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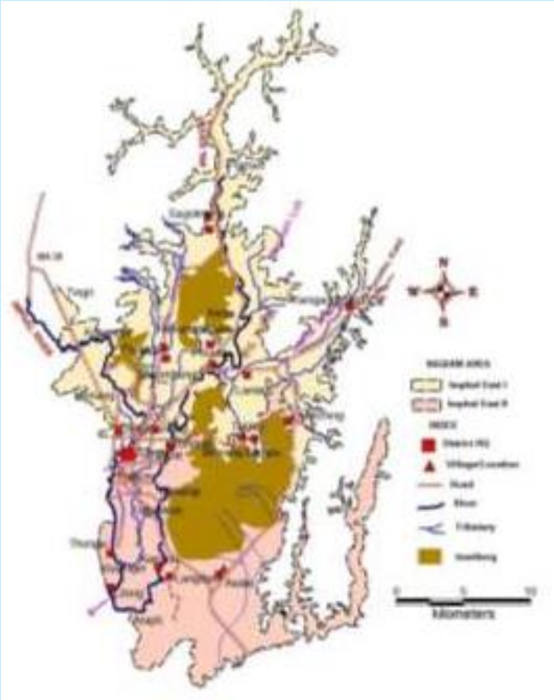
MINISTRY OF JAL SHAKTI
जल शक्ति मंत्रालय
DEPARTMENT OF WATER RESOURCES, RD & GR
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
CENTRAL GROUND WATER BOARD
केंद्रीय भूमि जल बोर्ड

AQUIFER MAPPING AND MANAGEMENT PLAN OF IMPHAL EAST DISTRICT, MANIPUR

ANNUAL ACTION PLAN, 2017-18



NORTH EASTERN REGION
उत्तरपूर्वी क्षेत्र
GUWAHATI
गुवाहाटी

GOVERNMENT OF INDIA

MINISTRY OF JAL SHAKTI, DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

REPORT
ON

"AQUIFER MAPPING AND MANAGEMENT PLAN OF IMPHAL EAST DISTRICT, MANIPUR"

(AAP 207-18)

By
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CENTRAL GROUND WATER BOARD
NORTH EASTERN REGION
GUWAHATI

Preface

Under National Aquifer Mapping and Management Plan (NAQUIM) program, Central Ground Water Board, North Eastern Region, Guwahati, Assam has carried out aquifer mapping and management plan in Imphal East district of Manipur. The objective was to understand the aquifer system down to the depth of 300 meters, decipher the aquifer geometry, its characteristics, quantity, quality and formulate a complete sustainable and effective management plan for groundwater development.

A multi-disciplinary approach of geology, geophysics, hydrology and chemistry was adopted to achieve the objectives of the study. A management plan was made with emphasis on irrigation for agriculture.

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

The groundwater management plan was made with an emphasis in providing irrigation facilities through groundwater development as agriculture is the main means of livelihood of the people in the district.

The study of the Aquifer mapping and management plan of Imphal East district was carried out under the guidance and supervision of Regional Director, CGWB, NER, Guwahati, Technical Secretary to RD, CGWB, NER, Guwahati and Nodal officer, NAQUIM, NER who has helped in all the aspects of technical inputs and report preparation.

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

Acknowledgement

I would like to acknowledge all the below mentioned for their help and support in all aspects related to this work.

At the outset, I would like to extend my heartfelt gratitude to Shri. G L Meena, Regional Director, CGWB, NER, Guwahati (now, Member (N&W) for his support and guidance during the course of study.

I render my sincere thanks to my supervisor Shri Tapan Chakraborty, Nodal officer of NAQUIM, NER and Shri Biplap Ray, HOO, CGWB, NER, Guwahati for their support, technical input, encouragement during the year.

Sincere thanks to Dr. D. J. Khound, Scientist-B for the technical inputs and guidance in preparation of report.

I would like to thank all the officers and staff of the Regional Chemical laboratory, NER, Guwahati for analysing the ground water samples and providing the data. I thank all the Engineers and Drilling staff of CGWB, Division VII, Guwahati for their contribution in ground water exploratory drilling activities in the study area.

I would also like to thank State Government officials of Irrigation Department, Minor Irrigation Department, Water Resources Department, Public Health Engineering Department, Statistical Department and Agricultural Department for providing the data and necessary information of the district.

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ABBREVIATION

AAP	Annual Action Plan
AMP	Aquifer Management Plan
AQM	Aquifer Mapping
BIS	Bureau of Indian Standards
BDL	Below detectable level
BCM	Billion Cubic Metres
CGWB	Central Ground Water Board
DGM	Directorate of Geology and Mining
DTWL	Depth to water table
DW	Dug Well
°C	Degree Celsius
EC	Electrical Conductivity
EW	Exploratory Well
GEC	Ground water Estimation Committee
GL	Ground Level
GIS	Geographic Information System
GSI	Geological Survey of India
Ha	Hectare
Ham	Hectare meter
IE	Imphal East
IMD	Indian Meteorological Department
IPD	Investigation & Planning Division
Km	Kilometre
LPM	Litres per minute
LPS	Litres per second
m	Metre
MASTEC	Manipur Science and Technology Council
Magl	Meter above ground level
mbgl	Meters below ground level
MCM	Million Cubic Meter
Mm	Milli meter
mg/l	milligram/litre
mamsl	Metre above mean sea level
MP	Measuring Point
MID	Minor Irrigation Department
µS/cm	Micro Siemens/centimetre
NAQUIM	National Aquifer Mapping and Management Plan
NER	North Eastern Region
OW	Observation Well
PHED	Public Health & Engineering Department
Ppm	Parts per million equivalents to mg/l
Pz	Piezometer
Sq.Km	Square Kilometre
SWL	Static water level
TDS	Total dissolved solid
TW	Tube Well
VES	Vertical Electrical Sounding
WRD	Water Resources Department

EXECUTIVE SUMMARY

Aquifer Mapping studies and Management Plan has been carried out in Imphal West district, Manipur under National Aquifer Mapping and Management Plan (NAQUIM) programme with an objective to know the different aquifer system prevailing in the study area, decipher the vertical and lateral extend of the aquifer down to the depth of 300 m, its characteristic, quantity as well as quality so as to bring a complete sustainable and effective aquifer management plan for ground water resources development in the district. This study has been done through multi-disciplinary approach so as to achieve the desired objectives.

The Imphal East district occupies the north eastern corner of the Manipur (Imphal) Valley. The district is bounded by latitudes 24°39'49.09" North to 25°4'5.45" North and longitudes 93° 55'30" East to 94° 8'42" East. The Senapati district bounds on the north and east, Thoubal district on the south and Imphal West district on the west. The Jiribam sub-division lies between latitudes 24°33' 49.09" N and 24° 51' 19.64" N and longitudes 93° 3' 39.6" E and 93° 15' E approximately and it is bounded on the north-east by Tamenglong district, north and west by Assam state and south-east by Churachandpur district.

Physiographically, the study area shows three prominent units i.e., a tiny plain topography and hilly areas. The valley is surrounded in all sides by hill ranges of denudostructural nature trending NNE-SSW direction. A number of isolated hillocks of denudational remnants are found within the valley. The Iril River, Imphal River, Thoubal River and some small streams like Kongba River, Naga River, Leimakhong River, etc. drain the district. The Iril River drains almost the entire district.

The district enjoys sub-tropical humid climate. Average annual rainfall in the area is 1632.4 mm. The average annual rainfall for last 5 years in Imphal East district is 1502.9 mm (as per IMD, data). The maximum rainfall is observed in the month of June and minimum is in the month of January. About 68 % of the annual rainfall is received during the period of June to September, July being the rainiest month of the year. Rainfall mostly as thundershowers occurs in the pre-monsoon months of April and May and in October.

Groundwater in the deeper aquifers occurs under sub-artesian and artesian conditions. Discharge of the tube wells constructed by State government ranged from 0.6 to 4 m3/hr. Considering the clayey nature of formation in the top aquifer, groundwater development is not considered promising on a large scale either in irrigation or water supply. Hydrogeological studies revealed that the valley area is underlined by a thin veneer of alluvial deposits, which is largely clayey in nature, underlined by rocks of Tertiary age. Since the upper formations are mainly silty and clayey, dug wells/open wells have poor yield prospects. However, the deeper zone, consisting of sandstones of Tertiary age, forms good aquifers which are under semi confined conditions. Auto flow conditions are also observed in the study area with a discharge range of 0.5 to 4.0 m3/hr.

The ground water quality is within permissible limit except for concentration of iron, which is found to be beyond permissible limit in certain pockets. The district has moderate groundwater potential and available net groundwater resource is 11536.9 ham. This available resource can be developed for irrigation and other domestic purposes.

The groundwater extraction by existing tube-wells for irrigation was 33.11 ham and development are found to be 0.36 %, as such scope exists for development of groundwater in the district. Based on the irrigation water requirement, additional 2063 nos. of medium duty shallow tube wells may be constructed, which will be able to generate irrigation potential of 6190 ham. The conjunctive use of surface and groundwater may be done for better ecological conditions of the district. As the district is blessed with good amount of rainfall, rain water harvesting structures may also be constructed for storing and artificial recharge of groundwater

Groundwater related problems of the district so far been identified is emanation of gas while construction of deep tube wells and existence of clayey deposit down to a depth range of 30 to 50 mbgl which invites problem for construction of tube wells. As such utmost care has to be taken during construction of tube wells so that any untoward incident can be averted.

Other groundwater related issues found in the district are low stage of ground water extraction, irrigation through ground water is not practice in large scale by individual villagers due to small land holding, high cost for construction and running of a well compared to production outcome. Another major obstacle in accelerating groundwater irrigation is the absence of power supply in most of the cultivated/cultivable area and meagre irrigational infrastructure and in major parts of the study area.

As per groundwater quality analysis data, it was found that groundwater in the district has found higher concentration of iron, which needs to be treated before consumption.

Available unirrigated land of 26712 ha can be brought under irrigation using the dynamic groundwater resources available in the district. It is proposed to bring 60% of area under paddy and 40% under non-paddy cultivation. Water requirement for paddy cultivation (Δ=1.2 m) would be 14698.80 ham while that for non-paddy cultivation (Δ=0.3 m) would be 9799.30 ham. Total water requirement to bring this entire uncovered area under irrigation is 24498.1 ham.

Although, groundwater cannot supply the entire irrigation water requirement, it can safely fulfil the demand of rabi crops including the rabi rice. However, kharif rice irrigation demand has to be filled up by surface irrigation schemes. Groundwater shortage can be further be reduced by increasing the irrigation efficiency.

Development of rainwater harvesting for the drinking water supply is also one of the appropriate measures for solving the scarcity of potable water as it involves relatively low cost, less time for implementation and provides almost entirely safe drinking water which does not require costly purification and treatment process.

Rooftop rainwater harvesting is yet to be exploited in the district. The district is facing acute drinking water shortage as the government's water supply facilities fully depends on the rivers and which are generally remain dry during the dormant season. Rooftop rainwater can be one of the best options to stored quality water for use during the dormant months. During the water crisis period, there are many other private traders who supply the drinking at much higher price, which increases hardship to the common people. Groundwater resources are not yet exploited in Manipur, so groundwater can be one of the options for supplies of water during non-rainy months and same groundwater can be recharged during the monsoon months.

AQUIFER MAPPING STUDY REPORT OF IMPHAL EAST DISTRICT, MANIPUR

1.0 INTRODUCTION

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers.

An area of 709 sq km covering Imphal East (undivided) district of Manipur has been undertaken as part of the National Aquifer Mapping Programme during the year 2017-18 by Central Ground Water Board, North Eastern Region, Guwahati.

1.1 Objectives

The objective of the study can be defined as follows:

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

1.2 Scope of the Study

This study was carried out to obtain an updated picture of groundwater occurrence, availability; its utilisation and also prevailing status of water quality with reference to the previous studies.

An accurate and comprehensive picture of the groundwater of the district may be generated by hydrogeological studies through groundwater exploration, geophysical and hydro chemical studies. The output of the study will enable robust groundwater management plans at the appropriate scale to be devised and implemented for this common-pool resource. This will help achieving drinking water security, improved irrigation facility and sustainability in water resources development in the rural as well as urban areas. This study is also important for planning suitable adaptation strategies to meet climate change in the area.

Therefore, hydrogeological information can be gathered in the entire study area. Similarly scope of exploration and use of geophysical technique to gather subsurface information can also be carried out.

1.3 Approach and Methodology

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

The methodology can be illustrated as follows:

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

Data Generation: Efforts were made to fill the data gaps by multiple activities such as exploratory drilling, geophysical techniques, hydro-geochemical analysis, water level monitoring, yield tests and soil infiltration studies. The structure contours of the study area have been matched across the existing map boundaries (geological, hydrogeological) of the Manipur Valley. New data of groundwater abstraction structures were collected during the aquifer mapping study by selecting key areas in the district and have been re-defined in the context of local hydrogeological set up and new findings.

Aquifer Map Preparation: On the basis of integration of data generated from aforesaid studies, aquifers have been delineated and characterized in terms of its potential and quality. Various maps have been prepared by 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). Relationship between the groundwater management units and the mapping units has been interpreted based on the findings of aquifer parameters from the existing hydrogeological data, litholog, quantity and quality of groundwater etc.

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

The aquifer mapping requires the analysis of large amounts of exploratory data. To ensure an efficient and logical approach to the study, data of the existing exploratory wells of CGWB and wells constructed by State Departments were also considered for better correlation of aquifer parameters.

1.4 Area Details

An area of 709 sq km covering Imphal East (undivided) district of Manipur has been undertaken as part of the National Aquifer Mapping Programme during the year 2017-18 by Central Ground Water Board, North Eastern Region, Guwahati.

The Imphal East district occupies the north eastern corner of the Manipur (Imphal) Valley but one of its sub-divisions namely Jiribam sub-division is geographically located on the western state border about 222 kms. The district falls under the Survey of India topo sheet Nos. 83 H/13, H/14, 83L/1 & L2 bounded by latitudes $24^0$39’49.09" North to $25^0$4’5.45" North and longitudes 93^0 55’30" East to 94^0 8’42" East. The Senapati district bounds on the north and east, Thoubal district on the south and Imphal West district on the west. The Jiribam sub- division lies between latitudes $24^0$33’ 49.09" N and 24^0 51’ 19.64" N and longitudes 93^0 3’ 39.6" E and 93^0 15’ E approximately and it is bounded on the north-east by Tamenglong district, north and west by Assam state and south-east by Churachandpur district. The Imphal East district excluding the portion of Jiribam sub-division looks like a bunch of flowers as interrupted by the Nongmaijing hill and other surrounding hills of the Senapati district. The total area of the district is 709 sq. km.

There are four Revenue Sub-Divisions in the district namely: - (1) Porompat Sub-Division; (2) Sawombung Sub-Division; (3) Keirao Bitra Sub-Division and (4) Jiribam Sub-Division. The total number of SDC Revenue Circles in the district is 9 (nine). There are 237 Revenue villages in the district. The total number of urban local bodies is 4 (four) comprising of 2 (two) Municipalities and 2 (two) Nagar Panchayats. The 2 Municipalities are Imphal Municipal Council and Jiribam Municipal Council whereas the 2 (two) Nagar Panchayats are Andro Nagar Panchayat and Lamlai Nagar Panchayat.

There are 2(two) C.D. Blocks in the district namely: - (1) Imphal East-I C.D. Block, Sawombung; (2) Imphal East-II C.D. Block, Keirao Bitra. There is altogether 56 Gram Panchayats in the District. The District Headquarters of Imphal East is at Porompat which is lying in between the Imphal River in the west and Kongba River in the east.

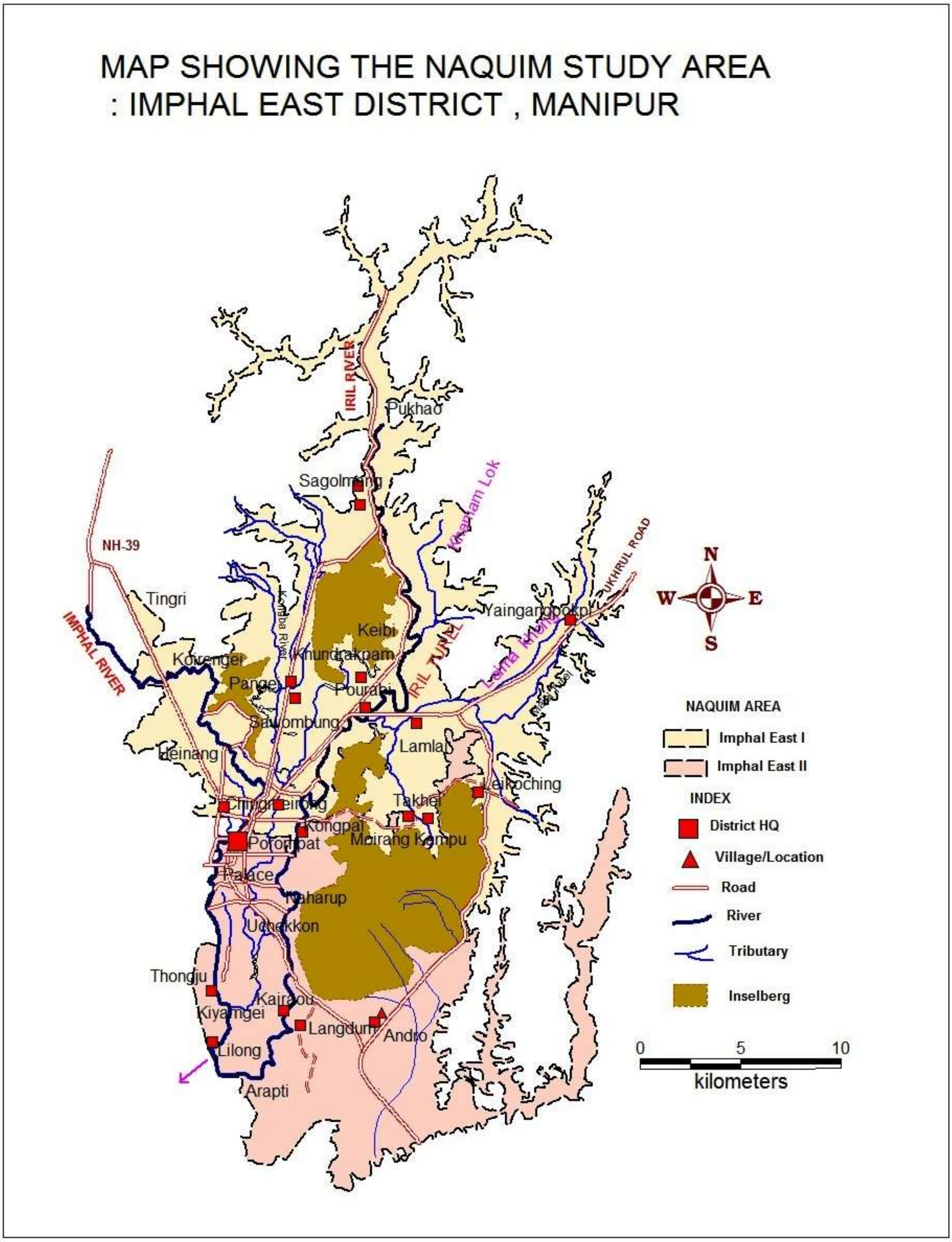


Fig.1 Index map of the NAQUIM study area: Imphal East district, Manipur

Table: 1. Administrative Sub-Divisions of Imphal East district, Manipur

District	Block	Area in sq.km.	Sub-Division	Head Quarters	No. Of Villages
Imphal East (Porompat is the district HQ)	Imphal East-I	232.90	Jiribam	Jiribam	51
			Sawombung	Sawombung	67
			Porompat	Porompat	50
	Imphal East-II	476.10	Keirao Bitra	Keirao Bitra	36
Total		**709**			**204**

Source: Directorate of Economics & Statistics, Govt. of Manipur

As per 2011 census, the total population of Imphal East district is 452661, out of which 226094 are male and 230019 are female population.

The district is connected with all other valley districts, hill districts and other States by State Highways and National Highways and also linked by air with Silchar, Guwahati, Dimapur, Calcutta, Delhi, etc. Dimapur, the nearest rail head is at a distance of 211 km from Imphal. The district is connected with N.H.39, N.H.53 and N.H.150. Air-ways and other road communication are also connecting other states of the country.

The study area is a part of the centrally located intermontane valley, i.e., Imphal valley of Manipur. It is bounded on the north and east by Senapati district, on the south by Thoubal district and on the west by Imphal west districts. The area covers fertile plain of Imphal valley.

Physiographically, the study area shows three prominent units i.e., a tiny plain topography and hilly areas. The valley is surrounded in all sides by hill ranges of denudostructural nature trending NNE-SSW direction. A number of isolated hillocks of denudational remnants are found within the valley. The Iril River, Imphal River, Thoubal River and some small streams like Kongba River, Naga River, Leimakhong River, etc. drain the district. The Iril River drains almost the entire district.

1.5 Data availability, data adequacy, data gap analysis and data generation

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

GSI has carried out geological studies in Imphal valley to delineate the lithological units, their structures and stratigraphic disposition. Public Health Engineering Department, Govt. of Manipur has also constructed 20 tube wells for domestic purposes. In addition to these data of 02 exploratory wells constructed by CGWB, NER, Guwahati during the study on hydrogeology and ground water conditions of Imphal valley in the year 1975, which falls in the NAQUIM area has also been incorporated for better comparison with the present exploratory data. The available data, data gap and data generation work is tabulated in Table 2

Table 2: Data availability, data gap and data generation in Imphal East district, Manipur

SN	Theme	Type	Data available	Data gap	Data generation	Total	Remarks
1	Borehole Lithology Data	Tube Well	14	6	Nil	20	Maximum depth of well is 98.3 mbgl only
2	Geophysical data	VES	39	6	Nil	45	Maximum depth of interpretation is 70 m
3	Groundwater level data	STW	Nil	15	12	27	
		DTW	Nil	5	5	10	
4	Groundwater quality data	Dug well Aquifer-I	Nil	6	01	07	
		Piezometer Aquifer-I	Nil	6	6	12	
5	Specific Yield		Nil	7	Nil	7	
6	Soil Infiltration Test		Nil	12	Nil	12	

1.6 Rainfall-spatial, temporal and secular distribution:

The study area enjoys sub-tropical humid climate. Average annual rainfall in the area is 1632.4 mm. About 60 to 65 % of the annual precipitation is received during south-west monsoon from June to September. Annual average temperature of the study area is recorded to be 20.4^{0}C and the temperature ranges from 0^{0}C to 36^{0}C. The relative humidity is high.

The beginning of winter is marked by a steep fall in temperature during December. January is the coldest month. In February the temperature starts rising gradually. The winter winds are generally weak and variable. The average annual temperature ranges from 18°C-20°C to 23°C-25°C respectively in the higher and lower elevation. The monsoon lasts for five months from May to September with June, July and August being the wettest months. The following agro-climatic zones are the main characteristic zones in the area:

- The cold season (December, January, February)
- The hot dry season (March, April)
- The rainy season (May, June, July, August, September)
- The Retreating monsoon season (October, November)

Records of rainfall in the study area are available for the periods of last fifty years. The average annual rainfall for last 5 years in Imphal East district is 1502.9 mm (as per IMD, data). The maximum rainfall is observed in the month of June and minimum is in the month of January. About 68 % of the annual rainfall is received during the period of June to September, July being the rainiest month of the year. Rainfall mostly as thundershowers occurs in the pre-monsoon months of April and May and in October.

Table.3 Monthly Rainfall data in mm for the last 5 years in Imphal East district

Rainfall in mm

Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
2013	0.0	1.0	29.0	103.7	376.2	137.9	275.9	313.8	250.1	75.9	0.0	1.3	1564.8
2014	0.0	23.0	29.4	36.2	228.8	308.5	72.3	228.1	99.8	31.0	0.0	0.0	1057.1
2015	41.3	5.4	17.8	199.9	45.5	225.1	328.6	251.3	154.2	112.7	9.8	0.2	1391.8
2016	6.6	25.6	51.0	211.9	310.9	153.5	305.9	89.1	162.3	122.9	58.5	2.1	1500.3
2017	7.2	20.1	212.2	209	150.9	275.2	358.2	124.3	301.7	234.9	3.6	103.2	2000.5
Average Annual Rainfall for the last 5 years in Imphal East district													1502.9

(Source: IMD Rainfall Data, Imphal)

1.7 Physiographic set up

Physiographically, the study area shows three prominent units i.e. a tiny plain topography, hilly areas and marshy land in the south-western periphery. The NAQUIM area as a whole fall in Imphal valley and it is virtually a flat alluvium filled valley. The valley area is nearly 780 m high above the mean sea level with a very low southerly gradient. The valley is surrounded in all sides by hill ranges of denudostructural nature trending NNE-SSW direction. A number of isolated hillocks of denudational remnants are found within the valley.

As for Jiribam sub-division, bordering Assam the Vangai range, which forms a wall in the eastern side stretching north - south as high as 708 metres above the MSL separates the sub-division from the Tamenglong and Churachandpur districts. The eastern portion of the sub-division is topographically, higher than the western portion containing the basins of the Barak and Jiri rivers.

1.8 Geomorphology

Flat elongated and south tapering valley with isolated hills are the main geomorphologic features around the study area. The study area is part of an intermountain valley surrounded by hillocks. The western part is flanked by abruptly rising hills while by low-lying rolling hills bound the eastern side. The average trend of slope is down from north to south from an altitude of 880 to 770 meters above MSL, which is common in Imphal valley.

Geomorphologically, the study area is classified into the following geomorphic units

Table.4. Geomorphic units in the study area (after Singh, 1993 &1996)

Geomorphic Unit of Imphal Valley (After Singh, 1993)	Geomorphic Unit of Imphal Valley (After Singh, 1996)
Alluvial Plain Flood Plain Abandoned Channel Meander Scar Natural Leeves Point bars Structural Hills Piedmonts Valley fills	Intermontane Valley (Alluvial Plain) Piedmont Structuro-Denudational hill Denudational hill Denudo-structural hill

Structural Hills

These hills are confined along the border of Imphal which further extends into the valley. Some hills like Khundrakpam and other small hillocks such as Angom Leikai (820 m), Chingaren (804 m) and Chingmeirong (802m) dotted in the district, however, partly belong to the Barail Group that was formed during the Oligocene and appear Eocene periods.

The Mount Nungsikom located in the Khundrakpam hill as high as 1,168 metres above the mean sea level (MSL) is the highest relief in the district. Generally, the district slopes southwards. The Nongmaijing hill administratively under the Senapati district stretches north - south from the Kameng village to the end of the district boundary as high as 1,565 metres near Nongmaijing Chiru village disturbs the physical feature of the district. They consist of shales and intercalations of sandstone belonging to the Disang Group. The drainage patterns are of sub-dendritic to sub-trellis. The structural hills are further sub classified into the following:

Denudo-Structural Hill: In the study area, it occupies the eastern, western, and northern parts with the highest relief of about 1565 m above men sea level. It consists of splintery shale, sandstones and siltstones of Disang Group of Upper Cretaceous to Eocene age. These hills have dendritic to sub dendritic drainage pattern. The drainage density is moderate to high as studied qualitatively.

Residual Hill (Denudational Hill): Residual hills are demarcated in the central part of the study area, with relief ranging from 900 to 1100 m above mean sea level. These are flanked on all sides by alluvial plain deposits. These hillocks lithologically consist of splintery shale, with sandstone and siltstone belonging to Disang Group of Eocene to Upper Cretaceous age. Sub-dendritic and radial drainage pattern are observed with moderate to fine drainage texture.

Structuro-Denudational Hill: These hills occupy the north eastern part of the district with highest relief of about 2331 m above mean sea level and consist lithologically of sandstone, shale, siltstone,

Piedmont: It is well demarcated in the eastern and northern margin of the alluvial valley surrounding the foot hill. It consists of colluvial and alluvial deposits comprising gravel, pebble, boulder, sand with silt/clay intercalations, formed by deposition of materials brought down by streams draining from the surrounding hills. This piedmont zone in the study area shows sensorial, coarse, braided and fanning stream patterns. Alluvial fans are prominently seen in this zone, which consists of sand, silt and clay.

Alluvial plain (Intermontane valley)

It occupies major part of the study area. The elongated intermontane valley consists of thick sequence of fluvio-lacustrine deposits. The average relief is about 780 m above mean sea level. The alluvial plain is made of rhythmic layering of sand, silt and clay. This zone shows coarse meandering to dendritic drainage pattern. The Imphal River is the major river with most of the major streams joining it. This unit, as a whole, was reported to have been a lake and filled in with the sediments brought down by streams draining from the surrounding hills. The southern part of the plain is covered by water bodies and marshes which are flooded during rainy season. Infilled channels seen in the alluvial valley consists of gravel, sand and clay in order of sequence. In the study area, a few infilled lakes e.g. The Lamphelpat (pat locally means lake) has been observed. This has been filled up with sediments.

In filled valleys are seen in the upper reaches of the major rivers in the district. The unconsolidated materials like gravel, pebble and loose sand are particularly favourable position to receive the water of the hill streams and transit it to all parts of the valley fill. They are filled with sand, gravel, pebble etc. In filled valleys are exposed at Yaingangpokpi Bazar, Sanasabi, Salu Dolaithabi etc. Groundwater potential is good to excellent in this zone.

Flood Plain

Flood Plains are the essential product of stream erosion. These are observed in most part of the study area along courses of Imphal and Iril River. Along Imphal river flood plains are extended more than 300 metre, e.g., Nilakuthi and Khabam area. These deposits are prominent along Imphal river at many places, e.g., Pukhao, Sawombung, Kanglasiphai etc. The common associated fluvial landforms such as meander scars meander loop, ox-bow lakes, natural leaves and river bars were identified by Singh (1993). Lithologically, it consists of sandy clay, gravel mixed with sand etc.

Valley Fills

Valley fills in the study area consist of unconsolidated and imperfect unsorted materials comprising of clay matrix embedded with pebbles and boulders. Valley fills in the study area were identified near the villages Laitalpokpi, Yaingangpokpi etc.

1.9 Land use Pattern: Land use pattern of the villages in different blocks are given in the following table (Table: 1.4)

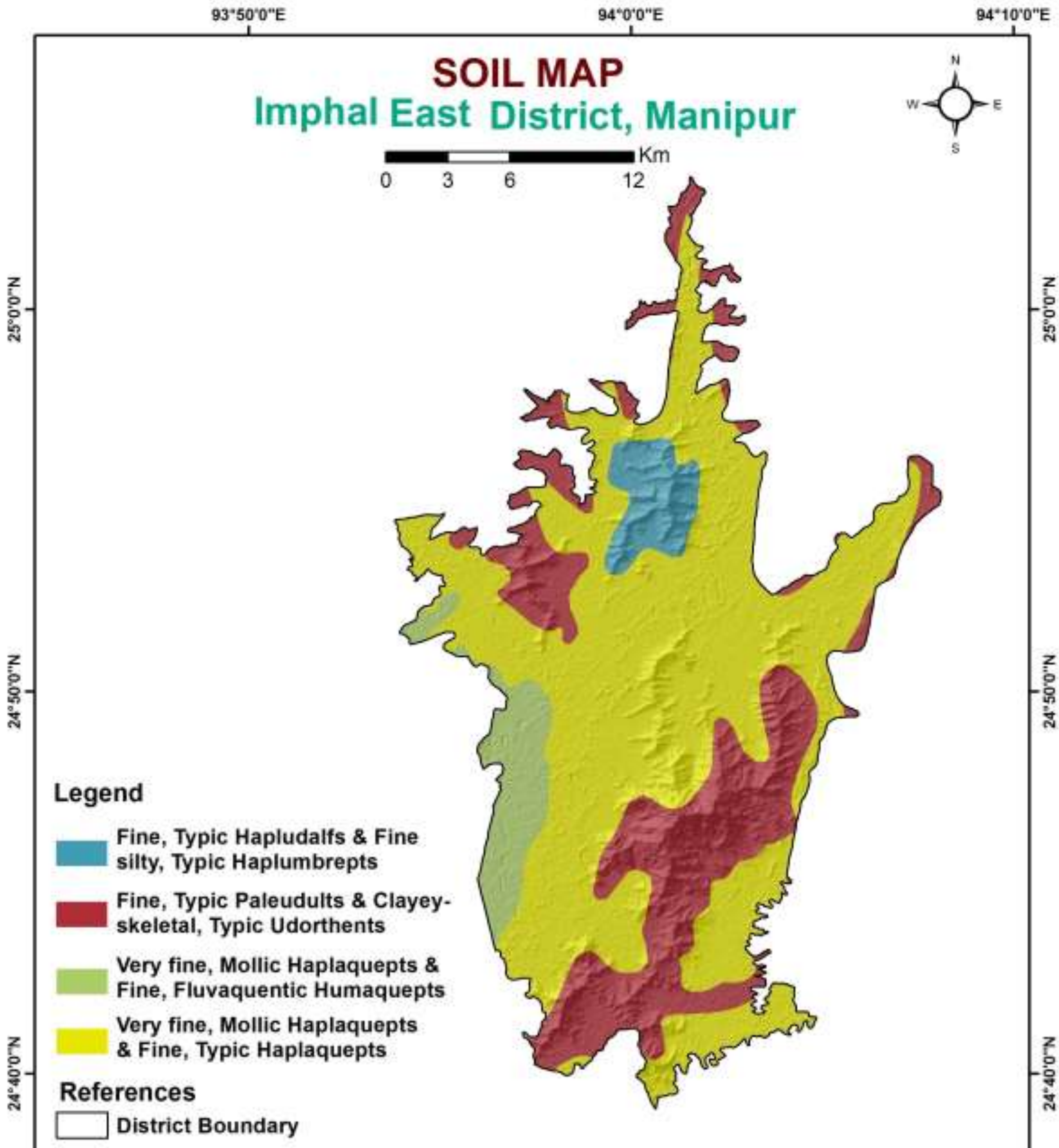
Table 5 Land use pattern of the study area (Source: Statistical Hand book of Manipur 2017)

Sl No	Name of NQUIM Area	Area in Hectare
1	Imphal East District	**70900**
2	Imphal East I CD Block	23290
3	Imphal East II CD Block	47610
4	Net area sown	20520
5	Net Cultivated area	20448
6	Culturable Waste Land	26
7	Total Uncultivated Land	26
8	Net Irrigated Area	1530
9	Irrigated area by canals, Tank, Well, Tube Well	0
10	Irrigated area by other sources	1530
11	Irrigated area for All Crops	1537
12	Unirrigated area for all crops	26712
13	Gross Cropped Area	28249

1.10 Soil Characteristic

The study area is fertile and is mainly made up of alluvial soil of recent origin. However, the soils are acidic with pH ranging between 4.5 to 6.8, rich in organic carbon. Availability of N is medium to high, P is low to medium and K is medium to high. The texture of soil varies from sandy to loam to clayey. The availability of N is not in proportion of the reserve N due to low rate of mineralization and crop is highly responsive to N and P fertilizers. Initially, factors such as soil parent material, rainfall, and type of vegetation are the major determinants of soil acidity.

Soil acidity problems are increasing in the study area because of continuous cropping and use of acidifying fertilizers. On the other hand, though soils of the area have moderate phosphorus as soil reserve, this is practically of no use to plants, as it is present in fixed or insoluble forms due to soil acidity. It also renders supplied phosphorus into insoluble form within a short period of time. All phosphorus ions either as primary orthophosphate ions or as secondary phosphate ions are subjected to fixation with hydroxides of aluminium and iron. In the nearby bordering hills, where soils are rich in organic matter, the availability of P is comparatively better which is mainly due to microbial activity.



SOIL TAXONOMY	DESCRIPTION
Fine, Typic Hapludalfs & Fine silty, Typic Haplumbrepts	Deep, somewhat excessively drained, fine soils on steeply sloping side slopes of hillocks having clayey surface with moderate to severe erosion
Fine, Typic Paleudults & Clayey-skeletal, Typic Udorthents	Deep, well drained, fine soils on gently to moderately sloping side slopes of hills having clayey surface with moderate erosion
Very fine, Mollic Haplaquepts & Fine, Fluvaquentic Humaquepts	Deep, extremely poorly drained, very fine soils on valleys having loamy surface with no erosion
Very fine, Mollic Haplaquepts & Fine, Typic Haplaquepts	Deep, very poorly drained, very- fine soils on nearly level valleys having clayey surface with very slight erosion

Fig. 2: Soil Map of the study area, Imphal East district, Manipur

Two major types of soils are found in the study area - residual and transported, which cover both the hills and plains. The residual soils are either laterised or non- laterised. It contains rich portion of nitrogen and phosphate, a medium acidity and lesser amount of potash.

The transported soils are of two types – alluvial and organic. The alluvial soils represent the soils of Imphal valley. The soils have general clayey warm texture and grey to pale brown colour. They contain a good proportion of potash and phosphate, a fair quantity of nitrogen and organic matter and are less acidic. The organic soils cover the low-lying areas of the valley. With dark grey colour and clayey loam texture, these peaty soils have high acidity, abundance of organic matter, a good amount of nitrogen and phosphorous but are poor in potash.

Main Soil classification of the study area –

(i) Younger alluvial soil
(ii) Older alluvial soil
(iii) Red gravelly sandy and loamy soil.
(iv) Piety and saline soil

1.11 Drainage

The Iril river, Imphal river, Thoubal river and some small streams like Kongba river, Naga River, Leimakhong river, etc. drain the district. The Iril river drains almost the entire district. It rises from the Lakhamai village of Senapati district and flows southwards. After draining for about 65 km long in the district, it joins with the Imphal river at Lilong. The Imphal river rises from the height of metres 2,332 above the MSL near Maohing village of Senapati district and flows southwards. It forms almost the entire district boundary with the Imphal West. The Khamenlok river rises from the Laphurak village (1,596 m) and flows south-west for about 17 km and falls into the Iril river at Keibi Heikakmapal village.

The Leimakhong river starts from the Mount Mung Ching (1,523m) and flows towards the south-west and drains more than 10 settlements for about 21 km long and falls into the Iril river at Phaknung village. The Thoubal river drains about 10 villages in the south-eastern corner of the district as long as for about 32 km. It starts from Fumi village of Ukhrul district and flows southwards and falls into the Manipur River at Irong Chesaba village. The Kongba river rises from the Mount Kongmaru (Isingthembi village) and flows southwards for about 32 km and meets the Imphal river at Kyamgei village. The Naga River starts from the Langol hill and drains about 6/7 villages and falls into the Nambul river (falling into the Loktak Lake) at Thongnambolbi Bridge in Imphal City.

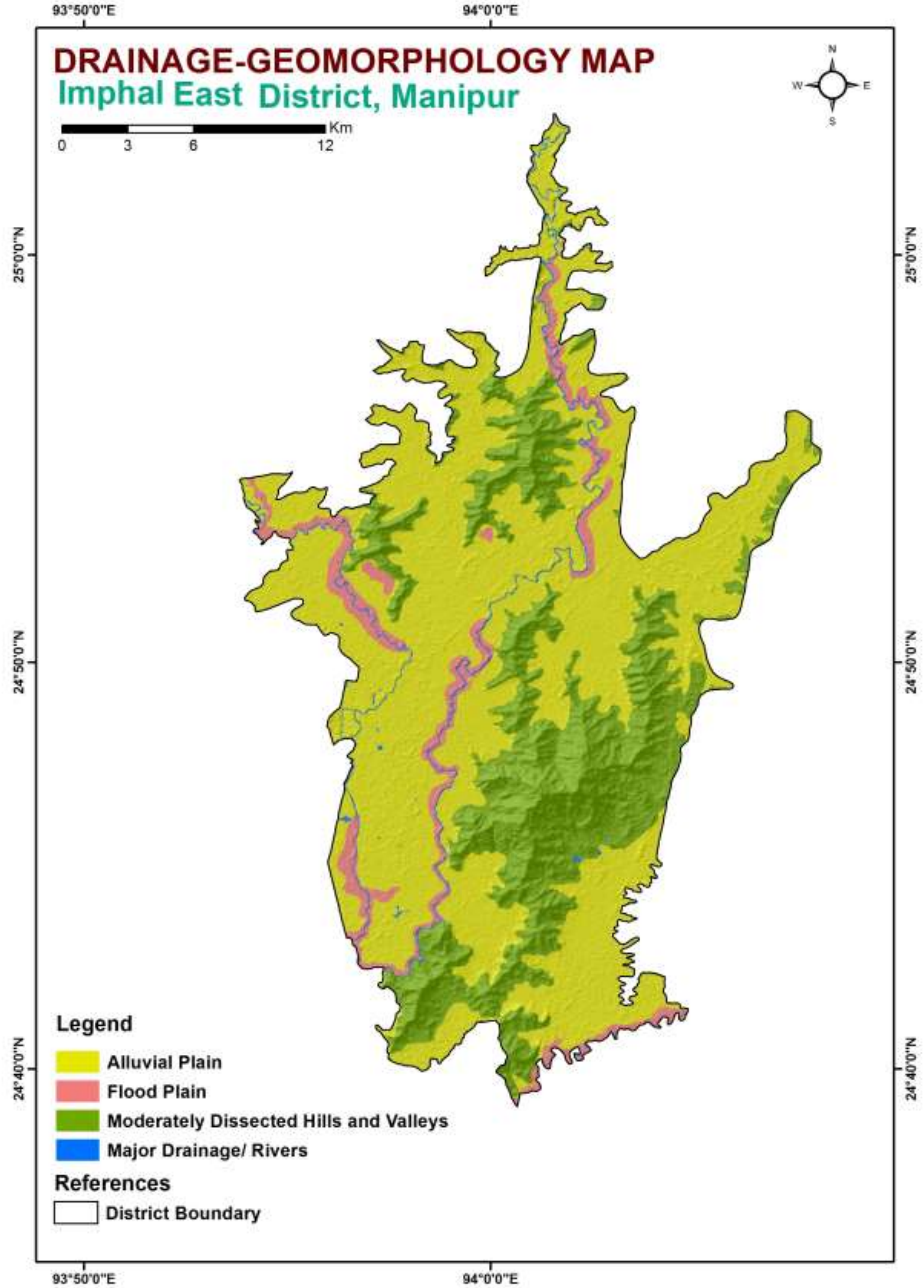


Fig. 3: Drainage -Geomorphology of the study area

The Barak River with its tributary, the Jiri River drains the Jiribam sub-division. The Jiri River rises from the height of 1,953 metres above the MSL near Thenbung village of

Assam state and flows southwards and falls into the Barak River at Jirimukh. It forms the state boundary with Assam for about half of the length of sub-division to the north. The Barak River rises from the Liyai Khunou village of Senapati district and flows westwards and after meeting with the Dzudko river, it turns towards the south up to Tipaimukh.It then turns northwards along with the state boundary between Assam up to Jirimukh and enters into Assam. Some small streams falling into the Irang river also drain the sub-division.

1.12 Regional Geology

The Hills of Manipur lie between the Naga–Patkai Hills on the north and northeast, and the Chin-hills on the south forming an integral part of the Indo-Myanmar (Burma) Ranges (IMR). The structural and tectonic pattern is transitional between the NE–SW trending pattern of Naga–Patkai Hills and N–S trend of Mizoram and Chin Hills (Brunnschweiler 1974). It comprises geologically young rock formations that were uplifted by the Tertiary orogeny of the Himalayas from the shallow bed of the Tethys Sea. The rocks are dominantly Tertiary and Cretaceous sediments with minor igneous and metamorphic rocks. Flysch sediments of Tertiary age underlie nearly 70% of the state (Soibam 1998).

Disang and Barail flysch sediments underlie much of Imphal valley or central valley. The oldest formation, the Disang Series (Eocene) comprises splintery shale with minor mudstone, siltstone, sandstone and limestone. The Disang is overlain by the Oligocene Barail Formation contained abundant carbonaceous matter. The Barail is succeeded by the predominantly argillaceous Surma and the Tipam formations. The sediments of the Surma basin are molasse (Nandy 1980). Ultrabasic igneous rocks, of the Ophiolite Zone, are intruded into the Disang Group in east of Manipur. The general tectonic trend of rock formations in the state is NNE-SSW, but varies between N–S and NE–SW, and locally NNW–SSE. Almost all the major structural elements such as folds reverse and thrust faults follow this regional strike/trend.

Topographically, Manipur comprises a ridge and furrow terrain where sediments derived from surrounding ridges are deposited in the furrows (Soibam 1998). In the Manipur Valley, lenses of argillaceous sediments were deposited in the Assam–Arakan trough.

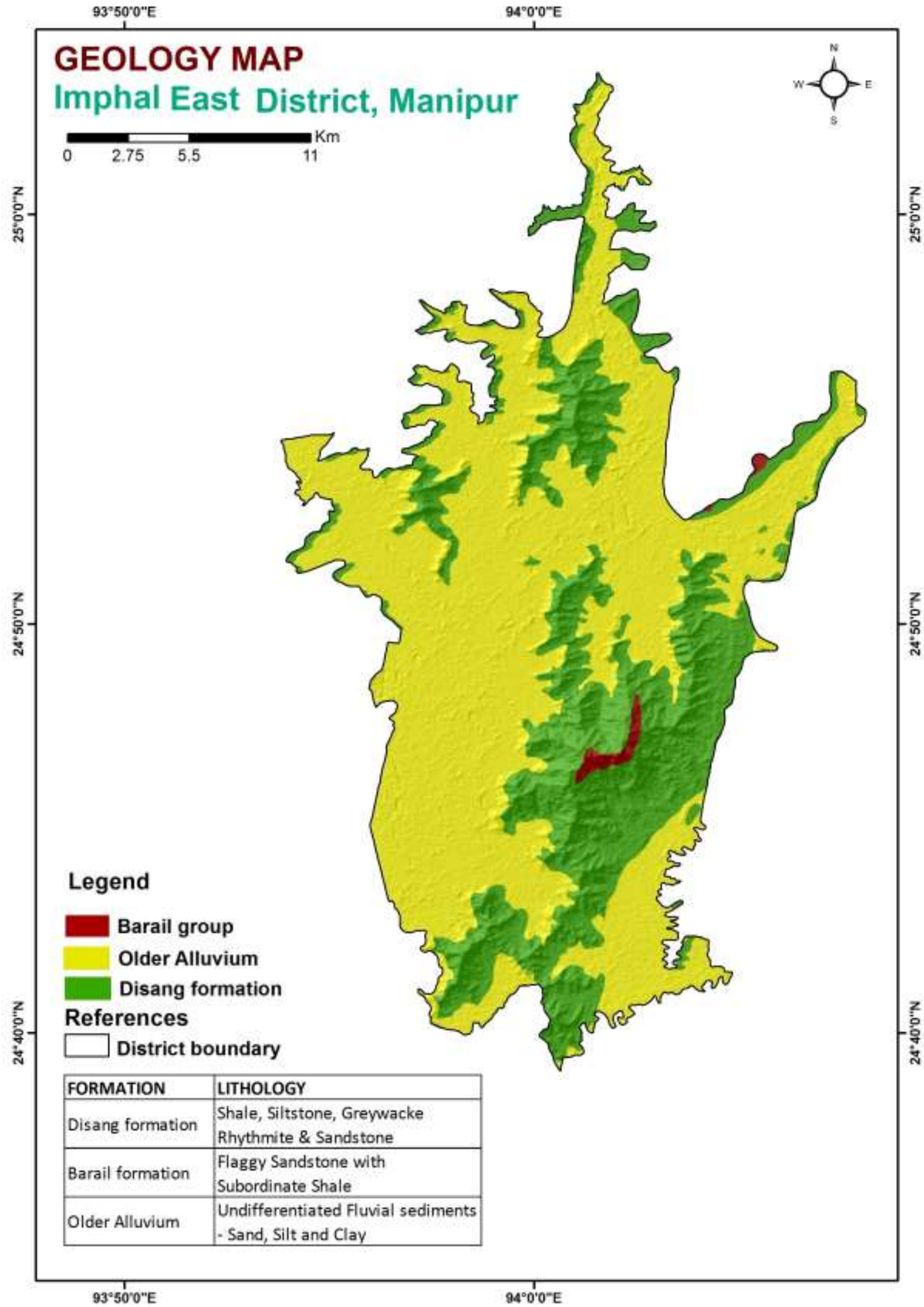


Fig.4 Map showing Geological set up of the study area

Manipur is divisible into a central valley and the surrounding mountains. About 25% of the valley is occupied by lakes, wetlands, barren uplands and hillocks. The NNW–SSE oriented valley is oval shaped, and slopes gently to the south. The Imphal or Manipur River meanders through the Manipur Valley in a NW–SE direction and passes through a gorge to flow out of the state to join the Chindwin River in Myanmar. The formation of the Manipur River and its tributaries that drain the area was closely connected with the upliftment of the South Manipur Hills and subsequent erosion of the weak crest of the anticlinorium. There were multiple episodes of low energy, fluvio-lacustrine deposition during the Quaternary, and these sediments are encountered to depths of 150 m. Disconnected lenticular water bodies dominate the valley.

The Manipur Valley has been infilled by thick alluvium which is subdivided into the Older (Pleistocene) and Newer Alluvium. The Older Alluvium is made up of clay, silt, coarse sand, gravel, pebble and boulders, deposited adjacent to the foothills and forming older river terraces in the lower part of Manipur Valley. The Newer Alluvium is composed of clay, sand, silt and dark clay with carbonaceous matter, deposited mainly in the central and upper part of the Manipur Valley.

Geology of the Study Area

Basically, the area is made up of alluvium of fluvio-lacustrine origin. They are usually dark grey to black in colour. The principal constituents are clay, silt and sand whereas sand, gravel, pebbles and boulders are found in the foothill regions. The hillocks in the study area are basically composed of Disang shales but some have sandstone capping. Alluvium covers the widest aerial extent in the area. They are mainly dark grey to black carbonaceous clay, silt and sand of which clay forms the main sediments while silt and sand are subordinate. Major parts of the area belong to Alluvial formation which is further divided into older and younger alluviums due to change in lithology.

1.13 Agriculture

Agriculture being the main occupation of the people in the area, it has an important place in the economy of the district. Agriculture sector contributes a major share to the total state domestic product and provides employment to about 63.95% of the total working force in the area. In fact, the domestic product fluctuates depending on the performance of agricultural sector. Despite the crucial importance of this primary sector in the economy of the area, the irregular and erratic behaviour of monsoon accompanied by inadequate irrigation facilities have resulted in severe of fluctuations in agricultural production. Agriculture becomes points of employment and income; agriculture plays a very crucial role in the economy.

In the study area paddy is the principal crops. The agriculture is rain fed. Majority of the population dependent on cultivation. Paddy is the dominant crop, however, double cropping pattern is not observed in this part mainly due to lack of irrigation facility.

CHAPTER 2.0
DATA COLLECTION AND GENERATION

2.1 Data collection

The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB, Minor Irrigation Department (Manipur), IPD wing PHED (Manipur), Geological Wing-Directorate of Industries & Commerce (Manipur) and MASTEC. All data were plotted in base map on GIS Platform (MapInfo-6.5 using Projection category longitude/latitude (Indian for Bangladesh, India and Nepal projection).

Data collection includes collection of rainfall data from IMD and state government, litholog collection from state groundwater departments, compilation of CGWB's earlier survey data, exploration and geophysical data. Population data is collected from Statistical Handbook of Manipur, 2017 and census of India website. Agricultural data is collected from the website of Ministry of Agriculture, Govt. of India.

CGWB had carried out hydrogeological studies in Imphal valley during 2004-05. The available hydrogeological data is incorporated in the present study. GSI has carried out geological studies in Imphal valley to delineate the lithological units, their structures and stratigraphic disposition. CGWB had constructed 2 nos. of exploratory wells in Imphal East district. Investigation and Planing Division (IPD) of Public Health Engineering Department, Manipur had constructed 19 nos. of tube wells for domestic and irrigational purposes in the area and the department provided depth and discharge information of the wells. Litho log of 14 nos. of tube wells have been collected from different sources like PHED, GSI, CGWB etc. Details of the wells are given in Table 11. Rainfall data was collected from Indian Meteorological Department (IMD) website and statistical Hand book of Manipur 2017. Ground water monitoring stations of Imphal East district established during the District Groundwater Development and Management studies, 2004-05 in Manipur valley were incorporated for water level data analysis (Table 6 and 7).

2.2 Data Generation

2.2.1 Hydrogeological data:

In Manipur development of groundwater is very limited. Exploration by Central Ground water Board (CGWB) has revealed that Imphal valley has groundwater potential but could not explore up to the desirable limit due to its nature of geological framework.

The present study area of NAQUIM in general is proved to be moderately potential from ground water point of view by the studies carried out by CGWB. Exploratory wells constructed down to 150 mbgl shows presence of granular zones in the area. No major, medium and small irrigation schemes are implemented so far in the district for irrigational purposes.

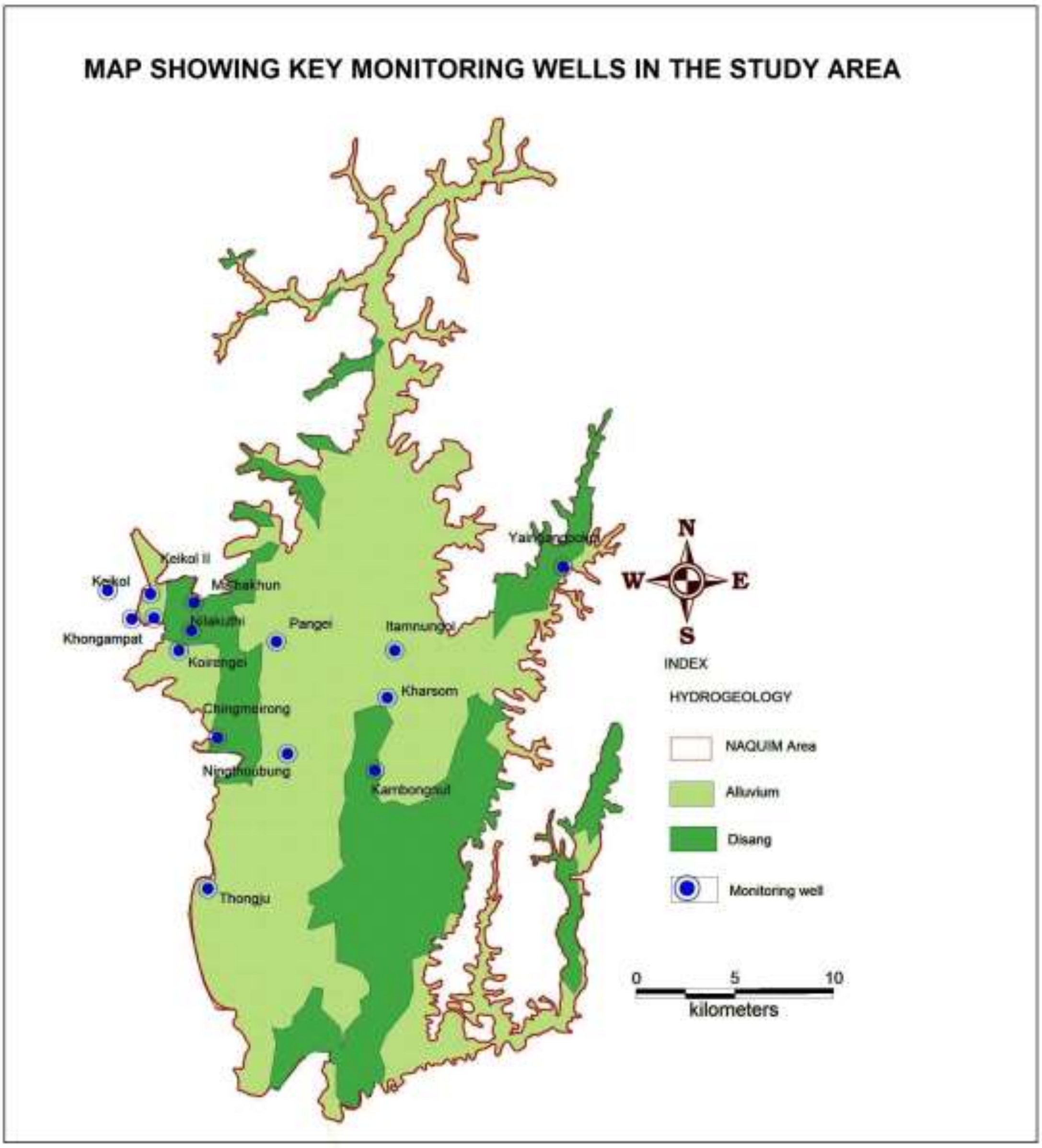
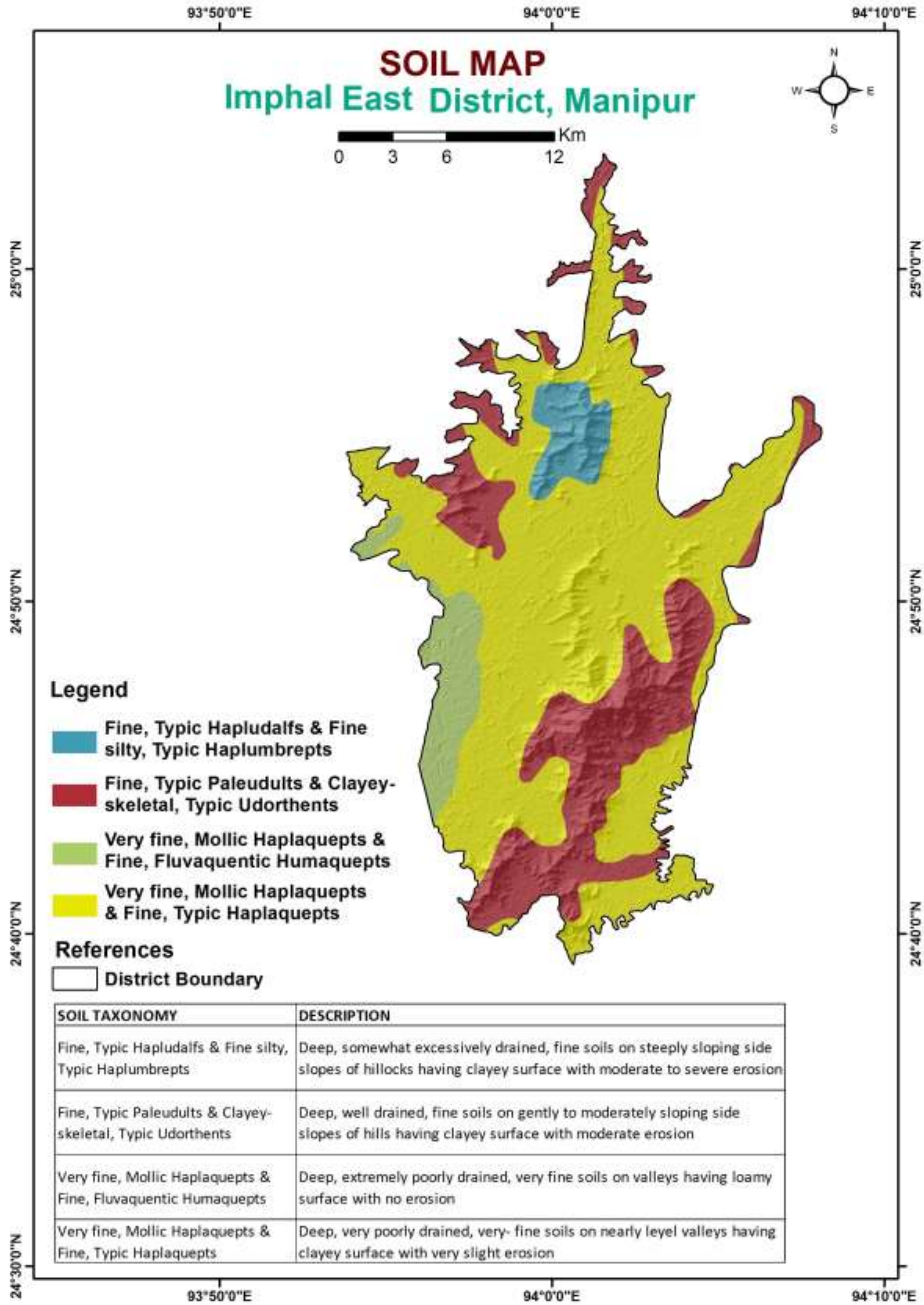


Fig. 5a Map showing Key monitoring wells in the study area



SOIL TAXONOMY	DESCRIPTION
Fine, Typic Hapludalfs & Fine silty, Typic Haplumbrepts	Deep, somewhat excessively drained, fine soils on steeply sloping side slopes of hillocks having clayey surface with moderate to severe erosion
Fine, Typic Paleudults & Clayey-skeletal, Typic Udorthents	Deep, well drained, fine soils on gently to moderately sloping side slopes of hills having clayey surface with moderate erosion
Very fine, Mollic Haplaquepts & Fine, Fluvaquentic Humaquepts	Deep, extremely poorly drained, very fine soils on valleys having loamy surface with no erosion
Very fine, Mollic Haplaquepts & Fine, Typic Haplaquepts	Deep, very poorly drained, very- fine soils on nearly level valleys having clayey surface with very slight erosion

Fig.5b: Hydrogeology map of Imphal East district

Groundwater in the deeper aquifers occurs under sub-artesian and artesian conditions. Granular zones are encountered at a depth of about 150 m in Imphal valley. Tube wells have been installed at various places of the valley areas with the yields ranging from 0.6 to 4 m3/hr. Considering the clayey nature of formation in the top aquifer, groundwater development is not considered promising on a large scale either in irrigation of water supply. Hydrogeological study has revealed that the district is underlined by a thin veneer of alluvial deposits, which is largely clayey in nature, underlined by rocks of Tertiary age. Since the upper formations are mainly silty and clayey, dug wells/open wells have poor yield prospects. However, the deeper zone, consisting of sand stones of Tertiary age, forms good aquifers which are under semi confined conditions, Auto flow conditions are observed in Imphal where the yield of the tube wells vary from 0.5 to 4 m3/hr.

2.2.2 Water level data: The entire NAQUIM area of Imphal East district is covered by regular monitoring of 17 key wells. All these wells are under monitoring after establishment. The location details of water level monitoring stations are given in Table 6 and 7.

Table 6: Key observation wells of shallow aquifers in the study area

Sl. No	Well Type	Topo No	Location	Latitude	Longitude	Block	RL (m AMSL)	Drill Depth (m)	Well Dia. (m)	MP (m,agl)	Aquifer Parameter
1	TW	83H/13	Chingmeirong	24º 49'52"	93º56'58"	Imphal East I	788.737	33.00	0.15	0.58	Sand & Gravel
2	TW	83H/13	Ningthoubung	24º 49'20"	93º59'04"	Imphal East II	787.095	46.00	0.15	0.48	Sand
3	TW	83L/1	Kharasom M Leikai	24º 50'55"	94º02'00"	Imphal East II	790.477	30.00	0.15	0.51	Gravel
4	TW	83H/13	Keikol I	24º 53'50"	93º54'35"	Imphal East II	795.738	31.00	0.15	0.43	Gravel
5	TW	83H/13	Keikol II	24º 53'44"	93º54'48"	Imphal East II	796.528	27.50	0.15	0.69	Gravel &sand
6	TW	83H/13	Keikol III	24º 53'42"	93º54'47"	Imphal East II	797.757	20.67	0.15	0.51	Grav. & Sandy gravel
7	TW	83H/13	Nilakuthi	24º 53'12"	93º55'00"	Imphal East I	796.248	39.97	0.15	0.43	Grav.sandy gravel
8	TW	83H/13	Koirengei II	24º 52'11"	93º55'45"	Imphal East I	789.623	28.54	0.15	0.31	Grav.sandy gravel
9	TW	83H/13	Khonghampat	24º 53'08"	93º54'12"	Imphal East II	796.713	28.34	0.15	0.57	sandy clay
10	TW	83H/13	Maibakhun	24º53'24"	93º56'07"	Imphal East II	793.036	33.00	0.15	0.54	Grav.sandy gravel
11	TW	83H/13	Pangei	24º 51'25"	93º58'35"	Imphal East II	797.217	31.00	0.15	0.26	Grav. & Fine sandy clay

12	TW	83H/13	Keikol Makha Leikai	24º 53'43"	93º54'46"	Imphal East II	797.00	22.00	0.15	0.72	Gravel, sandy Grav

Table 7: Key observation wells of deeper aquifers in the study area

Sl. No	Well Type	Topo No	Location	Latitude	Longitude	Block	RL (m AMSL)	Drill Depth (m)	Well Dia. (m)	MP (m,agl)	Aquifer Parameter
1	TW	83H/13	Thongju	24º 45'44"	93º56'43"	Imphal East I	782.614	94.00	0.15	0.49	Sand
2	TW	83L/1	Kambongput	24º 48'55"	94º01'37"	Imphal East I	805.084	55.00	0.15	0.55	Sand
3	TW	83 L/1	Itam Nungoi	24º 52'11"	94º02'09"	Imphal East II	794.122	64.00	0.15	0.38	Coarse sand
4	TW	83L/1	Yaingang Pokpi	24º 54'25"	94º07'15"	Imphal East I	810.834	52.00	0.15	0.42	Gravel
5	TW	83H/13	Koirengei I	24º 53'02"	93º55'45"	Imphal East I	792.47	52.49	0.15	0.50	Gravel, sand

Table 8: Depth to Water level data of shallow aquifers in Imphal East district

Sl. No	Location	Latitude	Longitude	RL mAMSL	Pre-monsoon (Mar, 2018) (mbgl)	Post – monsoon (Nov'2017) (mbgl)
1	Chingmeirong	24º 49'52"	93º56'58"	788.737	9.98	7.24
2	Ningthoubung	24º 49'20"	93º59'04"	787.095	1.00	1.00
3	Kharasom M Leikai	24º 50'55"	94º02'00"	790.477	1.63	1.60
4	Keikol I	24º 53'50"	93º54'35"	795.738	3.91	3.87
5	Keikol II	24º 53'44"	93º54'48"	796.528	4.00	3.4
6	Keikol III	24º 53'42"	93º54'47"	797.757	0.4	0.4
7	Nilakuthi	24º 53'12"	93º55'00"	796.248	0.81	0.77
8	Koirengei II	24º 52'11"	93º55'45"	789.623	1.13	1.12
9	Khonghampat	24º 53'08"	93º54'12"	796.713	2.43	2.22
10	Maibakhun	24º53'24"	93º56'07"	793.036	1.75	1.70
11	Pangei	24º 51'25"	93º58'35"	797.217	0.63	0.33
12	Keikol Makha Leikai	24º 53'43"	93º54'46"	797.00	9.98	9.00

Table 9: Depth to Water level data of deeper aquifer key wells

Sl. No	Location	Latitude	Longitude	RL (mAMSL)	Pre-monsoon (Mar, 2018) (mbgl)	Post – monsoon (Nov'2017) (mbgl)
1	Thongju	24º 45'44"	93º56'43"	782.614	4.54	4.46
2	Kambongput	24º 48'55"	94º01'37"	805.084	8.82	7.34
3	Itam Nungoi	24º 52'11"	94º02'09"	794.122	2.50	2.43
4	Yaingang Pokpi	24º 54'25"	94º07'15"	810.834	3.9	3.6
5	Koirengei I	24º 53'02"	93º55'45"	792.47	3.00	2.88

2.2.3 Water Quality

To understand the chemical quality of groundwater in the study area and its suitability for domestic, drinking and agricultural utilisation existing quality data of CGWB were collected. Water samples were collected from monitoring wells for detailed, iron, heavy metals and arsenic. However, heavy metal and arsenic analysis data are yet to be received**.**

2.2.4 Geophysical survey

Data of VES survey conducted by PHED, Manipur in Imphal East district were collected as part of data generation activity during study. The obtained VES data was plotted on double logarithmic graph sheet. The VES data was interpreted by using IP2WIN software technique. H, HK, K, Q type multi-layered VES curves was obtained. The location details of these VES survey is shown in Table 10.

Table 10 : Location details of VES survey points

SN	Name of the site	Longitude	Latitude	RL (mamsl)	Agency	VES/TEM	Depth of interpretation
1	Sanasabi	940646	245525		PHED	VES	53.2
2	Laikot	94.1206	24.9318		PHED	VES	52.5
5	Tellou	94.0953	24.8697		PHED	VES	36.0
6	Nongren	94.0901	24.8561		PHED	VES	43.0
7	Kameng	94.07173	24.8664		PHED	VES	70.0
8	Pudongbam	94.05267	24.87665		PHED	VES	64.4
9	Sekta	94.04756	24.88601		PHED	VES	59.5
10	Lamlai	94.05338	24.85879		PHED	VES	20.9
11	Takhel	94.0504	24.867		PHED	VES	55.2
12	Sangsabi	94.0285	24.8325		PHED	VES	26.75
13	Chingkhu	93.9908	24.9004		PHED	VES	61.6
14	Waiton	94.0003	24.8721	800	PHED	VES	45.0
15	Poarabi	94.0261	24.8844		PHED	VES	58.0
16	Khundrakpam	93.9858	24.8778		PHED	VES	34.0
17	Khabeisoi	93.9864	24.8495		PHED	VES	23.5
18	Khurai Angom Leikai	93.9897	24.8344		PHED	VES	46.2
19	Khurai Thangjam L	93.9707	24.8568		PHED	VES	35.0
20	Laipham Siphai	93.9450	24.8397		PHED	VES	15.9
21	Lamlongei	93.9308	24.8485		PHED	VES	66.0
22	Khabam Leikai	93.9416	24.8593		PHED	VES	16.2
23	Heingang	93.9543	24.8675		PHED	VES	22.5
24	Achanbegei	93.9332	24.8764		PHED	VES	8.17
25	Luwang Sangbal	93.92288	24.87301		PHED	VES	25.6

26	Nilakuthi	93.9130	24.8898	792	PHED	VES	10.8
27	Matai	93.9212	24.8601		PHED	VES	10.8
28	Maibakhul	93.9326	24.8945		PHED	VES	35.2
29	Momgjam	93.9469	24.88601		PHED	VES	42.0
30	Koirengei	93.9230	24.8913	792	PHED	VES	19.2
31	Potsangbam Khunou	93.91455	24.90135		PHED	VES	44.0
32	Yumnam Khonou	93.9971	24.91295	800	PHED	VES	32.0
33	Sanjenbam	94.0567	24.7918		PHED	VES	44.1
34	Taret khul	94.0498	24.9254		PHED	VES	24.2
35	Keibi	94.0520	24.9187		PHED	VES	14.25
36	Uyumpok	94.0420	24.9486		PHED	VES	25.2
37	Khongbal Tangkhul	94.0654	24.9531		PHED	VES	24.0
38	Lamboikhul	94.0540	24.9313		PHED	VES	46.2
39	Pukhao Ahallup	94.0354	24.9819		PHED	VES	30.30

2.2.5 Exploratory Drilling: During the NAQUIM study in AAP 2017-18, exploratory drilling activity was not carried out in Imphal East district, Manipur. Old drilling data of CGWB and Public Health Engineering Department were collected and examined. A list of wells constructed in the area was prepared incorporating location, well designs, etc.

Table 11: Details of exploratory wells in the study area

Sl.No.	Well Location	Co ordinates		Type	Drilled Depth	Discharge
		Longitude	Latitude		(metre)	(LPM)
1	Chanam Sandrok	93.98197	24.70475	TW	54.87	555.5
2	Changamdabi Mathak	94.06964	24.689598	TW	60.9	315.9
3	Kaina (Near Temple)	94.015369	24.675337	TW	62.5	325.79
4	Matai (Koirengei)	93.930035	24.862752	TW	80.9	247.43
5	Moirangpurel No 1	94.1272	24.7785	TW	51.6	228.83
6	Tumnam Khunou			TW	60.95	254.25
7	Kongba Chingjin Khunou			TW	55	245
8	Wairi (Sawombung)	94.0082	24.88071	TW	58	375
9	Tenduyan			TW	24	413
10	Kairang Chingkha	93.962	24.84285	TW	55	273
11	Yumnam Khunou	93.99322	24.92727	TW	54.9	150
12	Koirengei			TW	86.87	165
13	Chingaren(Phaknung)	94.01486	24.86309	TW	50.29	315
14	Tiger camp (Lamboi khul)	94.04076	24.93012	TW	51	245
15	Ishingthembi(Komgmaru)	93.99868	24.95573	TW	46	272
16	Waithou Chiru			TW	37	99
17	Lamlai	94.05338	24.85879	TW	98.3	
18	Pangei	93.971	24.8788	TW	43	
19	Sangaiprao			TW	91.5	2

CHAPTER 3.0

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Data Interpretation

Geophysical and aquifer Characterization:

Resistivity data were collected from IPD Wing, PHED, Manipur. The resistivity surveys were conducted at different places in Imphal East district by PHED in order to understand the nature of sub surface formation, thickness of aquifer etc. Type-H and type-K were commonly encountered in the district. Type –H sections are most suitable for groundwater exploration as the third layer is of weathered shale or sand. Resistivity varies for sand from 30 to 200 ohm-metre and for shale, from 70 to ∞ ohm-metre depending upon the degree of fracture and alteration to clay. The resistivity increases suddenly in shale with joints and fracture. Such H-type are observed at Laikot, Tellou, Nongren, Kameng, Khabeisoi, Achanbeegei, Luwangsangbam, Koirengei, Potsangbam, Uyumpok, Leitanpokpi, Pukhou etc. In the district, large quantity of water is exploited from shale at the foothill zones which are highly weathered, jointed and fractured. Water exploited from weathered rock (shale) is relatively poor in quality compared to the alluvial aquifer (sand).

Central Ground Water Board, North Eastern Region, Guwahati has drilled two exploratory wells in the area. Public Health Engineering Department has also drilled number of wells in the area. However, only fourteen lithologs are included in this study after proper verification. From the examination of this litholog it is observed that down to a maximum explored depth of 152.39 m in the sequence from 50 m is dominated by clay, sand, gravel with mixtures of silt and ground level to 50 mbgl is dominated by clay, shale, sand. The lithologs and the lithology identified in VES survey are used to understand 2D and 3D disposition of aquifer.

Range of the most common resistivities of rock formation in the district with normal resistivities are given below in Table 12 (*after IPD wing, PHED, Manipur*)

Table 12: Resistivities of common rocks of the district and Standard

Type of rock/Formation	**Imphal East district (Ohm-m)**	**Standard (Ohm-m)**
Sand with fresh water	30- 200	50-500
Weathered Shale	70-120	60-100
Fracture fresh Shale	100- infinity	100-200
Clay with silt	11-15	2-20
Sandstone	30-1000	50-1000

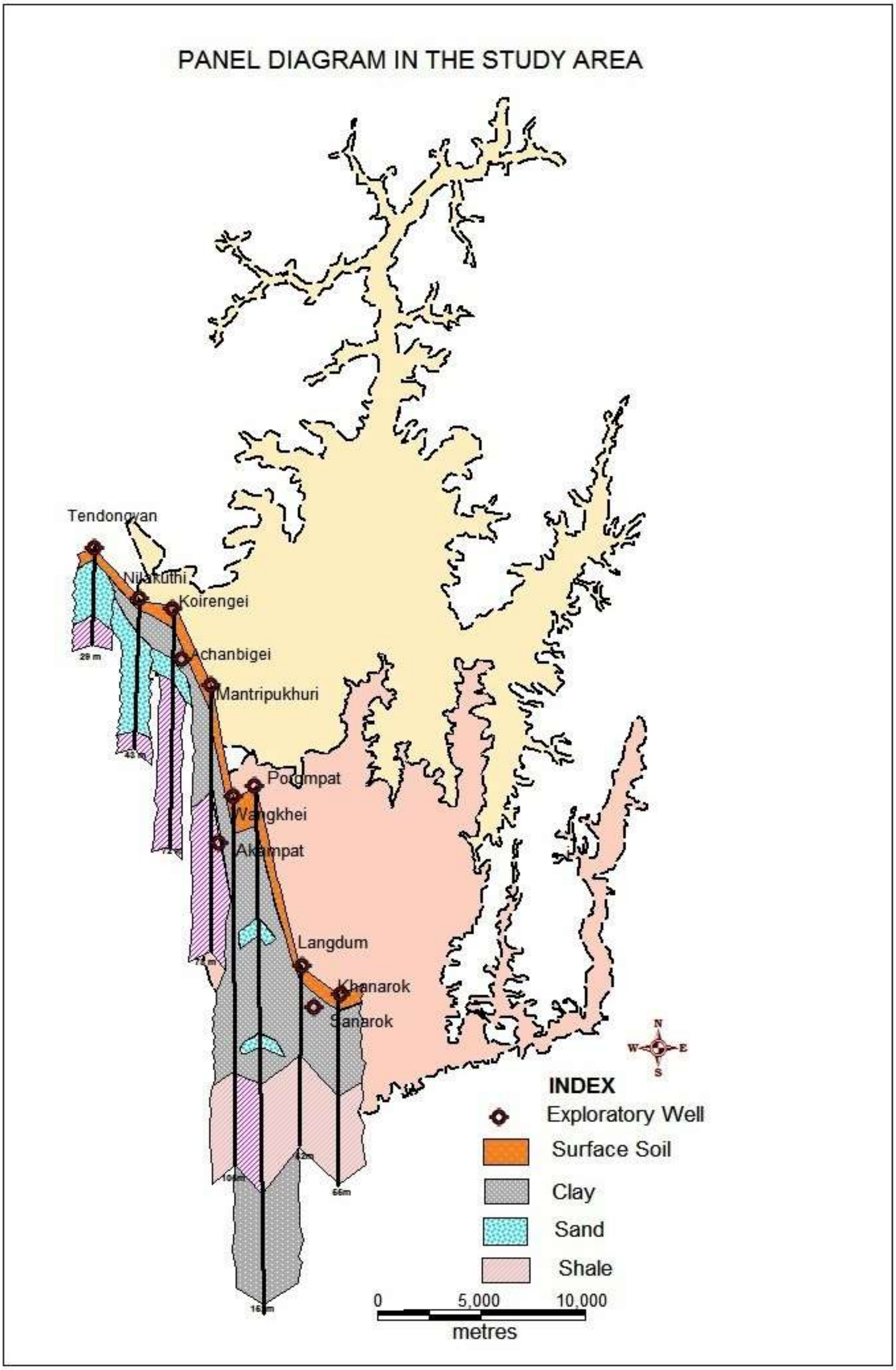


Fig.6 Aquifer Disposition in the study area

3.2 2D disposition: Two sections are constructed to visualize the aquifer disposition (a) a north west-south east section (Fig. 7)

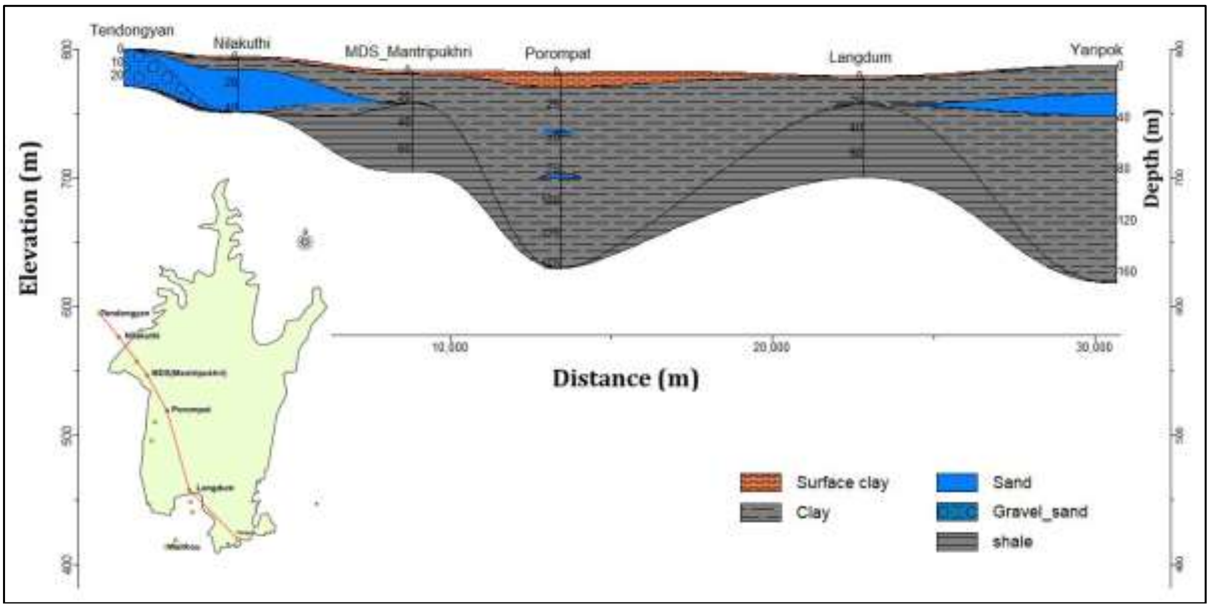


Fig. 7 2D section along Tendongyang-Nilakuthi-MDS- Porompat- Langdum-Yaripok

(b) a south west to north east section (Fig. 8).

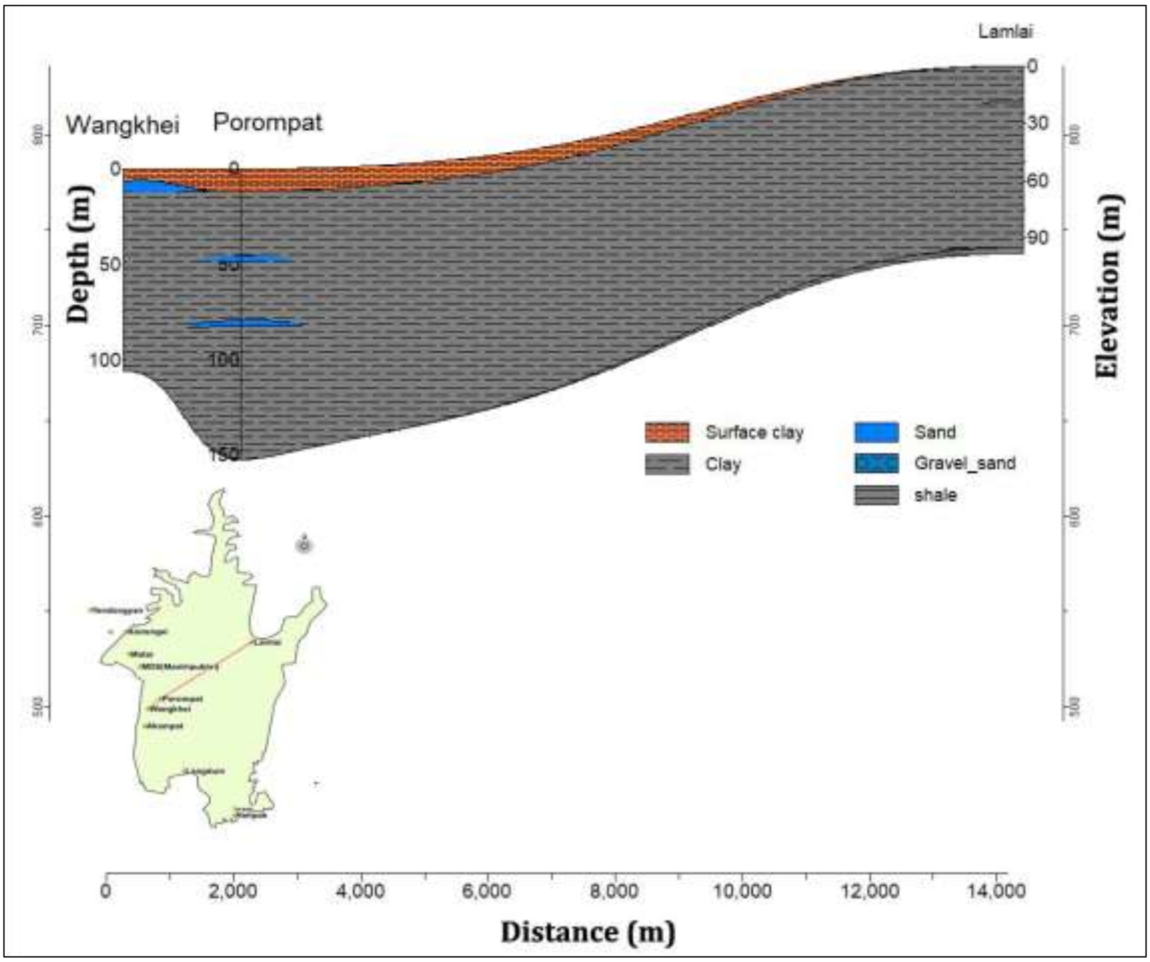


Fig. 2D section along Wangkhei- Porompat- Lamlai

The aquifer disposition of the area in the 3D block diagram indicates existence of a single aquifer in the area. The confining layers are not continuous throughout the area.

Table. 13 Aquifer character in the study area

Type of Aquifer	Depth range of the aquifers (mbgl)	Thickness (m)	Yield m^3/ hr	Draw down (m)	T m2/day
Aquifer - I (Unconsolidated)	GL to 50	5 to 11	6	17	5.3
Aquifer - II (Tertiary sandstone)	50 to 150	12 to 20	24	5	17

The discharge ranges from 19m^3/hr to 110 m^3/hr in the study area. The highest discharge recorded is 110 m^3/hr by giving transmissivity 5.3 m^2/s^3 with a drawdown of 11m. And, the lowest recorded is with a yield of 19 m^3/hrs with a transmissivity of 0.1m^2/s^3. Transmissivity value of well ranges from 0.1 m^2/s^3 to 48 m^2/s^3 in the district.

3.3 Ground water level

Shallow Aquifer: To study ground water regime of shallow aquifers, depth to water level from 12 monitoring stations (shallow aquifers) are measured seasonally (Map 12). Block wise variation of water level can be discussed as below. Pre-monsoon depth-to-water level of the key wells in Imphal East I block ranges from 0.81 to 9.98 mbgl and in Imphal East II block the pre monsoon depth-to-water level varies from 0.4 to 9.98 mbgl. The post monsoon depth-to-water level in Imphal East I block varies from 0.77 to 7.24 mbgl and it varies from 0.33 to 9.00 mbgl in Imphal East II block. Pre-monsoon and post-monsoon depth-to-water level contour for shallow aquifers is prepared (Fig. 10 & 11). Pre monsoon ad post monsoon water level fluctuation ranges from 0.01 to 2.74 m.

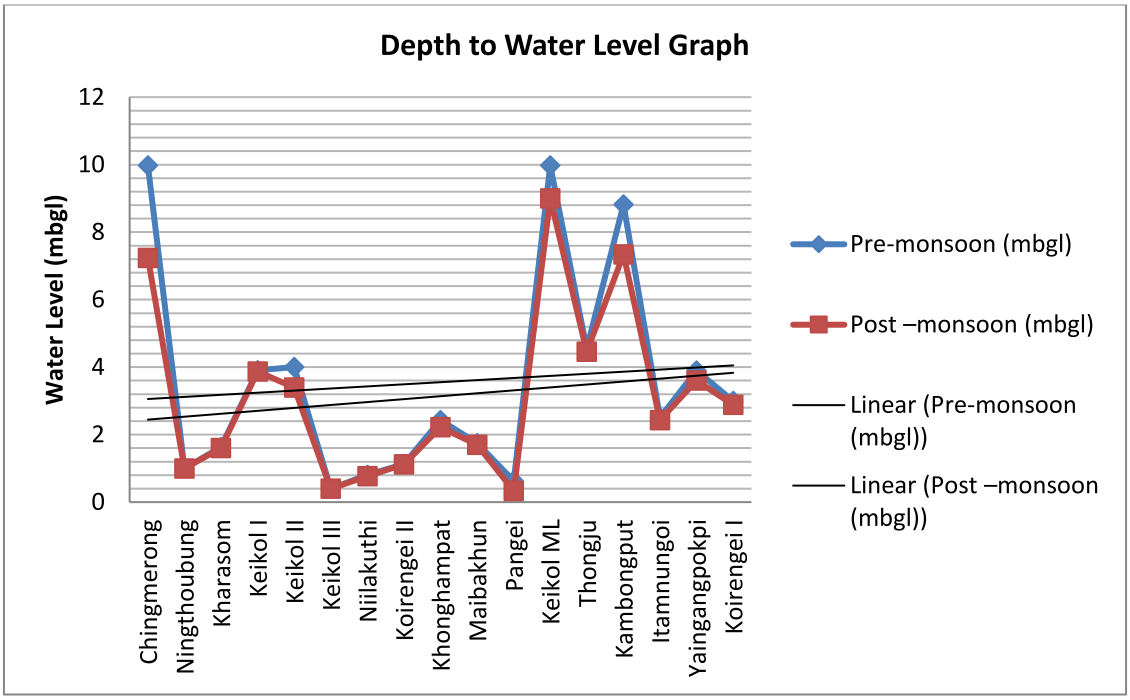


Fig.10. Depth to Water Level Graph of the Key monitoring wells

Deeper Aquifer: To study ground water regime of deeper aquifers, depth to water level from 5 monitoring stations were measured seasonally (Map 13). Pre-monsoon depth-to-water level of the key wells varies from 2.5 to 8.82 mbgl in deeper aquifers. The post monsoon depth-to-water level varies from 2.43 to 7.34 mbgl. Pre-monsoon and post monsoon water fluctuation in the deeper aquifer ranges from 0.07 to 1.48 m. The water level fluctuation in the study area is generally within 3.0m.

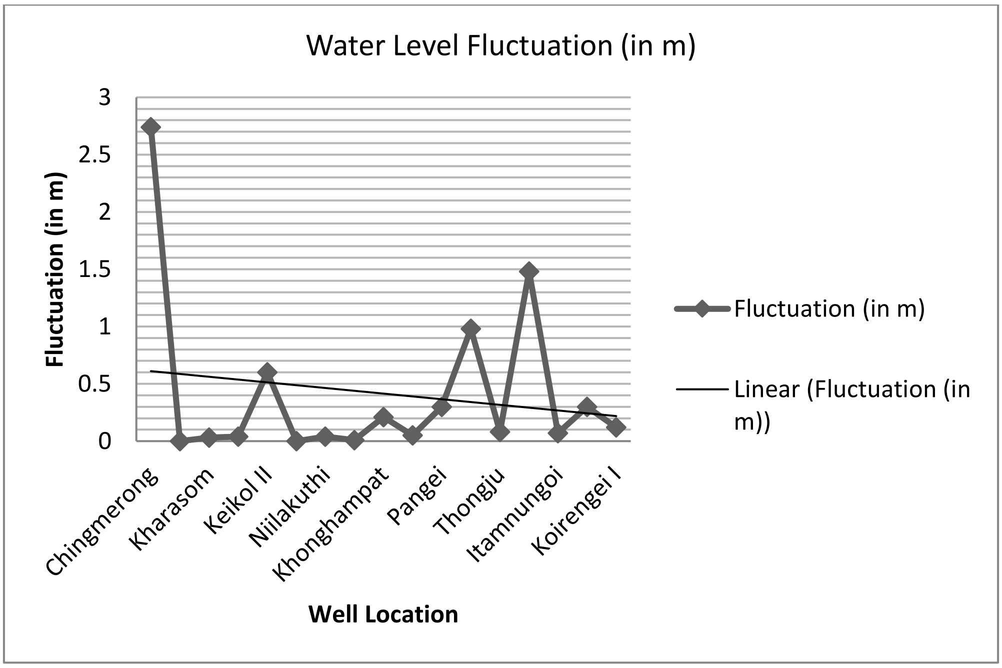


Fig.11. Water Level Fluctuation Graph

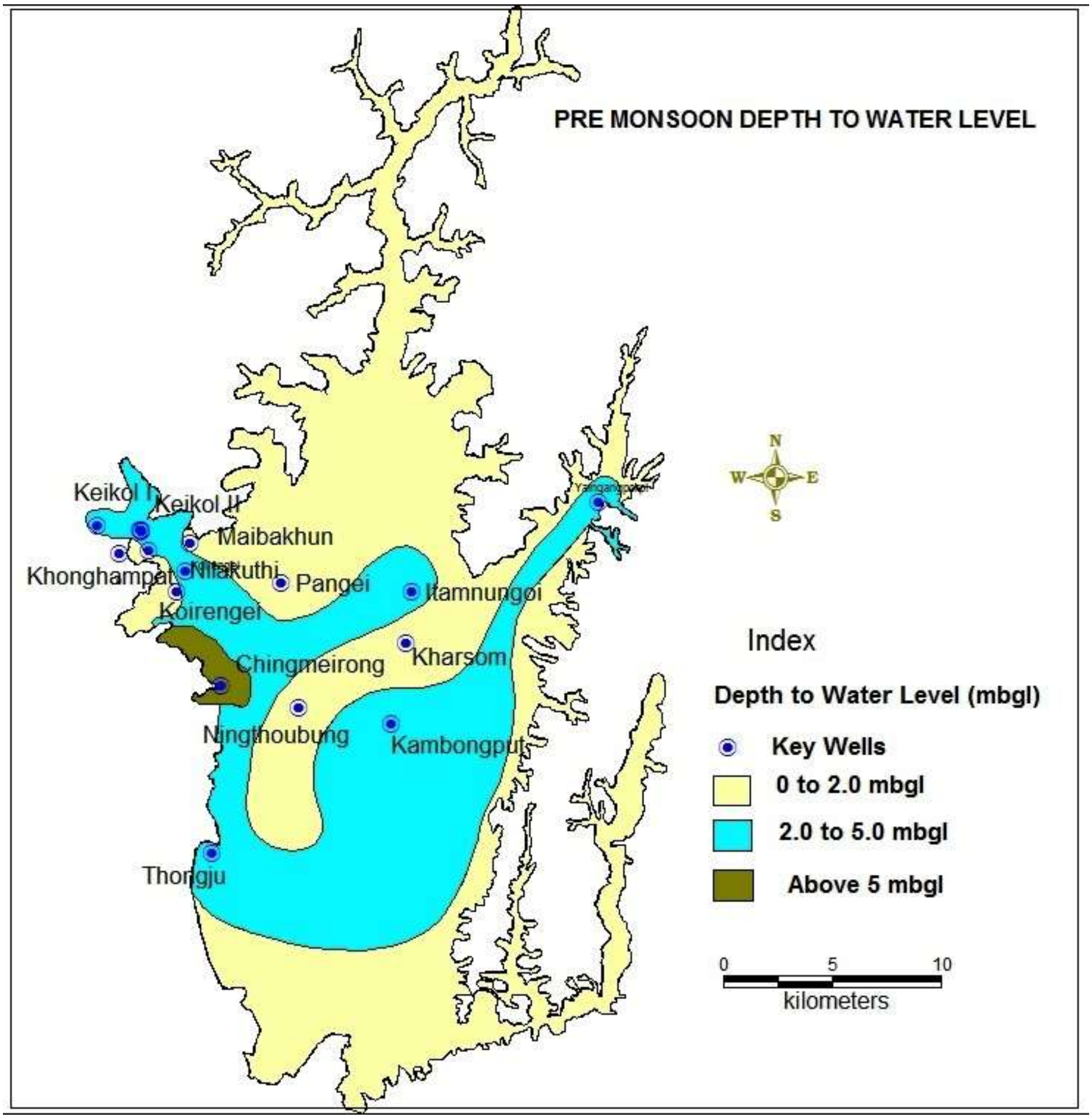


Fig. 12: Pre-monsoon DTW level contour of the study area

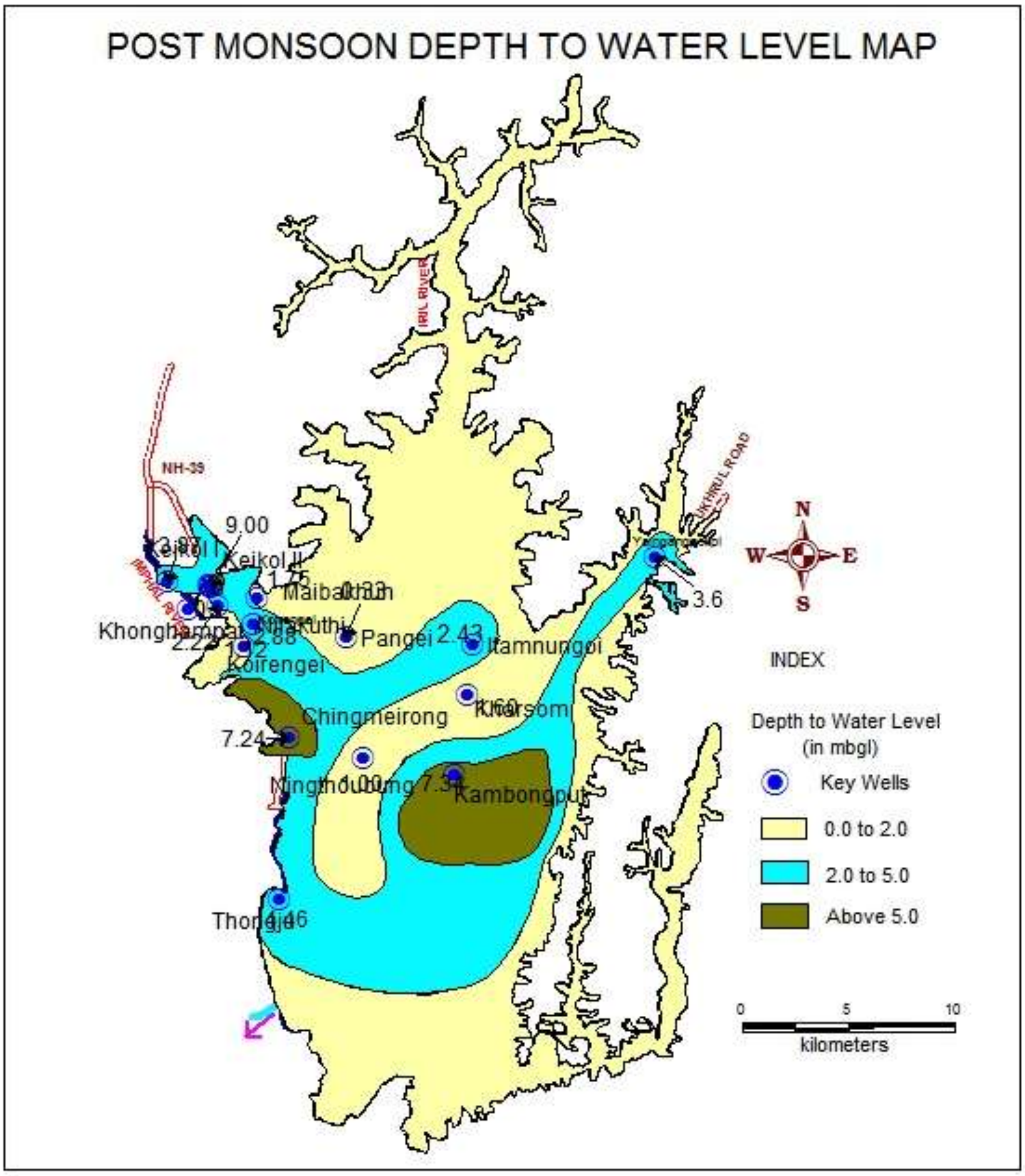


Fig. 13: Post-monsoon DTW contour of the study area

3.4 Ground Water Movement: The water table contour has been prepared based on water level of ground water monitoring stations (Fig.14). The ground water flow direction is from the higher elevation in north-western towards the south eastern region of the study area. The highest water table is 807.234 m above mean sea level while lowest contour is 778.154 m above mean sea level.

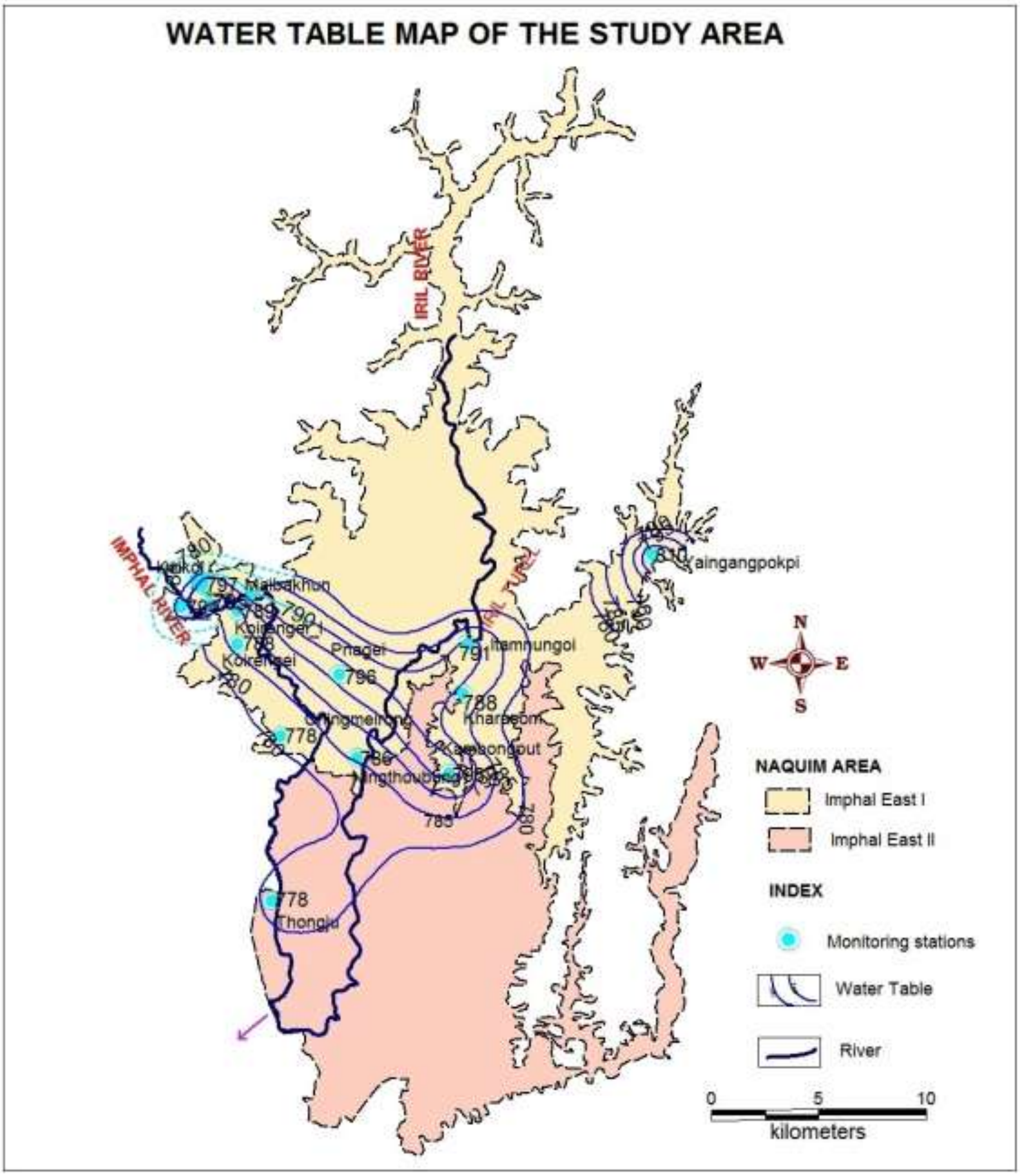


Fig. 14: Water table contour of the study area

3.5 Groundwater quality

Chemical analysis of ground water samples are carried out by regional chemical laboratory of Central Ground Water Board, North Eastern Region, Guwahati. Water quality data is also collected from Public Health Engineering Department, Govt of Manipur.

Pre-monsoon pH value ranges from 7.2 to 8.2 and in the post-monsoon pH value ranges from 7.3 to 8.0 indicating no major variation in pH. All the water samples collected during Pre-monsoon and post-monsoon are mostly alkaline in nature. Pre-monsoon pH value increases the chance of bacterial contamination. Pre-monsoon iron concentration range is BDL to 32.1 mg/l while the post monsoon Fe concentration in groundwater ranges from BDL to 24.5mg/l. Pre and post monsoon iron concentration in Imphal East I block is within permissible limit. In Imphal East II block its value ranges from 0.06 to 32.10 mg/l during pre-monsoon and 0.045 to 24.5 mg/l in post monsoon. It is observed that in both pre- and post-monsoon groundwater samples concentration of Ca, Mg, Cl, SO_4, TDS and hardness as $CaCO_3$ are within desirable limit. Block wise concentration range of different chemical elements in ground water during pre- and post-monsoon in the study area is given in Table 14.

Table 14: Pre monsoon Chemical quality analysis of groundwater samples in the study area

Sl.No	Location/ Village	Well Type	PH	EC (µS/cm at 25ºC)	Turbidity	TDS mg/l	CO_3 mg/l	HCO_3 mg/l	TH as $CaCO_3$ mg/l	Cl mg/l	F mg/l	SO_4 mg/l	NO3 mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Fe mg/l
1	Kambongput	TW	8.2	940	0.32	629.8	66	427	155	7.1	0.78	3.02	0.3	22	24	8.99	3.9	BDL
2	Itam Nungoi	TW	7.2	1230	0.5	824.1	118	616	205	21	0.66	0.99	0.5	38	27	90.98	3.5	0.06
3	Yaingangpokpi	TW	7.7	1490	1.0	998.3	164	824	265	39	0.72	4.67	1.12	52	135	23.63	2.53	BDL
4	Keikol	TW	7.7	310	BDL	207.7	32	159	70	11	0.54	4.87	2.72	12	9.7	112	1.96	17.8
5	Tendongyan	TW	7.5	195	0.2	130.6	BDl	97	55	11	0.3	1.6	0.61	10	7.9	15.22	3.72	32.1
6	Khonghampat	TW	7.8	370	0.3	247.9	45	146	100	7.1	0.56	3.21	0.34	20	7.3	8.3	3.03	25.8
7	Keikol Makha	DW	7.2	680	0.7	455.6	60	195	150	60	0.39	0.87	0.59	44	8.5	91	3.55	1.35

Table 15: Post-monsoon Chemical Quality Analysis of ground water samples in the study area

Sl.No	Location/ Village	Well Type	PH	EC (µS/cm at 25ºC)	Turbidity	TDS mg/l	CO_3 mg/l	HCO_3 mg/l	TH as $CaCO_3$ mg/l	Cl mg/l	F mg/l	SO_4 mg/l	NO3 mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Fe mg/l
1	Kambongput	TW	8.0	900	0.33	603	64	452	130	9.5	0.85	2.87	0.26	27	24	8.9	3.4	BDL
2	Itam Nungoi	TW	7.3	1200	0.54	804	112	640	165	28	0.62	0.78	0.39	42	33	90.5	3.0	0.045
3	Yaingangpokpi	TW	7.9	1450	1	971.5	160	844	235	48	0.65	4.12	1.03	58	156	21.3	2.53	BDL
4	Keikol	TW	7.4	300	BDL	201	32	179	56	9.5	0.51	4.33	2.16	18	12	108.2	1.87	14.3
5	Tendongyan	TW	7.6	125	0.22	83.75	BDl	116	45	19	0.33	1.3	0.53	14	10	15.2	3.34	23.4
6	Khonghampat	TW	7.9	310	0.34	207.7	46	154	95	11.9	0.61	2.54	0.29	27	16	7.9	3.00	24.5
7	Keikol Makha	DW	7.5	610	0.61	408.7	57	228	175	72	0.31	0.54	0.44	47	12.6	90.2	3.21	1.00

Table 16: Physical Properties of groundwater during pre-monsoon and post-monsoon periods

Sl.No	District	Period	PH	TDS (mg/l)	EC (μS/cm at 25ºC)	Temp. (in º C)
1	Imphal East	Pre-monsoon	7.2 – 7.8	100 –436	195 – 680	23 –24
		Post-monsoon	7.4 – 7.9	100 – 560	125 – 1450	14.5 – 15

CHAPTER 4.0

GROUND WATER RESOURCES

4.1 Groundwater Resources estimation

The computation of ground water resources available in the existing two blocks of Imphal East district has been done using GEC 1997 methodology. The Dynamic Resource estimation presented here is taken from the Dynamic Groundwater Resources of Manipur 2013 in block level.

In the present report, the smallest administrative unit viz. Imphal East-I block and Imphal East II block have been considered for resources assessment. Area with more than 20% slope has been excluded for the recharge assessment. The total area considered for the resources estimation is 709 sq.km, which is the total NAQUIM area in Imphal valley.

Since the poor-quality groundwater is only a localized phenomenon, the block-wise poor-quality area have been taken as Nil. The sub-unit demarcation into command and non-command is not carried out since the data for the same are not available.

Groundwater draft for domestic use has been estimated based on the number of different types of groundwater abstraction structures and their unit draft per year. The State Government authorities like PHED, IFCD (renamed as Water Resources Department), Minor Irrigation Department, MASTEC, DGM etc. provided the number of groundwater structures. Draft during monsoon and non-monsoon periods have been estimated separately by taking 04 months as monsoon and 08 months as non-monsoon period. The annual unit draft has been taken as 1.0 ham for shallow tube wells, considering the average discharge of wells as 15 m^3/hour with two hours pumpage per day.

Block-wise groundwater draft for irrigation was estimated based on the number of structures as provided by Minor Irrigation Department. The unit annual draft has been taken as 3 hams as given in GEC'97 for the states of some of the North Eastern States. Groundwater in the State is mostly used for domestic and irrigational purposes. Groundwater for Industrial draft is negligible. The details of canals have been collected from Irrigation and Flood Control Department, Govt of Manipur (now, renamed as Water Resources Department). All the canals are unlined and the canal seepage factor has been taken as 15 ham/day/million sq.m of wetted area. For estimating the recharge from surface water irrigation, details regarding various major and medium irrigation projects are collected from Water Resources Department, Govt of Manipur.

The return flow factor for surface water irrigation has been taken as 0.50 for paddy and 0.30 for non-paddy, which works out to be 0.374 for the assessment unit as a whole. Return flow factor for groundwater irrigation has been taken as 0.45 for paddy and 0.25 for non-paddy which works out to be 0.292 for the assessment unit as a whole. Recharge from tanks and ponds and Recharge from water conservation structure have been taken as Nil. In the absence of water level data, the recharge from rainfall has been calculated using Rainfall Infiltration Factor. Following the norms recommended by GEC'97, Rainfall Infiltration Factor has been taken as 0.12 for Tertiary Sedimentary Formations. The natural discharge during non-monsoon period is taken as 10% since only RIF method is considered. The population has been projected to 2025 based on decadal growth rate as given in Census of India, 2011. Categorization of assessment units are done based on stage of groundwater development only, since data on long term water level trend is absent.

The total annual groundwater recharge in Imphal East district is 12818.84 ham. The net groundwater availability worked out 11536.96 ham after deducting the natural discharge during non-monsoon season. The existing gross groundwater draft for all uses is 42.10 ham of which 33.11 ham is the gross groundwater draft for irrigation use and 8.99 ham is the gross groundwater draft for domestic use. The stage of groundwater development of the district is 0.36 %. As such the district falls under Safe category. Since there is no saline/ brackish water infested area in the district, the entire assessment area, i.e., Imphal East district has been considered as fresh water bearing area.

The pre-monsoon (monitored in the month of March) water level data of CGWB has been considered as the maximum depth below ground level up to which the zone of water level fluctuation occurs. Since the study area receives pre-monsoon showers, which commences from the first week of April, resulting in rise in water levels in the phreatic zones, the deepest water levels are recorded during the month of March. The specific yield of aquifer in Unconsolidated Alluvium Formation has been taken as 0.12.

Table.17. Balance of groundwater availability for future use as per dynamic groundwater resources in Imphal East district

Assessment Unit	Stage of Ground Water development (%)	Net GW Availability (ham)	Existing Ground Water Draft for Irrigation (ham)	Existing Ground Water Draft for domestic & industrial supply (ham)	Existing Gross Ground Water Draft for All Uses (ham)	Provision for Domestic & Industrial requirement for up to 2025 (ham)	Net GW Availability for Irrigation (ham)	GW Availability for Future Irrigation@ 60% Net GW Availability (ham)	No. of STW feasible as per Resource (Unit draft 3 ham)
IE	0.36	11536.96	33.11	8.99	42.10	1185.83	10318.02	6190.812	2063

In-storage Resources of Confined Aquifer down to Explored Depth which can be exploited safely (say 450 m.) The average thickness of total saturated aquifer below ground level has been considered based on the lithological logs of the bore holes drilled so far by CGWB.

As per the revised guidelines, the actual granular/ productive zones within the aquifers have been considered for the computation. Average Storability value of confined aquifer has been taken as 0.000169.

4.2 Extraction from unconfined aquifer/deeper aquifer: As mentioned earlier that groundwater in the district is utilized mainly for drinking or domestic purposes. Public Health Engineering Department water supply projects are mainly based on groundwater.

Table 18: Public water supply scenario in the study area

Block	Total number of Public Water Supply Scheme	Source
Imphal East I	292	Deep Tube Well
Imphal East II	292	Deep Tube Well

PHED tube well depth is within 100 m. Besides the public water supply scheme rural population utilize dug wells for drinking and domestic water purposes. Dug well depth is generally more towards piedmont zone. Dug well depth in this area is generally within 10m. In the alluvial plain area dug well depth 3 to 7m.

4.3 Present Groundwater Development

Groundwater exploitation concentrates only in the valley districts. There is no scope in the hill districts except the exploitation of springs and other methods of old age water collection from nallahs. Exploitation of groundwater for water supply of Imphal began in June 1996 in the Potsangbam well filed. The well field comprises ten production boreholes (total depth comprised between 45 m and 60 m, unit discharge of borehole ranges from 1,087 to 1,512 l/m.)

Table 19. Water supply situation of Imphal East District

Sources of Water	Production (in MLD) [1 MLD = 1000 m^3/day] (As on 2017)	Production (in MLD) [1 MLD = 1000 m^3/day] (As on 2030)
Surface Water	27.51	
Ground Water	1.613	
Total	29.123	
Water Demand	*120.92*	
Deficit in Water Supply	*15.67*	

(Investigation and Planning Division, PHED, Govt of Manipur)

CHAPTER 5.0

GROUNDWATER RELATED ISSUES

5.1 Major Groundwater Issues in the Area

Ground water related problems in the study area has so far been identified as emanation of gas while construction of deep tube wells and existence of clayey deposit down to a depth range of 30 to 50 m, bgl which invites problem for construction of shallow tube wells. As such utmost care has to be taken during construction of deep tube wells so that any untoward incident can be averted.

Other groundwater related issues found in the study area are-
Low stage of development;
Flood is a primary hazard in the valley during the monsoon season every year damaging crops and properties of the people;
In places, high concentration of iron in groundwater also observed;
Water scarcity during lean period

5.2 Manifestation and Reasons of Issues

The depth to water level in the shallow aquifers ranges from 0.4 to 9.98 mbgl during pre-monsoon and 0.33 to 9.0 mbgl during post monsoon. Water level fluctuation between pre and post monsoon for shallow aquifers ranged between 0.01 to 2.74 m and it ranges from 0.07 to 1.48 m in the deeper aquifers.

The study area enjoys sub-tropical humid climate. Average annual rainfall in the area is 1632.4 mm. About 60 to 65 % of the annual precipitation is received during south-west monsoon from June to September. Annual average temperature of the study area is recorded to be 20.4^{O}C and the temperature ranges from 0^{O}C to 36^{O}C. The relative humidity is high.

Infrastructure for irrigation in the study area is very meager. Rain fed agriculture is practiced in the area and the groundwater withdrawal for irrigation purpose is practically nil. The following table shows the rain fed irrigation data in the study area.

5.3 Future demand: Future demand of ground water is analyzed for domestic, drinking and irrigation purposes.

Domestic and drinking purpose: The drinking and domestic requirement is worked out for projected block population where requirement has been considered as 60 liters per person per day. The block wise requirement up to 2030 is worked out and tabulated (Table 20)

Table 20: Projected population and water demand for domestic purpose of the area

Block	Block Population 2011	Growth rate	Projected Population			Projected Water Demand considering per person water need of 60 litre per day (ham)		
			2016	2025	2030	2016	2025	2030
Imphal East I	347265	0.012	368,606	410381	435,602	61.4343	68.3968	72.6033
Imphal East II	108848		115,537	128631	136,536	19.2561	21.4385	22.756
District total	456113		480480	534934	567809	80.08	89.1556	94.6348

5.4 Sources of water in Manipur State

At the beginning of the twentieth century, there were approximately 500 lakes in Manipur State with innumerable small ponds, swamps and marshes along lakesides and inter-riverine tracts and many community and household ponds. Many of these water bodies no longer exist due to encroachments for paddy cultivation and human settlement. At present there are still a number of large and small lakes. Loktak in Bishnupur district is the largest and most important freshwater lake (289 km2) in the North Eastern Hill states and could be used as a potable water resource after appropriate treatment. There are 155 water bodies covering an area of 530 km2 (World Bank 2007). Two main rivers drain Manipur: the Barak drains the west and the Manipur drains the east, including the Manipur Valley. The Manipur catchment has an area of 6,332 km2 and an average annual yield is 51.9 9 108 m3.

Manipur receives rainfall from the SW and NE monsoons, with an average annual rainfall of about 2,000 mm. A water balance calculation, considering water demand and the available surface water resources, by MASTEC (2007) showed that the annual availability of 18.5 9 109 m3 of water is 66% in excess of current annual requirement of 11.1 9 109 m3. With the prospect of water recycling, various departments dealing with water resources and supply are optimistic that there is sufficient water to meet the long-term needs of the Manipur Valley.

5.4.1 Water use in Manipur State

Before 1980, almost 100% of water used for domestic purposes was from rivers, lakes, ponds (local name Pukhris) and in hilly areas dug-wells and streams. Still now rainwater is the main source for agricultural water. With the increase in population, use of land for human settlement, agricultural activities and extensive use of fertilizers, pesticides, insecticides, herbicides have not only reduced water availability but also led to deteriorating water quality.

Presently groundwater is readily available. It has been identified 1,173 Public Health Engineering Department (PHED) installed and 841 private tube wells. During interviews, villagers said that they do not like the taste of tube well water and mainly drink pond water. It appears that most villagers are not aware of the danger of drinking untreated pond water. In some cases, there are indications that sufficient surface water is not available. So local people have started installation of private tube wells, like in Khundrakpam village (Imphal East) they installed a tube well-based supply. Presently, there are 10 tube well-based schemes covering 31 villages in the Manipur Valley (PHED 2006). At present, underground water is not used for agriculture.

5.4.2 Hand tube well use in the Manipur Valley

Public Health Engineering Department installed the first tube well in the Manipur Valley early in 1982, and the first private tube well was installed in June 1982. PHED drilled more hand tube wells after 1991–1992, many more tube wells than private owners. PHED reported that they had installed 1,173 tube wells in the Manipur Valley up to 2006.

5.5 Future demand for agriculture: The district has rich and varied vegetation and the climatic conditions are suitable for various flora and a wide variety of medicinal plants are grown. And the lakes and marshy lands of the valley are a favourite habitat of a variety of migratory birds. The district by and large is plain in nature and rice is the principal crop grown.

Agriculture and allied is the main occupation of the district and crop production is an important activity for the economy of the district which provides livelihood-cum-employment opportunities to the rural population. Mono cropping is in vogue in the area. Major crop grown in the district is paddy. Other crops include Oil Seeds, Maize, Pulses, Sugarcane, Vegetables, Potatoes, Mushroom and Fruit crops like Pineapple, Orange, Banana, Papaya, Lemon, Passion fruit etc. The most predominant crop grown in the district is Paddy. Other major crops include Mustard, Pulses, Sugarcane, Potato and Fruit crops like Pineapple, Orange, Lemon, Passion fruit and Banana. The district receives moderate to high rainfall, the fertile, alluvial soils in the river basin. The new and emerging sectors/economic activities in the district are piggery and fishery.

Since the area has shallow water level condition, the total depth of water required to raise a crop over a unit area is considered as 1.2m

The total number of Cultivator in the district is 27895 out of which 8460 are marginal farmers. Moreover, there are 1, 45, 343 of main worker and 2, 61,265 of non-workers population in the rural and urban areas (Statistical Year Book of Manipur 2015) of the district respectively leading to vast unemployment.

Table 21: Block wise water requirement for winter paddy cultivation through irrigation

Block	Irrigated Area(ha)	Un Irrigated Area (ha)	Total Area (ha)	60% of net sown area bring under paddy cultivation and irrigation	Depth of water required to raise a crop over a unit area is considered as 1.2m	Water requirement for 60% of net sown area (ham)
Imphal East I	676	18960	1936	8457 ha	1.2	10148.4
Imphal East II	860	7752	8612	3792 ha		4550.40
Total water requirement						**14698.80** Ham

Table 22: Block wise water requirement for rabi crops other than paddy through irrigation				
Block	Total Area(ha)	in m	Base period for crops other than Rice	Water requirement for 40% of net sown area (ham)
Imphal East I	19636	1.2		6765.6
Imphal East II	8612	1.2		3033.6
Total water requirement				**9799.30**

5.6 Stress Aspects of aquifer: Stress aspects of aquifer are discussed comparing water demand in various sectors and supply.

Table 23: Total water requirement for the area

Block Name	Drinking water requirement up to 2025 Ham	Water requirement to bring 60% of net sown area under irrigation for paddy cultivation Ham	Water requirement to bring 40% of net sown area under irrigation for non-paddy cultivation Ham	Water allocated for drinking and domestic purposes up to 2025 Ham	Water allocated for irrigation up to 2025 Ham
Imphal East I	2462.286	10148.4	6765.6	812.55	3469.83
Imphal East II	771.786	4550.40	3033.6	254.69	6669.40
Total	3234.072	**14698.80**	**9799.30**	1067.24	9326.68

5.7 Supply and demand gap: It is observed that drinking water allocation is sufficient to meet the future demand and it will not give additional stress on the aquifer. However, if entire net sown area is brought under irrigation, then allocated water for irrigation will not be sufficient to meet the future demand.

Table 24: Supply and demand gap in drinking water sector

Block Name	Drinking water demand up to 2025 Ham	Water allocated for drinking and domestic purposes up to 2025 Ham	Gap between supply and demand Ham
Imphal East I	2462.286	812.55	1649.736
Imphal East II	771.786	254.69	517.096
Total	3234.072	1067.24	2166.832

Table 25: Supply and demand gap in irrigation

Block Name	Total irrigation demand Ham	Water allocated for irrigation up to 2025 Ham	60% of the allocated water for irrigation available for use	Gap between supply and demand Ham
Imphal East I	2782.25	3469.83	2018.898	687.58
Imphal East II	6708.57	6669.40	4001.64	(-) 39
Total	9490.82	9326.68	5596.008	(-) 164.14

CHAPTER 6.0
Management Strategy

The 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 groundwater resources has to be taken up after understanding the varied hydrogeological characteristics. In addition, the development of groundwater requires thorough understanding of the heterogeneity of the formation. The peneplain surfaces, buried pediments and valley fills are the most favourable localities for development of groundwater. Structures such as dug well and tube well are the feasible ground water structures.

The objective of management is to utilize the available groundwater 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.

- Based on the hydrogeological condition prospects for groundwater development in the district is confined to the foothills and valley sector only. The western and northern region are feasible for the development of groundwater through shallow to moderately deep tube wells down to 75 m tapping about 10 to 30 m of cumulative thickness of granular horizon capable of yielding 20 to 40 m^3/hr for drawdown up to 12 m.

- The tube wells may be constructed for tapping groundwater horizons with cumulative thickness of 10-meter bordering areas to Imphal West district around Sekmai and Koirengei area (Pebble, gravel mixed with sand) may yield 480 liters per minute for a drawdown of 6 m. Groundwater prospect is high within 5-7 kms from NH-39 bordering to Imphal West district.

- Tube wells may also be constructed around north-eastern parts of the district at the foot of residual hill, tapping deposits consisting of soil mixed with sand, gravel and underlain by soft shale followed by hard shale, give discharge of 100 to 180 lpm. In places where there is sandstone layer at depth, tube wells give comparativelt higher amount of water.

- In the central part of the district fine-grained granular horizons of cumulative thickness of 10 to 20 m are encountered up to 100 m. The area is suitable for the construction of tube wells for domestic supplies. In the eastern and southern part of the tube wells of moderate depth are considered to be feasible with discharges of 20 to 50 m^3/hr.

- The district has moderate groundwater potential and available net groundwater resource is 11536.9 ham. This available resource can be developed for irrigation and other domestic purposes. The groundwater extraction by existing tube-wells for irrigation was 33.11 ham and development are found to be 0.36 %, as such scope exists for development of groundwater in the district. Based on the irrigation water requirement, additional 2063 nos. (by taking 3 hams per well per year) of medium duty shallow tube wells may be constructed, which will be able to generate irrigation potential of 6190 ham. The conjunctive use of surface and groundwater may be done for better ecological conditions of the district. As the district is blessed with good amount of rainfall, rain water harvesting structures may also be constructed for storing and artificial recharge of groundwater.

- ❖ The study area is having meager irrigation facility. Available unirrigated land of 26712 ha can be brought under irrigation using the dynamic groundwater resources available in the district. It is proposed to bring 60% of area under paddy and 40% under non-paddy cultivation. Water requirement for paddy cultivation (Δ=1.2 m) would be 14698.80 ham while that for non-paddy cultivation (Δ=0.3 m) would be 9799.30 ham. Total water requirement to bring this entire uncovered area under irrigation is 24498.1 ham.

- ❖ Tube wells can be designed in the study area within a depth of 90 m, tube wells can be constructed by tapping 10 to 20 m of granular zone and expected yield is 15 m^3/hrs. for a maximum drawdown from 12- to18 m. Wells may be constructed by using 6// dia casing pipe down to 20m, 6// dia 1 to 1.5 mm slot pipes for 20m and 6// dia 10 m blank pipe.

- ❖ Although, groundwater cannot supply the entire irrigation water requirement, it can safely fulfil the demand of rabi crops including the rabi rice. However, kharif rice irrigation demand has to be filled up by surface irrigation schemes. Groundwater shortage can be further be reduced by increasing the irrigation efficiency.

- ❖ Development of rainwater harvesting for the drinking water supply is also one of the appropriate measures for solving the scarcity of potable water as it involves relatively low cost, less time for implementation and provides almost entirely safe drinking water which does not require costly purification and treatment process.

- ❖ Rooftop rainwater harvesting is yet to be exploited in the district. The district is facing acute drinking water shortage as the government's water supply facilities fully depends on the rivers and which are generally remain dry during the dormant season. Rooftop rainwater can be one of the best options to stored quality water for use during the dormant months. During the water crisis period, there are many other private traders who supply the drinking at much higher price, which increases hardship to the common people. Groundwater resources are not yet exploited in Manipur, so groundwater can be one of the options for supplies of water during non-rainy months and same groundwater can be recharged during the monsoon months.

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