केन्द्रीय भूमि जल बोर्ड

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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

Deoghar District
Jharkhand

मध्य पूर्वी क्षेत्र, पटना

Mid Eastern Region, Patna

भारत सरकार
Government of India
जल शक्ति मंत्रालय
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जलसंसाधन, नदी विकास और गंगा संरक्षण विभाग
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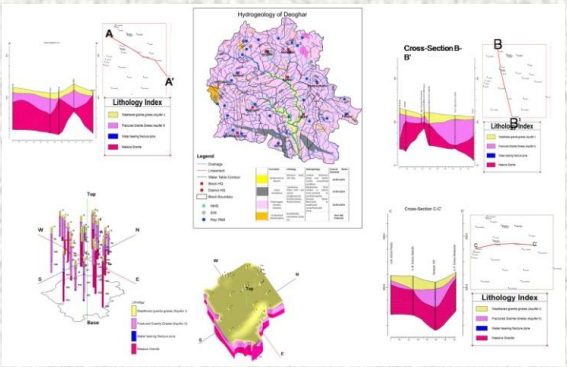
Central Ground Water Board

Aquifer Maps and Ground Water Management Plan of Deoghar district, Jharkhand
जलभृत नक्शे तथा भूजल प्रबंधन योजना
देवघर जिला, झारखण्ड



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July 2022

REPORT ON AQUIFER MAPPING AND GROUND WATER MANAGEMENT PLAN OF DEOGHAR DISTRICT, JHARKHAND 2019– 20

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REPORT ON AQUIFER MAPS AND MANAGEMENT PLAN OF DEOGHAR DISTRICT, JHARKHAND STATE (2019 - 20)

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AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN OF DEOGHAR 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. 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 National Aquifer Mapping Programme(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. The Aquifer Mapping programme has been continued till 2023 to cover whole country. The present studies of Deoghar district have been taken up in AAP 2019-20 as a part of NAQUIM Programme. The aquifer maps and management plans will be shared with the administration of Deoghar district and other user agencies for its effective implementation.

1.1Objective 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). Aquifer wise assessment of ground water resources
e). Preparation of aquifer maps and

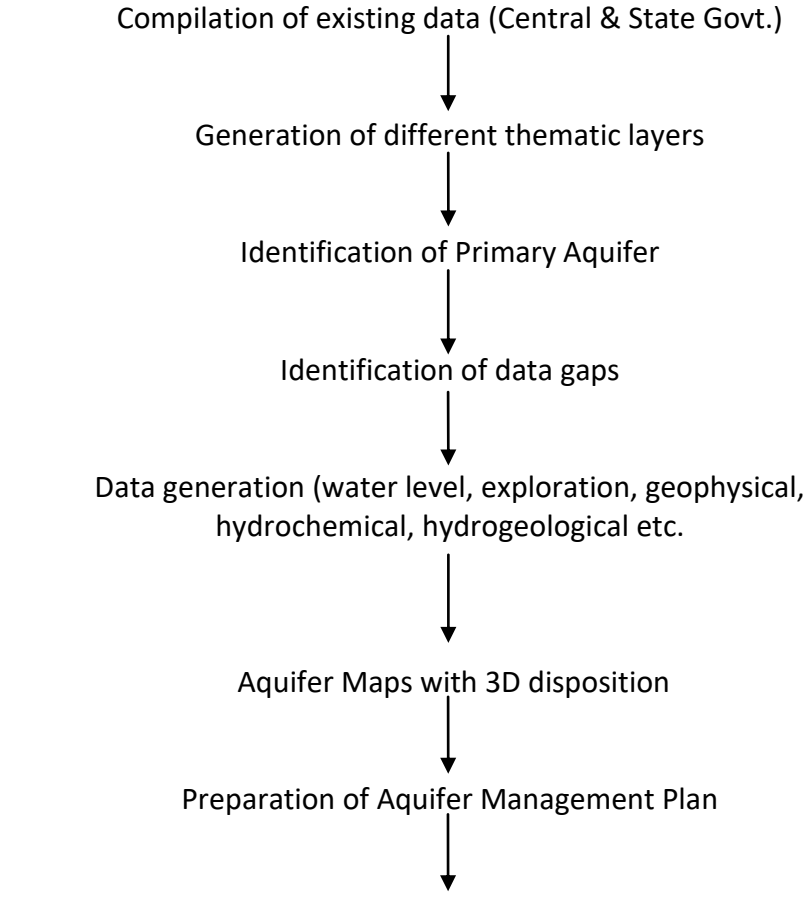
f). Formulate ground water management plan.

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 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: The district Deogharwas taken for aquifer mapping study during 2019-20. The district is spread over 2551 Sq. km of geographical area. Deoghar district is situated in the north–eastern part of the Jharkhand state. It is bounded in the north by Bhagalpurand Munger districts of Bihar state, in the south by Jamtaradistrict, in the east by Dumka district and in the west by Giridih district. The district is situated between 24^0 02' 36"and 24^0 37' 20" North latitude and $86^0$27' 48" and 87^0 4' 14" East longitude.The district covers Survey of India toposheets nos. 72 L/7, 72 L/8, 72 L/10, 72 L/11, 72 L/12, 72 L/14, 72 L/15, 72

L/15,72P/3 and 72 P/4. The district has two sub-divisions i.e.Deoghar and Madhupur and ten blocks namely – Deoghar, Devipur, Karon, Madhupur, Margounda, Mohanpur, Palojori, Sarath, Sarwan and Sonaraitharhi. Total population of the district is 1492073 (as per census of 2011) with rural population 1233712 and urban population 258361. The location map of the study area is shown in figure – 1.

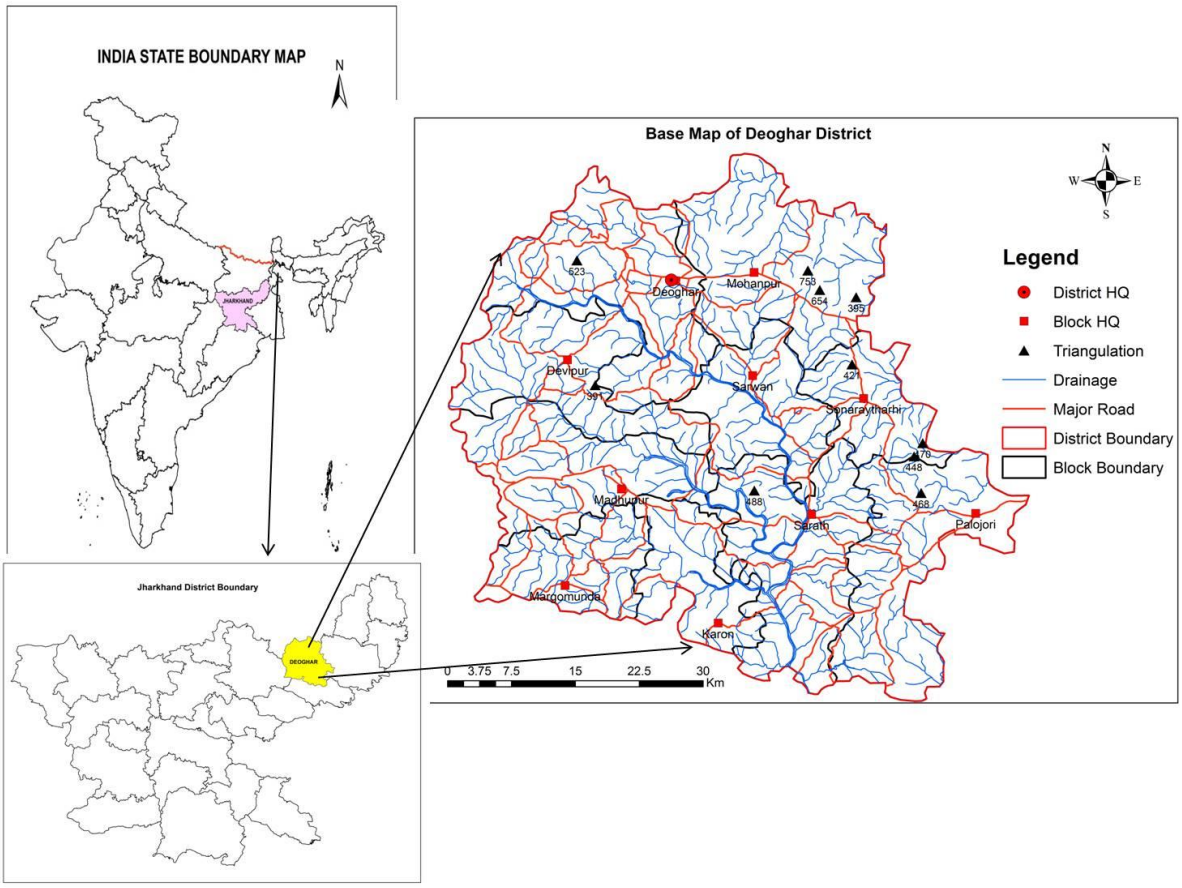


Figure 1: Location map of Deoghar district

Table-1: Block wise Area of Deoghar District, Jharkhand

Sr. No.	Block	Area in (Hectare)
1	Deoghar	44949
2	Dvipur	26315
3	Karon	15015
4	Madhupur	24604
5	Margo Munda	16217
6	Mohanpur	35395
7	Palojori	30298
8	Sarath	31788
9	Sarwan	17040
10	Sonaraitharhi	13484
Total		255105

1.4Data Availability, Data adequacy and Data Gap analysis

***1.4.1Data Availability*:**Central Ground Water Board has carried out exploratory drilling in the district and drilled 21 exploratory and 11 observation wells in hard rock formation by departmental rig during the year 1992-2000. 11 exploratory wells and 09 observation wells were drilled in the district in different places during the year AAP2019 to 2021. In addition 10 exploratory and 2 Observation wells drilled through outsourcing (WAPCOS). In additionseven numbers of permanent observation well (HNS) of Central Ground Water Board located in the district are being monitored for ground water regime and to assess the chemical quality of ground water.

***1.4.2 Data Adequacy and Data Gap Analysis*:**The available data of the Exploratory wells drilled by Central Ground Water Board, Mid–Eastern Region, Patna, 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 has been compiled. The summarised details of required, existing and data gap of exploratory wells, ground water monitoring and ground water quality stations are 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**	**Req.**	**Exis.**	**Gap**	**Req.**	**Exist.**	**Gap**	**Req.**	**Exis.**	**Gap**
30	42	0	91	10	85	38	38	0	38	38	0

The data adequacy as discussed above indicates that the existing data is sufficient for preparation of aquifer maps; hence data gap has been identified for Exploratory Wells,Geophysical Survey (VES), Ground Water Monitoring Wells and Ground Water Quality. Based on the data gap identification, the data generation activity was planned and completed in 2019-20.In addition 10 no of EW and 2 no of OW has been drilled through outsourcing through WAPCOS.

1.5 Climate and Rainfall: The district is characterized by humid to sub-humid climate. During summer the hot spell prevails from March to middle of June, when the maximum temperature reaches upto 44.4^0c. Rainy season starts from middle of June to middle & end of October. Winter starts from the middle of November and continues till the end of February. December is the coldest month, when the minimum temperatures fall down to 6.8^0c.

The area receives rainfall by South-West monsoon.The blockwise average monsoon rainfall (2010 to 2019) of the district varies from 829.49 to 1040.79 mm.(rainfall data of Margomunda and Sonaraitharhi is available only 7years). The rainfall data for the period of 2010 – 2019 has been analyzed for average annual monsoon rainfall, standard deviation and coefficient of variation which are given in table – 3.

Table – 3: Analytical data of monsoon rainfall (2010 – 2019) of Deoghar district

Sr. No.	Block	Average monsoon rainfall	Standard deviation	Coefficient of variation (%)
1	Deoghar	1040.79	189.13	18.17
2	Devipur	955.60	230.25	24.10
3	Karaon	829.49	263.74	31.80
4	Madhupur	987.04	218.30	22.12
5	Margomunda	942.74	287.03	30.45
6	Mohanpur	927.58	264.14	28.48
7	Palajori	887.72	317.79	35.80
8	Sarath	921.48	210.62	22.86
9	Sarwan	929.65	296.49	31.89
10	Sonaraithadhi	990.60	283.50	28.62

1.6 Physiography: The district has a heterogeneous assemblages of rock formations, Chotanagpur granite gneiss, Gondwana and alluvium are the main lithological formation of the area. In general physiography of the area shows:-

a) Mountaneous tracts of the chotanagpur granitic gneisses with isolated flat topped hills, steeper escapments and inter-montane valleys.

b) Plateau consisting of weathered granite gneiss and Gondwanas.

c) Alluvium as low tracts found in the immediate vicinity of major rivers as basin fill deposits.

In general the area shows a general slope from north to south. The major hills are confined to the eastern part with elevation 753m to 448m and western part 523m to 391m elevationin the district.The land surface is rugged and uneven ranging from flat lands to almost steep slopes. The Digital elevation model of Deoghar district has been presented in Figure-2

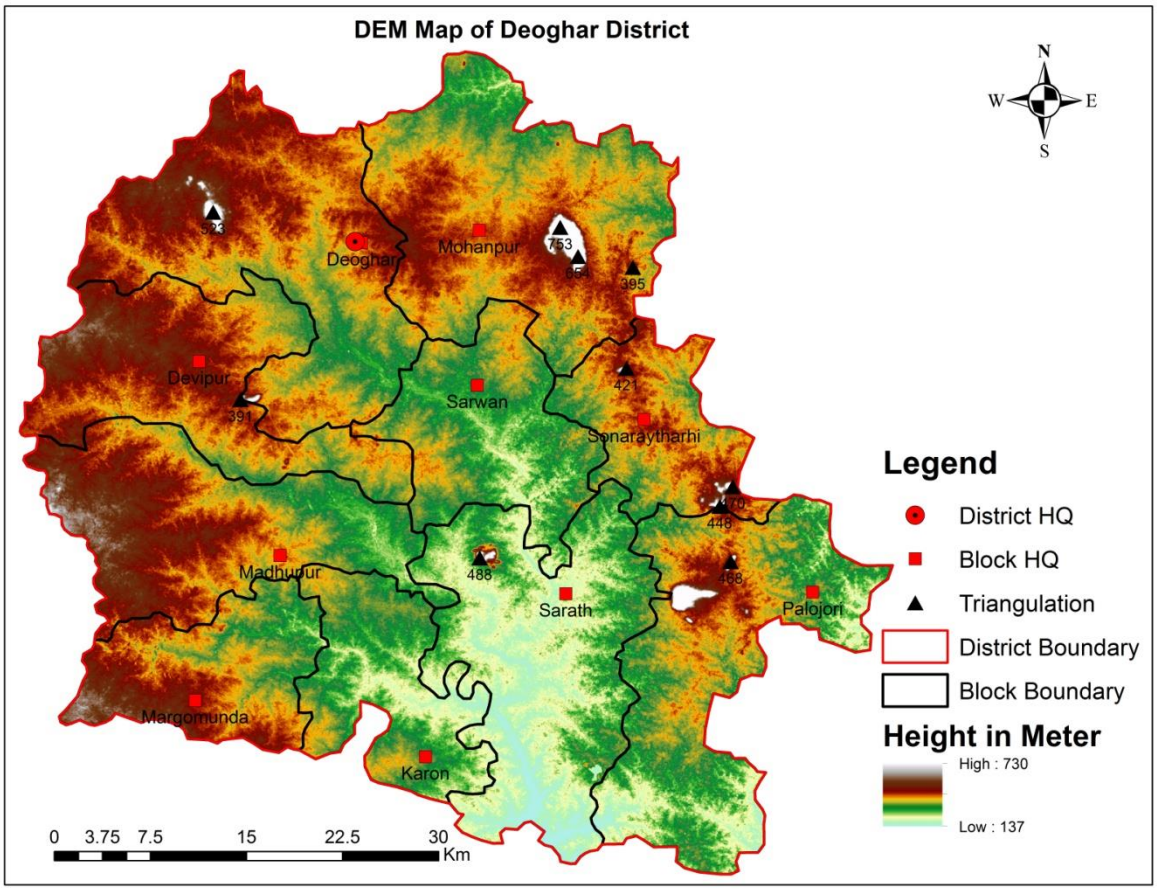


Figure – 2: Digital elevation model of Deoghar district

1.7 Geomorphology:

Based on visual interpretation of Landsat imageries, the various hydrogeomorphic features in the district are:-

i) **Pediment (Gneissic):-**Thes are highly fractured region with gneiss and schist as the underlying rocks.

ii) **Denudational hills (Gneissic):-**These are low hill groups with high rugged topography with gneiss as underlying lithology.

iii) **Low dissected hills (Gneissic):-** The hills of low height mainly composed of gneissic rocks.

iv) **Structural Ridge (Gneissic):-** These are long narrow ridges of low height with gneiss as the dominant rock types.

The geomorphological map of Deoghar district have been presented in Fig-3

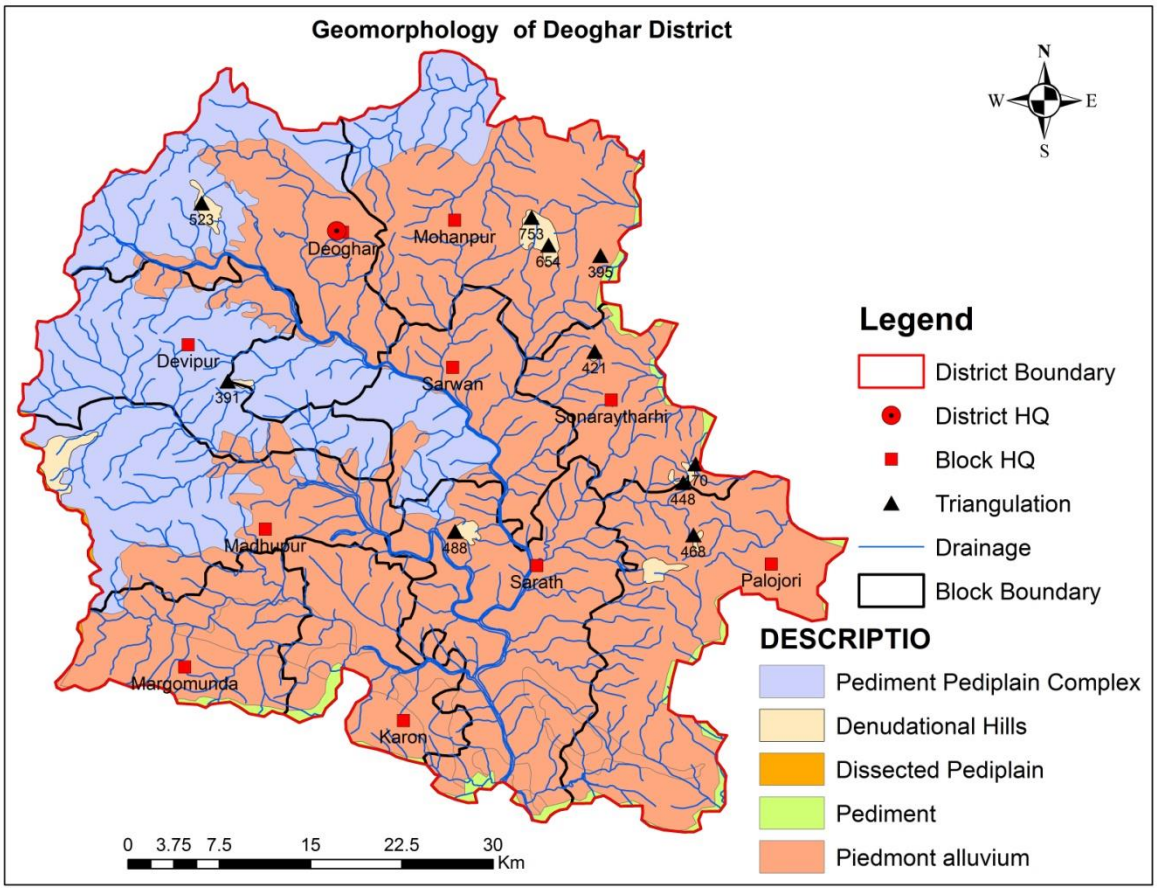


Figure – 3: Geomophology of Deoghar district

1.8 Land Use: Geographical features play a major role in information of land use pattern. Out of total geographical area of the district i.e2551 Sq. km, nearly 25% area comes under net sown area, 7% under forests and the rest area falls under barren, cultivable waste, pasture and other agricultural use. The land use pattern data of the area for the year 2013 –14is given below in table-4. The Land use map of the Deoghar district has been prepared and shown in figure – 4.

Table: 4: Land use pattern of Deoghar district (2013– 2014)(Source: District Statistical Hand Book Deoghar, area in hectares)

Block Name	Year	Reporting Area	Forest Area	Area under Non-agricultural use	Barren & unculturable land	Permanent pastures & other grazing land	Land under misc. tree groves	Culturable waste land	Fallow land other than Current fallow	Current fallow	Net area sown
Deoghar	2013-14	34714.58	4509.73	30.39.15	4579.80	1376.16	488.23	3091.41	5606.19	4690.18	7338.57
Devipur	2013-14	23533.56	3603.02	1885.36	332.97	1039.95	1044.46	1309.29	4246.43	5328.66	4743.39
Sarwan	2013-14	31684.70	1638.83	1179.59	388.02	727.98	2677.17	463.64	3807.22	8935.01	11057.50

Block Name	Year	Reporting Area	Forest Area	Area under Non-agricultural use	Barren & unculturable land	Permanent pastures & other grazing land	Land under misc. tree groves	Culturable waste land	Fallow land other than Current fallow	Current fallow	Net area sown
Mohanpur	2013-14	36186.84	1677.41	2986.16	1506.26	2050.57	2338.58	2796.96	3787.81	2441.15	12553.32
Palojori	2013-14	30298.26	1001.70	2589.55	4641.44	1465.07	4.10	4136.40	10701.88	1489.68	4302.51
Sarath	2013-14	31788.14	2181.61	3508.21	1956.77	1198.99	422.12	1374.19	5876.49	7264.10	8005.63
Madhupur	2013-14	27629.93	3610.32	2271.34	3477.57	1076.38	81.84	2665.86	3260.04	6469.37	4747.17
Sonaraithari	2013-14	13645.80	153.73	903.19	146.98	735.59	-	728.05	3224.17	1851.72	5902.34
Karon	2013-14	25844.08	1031.56	1891.67	1915.53	1228.53	-	2979.80	5385.83	5831.68	5579.44
Margomunda	Included with Karon										

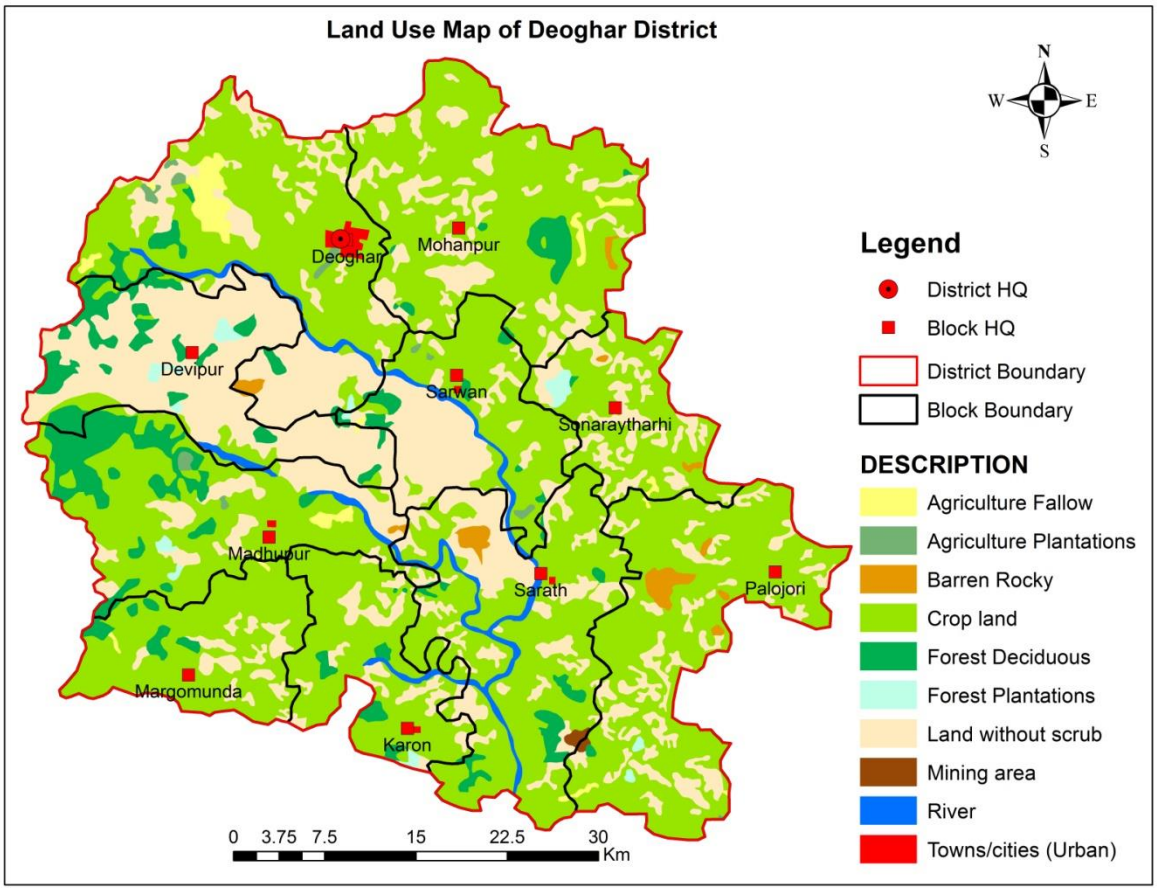


Figure – 4: Land Use Map of Deoghardistrict

1.9 Soils

The soils occurring in different landforms have been characterisedinsoil resource mapping of the state on 1:250,000 scale (Haldar et al. 1996) andthree soil orders namely Entisols, Inceptisols and Alfisols were observed inDeoghar district (Fig.1 and table 5). Alfisols were the dominant soils covering50.0 percent of TGA followed by Inceptisols (42.0 %) and Entisols (6.3 %).

Table 5. Soils of the district and their extent

Map unit	Taxonomy	Area ('00ha)	% of the TGA
16	Fine, mixed, hyperthermic Typic Haplustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	15	0.61
19	Loamy-skeletal, mixed hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	35	1.41
23	Fine, mixed, hyperthermic Typic Paleustalfs Fine, mixed, hyperthermic Typic Rhodustalfs	330	13.31
26	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	182	7.34
27	Fine-loamy, mixed, hyperthermic Typic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Haplustalfs	40	1.62
30	Loamy-skeletal, mixed, Typic Haplustepts Fine-loamy, mixed, hyperthermic Typic Haplustalfs	704	28.40
31	Fine-loamy, mixed, hyperthermic Typic Haplustepts Fine, mixed, hyperthermic Typic Paleustalfs	683	27.55
32	Fine-loamy, mixed, hyperthermic Typic Haplustepts Coarse loamy, mixed, hyperthermic Typic Ustorthents	321	12.95
34	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine-loamy, mixed, hyperthermic Typic Rhodustalfs	124	5.00
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	3	0.12
Miscellaneous		42	1.69
Total		**2479**	**100.00**

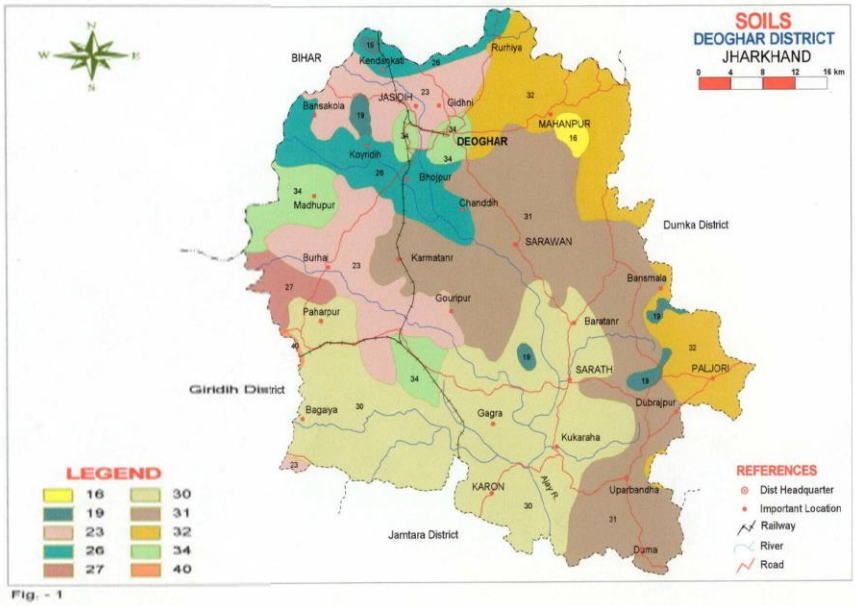


Figure 5 :Soil map (Source) National Bureau of Soil Survey and Land Use Planning (ICAR), Regional Centre, Kolkata And Deptt. Of Soil Science & Agricultural Chemistry, BAU, Ranchi, Jharkhand)

1.10 Hydrology and Drainage:

The principal river of the district is Ajay.The river Ajay and its tributaries control the drainage of the area. River Ajay originates from the hills of the Chotanagpur plateau at an elevation of 523m amsl. Prominent among the tributaries are the Bhagdura, Partho, Dama, and Jayanti. Apart from these tributaries, there are several seasonal streams and nallas which ultimately join the river Ajay and its tributaries. The irrigation and Water Supply projects in the district include Ajay Barrage project, Punasi Reservoir Scheme, Dhakwa Reservoir Scheme, Darua Reservoir and Burhai Reservoir Scheme

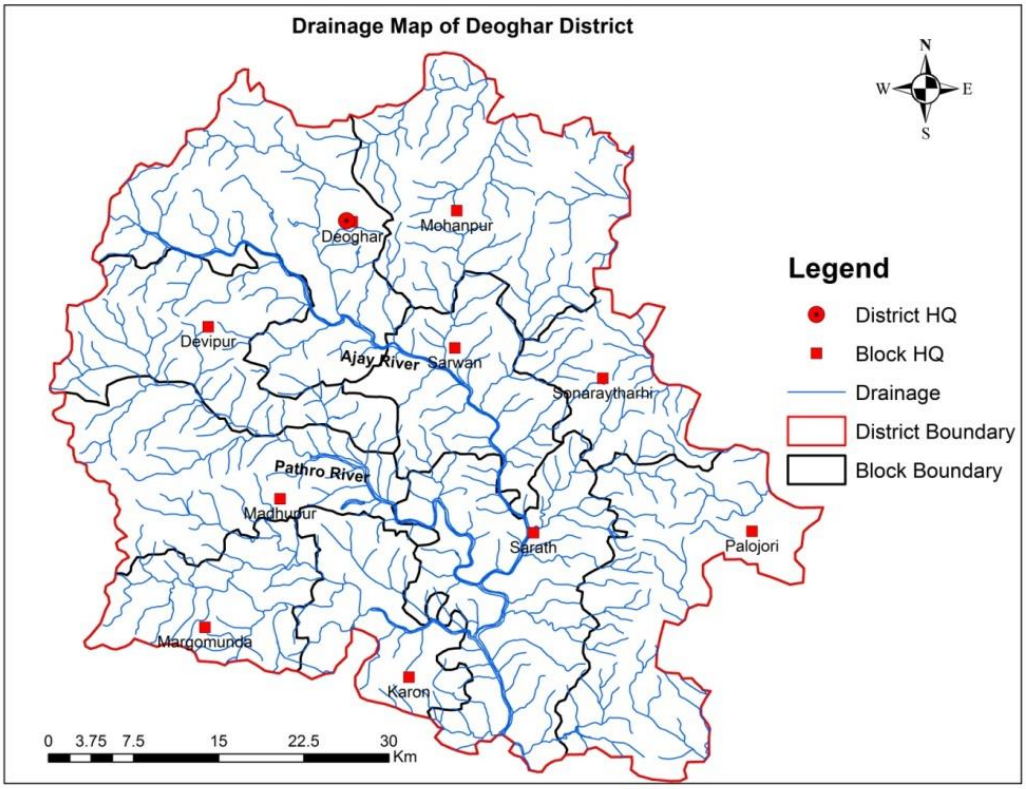


Figure – 6: Drainage Map of Deoghar district

1.11 Agriculture and Irrigation Practices

The local population of the district mostly depends on agriculture and forestry for their sustenance. The agriculture activity of the area is solely dependent upon the monsoon rainfall. Paddy is the main crop of the district. Wheat, Maize, Gram, Mustard oil Potato are other crops grown widely in Deogharand its adjoining areas. Irrigational facilities are not adequate in this district. The most common source is the dug well, but this is not a very dependable source of irrigation. The undulating nature of land makes it possible to store rain water by bunding. Apart from being dependent upon rains, these are by no means adequate. The result is that failure of rains invariably involves failure of crops except in small pockets. Minor irrigation structures like surface water, tanks and ponds are the other source for irrigation. Available source wise irrigation for the 2013-14 is given in table - 6.

Table 6: Details of source wise irrigationof district (2013-14)

Block	Surface water			Ground water			Other sources
	Canal	Tank	LI	DTW	STW	DW	
Deoghar	0	149	0	0	25	1109	0
Devipur	0	88	0	0	1	1052	7
Karon	0	28	0	0	17	1110	2
Madhupur	0	122	0	1	16	1134	18
Margomunda	0	33	0	1	0	690	882
Mohanpur	0	161	0	0	8	1435	0
Palojori	0	120	0	0	1	1751	7
Sarath	0	130	0	0	0	1551	0
Sarwan	0	53	0	4	19	1435	27
Sonaraithadhi		36	0	0	0	1308	0
Total	**0**	**920**	**0**	**6**	**87**	**12575**	**943**

1.12 Cropping Pattern:

The major crops cultivated in the area are **paddy, wheat, maize, gram, pulses and vegetable.** But the land available for cultivation is very limited because of the hilly and rugged topography. Area under different crops for the year 2015 – 16 of the district is presented in table –7.

Table – 7: Cropping pattern of Deoghar district (2015-16)

Name of Block	Maize	Gram	Mustard	Potato	Aus	Aman	Wheat
DEOGHAR	0	26	28	93	73.85	171.5	357.55
KAROWN	85.39	0	0	0	0	6156.25	321.3
MADHUPUR	256	18	44	58	0	0	920
SARWAN	1666	261	412	265	0	5100	688
DEVIPUR	3389.75	157	0	144	0	5250	593.48
MOHANPUR	0	193	333	2416	0	20122.45	2510.85
MARGOMUNDA	0	0	0	0	0	0	0
PALOJORI	1696	0	0	0	0	5250	593.48
SARATH	1696	0	0	0	0	5700	0
SONARAITHARI	157.64	53	132	460	0	10077.35	1067.3

(Area in Acre)

1.13 Geological set up

The Deoghar district consists mainly of Chotanagpur Gneissic Complex of Archean age. At some places the granite is migmatitic. Unclassified metamorphics of Archaean to Lower Proterozoic age comprise pyroxene granulite and Amphibolite. Quartzites are also present at places. Hornblende schist, metadolerite and metagabbros are present as smaller out crops. Khondalite of Archaean age is found in places. Dolerite dykes of Jurassic to

Cretaceous age are present within the Chotanagpur Granite Gnessic Complex. Intrussive granites of much younger age are present in the area.

The Precambrian formation are overlain by Gondwana formations, Alluvium. Shale, sandstone and conglomerate of Talchir Formation of Gondwana Supergroup are present mostly in the sourthern part of the district. Siltstone, sandstone, shale of Barakar Formation are found in association with coal seams. These Gondwana group of rocks are Carboniferous to Permian in age. Isolated patches of coal measures are found near Jainti and Saharjuri. Coal seams are thick and contain non-coking, low ash coal. The district possesses good quality of dimention stones in the form of black granite and multi coloured granite. The general geological succssession is given below(as per GSI, 2001)

Lithology	**Geological Unit**	**Age**
Sand, Silt, Clay	Allvium	Quaternary
Silt Stone, Sandstone, Shale with coal seams, Conglomerate	Barakar Formation & Talchir Formations(Gondwana Super Group)	Carbonnifereous to Permian
Granite-Gneiss, Biotite-Gneiss	Chotanagpure Gneissic Complex	Archean to Proterozoic
Quarzite, Amphibolite, Hornblend Schist etc	Unclassified Metamorphics	Archean to Lower Proterozoic
Khondalite	Eastern Ghat Super Group	Archean

The older group of granitic gneiss, Khondalitic schists represents parametamorphics, subjected to granitisation. The metabasic represented by metadolerite, Meta gabbro and metanorites represents syntectonicintrussives while pegmatites and vein quartz represents late and post tectonic intrusion. The Parametamorphics and syntectonicintrussives have been highly deformed and complexly folded.

The Gondwana have been developed in tectonic basin fill deposits and are resting on archaean basements. The Gondwana mainly consist of sandstone, shale and coal seams and maily observed in Karon and Madhupur block of this district. Coal seams are not prominent as in chitra coalfield and in general are of non-coking coal and relatively low as variety.

Alluvium occurs as lenses along the river channels and adjoining areas and are mainly composed of coarse to fine sand and clay. The Geological Map presented in fig.

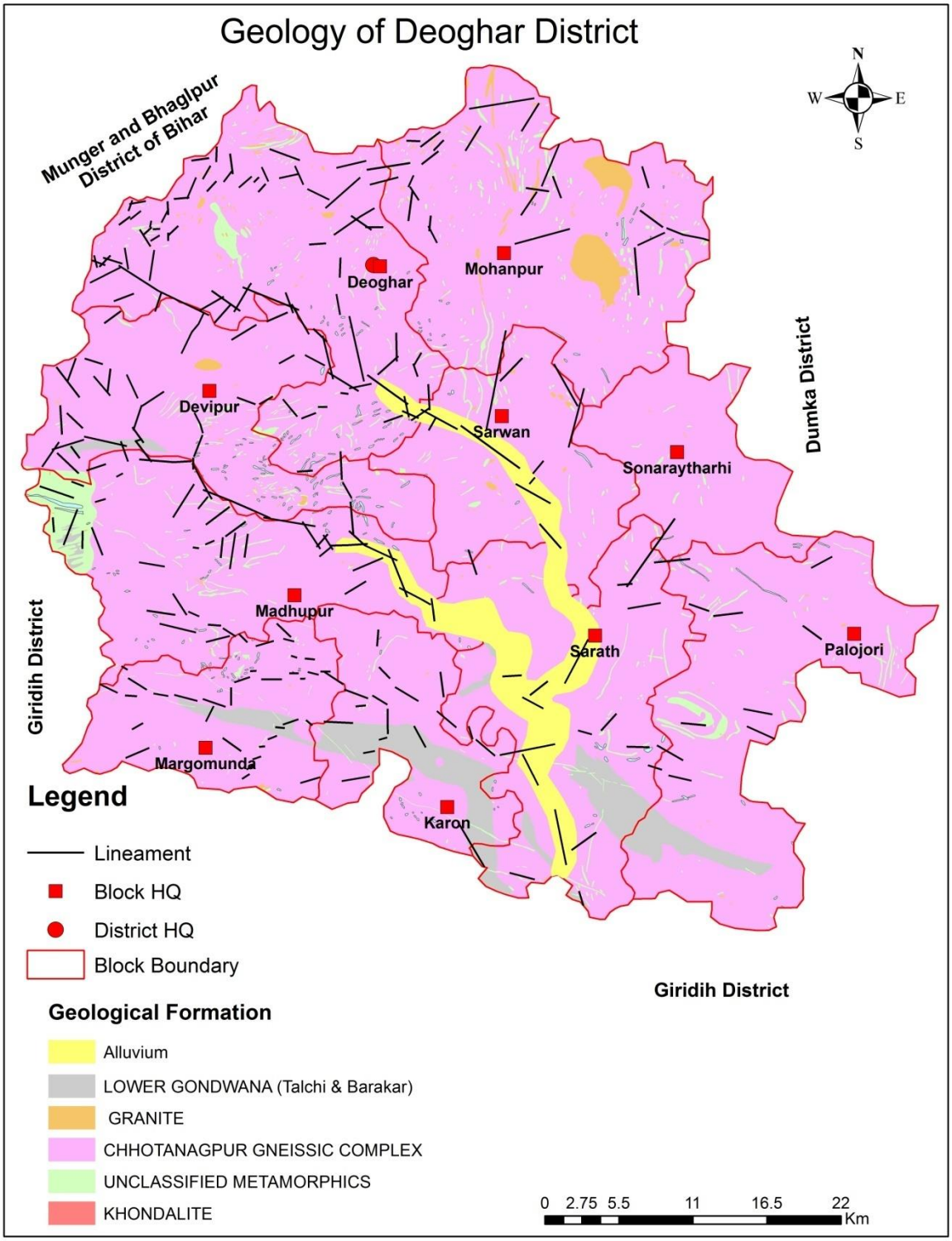


Figure – 7: Geological map of Deoghar district (source GSI)

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.

2.1 Hydrogeology

The occurrence and movement of ground water in the area is variable, which depends on geomorphology, structure, geological setting, hydraulic properties, tectonic setup etc. The hydrogeological condition of Deoghar is complex due to diverse geological trerrain vide variability of topography, drainage etc. Based on morphogenetic and geological diversities and relative ground water potentialities in the aquifer belonging to different geological formation, the study area can be broadly sub-divided into three hydrogeological unit.

1. Consolidated formation
2. Semi-consolidated formation
3. Uncosolidated formation

The consolidated formation is commonly reffered as hard rocks, the grains of which are firmly held together by cementation, compaction and recrystalization. They do not possess primary porosity. The availability of ground water depends on secondary porosity developed due to weathering and fracturing of these rocks. The chotanagpur gneiss complex, metasedimentaries and other associated rocks of Precambrian age, belongs to consolidated hydrogeological unit. The consolidated formation often termed as fissured formation.

The unconsolidated formation which forms porous formation is represented by quaternary alluvium. The Gondwana formations represent the semi-consolidated formation. Hydrogeological map of Deoghar district has been prepared (Fig-8)

2.1.1 Ground Water in Fissured Rock Formation

The chotanagpur gneissic complex, metasedimentaries and other associated rocks of Precambrian age, belongs to this fissured rock formation group. Ground water in precambrians rocks of the study area is dependent on thickness of weathered residuum, openness and interconnections of fractures. These rocks have been highly deformed and metamorphosed on regional scale. These have developed secondary porosity by fracturing and weathering which forms the conduits for occurrence and movement of ground water.

2.1.1.1 Ground water in Aquifer-I (Weathered Granite Gneisses):-

The Aquifer-I is represented by weathered Granite- Gneisses. Within the depth zone of dug wells, the weathered zone influences to a greater extent in the hard rock formation constituting potential phreatic shallow aquifer. Almost all the rock types in the Precambrian

formations show the effect of weathering however, degree and intensity varies depending on the structure, chemical and mineralogical composition of the rocks etc. The plateau and pediplain region is occupied by moderately thick weathered residium developed due to mechanical disintegration and chemical decomposition of impervious crystalline rocks. The thickness of weathered zone varies from 9.00-30.00 meter and average 18.92 meters Geophysical spot resistivity survey in Precambrian terrain reveals that the thickness of the wethered zone varies from 2.00-28.00m .

2.1.1.2 Ground Water in Aquifer – II (Fractured Granite Gneisses):

The Chotanagpur granite-gneiss, belonging to Precabmrian age, constitutes the group of Fissured formation hydrogeological units as an Aquifer-II i.e Deeper Aquifer in the area. The aquifers in these rocks lack the primary porosity and occurrence and movement of ground water is to a large extent controlled by the extent and development of secondary porosity like joints, fissure planes etc.These rocks are the part of Chotanagpur Craton of Indian Shield. They contain hard rocks of different age, grade of metamorphism and structure. Many orogenic movements have affected the shields. Some rock types are extensively fractured; while others are almost undisturbed, even though they belong to the same tectonic environment.

The extensive field investigations of deep exploratory wells drilled (up to 200m) by CGWB, Potential fractures have been identified in Precambrian formations. The fractures in granite gneiss at shallow depth are more productive compared to the fractures in amphibolites/ schists. Thus the type of rocks, grade of metamorphism and brittleness are the main geological controls which govern the occurrence and movement of ground water.

The deeper aquifers i. e Aquifer-II in Precambrian rock formation commonly occur within the depth up to 125m with few exceptions where they occur at more than 125m depth (137m, 154m, 164m, 165m and 177m, depth in the case of borewells at Pathrol, Madhupur,Sarath, Sikdardih and Baltharwa respectively). The yield of the theseaquifers i.e Aquifer-II are quite appreciable i.e. upto 151M^3/hr. e.g. BazarSamitiDeoghar.

Potential Fractures:-Fracture in consolidated formation are caused by changes in stress conditions that have taken place during various episodes in the geological history, such as folding, faulting, cooling of rocks etc.The openness and interconnections of fractures are very much decisive in storage of ground water in these formation.Number of boreholes has been constructed by CGWB in the district under groundwater exploration programmeand National Aquifer Mapping Programmeupto maximum depth of 200 m (Table-7). The structural geomorphology and morphotectonic analysis of crystalline formation of the study area reveal that the rocks have undergone several periods of tectonic deformation. These tectonic deformations have given rise to the development of deep seated tensile and shear fractures. The borehole data reveals that, in general potential fractures are encountered between 25-125 m in Precambrian Granite-Gneiss formation. Base on the results of field studies, exploratory drilling and analysis of available data, the potential fractures have been delineated. Table-8 shows the Potential Fracture encountered during Ground Water Exploration inDeoghar district.

Table-8 Potential Fractures Encountered during ground water Exploration in Deoghar district, Jharkhand

Sl. No.	Location	Block	Depth Drilled (mbgl)	Length of Casing pipe (in m)	Fracture Zone(in m)	Static Water level (m bgl)	Discharge (m3/hr.) Pumping /AirCompressor	Formation
1	Shivganga	Deoghar	153	17.29	017.00-018.00	5.85	12	Granite Gneiss
2	Chandih	Deoghar	102	-	101.00-102.00	4.78	70.44	Granite Gneiss
3	Sarath	Sarath	167	-	017.00-018.00 032.00-034.00 062.00-065.00 164.00-167.58	4.23	18	Granite Gneiss
4	Bazar samiti	Deoghar	56	10.6	051.00-052.00 052.00-056.00	6.63	151	Granite Gneiss
5	Chopa more	Mohanpur	180	12.4	69.00-72.00 72.00-79.00 079.00-082.00 086.00-090.00	6.3	58(Air comp	Granite Gneiss
6	Chopa more	Mohanpur	154	18.15	045.00-046.00 090.00-092.00 099.00-100.00 105.00-108.00 117.00-118.00	3.65	17(Air comp)	Granite Gneiss
7	Upgraded +2 School Tilakpur	Sonaraith arhi	92.84	12.1	74.00-75.00	8	37.8 (air comp.)	Granite Gneiss
8	Upgraded +2 High school, Pathrol	Karon	153.8	18	23.00-24.00 98.00-99.00 137.00-37.50	18	25.56 (air comp.)	Granite Gneiss
9	Upgraded Primary school, Sabritandi	Madhupur	100.46	18	27.00-28.00 58.36-59.00 81.00-81.50 97.00-97.50	12	44.28 (air comp.)	Granite Gneiss
10	Primary School, Mathurapur	Deoghar	76.6	18	23.00-23.50 46.00-47.00	6.15	37.8 (air comp.)	Granite Gneiss
11	Irrigation division SikitiaNawada	Madhupur	153.8	18	35.50-56.00 94.46-95.00	5.3	12.24 (air comp.)	Granite Gneiss
12	Primary school, Sarpata	Mathupur	100.46	9	66.00-66.50 84.00-84.50	5.5	52.2 (air comp.)	Granite Gneiss
12	Panchayat Bhawan, Jitjori,	Devipur	41.5	18	24.00-25.00 31.00-32.00 38.00-39.00	6.1	68.4 (air comp.)	Granite Gneiss

14	Upgraded Middle School, Maledih	Devipur	153.8	18.1	54.74-55.00	7.5	12.24 (air comp.)	Granite Gneiss
15	Margomunda	Margomunda	179.5	24.7	30.40-31.20, 177.5-178.5	9.12	18	Granite Gneiss

Source: CGWB

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

- In general in fissured formations, discharge of well has been found in the range of 9-151 m^3/hr.
- Overall in the district the major potential fractures zones are found between 25-125 m.
- First potential fracture zone encountered in the district widely varies from 15-125 m depth.
- Some of high yielding well where multiple fractures were encountered within 100 m depth are Upgaraded +2 Highschool Tilakpur(37.8 m^3/hr)BazarsamitiDeoghar (151 m^3/hr)
- At some occasion potential fractures were also encountered beyond 100 m depth (-137.00-137.50 m). The well has yielded copious amount of discharge e.gMahapur(15m^3/hr),Margomunda(9.12m^3/hr), Sikdardih(9 m^3/hr), Baltharwa(4.11m3/hr)

2.1.2 Ground Water in Unconsolidated Formation (Alluvium):-

Groundwater occurs under unconfined condition in the narrow stretches of alluvium along stream courses, how ever ground water potentiality in the alluvium is very limited.

2.1.3 Ground Water in Semi-Consolidated Formation(Gondwana):-The Gondwana mainly consist of sandstone, shale and coal seams and maily observed in Karon and Mathupur block of this district. Ground Water Potentialities in these formations are limited to moderate

The hydrogeological map of area is prepared and presented in figure -8.

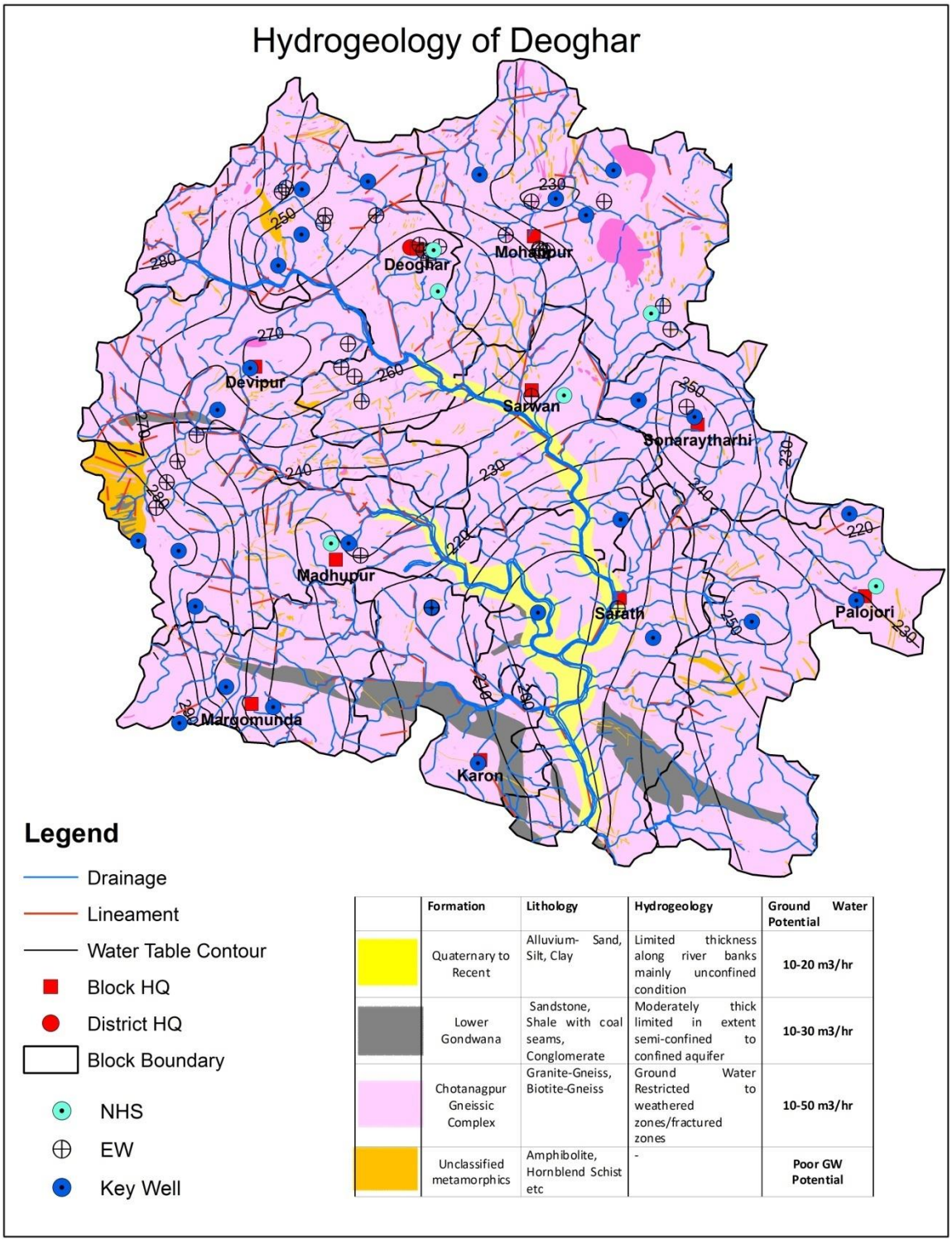


Figure – 8: Hydrogeological Map of Deoghar district

2.1.4 *Water Level Scenario*

2.1.4.1 Ground water Monitoring Wells: 24 key wells were established and 7 NHNS monitored toassess the ground water scenario of shallow aquifer (Aquifer-I) of the area. The depth of these dug well varies from 6.3 to 12.50mbgl. Similarly, the diameters of key wells

(dug wells) ranges from 1.40 to 5.30 m. A detail of key wells and water level data is presented in Annexure – I & II. Location of key wells and exploratory wells are shown in figure –9.

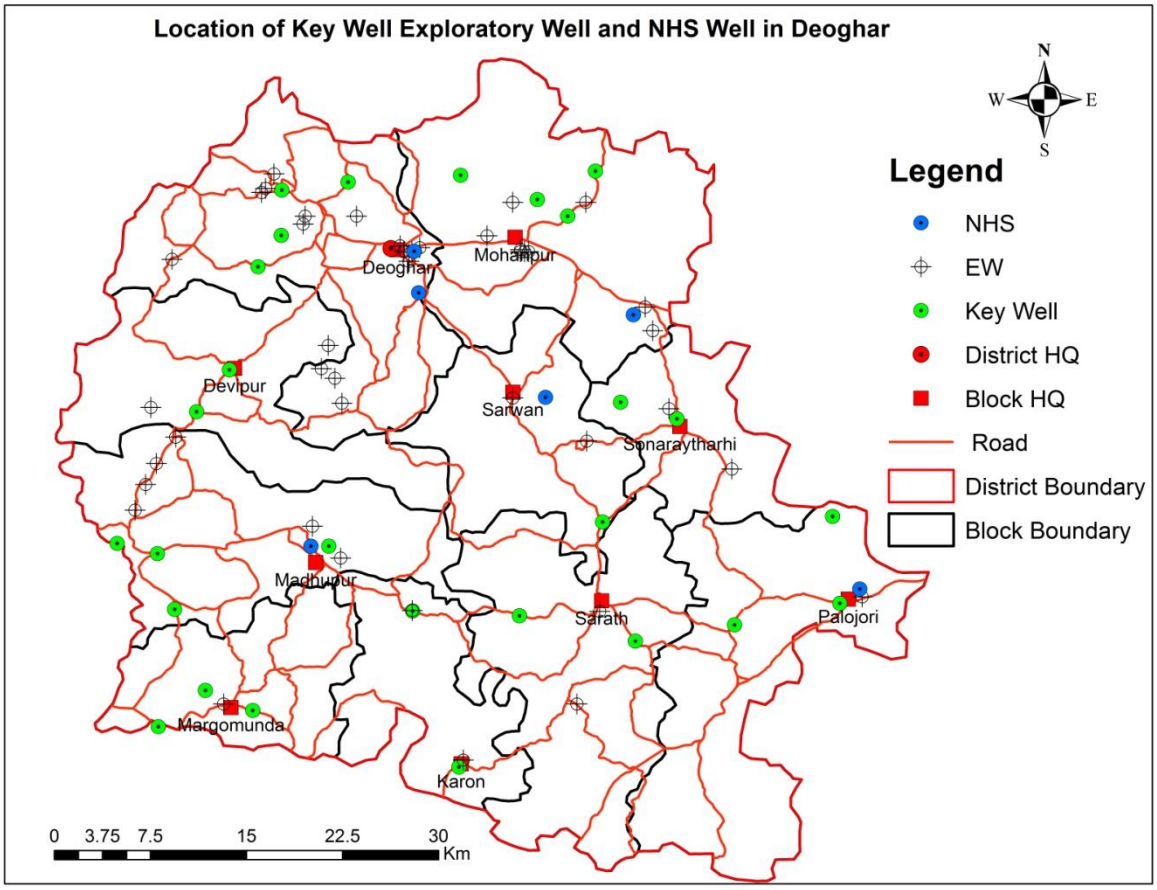


Figure – 9: Location of Key wells NHNS and Exploratory wells

2.1.4.2 Water Level Scenario(Pre-Post monsoon 2019)Aquifer – I (Shallow Aquifer):water level scenario of shallow aquifer was generated by utilizing water level data of 30 monitoring wells representing shallow aquifer. The pre monsoon (May 2019) depth to water level monitored between 2.60 to 9.85 mbgl and average 7.66m bgl. The post monsoon depth to water level (Nov. 2019) in the dug wells ranges from 1.20 to 5.80mbgl and average 3.13 m bgl respectively. Pre and post monsoon depth to water level maps were prepared for the year 2019 and shown in figure – 10, 11.

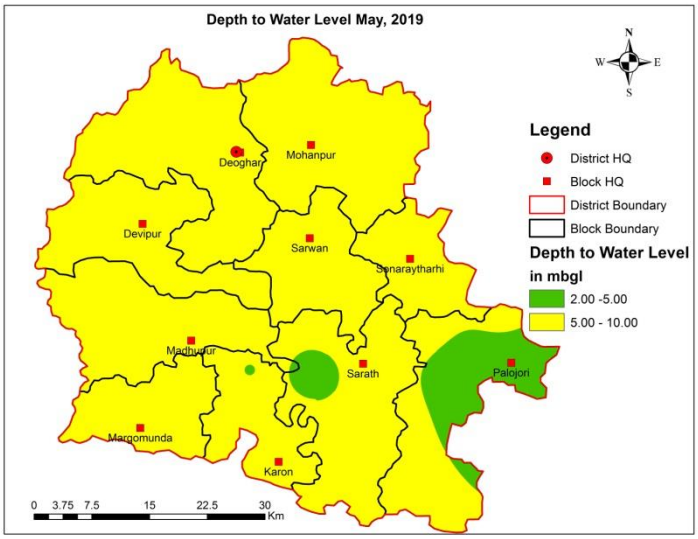


Figure – 10: Pre monsoon (May 2019) depth to water level map of Aquifer – I (shallow aquifer)

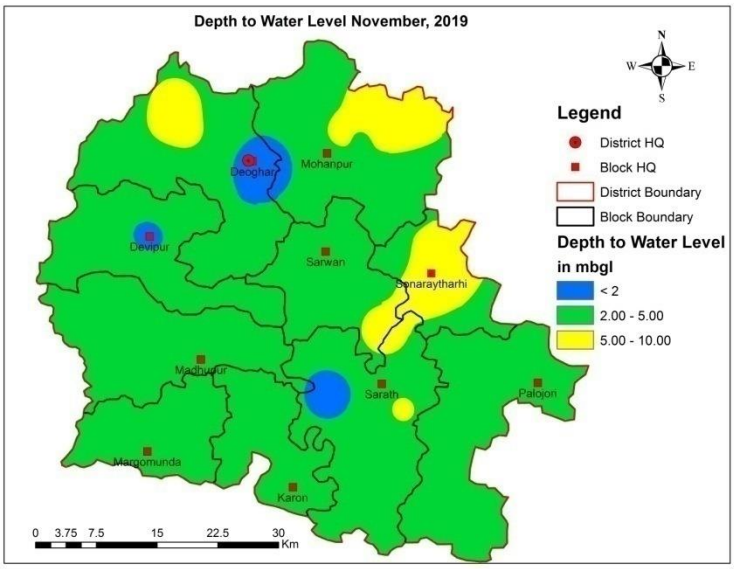


Figure – 11: Post monsoon (Nov. 2019) depth to water level map of Aquifer – I (shallow aquifer)

The water level monitored during pre and post monsoon period 2018 and 2018 was used to compute the seasonal fluctuation.

2.1.4.3 Water level fluctuation:

The seasonal water level fluctuation was observed between 0.25 to 7.60m for the period between pre monsoon and post monsoon 2019.

2.1.4.4 Ten yearsLong Term Water Level Trend (2010-2019):

In order to study long term behavior of the water levels and also the effect of various developmental activities with time, the data for the period 2010-2019 have been computed and analyzedwhich is presented in table - 9. The pre- monsoon decadal water level trend analysed and observed that out of 6 hydrographs stations 2 wells were declining and 4 well was rising. Post-monsoon decadal water level trend observed 4station rising and 2 stations falling. The annual decadal water level of the district was observed rising trend in 3 station and declining trend in 3 wells.

Table – 9: Long term water level trend of Deoghar district (2009 – 2018)

Sl No.	Location	PreMonsoon			PostMonsoon			Annual		
		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	Ghormara	10		0.0762	8		0.0927	38		0.0341
2	Jasidih	10	0.1108		9	0.4131		39	0.2707	
3	Madhupur1	8	0.0031		9	0.0449		34		0.1058
4	Palajori	10	0.3189		9	0.2803		39	0.341	
5	Sarath	10		0.2373	8		0.2499	37		0.1945
6	Sarawan	10	0.4725		9	0.6986		39	0.5912	

2.1.4.5 Hydrograph Analysis:

Analysis of five (05) hydrograph network stations, were carried out using GEMS software (Figure-12-15) and analysed for the period from 2010-2019. It is observed that the long-term water level trends during pre and post-monsoon seasons are declining trend in four stations and one station is rising in shallow aquifer-I represented by dug wells.

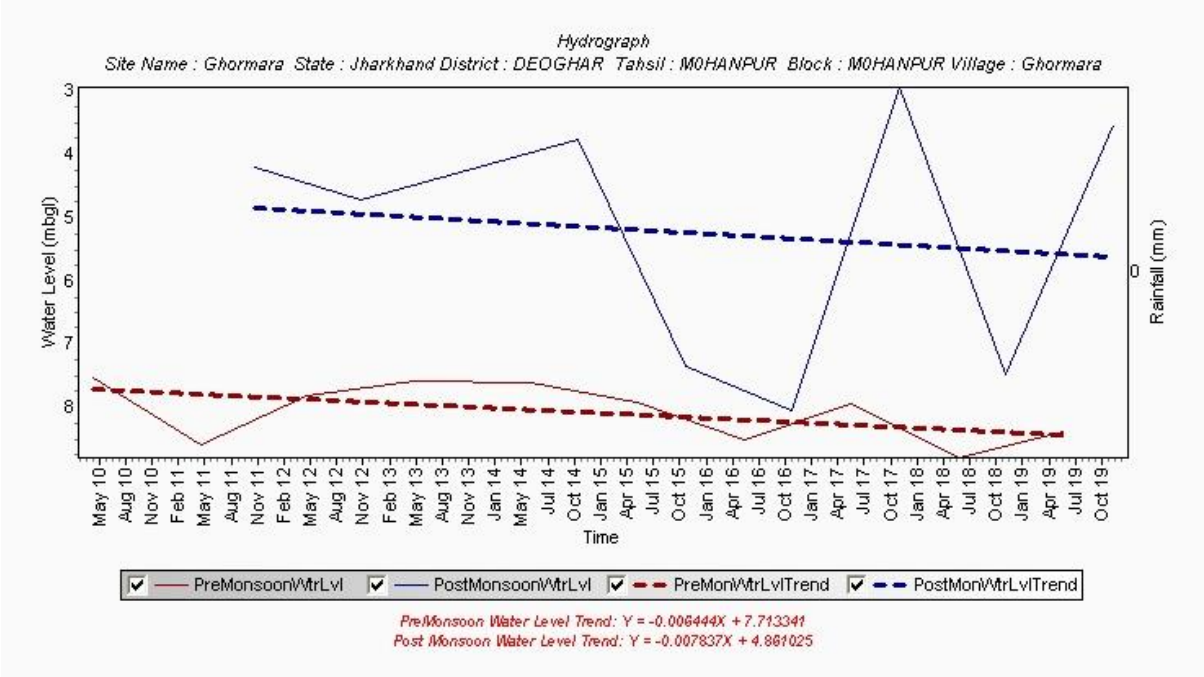


Figure 12: Hydrograph (2010-2019), Ghormara, Mohanpur block, Deoghar district

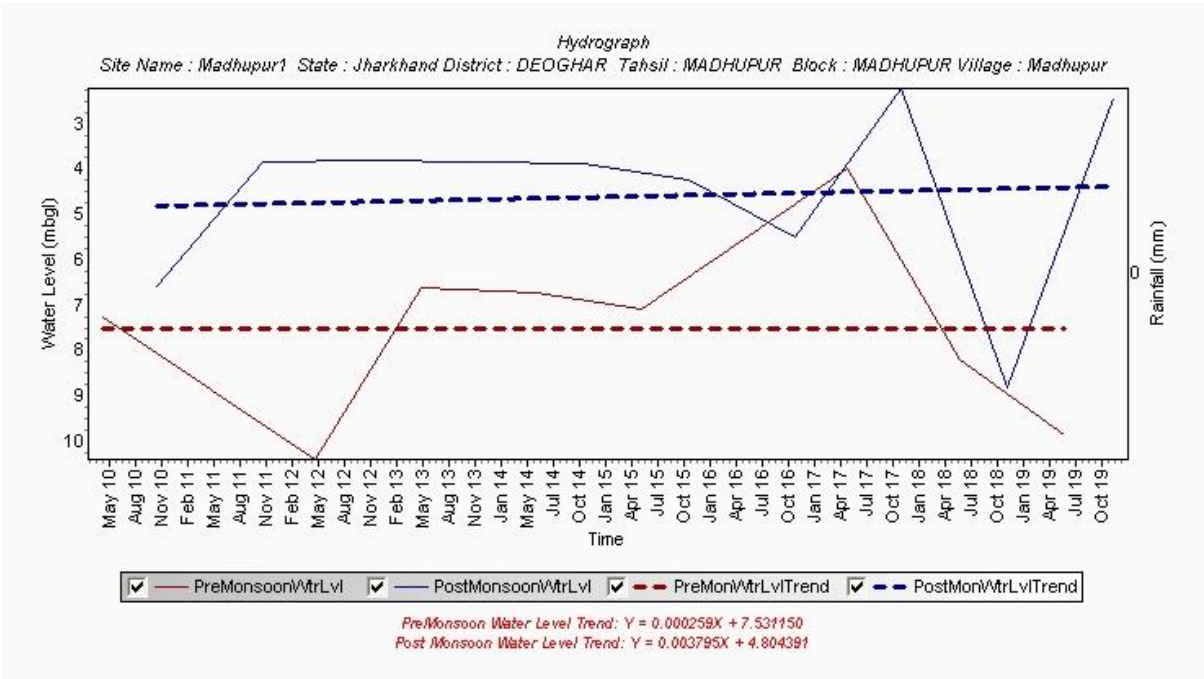


Figure-13: Hydrograph (2010-2019), Madhupur, Madhupur block, Deoghar district

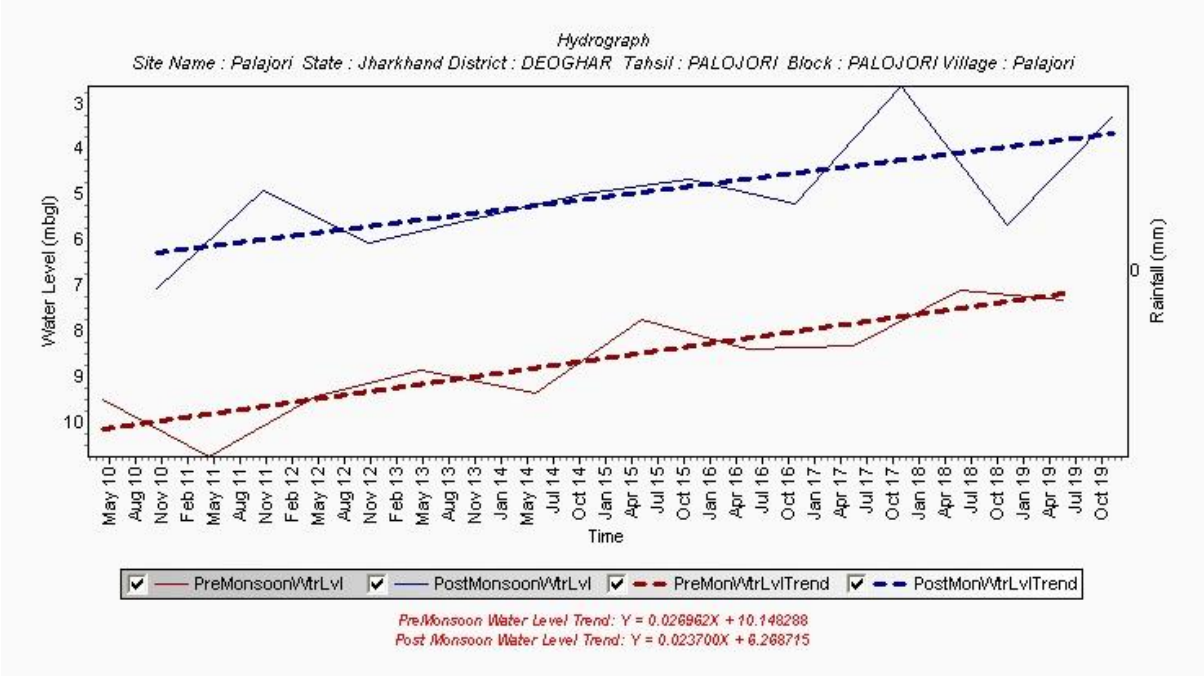


Figure- 14: Hydrograph (2010-2019), Palojori, Palojori block, Deoghar district

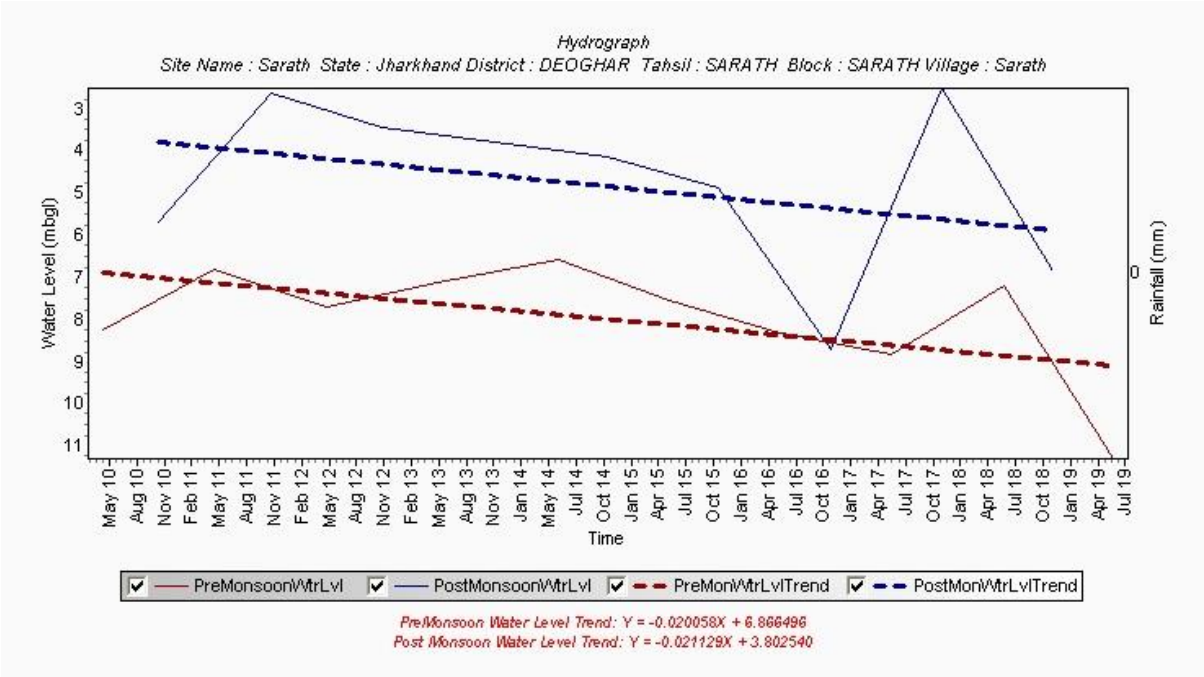


Figure- 15: Hydrograph (2010-2019), Sarath, Sarath block, Deoghar district

2.2 Ground Water Exploration:

The exploratory data particularly includes the information on sub–surface geology, hydrogeological information and geometry of aquifer in Alluvium as well as in hard rocks. Based on exploration data, prepared litholog of EW & OW, in hard rock area depth of fractured/joints encountered within 200m depth formation has been presented in **table - 10.** Drilling details of the exploratory and observation wells are presented in Annexure III.

Table – 10: Summary of success bore wells drilled by CGWB in Deoghar district

Location	Depth drilled (mbgl)	Discharge (m3/hr)	Draw-Down	T (m2/day)	Storativity
Shivganga	153	12		21.9	$2.8x10^{-4}$
Bazar-Samiti	56	151	30	128	$2.20X10^{-4}$
Chopa-more	180	58	3.61	67.7	$1.1X10^{-5}$
Margomunda	179.5	18	4.94	264.59	$2.749x10^{-6}$
Sikdardih	203	9	37.64	4.95	$3.505x10^{-8}$

2.3 Geophysical Survey:

Only 10 nos. of VES have been done through outsourcing to WAPCOS in Deoghar district.Deoghar district is mostly occupied by Precambrian granite gneiss. The Gondwana sediments (Talchir) occurs as an east-west stripe along Pathro River, towards south of Madhupur. A total of 10 VES were carried out in Deoghar district.

Interpreted results of VES are given in Annexure-VIII. The geoelectrical characteristics of the weathered and semi-weathered zones are given in Table 3.0. In Deoghar district, the weathered zone in granite gneiss terrain is, in general, thin and out of 10 VES sites at 6 VES sites it is absent. Wherever it is present, it extends to about 10 to 20 m depth. The range of resistivity for the weathered zone is 26 to 35 ohm.m. Underlying the weathered zone, the semi-weathered zone extends to a maximum depth of about 54m and mostly within 20 m. The resistivity of semi weathered zone ranges from 92 to 232 ohm.m.

2.4 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 30 dug wells .The analytical results of water samples dug wells are given in Annexure-V. 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. Since the samples are collected from the dug wells, they represent the quality of Aquifer I (phreatic/ shallow zone)

2.4.1 General Range Of Chemical Parameters Of Aquifer – I:-

Evaluation of ground water suitability in relation to its different purposes has been classified for drinking / domestic and irrigation. Water is very essential for life. Many a times it has raw consumption or indirectly (in food). Hence, it should be free from turbidity, odor, bacterial and poisonous contents and also chemically soft, low T.D.S value and other chemical constituents should range within low to tolerable limits. Excessive and longer use of water beyond these limits may endanger to many health problems. The variation range of the concentration in ppm of different chemical constituents and quality parameters of Aquifer I (dug wells samples) in table-11.

The distribution of different constituent in ground water can be described as follows:-

Hydrogen ions activity:

It is expressed in terms of pH and shows the acidity & basicity of the solution. Natural water reacts with H^+ &H^- ions and forms H_3O or ions. The recommended limit (6.5 to 8.5) by BIS,2012 is base on taste, corrosion and scale formation criteria. The pH value in Aquifer-I ranges from 6.96 to 8.24 mg/l.

Electrical Conductivity:

Generally, the water's electrical conductivity increases in the dry periods because of evaporation and decreases in the rainy days because of the precipitation and also to the surface runoff flow into reservoir. The EC value in Aquifer-I ranges from 291 to 1725Microsemen at 25^{0c}.

Carbonate & bicarbonate:

Naturally occurring carbondioxide is the foremost source of carbonate and bicarbonate ions in ground water along with the carbon cycle and carbonaceous rocks. Leaching of calcite or dolomite bearing rocks (mainly carbonate) is also a principal source of these ions at places. Carbonate content of the area is not detectable. The bicarbonate concentration ranges between 79.95 to 418.20 mg/l.

Chloride:

The chloride anions in a certain water environment are characterized by a high stability. Thus, the concentration of chlorides shows little change after long flow distance because the dissolution of chloride is greater in water and the reaction between Cl- and other ions in stratum is insignificant. The Chloride concentration ranges between 7.09 to 301.32 mg/l.

Fluoride:

Its low solubility in water makes it different form the rest of halogen family. Fluoride geochemistry is mainly governed by fluoride bearing minerals found in Chotanagpur Gneissic complex.The main sources are fluorite (CaF_2), fluorapatite & other minerals present in rocks contributing the ion in water. The Flouride concentration ranges between 0.21 to 3.88 mg/l. Flouride concentration figure is given in figure -16.

Sulphate

Sources of sulphate are minerals pyrite (FeS_2), anhydrite ($CaSO_4$). Under some conditions considerable quantities of sulphate may be obtained from organic Sulphur compounds. The generalized formulae for sulphate reaction ius;

$$SO_4^{2-} + 2CH_2O \rightarrow 2HCO_3^- + H_2S$$

The Sulphate value ranges between 10.92 to 125.17 mg/l.

Sodium

Sources of sodium are halite, sea spray, brines and some silicates. Common sodic silicates include plagioclase. The only common sink for sodium is reverse ion exchange that occurs when highly saline waters come in contact with calcium rich clays.
The Sodium concentration ranges between9.02 to 147.26 mg/l.

Calcium:
In mineral form, it is found as Calcite, aragonite, gypsum, anhydrite, anorthite, diopside etc. The Calcium concentration ranges between 28 to 112.42 mg/l.

Magnesium:

The most common source of large quantities of magnesium in natural waters is dolomite. Magnesium is also derived from the silicates olivine, pyroxene and amphibole. The main sink is montmomorillonite. The Magnesium concentration ranges between 7.29 to 74.11 mg/l.

Total Hardness:

It is expressed in terms $CaCO_3$ and it is equal to Calcium + Magnesium equivalent per litre. It can be classfied as under:-

Hardness range (mg/l $CaCO_3$) -	Class	
0- 60	-	Soft
61-120	-	Moderately hard
121-180	-	Hard
>180	-	Very Hard

In the study area, the total hardness value ranges from 100 to 515 mg/l.

Table - 11: Ranges of chemical constituents of Aquifer – I

Chemical Constituents and quality parameters	**Aquifer – I (Dug well samples)**
pH	6.96- 8.24
EC (micro siemens/cm at 25^0c)	291 - 1725
TDS (ppm)	189.15 - 1121.25
TH as $CaCo_3$ (ppm)	100 - 515
Ca (ppm)	28 - 112.42
Mg (ppm)	7.29 - 74.11
Na (ppm)	9.02 - 147.26
K (ppm)	0.66 - 12.29
HCO_3 (ppm)	79.95 - 418.20
Cl (ppm)	7.09 - 301.32
SO_4 (ppm)	10.92 - 125.17
NO_3 (ppm)	1.65 - 149
F (ppm)	0.21 -3.88

The ground water of Aquifer – I (shallow aquifers) in the area is alkaline in nature. On the perusal of table - 11, the pH value of the area is 6.96- 8.24. The TDS value is varies between 189.15 to 1121.25 mg/l. Overall values of Calcium and Magnesium varies between 28 to 112.42 mg/l and 7.29 – 74.11mg/l in the area respectively. Nitrate concentration is observed between 1.65 to 149 mg/l while the Fluoride value varies from 0.21 to 3.88 mg/l within the area.

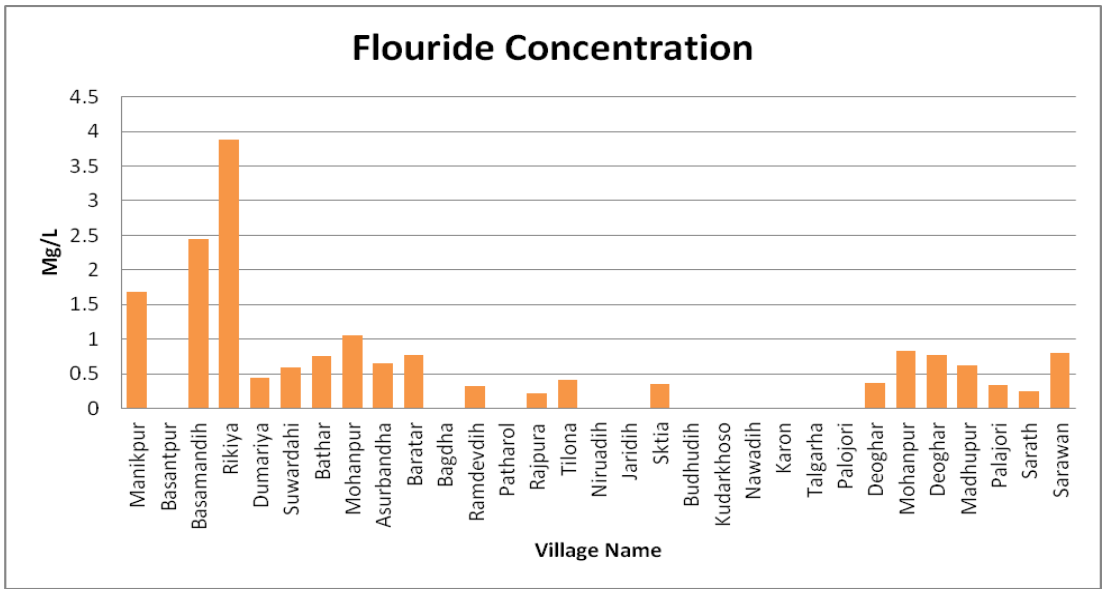


Figure 16. Flouride Concentration in Deoghar district

2.4.2 Suitability of Ground Water of Aquifer – I for Drinking Purposes: - The suitability of ground water for drinking purposes is determine on the basis of drinking water specification adopted by the Bureau of India Standards IS 10500 – 91 Revised 2012 and approved by World Health Organization (WHO). The number of water samples falling under various categories of permissible and desirable limits of various constituents and its percentage are given in table – 12 Aquifer – I.

Table-12: Suitability of ground water of Aquifer- I for drinking purposes

Chemical constituents and quality parameters	Ranges Desirable		No. of samples under desirable limits	No. of samples under permissible limit	No. of samples under excessive limits
	Desirable limit	Permissible limits in the absence of alternate source			
Ph	6.5 to 8.5	No relaxation	31 (100%)	Nil	Nil
TDS (ppm)	500	2000	19 (61%)	12(39%)	Nil
TH as $Caco_3$ (ppm)	200	600	12 (39%)	19(61%)	Nil
Ca (ppm)	75	200	30 (97%)	1 (3%)	Nil
Mg (ppm)	30	100	17 (55%)	14(45%)	Nil
Cl (ppm)	250	1000	30 (97%)	1(3%)	Nil
SO_4 (ppm)	200	400	31 (100%)	Nil	Nil
HCO_3 (ppm)	200	600	14 (45%)	17(55%)	Nil
NO_3 (ppm)	45	No relaxation	24 (77%)	Nil	7(23%)
F (ppm)	1.0	1.5	27(87%)	1(3%)	3 (10%)

The table - 12 indicates that all the water samples are falling in desirable to permissible category except Nitrate and Flouride. The value of Nitrate observed beyond permissible limit (mg/l) in 07 samples. Similarly, the value of in 27 Samples of Flouride were found within permissible limit and 03 samples are found beyond permissible limit.

2.4.3 Suitability of Ground Water of Aquifer – I 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. Various parameters viz. Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Salt Index (SI), Soluble Sodium Percentage (SSP) & Water Class have been evaluated to assess the suitability of ground water for irrigation purposes.

Sodium Percentage classification: -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. 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.

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

Table- 13: Classification of ground water of Aquifer - I based on sodium percent

Sl No.	Water class or category	Sodium percent	No. of samples falling	Percentage of samples
1	Excellent	< 20 %	6	20%
2	Good	20 – 40 %	23	74%
3	Permissible	40 – 60 %	2	6%
4	Doubtful	60 – 80 %		
5	Unsuitable	> 80 %		

(Where all ions are expressed in epm)

On the perusal of table 94% of water samples of aquifer – I (dug wells) falling under excellent to permissible category.

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:

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

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 shown in Table-14 which is showing that all the water samples (100%) of aquifer – I (dug wells) pertain to excellent class. In Deoghar district all all 21 water samples collected during the field falls in the (0-10) C1 category, ground water is excellent for irrigation.

Table: 14 Sodium Adsorption Ratio

Sodium Hazards Class	**SAR (meq/L)**	**Remarks**	**Study area quality**
C1	0-10	Excellent	All (31 sample)
C2	10-20	Good	-
C3	20-26	Doubtful	-
C4	>26	Unsuitable	-

Residual Sodium Carbonate (RSC)

The potential for a sodium hazard and Residual sodium carbonate (RSC) are directly proportional, and much of the calcium and magnesium are precipitated out of solution when water is supplied to the soil. In study area 30 samples are good 1 sample isSafe for semi-tolerant to tolerant cropsfor irrigation.

On The perusal of table-15, about 97 % of water samples of Aquifer – I (dug well) falling under good and 3% permissible water class.

Table: 15 Residual Sodium Carbonate (RSC)

Parameter	**Range**	**Irrigation Suitability**	**Sample**	**Percentage**
Residual Sodium Carbonate **(RSC)**	< 1.25	Safe for all type of crops	30	97
	1.25 – 2.50	Safe for semi-tolerant to tolerant crops	1	3
	>2.50	Safe with application of gypsum of the rate of 8.5g/ham of irrigation water applied for 1.0 ml/liter RSC		

(All the values are expressed in epm.)

Suitability of ground water based on Electrical Conductivity (EC):

To better understanding the suitability of ground water for irrigation purpose chemical result of collected water samples have been analyzed and described the different water class based on Electrical Conductivity (EC) which is presented in table – 16.

Table- 16: - Classification of ground water of Aquifer – I based on EC

Sl. No.	Water Class	Rages of EC	No. of samples falling and their percentage
			Aquifer – I
1	Excellent	< 250	Nil
2	Good	250 – 750	18 (58%)
3	Permissible	750 – 2250	13 (42%)
4	Unisuitable	>2250	Nil

2.4.3.1 Piper Diagrame for Classification of Irrigation Water:-

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 (HCO_3^{2-}) plus carbonate (CO_3^{2-})), chloride (Cl^-), and sulfate (SO_4^{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.

Based on the major cation and major anion content in the water samples and plotting them in the trillinear diagram, hydrochemical facies could be identified. In Aquifer I cation chemistry out of 31 samples,29 samples are no dominant type 1 samples is Calcium dominant and 1 samples isMagnesium dominant. In anion part 21 samples are Bicarbonate dominant, 7 samples are no dominant (mixed typed) and 3 samples are Chloride dominant. In the dimond part plotted chemical falling 22 samples are Magnesium bicarbonate type (Mg-HCO_3) and 9 samples are mixed type. The Diamond part of the Piper Diagram reveals that most of the water samples fall in the hardness region. Figure 17 and 18 is given below.

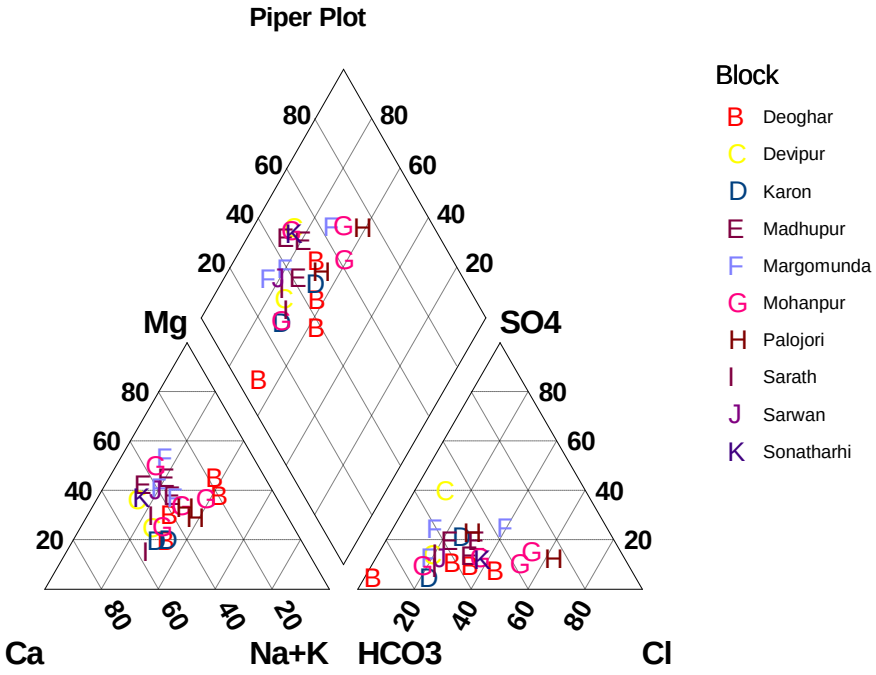


Figure:-17 Piper Diagrame for Aquifer – I

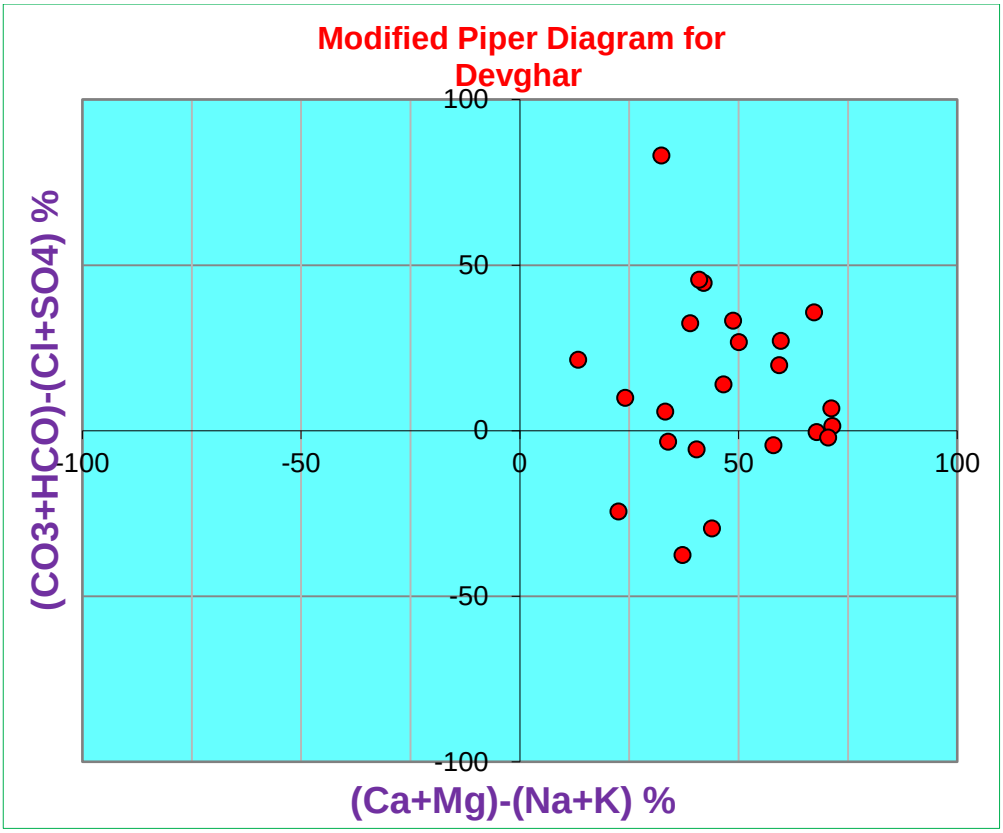


Figure:-18 Piper Diagrame modified by Gibbs for Aquifer – I

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, 2-D and 3-D sub-surface disposition of aquifers by drawing fence and lithological sections, aquifer wise yield potential, aquifer maps were generated

3.1 Aquifer Disposition

3.1.1 Hydrogeological Cross Section:-

To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. A-A' (NW to SE direction), B-B' (N-S direction) and C-C' (West to East Direction). 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.

3.1.1.1 Hydrogeological cross section A-A':

Hydrogeological cross section A-A' represents the area in Central part NE to SE direction of Deoghar district. Cross section covers exploratory wells ofPunasi, Sarwan, Lakhoriya, Mahapur and Faraimal. The Aquifer- I ranges 18 - 30.60 m representing weathered Granite gneiss, Granite, while Aquifer-II ranges from 25-116 m representing fractured granite gneiss. Generally 1-6 fracture zones were encountered. Discharge ranges from 3.6 m^3/hr to 8.4 m^3/hr. Maximum discharge found at Sarwan (8.4 m^3/hr) and minimum at Mahapur and Punasi (2.6 m^3/hr).

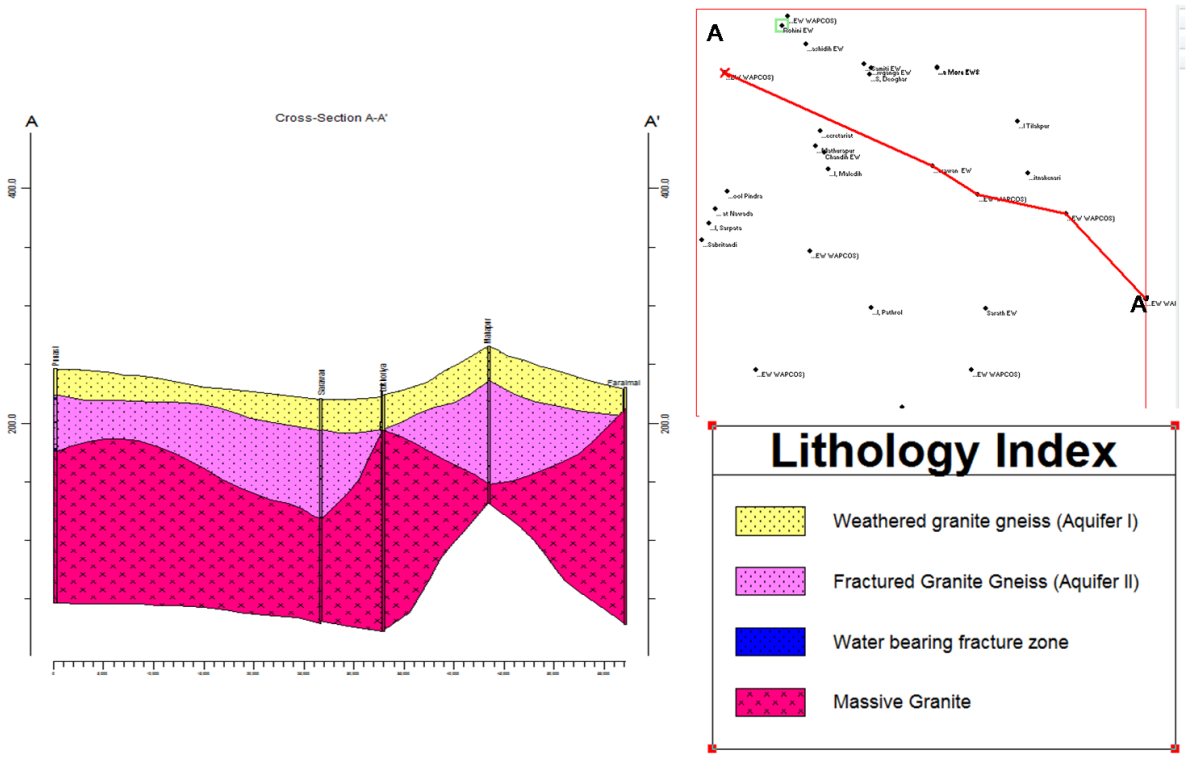


Figure-19: Hydrogeological cross section along A-A'

3.1.1.2 Hydrogeological cross section B-B': -

Hydrogeological cross section B-B' represents the area in N-S direction of Deoghar district. Cross section covers exploratory wells of Sikdardih, Jasidih, Jitjori, Upgraded Middle School SchoolMathurapur,Upgraded Middle School SchoolMaledih, +2 High School Pathrol and Karon. The Aquifer- I ranges 14- 26 m representing weathered Granite gneiss, while Aquifer-II ranges from 23-166 m representing fractured granite gneiss. Generally2-3 fracture zones were encountered. Discharge ranges from 1 m^3/hr. to 37.8 m^3/hr. Maximum discharge found at Upgraded Middle School SchoolMathurapur minimum at Jasidih.

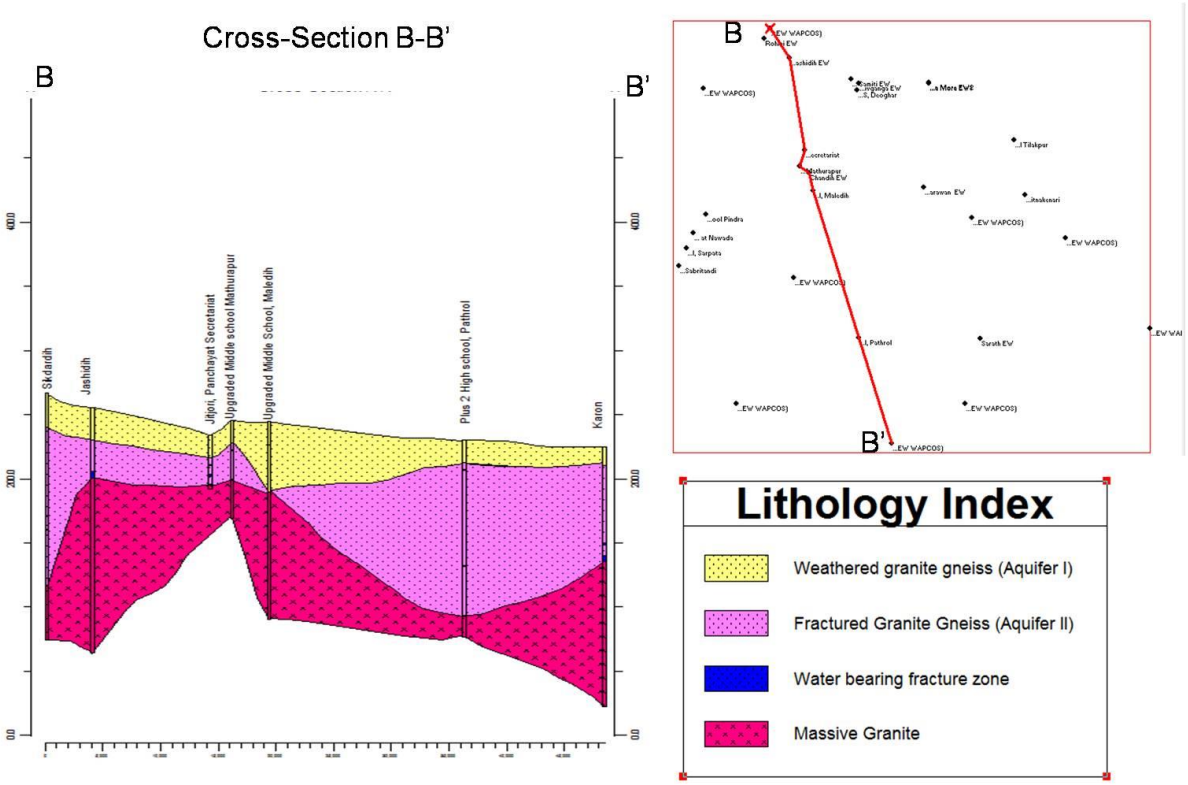


Figure-20: Hydrogeological cross section along B-B'

3.1.1.3 Hydrogeological cross section C-C':-

Hydrogeological cross section C-C' represents the area in West to East of Deoghar district. Cross section covers exploratory wells of Upgraded Middle school Pindra, Upgraded Middle schoolMaledih, Sarwan and Primary School Jitnakenari. The Aquifer- I ranges 14-27 m representing weathered Granite gneiss, while Aquifer-II ranges from 27-57 m representing Fractured in granite gneiss. Generally 0-1 fracture zones were encountered. Discharge ranges from Sepages to 12 m^3/hr. Maximum discharges found at Upgraded Middle schoolMaledih and minimum at Primary School Jitnakenari.

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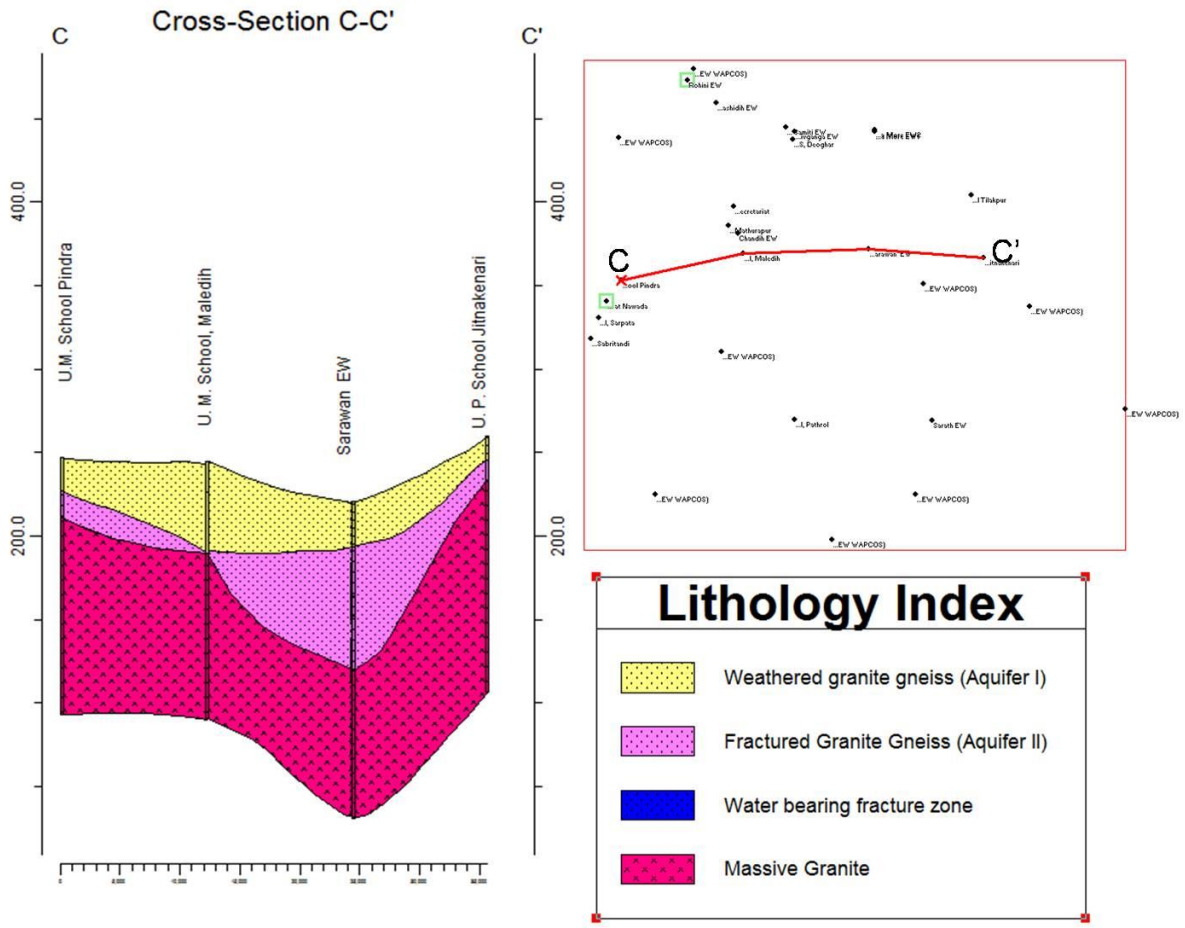

Figure -21: Hydrogeological cross section along C-C'

3.1.1.4 3-D Lithological Model:

The 3-D map in hard rock area of the district showing spatial disposition and vertical extent of Aquifer-Iindicating its depth of weathering while the Aquifer – II showing occurrence of fractured rock thickness is presented in figure – 19. Based on the drilling data of exploratory wells maximum thickness of Aquifer - I (weathered zone) in hard rock areais 30.0 m. The depth of Aquifer – II (fracture zone) ranges from 25.00 to 125.00 mbgl.

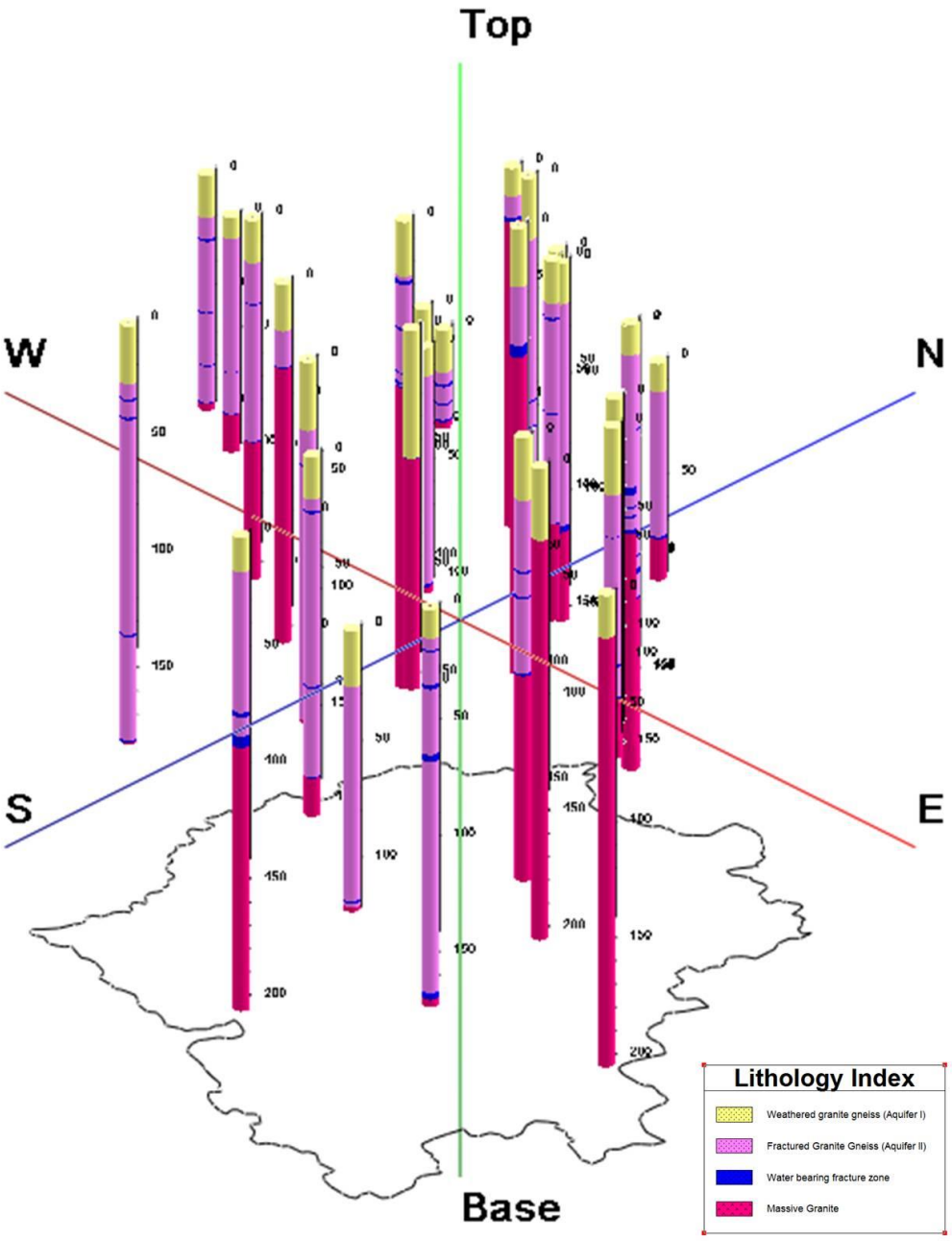

Figure –22:Three dimensional strip-log of EW drilled in Deoghar district

3.1.1.5 3D Aquifer Disposition

Hydrogeological Model has been prepared based on exploratory well data of CGWB.The inferred imaginary line between fractured rock zone and massive rock zone depicted in figure 23 are also based on exploratory data. This is a regional model of Granite gneiss.

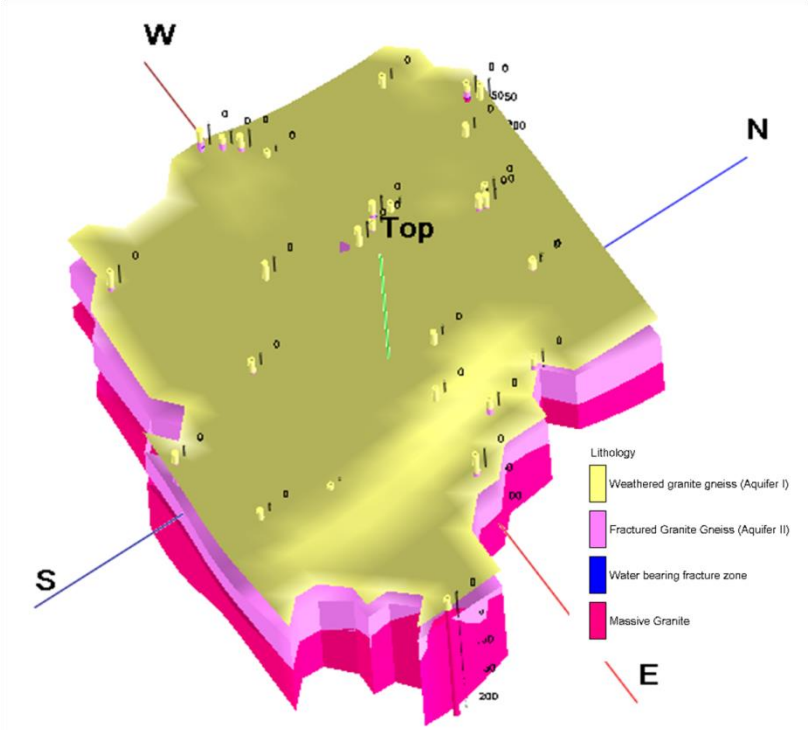

Fig-23. 3D Aquifer Disposition, Deoghar District

3.2 Aquifer Charcteristics:-

To know the aquifer Characteristics, Step Drawdown test (SDT) and Aquifer Performamce Tests (APT) were earlier conducted by CGWB is considered. Granite, Granite Gneiss forms the main aquifer of the area and comprises two distinct units viz, weathered zone and hard rock fractured zones. Granite gneiss is hard, compact and does not have primary porosity and hence impermeable. Weathering, jointing and fracturing induces secondary porosity in massive unit of granite gneiss. Average thickness of fractures in Aquifer-II is about 1-2 m. Along with yield potential, the aquifer parameters viz., transmissivity and storativity also form an important aquifer characteristic and provide valuable input on sustainability of the aquifers. The transmissivity of Aquifer-II ranges from 0.23-264 m^2/day, whereas storativity of the aquifer ranges from $2.2x10^{-4}$ to $2.749x10^{-6}$.

Table 17:Aquifer characteristics in hard rock areas of Deoghar district

Type of aquifer	Formation	Depth range of the aquifer	SWL (mbgl)		Thickness	Yield (m3/hr)	Aquifer parameter	
			Pre Monsoon (2019)	Post Monsoon (2019)			T (m^2/day)	Sy/S
Aquifer - I	Weathered Granite-Gneiss	9-30.6m	2.60 -9.85	1.20 - 5.80	5- 10 m	5-10	-	-
Aquifer - II	Jointed/ fractured Granite Gneiss	30-166 m	-	-	1-2 m	Upto151	0.23-264	$2.2x10^{-4}$ to $2.749x10^{-6}$.

3.3 Aquifer Maps in Hard Rock:- Based on Aquifer Disposition, Hydogeology of the area, Aquifer Characteristics, Aquifer Potentials, Aquifer Map for the hard rock area of Dhanbad district has been prepared as under:-

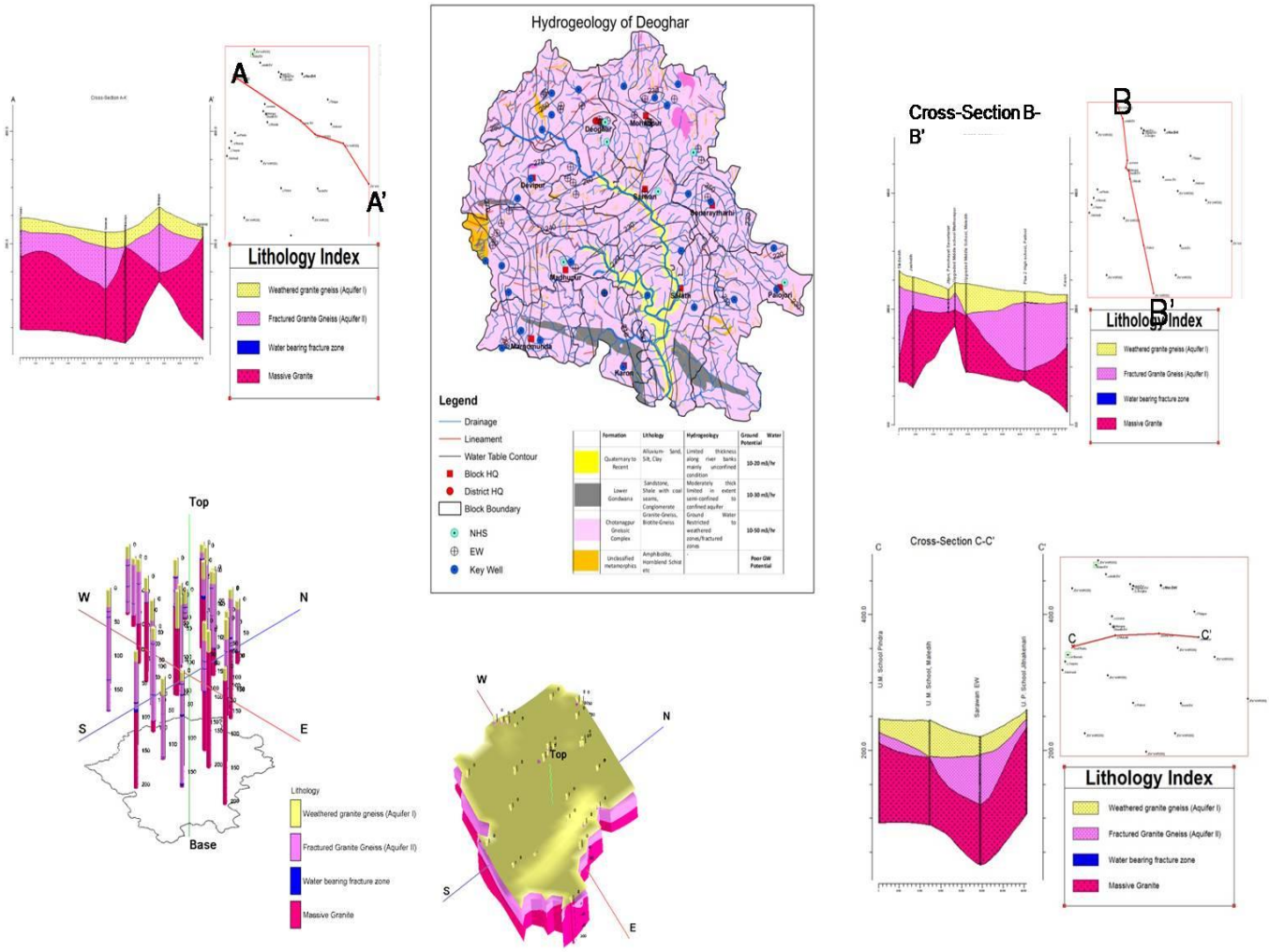

Figure -24 Aquifer maps of Deoghar district

4. GROUND WATER RESOURCE

Ground Water Resource of the area has been estimated block wise based on as on 2020 water year. In the present report GEC 2015 methodology has been used and based on the assessment has been made using appropriate assumptions. This methodology recommends aquifer wise ground water resource assessment of both theGround water resources components, i.e., Replenishable ground water resources or DynamicGround Water Resources and In-storage Resources or Static Resources.The assessment of ground water includes assessment of dynamic and in-storage groundwater resources, but the development planning should mainly depend on dynamic resourceonly as it gets replenished every year. Changes in static or in-storage resources reflect impactsof ground water mining. Such resources may not be replenishable annually and may beallowed to be extracted only during exigencies with proper recharge planning in thesucceeding 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

The dynamic Ground Water Resources has been assessed by CGWB, SUO,Ranchi in association with State Ground Water Direcorate, Jharkhand based on GEC, Methodology 2015. The summarized detail of Annually Replenishable or Dynamic Ground Water Resources of Deoghar district is in Table-18. Other details information regarding Dynamic Ground Water Resources of Deoghar district is provided in Annexure-VI.

Table- 18: Dynamic Ground Water Resources Availability, Draft and Stage of GW Development2020
(Figures in hectare meter)

Assessment Unit/ District	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	Net Ground Water Availability for future use	Stage of Ground Water Extraction in %	Category
Deoghar	2325.24	453.37	691.22	5.19	1149.78	1170.66	49.45	safe
Devipur	1454.71	396	141.21	0	537.21	916.52	36.93	safe

Karon	1047.42	441.75	116.45	0	558.21	488.4	53.29	safe
Madhupur	1250.18	469.25	315.48	0	784.73	463.25	62.77	safe
Margomunda	869.83	278.75	114.45	0	393.2	475.83	45.20	safe
Mohanpur	1597.91	550.125	232.04	0	782.17	814.13	48.95	safe
Palojori	1749.52	658.125	212.82	0	870.95	877.09	49.78	safe
Sarath	1791.24	581.625	223.32	200	1004.95	784.74	56.10	safe
Sarwan	1351.27	646.625	119.76	0	766.38	584.06	56.72	safe
Sonaraithadhi	831.40	490.5	100.44	0	590.94	239.76	71.08	Semi-critical
Total	**14268.72**	**4966.12**	**2267.19**	**205.19**	**7438.52**	**6814.44**	**53.03**	

4.2Ground Water Resources In-storage – Aquifer-I:-

The computation of the static or in-storage ground water resources is done after delineating the aquifer thickness and specific yield of the aquifer material. The computations can be done as follows:-

SGWR = A *(Z2 - Z1) * SY

Where, SGWR = Static or in-storage Ground Water Resources

A = Area of the Assessment Unit, Z2 = Bottom of Unconfined Aquifer, Z1 = Pre-monsoon water level,SY = Specific Yield in the In storage Zone

Table 19: Assessment of In-storage ground water resource of hard rock

AQUIFER I	
Area (A) (sqkm)	2551
Pre-monsoon (average) depth to water level (mbgl) (Z1)	7.66
Bottom of Unconfined Aquifer (mbgl) (Z2)	16.42
Specific yield (Sy)	3%
Saturated zone thickness (Z2-Z1) of aquifer (ST)	8.76
SGWR = A *(Z2 Z1) * SY	mcm
instorage	670.40

4.3 Assessment of Total Ground Water Availability in Unconfined Aquifer (Aquifer-I)

The sum of Annual Extractable Ground Water Recharge and the in storage ground waterResources of an unconfined aquifer are the Total Ground Water Availability of that aquifer.

Total Availability (unconfined Aquifer. i.e Aquifer-I) = Annual Extractable Ground Water Recharge + In-Storage Ground Water Resource

Total Availability (Mcm) = **142.69***mcm +***670.40***mcm =* ***813.09****mcm*

5. GROUND WATER RELATED ISSUES

The Deoghar district forms part of predominantly tribal belt wherein villagers have got very small land holdings and they do not find it economical to engage in agricultural activity in comparison to the earning, they earn by working as labourer in industrial units and Govt. Deprtments. Further, the cultivators are illiterate tribal and are ignorant of improved agricultural practices. By and large the district is not favoured with surface water irrigation system because of hilly and undulating geographical setting. The major ground water related issues are:-

5.1 Low Ground Water Development: One major issue of the area that is low ground water development. At present the overall stage of ground water development is only around 20.20%, based on 2020 GW resource assessment. Block wise stage of ground water development (SOD) varies from 36.93to 71.08 percent. Graphical presentation of SOD is shown in figure – 24.

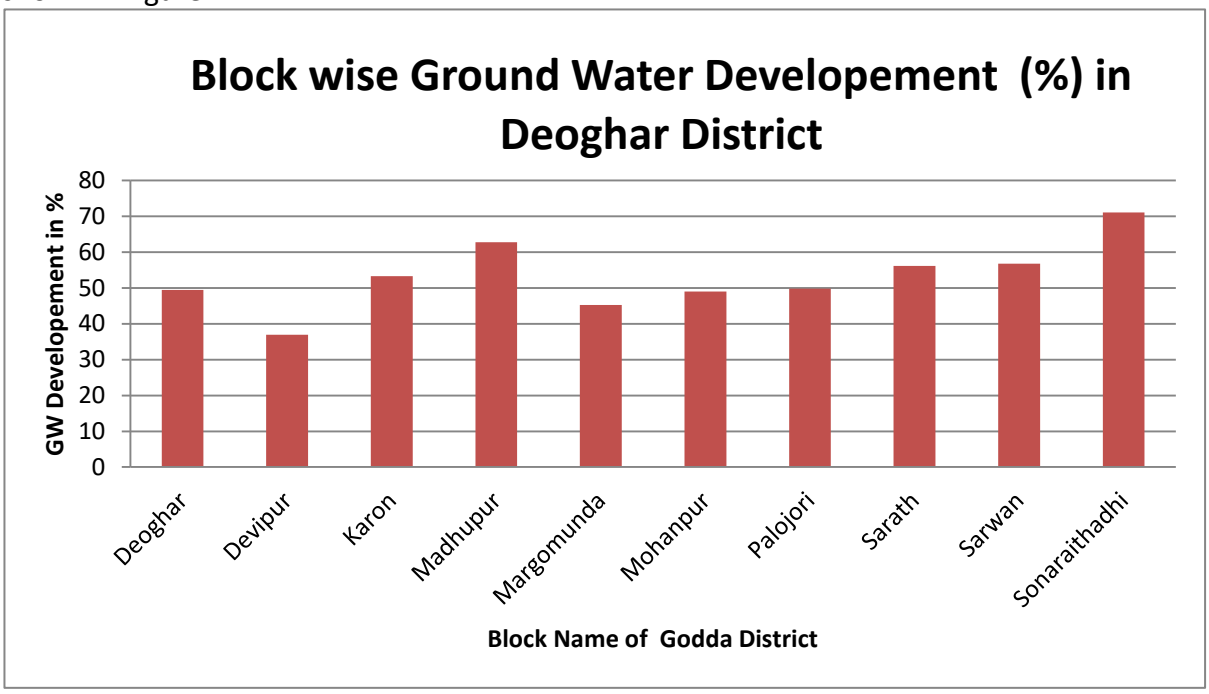

Figure 25 Block wise Ground Water Developement

5.2 Low Ground Water Potential / Limited Aquifer Thickness / Sustainability: Central Ground Water Board has constructed 42 exploratory and 22 observation wells in hard rock area of the district. The successful bore wells have 9-151m^3/h discharge.Average thickness of weathering is 1-2 m and secondary porosity i.e. fracture zone is 4-5 m. Transmissivity value is also very low which varies from 4.9 to 264.59 m^2/day in hard rock area. The exploratory drilling results show that fractures generally die down with the depth and below 175 m there is no fracture due to occurrence of massive rocks. The fracture encountered of bore wells drilled in the area is classified and presented below in figure – 25.

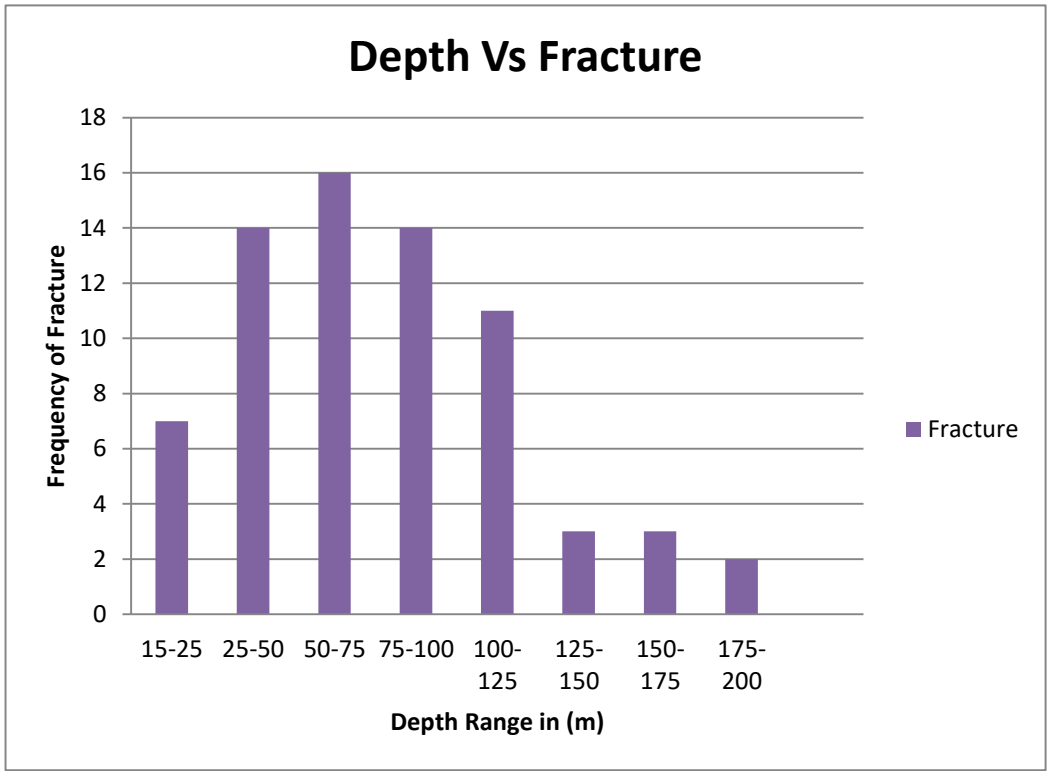

Figure – 26: Depth vs Frequency of fracture encountered in bore wells drilled in Deoghar district

5.3 Ground water contamination:-

Analytical result of water samples collected from the district, it is found the Nitrate concentration is beyond permissible limit in 9 samples of shallow aquifer (dug well) Similarly, Fluoride concentration is found beyond permissible limit in 3 samples of shallow aquifer. In addition, very high EC value 1725 µ S/cm has been observed in dug well sample existing at Mohanpurin Mohanpur block. Location details of Nitrate and Fluoride concentration found beyond permissible limit are given in table20 and 21 respectively and also represented in figure – 26.

5.3.1. Nitrate contamination:-

A variety of chemical constituents including Nitrate can pass through the soil and potentially contaminate ground water. Nitrate comes from the nitrogen, plant nutrient supplied by inorganic fertilizer and animal manure. Beneath agriculture land, nitrate is primary form of Nitrogen. It is soluble in water and can easily pass through soil to the ground water table. Nitrate can persists in ground water for decades and accumulated to high levels as more nitrogen is applied to the land surface every year. Nitrate is one of the most common ground water contaminations in rural areas. It is regulated in drinking water primarily because excess level can cause methemoglobinemia or blue baby disease. Nitrate can be removed from drinking water by distillation, reverse osmosis or ion exchange.

In shallow aquifer of Deogharditrict9 water samples out of 31have been found more than the permissible limit of NO_3 (45mg/l). Location details of NO_3 concentration found beyond permissible limit is given in table 20.

Table 20: Nitrate concentration found beyond permissible limit

Sl. no	Village	Block	Concentration NO_3
1	Palajori	Palajori	46.1
2	Talgarha	Palojori	55.7
3	Budhudih	Margomunda	63.5
4	Mohanpur	Mohanpur	67
5	Palojori	Palojori	79.4
6	Mohanpur	Mohanpur	97.6
7	Deoghar	Deoghar	98.4
8	Madhupur	Madhupur	147
9	Suwardahi	Mohanpur	149

5.3.2 Fluoride contamination:

Consumption of water with fluoride concentration above 1.5 mg/l is harmful which results in acute to chronic dental fluorosis where the tooth become coloured from yellow to brown. Skeletal fluorosis which causes weakness and bending of the bones also results due to long term consumption of water containing high fluoride. Presence of low or high concentration of fluoride in groundwater is because of geogenic or anthropogenic causes or a combination of both.

In shallow aquifer 3 samples, out of 31 have F concentration more than the desirable limit of 1.5mg/l. Location details of F concentration found beyond permissible limit is given in table-21 and sample wise Fluoride concentration is shown in figure-26for shallow aquifer.

Table – 21: Location details of Fluoride concentration found beyond permissible limit

Sl. no	Village	Block	Concentration F
1	Manikpur	Deoghar	1.68
2	Basamandih	Deoghar	2.44
3	Rikiya	Mohanpur	3.88

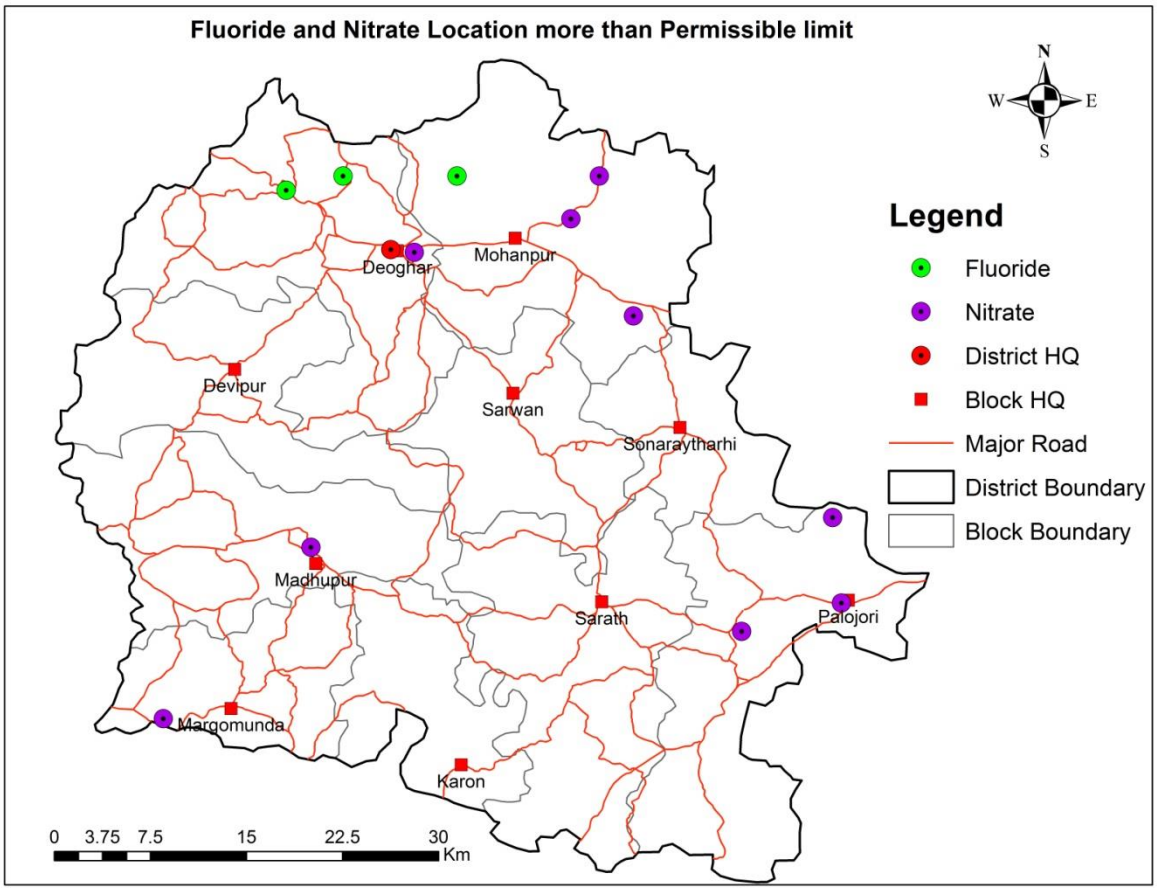

Figure – 27: Location map of NO_3 and F concentration found beyond permissible limit in ground water, Deoghar district.

5.3.3 Uranium Contamination

Total 7 samples were analysed for uranium concentration in Deoghar district. Uranium concentrations in Deoghar district were found to be in the range of 0.50 ppb to 13.75 ppb. Out of 7 samples, at all sample the uranium concentration was found within permissible limit. The detail results of chemical analysis for uranium are in Annexure-VI.

6. MANAGEMENT STRATEGIES

As discussed in previous chapter, the major ground water related issue in the Deoghar is low ground water development owing to many socio-economic and hydrogeological reasons. To overcome these, it is imperative to have a robust ground water resource development plan for the district.

6.1 Ground Water Resource Development Strategy: In view of above, the focus of proposed management plan was to enhance the overall ground water development from the present 52.13%to 60%.Total 3680 dug wells (15-20 m depth; 2 to 4 m diameter @ Rs. 2.50 lakh/dug well) are recommended to be constructed in feasible areas. Similarly, 537 shallow depth bore wells/tube wells (60 - 100m depth; 100-150 mm dia) are also recommended to be drilled in feasible areas. Proposed number of abstraction structure.

Table – 22: Future Irrigation Potential & Proposed number of Abstraction Structures based on SOD 60%

Block	Net GW Availability for Future Development	future irrigation potential available (ha) considering (Δ) 0.45m	60% of future irrigation potential created (ha)	Proposed number of ground water structure (Dug wells) 60%	Proposed number of ground water structure (STW/SBW) 35%
Deoghar	1170.66	526.797	316.0782	632	92
Devipur	916.52	412.434	247.4604	495	72
Karon	488.4	219.78	131.868	264	38
Madhupur	463.25	208.4625	125.0775	250	36
Margomunda	475.83	214.1235	128.4741	257	37
Mohanpur	814.13	366.3585	219.8151	440	64
Palojori	877.09	394.6905	236.8143	474	69
Sarath	784.74	353.133	211.8798	424	62
Sarwan	584.06	262.827	157.6962	315	46
Sonaraithadhi	239.76	107.892	64.7352	129	19
Total	**6814**	**3066**	**1840**	**3680**	**537**

It is necessary that proposed Additional ground water abstraction structure may be constructed in three phases with proper site selection. 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 to achieve 100% utlisation.

6.2 Supply side Interventions:

At present as per Ground Water Resource Estimation 2020, the stage of ground water development is low i.e., 52.13% and nine blocks of the district come under safe category and one block comes under Semi critical 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 envisages

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. 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. Thusnot only the drinking and domestic water sources will be strengthened but additional irrigation potential can be created through artificial recharge structures.

Augmentation plan of the resource through artificial recharge and water conservation Master plan 2020

Recently in 2020, artificial recharge to Ground Water master plan 2020 of Jharkhand state has been prepared.The area identified for artificial recharge has been made based on post monsoon depth to water level (Nov 2018) more than 3m bgl with declining trend of more than 0.1 m/yr (2009 – 2018). In addition, area with water level more than 9m bgl in the district has been considered for identifying the area given in figure -27. The volume of unsaturated zone available for recharge in identified areas is determined by computation of average depth of the unsaturated zone below 3 m bgl and then multiplied by area considered for recharge. Based on this master plan, feasible artificial recharge structures including roof rainwater harvesting structures in Deoghar district are in Table-23.

Figure – 28: Location map of AR plan area in Deoghar district

Table -23: Artificial recharge structures feasible in Deoghar district

Sl. No.	Block	Volume of unsaturated zone available for recharge (MCM	Total volume of Available Water for Recharge (MCM)	Percolation Tank	NalaBund/ Check dam / Gully Plug
1	Deoghar	8.6184	14.31	19	357
2	Devipur	4.4884	7.45	10	186
3	Karon	4.104	6.81	9	170
4	Madhupur	8.904	14.78	20	369
5	Margomunda	0.936	1.55	2	38
6	Mohanpur	15.3624	25.50	34	637
7	Palojori	5.7088	9.48	13	236
8	Sarath	7.3836	12.26	16	306
9	Sarwan	7.2594	12.05	16	301
10	Sonaraithadhi	5.805	9.64	13	240
Total Structures				**152**	**2840**

6.3 Demand side Management:-

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.)- In Deoghar district Principal crops of the areas are;(Kharif)- Paddy, Maize, pea, Green gram, Groundnut, Urd and (Rabi)- Wheat, Pea, Arhar, black gram. In the rabi crops advance irrigation practices like sprinklar and drip irrigation may be adopted to save about 70% ground water. solar pumps, etc.)

ii)Crop choice management and diversification (promote less intensive crop 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

6.4 Ground water management strategy for Nitrate and Fluoride affected areas:

Nitrate and Fluoride contamination are occurring in the granite gneisses of Mahagama, Basantrai, Boarijore, Sundarpahari, Deoghar, Poreyahat and Jarmundi blocks. Remedial measures recommended for Nitrate and Fluoride affected areas are as follows-

1.Purification/Filtration: Purification/filtration of Nitrate and Fluoride contaminated ground water by distillation, reverse osmosis or ion exchange etc.

2. Awareness raising Program /Participatory approach: Peoples should aware about the ground water pollution of Nitrate and Flouride. Management of schemes or project related Nitrate and Flourideremoval should be in hand of local peoples, so that peoples will keep the proper maintenance of machines and equipments.

6.5 Stress aspect against future demand (2021, 2031): Demand of water is increasing day by day against the increasing population. The detail demographic particular of the Deoghar district and water requirement for domestic purpose is worked out for the year 2031 and 2031 is presented in table – 24, 25&26.

Table 24: Detail demographic particular of Deoghar district

Population as per census			
2001		2011	
Rural	Urban	Rural	Urban
10,05,539	1,59,851	12,33,712	2,58,361

Table – 25: Projected population

Projected population			
2021		**2031**	
Rural	Urban	Rural	Urban
1534237	321271	1907970	399555

Table – 26: Requirement of water for domestic use

	Water requirement (assuming 90 liters per day per person for rural population and 130 liters per day per person for urban population)			
	2021		2031	
	Rural (Litres/day)	Urban (Litres/day)	Rural (Litres/day)	Urban (Litres/day)
	138081330	41765230	171717300	51942150
Total	**179846560litres / day**		**223659450litres / day**	

On perusal of table – 26, the requirement of water will be 223659450 litres per day in 2031. The demand of water is increasing due to highly increasing of population. Thus, recommended for alternate surface water supply from river to reduce the stress of ground water.

7.0 Sum-up

- The district Deoghar is spread over 2551 Sq. km area consisting of 2 subdivisions and 10 blocks situated in the north–eastern part of the Jharkhand state. It is bounded in the north by Bhagalpurand Munger districts of Bihar state, in the south by Jamtara district in the east by Dumka district and in the west by Giridih district. As per census of 2011, total population of the district is 14,92,073 with rural population of 12,33,712 and urban population 2,58,361.

- Aquifer Mapping Study wascarried inDeoghar district, Jharkhand covering an area of 2551 sq.km consisting of 10 blocks throughcollection of various data from state/Central Govt agencies, data gap analysis, data generated in-house/outsourcing All the available data/ data generated were analysed and integrated to prepare aquifer maps and aquifer management plans of the district.

- The predominant physical feature over major part of the district is the rolling topography dotted with isolated inselbergs. The major hills are confined to the eastern part of the district. The principal rivers of the district are Ajay River, Pathro river. The district is characterized by humid to sub-humid climate with Average Annual Rainfall of 1211.11mm.

- Geologically the study area represents highly deformed Archean gneisses called chotanagpur granite gneissic complex, older meta-sedimentaries. The pre-Cambrian formations are uncomfortably overlain by lowergondawanas comprising Talchirs&Barakar formation. Barakar sandstone and shale contains coal seams found in major coal belt of the area. Recent to Quaternary sediments represented along the river bank.

- Based on morphogenetic and geological diversities and relative ground water potentialities in the aquifer belonging to different geological formation, the study area can be broadly sub-divided into three hydrogeological unit-Consolidated formation(represented by chotanagpur gneiss complex), semi-consolidated formation(represented by Gondwana formations) and Uncosolidated formationbyRecent to quaternary alluvium.

- Ground water occurs in consolidated formation under unconfined to semi-confined state in Aquifer-I (upto the depth of 30m). Yield of the wells in Aquifer-I is very poor restricted upto 10 m3/hr weathered Granite-Gneiss and Recent to quaternary alluvium. These aquifers are generally tapped in the dugwells or shallow borewells.

- In fissured formations ofthe district the major potential fractures zones are found in Aquifer-II between 25-125 m. In general, discharge of well has been found in the range of 9-151 m^3/hr. The Transmissivity value and Storativity value range from 4.95 m2/day 264.59 m^2/day and $3.50x10^{-8}$ to $2.8x10^{-4}$ respectively. Ground Water occurs under semi-confined to confined state in Aquifer-II.

- First potential fracture zone encountered in the district widely varies from 12-101m.The potential fractures were encountered in Precambrian formation at shallow level upto 38.00 m with very high yielding wells(Panchayat bhawan Jitjori-64.4 m3/hr, Upgraded+2 School Tilakpur- 378 m3/hr, Bazar Samiti Deoghar-151 m3/h). Potential fractures were also encountered beyond 100 m depth(101-178 m) with cupious amount of discharge e.g+2 high school Patharol(25.56 m3/hr), Margomunda(18 m3/hr).

- The Recent to quaternary alluvium occurring along the bank of the Ajay river and Pathro river and three alluvial formations. The thickness of alluvium is as high as 30m. Thickness of aquifer may range from 5-10m, in which tubewell discharge range from 10-20 m3/hr.

- Ground Water quality is generally potable, however excessive limit of Flouride concentration was found in 3 number water samples out of 31, in two blocks and Nitrate concentration was found in 9 numbers water samples out of 31 in Deoghar block.

- The stage of ground water development in Deoghar district is 53.03%, nine blocks comes under safe categoryand one block is in semi-critical category.Therefore there is sufficient scope for further ground water development.

- Three major ground water related issues in Deoghar district are Low ground water development, Low ground water potential and Flouride contamination was found sporadic in twoblocks blocks and Nitrate in four blocks.

- To suggest a sustainable ground water management plan there are two options- Supply Side Management Options(Ground Water Resources development strategy, local water harvesting techniques etc) &Demand Side Management Options (real water-savings)

- Supply side management strategy-I:-Ground Water Management strategy suggested are construction of 3680dugwells and 537 Shallow Tubewells/borewells in the feasible ares in the district to enhance the overlall ground water development to 70%. Rain water harvesting and artificial recharge to be encouraged in feasible areas for ground water augmentation so that there is less possibility of development of ground water stressed condition in the area.

- Supply side management strategy-II:- Based on Artificial recharge to Ground Water master plan 2020 of Jharkhand state, the area has been identified for artificial recharge in Deoghar district. Based on this master plan, feasible artificial recharge structures including roof rainwater harvesting structures are 152 percolation tank, 2840 Nala Bund/Check Dam/Gully Plug recharge structures are suggested in the district

- 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 crop 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.)

- Alternative surface water supply in fluoride infested blocks of Deoghar district may be extended. In addition a purification/filtration ofFlouride/Nitrate may also be adopted.

Annexure - I

DETAILS OF KEY WELLS ESTABLISHED FOR NATIONAL AQUIFER MAPPING STUDY OF DEOGHAR DISTRICT, 2019 –20

Well No.	Village	Block	Owner	Location	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Dia. (m.)
1	Manikpur (Phutabandh)	Deoghar	Govt.	Back side of Piyush General store	DW	Granite Gneiss	Motorised	0.5	10.4	4.5
2	Basantpur	Deoghar	Govt.	in the Basantpur village, about 6 km from Jashidih	DW	Granite Gneiss	Rope and Bucket	0.4	11	3.4
3	Basamandih	Deoghar	Govt.	Chakaimore-Jashidih-Kotaria road LHS, near Panchayat Bhawan, Basmandih	DW	Granite Gneiss	Rope and Bucket	0	11.5	3.9
4	Rikiya	Mohanpur	Govt.	LHS,500m after crossing the bridge from Rikiya more to mohanpur road	DW	Granite Gneiss	Rope and Bucket	0.4	8.9	3.15
5	Dumaria	Mohanpur	Govt.	in the village of Dumaria LHS, from Rikia to Mohanpur road	DW	Granite Gneiss	Rope and Bucket	0.5	8.68	2.8
6	Suwardih	Mohanpur	Govt.	In the village of SuwardihRHS,o the village road and about 8km from Jaipur more	DW	Granite Gneiss	Rope and Bucket	0.1	9	2.5
7	Bathar	Deoghar	Govt.	in the village Bather, about 200m RHS, from School	DW	Granite Gneiss	Rope and Bucket	0.65	7.35	3.3
8	Mohanpur	Mohanpur	Govt.	in the campus of forest department, Mohanpur	DW	Granite Gneiss	Motorised	0.7	7.85	1.8
9	Asurbandha	Sonaratharhi	Govt.	RHS, from Ghormara to sonaraitharhi road about 1.5km before Sonaraitharhi	DW	Granite Gneiss	Rope and Bucket	0.45	10.15	3.8
10	Baratar(Banda jori)	Sarwan	Private owner Sabu Mahato	About 8 km LHS, from Sarath to Sarwan road	DW	Granite Gneiss	Rope and Bucket	0.7	11.8	3.2
11	Bagdha	Sarath	Govt.	In the village of Bagdha, near house of Pritam Mirdha	DW	Granite Gneiss	Rope and Bucket	0.6	7.47	1.7
12	Ramdeodih	Sarath	Govt.	in the village Ramdevdih, Well is located opposite to	DW	Granite Gneiss	Motorised	0.7	7.6	3.9

				parmanandManjhi house, 1.5 km LHS from Arajori village to Madhupur road near football ground						
13	Pathrol	Karon	Govt.	In the campus ofHigh School Patharol	DW	Granite Gneiss	Rope and Bucket	0.85	8.65	1.7
14	Devipur(Rajpura)	Devipur	Govt.	Well is located in open field 200m LHS befordevipur village from Madhupur (Madhupur-Devipur road)	DW	Granite Gneiss	Rope and Bucket	0.9	8.65	4.1
15	Tilona	Devipur	Govt.	Near trijuctionTilona	DW	Granite Gneiss	Rope and Bucket	0.6	8.85	2.5
16	Niruadih	Madhupur	Govt.	Well is located in the village of Ninuadih about 1.5 km from Bhirgabad	DW	Granite Gneiss	Rope and Bucket	0.6	9.2	3.8
17	Jaridih(Dhamini)	Madhupur	Private owner Sh. Ashif Khan	In the village of Jaridih RHS, of DhaminiMargomunda road about 1.2km	DW	Granite Gneiss	Rope and Bucket	0.7	9.4	2.1
18	Siktia(Jagdishpur)	Madhupur	Govt.	Near trijuctionSiktia, near Railway crossing, near Uday Ram's house	DW	Granite Gneiss	Rope and Bucket	0.6	9.4	1.8
19	Budhudih	Margomunda	Govt.	In the village of Budhudih, RHS about 100m near pond	DW	Granite Gneiss	Rope and Bucket	0.75	10.25	5.3
20	KudarKhaso	Margomunda	Private	In front of sh. Mukeh Kumar Tiwari in the village of Kudar before 1.5 km from Margomunda	DW	Granite Gneiss	Rope and Bucket	0.7	8.6	4.1
21	Nawadih	Margomunda	Govt.	In the village of Nawadih, LHS, about 2km from Margomundablock Margomunda to Karon road	DW	Granite Gneiss	Rope and Bucket	0.55	9.65	1.65
22	Karon	Karon	Govt.	in the premises of Karon Bazar	DW	Granite Gneiss	Rope and Bucket	0.5	9.7	2.8
23	Talgarha	Palojori	Govt.	Well is back side of Middle school Talgarha	DW	Granite Gneiss	Rope and Bucket	0.65	8.35	3.5
24	Palojori	Palojori	Private	Back side of of Star mobile and opposite to Palojori thana	DW	Granite Gneiss	Rope and Bucket	0.65	5.65	1.4

Annexure – II

WATER LEVEL DATA OF KEY & NHNS WELLS OF NAQUIM STUDY AREA OF DEOGHARDISTRICT, JHARKHAND, 2019-20

Sl No	Village	Block	District	May 2019DWL(inmbgl)	Nov. 2019DWL(inmbgl)	Pre-post Fluctuation
1	Manikpur	Deoghar	Deoghar	9	5.8	3.2
2	Basantpur	Deoghar	Deoghar	7.05	2.2	4.85
3	Basamandih	Deoghar	Deoghar	7.9	3.2	4.7
4	Rikiya	Mohanpur	Deoghar	6.3	2.8	3.5
5	Dumaria	Mohanpur	Deoghar	8.3	4.1	4.2
6	Suwardih	Mohanpur	Deoghar	8.7	4.6	4.1
7	Bathar	Deoghar	Deoghar	6.65	3.05	3.6
8	Mohanpur	Mohanpur	Deoghar	7.6	3.8	3.8
9	Asurbandha	Sonaratharhi	Deoghar	8.05	5.25	2.8
10	Baratar(Bandajori)	Sarwan	Deoghar	8.4	4.25	4.15
11	Bagdha	Sarath	Deoghar	6.7	4	2.7
12	Ramdeodih	Sarath	Deoghar	5.4	1.2	4.2
13	Pathrol	Karon	Deoghar	6.17	2.35	3.82
14	Devipur(Rajpura)	Devipur	Deoghar	6.5	1.7	4.8
15	Tilona	Devipur	Deoghar	7.95	2.6	5.35
16	Niruadih	Madhupur	Deoghar	8.9	3.1	5.8
17	Jaridih(Dhamini)	Madhupur	Deoghar	8.6	3.1	5.5
18	Siktia(Jagdishpur)	Madhupur	Deoghar	9.3	2.15	7.15
19	Budhudih	Margomunda	Deoghar	8.55	3	5.55
20	KudarKhaso	Margomunda	Deoghar	7.75	2.75	5

21	Nawadih	Margomunda	Deoghar	8.85	3.1	5.75
22	Karon	Karon	Deoghar	7.8	3.15	4.65
23	Talgarha	Palojori	Deoghar	5.95	2.35	3.6
24	Palojori	Palojori	Deoghar	2.6	2.35	0.25
25	Deoghar	Deoghar	Deoghar	7.6		
26	Ghormara	Mohanpur	Deoghar	8.39	3.54	4.85
27	Deoghar	Deoghar	Deoghar	8.9	2.2	6.7
28	Madhupur	Madhupur	Deoghar	9.86	2.45	7.41
29	Palajori	Palajori	Deoghar	7.3	3.25	4.05
30	Sarawan	Sarawan	Deoghar	8.8	3.25	3.2

Annexure - III

Hydrogeological Details of Exploratory Wells in Deogarh District
Wells drilled through Department Rigs

Sl.No.	Location	Block	Co-ordinate	Depth Drilled (m)	Casing Depth/Dia. (m)	Fractures encountered (m)	Static Water level (m bgl).	Discharge (m^3/hr)	Drawdown (m)	T (m^2/day)	S	Diameter of assembly (mm)	Formation	Year
1	**Ghormara** EW	Mohanpur	$24^0$26'50" $86^0$52'20"	191	-	-	5.03	18.08				165	Granite Gneiss	Aug-92
2	**Jashidih**	Deoghar	$24^0$30'40" $86^0$38'00"	191	25.05	050.00-055.00	5.83	1.08				165	-do-	Sep-92
3	**Shivganga** EW	Deoghar	$24^0$29'10" $86^0$42'30"	153	17.29	012.00-018.00	5.85	12	-	21.9	$2.8x10^{-4}$	165	-do-	Oct-92
4	**Chandih** EW	Deoghar	$24^0$24'38.052" $86^0$42'48.528"	102	-	101.00-102.00	4.78	70.44				165	-do-	Dec-92
5	**Sarath** EW	Sarath	$24^0$14'00" $86^0$50'25"	167	-	017.00-018.00 032.00-034.00 062.00-065.00 164.00-167.58	4.23	18				165	-do-	Jan-93
6	**Devipur** EW	Devipur	$24^0$16'15" $86^0$39'30"	198	-	-		-	-			165	-do-	Mar-93
7	**Rohini** EW	Deoghar	$24^0$28'39.432" $86^0$38'39.984"	178	19	021.00-023.00	1.5	-	-	-	-	165	-do-	Dec-94
8	**Sarawan** EW	Sarawan	$24^0$23'00" $86^0$46'45"	190	27	057.00-058.00 068.00-069.00 101.00-102.00	7.48	8.4	-	-	-	165	-do-	Jan-95
9	**Water Tower** EW	Deoghar	$24^0$29'20" $86^0$42'50"	180	-	-	-	0.6	-	-	-	165	-do-	Mar-95
10	**Bazar Samiti** EW	Deoghar	$24^0$29'25" $86^0$42'00"	56	10.6	051.00-052.00 052.00-056.00	6.63	151	30	128	$2.20X10^{-4}$	165	-do	Mar-95
11	**Choppa**	Mohanpu	$24^0$29'10"	180	12.4	069.00-072.00	6.3	58	3.61	67.7	1.1X10	165	-do-	Apr-96

Sl.No.	Location	Block	Co-ordinate	Depth Drilled (m)	Casing Depth/Dia. (m)	Fractures encountered (m)	Static Water level (m bgl).	Discharge (m^3/hr)	Drawdown (m)	T (m^2/day)	S	Diameter of assembly (mm)	Formation	Year
	More EW_1	r	$86^0$47'05"					(Air comp)			$^{-5}$			
12	**Chopa More** EW_2	Mohanpur	$24^0$29'15" $86^0$47'05"	191	13.6									Apr-96
	OW			154	18.15	045.00-046.00 090.00-092.00 099.00-100.00 105.00-108.00 117.00-118.00	3.65	17 (Air comp)						
13	**Sarmul** EW	Deoghar	$24^0$29'10" $86^0$42'10"	191	-	-	-	1.5 (Air comp)	-	-	-	-	-	Jul-95
14	**Mohanpur**	Mohanpur	$24^0$29'10" $86^0$47'25"	199.17	15	-	-	-	-	-	-	-	-	Oct-99
15	**Police Line** EW	Mohanpur	$24^0$29'10" $86^0$47'15"	103.96	14.5	-	-	70	-	-	-	-	-	Nov-99
16	**Jasidih** EW	Deoghar	$24^0$30'20" $86^0$37'55"	152	16	-	-	-	-	-	-	-	-	Mar-95
17	**Jasidih Ind.Area**	Deoghar	$24^0$30'40" $86^0$40'10"	145.58	15.4	-	-	12	-	-	-	-	-	Jan-00
18	**Kalyanpur** EW	Mohanpur	$24^0$31'15" $86^0$46'45"	115.1	15.5	-	-	50	-	-	-	-	-	Feb-00
19	**Bariarbandh**	Mohanpur	$24^0$31'15" $86^0$49'50"	125.3	14	-	-	40	-	-	-	-	-	2000
20	**Raydih** EW	Deoghar	$24^0$29'50.208" $86^0$38'06.684"	161.3	14	-		-	-	-	-	-	-	Mar-00
21	**Training**	Mohanpu	$24^0$29'50"	142.										Apr-00

Sl.No.	Location	Block	Co-ordinate	Depth Drilled (m)	Casing Depth/Dia. (m)	Fractures encountered (m)	Static Water level (m bgl).	Discharge (m^3/hr)	Drawdown (m)	T (m^2/day)	S	Diameter of assembly (mm)	Formation	Year
	College EW	r	$86^0$45'40"	06										
22	Jitna Kenari	Sonaraithari	$24^0$22'32.88" $86^0$53'19.68"	153.8	14.35	31.88-32.5	8	0.504					Granite Gneiss	2019-20
23	Tilakpur	Sonaraithari	$24^0$25'49.8" $86^0$52'39"	92.84	13.5	27.88-28.5 35.5-36.0 65.98-67	12	37.8					Granite Gneiss	2019-20
24	Pathrol	Karon	$24^0$14'42.288" $86^0$42'15.3"	153.8	17.5	23.0-24.0 98.0-99.0 121-122 137-138	9.1	25.56					Granite Gneiss	2019-20
	OW			153.8	17.5	23-24 100-101 137-138		25.56						2019-20
25	Jitjori	Devipur	$24^0$25'08.76" $86^0$38'36.96"	41.5	18	26.26-27.0 31.88-32.4 38.0-39.0 41.5-43.5	5.5	69.84					Granite Gneiss	2019-20
	OW			77.60	18	31.88-32.88 39.5-40.8 50.74-52.74		69.84					Granite Gneiss	2019-20
26	**Maledih**	Devipur	86.643 24.416	153.8	18.1	54.74-55.00	7.5	12.24					Granite Gneiss	2020-21
	OW			153.8	18.5	54.74-55.00							Granite Gneiss	2020-21
27	**Mathurapur**	Deogarh	86.644 24.403	77.60	18	23.00-23.50, 46.00-47.00	6.15	37.8					Granite Gneiss	2020-21
28	**Pindra**	Madhupur	$24^0$16'40.404" $86^0$30'49.464"	153.8	20	35.5-36.00	13	2.88					Granite Gneiss	2020-21
29	**Sabritan**	Madhupu	86.513	100.	18	27.00-28.00	12	44.28					Granite	2020-21

Sl.No.	Location	Block	Co-ordinate	Depth Drilled (m)	Casing Depth/Dia. (m)	Fractures encountered (m)	Static Water level (m bgl).	Discharge (m^3/hr)	Drawdown (m)	T (m^2/day)	S	Diameter of assembly (mm)	Formation	Year
	di	r	24.304	46		58.36-59.00 81.00-81.50 97.00-97.50							Gneiss	
30	**Bharat Seva Sharam**	Deogarh	86.706 24.479	153.80	18	24.00-25.00 65.00-65.50 112.00-112.50	7	6.48					Granite Gneiss	2020-21
	OW			130.94		51.0-52.0 95.0-96.0		6.48					Granite Gneiss	2020-21
31	**Nawada**	Madhupur	86.528 24.337	153.8	18	35.50-56.00, 94.46-95.00	5.3	12.24					Granite Gneiss	2021-22
	OW					35.0-36.0 93.0-94.0		10.8					Granite Gneiss	2021-22
32	**Sarpata**	Madhupur	86.521 24.322	100.46	9	66.00-66.50, 84.00-84.50	5.5	52.2					Granite Gneiss	2021-22
	OW					64.0-65.0 87.0-88.0		1.8					Granite Gneiss	2021-22

Through Outsource Drilling (WAPCOS)

Sl. No.	Location	Block	Co-ordinate	Depth Drilled (m)	Casing Depth/Dia. (m)	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	Year
33	Baltharwa	Devipur	$24^0$22'36.2" $86^0$31'30.2"	203	20.8	Not encountered	4.11	0.0504			0.63(slug test)		Granite Gneiss	**2020**
34	Margomunda	Margomunda	$24^0$10'05.7" $86^0$34'34"	179.5	24.7	30.4-31.2 177.5-178.5	9.62	39.6	18	4.94	528.08	$2.749x10^{-6}$	Granite Gneiss	**2020**
	OW		$24^0$10'05.7" $86^0$34'34"	145	23.5	105.0-106.0 131.0-131.5	8.45	36					Granite Gneiss	**2020**

Sl. No.	Location	Block	Co-ordinate	Depth Drilled (m)	Casing Depth/Dia. (m)	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	Year
35	karon	Karon	$24^0$07'43.8" $86^0$44'40.2"	203	14.74	75.0-77.0 85.0-92.0	**4.35**	3.024			0.23 (slug test)		Granite Gneiss	**2020**
36	Kukarha	Sarath	$24^0$10'05.8" $86^0$49'27.2"	122	23.67	52.0-52.2 91.4-91.8 115.5-116.5 118.2-120.0	**7.36**	50.4	**3.6**	**2.9**	19.02		Granite Gneiss	**2020**
37	Sikdardih	Deogarh	$24^0$32'27.0" $86^0$36'41.4"	203	26.2	**95.0-95.8 106.0-107.0 149.1-150.0**	**6.35**	11.88	**9**	**37.64**	**18**	**$3.505x10^{-8}$**	Granite Gneiss	**2020**
	OW		$24^0$32'27.0" $86^0$36'41.4"	203	26.2	**91.0-92.0 165.0-166.0**	**6.42**	4.32		**7.77**				**2020**
38	Punasi	Deogarh	$24^0$28'50.6" $86^0$32'23.5"	203	23.24	**25.0-26.8 45.3-46.3 64.3-65.0 68.4-69.6 70.3-70.87**	**2.94**	9	**3.6**	**2.48**	**28.3**		Granite Gneiss	**2020**
39	Mahapur	Sonaraithari	$24^0$20'00.3" $86^0$55'58.8"	135	28.76	**46.5-46.9 101.5-102.5 115.2-116.3**	**15.06**	9	**3.6**	**2.08**	**33.04**		Granite Gneiss	**2020**
40	Farasimal	Palojori	$24^0$14'36.6" $87^0$01'28.3"	203	18.1	**Not encountered**	**11.60**	0.756			**1.32**		Granite Gneiss	**2020**
41	Lokhoriya	Sarwan	$24^0$21'11.0" $86^0$49'51.9"	204	30.6	**Not encountered**	**7.35**	0.2772			**1.1**		Granite Gneiss	**2020**
42	Madhupur	Madhupur	$24^0$17'35.4" $86^0$38'18.4"	167	29.2	**44.0-44.8 153.5-154.5**	**10.95**	9	**3.6**	**1.36**	**44.01**		Granite Gneiss	**2020**

Annexure - IV

Water quality data of aquifer – I (dug well samples) of aquifer mapping study area of Deoghar district

Sl. No	District	Block	Village/Location	TH	Ca2+	Mg2+	Na+	K+	CO32-	HCO3-	Cl-	SO42-	NO3-	F-	TDS	PO43-	pH	EC(µs/cm) at 25°C
1	Deoghar	Deoghar	Manikpur	155	44	10.935	36	0.66	ND	282.9	7.09	10.92	BDL	1.68	331.5	BDL	8.24	510
2	Deoghar	Deoghar	Basantpur	295	68	30.375	50.25	12.29	ND	246	138.25	29.68	BDL	BDL	562.25	BDL	8.04	865
3	Deoghar	Deoghar	Basmandih	210	28	34.02	72.8	1.73	ND	295.2	81.535	40.15	BDL	2.44	513.5	BDL	8.06	790
4	Deoghar	Mohanpur	Rikiya	170	44	14.58	31.24	1.09	ND	215.25	31.905	21.68	BDL	3.88	321.75	BDL	8.13	495
5	Deoghar	Mohanpur	Dumariya	310	52	43.74	22.75	1.68	ND	184.5	77.99	35.7	37.8	0.448	456.95	BDL	8.08	703
6	Deoghar	Mohanpur	Suwardahi	470	96	55.89	97.85	1.63	ND	215.25	216.245	80.62	149	0.587	904.8	BDL	7.92	1392
7	Deoghar	Deoghar	Bathar	275	30	48.6	76.57	1.24	ND	301.35	113.44	40.76	11.8	0.754	584.35	BDL	8.09	899
8	Deoghar	Mohanpur	Mohanpur	515	84	74.115	147.26	3.82	ND	375.15	301.325	78.23	97.6	1.06	1121.25	BDL	7.95	1725
9	Deoghar	Sonatharhi	Asurbandha	170	38	18.225	14.55	0.69	ND	110.7	49.63	20.65	25.7	0.652	255.45	BDL	8.21	393
10	Deoghar	Sarwan	Baratar	250	50	30.375	28.06	1.58	ND	227.55	49.63	35.42	11.1	0.777	392.6	BDL	8.09	604
11	Deoghar	Sarath	Bagdah	190	46	18.225	28.46	0.95	ND	172.2	35.45	30.42	31.7	BDL	333.45	BDL	7.83	1725
12	Deoghar	Sarath	Ramdevdih	165	52	8.505	31.5	3.09	ND	209.1	46.08	21.54	BDL	0.317	336.7	BDL	7.91	518
13	Deoghar	Karon	Patharol	185	52	12.15	32.15	4.21	ND	233.7	42.54	11.11	1.67	BDL	334.1	BDL	7.96	514
14	Deoghar	Devipur	Rajpura	150	30	13.365	9.02	2.25	ND	79.95	10.635	51.24	14.2	0.216	189.15	BDL	7.77	291
15	Deoghar	Devipur	Tilona	140	36	10.935	20.85	0.89	ND	123	21.27	19.7	22.2	0.41	228.15	BDL	7.97	351
16	Deoghar	Madhupur	Niruadih	210	36	29.16	23.82	3.13	ND	141.45	56.72	44.9	17.8	BDL	341.9	BDL	7.89	526
17	Deoghar	Madhupur	Jaridih	245	50	29.16	17.52	2.38	ND	184.5	67.35	35.68	3.8	BDL	388.7	BDL	7.83	598
18	Deoghar	Madhupur	Sktia	185	36	23.08	28.3	4.6	ND	178	42.54	48.18	1.65	0.352	336.7	BDL	7.87	518
19	Deoghar	Margomunda	Budhudih	175	34	21.87	30.45	1.51	ND	79.95	53.175	43.78	63.5	BDL	322.4	BDL	7.72	496
20	Deoghar	Margomunda	Kudarkhoso	195	32	20.65	18.52	1.43	ND	116.85	17.72	37.56	41.9	BDL	269.75	BDL	7.91	415
21	Deoghar	Margomunda	Nawadih	275	40	42.52	21.92	4.7	ND	233.7	38.99	34.35	34.1	BDL	420.55	BDL	7.59	647
22	Deoghar	Karon	Karon	100	28	7.29	22.43	0.98	ND	98.4	28.36	30.64	2.7	BDL	206.7	BDL	7.86	318
23	Deoghar	Palojori	Talgarha	205	42	24.3	45.39	1.94	ND	141.45	49.63	51.78	55.7	BDL	391.95	BDL	7.78	603
24	Deoghar	Palojori	Palojori	340	72	38.85	96.82	2.29	ND	147.6	216.24	57.29	79.4	BDL	739.7	0.24	7.73	1138
25	Deoghar	Deoghar	Deoghar	289	51.42	38.88	103.34	1.261	0	356.7	35.06	125.17	98.4	0.37	738.4	NA	7.92	1136
26	Deoghar	Mohanpur	Mohanpur	303	64.68	34.42	69.71	0.698	0	319.8	41.9	43.04	67	0.831	603.85	NA	6.96	929
27	Deoghar	Deoghar	Deoghar	240	52.6	26.32	37.76	5.47	0	246	33	50.22	31.4	0.764	461.5	NA	7.27	710
28	Deoghar	Madhupur	Madhupur	448	112.426	40.45	108.97	1.562	0	375.15	83.4	78.05	147	0.62	830.05	NA	7.31	1277
29	Deoghar	Palajori	Palajori	414	58	65.306	91.429	4.298	0	418.2	84.45	59.25	46.1	0.34	769.6	NA	7.49	1184
30	Deoghar	Sarath	Sarath	340	74	37.665	33.64	2.125	0	264.5	55.78	48	39.5	0.25	528.45	NA	7.6	813
31	Deoghar	Sarawan	Sarawan	292	68	29.58	42.787	3.83	0	258.3	67	38.6	35.2	0.8	537.55	NA	7.57	827

Annexure-V

Results of Ground Water Samples for Uranium(ppb) in Deoghar District					
Sample no.	**District**	**Block**	**Well Name**	**Type of Well**	**Uranium Concentration (ppb)**
1	Deoghar	Deoghar	Deoghar	D/W	13.75
2	Deoghar	Mohanpur	Mohanpur	D/W	1.24
3	Deoghar	Deoghar	Deoghar	D/W	3.01
4	Deoghar	Madhupur	Madhupur	D/W	6.50
5	Deoghar	Palajori	Palajori	D/W	1.50
6	Deoghar	Sarath	Sarath	HP	0.50
7	Deoghar	Sarawan	Sarawan	D/W	0.64

Assessment of Dynamic Ground Water Resources of Jharkhand State (2020)

Annexure-VI A

Sl. No.	District	Administrative Units	Ground water Assessment Sub- Unit	Recharge from Rainfall		Recharge from Other Sources		Total Annual Ground Water Recharge	Total Natural Discharge	Annual Extractable Ground Water Recharge
				Monsoon	Non-monsoon	Monsoon	Non-monsoon			
				(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)
1	Deoghar	Deoghar	Non-Command	1956.13	241.43	113.92	136.14	2447.62	122.38	2325.24
2	Deoghar	Devipur	Non-Command	1156.97	157.5	102.25	114.55	1531.27	76.56	1454.71
3	Deoghar	Karon	Non-Command	784.25	92.41	105.57	120.32	1102.55	55.13	1047.42
4	Deoghar	Madhupur	Non-Command	967.04	146.14	145.35	130.56	1389.09	138.91	1250.18
5	Deoghar	Margomunda	Non-Command	770.47	77.62	39.84	78.55	966.48	96.65	869.83
6	Deoghar	Mohanpur	Non-Command	1231.02	174.84	121.35	154.8	1682.01	84.1	1597.91
7	Deoghar	Palojori	Non-Command	1369.53	179.15	128.18	164.75	1841.61	92.09	1749.52
8	Deoghar	Sarath	Non-Command	1306.84	197.49	281.68	204.25	1990.26	199.02	1791.24
9	Deoghar	Sarwan	Non-Command	1037.45	104.52	181.04	178.4	1501.41	150.14	1351.27
10	Deoghar	Sonaraithadhi	Non-Command	547.31	82.71	171.31	122.45	923.78	92.38	831.40
District Total				**11127.01**	**1453.81**	**1390.49**	**1404.77**	**15376.08**	**1107.36**	**14268.72**

Annexure-VI B

Assessment of Dynamic Ground Water Resources of Jharkhand State (2020)

Assessment Unit/ District	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	Net Ground Water Availability for future use	Stage of Ground Water Extraction in %	Category
Deoghar	2325.24	453.37	691.22	5.19	1149.78	1170.66	49.45	safe
Devipur	1454.71	396	141.21	0	537.21	916.52	36.93	safe
Karon	1047.42	441.75	116.45	0	558.21	488.4	53.29	safe
Madhupur	1250.18	469.25	315.48	0	784.73	463.25	62.77	safe
Margomunda	869.83	278.75	114.45	0	393.2	475.83	45.20	safe
Mohanpur	1597.91	550.125	232.04	0	782.17	814.13	48.95	safe
Palojori	1749.52	658.125	212.82	0	870.95	877.09	49.78	safe
Sarath	1791.24	581.625	223.32	200	1004.95	784.74	56.10	safe
Sarwan	1351.27	646.625	119.76	0	766.38	584.06	56.72	safe
Sonaraithadhi	831.40	490.5	100.44	0	590.94	239.76	71.08	Semi-critical
Total	**14268.72**	**4966.12**	**2267.19**	**205.19**	**7438.52**	**6814.44**	**53.03**	