GOVERNMENT OF INDIA
भारत सरकार
MINISTRY OF JAL SHAKTI
जल शक्ति मंत्रालय
Department of Water Resources, River Development and Ganga Rejuvenation
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
CENTRAL GROUND WATER BOARD
केंद्रीय भूजल बोर्ड

INCEPTION REPORT

ON

URBAN AGGLOMERATION STUDIES IN GREATER SHILLONG AREA, MEGHALAYA

UNDER NAQUIM 2.0

(AAP 2023-24)

STATE UNIT OFFICE
SHILLONG
APRIL 2023

INCEPTION REPORT ON URBAN AGGLOMERATION STUDIES IN GREATER SHILLONG AREA, MEGHALAYA
Target area - 180 Sq.km

Introduction

Aquifer Mapping and Management programme (NAQUIM) was launched by CGWB in the year 2012 as per the recommendations of the Report of the Steering Committee on Water Resources and Sanitation for Twelfth Five Year Plan (2012-2017) Planning Commission. NAQUIM was taken up with the objectives of delineating aquifers, characterizing aquifers and preparing aquifer management plans in 1:50,000 scale. The outputs of the NAQUIM studies has been fruitful for sustainable management of groundwater resources at district level and block level however large scale implementation of its recommendations at ground level by the user agencies has been lacking.

As per the feedback received from the agencies using the NAQUIM outputs, major limitations of the ongoing studies include i) non-availability of printed maps at usable scales and ii) lack of site specific recommendations for implementation at Panchayat or village level. Keeping the above limitations in mind and considering the future requirements, broad objectives of NAQUIM 2.0 studies will be i) providing information in higher granularity with a focus on increasing density of dynamic data like ground water level, ground water quality etc. ii) providing issue based scientific inputs for ground water management upto Panchayat level, iii) providing printed maps to the users and iv) putting in place a strategy to ensure implementation of the recommended strategies. Involving state agencies in the studies for a sense of ownership.

NAQUIM 2.0 is designed to provide detailed information to support groundwater management decisions at ground level. Since the issues are different in different areas, the studies under NAQUIM 2.0 are proposed as issue specific and will be undertaken in prioritized focus areas. Broadly 11 Priority areas are identified based on ground water related issues as given below,

1. Water Stressed Areas, **2. Urban Agglomerate,** 3. Coastal Areas, 4. Industrial Clusters and Mining Areas, **5. Areas with springs as the principal source**, 6. Areas with Deeper Aquifers, 7. Ground Water Contamination, 8. Autoflow zones, 9. Canal Command Areas, 10. Areas with poor ground water quality, 11. Other specific Issues.

Table 1: Priority area wise deliverables for Urban Agglomeration studies

S.No	Priority area	Deliverable Required
1	Aquifer Dispositions	✓
2	Aquifer-wise ground water Water Levels	✓
3	Delineation of Recharge Areas	✓
4	Estimation/Refinement of parameters used for resource assessment	✓
5	Assessment of ground water resources	✓
6	Location, Discharge and water quality of the springs, vulnerability of the springs	✓
7	Demarcation of the springshed	✓
8	Ground Water Quality in every habitation	NA

9	Ground Water Quality	✓
10	Areas showing signs of subsidence	NA
11	Extents of autoflow zones	NA
12	Extent of saline ingress	NA
13	Ground Water Quality Management Interventions including demarcation of safer aquifers	✓
14	Impact of Mining or Industrial activities and vulnerability of the aquifers.	NA
15	Artificial Recharge Plan	✓
16	Other measures	✓
17	Identification of potential aquifers for drinking water supply	✓
18	A plan for drinking water source sustainability	✓
19	Identification of potential aquifers for Irrigation	NA
20	Recommended interventions for containing saline ingress (Artificial Recharge, Regulation etc.)	NA
21	Potential aquifers that can be used for carbon sequestration	NA
22	Recommendations for springshed management	✓
23	Recommendations for spring water harvesting	✓
24	Potential to be used as rainy-day resource.	NA
25	Ways to minimise ground water losses because of free flowing wells.	NA
26	Plan for Conjunctive use of surface water and ground water	NA
27	Recommendations for tackling water logging	NA
28	Demand driven studies like- Source Finding, Development of new cities, Waste disposal sites etc.	NA

1. About The Study Area

The proposed study area of Greater Shillong under NAQUIM 2.0 covers an area of 180 Sq. km. The area has to be mapped in 1:10,000 scale. Greater Shillong area has been selected under the pre-defined priority type of "Urban Agglomeration" out of 11 Priority areas as per Central Ground Water Board national mandate.

Shillong is the capital of Meghalaya and it is also the district headquarters of East Khasi Hills District. It is situated at an altitude of 1,496 m (4,908 ft) above sea level and is located in the center of the Shillong plateau. Shillong urban agglomerate comprising of Shillong Municipality and 11 suburbs (Census Towns), viz., Shillong Cantonment, Madanryting, Mawlai, Nongthymmai, Pynthorumkhrah, Nongmynsong, Mawpat, Umlyngka, Umpling, Nongkseh and Lawsohtun. The Greater Shillong area falls under Mylliem block, East Khasi Hills district, Meghalaya and covers an area of approximately 180 sq. km. The area lies between north latitudes 25°33'15" to 25°36' 02" and east longitude 91°50'50" to 91°56'17" and falls in the survey of India toposheet No. 78 O/14. Location Map of Greater Shillong is shown in Fig.1. A few reserve forests can be found around and near Shillong viz., Riatkhwan, Short Round, Shyrwat, Upper Shillong, Riatlaban & Laitkor. As per 2011 Census, the total population of the urban area is 354,759 as against 267,662 in 1991 indicating a decadal growth of about 24%. The city features a subtropical highland climate with temperature varying from 2° to 25.0° C. Winter usually starts from October and continues up to March. During the months of December and January ground

frost in early morning is very common. Summer is rather of short duration followed by monsoons which generally starts from May and continues till October and so. 90% of the total annual rainfall takes place in this season. Average annual rainfall is about 2022 mm.

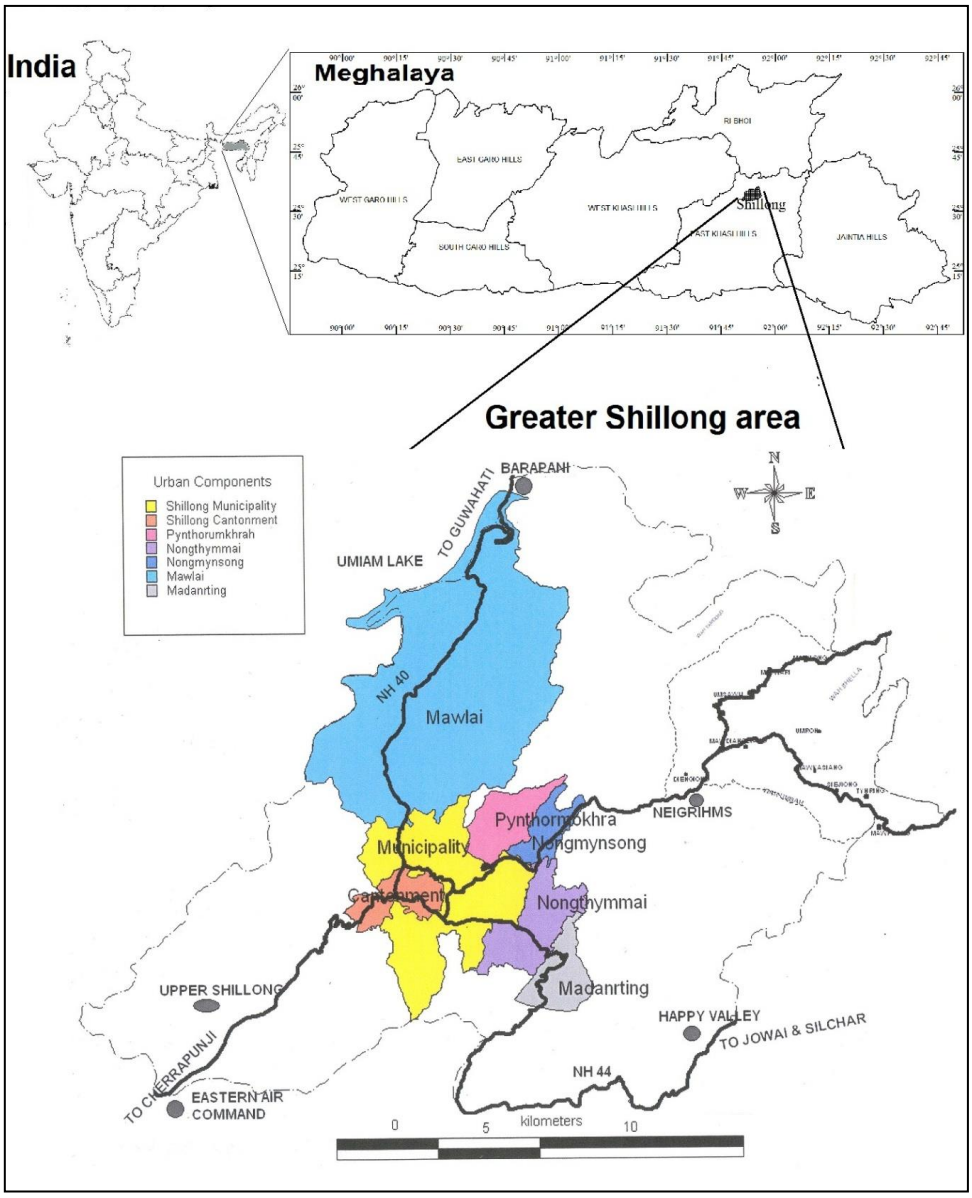

Fig.1: Location Map of Greater Shillong

Physiography and Drainage

The area under Greater Shillong forms a part of the Shillong plateau. It is located on a gently undulatory area with steep slopes running in different directions. The master slope runs mainly in south-west to north-east direction. The average height of the area is about 1400-1500 m above msl. The highest point of Shillong is Shillong peak, which is situated at a height of 1960 m above mean sea level. The plateau is dissected by a number of streams into hills and intermontane valleys. One major intermontane valley lies to the north of the city along Wah Umkhrah river in the Polo Ground area.

The main drainage of Shillong is carried by two rivers, namely Wah Umshirpi and Wah Umkhrah, which confluence near Beadon and Bishop Falls to form the Wah Ro Ro river, a tributary to Wah Umium river. These two rivers surround the Shillong town and roughly determine the Municipal limits. The numerous streams in the western and southern parts of the city are tributaries of Wah Umshirpi, whereas streams in northern and eastern parts of the city are tributaries of Wah Umkhrah which starts as Umpling river near Umpling. The drainage pattern of the area is angular to sub-angular, typical of hard rock hilly terrain. The streams are not perennial in nature. The discharge in the streams varies from season to season.

Soil Type

The soils present in and around Shillong Urban area are Ultisols, colloquially known as "red clay soil". The soils are shallow to moderately deep, loamy, skeletal, fine and excessively drained, with severe to very severe erosion hazards. Ultisols vary in color from purplish-red, to a blindingly bright reddish-orange, to pale yellowish-orange and even some subdued yellowish-brown tones. They are typically quite acidic, often having a pH of less than 5. The red and yellow colors result from the accumulation of iron oxide (rust) which is highly insoluble in water. Major nutrients, such as calcium and potassium, are typically deficient in Ultisols, which means they generally cannot be used for sedentary agriculture without the aid of lime and other fertilizers such as superphosphate.

Hydrogeological conditions in Greater Shillong Urban Area

Geology

The area is underlain by Shillong group of rocks consisting of quartzite & phyllites and Khasi Greenstone (Epidiorite). The base of Shillong Group is marked by conglomerate bed containing cobbles and boulders of earlier rocks, i.e., Archaean crystalline rocks, which formed the basement rocks over which the Shillong Group of rocks were laid down as sedimentary deposits during Pre-Cambrian times and metamorphosed over time. The rocks were intruded by epidiorite rocks known as Khasi greenstone. These metabasic rocks occur mostly as sills being concordant with the formations they intruded.

The surface area is covered by red soil to mixed soil type having thickness ranging from few centimeters to 2 m. The rocks are highly weathered at shallow depth leading to the formation of thick soil cover in the low lying areas & thin veneer of soil layer at higher elevation. This weathered zone is underlain by jointed and fractured quartzite. The distribution and disposition of these joints and fractures are of complex nature due to the various tectonic and structural disturbances to which country rocks are subjected to. The depth of this zone varies from 10-60 m below ground level. This is followed by hard massive quartzites, which are generally devoid of prominent structural features. However fracture/jointed rocks are found to occur at greater depths in certain exploratory wells drilled in similar formations in the area. Broadly, there are three sets of lineaments in the area, mainly along

ENE–WSW, NW–SE and E–W directions. Lineaments along NE–SW, NNW–SSE and N–S directions are also developed.

Ground Water Scenario

Ground water occurs in the area under water table conditions in the top weathered and fractured zone of quartzite and in some pockets Khasi Greenstone. Further below, semi-confined to confined condition exist in the interconnected joints, fractures etc of the underlying hard quartzite. The weathered quartzites have poor to moderate yields. The underlying second zone is fissured and jointed which is the zone of saturation. The distribution and disposition of these joints and fractures are of complex nature due to the various tectonic and structural disturbances to which country rocks are subjected to. Groundwater occurs under semi-confined condition in this zone.

Quartzite and recent valley fills constitute the major aquifer system in the area. Ground water occurs under unconfined condition in the weathered rock and residuum. Ground water development in the urban agglomeration is both by dug wells generally confining to the weathered zone & bore wells which mainly tap the fractured zone. These fractures sometime extend very deep occurring even beyond 180 mbgl.

As the topography is uneven and the thickness of the weathered horizon varies considerably, open wells are restricted to the Umkhrah valley in polo ground and Pynthorumkhrah area. Central Ground Water Board has drilled 12 nos. of borewells till date under Ground water Exploration Programme to identify aquifers present in the area. The lithological studies of the wells drilled by CGWB reveal that ground water occurs under semi-confined to confined condition in fracture quartzites and Khasi greenstone. The ground water prospect in these formations are poor to moderate.

Occurrence of Ground Water as springs

Spring plays a major role for the water requirement of the people in Shillong. They serve as a major source of water supply for drinking and other uses. Spring discharge is controlled by rainfall, land use, vegetation, geology and geomorphology of the recharge zone. Geologically, the springs monitored in the study area are of mainly depression and fracture type. It has been observed that all the springs monitored shows relatively higher discharge in May-June compared to January-March, which is due to the incidence of high rainfall during April-June. The discharge of the springs, according to urban hydrogeological survey during 2017-18, in dry period (January to March) varies from 15552 lpd to 51,8400 lpd and in post monsoon period (November) from 43200 lpd to 691200 lpd. Looking at the hydrogeological behavior of these springs, it can be inferred that each spring has its own character, which is influenced by a combination of factors operated in the recharge zone.

Groundwater resource

As per Dynamic Ground Water Resource of Meghalaya as on 2022, the total annual groundwater recharge in Greater Shillong is 2701.26 Ham. The annual extractable ground water resource of Greater Shillong is worked out as 2566.22 Ham. The existing current annual gross ground water extraction for all uses is 316.63 Ham of which 9.91 Ham is the current annual gross ground water extraction for industrial use and 306.72 Ham is the current gross ground water extraction for domestic use. Annual ground water allocation for domestic use as on 2025 is 353.8 Ham and Net ground water availability for future use is 2202.51 Ham. The over-all stage of groundwater extraction of Greater Shillong is 12.34 %.

2. Priority types

Greater Shillong area has been selected under the pre-defined priority type (Priority Area 2) of "Urban Agglomerate" out of 11 Priority areas as per Central Ground Water Board national mandate under NAQUIM 2.0.

3. Previous Studies

Under different activities and studies of Central Ground Water Board, some of the work carried out in the area and report published are as follows;

Aquifer Mapping and Management Plan of East Khasi Hills district (2017-18), Dynamic Ground Water Resource of Meghalaya (as on 2017, 2020 and 2022), Ground Water Resources of Shillong Urban Area (Greater Shillong), Meghalaya (2013), Development of water supply through springs in East Khasi Hills District (2009-10), Urban areas of East Khasi Hills District (2004-5), Basic data report of Exploration carried out in 12 locations and geophysical investigation in Meghalaya state (2010-11).

4. Objectives of the present study

NAQUIM 2.0 is designed to provide detailed information to support groundwater management decisions at ground level. Since the issues vary in different areas, the studies under NAQUIM 2.0 are proposed as issue specific and will be undertaken in prioritized focus areas.

The main objectives for Urban Agglomeration studies is shown in the table below;

Table 2: Main objectives for Urban Agglomeration studies

Sl. No.	Objectives
1	Preparation of map in 1:10,000 scale
2	Aquifer Dispositions
3	Defining aquifer management unit (AMU) and its extension
4	Aquifer-wise ground water levels

5	Delineation of Recharge Areas
6	Estimation/Refinement of parameters used for resource assessment
7	Assessment of ground water resources
8	Location, Discharge and water quality of the springs, vulnerability of the springs
9	Demarcation of the springshed
10	Ground Water Quality
11	Ground Water Quality Management Interventions including demarcation of safe aquifers
12	Identify garbage/sewage disposal points in the city and their impact on groundwater
13	Artificial Recharge Plan and feasible water conservation measures underlining the cost to benefit ratio
14	Other measures
15	Identification of potential aquifers for drinking water supply
16	A plan for drinking water source sustainability
17	To understand the current water demand and supply of the city and calculate the gap if any
18	Recommendations for springshed management
19	Recommendations for spring water harvesting

5. Existing data

Central Ground Water Board has drilled 12 nos. of borewells till date under Ground water Exploration Programme to identify aquifers present in the area. The lithological studies of the wells drilled by CGWB reveal that ground water occurs under semi-confined to confined condition in fracture quartzites and Khasi greenstone. The ground water prospect in these formations are poor to moderate

Central Ground Water Board is regularly monitoring water level from 3 dug wells, 1 piezometer and 2 springs. In unconfined aquifer (dug wells), depth to water level ranges from 0.95 mbgl to 6.97 mbgl during pre-monsoon and during post-monsoon it ranges from 0.84 mbgl to 3.05 mbgl. The spring discharge ranges from 0.001 to 2.56 lps (pre-monsoon) and 0.01 to 4.5 lps (post monsoon) .The piezometric head ranges from 2.63 - 17.2 m bgl (pre-monsoon) and 1.97 - 14.32 m bgl (post-monsoon).

Resistivity surveys employing Schlumberger electrode configuration was carried out in the area with a maximum electrode separation (AB) ranging from 100m to 280m depending on the availability of space. The space constraint was due to either water logging condition in some of the fields or the terrain being highly undulating. 19 VES were conducted in Polo grounds, Shillong, 18 VES in Golf Course and its environs at Shillong and 5 in Happy valley.

6. Data gap analysis

NAQUIM 2.0 study area is divided into 1'*1' grid (approx. 3sq.km) to study the data of ground water, spring sources, geophysical and chemical analysis. The existing data and data gap map is shown in the figure below;

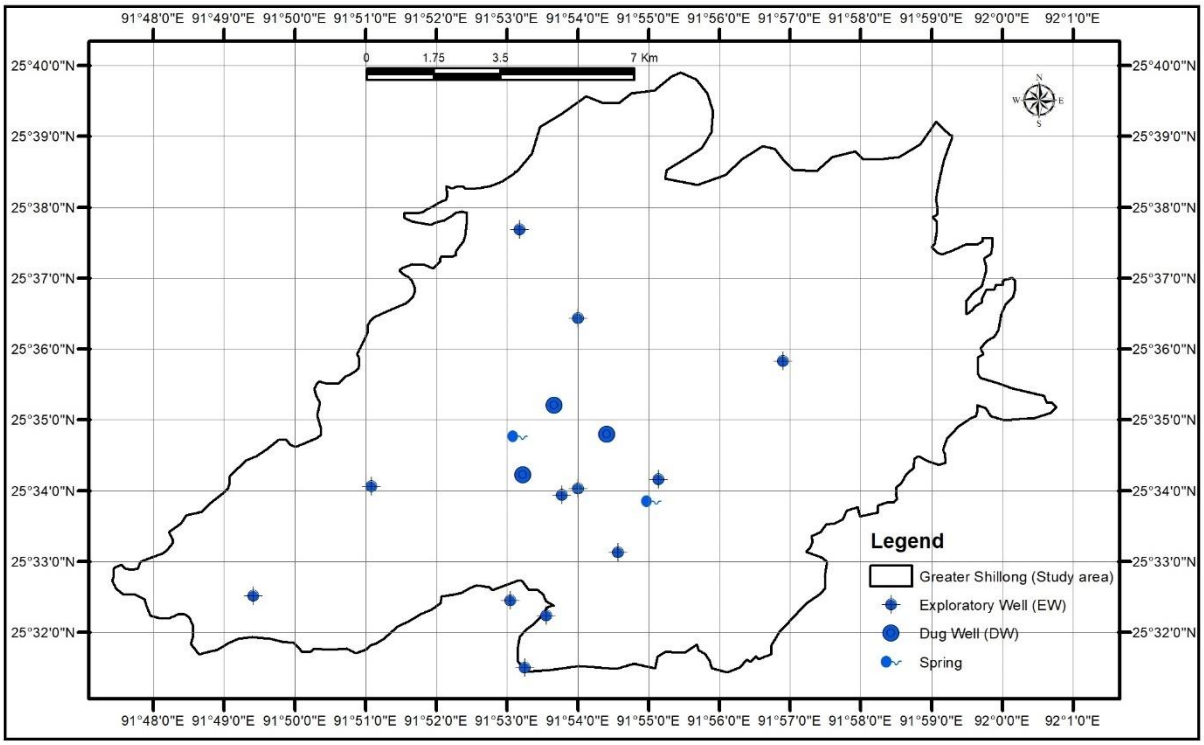

Fig.2: Existing data and data gap map

Table 3: Data Availability and Data Gap Analysis

Sl. No.	Items	Data Requirement	Data Availability	Data Gap/ New Data generation plan
1	Ground Water Exploration Data	Both first aquifer and second aquifer	12 EW & 1 OW	3 EW & 5 OW
2	Geophysical data	Geophysical data of the Study area	42 nos.	10 nos.
3	Ground Water Monitoring Regime	Representative monitoring wells/ springs distributed over the study area.	3 Dug well 2 Spring 1 Piezometer	20 nos.
4	Ground Water Quality	Representative monitoring wells/ springs distributed over the study area.	3 Dug well 2 Spring 1 Piezometer	20 nos.
5	Soil Infiltration test	RIF	Nil	4 nos.
6	Isotope study	To delineate recharge area	Nil	10 nos.

7. New Data generation plan and Month-wise activity plan

Table 4: New Data generation plan and Month-wise activity plan

Sl.No.	Activities	Officers Assigned	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24
1	Training/Workshop on NAQUIM 2.0	DR												
2	Base Map Preparation & Inception Report	DR, SK, AP												
3	Field Visit and interaction with State Govt	DR, SK, AP												
4	Detailed Field Work	DR, SK, AP												
5	First review	SK												
6	Key Well Establishment	DR, SK, AP												
7	Pre-Monsoon Water level Monitoring	DR, SK, AP												
8	Data Entry in WIMS	DR, SK, AP												
9	Pre-Monsoon Sampling	DR, SK, AP												
10	Data Collection	DR, SK, AP												
11	Second review	DR												
12	Pre-Monsoon Sample Analysis-Inhouse	DSD												
13	Pre-Monsoon Map Preparation	DR, SK, AP												
14	Third review	DR												
15	Post-Monsoon Water level Monitoring	DR, SK, AP												
16	Post-Monsoon Sampling	DR, SK, AP												
17	Post-Monsoon Sample Analysis-Inhouse	DSD												
18	Post-Monsoon WQ Data Analysis	DSD												
19	Post-Monsoon Map Preparation	DR, SK, AP												
20	Geophysical Data Acquisition & Map Preparation	TRB												
21	Fourth review	DR												
22	Data Entry in WIMS	DR, SK, AP												
23	Aquifer Parameter Tests	DR, SK, AP												
24	Climatological Data Analysis	DR, SK, AP												
25	Interaction with Villagers/ Stakeholders	DR, SK, AP												
26	Preparation of management plan	DR, SK, AP												
27	Report Preparation	DR, SK, AP												
28	Draft Report Submission	DR, SK, AP												
29	Final Report Submission	DR, SK, AP												

Note: DR - Ms. D Rabha, SK- Shri Shasinlo Kent, AP - Ms. Anenuo Pienyu, DSD - Dr. Snigdha Dutta, TRB - Sh. T. Raja Babu.

8. Composition of the team.

- Team Leader : Ms. D Rabha, Scientist-D (HG)
- Hydrogeologist : 1. Shri Shasinlo Kent, Scientist-C (HG)
  2. Ms. Anenuo Pienyu, Scientist-C (HG)
- Chemist : Dr. Snigdha Dutta, STA (Ch)
- Geophysicist : Sh. T. Raja Babu, Scientist-D (GP)

9. Team-member-wise responsibilities and monthly targets for entering in the MIS

Table 5: NAQUIM 2.0 Task detail Table (Month-Wise)

NAQUIM 2.0 (2023-24)	Field Work/ Lab Work Activity											
	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Ms. D. Rabha Scientist-D (HG)	LW	LW	FW	FW	LW	LW	FW	FW	LW	LW	LW	LW
Shri Shasinlo Kent Scientist-C (HG)	LW	LW/FW	FW	FW	FW	LW/FW	FW	FW	FW	FW	FW	LW
Ms. Anenuo Pienyu Scientist-C (HG)	LW	LW	FW	FW	FW	FW	FW	FW	FW	FW	FW	LW
Dr. Snigdha Dutta, STA (Ch)								LW	LW	LW	LW	
Sh. T. Raja Babu, Scientist-D (GP)							LW	FW	FW	LW	LW	
Note: FW - Field Work, LW - Lab work												