census Handbook of Morigaon District 2011.

x. **Soil Survey report of Morigaon (Assam), North Eastern Regional Centre Jorhat**, National Bureau of Soil Survey & Land Use Planning (Indian Council of Agricultural Research)

xi. **Nautiyal M.D 1991,** Specific yield and hydraulic conductivity of unconfined aquifers of Upper Ganga Basin.

Annexure 1: Hydrogeological details of bore wells constructed by CGWB in Aquifer mapping area.

S.No.	Type of well	Site Location	Block	Longitute	Latitute	Elevation m.amsl	Depth drilled	Aquifer			Aquifer Parameters			
								Zones tapped	Aquifer material & thickness	DTWL mbgl	Q m^3/hr / dd-m	KD sq.m/day	K m/d	S
1	EW	Dharamtul	Mayang	92.3667	26.175	56.5	239.75	117-129 , 143-146 , 156-162 , 164-176	Fine sand to medium gravel 33 m	4.665	205/10.80	33.4	33	-
2	EW	Jagiroad	Mayang	92.1875	26.1125	58	95	36-56 , 60-62	Sand fine to medium 22m	2.16	31.4/7.34	-	-	-
3	EW	Mairabari	Laharighat	92.4111	26.4583	56.151	300.7	80-83 , 92-95 , 123-125 , 146-148 , 175-178	Sand medium to coarse gravel 36m	3.191	177.3/6.0	35	35	3.4*10
4	EW	Phaliamari	Bhurbanda	92.475	26.3222	54.885	300.7	34-40 , 56-68 , 70-82 , 88-100 , 106-112	Sand fine to coarse gravel 48m	1.369	223/4.261	125	125	3.27*1
5	EW	Rajagaon	Bhurbanda	92.3389	26.2639	54.225	254	62-74 , 78-90 , 93-105 , 107-119	Sand medium to coarse 48m	2.3	176.4/5.47	53	53	-
6	EW	Markongkuchi	Mayang	92.2	26.125	56.7	67.58	53--65	Gravelly sand 12m	-	-	-	-	-
7	EW	Jhargaon	Mayang	92.1333	26.225	53.3	108	38-50 , 88-100	Sand fine to medium 24.30m	-	-	-		-
8	EW	Bogalipara	Laharighat	92.3222	26.4172	58	200.2	59-79 , 95-107 , 119-131 , 143-151	Gravelly sand fine to medium 53m	-	-	-	-	-
9	EW & SH	Bhuragaon		92.2333	92.4089	54.5	300	-	Sand fine to medium	-	103.67	-	-	-
10	Piezometer	Santipur	Mayang	92.3583	26.15	63.717	45.75	31.53-33.02	Sand fine to medium 1.49m	-	-	-	-	-

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

S.No.	Location	Latitute	Longitiute	RL (m)	Dia (m)	Depth	MP	WL pre monsoon	WL post monsoon
1	Jagiroad	26.12	92.197222	61.4	0.75	8.00	0.6	13.44	2.03
2	Deosal	26.126389	92.2525	40	0.85	10.40	0.9	3.62	3.99
3	New Nellie	26.099722	92.316111	59.9	0.98	12.30	0.8	6.8	3.48
4	Silsang Namghar	26.121667	92.350833	52.1	0.90	7.50	0.9	3.4	0.59
5	Daponibari N	26.143889	92.374167	61.8	0.95	8.00	0.8	3.83	1.27
6	Mairabari/Moirabari	26.453611	92.428333	94.6	1.50	10.20	0.9	5.5	2.9
7	Bichamari	26.40139	92.46	63.7	0.95	11.00	0.9	2.27	2.01
8	Solmari	26.236389	92.376111	66	0.45	12.30	0.7	1.02	1.42
9	Charibahi	26.291667	92.455278	69.3	0.40	8.90	0.6	3.15	2.15
10	Basanaghat	26.258056	92.311667	52	0.90	13.05	0.9	3.45	1.09
11	Baghara	26.226667	92.275833	39	1.10	11.20	0.9	3.36	0.23
12	Pamibaghara	26.240898	92.26362	64.3	0.90	6.50	0.9	4.08	1.28
13	Kumoi	26.193611	92.245278	45	0.60	12.00	0.9	1.28	1.03
14	Garmari Gaon	26.263056	92.223611	38	0.92	9.00	1	4.7	1.65
15	Barukati	26.4	92.231944	41	0.4	9.32	0.7	4.07	2.33
16	Karmarpur	26.21733	92.03009	85	1.2	15.2	0.9	6.9	6.23
17	Mayang Police Station	26.26219	92.03577	52	0.94	5.6	0.9	1.93	1.83
18	Kathargaon	26.2469	91.97594	60	0.86	13.2	0.8	11.25	6.9
19	Buraburi bazaar	26.23033	92.11375	52	0.89	1.8	1	5.65	3.75
20	Manaha Kacharigaon	26.21727	92.16654	59	1.34	9	0.5	2.62	2.79
21	Jajuli Barmanipur (Hajukuti)	26.32518	92.54496	56	1	4.26	2.6	0.97	0.89
22	Naruloboi TW	26.34208	92.49791	63	0.203	15		3.3	1.22
23	Himuliguri	26.32613	92.45942	49	0.73	3.76	0.5	1.91	0.99
24	Sohuriapam	26.3881	92.41464	61	0.79	4.13	0.6	1.69	0.78
25	Datiaburi	26.4254	92.36069	56	0.74	7	0.6	4.68	4.16
26	Tinisukia Mohomari	26.41305	92.29672	62	1.04	12.1	1	0.6	0.7
27	Bogolibar	26.41126	92.31544	74	1.08	8	0.9	7.09	1.74
28	Dighalbari Pagai	26.31474	92.298	56	1.03	16	1.1	3.44	2.64
29	Rajabari	26.34981	92.2311	48	0.8	14	2.8	1.5	0.09
30	Borongabari	26.28494	92.34294	29	0.76	4.4	0.4	1.39	2.75
31	Goroimari	26.33468	92.36274	57	1.1	6.13	1	4.39	2.17
32	Hukdol Borbori	26.32288	92.39083	69	0.79	4.49	1.9	1.46	0.5
33	Sabhokdhara	26.32023	92.49571	65	0.9	5.32	1	1.25	1.4
34	Niskapahara	26.29052	92.49799	45	1	10	1.1	2.11	0.93
35	Tokanabari	26.28053	92.42254	59	0.7	4.14	0.5	2.46	1.48
36	Betoni Rajasuk	26.20586	92.33249	54	0.92	7.14	0.8	1.86	2.73
37	Telahi Bhatgaon	26.20167	92.36798	59	0.9	10.7	0.5	4.38	6.21
38	Borbori	26.16246	92.40801	47	1.05	35	0.9	0.25	0.38
39	Amsoi	26.13339	92.42239	46	0.93	3.75	0.7	2.51	2.22
40	Sat Kendra Dharamtul	26.15781	92.35268	47	1.02	8.2	0.5	1.76	1.46
41	Polaguri	26.10765	92.28243	51	0.87	8.17	0.8	5.69	4.56
42	Datiaburi	26.425403	92.360694	56	0.84	7	0.6	4.68	2.28

Annexure IV: Water quality data of Aquifer mapping area in Morigaon district during pre-monsoon

Location	Lat DMS	Long DMS	Source	TempºC	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO_3^{-2}	HCO_3^{-1}	TA (as CaCO3)	Cl-	SO_4^{-2}	NO_3^{-1}	F-	Ca^{+2}	Mg^{+2}	TH (as CaCO3)	Na	K
								(in mg/L)		Mg/l										
Jagiroad			DWl	29.5	8.25	554.80	BDL	366.17	BDL	170.94	170.94	56.72	70.70	5.44	0.05	22.02	27.90	170.00	53.23	22.10
Pamibaghara	26.12	92.2	DWl	28.5	8.03	182.20	BDL	120.25	BDL	61.05	61.05	21.27	11.37	1.22	0.10	20.02	4.84	70.00	11.75	3.05
Kumoi	26.24	92.26	DWl	28.9	8.45	533.40	BDL	352.04	9.00	280.82	289.82	46.08	30.92	1.54	0.74	20.02	42.47	225.00	35.14	9.37
Garmari Gaon	26.19	92.25	DWl	27.6	8.07	281.10	BDL	185.53	BDL	79.36	79.36	17.73	19.80	38.69	0.10	22.02	15.77	120.00	9.48	4.69
Basanaghat	26.26	92.22	DWl	27.4	8.24	380.60	0.10	251.20	BDL	152.62	152.62	35.45	43.81	2.51	0.12	62.05	2.40	165.00	11.80	16.28
Borongabari	26.26	92.31	DWl	27.9	7.98	477.30	BDL	315.02	BDL	195.36	195.36	35.45	29.77	15.97	0.12	28.02	15.76	135.00	25.09	70.86
Dighalbari Pagai	26.28	92.34	DWl	26.4	8.44	442.80	BDL	292.25	6.00	225.88	231.88	17.73	36.63	2.43	0.10	58.05	10.89	190.00	9.48	42.99
Rajabari	26.31	92.3	DWl	29.5	8.02	654.40	BDL	431.90	BDL	225.88	225.88	67.36	74.62	21.69	0.07	24.02	50.96	270.00	32.92	31.05
Barukati	26.35	92.23	DWl	28.8	8.14	512.30	BDL	338.12	BDL	262.51	262.51	28.36	24.58	6.81	0.07	30.02	44.89	260.00	20.30	6.62
Moirabari	26.4	92.23	DWl	28.6	8.28	382.60	0.20	252.52	BDL	170.94	170.94	46.09	0.01	0.44	0.08	30.02	18.19	150.00	26.26	14.12
Datiaburi	26.45	92.43	DWl	27.9	7.91	861.70	BDL	568.72	BDL	354.08	354.08	113.44	31.55	17.88	0.08	26.02	54.60	290.00	80.32	9.55
Bogolibar	26.43	92.36	DWl	28.4	8.37	383.40	BDL	253.04	6.00	158.73	164.73	46.09	14.97	1.91	0.07	22.02	35.18	200.00	17.23	5.56
Bechamari	26.41	92.32	DWl	30.1	7.93	455.80	BDL	300.83	BDL	231.99	231.99	39.00	16.06	13.43	0.11	16.01	38.83	200.00	29.62	4.88
Himuliguri	26.4	92.46	DWl	27.3	8.09	445.70	BDL	294.16	BDL	219.78	219.78	35.45	23.97	7.49	0.04	40.03	19.40	180.00	24.91	40.27
Hukdol Borbori	26.33	92.46	DWl	28	8.19	479.20	0.10	316.27	BDL	207.57	207.57	49.63	44.09	18.12	0.12	16.01	55.82	270.00	18.54	10.34
Goroimari	26.32	92.39	DWl	29.6	8.19	384.40	BDL	253.70	BDL	231.99	231.99	31.91	13.54	0.50	0.09	24.02	29.11	180.00	18.63	4.68
Sohuriapam	26.33	92.36	DWl	27.9	7.79	426.10	BDL	281.23	BDL	231.99	231.99	24.82	26.32	0.10	0.05	8.01	40.04	185.00	27.41	3.65
Manaha Kacharigaon	26.39	92.41	DWl	31	8.27	700.20	BDL	462.13	BDL	451.76	451.76	46.08	36.10	3.65	0.04	18.01	60.67	295.00	47.65	25.20
Buraburi bazaar	26.22	92.17	DWl	30.9	8.17	1186.00	BDL	782.76	BDL	445.66	445.66	184.34	56.69	14.28	0.03	138.11	27.85	460.00	72.11	9.97
Karmarpur	26.23	92.11	DWl	28.4	7.86	541.40	BDL	357.32	BDL	67.15	67.15	70.90	29.10	43.92	0.10	20.02	27.90	165.00	30.32	7.49
Mayang Police Station	26.22	92.03	DWl	27.4	7.98	775.40	BDL	511.76	BDL	457.87	457.87	49.63	36.32	2.74	0.06	48.04	55.80	350.00	43.24	2.24
Kathargaon	26.26	92.04	DWl	28.1	7.65	603.70	BDL	398.44	BDL	207.57	207.57	60.27	41.27	17.00	0.11	14.01	43.68	215.00	55.78	4.24

Amsoi	26.25	91.98	DWl	28.2	8.15	440.10	BDL	290.47	BDL	128.20	128.20	63.81	20.82	5.46	0.11	20.02	26.69	160.00	26.11	20.81
Niskapahara	26.13	92.42	DWl	33.4	7.97	345.70	0.20	228.16	BDL	213.67	213.67	21.27	BDL	0.50	0.10	10.01	36.40	175.00	18.52	7.95
Charibahi	26.29	92.5	DWl	28.8	8.24	226.30	BDL	149.36	BDL	134.31	134.31	17.73	BDL	BDL	0.06	26.02	13.34	120.00	8.80	4.65
Tokanabari	26.29	92.46	DWl	26	7.85	1183.00	BDL	780.78	BDL	567.75	567.75	120.53	37.59	2.94	0.12	64.05	35.16	305.00	131.80	118.40
Solmari	26.28	92.42	DWl	29.9	7.65	340.70	BDL	224.86	BDL	170.94	170.94	17.73	5.05	BDL	0.13	16.01	23.05	135.00	14.97	5.63
Betoni Rajasuk	26.24	92.38	DWl	29.8	8.03	439.40	BDL	290.00	BDL	170.94	170.94	39.00	46.63	2.96	0.11	10.01	40.04	190.00	30.47	1.97
Sat Kendra Dharamtul	26.21	92.33	DWl	28.9	8.10	143.70	BDL	94.84	BDL	61.05	61.05	31.91	2.95	BDL	0.05	14.01	12.13	85.00	8.11	2.88
Silsang Namghar	26.16	92.35	DWl	27.5	8.04	210.90	0.30	139.19	BDL	97.68	97.68	21.27	18.96	BDL	0.04	20.02	13.34	105.00	7.54	13.36
Polaguri	26.12	92.35	DWl	28.1	8.24	358.80	BDL	236.81	BDL	91.57	91.57	24.81	58.41	BDL	0.08	16.01	24.26	140.00	17.49	6.29
Jajuli Barmanipur (Hajukuti)	26.11	92.28	DW	22.9	8.32	468.60	BDL	309.28	6.00	201.46	207.46	49.63	25.57	7.92	0.02	48.04	12.11	170.00	27.79	16.09
Naruloboi TW	26.33	92.54	TW	24.8	8.31	519.90	BDL	343.13	12.00	274.72	286.72	49.63	7.83	4.64	0.02	24.02	10.91	105.00	69.78	32.63
Sabhokdhara	26.34	92.5	DW	22.8	8.34	407.90	BDL	269.21	12.00	238.09	250.09	35.45	1.73	4.50	0.03	16.01	6.06	65.00	61.52	36.32

Annexure V: Water quality data of Aquifer mapping area in Morigaon district during post monsoon

Location	Lat DMS	Long DMS	Type of sample	Tempº C	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO_3^{-2}	HCO_3^{-1}	TA (as CaCO3)	Cl-	SO_4^{-2}	NO_3^{-1}	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K
								(mg/L)												
Jajuli Barmanipur (Hajukuti)	26.33	92.54	DW	25.3	7.74	321.60	BDL	192.40	BDL	122.10	122.10	49.63	12.70	16.08	0.30	14.01	15.77	100.00	36.26	5.68
Naruloboi TW	26.34	92.5	TW	26.4	8.08	409.50	BDL	236.10	BDL	262.51	262.51	39.00	7.14	2.75	0.41	34.03	29.11	205.00	19.53	4.78
Himuliguri	26.33	92.46	DW	28.2	8.13	546.50	0.30	314.30	BDL	317.45	317.45	42.54	14.04	BDL	0.44	40.03	23.04	195.00	30.41	48.94
Hukdol Borbori	26.32	92.39	DW	26.4	7.89	441.50	BDL	255.50	BDL	195.36	195.36	53.18	17.31	10.36	0.48	32.03	29.11	200.00	25.95	20.02
Goroimari	26.33	92.36	DW	29.2	8.14	353.50	BDL	206.00	BDL	274.72	274.72	14.18	10.63	BDL	0.76	48.04	18.18	195.00	16.35	2.33
Sohuriapam	26.39	92.41	DW	27.4	8.00	339.10	BDL	196.10	BDL	231.99	231.99	21.27	9.49	0.21	0.79	32.03	23.04	175.00	19.67	2.05
Mairabari/Moirabari	26.45	92.43	DW	28.4	7.83	2181.0	BDL	1262.0	BDL	616.59	616.59	336.78	63.00	39.61	0.56	114.09	109.17	735.00	172.32	64.32
Datiaburi	26.43	92.36	DW	27.1	8.39	605.10	BDL	356.40	9.00	335.77	344.77	77.99	2.00	2.84	0.76	22.02	53.39	275.00	37.10	7.82
Bogolibar	26.41	92.32	DW	26.6	8.50	471.80	BDL	273.20	9.00	225.88	234.88	56.72	18.80	BDL	0.83	8.01	38.83	180.00	32.30	18.21
Barukati	26.4	92.23	OW	26.9	8.39	369.10	BDL	213.20	9.00	201.46	210.46	28.36	8.98	0.20	0.98	18.01	35.19	190.00	10.27	3.01
Niskapahara	26.29	92.5	DW	27.5	8.41	288.20	0.20	166.20	9.00	195.36	204.36	21.27	0.66	BDL	0.77	12.01	31.55	160.00	12.53	3.71
Jagiroad	26.12	92.2	DW	36	8.34	465.80	0.10	268.70	9.00	170.94	179.94	67.36	18.53	BDL	0.57	20.02	26.69	160.00	38.69	13.17
Kumoi	26.19	92.25	DW	26.5	8.38	413.70	BDL	240.50	6.00	140.41	146.41	39.00	10.85	BDL	1.40	22.02	19.41	135.00	20.64	3.73
Pamibaghara	26.24	92.26	DW	26.9	8.35	183.70	BDL	106.40	9.00	79.36	88.36	31.91	8.60	BDL	0.73	22.02	9.70	95.00	10.81	3.90
Garmari Gaon	26.26	92.22	DW	27.6	7.63	251.90	BDL	146.10	BDL	67.15	67.15	31.91	10.85	34.1	0.54	28.02	16.98	140.00	5.22	2.19
Basanaghat	26.26	92.31	DW	26.4	8.37	270.60	BDL	155.30	9.00	97.68	106.68	31.91	13.92	BDL	0.71	28.02	12.12	120.00	5.84	7.50
Charibahi	26.29	92.46	OW	25.1	8.33	166.00	0.10	94.55	3.00	122.10	125.10	17.73	0.17	BDL	0.70	20.02	14.55	110.00	4.77	1.82
Tokanabari	26.28	92.42	DW	26.1	8.47	827.10	BDL	475.80	18.0	311.35	329.35	92.17	30.67	BDL	0.65	24.02	21.83	150.00	76.83	69.20
Borongabari	26.28	92.34	DW	26.7	8.38	523.80	BDL	303.50	9.00	231.99	240.99	56.72	18.50	0.27	0.58	40.03	20.61	185.00	24.40	55.92
Dighalbari Pagai	26.31	92.3	DW	26.9	7.58	157.20	BDL	89.91	BDL	85.47	85.47	14.18	7.07	0.35	0.54	12.01	14.56	90.00	6.34	2.02
Rajabari	26.35	92.23	DW	27.3	8.39	482.70	BDL	303.30	6.00	152.62	158.62	67.35	18.92	11.07	0.45	26.02	30.33	190.00	18.81	17.35
Solmari	26.24	92.38	TW	27.4	8.33	389.70	BDL	220.20	6.00	134.31	140.31	56.72	12.45	30.72	0.61	20.02	30.33	175.00	18.84	1.52
Betoni Rajasuk	26.21	92.33	DW	26.8	8..34	461.10	0.10	259.60	9.00	189.25	198.25	49.63	12.01	BDL	0.88	24.02	27.90	175.00	26.91	0.36

Sat Kendra Dharamtul	26.16	92.35	DW	27.1	7.36	103.00	0.10	58.30	BDL	54.94	54.94	17.73	4.53	BDL	0.88	12.01	9.70	70.00	3.23	1.51
Amsoi	26.13	92.42	DW	26.3	8.39	272.40	BDL	154.90	3.00	122.10	125.10	53.18	8.56	BDL	0.66	24.02	7.27	90.00	27.13	14.86
Silsang Namghar	26.12	92.35	DW	27.6	8.59	214.50	BDL	121.10	3.00	91.57	94.57	24.82	11.13	BDL	0.74	28.02	12.12	120.00	2.41	8.44
Polaguri	26.11	92.28	DW	28.2	8.32	290.10	BDL	167.50	6.00	97.68	103.68	49.63	11.98	BDL	0.54	26.02	23.05	160.00	11.59	3.06
Kathargaon	26.25	91.98	DW	27.1	8.48	604.10	BDL	342.10	9.00	164.83	173.83	92.17	16.48	25.30	0.73	20.02	32.76	185.00	45.07	5.00
Mayang Police Station	26.26	92.04	DW	26.4	8.66	564.10	0.20	323.10	9.00	213.67	222.67	46.08	10.94	1.16	1.10	16.01	38.83	200.00	23.77	0.30
Karmarpur	26.22	92.03	DW	26.2	7.94	389.70	BDL	224.20	BDL	42.73	42.73	67.36	11.79	36.25	0.54	32.03	16.97	150.00	15.79	4.84
Buraburi bazaar	26.23	92.11	DW	27.1	8.39	1032.00	BDL	590.60	9.00	195.36	204.36	194.98	17.50	4.54	0.91	92.07	27.87	345.00	45.21	4.65
Manaha Kacharigaon	26.22	92.17	DW	27.3	8.49	435.30	0.20	248.60	6.00	128.20	134.20	31.91	12.05	BDL	1.30	20.02	16.98	120.00	15.81	4.29

Annexure VI : Irrigation Statistics/data pertaining to Morigaon-Laharighat-Jagiroad Division (Irrigation), Jagiroad

Sl. No.	Name of Scheme	Block	Source of Irrigation Water	Command Area (in Ha)	Season Wise & Crop Wise Irrigated Area						
					Rabi & Pre Kharif						Kharif
					Bodo Paddy	Sugarcane	Jute	Mustard	Others (Vegetables/Maize)	Total	(Sali Paddy)
1	2	4	5	6	7	8	9	10	11	12	13
Surface Water Irrigation											
1	Udari LIS	Bhurbandha	LIS from water body	40	18	0	2	10	0	30	0
2	Revival and Remodelling of Ahotguri LIS	Bhurbandha	LIS from River	300	178	0	0	48	24	250	0
3	Barunguri Pathar IS	Bhurbandha	LIS from river	120	27	3	3	20	7	60	0
4	Basanaghat LIS	Bhurbandha	LIS from river	100	38	0	0	11	1	50	20
5	Charaihagi LIS	Bhurbandha	LIS from river	40	0	0	0	0	0	0	0
6	Jengorbori L.I.S	Laharighat	LIS from natural water body	120	21	1	0	8	10	40	0
7	Bhuyanbari Pathar IS	Laharighat	LIS from natural water body	120	25	0	0	6	9	40	0
8	Besamari LIS	Laharighat	LIS from natural water body	120	28	0	0	7	5	40	14
9	Lahorighat LIS	Laharighat	LIS from natural water body	810	0	0	0	0	0	0	0
10	Sonduba L.I.S	Laharighat	LIS from natural water	730	0	0	0	0	0	0	0

			body								
11	RajagadhuwaPathar LIS	Laharighat	LIS from natural water body	120	0	0	0	0	0	0	0
12	Satiantoli L.I.S	Laharighat	LIS from natural water body	120	17	0	0	12	11	40	0
13	Thengbhanga PC2A	Mayang	LIS from river	40	20	0	0	13	7	40	0
14	Thengbhanga PC 2B	Mayang	LIS from river	40	25	0	0	10	5	40	0
15	Borpakghat PC 1	Mayang	LIS from river	40	10	0	0	8	2	20	0
16	Thengbhanga PC5	Mayang	LIS from river	40	30	0	0	4	6	40	0
17	Chotabori PC 1,2 & 3	Mayang	LIS from river	120	40	0	0	25	15	80	27
18	Chotabori PC 4	Mayang	LIS from river	40	15	0	0	8	2	25	6.5
19	Jagiroad Sapna Mazika FIS	Mayang	FIS (Stream)	105	50	0	0	3	7	60	0
20	Dimaruguri PC	Mayang	LIS from river	40	32	0	0	0	8	40	8
21	Sarukuloi&Borkuloi PC	Mayang	LIS from river	120	70	0	0	30	20	120	13
22	Rajakuchi PC	Mayang	LIS from river	40	25	0	0	5	10	40	7
23	Bordoloni PC 1	Mayang	LIS from river	40	22	0	0	5	3	30	0
24	Bordoloni PC 2	Mayang	LIS from river	40	19	0	0	11	10	40	0
25	Borpak PC 1	Mayang	LIS from river	40	20	0	0	12	3	35	0
26	Borpakghat PC 2	Mayang	LIS from river	40	14	0	0	0	8	22	0
27	Murkota I/S.	Mayang	LIS from river	200	70	0	0	5	45	120	0
28	Improvement of Diprang PC	Mayang	LIS from river	40	20	0	0	8	12	40	0
29	Renovation of Matiapahar PC	Mayang	LIS from river	80	26	0	0	0	12	48	0
30	Improvement of Thengbhanga PC1	Mayang	LIS from river	40	30	0	0	6	4	40	0

31	Renovation of Thengbhanga PC 3	Mayang	LIS from river	40	28	0	0	8	4	40	0
32	Improvement of Hatigarh LIS	Mayang	LIS from river	60	33	0	0	7	20	60	0
33	Dungabori PC2 (Improvement of Baghjap PC)	Mayang	LIS from river	40	12	0	0	2	6	20	18
34	Khudradal PC	Mayang	LIS from river	40	22	0	0	7	11	40	12
35	Barjari PC 1	Mayang	LIS from river	40	11	0	0	3	6	20	4
36	Buraburi ELIS	Mayang	LIS from river	110	60	0	0	20	20	100	0
37	Jagi PC 2	Mayang	LIS from river	40	14	0	0	0	6	20	0
38	Barpaktup PC	Mayang	LIS from river	40	16	0	0	11	1	28	4
39	Dungabori PC1	Mayang	LIS from river	40	21	0	0	10	9	40	0
40	Sarumanaha PC 1 & 2	Mayang	LIS from natural water body	40	18	0	0	2	10	30	0
41	Nepali Khuti PC	Mayang	LIS from river	40	25	0	0	5	3	33	8
42	Thengbhanga PC 4	Mayang	LIS from river	40	27	0	0	3	10	40	0
43	Bahapahar PC 2	Mayang	LIS from river	40	30	0	0	4	6	40	0
44	Bahapahar PC 1	Mayang	LIS from river	40	29	0	0	1	10	40	10.5
45	Thengbhanga Kalimandir PC	Mayang	LIS from river	40	32	0	0	3	5	40	0
46	Rajamayong ELIS	Mayang	LIS from river	600	250	0	0	60	90	400	13
47	Barmanaha ELIS	Mayang	LIS from natural water body	405	190	0	0	55	55	300	29
48	Baruntola PC	Mayang	LIS from river	60	17	0	0	2	8	27	4
49	Sarumanaha PC 1	Mayang	LIS from natural water body	40	22	0	0	3	5	40	0
50	NabahatiaKhanajan PC	Mayang	LIS from river	120	60	0	0	15	25	100	0

51	Nepali Khanajan PC	Mayang	LIS from river	64	26	0	0	8	6	40	13
52	Silbheta LIS	Mayang	LIS from river	120	45	0	0	13	12	70	5.3
53	Kanjulipathar PC of Kamarpur LIS	Mayang	LIS from river	60	30	0	0	11	19	60	0
54	Thengkhari Borholapathar LIS (PC 1)	Kapili (Part)	LIS from river	160	105	0	0	32	3	140	0
55	Thengkhari Borholapathar LIS (PC 2)	Kapili (Part)	LIS from river	160	97	0	0	3	5	105	0
56	Charaibahi LIS (PC-1,PC-2, PC-3)	Kapili (Part)	LIS from river	180	63	0	0	13	4	80	4
57	Borbheti PC	Kapili (Part)	LIS from river	40	27	0	0	8	5	40	3
58	Jagi PC 1	Kapili (Part)	LIS from river	40	23	0	0	7	3	40	4
	TOTAL COMMAND AREA =			**6624**			**5**			**3463**	**227.3**
Ground Water Irrigation											
1	Oujarigaon DTWS	Bhurbandha	DTW	40	0	0	0	0	0	0	0
2	Khatorbori DTWS	Bhurbandha	DTW	40	13	0	0	5	2	20	5
3	Patidaya DTWS (Pt-1)	Bhurbandha	DTW	40	14	0	0	0	6	20	5.27
4	Patidaya DTWS (Pt-2)	Bhurbandha	DTW	40	17	0	0	0	5	22	9.6
5	Tengaguri DTWS	Laharighat	DTW	40						25	10
6	Darangialgaon DTWS	Mayang	DTW	40	18	0	0	0	4	22	3
7	Alikuchi Pathar DTW Scheme (1 Point) at Alikuchi Area	Kapili (Part)	DTW	50	26	0	0	8	6	40	0
8	Bechapatty to Manipurtup DTW Scheme (1 Point) at	Kapili (Part)	DTW	25	12	0	0	5	3	20	0

	Manikpurtup village										
9	Dharamtul DTWS	Kapili (Part)	DTW	40	22	0	0	6	2	30	2.6
10	Basanaghat Pathar (1Pt.) under RIDF-XXV (NABARD) for the year 2019-20	Bhurbandha	MDTW	10	7	0	0	2	1	10	0
11	Nowkata Pathar MDTW (Solar) Scheme under RIDF-XXV (NABARD)	Bhurbandha	MDTW	10	6	0	0	3	1	10	0
12	Jurahat MDTW Scheme (Solar) under SOPD for the year 2020-21	Bhurbandha	MDTW	10	8	0	0	0	2	0	0
13	Gasarguri MDTWS (Solar)	Bhurbandha	MDTW	10	7	0	0	1	2	10	3.93
14	Manipur gaon STWS PT 1-20	Bhurbandha	STW	105	38	0	0	11	13	62	0
15	Borchala MDTW Scheme (Solar) under SOPD for the year 2020-21	Laharighat	MDTW	10	0	0	0	0	0	0	0
16	Hatimuria MDTW (Solar) Scheme (1 Pt.) under SOPD for the year 2020-21	Laharighat	MDTW	10	0	0	0	0	0	0	0
17	Barhampur MDTW (Solar) scheme under RIDF-XXV (NABARD) for the year 2019-20.	Mayang	MDTW	10	6	0	0	3	1	10	0

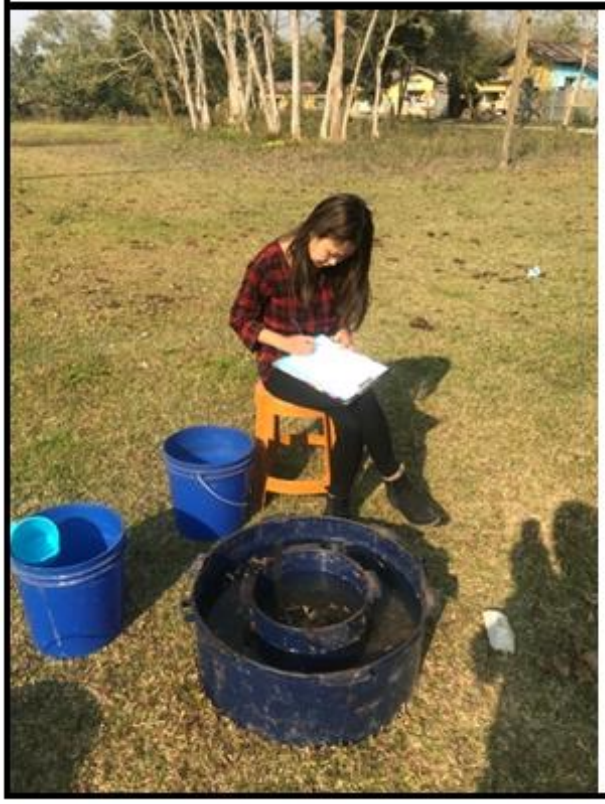
18	Borola MDTW (Solar) Scheme under RIDF-XXV (NABARD) for the year 2019-20	Mayang	MDTW	10	5	0	0	2	3	10	0
19	Bihita MDTWS (Solar)	Mayang	MDTW	10	7	0	0	1	2	10	0
20	Ahotguri Morakollongpather MDTWS (Solar)	Mayang	MDTW	10	6	0	0	2	2	10	0
21	Barhampur Point No.-2 MDTW (Solar) Scheme (1 Pt.) under SOPD for the year 2020-21	Mayang	MDTW	10	0	0	0	0	0	0	0
22	Installation of 150 Numbers Tube well scheme under PMKSY HKKP access to ground water (phase II) under 80-**Morigaon LAC** (38 Nos. solar TW and 112 Nos. Electrical TW) under Morigaon Division Irrigation, Morigaon for the year 2020-21	Bhurbandha (118)	STW	472	260	0	0	60	80	400	100
		Dologghat (3)		12							
		Kapili (26)		104							
		Mayang (3)		12							

23	Installation of 90 nos tube well scheme Under PMKSY- HKKP - access to ground water (Phase II) under 81 **Laharighat LAC** (23 nos solar TW and 67 NOs Electrical TW) under Morigaon Division Irrigation, Morigaon for the year 2020-21	Laharighat	STW	360	210	0	0	90	48	348	120
24	Installation of 150 nos tube well scheme Under PMKSY- HKKP - access to ground water (Phase II) under 79 **Jagiroad LAC** (38 nos solar TW and 112 NOs Electrical TW) under Morigaon Division Irrigation, Morigaon for the year 2020-21	Mayang	STW	600	198	0	0	88	110	396	140
	TOTAL COMMAND AREA =			**2130**			**0**			**1475**	**399.4**
			Gross Total=	**8754**			**5**				**626.7**

FIELD PHOTOGRAPHS

Water level measurement

GW quality analysis in the field analysis



Soil infiltration test