केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Chatra District
Jharkhand

मध्य पूर्वी क्षेत्र, पटना

Mid Eastern Region, Patna

भारत सरकार
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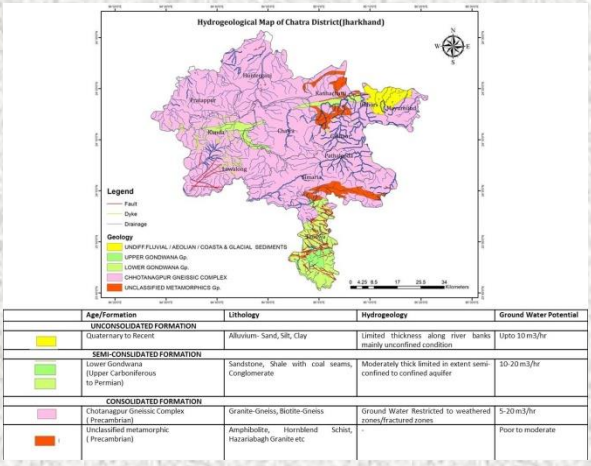
Central Ground Water Board

AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN , CHATRA DISTRICT, JHARKHAND STATE

जलभृत नक्शे तथा भूजल प्रबंधन योजना चतरा जिला, झारखंड



	Age/Formation	Lithology	Hydrogeology	Ground Water Potential
	UNCONSOLIDATED FORMATION			
	Quaternary to Recent	Alluvium- Sand, Silt, Clay	Limited thickness along river banks mainly unconfined condition	Upto 10 m3/hr
	SEMI-CONSLIDATED FORMATION			
	Lower Gondwana (Upper Carboniferous to Permian)	Sandstone, Shale with coal seams, Conglomerate	Moderately thick limited in extent semi-confined to confined aquifer	10-20 m3/hr
	CONSOLIDATED FORMATION			
	Chotanagpur Gneissic Complex (Precambrian)	Granite-Gneiss, Biotite-Gneiss	Ground Water Restricted to weathered zones/fractured zones	5-20 m3/hr
	Unclassified metamorphic (Precambrian)	Amphibolite, Hornblend Schist, Hazaribagh Granite etc		Poor to moderate

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September 2022

REPORT ON AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN OF CHATRA DISTRICT, JHARKHAND, 2020-21

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ACKNOWLEDGEMENT

I express my sincere gratitude to Shri Sunil Kumar, Chairman, CGWB for providing an opportunity for being part of the prestigious National Aquifer Mapping Program. My sincere thanks to Sh. A.K.Agrawal, Member(CGWA), Sh Satish Kumar, Member(East),Sh. T.B.N. Singh RD, MER, Patna , Late Shri G.K.Roy,Sc-D & Ex OIC, Shri B.K.Oroan, RD, NHR, Dharamshala, Shri Rajeev Ranjan Shukla, Scientist-E &OIC, SUO, Ranchi for their valuable guidance and advises throughout the period. I am very much thankful to Dr Sudhanshu Shekhar, Scientist-D, who has not only supervised the study but also thoroughly scrutinized the report. I express my thanks to my colleagues Shri Sunil Toppo, Scientist-B, Dr Anukaran Kujur, Scientist-B, Ms Manasi Bhattacharjee Chemist & Dr Suresh Kumar, Asstt. Chemist for their valuable inputs

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REPORT ON NATIONAL AQUIFER MAPPING AND MANAGEMENT PLAN OF CHATRA DISTRICT, JHARKHAND, 2021-22

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AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN OF CHATRA DISTRICT, JHARKHAND STATE

1.0 INTRODUCTION:

The vagaries of rainfall, inherent heterogenity & unsustainable nature of hard rock aquifers, over exploitation of once copious aquifers, lack of regulation mechanism etc has a detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from "**Traditional Groundwater Development concept" to "Modern Groundwater Management concept"**. Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. This leads to concept of Aquifer Mapping and Ground Water Management Plan programme. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers. The proposed management plans will provide the "Road Map" for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus the crux of NAQUIM is not merely mapping, but reaching the goal-that of ground water management through community participation.

During XII five year plan (2012-17) National Aquifer Mapping (NAQUIM) study was initiated by CGWB to carry out detailed hydrogeological investigation, which is continued till 2023. In pursuance of AAP 2021-2022, CGWB State Unit Office, Ranchi, has carried out Aquifer mapping and Management Plan in Chatra district of Jharkhand State with the aim of delianation and characterization of aquifers and its quantity, quality and sustainability of ground water in aquifers. The study is a part of the fulfilment of National Aquifer mapping and Management Plan. The aquifer maps and management plans will be shared with the Jharkhand Govt for its effective implementation.

1.1 Objective and Scope of the study:

The major objectives of aquifer mapping are delineation of lateral and vertical disposition of aquifers and their characterization. Quantification of ground water availability and assessment of its quality to formulate aquifer management plans to facilitate sustainable management of ground water resources at appropriate scales through participatory management approach with active involvement of stakeholders.

The groundwater management plan includes Ground Water recharge, conservation, harvesting, development options and other protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e, the aquifer map and management plan.

The main activities under NAQUIM are as follows:

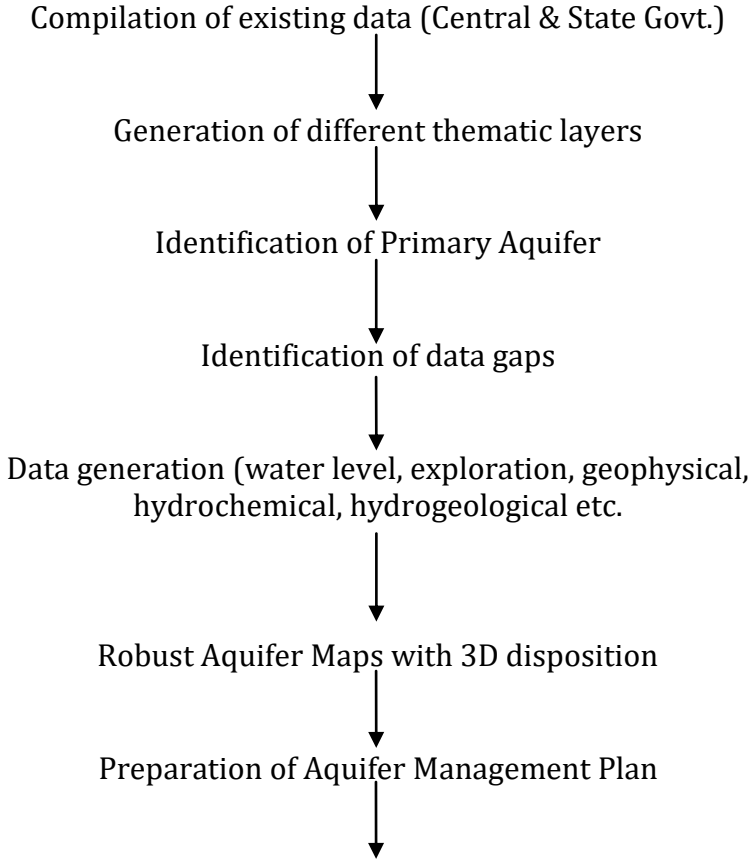
a). Identifying the aquifer geometry
b). Aquifer characteristics and their yield potential
c). Quality of water occurring at various depths

d). Assessment of ground water resources
e). Preparation of aquifer maps and
f). Formulation ground water management plan.
The demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and implementable ground water management plan will provide a **"Road Map"** to systematically manage the ground water resources for equitable distribution across the spectrum.

1.2 Approach and methodology:

The ongoing activities of NAQUIM include hydrogeological data acquisition supported by geophysical and hydro-chemical investigations supplemented with ground water exploration in hard rock terrain down to the depths of 200 meters.

Considering the objectives of the NAQUIM, the data on various components was segregated, collected and brought on GIS platform by geo-referencing the available information for its utilization for preparation of various thematic maps. The approach and methodology followed for Aquifermapping is as given below:



1.3 Area details:

Chatra, as a district was created through bifurcation from Hazaribag district in 1991. It falls in the Western part of Northern Chotanagpur division of Jharkhand State. Spread over an area of 3931 sq. km, it is bounded between 23°38′34′′-24°27′48′′ North latitudes and 84°26′50′′ -85°23′41′′ East longitudes. The Chatra district falls in the survey of India Toposheet Nos. 72D/11, 72D/12, 72D/15 72D/16,and 73A/13 (partly) and 72 H/04(partly). It is bordered by Gaya district of Bihar State in the North, Palamu district in the West, Hazaribag in the East and Latehar in South West and Ranchi in the South. Chatra district is situated within lush green area with 60.4% of geographical area under forest. It is primarily a rural district with 93.4% of population residing in rural areas. The settlement pattern of district is scattered with a very low population density at 275 persons per sq. km. Chatra‟s economy is primarily agrarian based with more than 75% of workers engaged in agriculture either as cultivators or agricultural labourers. Thus, any significant improvement in agriculture has a tremendous impact on the populace of Chatra.

Currently, the district has two sub-divisions – Chatra and Simaria; and 12 blocks viz. Hunterganj (also called ShaligramNarayanpur), Pratappur, Kunda, Lawalong, Chatra, Kanhachatti, Itkhori, Mayurhand, Gidhour, Pathalgada, Simaria, Tandwa. There are two Census Towns in Chatra district – Tandwa and Chatra town. Chatra town, the headquarters of the district is a Nagar Parishad with a population of 49,985. The district has seen tremendous growth in recent years. Further, the commissioning of a 1860 MW NTPC power plant in Tandwa Block and an Integrated Steel Plant by NMDC in Kanhachatti augurs well for the much higher growth for district in near future.
The district administrative unit and base map of Chatra district is given and shown in table 1 and figure 1 respectively.

Table 1: The district administrative unit with geographicl area (sq.km)

S.No.	Blocks	Geographical area (sq.km)	No of gram Panchayat	No of Villages
1	Chatra	382.85	16	182
2	Gidhaur	167.32	06	38
3	Hunterganj	508.93	28	270
4	Itkhori	172.44	12	159
5	Kanhachatti	259.15	10	124
6	Kunda	285.67	05	78
7	Lawalong	399.13	08	103
8	Mayurhund	127.97	10	118
9	Pathalgoda	136.98	05	30
10	Pratappur	375.73	18	176
11	Simaria	520.72	17	100
12	Tandwa	595.00	19	96
	Total	**3931**	**154**	**1474**

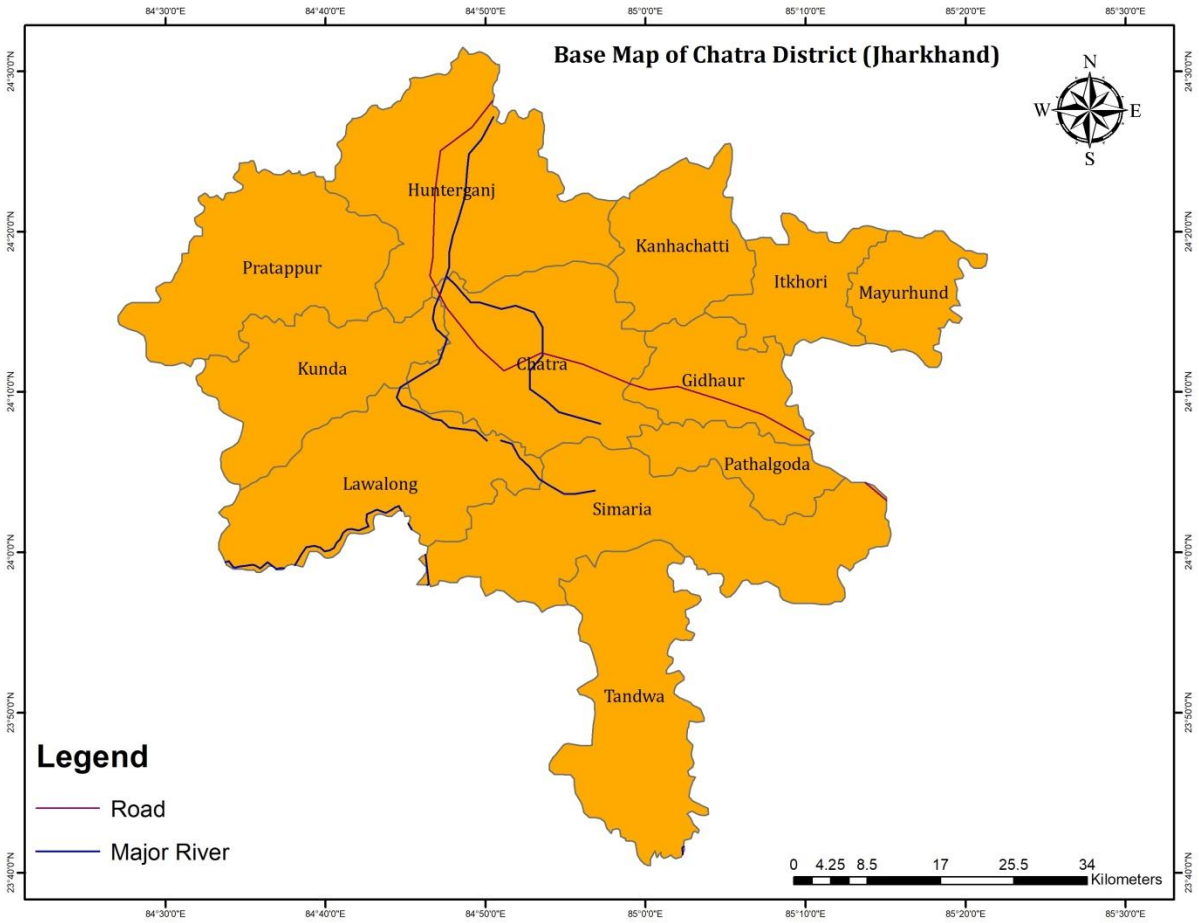


Figure 1: Base map of Chatra district

1.4 Data Availability, Data Adequacy and Data Gap Analysis

1.4.1 Data Availability:-

Central Ground Water Board has carried out exploratory drilling in the district and drilled twenty exploratory / observation wells by departmental and through outsourcing rigs as on March 2022 to know the sub–surface geology, depth and thickness of water bearing formation with their yield and determining the different aquifer parameters and variable lithology in the area. In addition of that, eleven numbers of permanent observation well (HNS) of Central Ground Water Board located in the district are being monitored (4 times in a year) before ground water regime and to assess the chemical quality of ground water. Ninteen key wells are also established during field study.

1.4.2 Data Adequacy and Data Gap Analysis:

The available data of the exploratory wells drilled by Central Ground Water Board, SUO, Ranchi, geophysical survey carried out in the area, ground water monitoring stations and ground water quality stations monitored by Central Ground Water Board were compiled and analyzed for adequacy of the same for the aquifer mapping studies. After taking into consideration, the available data of ground water exploration, geophysical survey, ground water monitoring and ground water quality, the data adequacy is

compiled and the summarised details of required, existing and data gap of exploratory wells, ground water monitoring and ground water quality stations is given in table – 2.

Table – 2: Data adequacy and data gap analysis

Exploratory data				**Geophysical data**				**GW monitoring data**				**GW quality data**			
Req.	Exist.	Gap	Generation	Req.	Exist.	Gap	Generation	Req.	Exist.	Gap	Generation	Req.	Exist.	Gap	Generation
20	0	20	20	109	0	109	109	11	11	0	0	30	11	19	19

Based on the data gap identification, the data generation activity was planned and completed in 2020-21.

1.5 Climate and Rainfall

The climate of Chatra ranges from dry semi-humid to humid semi-arid type. The district receives an average annual rainfall of about 1174 mm. Of this, 80% is received during monsoon months from June till September that arrives in Chatra in the third week of June.The average number of rainy days is 59, of which 47 days are during monsoon months. Rainfall during winter months is unpredictable discouraging many farmers from going for a double crop. The mean annual temperature remains about 25^0C. Mean maximum of 38.6^0C is observed in May and a mean minimum of 10.1^0C is observed during December. Further, the peak temperature in summer sometimes reaches to 46^0C and in winter, it comes down to as low as 2 -3^0C. These facts point towards a rather high range of temperature. Rainfall pattern of Chatra district is given in table 3

Table – 3: Rainfall pattern in Chatra district

Rainfall Pattern in Chatra													
(Source: Department of Agriculture)													
Month	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Overall**
Normal Rainfall (mm)	22.0	18.7	14.7	8.0	28.1	167.1	308.2	310.8	210.8	73.5	8.2	3.9	**1174.0**
Average Rainfall (mm)	2.6	10.5	3.4	7.1	25.9	177.9	256.2	260.9	158.7	41.3	4.4	0.3	**949.2**
No. of rainfall days	1	2	0	1	3	7	15	17	8	4	1	0	**59**

1.6 Physiography:

Chatra has a rolling topography marked by isolated hills and valleys. The general slope of the district is from North to South with an average elevation of 487 m. Since the district consists of part of Upper & Lower Hazaribag plateau and northern scarp, it presents diverse physiographic features. The physiography map of Chatra district is shown in figure 2

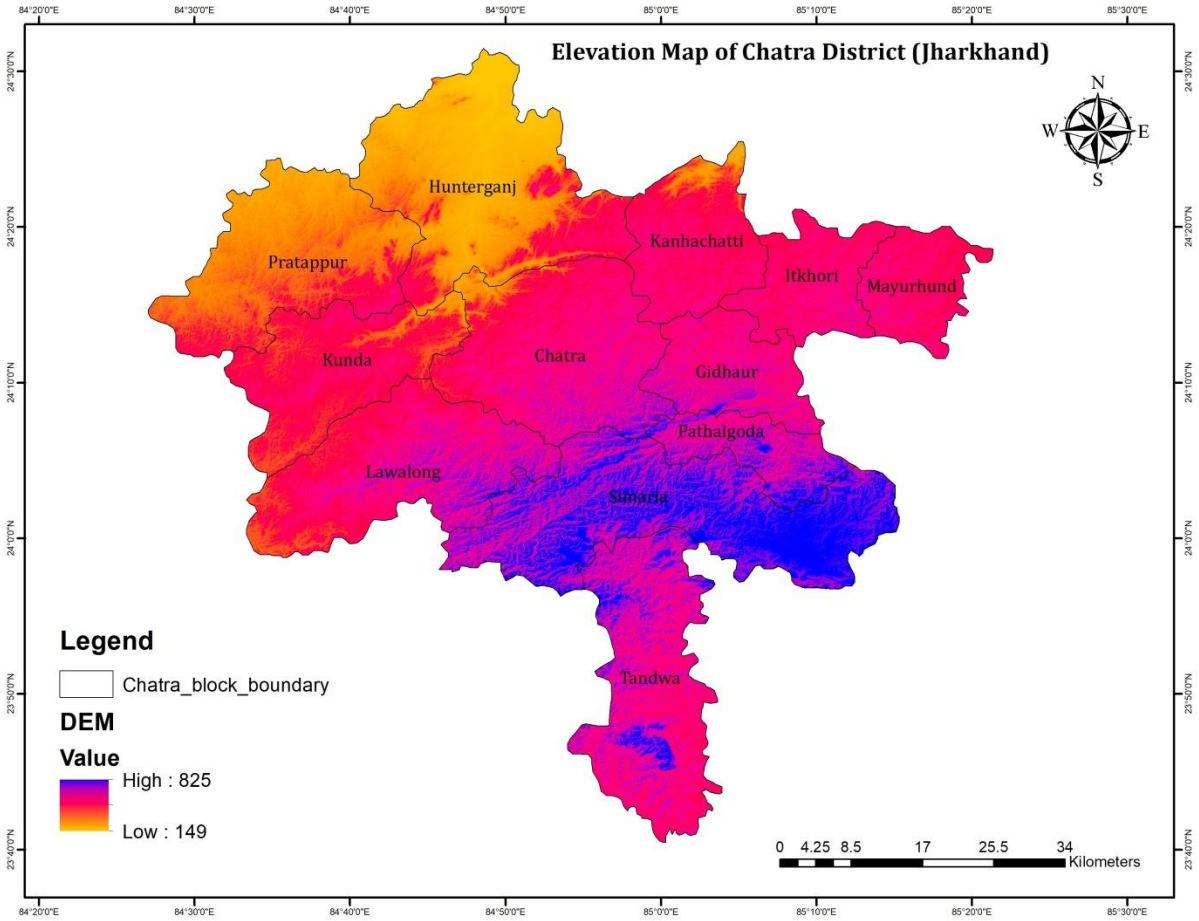


Figure 2: Elevation map of Chatra district

1.7 Geomorphology:

The area is represented by the isolated hills, linear ridges, low uplands, buried pediment, pediplain, undulating pediplain and waterbody/ active channel. The northern most part of the district bordering Bihar is a low-lying area and most suitable for agriculture. Just to the south of this plain region is Kalua and Lahabar hills that forms the higher elevations of the district. These hills fall in northern blocks namely Hunterganj, Pratappur, Kunda and Lawalong. They are covered by dense forests and are hot-bed for Left wing Extremist activities. The middle and southern regions of the district are a part of Chotanagpur plateau. These regions have an undulating terrain with a mix of up, medium and low lands. The scarp landforms of the district gave rise to scenic waterfalls. Tamasin Waterfalls in Kanhachatti block is a famous tourist spot that has been formed due to scarp landform. The geomorphological map of Chatra district is shown in figure3

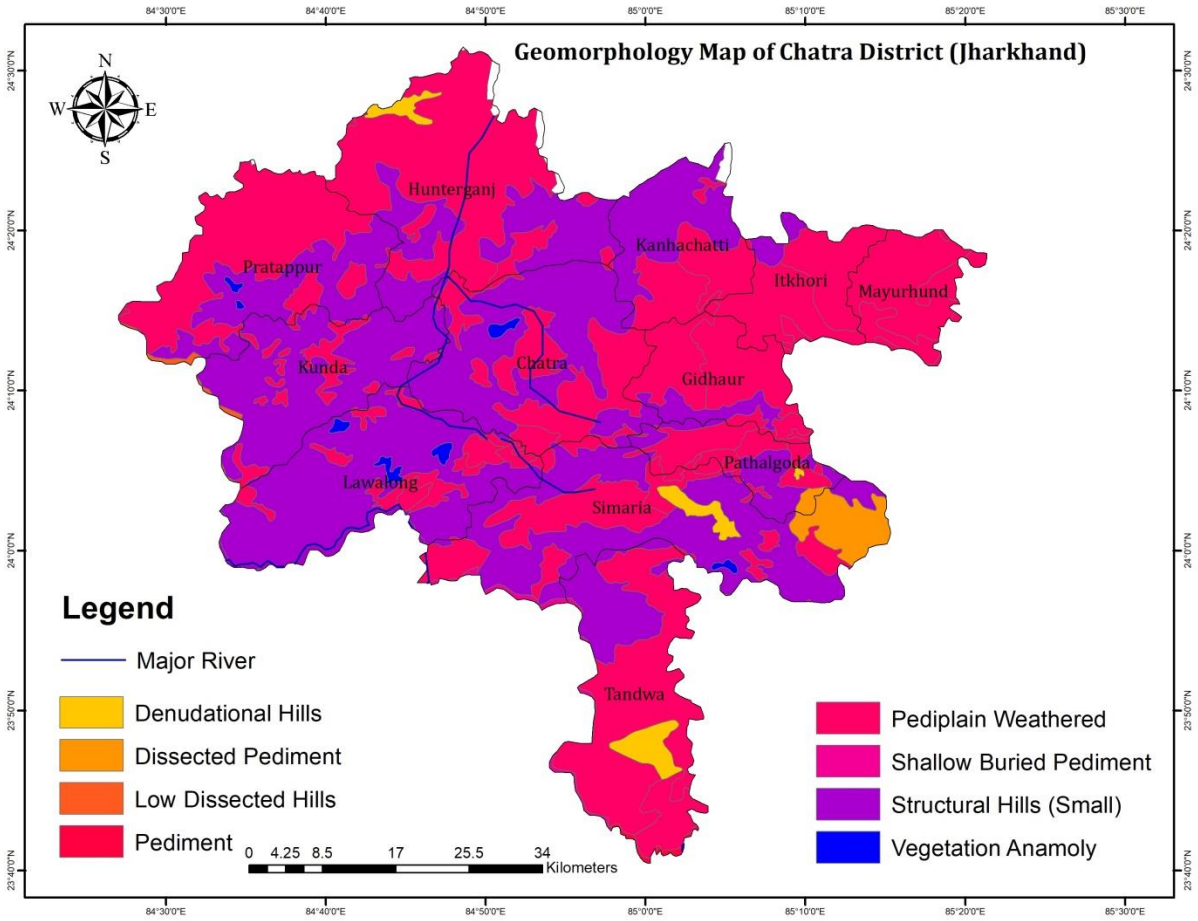


Figure 3 – : Geomophological Map of Chatra district

1.8 Land Use:

60% of the total geographical area is covered by forest. And being a plateau region with intermittent hills – less amount of land is available for agriculture. Hence, the net sown area is only 69394 hectares (18.47%) despite being an agrarian economy. The land use map and land use classification table of Chatra district is shown in figure 4 and table 4

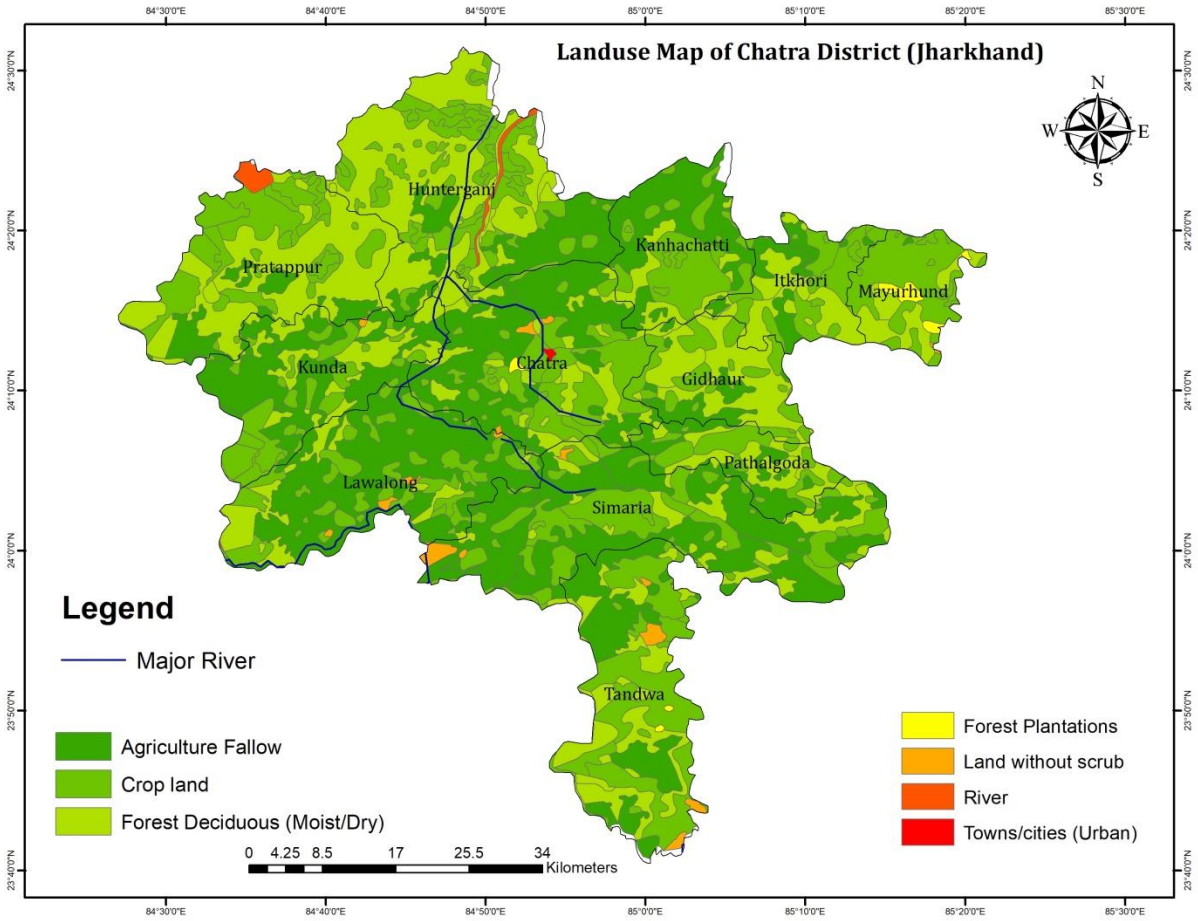


Figure 4– : Land-Use map of Chatra district

Table 4: Classification of Land utilisation statistics in Chatra district

Year	Geographical Area	Forest Area	Barren & unculturable land	Culturable waste land 8	Fallow land other than Current fallow	Net area sown
2020-21	394290	221117	16800	139300	33800	88700

1.9 Soil:

Soil type and nature depend on various physical factors such as parent rock, natural vegetation, climate, topography. These factors affect the texture, porosity, permeability, organic matter, nutrients etc that help determine cropping pattern and fertility. National Bureau of Soil Sampling and Land Use Planning‟s (NBSSLUP) report reveals in-depth analysis of soil profile of the district. Broadly, soils are classified into Entisols, Inceptisols and Alfisols. Of these three soil orders, Alfisols were observed in Chatra district Alfisols were the dominant soils covering 52.2 percent of TGA followed by Entisols (33.9 %) and then Inceptisols (13.0).

1.10 Hydrology and Drainage:

There are as many as 40 rivers that flow in or through Chatra covering a length of 561.37 km overall. Of these, the major rivers include Lilanjan in Hunterganj (69 km), Mohani in Itkhori (50 km) Hiru (32 km) in Chatra and Chako (23 km) in Lawalong. None of these rivers is perennial. The general trend of the drainage is from SE-NW. The structural features particularly the foliation and joints exert profound impact upon the drainage and control the drainage pattern of the district. The drainage map of Chatra district is shown in figure 5

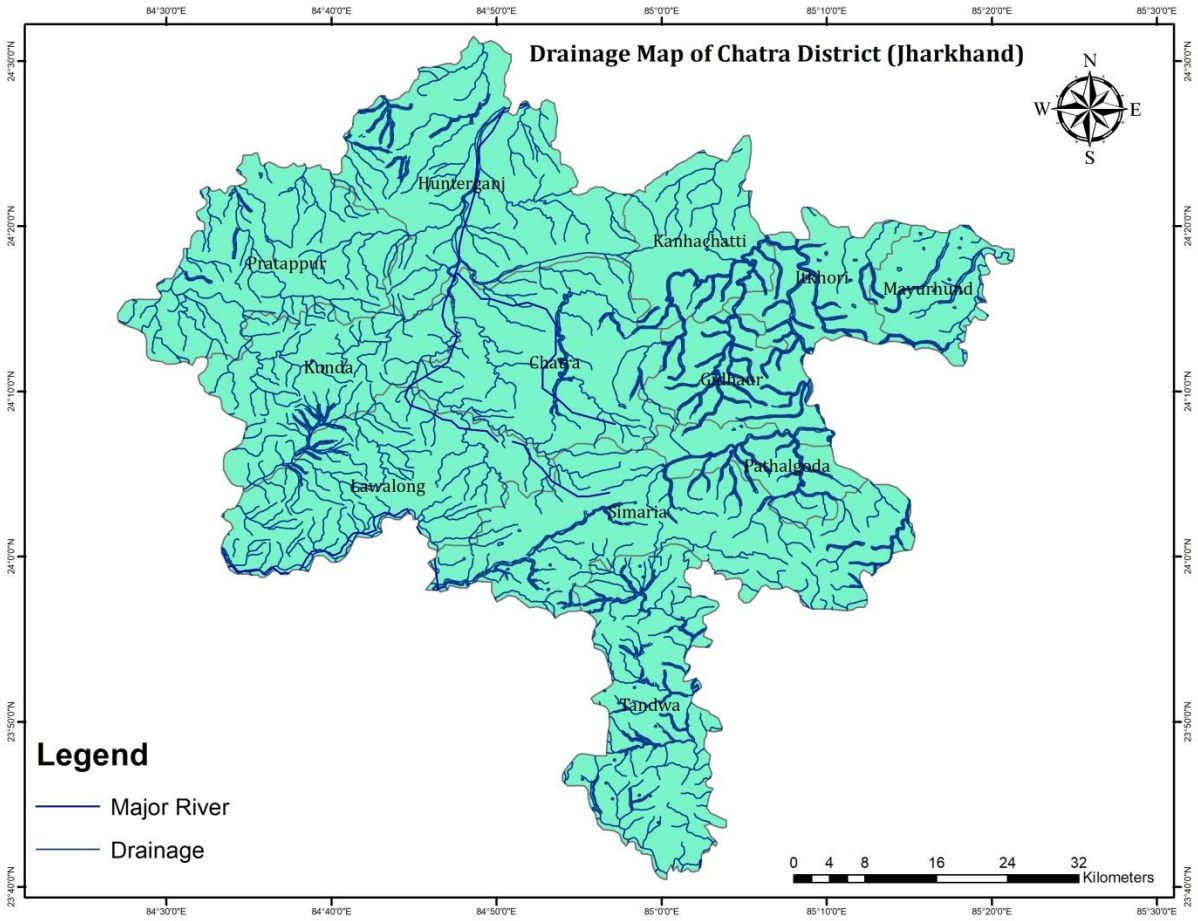


Figure 5–: Drainage Map of Chatra district

1.11 Agriculture and Irrigation Practice:

Agriculture is the main source of livelihood for more than 75% of the population in the district. Agriculture practiced in this region can be characterised as rainfed monocrop subsistence type cultivation mainly due to lack of agricultural development, lack of irrigation facilities and a rolling terrain. Paddy and Maize are the two main crops grown in the district. Other major crops include wheat, pulses, oilseeds. Among pulses, tur/arhar, gram (chana), lentil are widely grown. Among oilseeds, mustard is most widely grown crop. However, the district is deficient in food grain production.

District-wise numbers of different types of ground water abstraction structures as per final 5th MI Census are given below which indicates that Dug wells are the major structure for irrigation in the district. For dug wells, considered unit draft value of varies from 0.075 to 0.3 ham for monsoon and non-monsoon period. Unit drafts of shallow tube-well and deep tube-well are considered 1.2 ham/yr and 16 ham/yr respectively. Block-wise surface water and ground water based irrigation practices is given in table 5.

Table 5: Block-wise surface water and ground water based irrigation practices in Chatra district

Blocks	Number of Structures			Unit Draft of GW Structures for Irrigation					
				DW		STW		DTW	
	DW	STW	DTW	Monsoon	Non Monsoon	Monsoon	Non Monsoon	Monsoon	Non Monsoon
Chatra	853	5	0	0.100	0.4	0.3	1.2	4	16
Gidhaur	791	6	0	0.100	0.4	0.3	1.2	4	16
Hunterganj	2706	6	3	0.100	0.4	0.3	1.2	4	16
Itkhori	976	0	1	0.100	0.4	0.3	1.2	4	16
Kanhachatti	456	2	0	0.100	0.4	0.3	1.2	4	16
Kunda	469	3	0	0.100	0.4	0.3	1.2	4	16
Lawalong	468	0	0	0.100	0.4	0.3	1.2	4	16
Mayurhund	894	2	1	0.100	0.4	0.3	1.2	4	16
Pathalgoda	733	0	1	0.100	0.4	0.3	1.2	4	16
Pratappur	895	0	0	0.100	0.4	0.3	1.2	4	16
Simaria	1794	4	0	0.100	0.4	0.3	1.2	4	16
Tandwa	850	5	0	0.100	0.4	0.3	1.2	4	16
	11735	**33**	**6**						

1.12 Geological setup

Geologically, the area is comprised with Archean granites and gneisses. In southern part of the district, Gondwana rock formations occur in patches. Overall, the geological formations of Chatra can be have been grouped two main categories:

1. The gneissic complex in the southern and the central part
2. Gondwanas overlain by thin mantle of alluvial cover in the northern and central part.

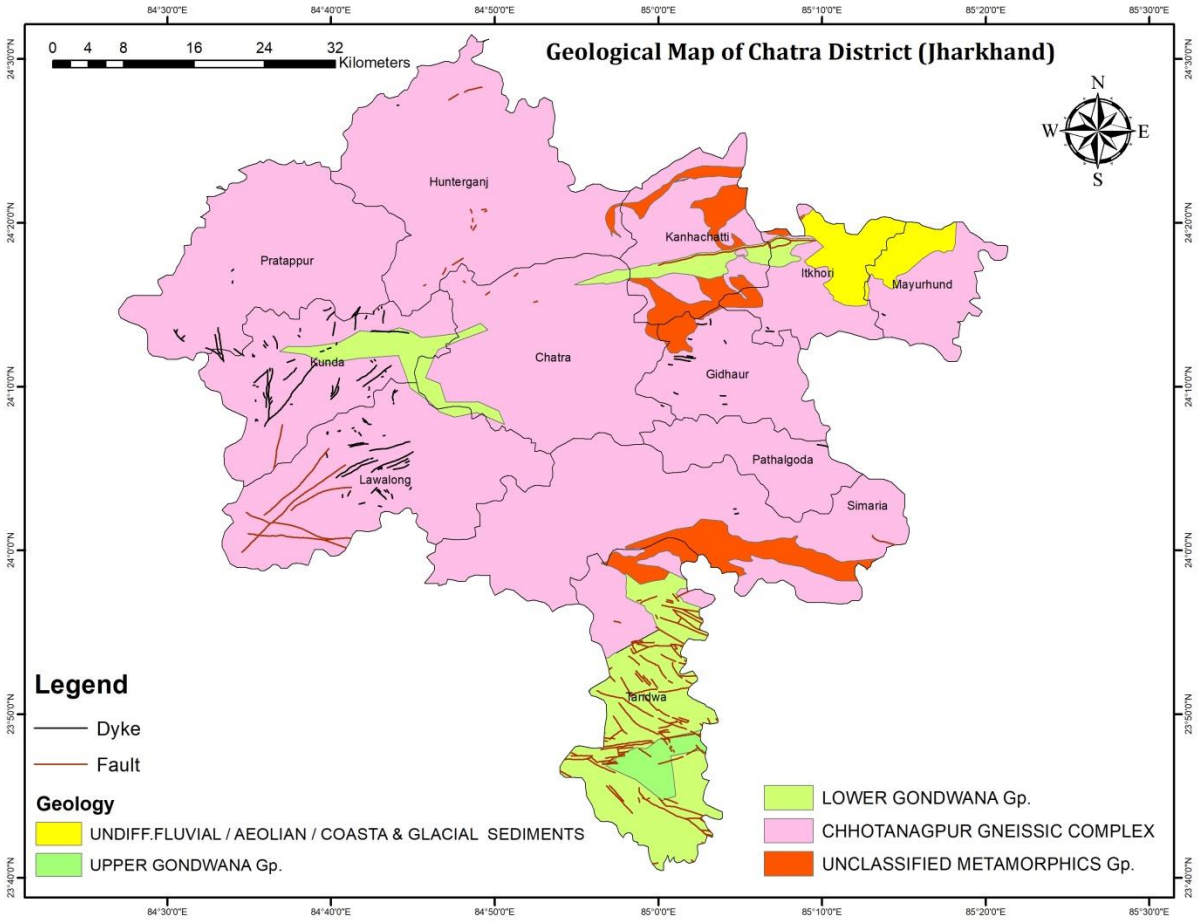


Figure 6– : Geological Map of Chatra district

The area forms part of the chhotanagpur pleateau. The Chhotanagpur Gneissic Complex is represented by granite gneiss, migmatites, biotite gneiss; hornblende granite gneiss with enclaves of basic rocks. A broad spectrum of Archean to Quaternary formations comprising crystalline, sedimentary and metamorphic rock occurs in the area. The unclassified metamorphics, Gneissic complex and Proterozoic intrusive rocks suffered strong folding deformation and medium grade metamorphism. In the central and southern part of the district the rocks of Barakar formation consisting of feldspathic sandstones, shales and coal seams overlying the metamorphics are exposed. The gondwana rocks are not folded or metamorphosed. Most of the faults and shear zones are in the gneisses, metamorphics. The Unclassified Metamorphics consists of hornblende schist, crystalline limestone and basic associates. These are enclaves of older meta-sedimentaries and meta-igneous rocks collectively known as unclassified metamorphics. The hornblende schist occurs as lenses within Chhotanagpur gneissic complex. The geological map of Chatra district is given in figure 6.

2. DATA COLLECTION AND GENERATION

The primary Data such as water level, quality, geophysical data and exploration details, available with CGWB has been collected and utilised as baseline data. The Central Ground Water Board has established a network of observation wells under National Hydrograph Network programme to study the behavior of ground water level and quality of ground water in the district. To understand the sub–surface geology, identify the various water bearing horizons including their depth, thickness and compute the hydraulic characteristics such as transmissivity and storativity of the aquifers, exploratory drilling programme was carried out by Central Ground Water Board. For other inputs such as hydrometeorological, Landuse, cropping pattern etc were collected from concerned state and central govt departments and compiled. There is no aquifer-wise data available from State or any other agencies.

2.1 Data collection, Compilation and Data Generation: The data collection and compilation for various components was carried out as given below –

2.1.1 Data collection, Compilation

i. Hydrogeological Data: Water level data of 19 key wells and 11 NHS monitoring wells historical water level trend of monitoring wells were collected and compiled representing Aquifer-I.

ii. Hydrochemical Data: To evaluate the quality of ground water, 19 samples were collected from dug wells representing shallow aquifer (Aquifer – I)

***iii. Geophysical survey*:** VES were carried out to identify the weathered zone resistivity and its thickness as wells as find out deeper fracture zone and different layer of basaltic formation.

***iv. Exploratory drilling*:** 20 wells drilled in hard rock area of the district through departmental rigs as well as through out sourcing private rig.

v. Hydrometeorological Data: Last ten years (2001 – 2022) monsoon rainfall data for each of the block from the office of District Agriculture Department, Chatra.

***vi. Land use and cropping pattern data*:**The data of land use and cropping pattern from the office of Director Statistics, Ranchi.

vii. **Thematic Layers:** The following thematic layers were also generated which supported the primary database and provided precise information to assess the present ground water scenario and also to propose the future management plan.

1. Drainage
2. Geomorphology
3. Geology & structures

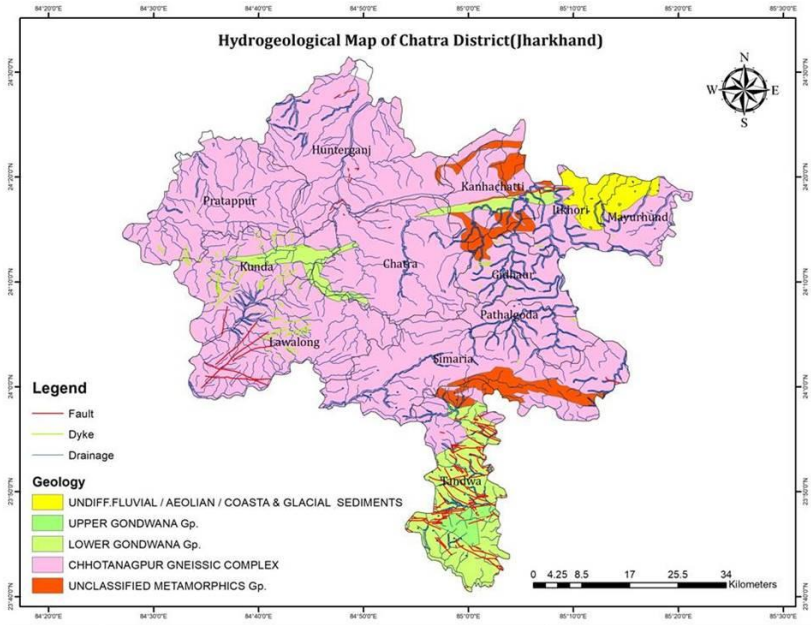
The thematic layers such as drainage and geomorphology have been described in Chapter – I.

2.1.2 Data Generation:

After taking into consideration, the data available with CGWB on ground water monitoring wells (GWMW), ground water quality, geophysical survey and ground water exploration, the data adequacy was compiled and it indicated that exploratory drilling is required at least 02 locations of each block of Chatra district

2.2 Hydrogeology:

Ground water occurs mostly under phreatic condition in all the lithological units within the shallow aquifers and locally under semiconfined and confined condition in deeper auifers.



	Age/Formation	Lithology	Hydrogeology	Ground Water Potential
	UNCONSOLIDATED FORMATION			
	Quaternary to Recent	Alluvium- Sand, Silt, Clay	Limited thickness along river banks mainly unconfined condition	Upto 10 m3/hr
	SEMI-CONSLIDATED FORMATION			
	Lower Gondwana (Upper Carboniferous to Permian)	Sandstone, Shale with coal seams, Conglomerate	Moderately thick limited in extent semi-confined to confined aquifer	10-20 m3/hr
	CONSOLIDATED FORMATION			
	Chotanagpur Gneissic Complex (Precambrian)	Granite-Gneiss, Biotite-Gneiss	Ground Water Restricted to weathered zones/fractured zones	5-20 m3/hr
	Unclassified metamorphic (Precambrian)	Amphibolite, Hornblend Schist, Hazariabagh Granite etc	-	Poor to moderate

Figure 7: Hydrogeological Map of Chatra District

2.2.1 Ground Water In Aquifer-I

Ground water occurs under phreatic/ unconfined to semi-confined conditions in Aquifer-I which is represented by weathered granite and Weathered Shale/Sandstone. Ground water occurs in unconfined state in shallow Aquifer-I tapped by alluvium, laterites, weathered granite and weathered Shale and Sandstone(Upto 30 m depth) , however in some cases depth varies from more than 30m. Yield of the wells in Aquifer-I ranges from 0.8 to 3 lps in this formation. Weathered zones of granites and gneisses are the most productive zone for ground water development in shallow aquifer. The depth of weathering varies from place to place, which influences the aquifer characteristics. The drinking water and sanitation department has drilled a number of tube wells in Chatra district having a yield of approximately 80 liter per minute. The dug wells in this formation has a depth to water level range from 4 m to 10 m bgl and the wells can sustain 2 hours of pumping with a yield range of 4000 to 8000 litres per hour.

2.2.2 Ground Water In Aquifer-II

Ground water occurs under Semi-confined to confined condition in Aquifer-II represented by Fractured/Jointed granite-gneiss, Fractured Shale and Sandstones upto the of 200 mtr depth. Generally extent of Aquifer-II in Precambrian formation ranges from 30-120m. Granites and Gneisses are the most predominant rock types among all other rocks falling under the consolidated unit. Tectonic disturbances in granitic rocks are pronounced and fissures and joints etc are also well developed. These rocks are traversed by numerous veins of quartz and pegmatite. Fracture porosity plays an important role but with varying degree, in different parts of the area depending upon the pattern and intensity of joints and fractures. The potentiality and yielding property of these aquifers vary considerably. Bore wells can be constructed tapping the deep-seated fractures and joints. The semi-consolidated (Gondwana) formation occurs in isolated pockets in the northern part of the district. The rocks are mainly sandstones and shales belonging to the Barakar and Talchir formation. Barakar sandstones are coarse to medium grained, weathered in nature and may be a productive zone for ground water development. Hoever, the exploratory Driliing has not been taken up in Gondwana formation. Yield of the wells in Aquifer-II in granite-gneisses are found to be upto 7.5 lps.

Potential Fractures in Aquifer-II

Total 20 Number of boreholes has been constructed by CGWB in the district under groundwater exploration programme upto maximum depth of 200 m (Table-8). The borehole data reveals that, in general potential fractures are encountered between 30-120 m. Some times dry fractures have also been encountered. In table 6- shows the Potential Fracture encountered during Ground Water Exploration in Chatra district.

Table-6 Potential Fractures encountered during ground water Exploration in Chatra district, Jharkhand

S. No.	Location	Block	Depth Drilled (m)	Major Lithology Encountered	Depth of casing (m)	Potential Fracture Zone encountered (m bgl)	Discharge (lpm)
1.	Kanhachatti	Kanhachatti	183.84	Granite gneiss	27.85	59-60,88.7-88.9, 93-93.2, 95-96, 173-173.5	450
2.	lAHRANGA	Tandwa	157	Granite gneiss	17.8	34-35.2	420
3.	Simaria	Simaria	161	Granite gneiss	38.8	83.5-83.9, 94.8-95.2, 98.6-98.8	240

On the basis of field investigations and results of exploratory wells drilled in the district, salient findings are summarized as:-

- Overall in the district the major potential fractures zones are found upto 120 m.
- Potential fracture zone encountered in the district widely varies from 20-173 m
- In general in fractured/jointed/fissured formations, discharge of well has been found upto 450 lpm.

- At some places fractures occur upto 100m with high discharge, i.e Laharanga-420 lpm , Simaria-240 LPM, etc while deeper aquifer upto 173m also encountered potential fracture with high yield of 450 lpm(Kanchachatti) .

2.2.3 Ground water Dynamics

***2.2.3.1 Ground water Monitoring Wells*:** Water level and water quality is being monitored from 30 dug wells (existing NHS 11 well + established -19 well). 19 key wells were established to assess the ground water scenario of shallow aquifer (Aquifer-I) of the area. Location of key wells and exploratory wells are shown in figure 8 and given in *Annexure-II*

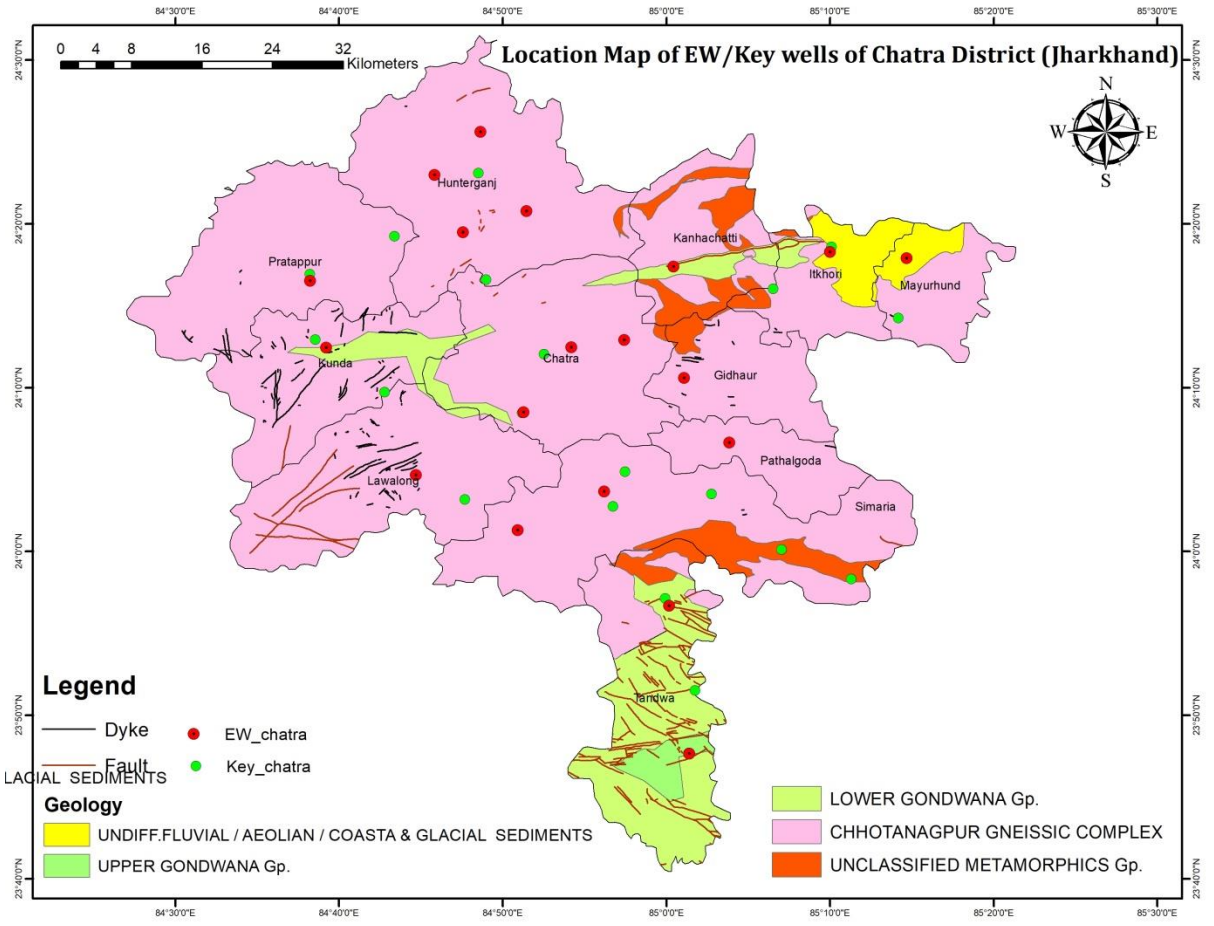


Figure 8–: Location of EW and key wells in Chatra district

2.2.3.2 Water Level Scenario – Aquifer – I (Shallow Aquifer):

Ground water regime is monitored through 08 dug wells in the study area. With the field data, maps were prepared for visual interpretation of the behavior of the ground water levels. Depths to ground water level were demarcated into various zones in the ranges of less than 2 m, 2-5 m, 5-10 m, 10-20 m. The description of depth to water levels during pre-monsoon and post monsoon is as follows:

Depth to Water level May 2019:

Depth to ground water level during May 2019 ranges from 5.10 mbgl to 15.75 mbgl. Minimum depth to water level 5.10 mbgl recorded at Birhu village and maximum depth to water level 15.75mbgl recorded at Bagra village of Chatra district. Depth to water level map May 2019 is shown in figure-9

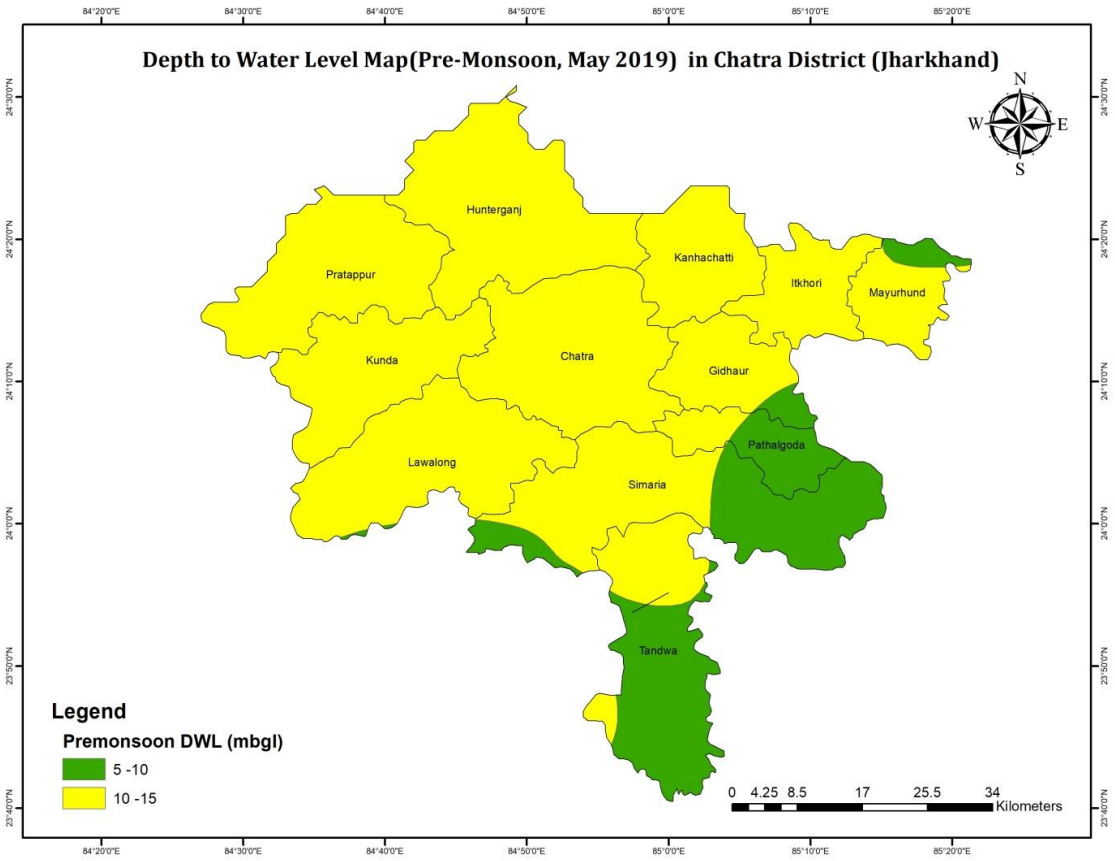


Figure-9–: Pre monsoon (May 2019) depth to water level map of Chatra District

Depth to Water level November 2019:

During month of November 2019 (post-monsoon) depth to water level varied from 2.10 m bgl to 10.00 m bgl. Minimum depth to water level 2.10 mbgl recorded at Tandwa village of tandwa block of Chatra district and maximum depth to water level 10.00 mbgl recorded at Bagra village of Chatra district. Depth to water level map November 2019 is shown infigure10

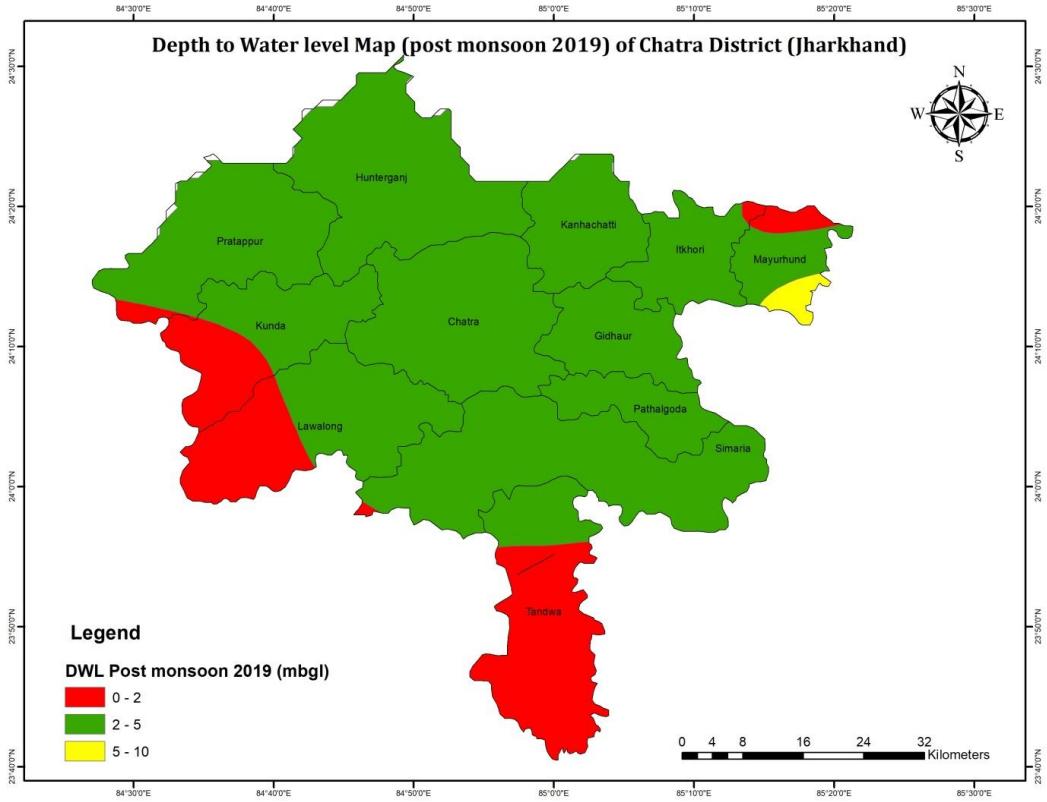


Figure 10–: Post monsoon (May 2019) depth to water level mapof Chatra District

2.2.3.3 Long Term Trend of Water level:

Pre-monsoon/Post-monsoon trend of water level:

The Pre-monsoon long-term trends of water level for the period 2011 to 2020 have been shown in table-. In the tutilwa and chatra well of Chatra district the monitoring well show declining trend in the range of 0.0057 m/year to 0.0087 m/year whereas annual falling trend is 0.0564 m /year to 0.1227m/year . Trend of Water Level for last ten years (2011 to 2020) of Chatra district is given in table 7.

Table 7: Trend of Water Level for last ten years (2011 to 2020) Chatra

Trend of Water Level for last ten years (2011 to 2020) Chatra										
			PreMonsoon			PreMonsoon			Annual	
Sl No.	Location	Data Points	Rise (m/year)	Fall (m/year)	Data Points	Rise (m/year)	Fall (m/year)	Data Points	Rise (m/year)	Fall (m/year)
1	Tandwa	5			8	0.0326		29	0.4074	
2	Birhu	6	0.9138		8	0.39		27	0.3651	
3	Bagra	7	0.0792		10	0.0915		38	0.1539	
4	Tutilawa1	5			7		0.0057	25		0.0564
5	Simaria	7		0.0758	10	0.0005		35	0.1048	
6	Chatra	2			3			12		
7	Chatra1	5			8		0.0087	27		0.0718
8	Pitij	6		0.6315	8	0.1876		28	0.03	
9	Itkhori1	5			8	0.0492		27		0.1227

2.3. Ground Water Exploration: The exploratory data particularly includes the information on sub–surface geology, hydrogeological information and geometry of aquifer in hard rocks terrain. Based on exploration data, prepared litholog of exploratory wells&observatory wells, identified the potential fracture zone encountered within 200 m depth in granitic terrain.To assess the potentiality of the deep fractured rock, 20 exploratory/Observatory wells were drilled in Chatra district.The drilling results have indicated that granite gneiss of different colour varying from grey to dark grey to pink, having course grained texture sometime porphyritic, are the most dominant rock types met in the area. In the bore wells upper weathered zones are cased and only the fractured zones are tapped in the uncased well. The details of the exploratory and observation wells drilled in Chatra district is presented in Annexure –I Location of exploratory wells is shown in figure- 11

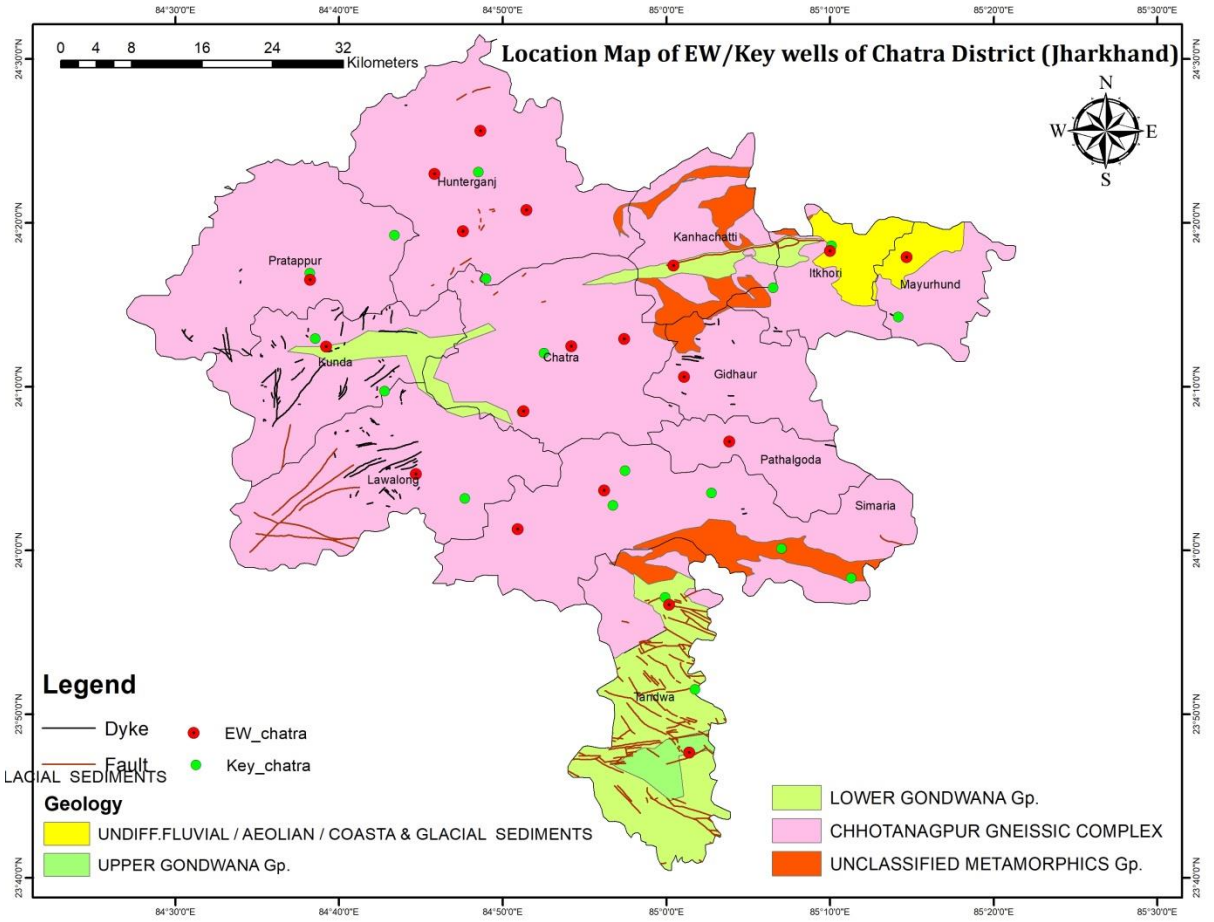


Figure 11: Location of exploratory wells drilled in Chatra district

2.4 Geophysical survey:

A total of 116 VES were carried out at 116 locations (figure 12)in the district area of Chatra under aquifer mapping in Jharkhand state through outsourcing. The surface geophysical methods sense the subsurface remotely. Therefore the depth and dimension of the subsurface target, its position with respect to the sensor at the surface, physical property contrast of the target with the surrounding and scale and orientation of measurement controls the response. The resolution reduces with depth and to obtain

a resolvable response from deeper target, it is also necessary that the deeper target has distinct physical property contrast and an adequate dimension. To reduce the ambiguities, constrain the interpretation and enhance precision, it is necessary to design the data acquisition procedure to a possible extent which could sense the variations in physical properties of the deeper target and the surrounding. The incongruity in data acquisition and the target character brings in non-uniqueness in inversion and thus ambiguity creeps in hydrogeological transformation of geophysical response. Coming out with a positive solution satisfying the conditions is quite a difficult geophysical task and hence the approach becomes a complex geophysical endeavor. For example, to estimate the weathered zone thickness a vertical electrical sounding with conventional current electrode spacings is adequate, but to even qualitatively estimate the depth of saturated fractured zones, a closer increment in current electrode spacing is essential. The success in geophysical investigations for weathered and fractured zone aquifer mapping in hard rocks depends on a number of factors.

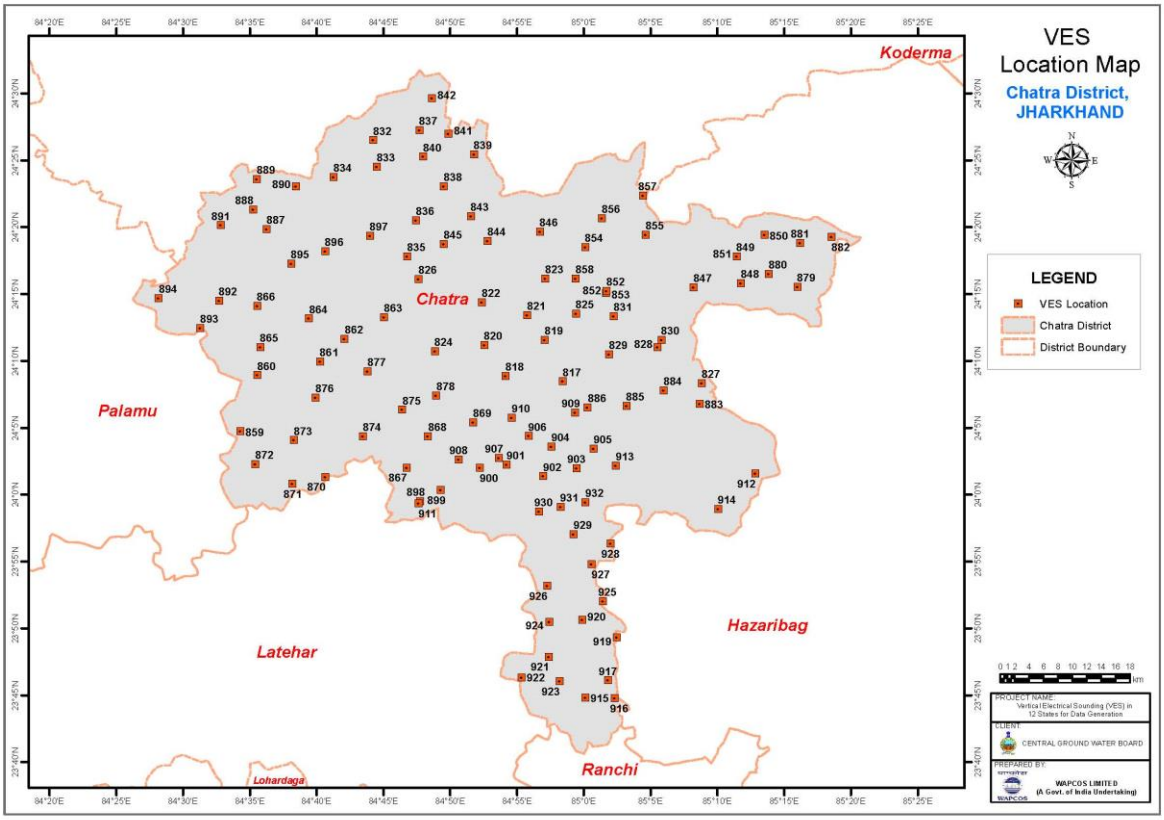


Figure 12: Location map of VES conducted in Chatra district

Interpreted Results of VES

Based on the interpreted results of 116 VES conducted, it is observed that at 58 VES sites the weathered zone is absent. At 27 VES the weathered zone is having the depths more than 9 meters which can be considered for shallow depths ground water tube wells. At the rest 31 VES the weathered zone is very thin, less than the depth range 9 meter. At 10 VES sites the weathered zone in granite gneiss terrain extends more than the depth 20 m depth. The thickenning of weathered zone at these sites as well as other

sites appears to be structurally controlled. The resistivity ranges from 15 to 50 ohm.m is considered as weathered zone. Also the depth less than 9 meter is not considered as an weathered zone aquifer.The semi weathered or less compact formation zone resistivity is considered from 50 to 300 ohm m. But a good semi weathered or less compact zone aquifers are considered when the resistivity is within 50 to 150 ohm m.These range of resistivity at shallow depths are considered as semi weathered formation and that of at deeper depths these are considered as less compact formations. On basis of these considerations 42 sites are detected to be semi weatherd zones/ Less compact zones . The fractured zones have been delineated at so many sites.These are generally delineated on the basis of curve break techniques and current increase methods. These fracture zones are generally available when the over all resistivity of the curve is little lesser than the very high resistivity. When the resistivity is trending 45 degree angle or close to that, the curve breaking, generally, does not agree with the real fracture zone formation.That may be due to other factors. In some cases weathered or semi weathered zones are not available, but there may be presence of fractures. Most of the cases the when the depths of the less compact formation is more or depth to the compact formation is not available, the probability of presence of fractures are more. On the basis of these considerations in 94 nos of VES the fracture zones are detected. In a few cases the fractures may be dry and feeble.

2.5 Ground Water Quality:

The quality of water plays prominent role in promoting both the standards of agriculture production and human health. To evaluate the quality of ground water, samples have been collected from 44 monitoring wells including NHS which represent the quality of phreatic/ shallow zone i.e Aquifer I. The analytical results of water samples from dug wells are given in Annexure-III &IV-. The ground water samples were analyzed for major chemical constituents by using standard procedure at chemical laboratory in CGWB, MER, Patna. These samples have been considered to assess the chemical quality of ground water and its suitability for drinking and irrigational purposes.

2.5.1General Range of Chemical Parameters

With reference to analyzed parameters the water of Chatra appears chemically potable for domestic as well as agricultural purposes in most of the locations, except high Fluoride and Nitrate. Groundwater is neutral to slightly alkaline in nature. Out of 19 samples analysed, Total dissolved solids (TDS) are well within the permissible limit (2000 mg/L) at each location as per BIS, 10500. Fluoride concentration is more than the permissible limit (>1.5 mg/L) at four locations . Hydro-chemical data of (phreatic aquifer) monitoring wells existing in Chatra district is tabulated below in Table-8

Table 8: Details of Hydro-chemical data of monitoring wells

S.No.	Constituents	Minimum	Maximum	BIS (2012)	
				Desirable	Permissible
1.	pH	7.07	7.84	6.5-8.5	No relax.
2.	EC	154	1521		
3.	TDS (mg/l)	100.2	988.7	500	2000
4.	HCO3 (mg/l)	55.35	393.6	200	600
5.	Cl (mg/l)	7.09	287.1	98	1000
6.	TH (as CaCO3) mg/l	55	549.98	300	600
7.	Ca (mg/l)	12	112	75	200
8.	Mg (mg/l)	2.43	38.88	30	100
9.	Na (mg/l)	7.57	127.8	200	-
10.	K (mg/l)	0.36	2.75	200	-
11.	NO3 (mg/l)	0.4	107	45	No relax.
12.	F(mg/l)	BDL	2.88	1.0	1.5
13.	SO4(mg/l)	7.9	73.88	200	400

Hydrogen ion concentration (pH):

The pH of water indicates that whether the water is acidic or alkaline. The hydrogen (pH) is a measure of the hydrogen ion concentration in the water. The measurement scale of pH ranges from 1 to 14 with a pH of 7 indicating as neutral condition environment. The value of pH lower than 7 indicate acidic and more than 7 indicates alkaline. The pH of ground water in Chatra district ranged in between 7.07 to 7.84. The ground water of the study area can be assessed as slightly alkaline to neutral in nature. Minimum 7.07 PH value observed in Tandwa village of Chatra block whereas Maximum PH value 7.84 recorded in Talbarwan village of Hunterganj block of Chatra district.

Electrical Conductivity (EC):

Electrical conductance is the ability of water to conduct electric current and it depends on, the concentration of ion, nature and types of ions and temperature. BIS has recommended desirable limit for Total Dissolve Solid (TDS) as 500 mg/l corresponding to EC value approximately as 750 µS/cm at 25°C which is extendable to permissible limit as 2000mg/l. TDS corresponding to EC value is about 3000 µS/cm at 25°C in absence of alternate source of water.

The electrical conductivity of ground water in Chatra district ranges in between 154 to 1521 µS/cm at 25°C. Minimum 154 µS/cm at 25°C EC value observed in Piri village of Simaria block whereas Maximum 1521 µS/cm at 25°C EC value recorded at Karma village of Mayurhund block of Chatra district.

Carbonate and Bicarbonate (Alkalinity):

Presence of alkalinity in water is the capacity to neutralize a strong acid due to the presence of carbonate, bicarbonate and hydroxide of magnesium and calcium. The concentration of bicarbonate ranged in between 55.35 to 393.6 mg/l. Minimum concentration of bicarbonate 55.35 mg/l value has been recorded in piri village of

Simaria block whereas Maximum concentration 393.6 mg/l value has been recorded in Garwari village of Hunterganj block of Chatra district.

Chloride:

Chloride in ground water can be geogenic in deep aquifers or caused by industrial or domestic wastes and pollution from brine. The BIS has set 250 mg/l chloride ions as acceptable limit and 1000 mg/l as permissible limit in the absence of alternate source in drinking water. In Chatra district Chloride concentration ranges in between 7.09 to 287.14 mg/l. Minimum concentration value of chloride 7.09 mg/l has been recorded in Talbarwan village of hunterganj block whereas Maximum concentration value of chloride 287.14 mg/l has been recorded in Chatra village of Chatra block of Chatra district.

Fluoride:

Fluoride occurs in low concentration in natural water. It is an essential element to maintain normal development of teeth and bones. The consumption of low fluoride concentration prevents the dental caries. The higher concentration of fluoride consumption causes mottling of teeth and skeletal fluorosis. The BIS has set the maximum concentration of fluoride in drinking water is 1.5 mg/l as permissible limit. The fluoride concentration in Chatra district ranged in between BDL to 2.88 mg/l. The maximum concentration 2.88 mg/l of fluoride has been recorded in Tandwa village of Tandwa block of Chatra district. Fluoride concentration map of Chatra district is shown in figure 13

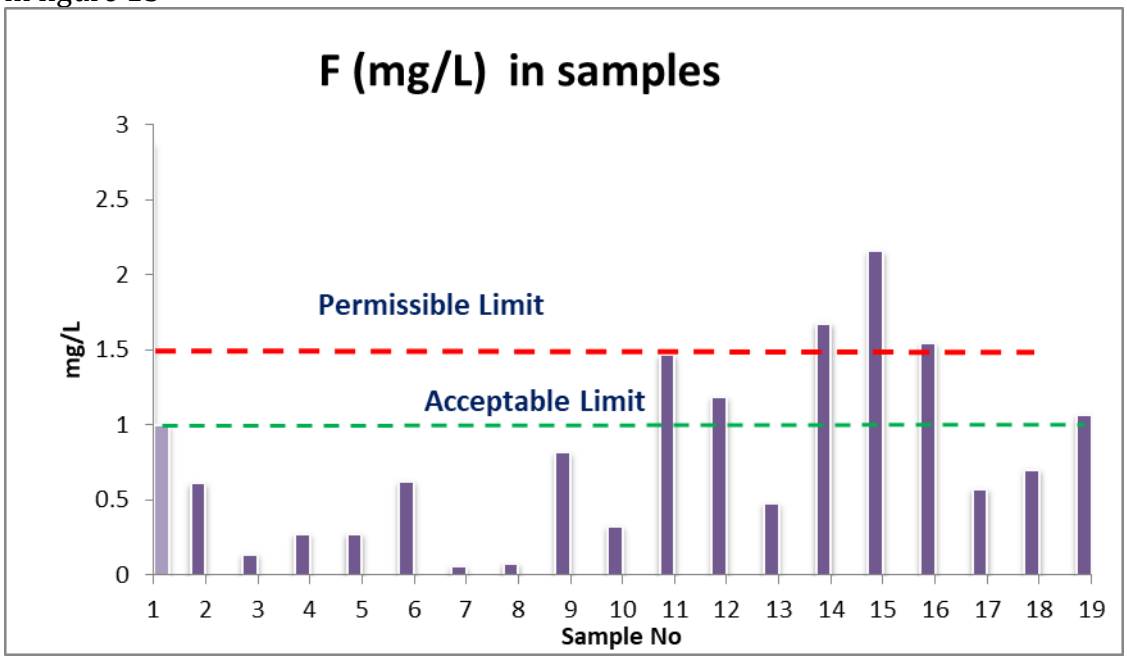


Figure 13: Fluoride concentration map of Chatra district

Nitrate:

Nitrate is the end product of oxidation process of nitrogen in the environment and its higher concentration in ground water is an indication of pollution from human and animal wastes, nitrogenous fertilizers and industrial wastes. Nitrate is a non-essential constituent of ground water. The BIS has set a acceptable limit of nitrate concentration in drinking water as 45 mg/l with no relaxation. The consumption of

nitrate more than 45 mg/l is harmful for human being, particularly to infants as it may cause blue baby syndrome. In Chatra district nitrate concentration in ground water ranges in between 0.4 to 107 mg/l. The maximum Nitrate concentration has been recorded at Bagra village of Simaria block of Chatra district.

Sulphate

The concentration of sulphate in drinking water set by BIS as acceptable limit is 250 mg/l and 400 mg/l permissible limit in absence of alternate source. Higher concentrations are undesirable taste because of laxative effects. Sulphates in groundwater are released by natural deposition of calcium sulphate, magnesium sulphate, or sodium sulphate. These natural sources can be applied as soil conditioners. The ground water of study area recorded sulphate concentration ranges in between 7.9 to 73.88 mg/l.

Total Hardness:

As per Bureau of Indian Standard (BIS): 10500-2012 (Drinking Water), the acceptable limit of total hardness is 300 mg/l and permissible limit is 600 mg/l in absence of alternate sources.Total hardness of ground water in the study area ranges in between 55 to 549 mg/l.

Sodium:

Sodium does not find freely in nature because it is very active element. It always combines with other elements. In human body, sodium helps in maintaining water balance. The higher sodium intake may cause congenial heart diseases, hypertension and also kidney problem.In Chatra district, water samples observed sodium concentration ranges in between 7.57 to 127.8 mg/l.

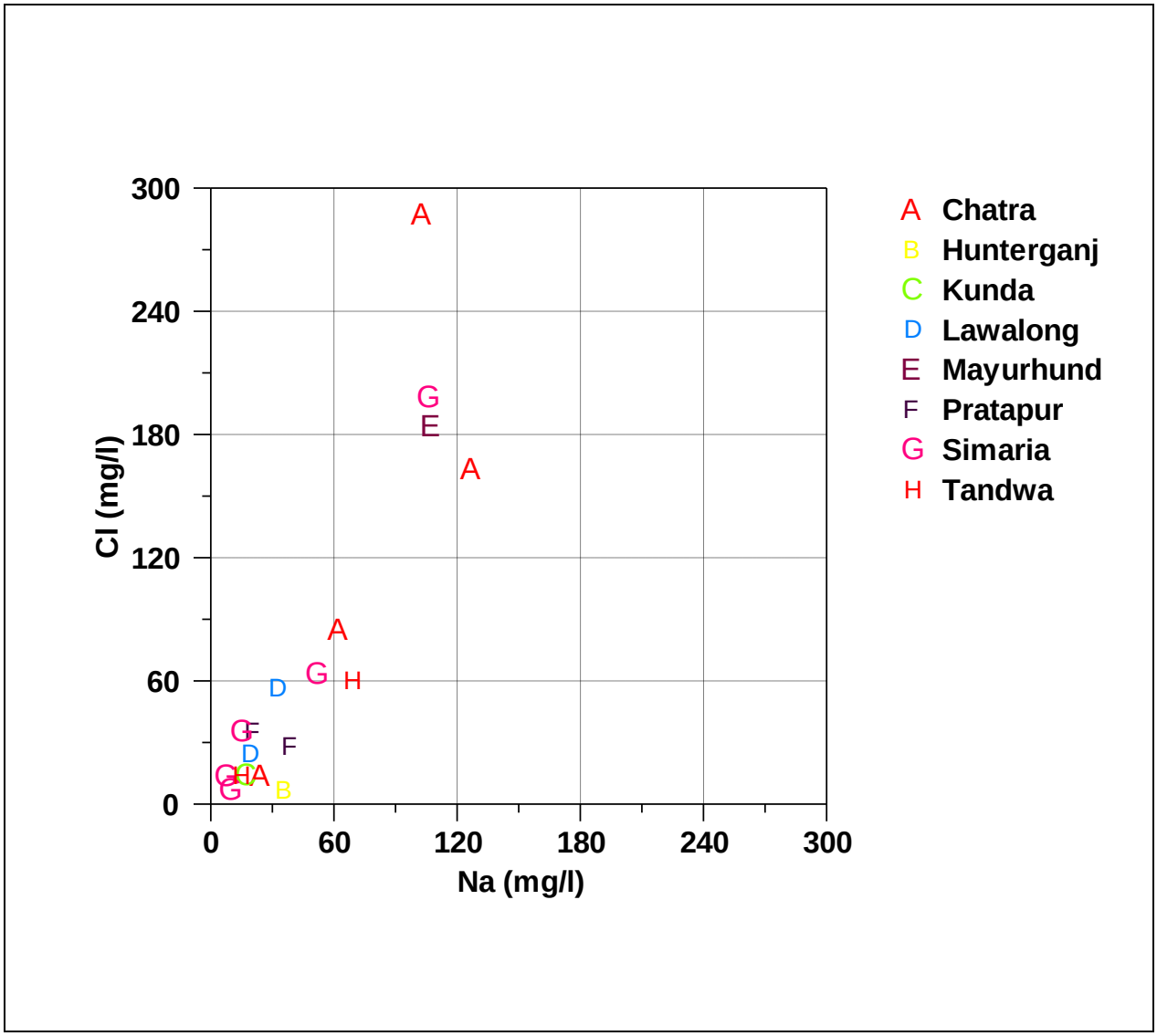


Figure 14: Sodium concentration in Chatra district

Potassium:

The common sources of potassium are minerals of igneous, metamorphic and sedimentary rocks. Potassium concentration in water is generally very low. BIS has not given any guideline for potassium concentration in drinking water. In the study area of Chatra district, Potassium concentration observed in water samples ranged in between 0.36 to 2.75 mg/l.

2.5.2 Suitability of Ground Water for Drinking Purposes: -

The suitability of water is evaluated on the basis of electrical conductivity which represents salinity and also the concentration of Fluoride and Nitrate ions. The maximum and minimum values and values exceeding desirable and permissible limit for drinking use of different parameters is given in the Table

The classification of water on the basis of EC it is found that 97 % wells have EC values less than 1500 µS/ cm at 25^{0}C. Regarding fluoride, in 89.18 % wells its concentration was found less than desirable and permissible limit i.e 1 to 1.5 mg/l for drinking water.

The nitrate was observed more than permissible limit of 45 mg/l in 3 % wells. Perusal of the analytical data reveals that there is no specific trend observed for distribution of higher values of EC, fluoride and nitrate in the ground water and higher values may be due to local pollution/ geogenic sources. As such in general the quality of ground water in the study area is good and suitable for drinking.

2.5.3 Suitability of ground water of Aquifer–I for irrigation purposes: -

Apart from domestic consumption, irrigation is consuming a major share of ground water for agricultural activities. The quality of water used for irrigation is an important factor in productivity and quality of irrigated crops. The suitability of water for irrigation purpose depends upon the Total Dissolved Solid in terms of EC value, concentration of Na, bicarbonate and its relative proportion to Mg and Ca. All these mentioned above either individual or with combination create concentration of Sodium (salinity) bicarbonate and alkalis type of hazard. To better understanding the suitability of ground water for irrigation purpose chemical result of collected water samples have been analyzed and described the different classifications.

2.5.4: Sodium Percentage Classification: -

Electrical Conductivity (EC) and sodium concentration are very important in classifying irrigation water. The salts, besides affecting the growth of the plants directly, also affect soil structure, permeability and aeration, which indirectly affect plant growth. Sodium is a major ion used for the classification of irrigation water due to its reaction with soil that reduces its permeability.Classification of ground water of Aquifer - I based on sodium percentis tabulated in table. Percentage of Na is generally used for assessing the suitability of water for irrigation purposes. Na is expressed as percent sodium or soluble-sodium percentage (Na %) using Eq.

$$\%\mathbf{Na} = \left(\frac{\mathbf{Na^{+}+K^{+}}}{\mathbf{Ca^{2+}+Mg^{2+}\,Na^{+}\,K^{+}}}\right) * \mathbf{100} \qquad \text{.....}$$

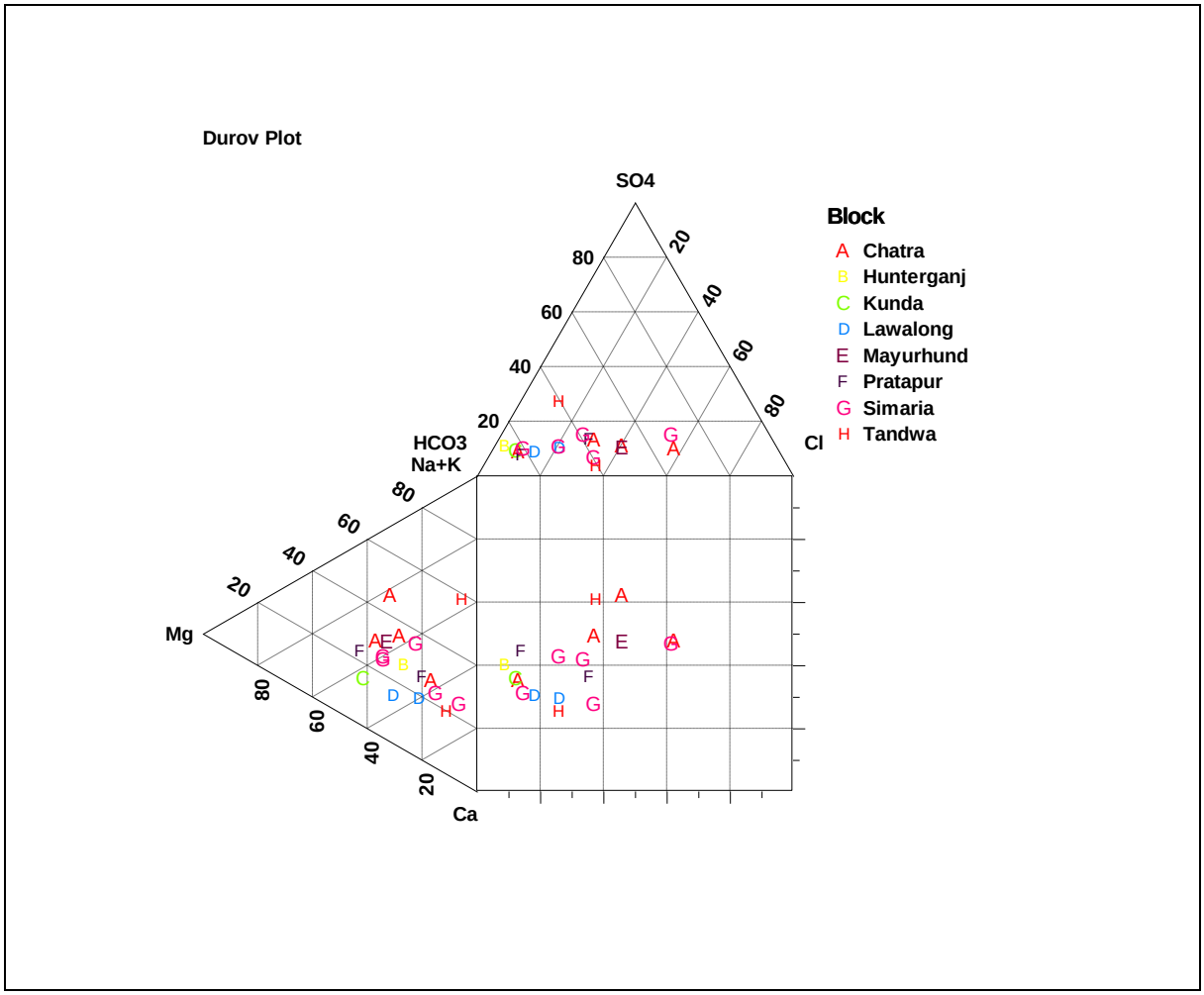


Figure 15: Sodium Percentage Classification in Chatra district

2.5.5 Sodium Adsorption Ratio (SAR): -In assessment of the quality of water used for irrigation, sodium adsorption ratio (SAR) is a vital parameter. Enhanced salinity decreases the osmotic activity of plants as well as stops water to reach to the branches and leaves of plants resulting in inferior production. Moreover, irrigation water with high sodium and low calcium favors ion exchange by saturation of Na and is detrimental to the soil structure due to scattering of clay particles resulting in minor production because of difficulty in cultivation. The sodium adsorption ration is calculated from the ionic concentration of Sodium, calcium and magnesium according the following relationship:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}} \ldots\ldots\ldots$$

SAR values can be used to predict the degree to which irrigation water tends to enter into cation exchange section in soil. The higher value of SAR indicates damage of soil. Based on the SAR value the groundwater suitability classification is tabulated in table 9 and figure 16 which is showing that all the water samples (100%) of aquifer– I (dug wells) pertain to excellent class.

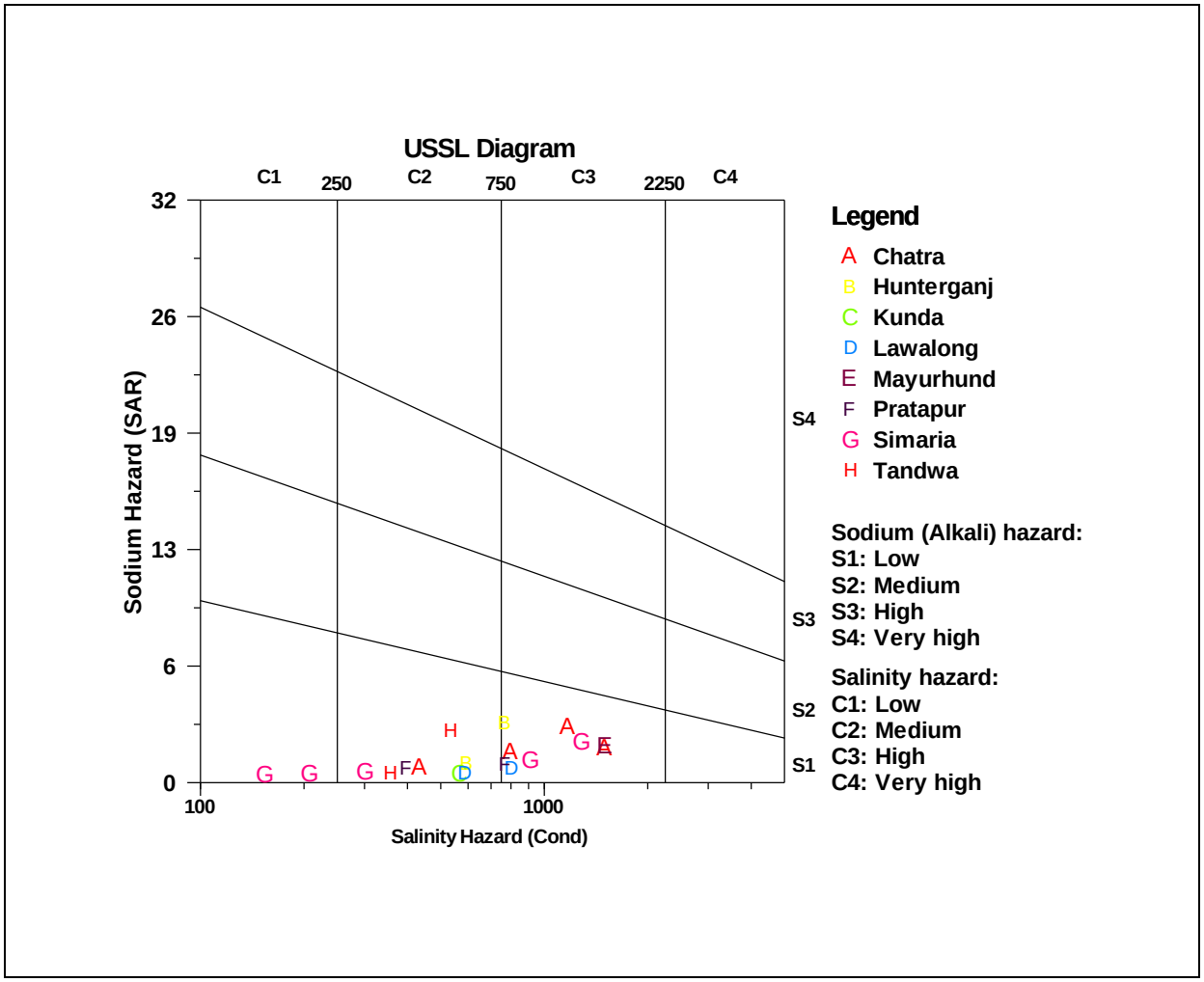


Figure 16: Sodium Adsorption Ratio (SAR) in Chatra district

Table 9: - Classification of ground water of Aquifer – I based on SAR value

Sl No.	Water class	Type of Water	SAR Value	No. of samples falling
1	Excellent	Low sodium water	< 10	2
2	Good	Medium sodium water	10 – 18	8
3	Fair	High sodium water	18 – 26	8
4	Poor	Very high sodium water	> 26	

(Where all ions expressed in epm)

2.5.6Piper Diagrame for Classification of irrigation Waters

The Piper diagram is used to categorize the type of water. It comprises of three parts: one diamond shaped diagram in the middle and two trilinear diagrams sideways in the bottom. The comparative concentrations of cations (left diagram) and anions (right diagram) in each sample is depicted in the trilinear diagram. For presenting ions in a piper diagram, the cations are clustered into three major divisions: sodium (Na) plus potassium (K), calcium (Ca), and magnesium (Mg). The anions are likewise grouped into three main categories: bicarbonate (HCO3-2) plus carbonate (CO3-2), chloride (Cl-), and sulfate (SO4-2). Each sample is denoted by a point in each trilinear diagram; the type of

water samples will make the grade according to the symbolic area in piper diagram shown in figure 17.

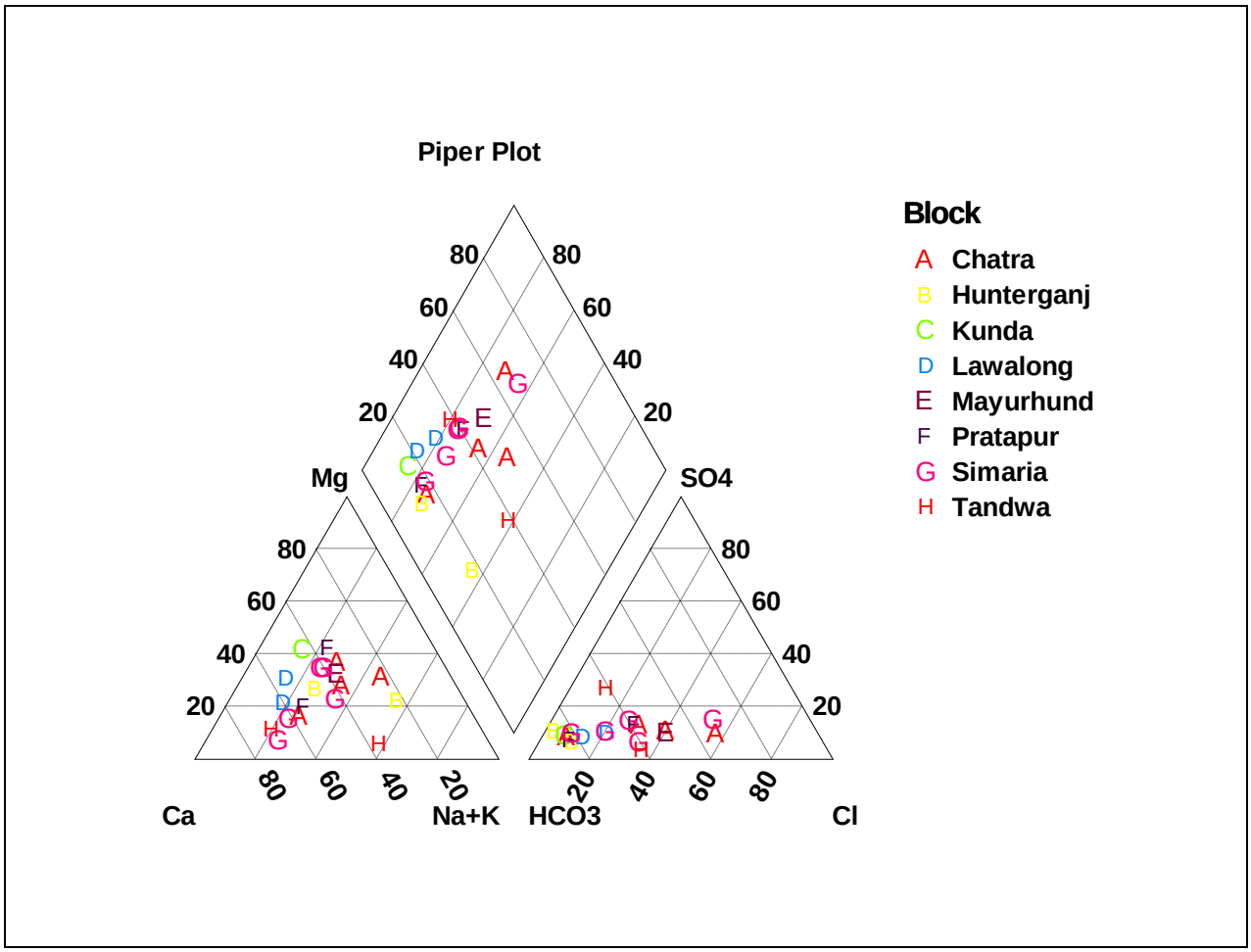


Figure 17: Piper Diagram

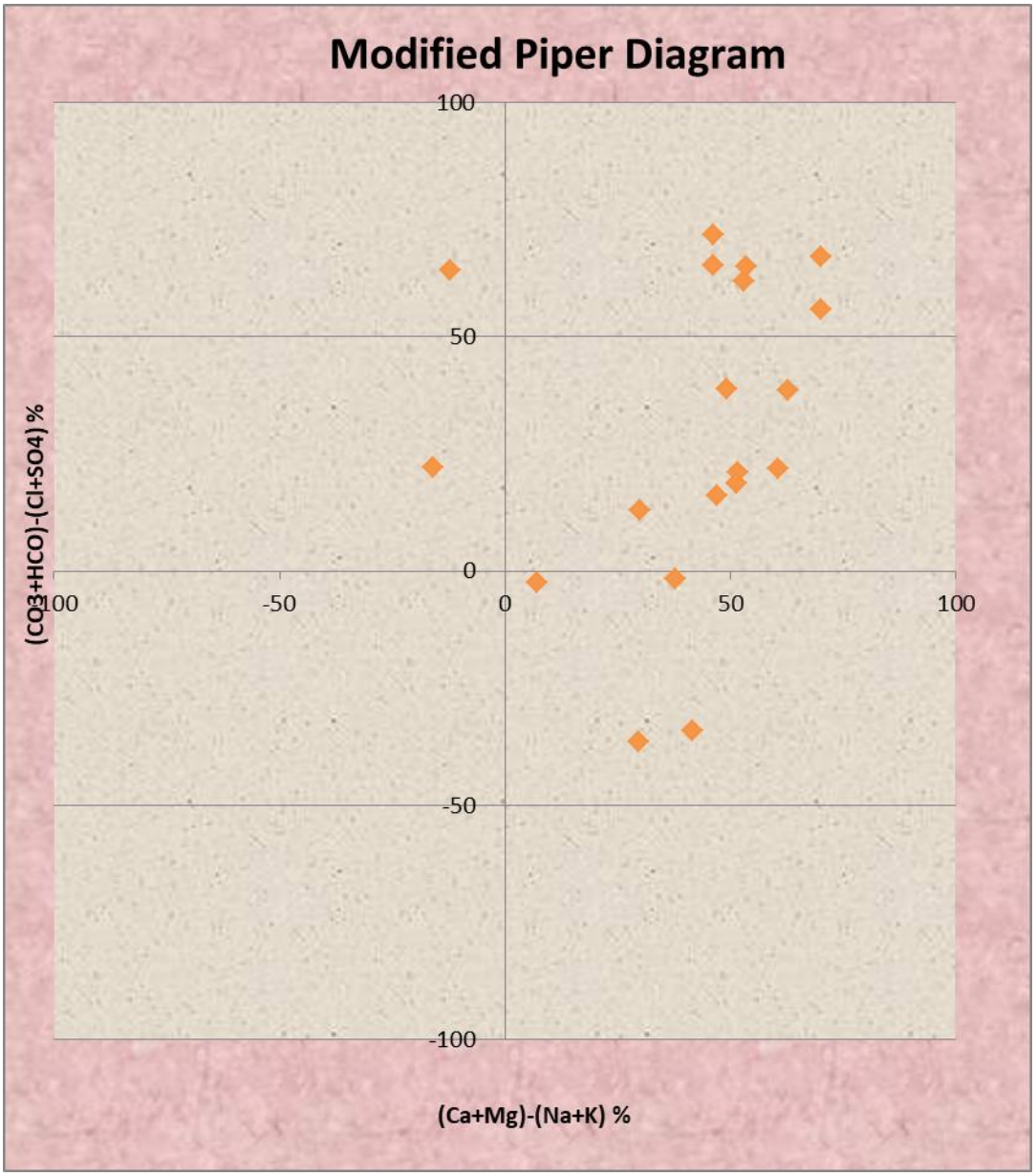


figure 18: Modified Piper Diagram

Interpretation of Chadha's modified Piper diagram,in shallow aquifer, 65% water sample belong to calcium–magnesium–chloride (Ca–Mg–Cl) type and only 28% water samples belong to calcium-bicarbonate (Ca-HCO3) type.

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

The data collected and generated on various parameters viz., water levels, water quality, exploration, aquifer parameters, geophysical, hydrology, hydrometeorology, irrigation, thematic layers was interpreted and integrated. Based on this the various aquifer characteristic maps on hydrogeology, aquifer wise water level scenario both current and long term scenarios, aquifer wise ground water quality, 2-D and 3-D sub surface disposition of aquifers by drawing fence and lithological sections, aquifer wise yield potential, aquifer wise resources, aquifer maps were generated and as discussed in details

3.1 Aquifer Disposition

3.1.1 Hydrogeological Cross Section: To study the aquifer disposition in detail, hydrogeological cross section indicating aquifer geometry has been prepared viz. A-A' and B-B'. In the cross section X & Y axis represents elevation in MSL and Horizontal distance respectively.

3.1.1.1 Hydrogeological cross section A-A':

Hydrogeological cross section A-A' represents the area in North-western to South eastern part of the district. The data of 4 exploratory wells i.e. Pratapur, Kunda, Jabda, and Khadaiya have been utilised (figure). In section A-A' one to four fracture zone has been encountered in different exploratory wells and out of 04 exploratory wells Kunda well has got four fracture zone upto depth of 156 mbgl. The discharge range varies from 25-425 lpm. The Aquifer-I bottom ranges from 12.2-30.5m representing weathered Granite-Gneiss while Aquifer-II ranges from 12.0-156 mbgl representing fractured granite gneiss .Hydrogeological cross section of A-A' is shown in figure-19

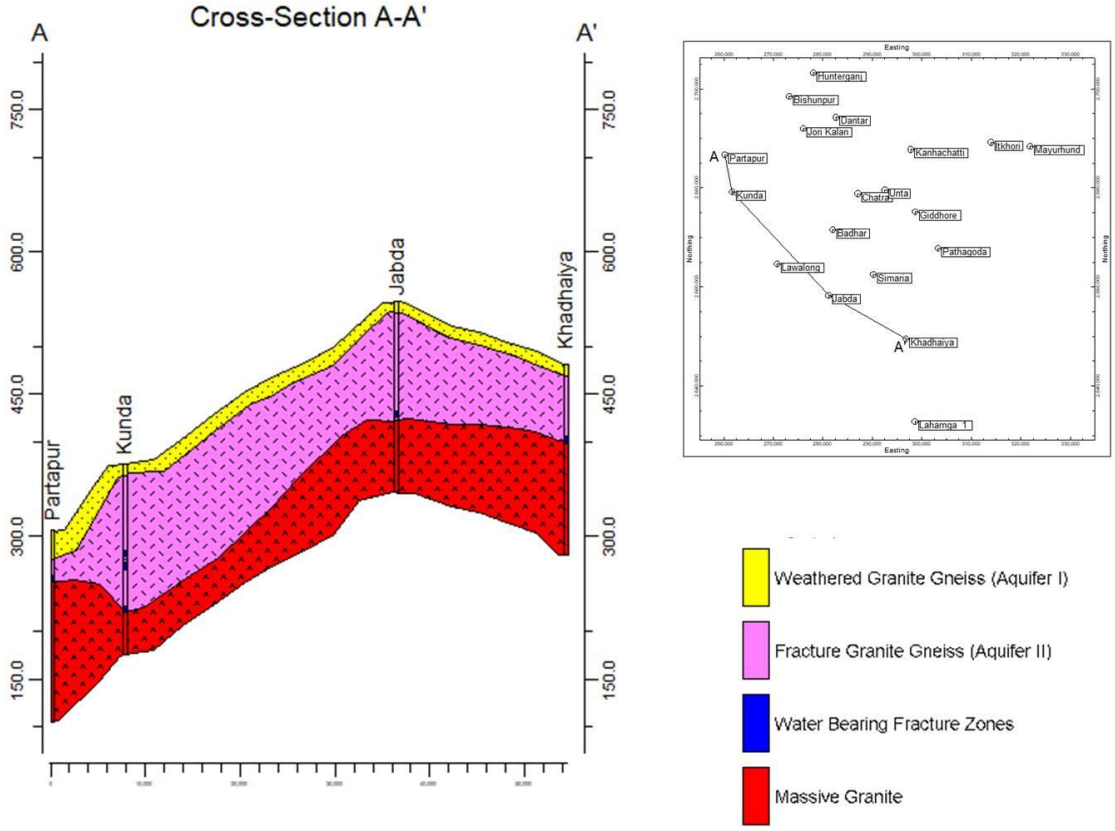


Figure 19-: Hydrogeological cross section along A-A'

3.1.1.2 Hydrogeological cross section B-B':

Hydrogeological cross section B-B' represents the area in North to eastern Part of Chatra district. The data of five exploratory wells i.e. huntergang, Bishunpur, Jorikalan, Kanchanchatti and Itkhori wells have been utilised (figure20). Out of five exploratory wells all five exploratory well has got fracture zone upto depth of 173 mbgl. The Aquifer- I bottom ranges from 13-29.00 mbgl representing weathered Granite-Gneiss/Laterites, while Aquifer-II ranges from 13-173 mbgl representing fractured granite gneiss. Generally 1-4 sets of fracture zones were encountered. Well yield varies from 112-450 lpm.

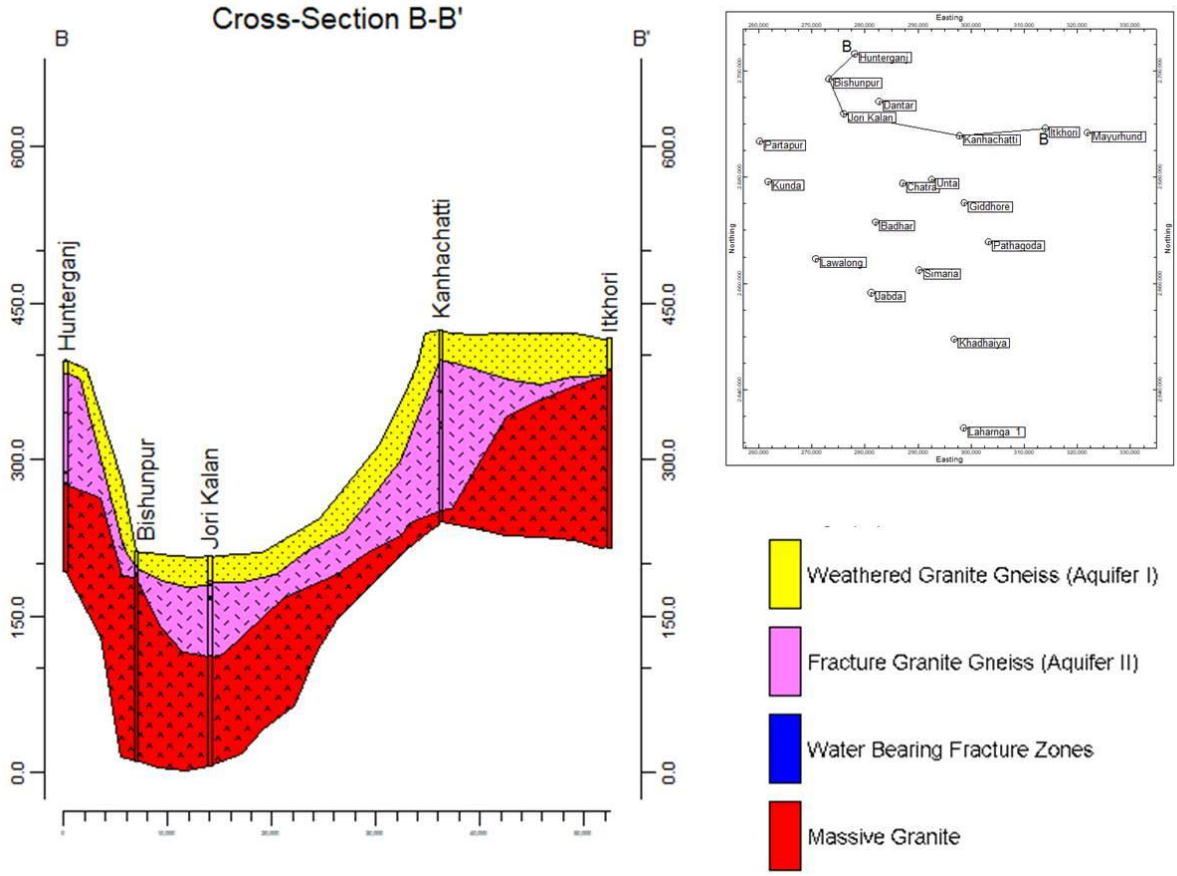


Figure 20-: Hydrogeological cross section along B-B'

3.1.2 3-D Aquifer Disposition

The 2D & 3-D map in hard rock area of the district showing spatial disposition and vertical extent of Aquifer-I(weathered granite-gneiss/weathered shale/sandstone)indicating its depth of weathering while the Aquifer–II (fractured granite-gneiss/fractured Shale/sandstone) showing occurrence of fractured rock thickness is presented in different stratigraphical model (exploded) of hard rock in Chatra district (figure-21). Based on the drilling data of exploratory wells maximum thickness of

Aquifer - I (weathered zone) in hard rock area is 38 m. The depth of Aquifer – II (fracture zone) ranges from 20-181 mbgl.Three dimensional sub-surafce Stratigraphical models with Aquifer disposition in hard rock areas of Chatra district have also been prepared based on exploratory driiling data which is shown in figure 22

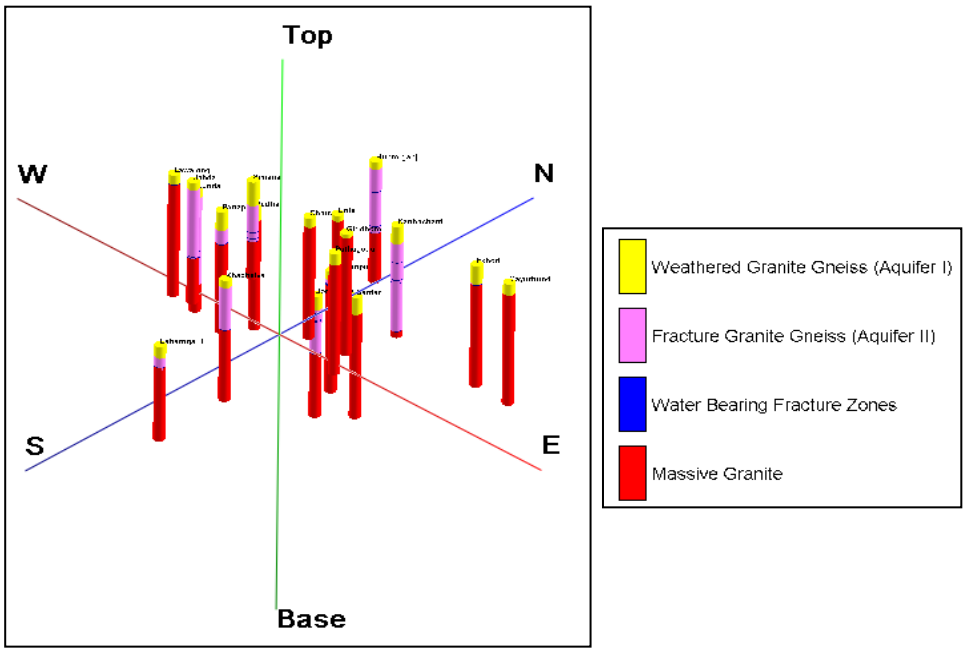


Figure 21: Three-dimensional Striplog (Model) of Hard rock area ofChatra district

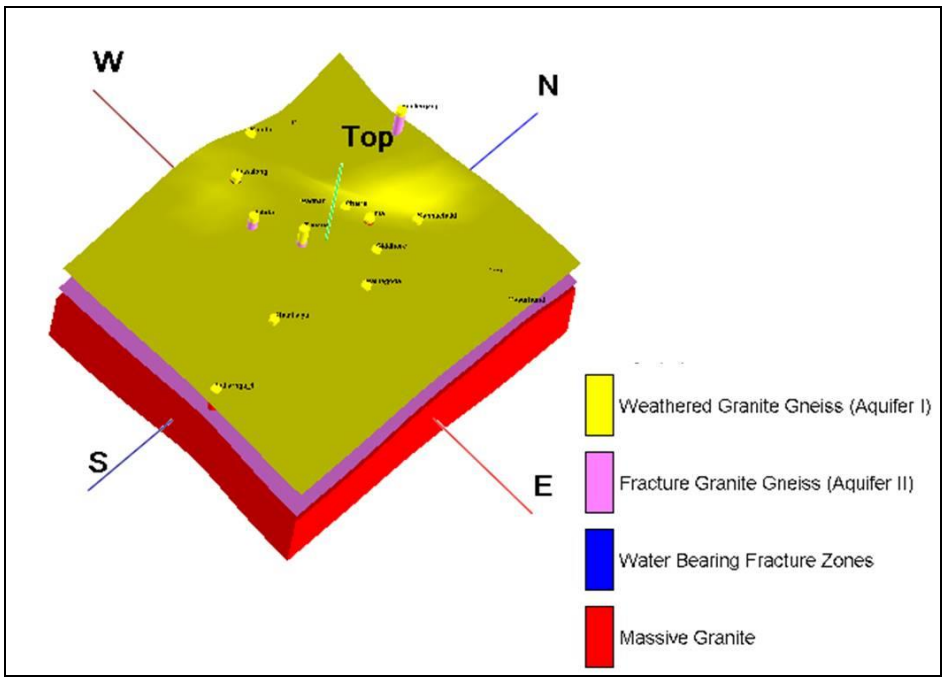


Figure 22: Three Dimensional Stratigraphy Model of Hard Rock area of Chatra District

Hydrogeological cross section of A-A' B-B'' shown in figure- 19 & 20 has been prepared based on exploratory well data of CGWB.The inferred imaginary line between fractured rock zone and massive rock zone depicted in Fig 19 & 20 are also based on exploratory data. This is a regional model of hydrogeological cross setion. The heterogeneity of hard rock aquifer being high, the hydrogeological cross sections drawn by inferring the continuity of fracture zones in the second aquifer is tentative. Any additional data from the area in future may change the geometry of aquifer that can consider as well.

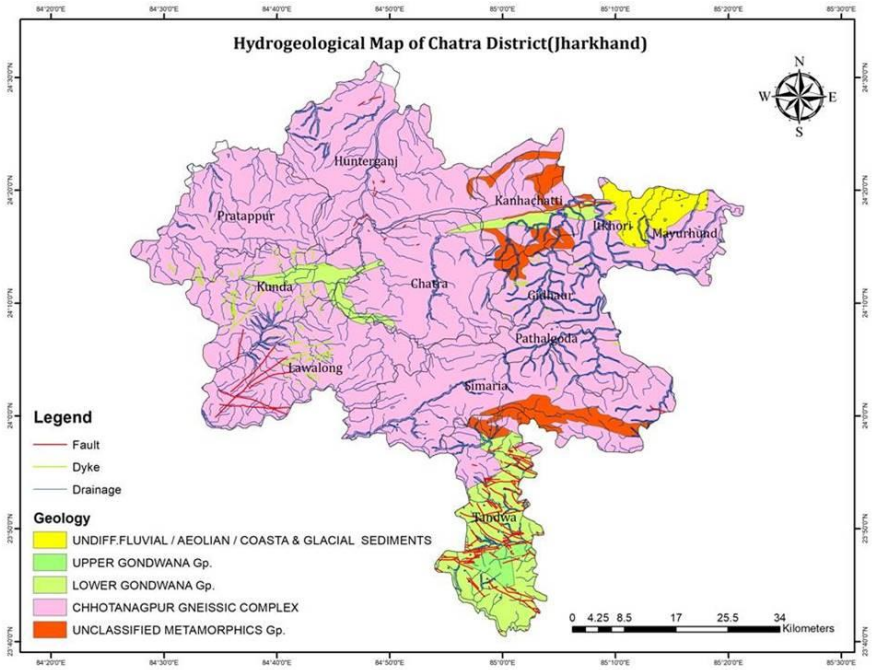
3.2 Aquifer Characteristics:-

The sustainability of ground water Resources are better understood by the aquifer properties. The table 10 depicts the aquifer characterstics in Chatradistrict.

Table 10 : Aquifer characteristic of Chatra district

Type of aquifer	**Formation**	**Depth range of the aquifer (mbgl)**	**SWL (mbgl)**		**Thickness (m)**	**Yield (lpm)**	**Aquifer parameter**	
			Pre Monsoon (2019)	**Post Monsoon (2019)**			**T (m2/day)**	**Sy/S**
Aquifer - I	Weathered Granite gneiss	3.00–39.00	2.2-14.4	1.1-8.05	1 - 5	0 - 60	--	--
Aquifer - II	Fractured Granite gneiss	39-173	--	--	0.50 – 2.00	27– 450	041-123.53	2.15x10-5 (Lahranga)

3.3 Aquifer Maps:- Based on Aquifer Disposition, Aquifer Geometry, Aquifer Characteristics, Aquifer Maps in Chatra district have been prepared as under in figure 23



	Age/Formation	Lithology	Hydrogeology	Ground Water Potential
	UNCONSOLIDATED FORMATION			
	Quaternary to Recent	Alluvium- Sand, Silt, Clay	Limited thickness along river banks mainly unconfined condition	Upto 10 m3/hr
	SEMI-CONSLIDATED FORMATION			
	Lower Gondwana (Upper Carboniferous to Permian)	Sandstone, Shale with coal seams, Conglomerate	Moderately thick limited in extent semi-confined to confined aquifer	10-20 m3/hr
	CONSOLIDATED FORMATION			
	Chotanagpur Gneissic Complex (Precambrian)	Granite-Gneiss, Biotite-Gneiss	Ground Water Restricted to weathered zones/fractured zones	5-20 m3/hr
	Unclassified metamorphic (Precambrian)	Amphibolite, Hornblend Schist, Hazariabagh Granite etc	-	Poor to moderate

Figure 23: Aquifer Map of Chatra District

4. GROUND WATER RESOURCE

Ground Water Resource of the area has been estimated block wise with base year as on March-2020. In the present report GEC 2020methodology has been used and based on this, assessment has been made using appropriate assumptions. This methodology recommends aquifer wise ground water resource assessment of both the Ground water resources components, i.e., Replenishable ground water resources or Dynamic Ground Water Resources and In-storage Resources or Static Resources. The assessment of ground water includes assessment of dynamic and in-storage ground water resources, but the development planning should mainly depend on dynamic resource only as it gets replenished every year. Changes in static or in-storage resources reflect impacts of ground water mining. Such resources may not be replenishable annually and may be allowed to be extracted only during exigencies with proper recharge planning in the succeeding excess rainfall years.

4.1 Assessment of Annually Replenishable or Dynamic Ground Water Resources (Unconfined Aquifer i. e Aquifer-I)

The methodology for ground water resources estimation is based on the principle of waterbalance as given below –
Inflow – Outflow = Change in Storage (of an aquifer)
The equation can be further elaborated as
ΔS= RRF+RSTR+RC+RSWI+RGWI+RTP+RWCS±VF ± LF -GE-T-E-B
Where,
ΔS – Change is storage, RRF – Rainfall recharge,RSTR- Recharge from stream channels
Rc – Recharge from canals,RSWI – Recharge from surface water irrigation
RGWI- Recharge from ground water irrigation,RTP- Recharge from Tanks& Ponds
RWCS – Recharge from water conservation structures,VF – Vertical flow across the aquifer system, LF- Lateral flow along the aquifer system (through flow),GE-Ground Water Extraction, T- Transpiration ,E- Evaporation, B-Base flow

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RWCS – Recharge from water conservation structures,VF – Vertical flow across the aquifer system, LF- Lateral flow along the aquifer system (through flow),GE-Ground Water Extraction, T- Transpiration, E- Evaporation, B-Base flow

The dynamic Ground Water Resources as on 2020has been assessed by CGWB, SUO, Ranchi in association with State Ground Water Direcorate, Jharkhand based on GEC, Methodology 2020. The summarized details of Annually Replenishable or Dynamic Ground Water Resources of Chatra district are in table 11.

Table 11: Details of Ground Water Resource of Chatra District (As on March -2020)

S.No.	Items	Ground water in ham
1	Total annual ground water recharge	23603.87
2	Total Natural discharge	2028.82
3	Annual extractable ground water recharge	23603.87
4	Current Annual Ground Water Extraction for irrigation	6112
5	Current Annual Ground Water Extraction for domestic	1448.85
6	Current Annual Ground Water Extraction for industrial	709.17
7	Current Annual Ground Water Extraction for All uses	8270.03
8	Annual GW Allocation for Domestic use as on 2025	1458.92
9	Net Ground Water Availability for future use	15323.78
10	Number of semi-critical blocks	0
11	Number of critical blocks	0
12	Number of over-exploited blocks	0
13	Number of safe blocks	12
14	Stage of development	35.04 %

The block wise Dynamic Ground Water Resource of Chatra District - (As on March - 2020) is given in *Annexure- IV*

5.0 GROUND WATER RELATED ISSUES

5.1 Identification of Issues:

The major ground water related issues of the Chatra are grouped into following broad categories:

a. Quantity aspects (limited fracture thickness)
b. Low ground water development
c. Quality aspects

A variety of nature's factors affect the quantity and quality aspects of ground water over space and time. The major ground water related issues are discussed as follows;

5.1.1 Quantity Aspects:

Ground water potential at any area mainly depends on the topography, rainfall, and geology. Because of plateau topography and Chotanagpur granitic gneiss complex and Gondwana formation as the litho-units occurring in the study area, the ground water potential is not uniform and it changes from one area to another.

Thus the availability of water resource is not uniformly distributed over space and time. This resource depletes often in summer, Therefore reduction of bore well's yield in lean period. The area is covered by Chotanagpur granite gneiss complexes and Gondwana formation where ground water potential of deeper aquifer is very less and limited thickness of fracture/joints are encountered in exploratory well drilling programme. In lower gondwana rock area weathered formation also possess low potential aquifers.

5.1.2 Low ground water Development:

The study area experiences low ground water development. In the southern, central, western and some part of eastern area the ground water resources are under utilized. Ground water related issues and problems are not getting scientific attention of the Government, planners and stakeholders. The plan and policy of the water resources department are mostly related to the surface water only. There is urgent need to pay attention towards ground water also. The need of GW development and irrigation potential creation is required in underutilized area of Chatra district.

5.1.3 Quality Aspects:

The ground water quality of the study area is potable and is suitable for irrigation, however at few localities contamination in ground water due to geogenic cause. The major problems and issues related to the quality is, Flouride and nitrate. The concentration of fluoride in the study area having more than permissible limit i.e 1.5 mg/l encountered in shallow aquifer in Hunterganj and Tandwa block of Chatra district whereas Nitrate concentration more than permissible limit found in Simaria block of Chatra district.

6.0 MANAGEMENT STRATEGIES

As discussed in previous chapter, the major ground water related issue in Chatra is low ground water development and Quality issues related to Flouride and Nitrate due to hydrogeological reasons. To overcome these, it is imperative to have a robust ground water resource development plan for the district. Various Management strategies to overcome the ground water related issues are;

6.1 Supply side Interventions:

At present as per Ground Water Resource Estimation 2020, the stage of ground water extraction is very low i.e., 35.04 % and all the block of the district comes under safe category. However, in some parts of the district long term declining trend has been noticed. Therefore, the ground water development should also be coupled with ground water augmentation, so that there is no stress on ground water regime of the area.

The supply side interventions envisage Ground Water Resource Development Strategy & construction of Rainwater Harvesting and Artificial Recharge structures in the areas feasible for construction of recharge structures based on the long-term water level scenario and recharge potential of the aquifer.

6.1.1 Ground Water Resource Development Strategy

Ground water management strategies for the study area, we have to prepare separate plan for over-exploited blocks, Critical and Semi-critical blocks and safe blocks based on the ground water resource availability and draft condition of the area. The Annual extractable ground water recharge in the Chatra district is 23603.87 ham and Current annual GW extraction for all uses is 8270.03ham, making stage of ground water development 35.04 % as a whole for the study area .Although there are ample scope of ground water development in eastern, western, and southern part of the area.

Considering the net ground water availability for future use, unit draft of different structures like Dug wells/Shallow Tubewell/Borewell, feasible structure has been determined for further ground water development in the district. Proposed number of dug wells/Shallow Tubewell/Borewell is given in table 12.

Table 12 Proposed number of dug wells/Shallow Tubewell/Borewell

District	Assessment unit	Net ground water availability and future irrigation development (ham)	future irrigation potential available (ha)	60% of future irrigation potential created (ha)	Proposed number of ground water structure (Dug wells)	Proposed number of ground water structure (Shallow tube wells)
Chatra	Chatra	948.38	2107.511	1264.507	379	74
	Gidhaur	832.21	1849.356	1109.613	333	65
	Hunterganj	993.91	2208.689	1325.213	398	77
	Itkhori	481.82	1070.711	642.4267	193	37

	Kanhachatti	967.80	2150.667	1290.4	387	75
	Kunda	1548.71	3441.578	2064.947	619	120
	Lawalong	1446.79	3215.089	1929.053	579	113
	Mayurhund	300.26	667.2444	400.3467	120	23
	Pathalgoda	377.42	838.7111	503.2267	151	29
	Pratappur	1213.58	2696.844	1618.107	485	94
	Simaria	1784.17	3964.822	2378.893	714	139
	Tandwa	4428.73	9841.622	5904.973	1771	344
	Total	**15323.78**	**34052.84**	**20431.71**	6130	1192

Development of ground water for the safe blocks in Chatra district requires thorough understanding of the heterogeneity of the formations, e.g degree of weathering, thickness of fracture zones and depth of occurrences of the aquifer. It is necessary that proposed Additional ground water abstraction structure may be constructed in phases with proper site selection/ Hydroegeological/Geophysical Investiagtions etc The results of the first phase of ground water development together with studies of the behavior of ground water regime will guide futher ground water development.

6.1.2 Artificial recharge to ground Water

Recently in 2020, artificial recharge to Ground Water master plan 2020 of Jharkhand state has been prepared. The identification of feasible areas for artificial recharge to ground water in Chatra district has been carried out based on depth to water level (post-monsoon) and ground water level trend. The computation of unsaturated zone available, surface water requirement and source water availability for Artificial recharge and proposed numbers of different types of artificial recharge structures feasible in Chatra district has been worked out. Based on the study 1044 No of Nala Bund/Check Dam/Gully Plus and 166 No of Percolation tanks may be constructed in phased manner with proper site selection In addition, Roof Top rainwater harvesting system may also be installed in buildings. The implementation of water conservation through artificial recharge measures will have a positive impact on drinking water sources of the area. It will ensure that the wells don't go dry during summer/lean/stress period in the areas of implementation and sufficient ground water availability is there in the wells even during the summer season. Thus, not only the drinking and domestic water sources will be strengthened but additional irrigation potential can be created through artificial recharge structures. Proposed number of Artificial recharge structures feasible in Chatra district is given in table 13

Table -13: Artificial recharge structures feasible in Chatra district

Sl. No.	District	Volume of unsaturated zone available for recharge (MCM	Total volume of Available Water for Recharge (MCM)	Percolation Tank	NalaBund/ Check dam / Gully Plug	Recharge Shaft
1	**Chatra**	37.77	101.83	166	1044	0

6.2 Demand side management:

It is always essential to address the issue of constraining demand for groundwater abstraction since this will normally contribute more to achieving the groundwater balance. The concept of real water savings is critical in this regard. The main demand side interventions may be: -

1. Promote improved irrigation technologies (drip or sprinkler irrigation, etc.)
2. Crop choice management and diversification (promote less intensive crops like pulses and horticulture)
3. Promote treated municipal waste water for irrigation and construction use.
4. Managing energy and irrigation nexus (provide quality power supply when needed through separate feeders, high voltage distribution lines, solar pumps, etc.)

7.0 Sum-up

- The district of Chatra spread over an area of 3931 sq. km, It is bordered by Gaya district of Bihar State in the North, Palamu district in the West, Hazaribag and Chatra in the East and Latehar in South West and Ranchi in the South.Chatra is situated within lush green area with 60.4% of geographical area under forest. It is primarily a rural district with 93.4% of population residing in rural areas. The settlement pattern of district is scattered with a very low population density at 275 persons per sq. km. Chatra district economy is primarily agrarian based with more than 75% of workers engaged in agriculture either as cultivators or agricultural labourers.
- Topographically the area is marked by isolated hills and valleys. The general slope of the district is from South to North with an average elevation of 487 m. Since the district consists of part of Upper & Lower Hazaribag plateau and northern scarp, it presents diverse physiographic features.

- The area is represented by the isolated hills, linear ridges, low uplands, buried pediment, pediplain, undulating pediplain and waterbody/ active channel. The northern most part of the district bordering Bihar is a low-lying area and most suitable for agriculture. Just to the south of this plain region is Kalua and Lahabar hills that forms the higher elevations of the district. These hills fall in northern blocks namely Hunterganj, Pratappur, Kunda and Lawalong. The middle and southern regions of the district are a part of Chotanagpur plateau. These regions have an undulating terrain with a mix of up, medium and low lands. The scarp landforms of the district gave rise to scenic waterfalls. TamasinWaterfalls in Kanhachatti block is a famous tourist spot that has been formed due to scarp landform

- The area forms part of the chhotanagpur pleateau. A broad spectrum of Archean to Quaternary formations comprising crystalline, sedimentary and metamorphic rock occurs in the area. The unclassified metamorphics, Gneissic complex and Proterozoic intrusive rocks suffered strong folding deformation and medium grade metamorphism. The gondwana rocks are not folded or metamorphosed. Most of the faults and shear zones in the gneisses, metamorphics.

- To assess the potentiality of the deep fractured rock, 20 exploratory wells were drilled in Chatra district. Based on exploratory drilling carried out by CGWB potential fracture have been identified which widely varies from 21-156 m. However overall in the district the major potential fractures zones are found upto 120m.
- At some places fractures occur upto 100m with high discharge, i.e Laharanga-420 lpm , Simaria-240 LPM, etc while deeper aquifer upto 173m also encountered potential fracture with high yield of 450 lpm(Kanchachatti) .
- Due to limited fractured thickness and well yield depends on occurrence of potential fractures, therefore before going to any ground water exploration detailed hydrogeological, geophysical studies should be carried out.
- Ground Water quality is generally potable, except few patches of high Flouride and Nitrate in Ground Water.

- The stage of ground water development in Chatra district is 35.04% and all the block comes under safe category.Therefore, there is sufficient scope for further ground water development.
- The major ground water related issues in Chatra district are Low ground water development, Low ground water potential/ sustainability, quality related issues like fluoride and Nitrate also persisit in Chatra district.
- To suggest a sustainable ground water management plan there are two options- Supply Side Management Options & Demand Side Management Options
- The supply side interventions-I envisages Ground Water Management strategy through construction of 6130 dug wells and 1192 shallow bore wells in the feasible areas in the district. Rain water harvesting and artificial recharge to be encouraged in feasible areas for ground water augmentation. In additional purification/filtration of Fluoride may also be adopted.
- The supply side interventions-II also envisages construction of feasible artificial recharge structures - 166 percolation tank, 1044 Nala Bund/Check Dam/Gully Plug in Chatra district, which is based on Artificial recharge to Ground Water master plan 2020 of Jharkhand state in phased manner with proper site selection
- The demand side intervention envisages the real water savings. The main demand side interventions may be-i) Promote improved irrigation technologies (drip or sprinkler irrigation, etc.), ii) Crop choice management and diversification (promote less intensive crops like pulses and horticulture), iii) Promoting treated municipal waste water for irrigation and construction use, and iv) Managing energy and irrigation nexus (provide quality power supply when needed through separate feeders, high voltage distribution lines, solar pumps, etc.) The government should encourage and provide incentive the use of drip irrigation and sprinkler system.

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Annexure - I

Hydrogeological Details of Exploratory Wells drilled through Out-sourcing in Chatra

Sl.No.	Location	Block	Co-ordinate	Depth Drilled m	Casing Depth/ Dia. m/mm	Fractures Encountered m	Static Water level m bgl.	Discharge (Comp) m^3/hr	Discharge (Pumping Test) m^3/hr	Drawdown m	T m^2/day	S	Formation
1	Khadhaiya	Tandwa	85°00'11.1" 23°56'41.0''	201	11.69	82-85		dry					Gondwana
2	Jabda	Simaria	84°50'54.8" 24°01'16.9''	201	17.78	122.5-123.5 125-126	3.35	1.548			11.03 (slug)		Granite Gneiss
3	Pathagoda	Pathalgoda	85°03'51.2" 24°06'38.2''	201	17.79	56.0-57.0		dry					Granite Gneiss
4	Lawalong	Lawalong	84°44'42.3" 24°04'39.3''	201	14.35	15.0-16.0	11.05	1.08			4.41(slug)		Granite Gneiss
5	Chatra	Chatra	84°54'12.1" 24°12'27.7"	201	14.74	-	**3.22**	1.458			0.419slug)		Granite Gneiss
6	Giddhore	Giddhore	85°01'05.2" 24°10'35.6''	201	6.47	22.0-23.0		dry					Granite Gneiss
7	Kanhachatti	Kanhachatti	85°00'27.2" 24°17'23.7''	183.84	27.85	59.5-60.5, 88.7-88.9 93-93.2, 95.0-96.0 173-173.5	**3.63**		28.04	8.51	**74.79**		**Gondwana/ Gneisss**
8	Itkhori	Itkhori	85°10'00.1" 24°18'17''	201	29.37	31.0-34	**10.31**	1.55			**0.60(slug)**		**Granite Gneiss**
9	Mayurhund	Mayurhund	85°14'41.9" 24°17'53.6''	201	17.78		**3.90**	1.08			**1.65(slug)**		**Granite Gneiss**
10	Badhar	Chatra	84°51'16.188" 24°08'29.51	201	20.8			dry					**Granite Gneiss**

			4"										
11	Unta	Chatra	84⁰57'25.8" 24⁰12'54.7"	201	9			dry					**Granite Gneiss**
12	Partapur	Partapur	84°38'14.838" 24°16'30.5328"	201	30.0	53.0-54.0	**5.58**		7.056	**30.10**	**1.91**		**Granite Gneiss**
13	Kunda	Kunda	84⁰39'13.44" 24⁰12'26.196"	201	11.70	96.0-97.0, 100-101 104-104.5, 110-111 113-115, 156-157	**9.24**		4.5	11.07	**17.07**		**Gondwana/ Granite Gneiss**
14	Jori Kalan	Hunterganj	84⁰47'34.2" 24⁰19'29.3"	201	22.70	27-28, 30-31 39.2-41, 41.5-42.5 44-45.5, 95.8-96.2	**-**	dry	dry	**-**			**Granite Gneiss**
15	Bishunpur	Hunterganj	84⁰45'50.6" 24⁰22'59.2"	201	13.21	14.2-16.2, 21.0-22.0 23.0-25.0	**3.67**		6.76	**9.82**	**5.14**		**Granite Gneiss**
16	Huntergaanj	Hunterganj	84⁰48'39.5" 24⁰25'36.2"	201	11.70	49-50, 106.9-107.3 117-118, 122-123 180-181	**5.63**		7.128	16.26	**3.77**		**Granite Gneiss**
17	Dantar	Hunterganj	84⁰51'27.6" 24⁰20'47.2"	201	27.5			dry					**Granite Gneiss**
18	Laharnga	Tandwa	85°01'23.6" 23°47'38.5''	157	17.8	34.0-35.2	**13.98**		25.27	13.32	**123.56**	**2.15×10^{-5}**	**Gondwana**
	OW		85°01'23.6" 23°47'38.5''	156	19.0	39.0-40.0	**13.90**			3.32			**Gondwana**
19	Simaria	Simaria	84°56'12.2" 24°03'39.3''	161	38.8	83.5-83.9, 94.8-95.2 98.6-98.8	**7.98**		18	18.53	**39.60**		**Granite Gneiss**

Annexure – II

LOCATION OF NHS &KEY WELLS ESTABLISHED UNDER NAQUIM STUDY IN CHATRA DISTRICT, JHARKHAND,

S.No.	State	District	Block	Village/Location	Long	Lat	Type	Depth
1	Jharkhand	Chatra	Tandwa	Tandwa	85.02916667	23.85833333	Dug Well	4.5
2	Jharkhand	Chatra	Tandwa	Teliyadih	84.99888889	23.95222222	Dug Well	2.36
3	Jharkhand	Chatra	Simaria	Simaria	84.95777778	24.08083333	Dug Well	8.8
4	Jharkhand	Chatra	Simaria	Bagra	84.94583333	24.04583333	Dug Well	8.9
5	Jharkhand	Chatra	Lawalong	Jojowari	84.79477	24.05281	Dug Well	2.8
6	Jharkhand	Chatra	Simaria	Tutilawa	85.04583333	24.05833333	Dug Well	6.65
7	Jharkhand	Chatra	Simaria	Piri	85.1175	24.00166667	Dug Well	1.3
8	Jharkhand	Chatra	Simaria	Birhu	85.18833333	23.97166667	Dug Well	9.2
9	Jharkhand	Chatra	Chatra	Bhagwani	84.85306	24.14076	Dug Well	1.6
10	Jharkhand	Chatra	Chatra	Chatra	84.87555556	24.20055556	Dug Well	4.2
11	Jharkhand	Chatra	Chatra	Pitij	85.10888889	24.26694444	Dug Well	6.7
12	Jharkhand	Chatra	Chatra	itkhori	85.16833333	24.30972222	Dug Well	5.75
13	Jharkhand	Chatra	Mayurhund	Karma	85.23622	24.23749	Dug Well	4.1
14	Jharkhand	Chatra	Hunterganj	Talbarwan	84.81638	24.27657	Dug Well	4.8
15	Jharkhand	Chatra	Hunterganj	Garwari	84.8085	24.38497	Dug Well	0.9
16	Jharkhand	Chatra	Pratapur	Sijwa	84.72298	24.32076	Dug Well	4.1
17	Jharkhand	Chatra	Pratapur	Pratapur	84.63679	24.28191	Dug Well	5.4
18	Jharkhand	Chatra	Kunda	Bariyachak	84.64266	24.21538	Dug Well	4.2
19	Jharkhand	Chatra	Lawalong	Chukru	84.71303	24.16189	Dug Well	3.2

Annexure – III

CHEMICAL ANALYSIS RESULT OF WATER SAMPLES COLLECTED TROUGH KEY WELLS UNDER NAQUIM STUDY IN CHATRADISTRICT, JHARKHAND

District	Block	Type of well	pH	EC(µs/cm) at 25^{0}C	TDS	F-	Cl-	HCO3-	CO32-	SO42-	NO3-	PO43-	TH as CaCO3	Ca2+	Mg2+	Na+	K+
					mg/L								mg/L				
													mg/l				
Chatra	Tandwa	DW	7.5	535	347.8	2.88	60.29	178.35	ND	7.9	0.4	BDL	110	38	3.645	69.38	0.57
Chatra	Tandwa	DW	7.5	358	232.7	0.62	14.18	123	ND	42.85	6.76	BDL	140	48	4.86	15.23	0.9
Chatra	Simaria	DW	7.46	302	196.3	0.14	35.45	110.7	ND	8.86	4.8	BDL	110	40	2.43	15.26	1.45
Chatra	Simaria	DW	7.71	1287	836.6	0.28	198.5	202.95	ND	73.88	107	BDL	430	112	36.45	106.2	1.89
Chatra	Lawalong	DW	7.84	805	523.3	0.28	56.72	325.95	ND	36.97	39.85	BDL	325	96	20.655	32.88	2.35
Chatra	Simaria	DW	7.84	913	593.5	0.63	63.81	375.15	ND	43.75	28	0.11	335	72	37.665	51.83	1.16
Chatra	Simaria	DW	7.51	154.1	100.2	BDL	14.18	55.35	ND	10.55	0.9	BDL	55	12	6.075	7.57	0.97
Chatra	Simaria	DW	7.57	208	135.2	BDL	7.09	104.35	ND	9.74	1.5	BDL	75	24	3.645	9.78	1.32
Chatra	Chatra	DW	7.46	806	523.9	0.82	85.08	270.6	ND	48.45	10.4	BDL	255	58	26.73	63.11	0.39
Chatra	Chatra	DW	7.07	1517	986.1	0.33	287.1	282.9	ND	64.05	41.07	BDL	549.98	106	69.25	103.7	1.37
Chatra	Chatra	DW	7.52	1183	769	1.47	163.1	338.25	ND	58.1	10.6	BDL	325	54	46.17	127.8	2.53
Chatra	Chatra	DW	7.78	439	285.4	1.19	14	221.4	ND	17.8	BDL	BDL	155	48	8.505	25.14	1.82
Chatra	Mayurhund	DW	7.24	1521	988.7	0.48	184.3	381.3	ND	60.8	99	BDL	530	112	60.75	108.3	2.75
Chatra	Hunterganj	DW	7.84	598	388.7	1.68	7.09	301.35	ND	29.22	6.85	BDL	220	56	19.44	36.36	1.26
Chatra	Hunterganj	DW	7.59	773	502.5	2.16	31.91	393.6	ND	24.59	7.37	BDL	169.98	34	20.65	99.06	1.18
Chatra	Pratapur	DW	7.46	777	505.1	1.55	28.36	387.45	ND	26.47	27.2	BDL	290	52	38.88	39.54	1.24
Chatra	Pratapur	DW	7.51	400	260	0.58	35.45	123	ND	21.81	15	BDL	130	38	8.505	21.35	0.36
Chatra	Kunda	DW	7.49	570	370.5	0.71	14.18	264.45	ND	21.73	2.17	BDL	225	46	26.73	17.53	1.22
Chatra	Lawalong	DW	7.61	589	382.9	1.07	24.82	239.85	ND	19.99	35.5	BDL	250	64	21.87	19.43	1.4

Annexure-IV

DYNAMIC GROUND WATER RESOURCES (2020) CHATRA DISTRICT, JHARKHAND

Sl. No.	District	Administrative Units	Ground water Assessment Sub- Unit	Annual Extractable Ground Water Recharge	Current Annual Ground Water Extraction for irrigation	Current Annual Ground Water Extraction for domestic	Current Annual Ground Water Extraction for industrial	Current Annual Ground Water Extraction for All uses	Annual GW Allocation for for Domestic Use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction
				(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(%)
1	Chatra	Chatra	Non-Command	1641.12	434.00	256.97	0.00	690.96	258.75	948.38	42.10
2	Chatra	Gidhaur	Non-Command	1291.08	404.50	54.00	0.00	458.50	54.37	832.21	35.51
3	Chatra	Hunterganj	Non-Command	2665.17	1422.00	247.54	0.00	1669.54	249.26	993.91	62.64
4	Chatra	Itkhori	Non-Command	1089.38	508.00	98.87	0.00	606.87	99.56	481.82	55.71
5	Chatra	Kanhachatti	Non-Command	1282.53	231.00	83.15	0.00	314.15	83.73	967.80	24.49
6	Chatra	Kunda	Non-Command	1827.60	239.00	39.61	0.00	278.61	39.89	1548.71	15.24
7	Chatra	Lawalong	Non-Command	1747.95	234.00	66.71	0.00	300.70	67.17	1446.79	17.20
8	Chatra	Mayurhund	Non-Command	848.55	470.00	77.76	0.00	547.75	78.30	300.26	64.55
9	Chatra	Pathalgoda	Non-Command	805.82	386.50	41.61	0.00	428.11	41.90	377.42	53.13
10	Chatra	Pratappur	Non-Command	1820.82	447.50	158.64	0.00	606.14	159.74	1213.58	33.29
11	Chatra	Simaria	Non-Command	2830.51	903.00	142.34	0.00	1045.35	143.33	1784.17	36.93
12	Chatra	Tandwa	Non-Command	5753.34	432.50	181.66	709.17	1323.35	182.92	4428.73	23.00