केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

DUMKA DISTRICT, JHARKHAND

राज्य एकक कार्यालय, रांची

State Unit Office, Ranchi

भारतसरकार

Government of India

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Department of Water Resources, River Development & Ganga Rejuvenation

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Central Ground Water Board

Aquifer Maps and Ground Water Management Plan of Dumka district, Jharkhand(2018-19)

जलभृत नक्शे तथा भूजल प्रबंधन योजना

दुमका जिला,झारखण्ड (2018-19)

Auto flow well at Primary School, Pokharia West, Sikaripara block, Dumka

DTH drilling of EW at village Bedia of Jama block, Dumka district

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State Unit Office, Ranchi

Mid- Eastern Region, Patna, 2020

REPORT ON NATIONAL AQUIFER MAPPING AND MANAGEMENT PLAN OF DUMKA DISTRICT, JHARKHAND 2018 – 19(PART – I)

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REPORT ON AQUIFER MAPS AND MANAGEMENT PLAN OF DUMKA DISTRICT, JHARKHAND STATE 2018 - 19 (PART – I)

List of tables

List of figures

List of Annexure

REPORT ON AQUIFER MAPS AND MANAGEMENT PLAN OF DUMKA DISTRICT, JHARKHAND STATE 2018 – 19(PART – I)

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 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 study of Dumka district has been taken up in AAP 2018-19 as a part of NAQUIM Programme. The aquifer maps and management plans will be shared with the administration of Dumka district and other user agencies for its effective implementation.

1.1 Objective and Scope of the study:

The major objectives of aquifer mapping are

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

Thegroundwater 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.

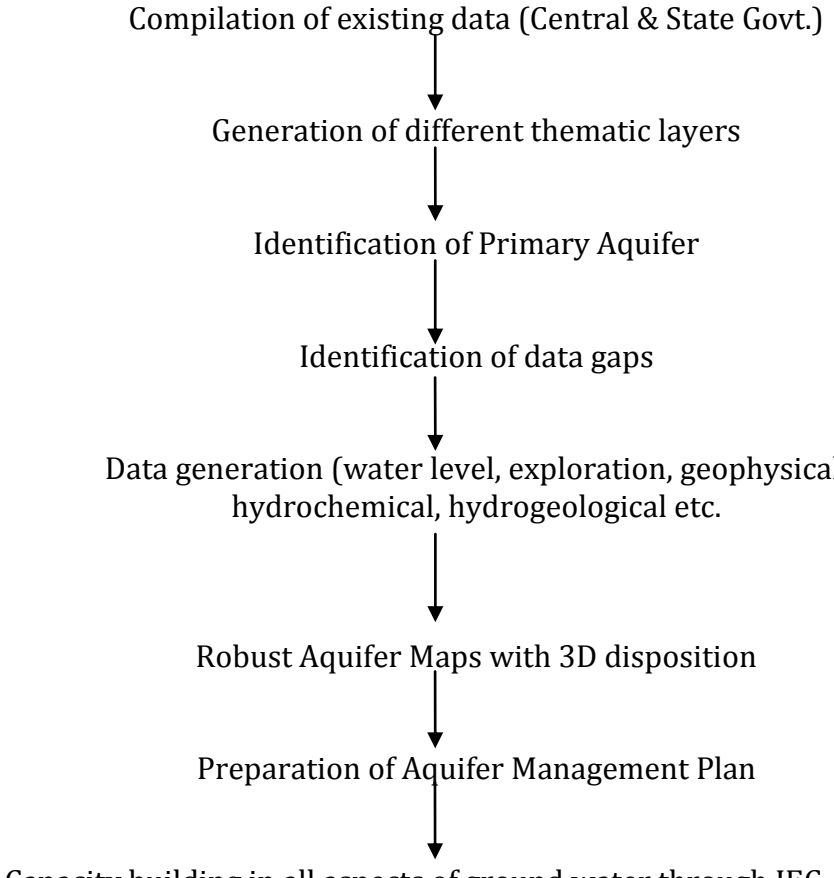
The main activities under NAQUIM are as follows:
a). Identifying the aquifer geometry
b). Aquifer characteristics and their yield potential
c). Quality of water occurring at various depths
d). Aquifer wise assessment of ground water resources
e). Preparation of aquifer maps and
f). Formulate ground water 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:

Dumka district is the part of Santhal Pargana Commissionery and is located in the north eastern part of the Jharkhand state, lies between North Latitude 23°47'20" & 24°38'57" and East Longitude 86°28'25" & 86°42'16" and is covered under the Survey of India Toposheet nos. 72 P/2, 3,4,6,7,8,10,11,12,16; 72 L/12, 14, 16; 73 M/1, 5 and 73 I/9, 13. It is bounded by Godda and Banka district in the north, Pakur in the east, West Bengal in the south, Jamtara in SW and Deoghar in the west.The District has an area of 3716.02 Sq. km and the total population of Dumka district is 1321442 (census 2011) with 12.31 lakh rural population and 0.90 lakh of urban population.

The district comprises only one sub-division, Dumka and it consists 10 blocks: viz. Saraiyahat, Jarmundi, Jama, Ramgarh, Dumka, Gopikander, Kathikund, Shikaripara, Raneshwar and Masalia with 2944 villages. The index map of the study area is shown in figure – 1.

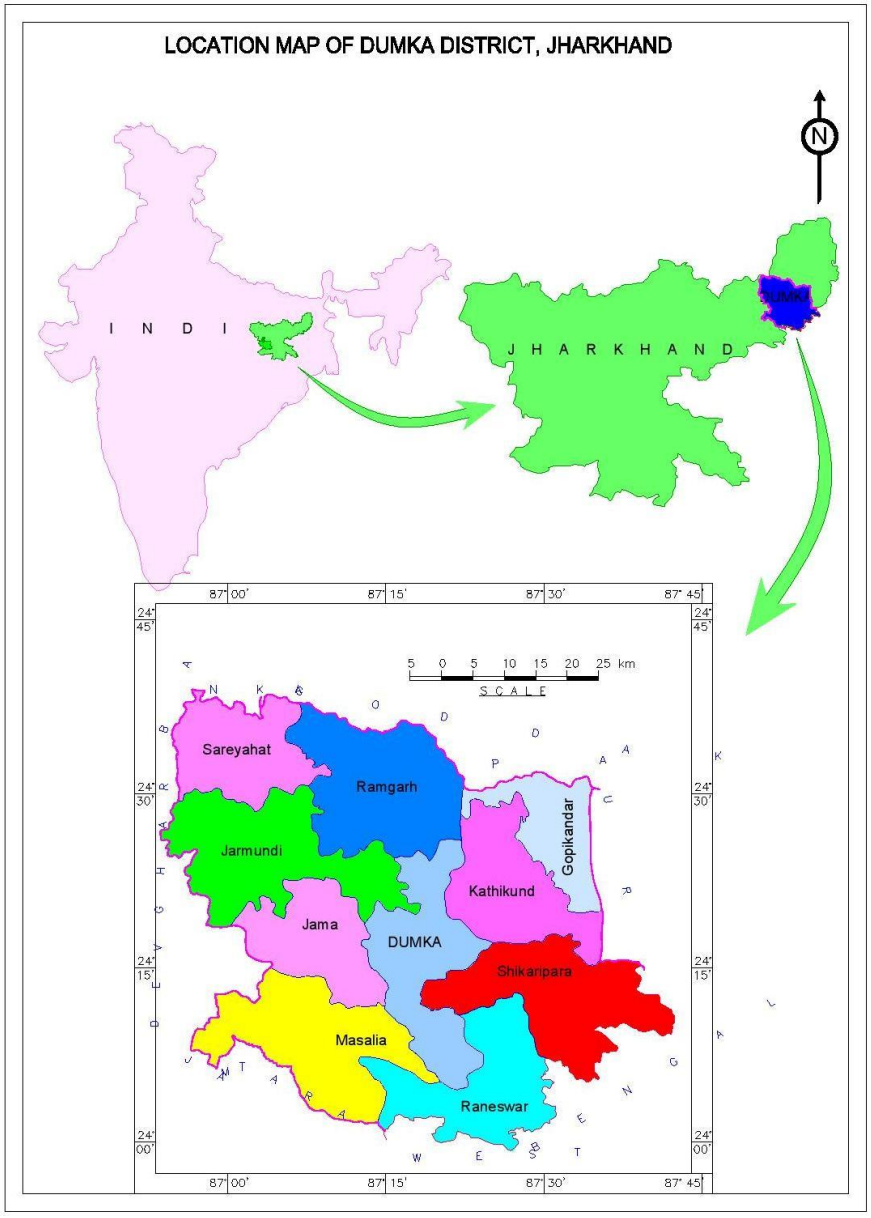


Figure -1: Location map of Dumka district

1.4 Data Availability, Data Adequacy and Data Gap Analysis

1.4.1.Data availability: Central Ground Water Board has carried out exploratory drilling in the district and drilled 19 exploratory and 16 observation wells by departmental rig during the year 1989-2003. Similarly, 09 exploratory wells and 02 observation wells were drilled during the year 2018-19. In addition, 03 numbers of exploratory wells were drilled through outsourcing drilling during the year 2012in the district.At least three exploratory and one observation wells are to be drilled in each block to know the sub – surface geology, depth and thickness of water bearing formation with their yield and determine the different aquifer parameters.

In addition,sixteen numbers of permanent observation well (HNS) of Central Ground Water Board located in the district for monitoring of 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, State Unit Office, Ranchi, Geophysical Survey carried out in the area, ground water monitoring stations and ground water quality stations monitored by Central Ground Water Board were compiled and analyzed for adequacy of the same for the aquifer mapping studies.

After taking into consideration, the available data of ground water exploration, geophysical survey, ground Water monitoring and ground water quality, the data adequacy is compiled and the summarised details of required, existing and data gap of exploratory wells, ground water monitoring and ground water quality stations is given below in Table-1

Table – 1: Data adequacy and data gap analysis

Exploration data			**Geophysical data**			**GW monitoring data**			**GW quality data**		
Req.	Exist.	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap
30	31	8	47	24	23	20	16	4	20	29	0

The data adequacy as discussed above indicates that the existing data is not 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 2018-19. Each two numbers of exploratory wells are required in Gopikandar, Kathikund, Shikaripara and Raneshwar blocks of the district. In addition 11 wells have also been proposed for outsourcing in Dumka district.

1.5 Climate and Rainfall: The climate of the district has been divided into three different seasons. The winter commences from middle November and extends upto middle of March, December and January being the coldest months. The winter is characterized by heavy dew, thick fog and associated cold wave. The winter is followed by summer which lasts upto middle June. The heat is sometimes oppressive but generally nights are pleasant due to cool breeze. The monsoon sets in by the middle of June and continues upto end of September. The beginning of monsoon is marked by the strong dust storms from north – west with thunder and lightning. Normal atmospheric temperature recorded in the district is of the order of 42^0 C to 46^0 C in summer. In winter the minimum temperature goes down to about 4^0 C. The relative humidity varies from 50 – 60%.

The district receives its share of rainfall mainly by south–west monsoon during rainy period and from the retreating monsoon during the inter monsoon period which originates in the Bay of Bengal. The district receives 80% of the annual rainfall during monsoon period. Rainy season sets in the middle of June and continues till middle of October. The rainfall generally decreases from South – East to North – West. The Decadall average monsoon rainfall (2008 to 2018) of the district is 1043.67 mm and block wise it varies from 776.12 to 1351.07 mm.The rainfall data forthe period of 2008–19 has been work out and analyzed Decadal annual monsoon rainfall, standard deviation and coefficient of variation which are given table – 2. Block wise monsoon rainfall (2008 – 2018) is presented in Annexure - 1.

Table – 2: Analytical data of monsoon rainfall (2008 – 18) of Dumka district

Sr. No.	Block	Decadal average monsoon rainfall (mm)	Standard deviation	Coefficient of variation (%)
1	Dumka	1351.07	515.03	38.12
2	Jama	776.12	256.02	32.99
3	Jarmundi	1196.22	191.68	16.02
4	Saraiyahat	1270.81	391.93	30.84
5	Ramgarh	999.86	314.48	31.45
6	Gopikandar	9.34.88	242.19	25.91
7	Kathikund	855.02	404.63	47.32
8	Sikaripara	869.34	190.66	21.93
9	Raneshwar	1125.38	260.82	23.18
10	Masalia	1058.00	203.69	19.25

1.6 Physiography:

Topographically the district is an upland tract with a hilly backbone running from north to south. The general elevation of the area is between 150 m to 640 m amsl. The prominent hills are Rajmahal hills, Ramgarh hills, Karakata and Sapchala hills. Among the loftiest peaks are Mahuagachi (528 m), Korcho hills (640 m), Karakata (210 m). The general slope of the district is from North West toSouth East. The hills in many parts are covered with dense forests, while in the valleys small villages surrounded by cultivated clearing are found.

1.7 Geomorhpology: The land scape of the district is to a large extent comprises of long undulated ridges forming rugged and coarse dissected topography between which runs the drainage channels. The trough in between the undulations is full of rich alluvial soil. Geomorhologically the district can be broadly be divided into three well defined, physically identifiable and genetically significant units: the hilly area, the undulating terrain, peneplained flat country and valleys.

Geomorphological map of the Dumka district has been prepared and represented as figure – 2.

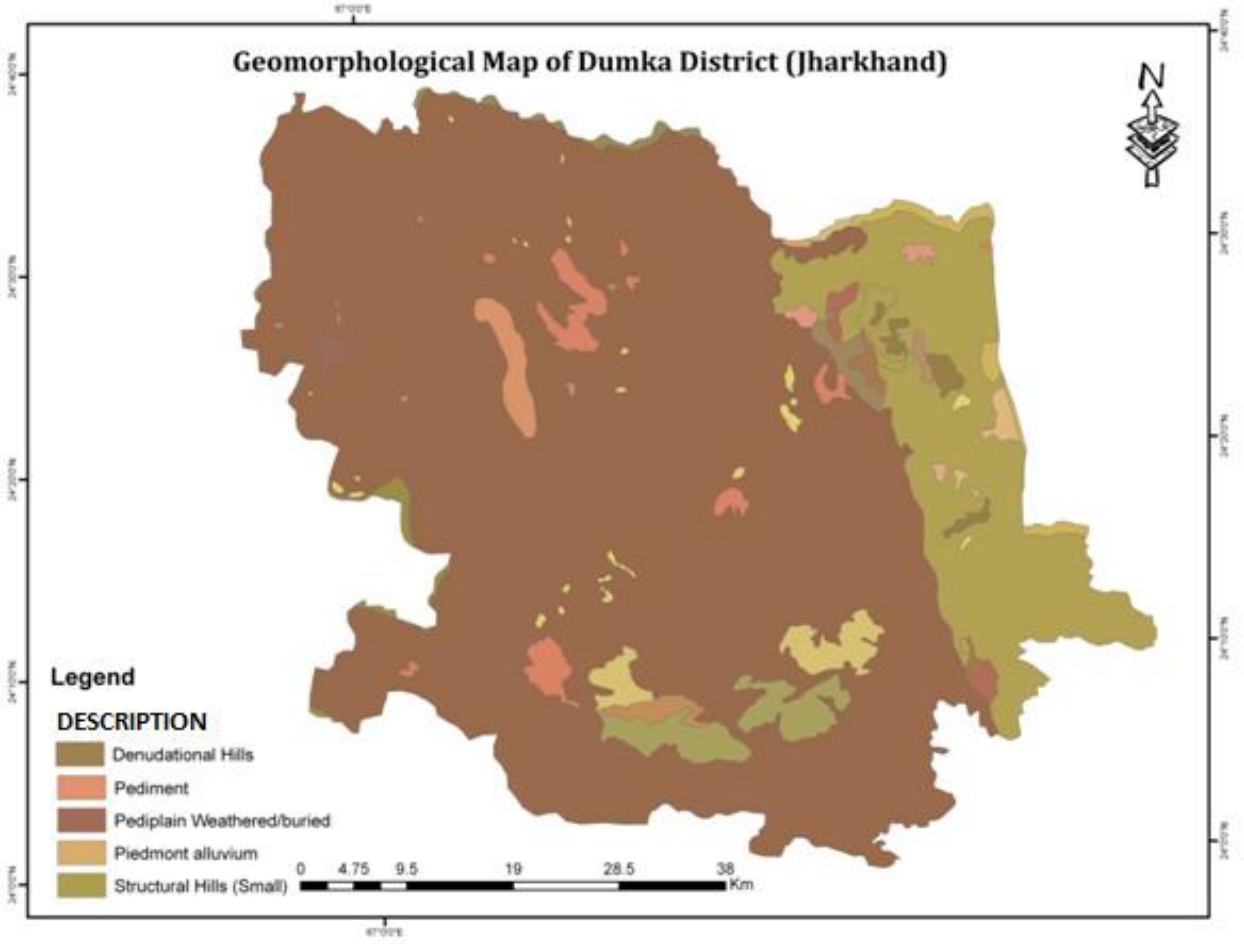


Figure – 2: Geomorphological map of Dumka district

1.8 Land use:

Thedistrict has seen constant migration of aboriginals and plain dwellers from other part of the State, who has contributed to the various uses of land and its resources. There is dominance of cultivation over other uses of land in plains whereas the significance of forest in high land attains almost the same significance as that of agricultural land use. The forests are store house of manifold resources like fuel, timber, herbs and are source of raw materials from farm to factories. Moreover forests are linked with the culture and socio-economic conditions of the aborigines. Their survival depends on the existence of forests as they are rain bringer, soil binder and pasture preserver.

Out of total geographical area of the district i.e 3716 Sqkm, nearly 15 % area comes under net sown area,13% under forests and the rest area falls under barren, cultivable waste, pasture and other agricultural use. Block wise land utilization data of the Dumka district for the year 2016-17 is given in table – 3.

Table: 3: Land use pattern of Dumka district (2016– 2017)

Sr. No.	Block	Area (in Sq. km.)	Forest land (ha)	Barren & non agricul-ture land (ha)	Cultivable waste land (ha)	Perma-nent postur e & other grassi ng land (ha)	Land under miscall-aneous tree (ha)	Other than curren t fallow (ha)	Current fallow (ha)	Net area sown (ha)
1.	Dumka	378.8	3996.92	4064.75	2325.35	1510.85	507.89	4834.43	10038.42	5419.08
2.	Jama	585.9	2148.11	2677.00	2855.55	2263.44	758.83	5195.81	12609.14	6768.93
3.	Jarmundi	399.2	777.99	1663.22	2180.06	3007.76	257.27	5077.27	15756.04	8349.70
4.	Saraiyahat	298.1	1258.94	1638.29	1191.55	1897.50	444.27	3551.72	11536.50	6425.14
5.	Ramgarh	481.4	2867.23	4235.07	3720.52	2042.95	1306.34	6396.54	20140.31	4266.42
6.	Gopikandar	220.6	7353.26	1823.53	990.78	680.92	501.58	2896.31	2880.68	4219.21
7.	Kathikund	306.2	10079.69	1343.35	1599.11	1092.67	228.70	4405.21	4796.39	5710.98
8.	Shikaripara	339.2	4749.12	3539.86	3471.39	2032.56	555.42	4491.26	17211.16	3259.77
9.	Raneshwar	246.6	6315.14	1832.90	1285.48	1551.15	611.49	3095.15	12587.13	5499.61
10.	Masaliya	460.2	8185.85	2899.26	2879.77	2078.54	421.75	6050.93	14753.08	6937.42
Total		3716.2	47732.25	25717.23	22499.55	18158.35	5971.99	45994.65	122308.84	56856.27

1.9 Soil:

Soils in Dumka district has formed as a result of insitu weathering of the crystalline basement. Climate, topography and vegetation have all contributed in the formation of soils. The following different types of soil occur in the entire district.

1.9.1Alluvial Soil: All the river channels in this district are covered with alluvial soil of recent origin, deposited over crystalline bed rocks. Alluvial fills are also found in patches away from the river channels. Thickness of these fills depends upon the topographical control. The alluvial material consists mainly of silt and sand mixed with clay, silty material dominating over clayey material. These are yellowish – grey in colour.

1.9.2 Grey eroded scarp Soil: Thiscovers almost the entire area as a thin capping over granitic/ gneissic rocks.

1.9.3 Laterite: Pallety, nodular, ferruginous, brownish laterites of Pleistocene age are found to occur as patches. The lateritic soil has been formed by the process of laterisation of the weathering material aided by favorable climate and the local topography. They are highly permeable with poor holding capacity. However laterite formed due to the weathering of

Rajmahal trapa are generally brown to reddish in colour, porous, pitted and show vermicular cavities, and are good repository of ground water.

1.9.4 Forest soil: Forest soil is confined to the reserve forest area and has a surface layer of organic matter.

The pH value of all the soils varies from 5 – 6.5 indicating that these soils are acidic in nature. Undulating terrain and porous character of the soil have resulted in soil erosion all over the area.

1.10 Hydrology and Drainage:

There is only one major irrigation project in the district viz. the Mayurakshi Reservoir Project. The project has been completed in all resptects in th year 1985. The irrigation potential created after completion of project comes to 250860 Ha in the districts of Brbhum, Murshidabad and Burdwan of West Bengal state. Irrigation water is also supplied to the state of Jharkhand from this reservoir to an area of about 6000 ha. The project was planned originally for giving water to Kharif and Boro seasons.

Massanjore Dam has been constructed over the Mayurakshi River located at Massanjore near Dumka in the state of Jharkhand. The Massanjore dam (also called Canada Dam), across the Mayurakshi, was commissioned in 1955. The Mayyrakshi River at the dam site has a catchment area of 1869 sq.km. Massanjore dam is 47.25 m high from its base and is 661.58 m long. The reservoir has an area of 67.4 square kilometres (16,650 acres) when full and has a storage capacity of 620,000,000 cubic metres. The length of the overflow section is 225.60 m and is controlled by 21 bays, each 9.144 m wide. The design discharge is 4.446 cumecs. The full reservoir level is 121.34 m and the flood level is 122.56 m.

Dumka district is highly dissected with rivers of varying magnitude. The Brahmani, Bansloi, Mayurakshi, and their numerous tributaries form the main drainage of the district. These streams are ephemeral in nature. Most of these stream courses are structurally controlled. Mor with its tributaries carry the drainage to the western part of the district which finally meet the Bhagirathi river below Murshidabad, West Bengal. The Brahmani raises in the west of the Dudhua hills in the north of the Dumka district. Dendritic drainage pattern, a typical of hard rock terrain has developed over the district. However, radial drainage is also developed locally in some areas. All these drainage are having rapid surface runoff. Surface flow of most of the rivers dries up during summer; however there is sub-surface flow for a considerable part of the year, which indicates the effluent nature of the rivers. The drainage map of the Dumka district is shown in figure - 3.

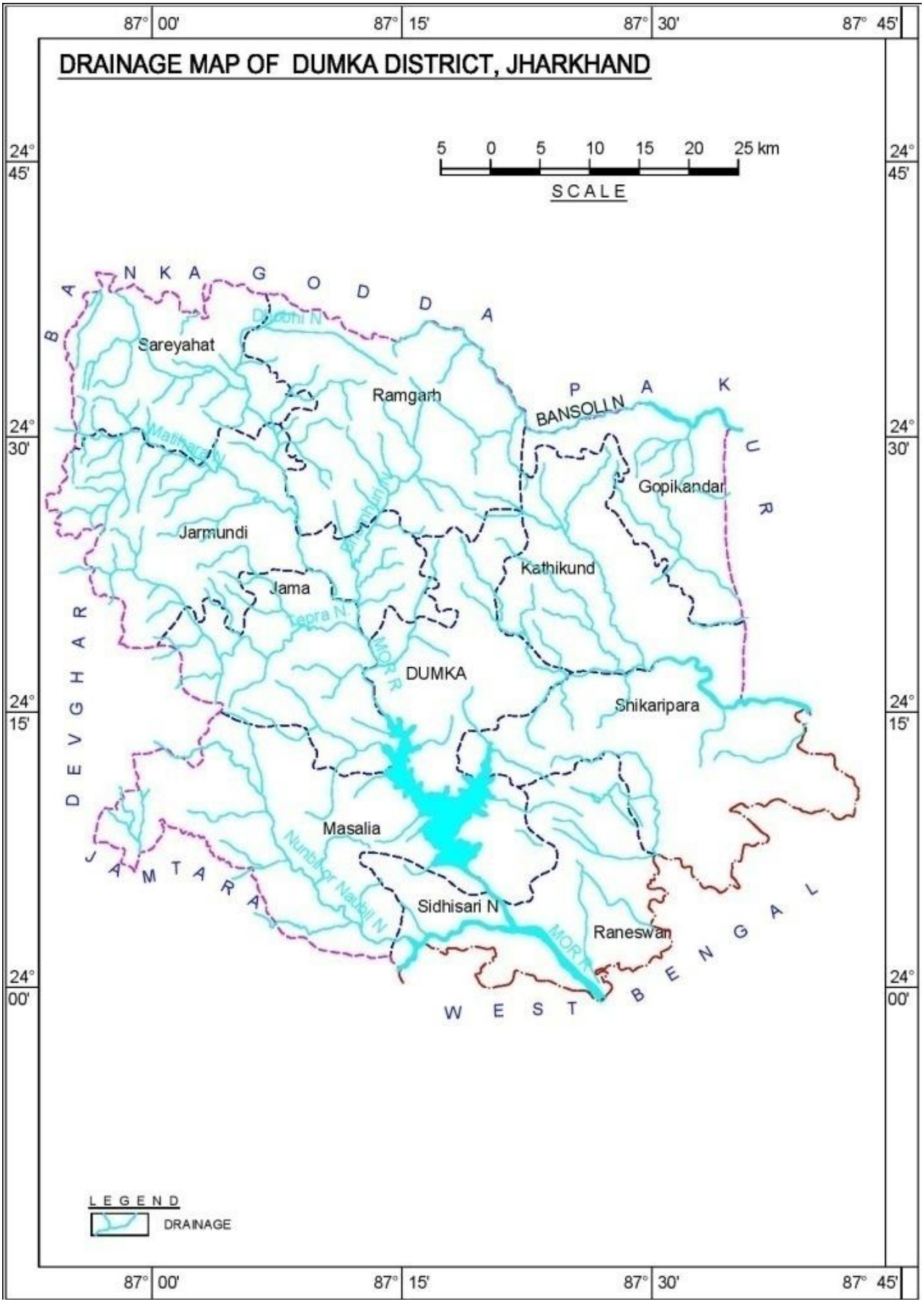


Figure – 3: Drainage map of Dumka district.

1.11 Agriculture and Irrigation practice:

Agriculture is the major occupation of the rural population of the district. Since the density of population is high, there is acute pressure on land for agriculture use. But the land available for cultivation is limited because of rugged and hilly geomorphological set-up.

There is only one major irrigation project in the district i.e. Mayurakshi River valley Project located at Masanjor. As per irrigation data for the year 2016-17, only 410.03 hectare of land of the district is being irrigated from this project. In addition to this project, there are ponds and few lift irrigation schemes operating in this district irrigating some hectare of land. The most common ground water source is the dug well, but this is not a very dependable source of irrigation. The major part of the district being rocky in nature, it is difficult to dig wells. 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. Block wise number of irrigation structure and source wise irrigation data of the district is given in table – 4&5 respectively.

Table – 4: Block wise number of irrigation structure of Dumka district (2016-17)

Sr. No.	Name of Block	Surface water			Ground water
		Canal	Pond	LI	Dug well
1	Dumka	1	340	7	445
2	Jama	--	336	9	438
3	Jarmundi	--	314	5	523
4	Saraiyahat	--	361	3	447
5	Ramgarh	--	371	5	420
6	Gopikandar	--	378	5	488
7	Kathikund	--	398	7	411
8	Shikaripara	--	356	8	386
9	Raneshwar	2	344	15	399
10	Masaliya	--	437	17	453
Total		3	3635	81	4410

(Source: District Statistics Officer, Dumka)

Table – 5: Source wise irrigation data of Dumka district(Area in Hectare)

Sr. No.	Name of Block	Surface water			Ground water	Other sources	Total
		Canal	Pond	LI	Dug well		
1	Dumka	183.25	315.30	68.25	227.26	265.50	1059.56
2	Jama	--	1048.20	72.15	229.38	298.56	1648.29
3	Jarmundi	--	693.17	414.46	1075.66	192.48	2375.77
4	Saraiyahat	--	1714.30	319.85	1081.40	357.62	3472.77
5	Ramgarh	--	1621.10	49.75	705.22	757.61	3133.60
6	Gopikandar	--	330.70	73.65	339.77	36.29	707.83
7	Kathikund	--	278.23	38.98	191.98	69.90	578.09
8	Shikaripara	--	462.24	109.45	504.90	153.41	1230.00
9	Raneshwar	226.78	418.70	95.45	531.22	149.85	1422.00
10	Masaliya	--	734.37	235.15	725.55	211.18	1906.25
Total		**410.03**	**7616.31**	**1477.14**	**5612.34**	**2492.40**	**17534.16**

(Source: District Statistics Office, Dumka)

1.12 Cropping pattern:

Paddy is the major crop of the district.Apart from paddy, maize, gram, oil seeds, pulses and vegetables forms the main crop of the district. Wheat has also been started to be sown on a limited scale wherever some irrigation facilities are available. Area under crop for the year 2016 – 17 of the district is presented in table - 6.

Table – 6: Cropping pattern of Dumka district (2016-17) (Area in hectare)

Sr. No.	Block	Major Crops					
		Paddy	**Wheat**	**Gram**	**Maize**	**Pulses**	**Vegetable**
1.	Dumka	5324.29	98.90	60.56	594.91	124.66	214.61
2.	Jama	8245.63	390.44	32.17	934.57	284.00	338.45
3.	Jarmundi	6740.95	463.46	54.90	651.02	489.24	710.47
4.	Saraiyahat	5699.71	518.52	30.61	914.58	222.34	930.16
5.	Masaliya	9063.37	238.91	32.31	2001.30	761.86	467.39
6.	Raneshwar	12653.00	321.47	176.30	184.75	302.42	191.34
7.	Shikaripara	6224.07	311.81	129.56	665.89	111.80	120.74
8.	Ramgarh	7878.75	554.22	64.85	1507.92	504.35	686.67
9.	Kathikund	5395.55	156.98	50.79	665.86	182.98	87.38
10.	Gopikandar	3096.91	186.31	38.10	695.88	267.78	119.83
Total		**70322.23**	**3241.02**	**670.15**	**8816.68**	**3251.43**	**3867.04**

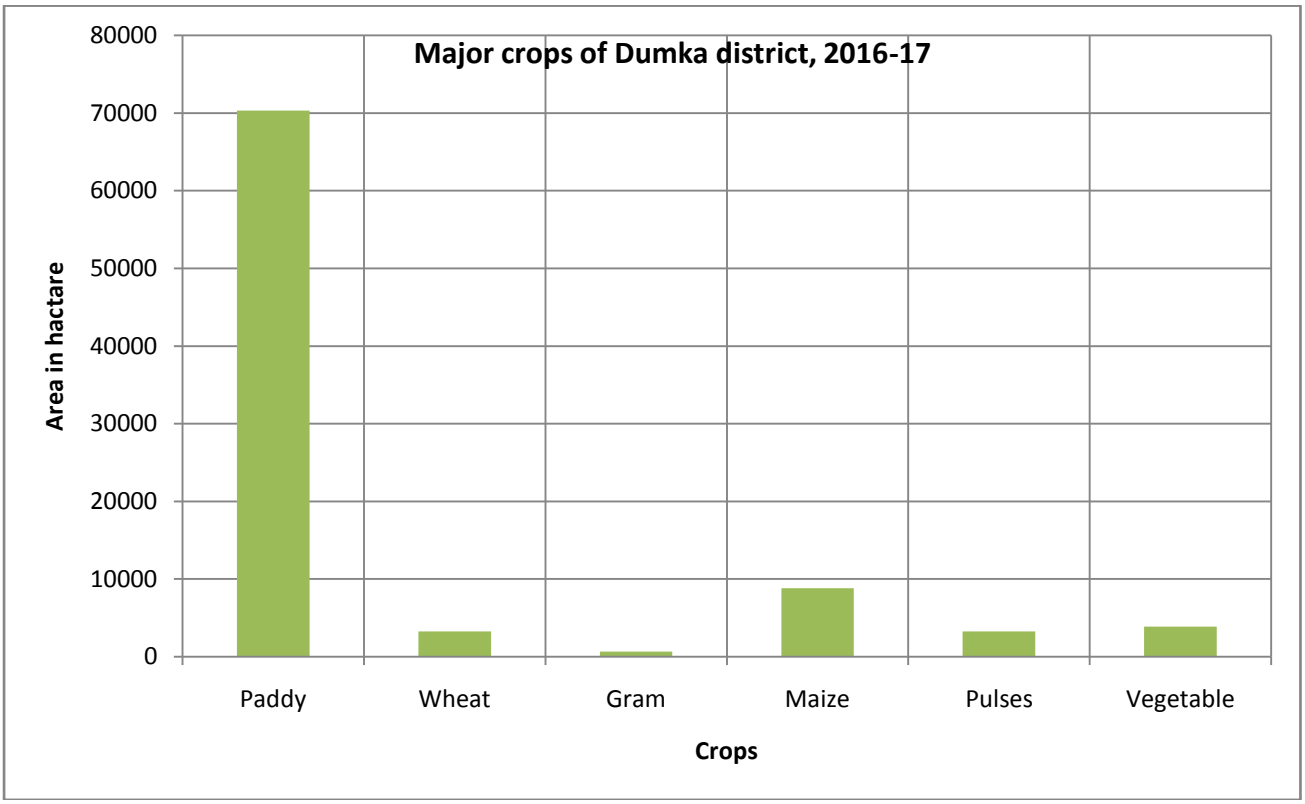


Figure – 4: Major crops of Dumka district (2016-17)

2. DATA COLLECTION AND GENERATION

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 during Annual Action Plan (1989 – 2003) and 19 exploratory wells and 16 observation wells were drilled in the district. During 2012, three exploratory wells were drilled in the district through outsourcing drilling. Similarly, 09 exploratory wells and 02 observation wells were drilled during the year 2018-19 by departmental rig.

2.1 Data Collection and Compilation: The data collection and compilation for various components were carried out as given below -

i. Hydrogeological Data: Water level data of 37 key wells(during 2018) and historical water level trend of monitoring wellswere collected and compiled representing Aquifer-I. Prepared litholog, collected depth and thickness of water bearing zones with their yielding capacity, data from exploratory and observation wells drilled in the district during the year. Also conducted three numbers of soil infiltration tests.

ii. Hydrochemical Data:To evaluate the quality of ground water, 29 samples were collected from dug wells and 32 samples from hand pumps representing shallow aquifer (Aquifer – I) and deeper aquifer (Aquifer – II).

iii. Geophysical survey: 24 VES were carried out to identified the weather zone resistivity and its thickness as wells as find out deeper fracture zone in hard rock formations.

vi. Exploratory drilling:31 exploratory and 18 observation wells were drilled in hard rock area of the district.

vii. Hydrometeorological Data: Collected last ten years (2008 – 2018) annual rainfall data for each of the block from the office of District Statistics, Dumka.

viii.Land use and cropping pattern data: Data of land use and cropping pattern from the office of District Statistics, Dumka.

ix. Irrigation data: Collected number of irrigation structures and source wise irrigation data from the office of District Statistic, Dumka.

2.2Data Generation: After taking into consideration, the data available with CGWB on ground water monitoring wells (GWMW), ground water quality, geophysical survey and ground water exploration, the data adequacy was compiled and it indicated that 23 numbers of geophysical survey (VES) are required in the district.The requirement, availability and gap of major data inputs i.e., exploratory wells, geophysical data, ground water monitoring wells and ground water quality data are detailed in the table – 1.

2.2.1 Ground water monitoring wells:37 key wells were established toassess the ground water scenario of shallow aquifer (Aquifer-I) of the area. The depth of these dug well varies from 4.80 to 10.75 mbgl. Similarly, the diameters of key wells (dug wells) ranges from 1.15 to 3.70 m. During 2018, the pre monsoon (May) depth to water level in these wells monitored between 1.97 to 9.55 mbgl. The post monsoon depth to water level (Nov. 2018) in the dug wellsranges from 1.35 to 9.40 mbgl. Detail of key wells and water level data is presented in Annexure – II & III. Location map of key wells is given in figure – 5.

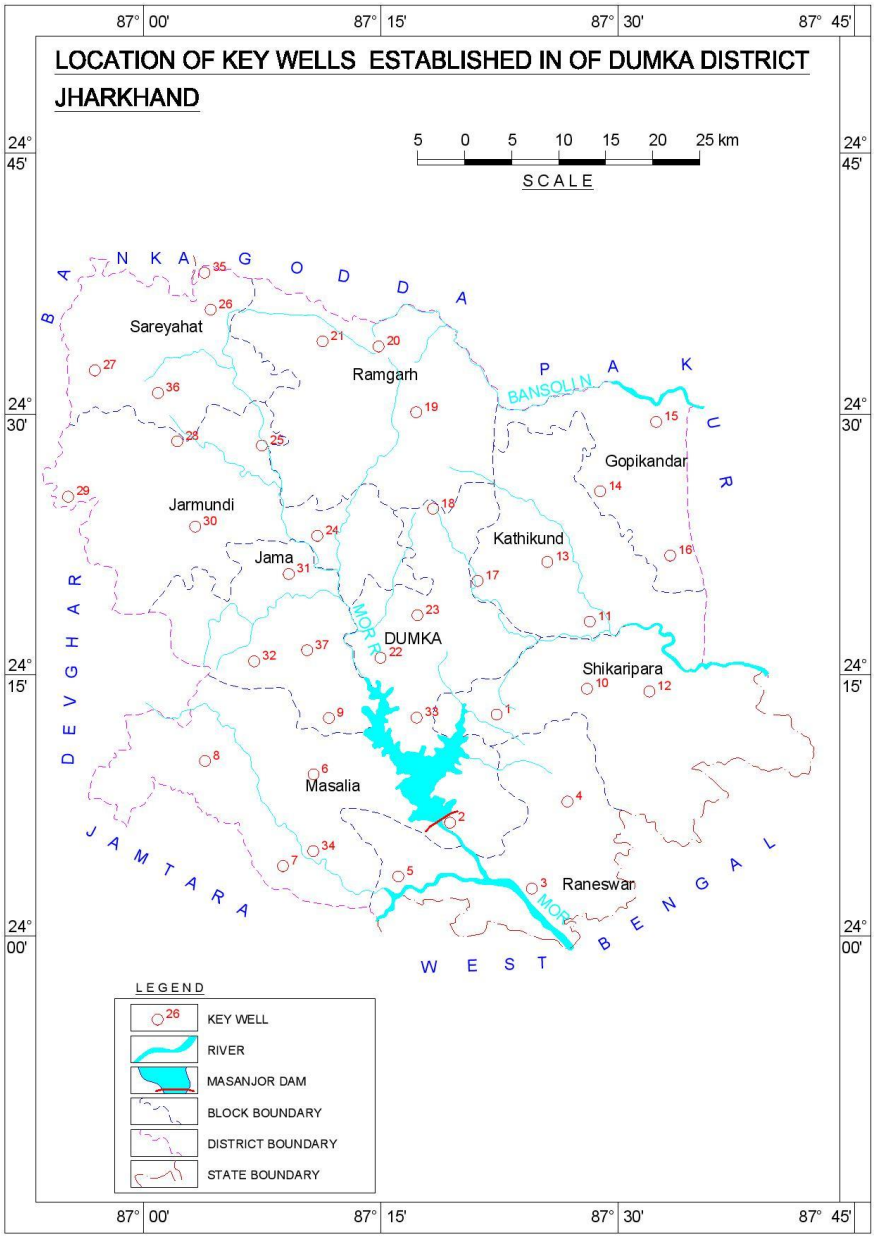


Figure – 5: Location map of key wells established in Dumka district (2018)

2.2.2 Ground water exploration: Till date 31 exploratory and 18 observation wells have been drilled in hard rock area of the district to assess the lithological disposition of shallow aquifer (Aquifer-I) and deeper aquifer (Aquifer-II). The details of exploratory and observation wells are given in Annexure-IV & V.

2.2.3 Ground water quality: To assess the quality of ground water, 30 samples were collected from dug wells representing Aquifer – I. Similarly, 63 samples from hand pumps were collected to evaluate the ground water quality of Aquifer – II.

2.2.4 Geophysical survey: At least 4 VES is required in each block and total 47 VES is required in the district. 87 VES have been carried out by CGWB in the Dumka district.

2.2.5Soil infiltration test: To obtain the actual rate of infiltration of various soil cover and their impact on recharge to ground water, 3 infiltration tests have been conducted in the district. The data has been analyzed and the salient features of the infiltration tests are

presented in table - 7, whereas the data is presented in Annexure –VIand the plots of soil infiltration tests are presented in figure - 6 (a – c).

Table – 7: Salient features of the soil infiltration test

Sr. No.	Village	Block	Co-ordinates	Date	Formation	Initial water level (mm)	Final infiltration rate (mm/hr)
1	Mahura	Saraiyahat	24⁰ 31' 13" 87⁰ 00' 53"	03/03/2019	Granite gneiss	172	55.2
2	Jama	Jama	24⁰20' 37" 87⁰08' 51"	03/03/2019	Granite gneiss	153	27.60
3	Nonihat (Bhadwari)	Ramgarh	24⁰29' 00" 87⁰07' 49"	04/03/2019	Granite gneiss	168	14.40

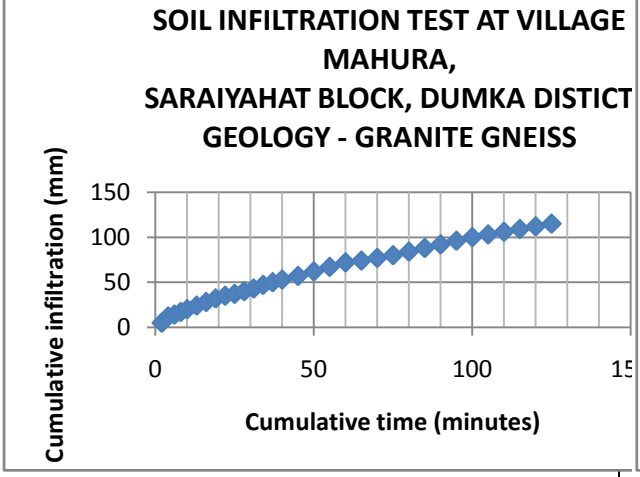


Figure – 6(a)

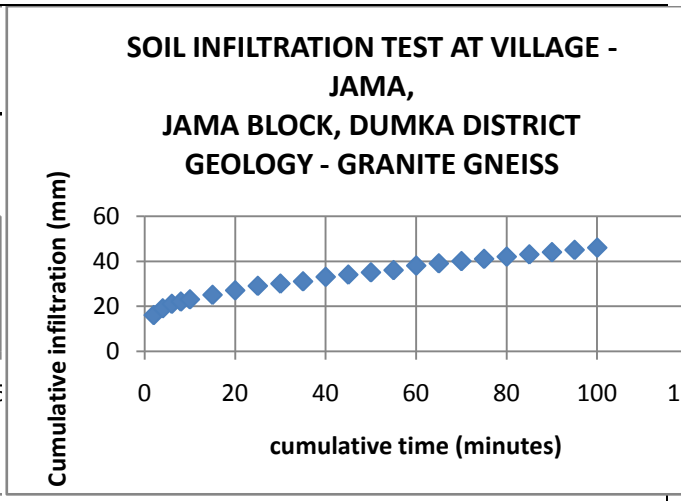


Figure – 6(b)

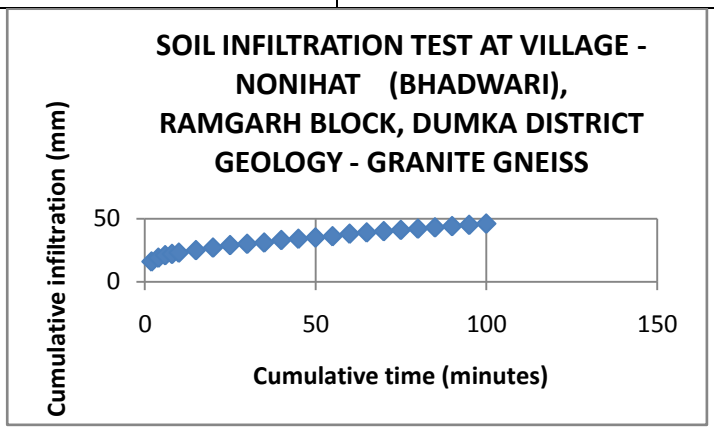


Figure- 6(c)

2.2.6 Pumping test: Based on exploratory wells drilled during 1989–2019, eight numbers of pumping tests were conducted for evaluating the well characteristics and for determining the hydraulic parameters of the deeper fractured aquifer- II. The drawdown data of aquifer performance test (APT) was analyzed and calculated aquifer parameters such as Transmissivity (T) Storage coefficient (S) value of Aquifer – II. Summarized result of aquifer performance test (APT) is given below in table – 8.

Table – 8: Summarized result of APT

Sr. No.	Location	Block	Discharge (m^3/hr.)	Duration of Pumping (in minutes)	Drawdown (m)	T (m^2/day)	S
1	Shiv Pahar	Dumka	11.85	1000	14.91	107.8	0.00020
2	Kathikund	Kathikund	26.4	1080	12.04	29.50	0.00080
3	Raneshwar	Raneshwar	17.82	1000	20.55	41.00	0.00052
4	Basukinath	Jarmundi	43.36	1000	14.70	186.00	0.00025
5	Shikaripara	Shikaripara	34.32	1000	20.05	14.10	0.000073
6	Nishchintpur	Dumka	19.35	2800	17.68	14.04	0.00082
7	Masaliya	Masaliya	66.49	1500	10.25	174.04	0.023
8	Nawasar	Masaliya	32.94	1000	18.61	19.66	0.0011
9.	Dumka	Dumka	11.16	-	26.67	5.0	-

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

1. Drainage
2. Geomorphology
3. Geology & structures

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

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

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

3.1 Geological set up:

Geologically, Dumka district(GSI,) is represented by Chotanagpur Granite-Gneiss of Archaean age to Proterozoic and Eastern Ghat super Group of Archean age, which are overlain by Gondwana Super Group , Rajmahal basaltic lava flows (Upper Jurrassic to lower cretaceous age) with intertrappean beds and at places Laterites.

The Chotanagpur Gneissic complex is largely represented lithological unit in the area and covers the major part of the district uninterruptedly. They form more or less gently undulating plains and high grounds pediments and buried pediments, seldom giving rise to small hillocks mounds. They are mostly biotite gneisses and granite gneisses and in general coarse grained with porphroblastic texture and traversed by pegmatititeand quartz vein of various dimensions. It contains enclave of amphibolites and mica schists. These rocks are highly folded and have very steep foliation dip.These gneissic rock have been intruded by numerous dykes. Eastern Ghat Super Group is represented by Patches of acid to basic charnockite and Khondalite/Garnet Sillimanite-Biotite Gneiss.

The precambrian formations are overlain by Gondwana formations. Gondwanas are represented by Barakar, Talchir and Dubrajpur formations in the form of a strip running roughly in the NW-SE direction. However isolated patches of this formation are also found to occur in the central part of the district. Talchir formations consist of sandsone and shales. Barakar formation consists of white to fawn colored coarse grained sandstone, grits with occasional conglomerstes and carbonaceous shales, thin lenticles and streaks of coal are found in this formation. Common plant fossils occurring in Barakar shales incude gangomopteris, cyclipteris, glossoperis indica and vertebraria indica.Dubrajpur formations consist of sandsone and shales.

The precambrian formations/Gondwana formations are further overlapped by Rajmahal Traps consists of basaltic lava flows with sedimentary intertrappeans. The basaltic rocks are hard and fine to medium grained.Some of the lava flows are vesicular and cavities being filled by calcite and chalcedony. The non vesicular lava flows are hard, tough, compact and fine to medium grained in nature. The vesicular types are comparatively soft and break easily. They are greenish to dark in colour with number of flows not clearly delineated in this district. In general the Rajmahal traps show vertical to horizontal joints trending E-W and N-S. Typical columnar joints are also common. These rocks are weathered with characteristic spherical exfoliation which gives rise to large rounded boulders as the out crops. It has been proved that basalts too are productive when either weathered or fractured.
The Laterites are found in patches over Rajmahal traps. The alluvium patches are generally seen along major streams. Narrow, discontinuous patches of alluvium particularly in granitic country are identified. They comprises medium to coarse grained sand associated with silt and clay. Occasionally calcareous nodules are also found to occur. They are light grey to

brownish colour. The thickness of the alluvium varies from place to place and is largely controlled by topography of the basement crystalliones.

In the district, the rocks are highly deformed and metamorphosed. The exposure of granite and other associated rocks show intricate folding. Based on morphotectonic analysis, the area has undergone several phases of tectonic deformations which leads to various sets of fractures, fissures, faults etc which leads to lineaments. Based on lineament study of the area, various sets of fractures have been identified

The general geological succession as encountered in Dumka district (As per GSI) is given below

Lithology	**Formation**	**Age**
Alluvium	Quaternary	Recent
Laterite	Laterite	Cenozoic
Rajmahal trap & Intertrapeans	Rajmahal	Middle Jurrasic to Cretaceous
Sandstone and shale	Dubrajpur	Upper Gondwana (Triassic to Lower Jurassic)
……Unconformity……..		
Silt stone, sandstone and shale with Coal seams	Barakar	Lower Gondwana (Carboniferous to Permian)
Shale, sandstones and Conglomerate	Talchir	
……Unconformity……..		
Granite gneiss, biotite-Gneiss, schists, amphibolites, Hornblend schist,pegmatite, quartz veins	Chotanagpur Granite-Gneissic Complex & Unclassified metamorphics	Archean to proterozoic
Charnockites and Khondalites	Eastern Ghat Super Group	Archean

The weathering zone in Dumka district varies from 6 to 41 m, as per lithologs of the exploratory bore well.

Geological map of Dumka district has been prepared and presented in figure – 7.

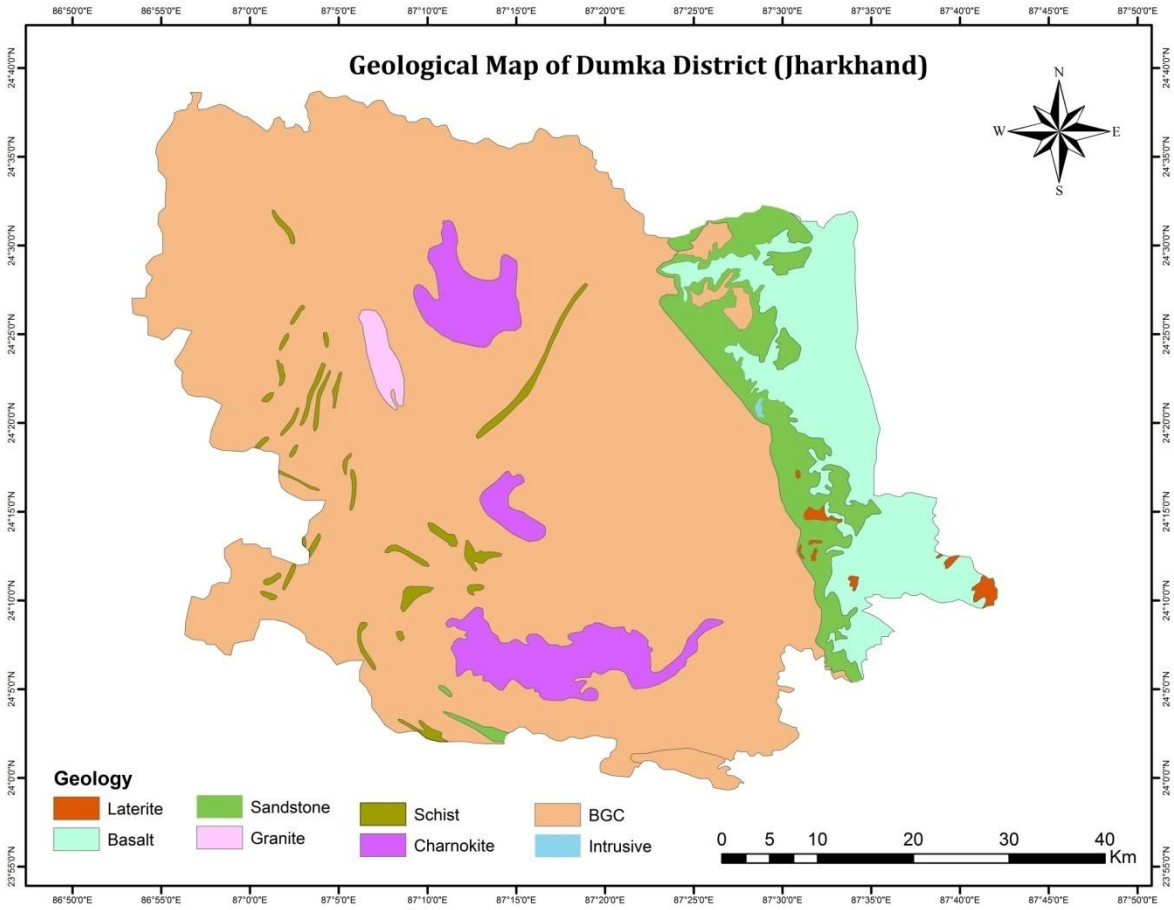


Figure – 7: Geological map of Dumka district

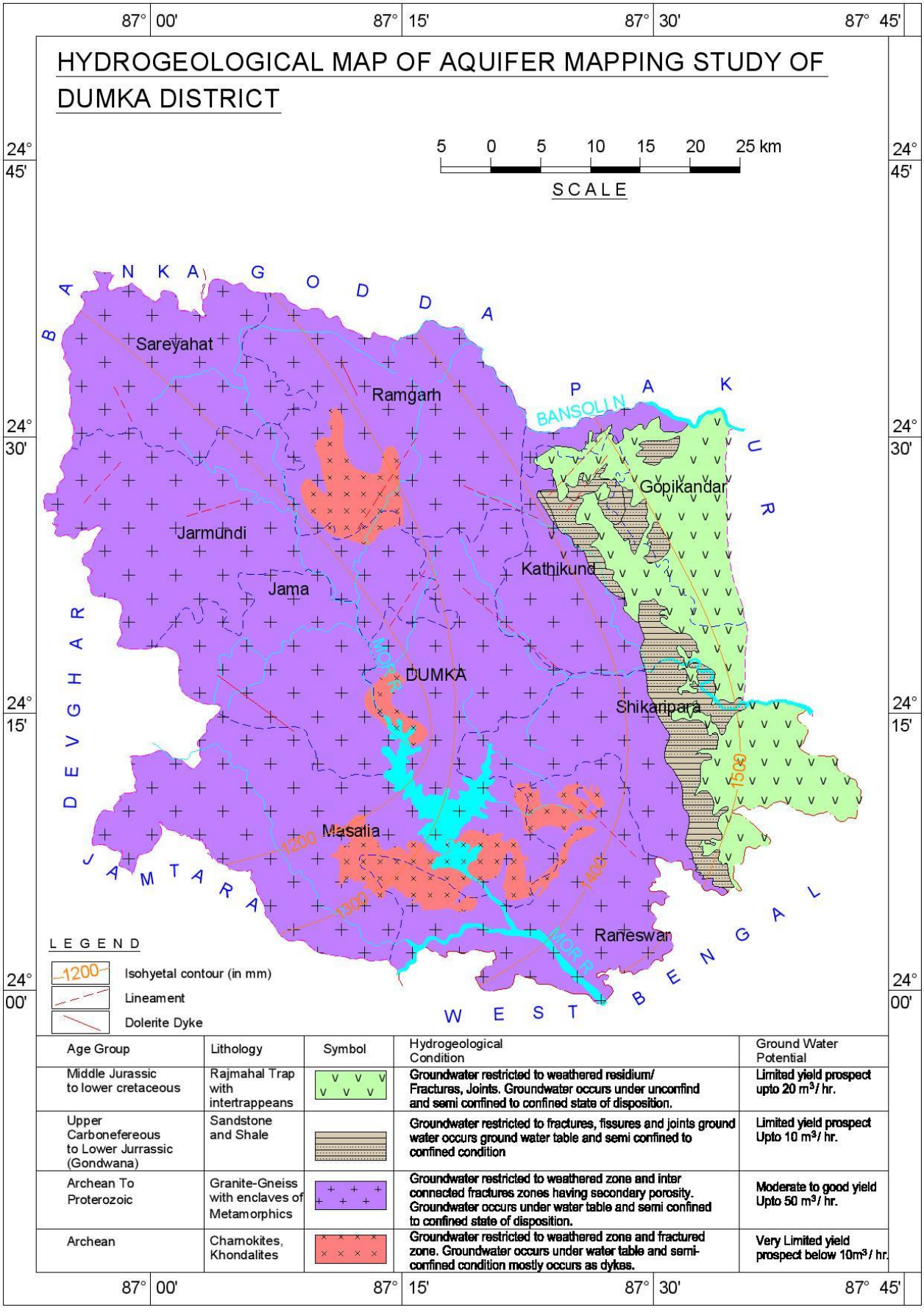
3.2 Hydrogeology:

Ground water in the district is replenished mainly by the atmospheric precipitation. The depth to water and water level fluctuation depends mainly on the amount and distribution of rainfall, geomorphological set up, lithology etc. The occurrence and movement of Ground Water in the area is broadly governed by geological frameworks, i.e nature of rock formations including their porosity and permeability. A fracture system roughly corresponds to a hydraulic system in the rock. A rock which has been exposed to a two-phase brittle deformation can also constitute one hydraulic system if there is a good connection between the two fracture systems. Highly fractured rocks may be treated in hydrological computations in a similar way as porous media (Larsson, 1984). Based on morpho-genetic, geological diversities and relative ground water potentialities of the aquifers, the district can be broadly divided into three Hydrogeological units: Consolidated or Fissured formations, Semi-Consolidated and unconsolidated or Porous formations .

1. Consolidated or Fissured formations - Precambrians and Rajmahal Trap
2. Semi-Consolidated formations -Gondwanas
3. Unconsolidated or Porous formations - Laterites and Alluvium

In major part of this district Fissured formations i. e hard rock form the principal aquifers, which include mainly Chotanagpur Granite gneissic complex and Rajmahal Traps. However, in isolated areas Gondwana formations, laterites, as well as valley fill materials along the vicinity of the rivers also form potential aquifers.

Hydrogeological map of Dumka district has been prepared and presented in figure – 8.



Age Group	Lithology	Symbol	Hydrogeological Condition	Ground Water Potential
Middle Jurassic to lower cretaceous	Rajmahal Trap with intertrappeans		Groundwater restricted to weathered residium/ Fractures, Joints. Groundwater occurs under unconfind and semi confined to confined state of disposition.	Limited yield prospect upto 20 m^3/ hr.
Upper Carbonefereous to Lower Jurrassic (Gondwana)	Sandstone and Shale		Groundwater restricted to fractures, fissures and joints ground water occurs ground water table and semi confined to confined condition	Limited yield prospect Upto 10 m^3/ hr.
Archean To Proterozoic	Granite-Gneiss with enclaves of Metamorphics		Groundwater restricted to weathered zone and inter connected fractures zones having secondary porosity. Groundwater occurs under water table and semi confined to confined state of disposition.	Moderate to good yield Upto 50 m^3/ hr.
Archean	Charnokites, Khondalites		Groundwater restricted to weathered zone and fractured zone. Groundwater occurs under water table and semi-confined condition mostly occurs as dykes.	Very Limited yield prospect below 10m^3/ hr.

Figure – 8: Hydrogeological map of Dumka district

3.2.1 Ground Water in Aquifer-I (Weathered Granite- Gneisses, Sandstone ,weathered basalt, Laterites): The aquifer-I i.e shallow aquifer is represented by Weathered Granite-

Gneisses,Weathered sandstone ,weathered basalt & Laterites. Within the depth zone of dug wells, the weathered zone influences to a greatextent in the hard rock formation constituting potential phreatic shallow aquifer. Almost all the rock types in the precambrial 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. Laterites are mainly of insitu origin and have formed by subaerial erosion of underlying basalts under favourable climatic condition. Potential aquifer exists at shallow to moderate depth. The thickness of weathered zone varies from 6.00-41.00.

Ground water occurs in 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 m^3/hr in laterites/weathered Granite-gneiss /Weathered basalt. In the shallow zones of weathered hard rock the depth of the dug wells varies from 10–15 mbgl. This zone should be developed either through large diameter open wells or shallow borewells of 20 –35 m depth which permits draft upto 10 m^3/hr for domestic as well as irrigating small holdings of land.

3.2.2 Ground Water in Aquifer – II (Fractured Granite & Gneisses, sandstone and fractured basalt):

The Chotanagpur granite-gneiss, belonging to Precabmrian age and Rajmahal traps constitutes the group of Fissured formation hydrogeological units and to some extent Gondwana sandstones 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,(Shekhar& Mukherjee, 2010). The Precambrian shields are among the oldest parts of the earth's crust. 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 coupled with satellite data and deep exploratory wells drilled 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 amphibilite 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.

Rajmahal Traps in the area constitutes number of basaltic flows separated by intertrappean beds which are often agillaceous and arenacious in nature. The intertrappean beds seperates two flows occurs as impermeable beds. The distinctive hydrogeological features of the basaltic rocks is the significant primary porosity in the form of vesicles, cracks etc. The secondary porosity is developed due to fracturing during cooling of lavas, tectonic disturbances, weathering etc. The contact of two flows where vesicles are not filled with secondary minerals also found to be potential aquifers.The study reveals that vesicular basalt, intertrappeans formation etc form suitable condition for ground water storage.

3.2.2.1 Potential Fractures in Aquifer-II: Number of boreholes has been constructed by CGWB in the district under groundwater exploration programme upto maximum depth of 200 m (Table-9). The borehole data reveals that, in general potential fractures are encountered between 30-100 m. The fractures in the directions of NW-SE, NE-SW and N-S are found to be

intense(Shekhar & Mukherjee, 2010). The other fractures have also of good potential. Table-9 shows the Potential Fracture encountered during Ground Water Exploration in Dumka district

Table – 9: Potential fractures encountered during ground water Exploration in Dumka district, Jharkhand

S. No.	Location	Block	Depth Drilled (m)	Major Lithology	Depth of casing (m)	Potential Fracture Zone (m bgl)	Static Water Level (m bgl) at the time of drilling	Discharge (m^3/h) compressor
1	Hijlapahar	Dumka	150	GG	8	22-24, 56-59, 112-113.00	5.36	7.38
2	Shiv pahar	Dumka	159	GG	9.2	151.00-153.00	25.45	35.4
3	Kathikund	Kathikund	140	GG	15.82	32.00-34.00, 39-40, 48.00-49.00, 58-60,78.00-81.00, 100-103	9.96	26.4
4	Raneshwar	Raneshwar	200	GG	18.5	50-52, 74.00-75.00, 117-118, 121-123,	5.18	17.82
6	Basukinath	Jarmundi	121.1	GG	15.03	24-26, 42-43, 45-46, ,61-63,106 - 108	3.55	43.34
7	Hansdiha	Hansdiha	115	GG	13	31-32, 33-36, 70-71, 92-93,102-103, 106-107	5.14	34.32
8	Sikaripara	Sikaripara	178	GG	21	25-28, 56-60, 90-92, 160-163, 177-178	4.93	34.32
9	Nischintpur	Masaliya	87.62	GG	12.5	23-24, 44-45, 54-58,59-61, 84-87	8.25	19.34
11	Masaliya	Masaliya	57.86	GG	9	11-16, 36-37, 51-53, 57-58	3.9	66.49
12	Nawasar	Masaliya	92.24	GG	8	11-14, 17-18,37-39,67-69,90-91	5.31	32.94
13	Nawadih	Masaliya	84.74	GG	15.5	22-23, 28-29,37-39,45-54,64-65,79-84	6.75	76.8
14	Dalahi	Masaliya	177.2	GG	12	33-34,45-47, 98-100, 159-161, 162-163	1.05	22.56
15	Karudih	Gopikander	138	RT/DS	22	93-94,106-107,114-115, 133-134, 137-138	0.92 m. agl.	31.2

S. No.	Location	Block	Depth Drilled (m)	Major Lithology	Depth of casing (m)	Potential Fracture Zone (m bgl)	Static Water Level (m bgl) at the time of drilling	Discharge (m^3/h) compressor
17	Nunihat	Ramgarh	94	GG	23	37-39, 60-62, 66-71, 81-82,93-94	-	81
18	Dumka	Dumka	200	GG	41	52-53, 143-144	14.83	11.16
19.	Bedia	Jama	68.5	GG	30	57-59	5.8	44.28
20	Chikania	Jama	202.7	GG	16.5	176-177,184-185		12.24
21.	Mahura	Seriyahat	153.9	GG	18.5	114-115	17.15	14.04

GG- Granite-gneiss, RT- Rajmahal Trap, DS- Dubrajpur sandstone
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 1.0-81 m^3/hr.
- Overall in the district the major potential fractures zones are found upto 100m.
- First potential fracture zone encountered in the district widely varies from 13-176 m.
- At come places the potential fractures were encountered at very shallow level 56.00-80.00 m with very high yielding wells. These potentialfractures maybe tensilein nature occurring at shallow level, which is found to be potential repository of ground water. Some of the exploratory wells encountered upto the depth of 80m which yielded high discharge eg Nishchinpur(19.35 m^3/hr), Masaliya(66.49 m^3/hr), Nawadih (76.8 m^3/hr), Bedia(44.28m^3/hr)
- Some of high yielding well where multiple fractures were encountered within 100 m depth are Basukinath (43.36 m^3/hr), Nunihat (81 m^3/hr).and Kathikund(26.4 m^3/hr).
- In some occasion potential fractures were also encountered beyond 100 m depth(120-185 m). The well has yielded copious amount of discharge e.g Raneshwar(17.82 m^3/hr), Sikaripara(34.32 m^3/hr), Shiv pahar(35.4 m^3/hr), Chikania(44.28m^3/hr), Dalhi(22.56 m^3/hr), Karudih(31.2 m^3/hr), Dumka(11.16 m^3/hr)
- At Karudih well drilled at 138.00 in contact of Rajamahal trap and Dubrajpur Sandstone formation, yielded discharge of 31.2 m^3/hr with auto flow of peizometeric head 0.92 magl.
- At Shiv Pahar the single fracture system, encountered at deep level at 151.00 has yielded 35.4 m^3/hr discharge. The deep seated fractures were found in Augen gneiss.
- At Dalahi, potential fractures were encountered within 50.00 m and yielded about 30 m^3/hr, however further drilling down to 100 m the yield decreases to 22.56 m^3/hr, which shows dry fractures between 50-100 m.

3.3 Geophysical survey: To identify the weathering thickness, depth of bed rock, fractures depth etc, total 87 numbers of geophysical surveys (VES) were carried out in district through inhouse (CGWB).

3.3.1 Geophysical survey through Inhouse: Total 87 numbers of VES have been carried out in Dumka district under AAP 1988-89, 1992-93 and 2018 – 19. Block wise and year wise number of VES carried out is given below in table 10 and the details of VES are provided in Annexure – XI.

Table - 10: Block wise and year wise number of VES carried out in Dumka district

Sr. No.	Block	No. of VES carried out		
		1988 - 89	**1992 - 93**	**2018 - 19**
1	Dumka	16	--	--
2	Shikaripara	04	--	--
3	Kathikund	06	--	--
4	Raneshwar	04	--	--
5	Masaliya	--	42	--
6	Ramgarh	--	--	06
7	Jama	--	--	05
8	Saraiyahat	--	--	03
9	Gopikandar	--	--	01
Total		**30**	**42**	**15**

The salient features of interpretation of the VES conducted in Dumka districts are as under

3.3.1.1 Dumka, Shikaripara, Kathikund and Raneshwarblocks:A total of 30 VES were conducted in Dumka, Shikaripara, Kathikund and Raneshwar blocks of Dumka District. The VES curves obtained in the study area of Dumka district are A, H, HA and HK types. The interpreted results of VES show three to five geo-electrical layers**.** The top layer resistivity varies from 47 ohm-m to 285ohm-m and thickness 1.2m to 3.9m. The second layer resistivity varies from 16.5 ohm-m to 189 ohm-m and thickness varies from 1.60m to 16.50m indicating weathered to Semi weathered formation. The Semi weathered formations were deciphered at four locations of Karua village and one location at police station, Kathikund. The second layer is followed by hard to very hard formation in Dumka block (except the HijlaPaharpur locations), Shikaripara blocks area and one location in Kathikund block.The third layer resistivity varies from 98 ohm-m to 325 ohm-m indicating Semi weathered formation. In Police station, Kathikund and Raneshwar village, the third layer is followed by very hard formation. The fourth layer varies from 85 ohm-m to 107 ohm-m with thickness 9.60 to 13.10m indicating weathered formation in Kathikund block. At this site, hard rock deciphered to the depth within 21.50m and underlain by compact formation. On the basis of interpreted results, the electrical resistivity characteristic in hard rock of above four blocks of Dumka district is given below:

Sl. No.	**Resistivity ranges** (In ohm-m)	**Possible lithology**
1.	45 - 285	Top soil
2.	1 - 15	Highly weathered
3.	15-100	weathered
4.	100-350	Semi weathered / Fractured
5.	More than 350	Compact rock

3.3.1.2 Masaliya block: Total 42 VES were carried out during the year 1992-93 at the different location of exploratory wells sites of Masaliya block of Dumka district. The geo-electric resistivity ranges were correlated with lithologs based on borehole data. The following correlations were made –

Resistivity ranges			Possiblelithlogs	
0	-	30 ohm-m	- Wet	Top soil
30	-	820 ohm-m	- Dry	Top soil
30	-	130 ohm-m	-	Weathered formation
130	-	400 ohm-m	-	Fractured formation
More than 400 ohm-m			-	Massive and compact bed rock

Three representative correlation of VES curve to exploratory borehole lithology are given as below –

- **Exploratory drilling site at Masaliya**: The VES curve is H-type, representing three geo-electric layers. The resistivity are 18 ohm-m, 180 ohm-m and 280 ohm-m and thickness are 4.0 m and 64.0 m respectively for the last two resistivity values. The top layer resistivity value of 18 ohm-m is indicative of surface soil and the resistivity value of 180 ohm-m of the second layer represents fractured zones saturated with water. Last layer resistivity is 280 ohm-m also suggesting presence of fracture zone.

- **Exploratory drilling site at Dalahi**: The VES curve represents H-type with three geo-electric layers. The layer resistivity is 50 ohm-m, 350 ohm-m and very high and corresponding thickness is 6.0 m and 60.0 m. The weathered zone is of resistivity value 50 ohm-m, having thickness of 6.0 meters. The semi-weathered zone of resistivity value 350 ohm-m is 60 m thick. The fracture is expected to be occurring in the depth range 20 – 100 m.

- **Exploratory drilling site at Nawasar**: At this exploratory drilling site the curve represents HA-type with four geo-elect layers. As per interpretation of VES data resistivity of four layers are 65, 52, 137 ohm-m and very high. Thickness of top layer is 2.8 m of resistivity 65 ohm-m indicates top soil. The resistivity of second layer is 52 ohm-m indicating weathered zone. The third layer resistivity is 137 ohm-m and suggested occurrence of fracture zones saturated with water. Last layer is showing very high resistivity and indicate massive compact rock.

3.3.1.3 Ramgarh, Jama, Gopikander&Seriayahat block: During the year 2018-19, a total of 15 VES were carried out at 15 locations in parts of Ramgarh, Jama, Gopikander&Seriayahat block of Dumka district for data generation under aquifer mapping studies. The interpreted results show three to four geo-electrical layers in these blocks. The resistivity of the first geo-electrical layer representing the top soil varies from 54.10 ohm-m to 425 ohm-m. It is minimum at Bedia (Jama block) and maximum at Mahura (Saraiyahat block) in north–western part of the district. The resistivity of the second geo-electrical layer ranges from 45 ohm-m to 92.10 ohm-m with thickness of 4.15 m to 14.0 mindicating weathered formation. The highly weathered formation has been deciphered at Bedia (Jama block) and BaraPather site (Gopikandar block). The third geo-electrical layer resistivity representing the semi weathered zone varies from 125 ohm-m to 235 ohm-m with thickness of 7.50 m to 28.53 m. The resistivity of 455 ohm-m to very high indicates the massive compact rock.

3.4 Ground Water Dynamics

3.4.1 Water Level Scenario – Aquifer – I (Shallow Aquifer): Water level scenario of shallow aquifer was generated by utilizing water level data of 37 monitoring wells representing

shallow aquifer. The pre monsoon (May 2018) depth to water level monitored between 1.97 to 9.55 mbgl. The post monsoon depth to water level (Nov. 2018) in the dug wells ranges from 1.35 to 9.40 mbgl. Pre and post monsoon depth to water level maps were prepared for the year 2018 and presented in figure – 9 & 10.

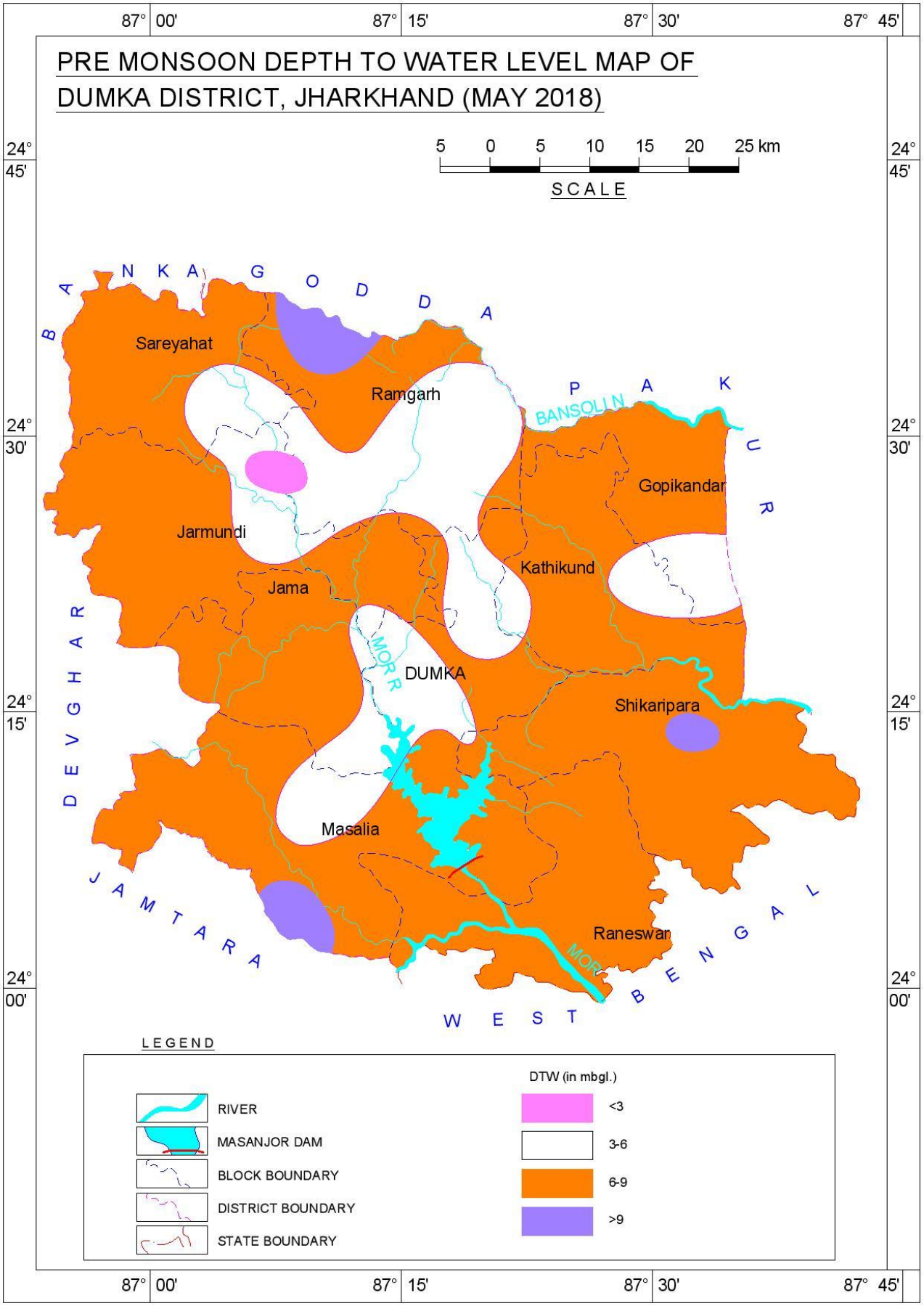


Figure – 9: Pre monsoon depth to water level map of Dumka district (May 2018)

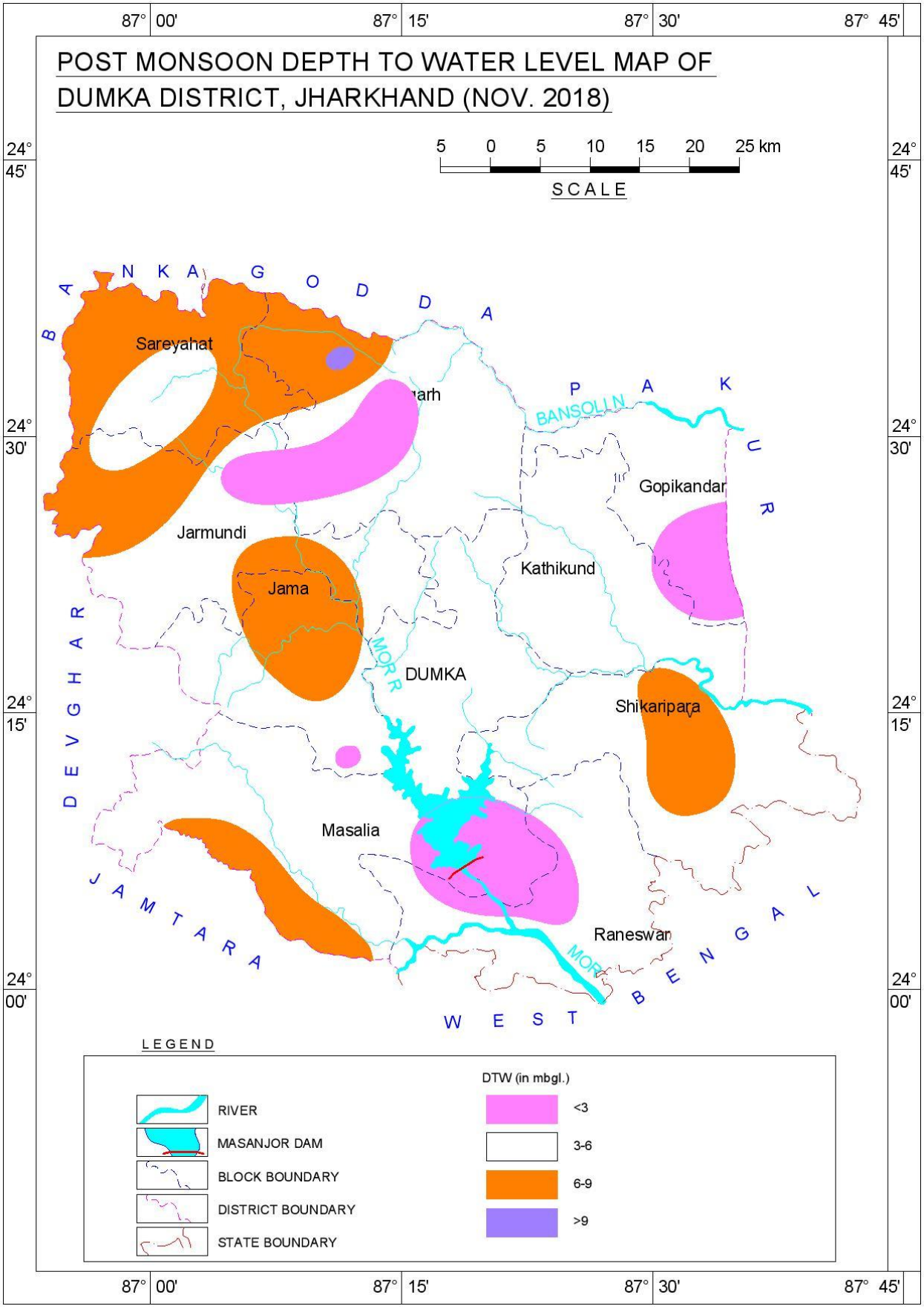


Figure – 10: Post monsoon depth to water level map of Dumka district (Nov. 2018)

3.4.2 Water level fluctuation: Seasonal ground water level fluctuation in shallow aquifer was studied with the help of 37 key wells which were monitored four times in different seasons

during the year 2018. Any decline in water level in the dry and lean period is immediately restored with the onset of monsoon precipitation. Deletion of water in the ground water reservoir is replenished and thus the annual cycle of decline and rise of water level is maintained through time. The seasonal rise of water level varies from place to place. The seasonal water level fluctuation between pre and post monsoon period for the year 2018 observed between 0.14 to 3.78 m in the district. Seasonal water level fluctuation map between pre monsoon (May 2018) and post monsoon (November 2018) has been prepared and presented in figure – 11.

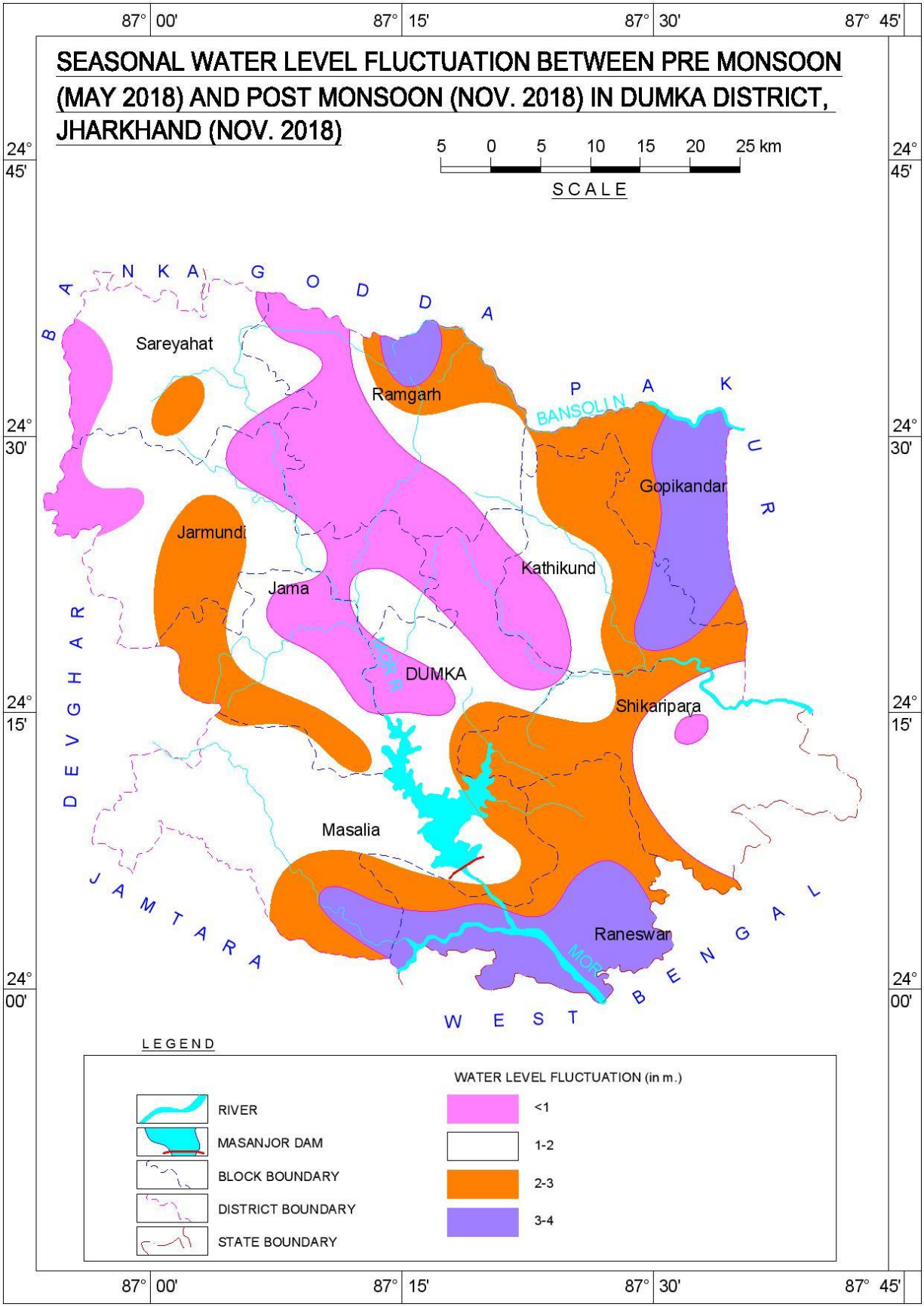


Figure – 11: Seasonal water level fluctuation map of Dumka district (2018)

3.4.3 Last ten years long term water level trend (2010 – 2019): In order to study long term behaviour of the water levels and also the effect of various developmental activities with

time, the data for the period 2010 - 2019 have been computed ,analyzed and presented in table - 11. The pre and post monsoon water level trend analysis showing rising trend in 85% and 77% wells respectively. It may be due to extraction of ground water from dug well is very less because sufficient availability of hand pumps in recent years. The dug well was main source for ground water extraction 20 - 30 years back

Table -11: Last ten years long term water level trend of Dumka district (2010 – 2019)

Sr. No.	Location	Water level trend (m/year)			
		Pre monsoon		Post monsoon	
		Rise	Fall	Rise	fall
1	Jama	--	0.1623	0.0420	--
2	Jarmundi	0.1002	--	0.2390	--
3	Nonitat	0.0420	--	0.0001	--
4	Gopikandar	0.5588	--	0.2035	--
5	Gamharia	--	0.1180	--	0.3966
6	Hansdiha	0.0400	--	0.1184	--
7	Raneshwar	0.0224	--	0.2098	--
8	Masanjor	0.0496	--	0.1549	--
9	Masalia	0.2038	--	--	0.0497
10	Patabari	0.0182	--	0.1139	--
11	Shikaripara	0.0779	--	0.2715	--
12	Chikania	0.0637	--	--	0.0082
13	Kathikund	0.1766	--	0.1565	--

3.4.4 Hydrograph Analysis: Analysis of eight (08) hydrograph network stations, were carried out using GEMS software (Figure -12 a-h) and analysed for the period from 2010-2019. It is observed that the long-term water level trends during pre monsoon seasons are rising trend (except Jama) in shallow aquifer-I represented by dug wells. Similarly, post monsoon long term water level trend is observed rising trend in the wells located at Jarmundi, Masanjor, Patabari, Raneshwar and Shikaripara while declining trend observed in the wells located at Jama, Masalia and Hansdiha.

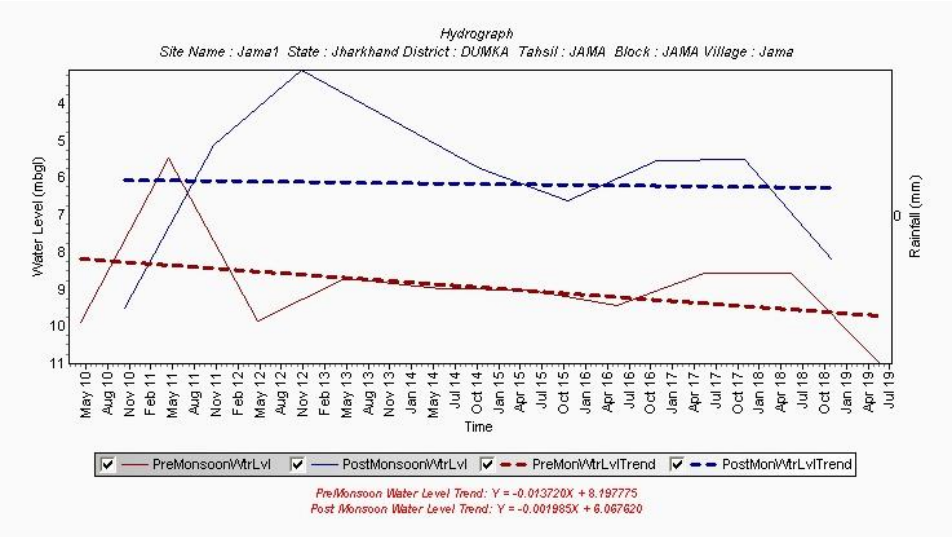


Figure – 12 (a): Hydrograph (2010-2019) of Jama network station

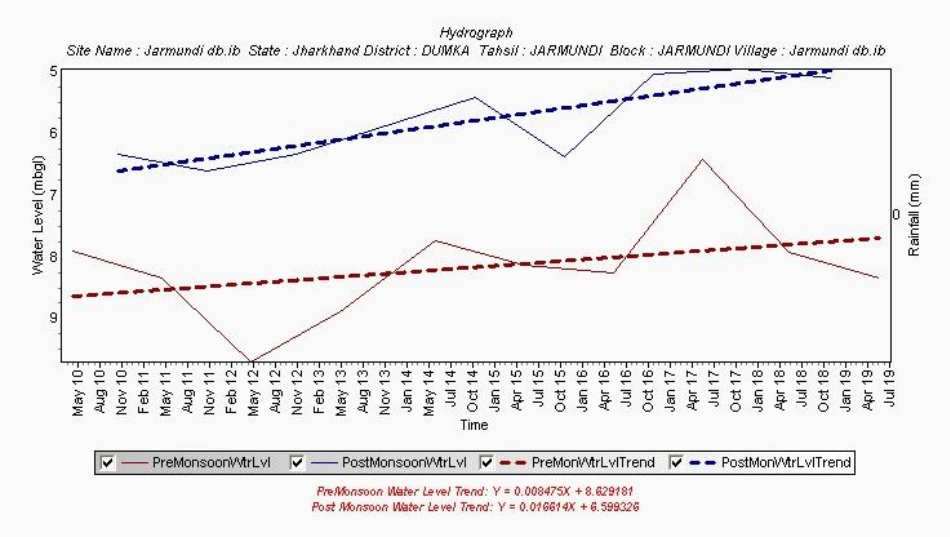


Figure – 12 (b): Hydrograph (2010-2019) of Jarmundi network station

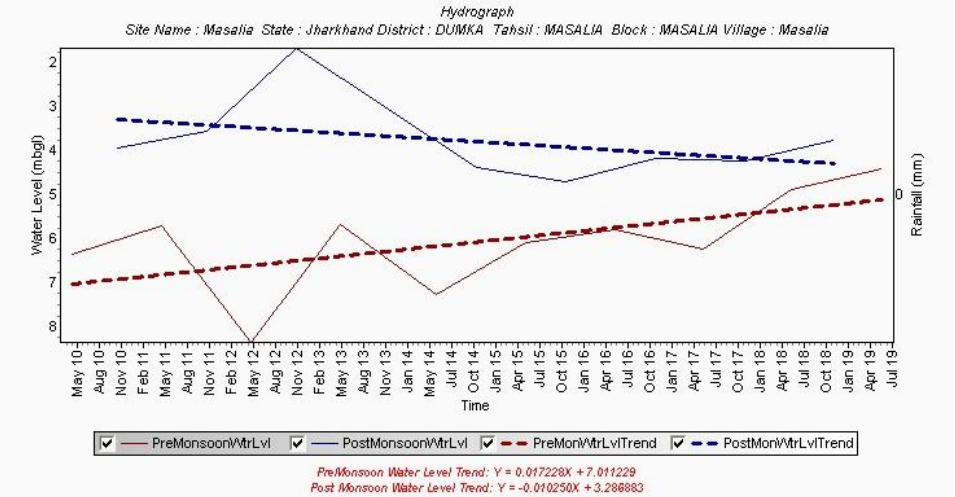


Figure – 12 (c): hydrograph (2010-2019) of Masalia network station

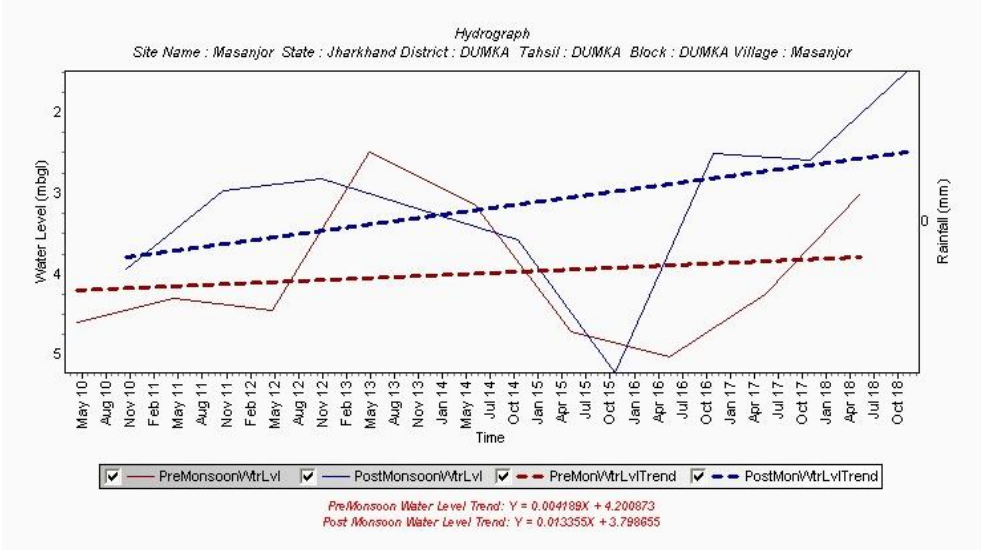


Figure – 12 (d): hydrograph (2010-2019) of Masanjor hydrograph network station

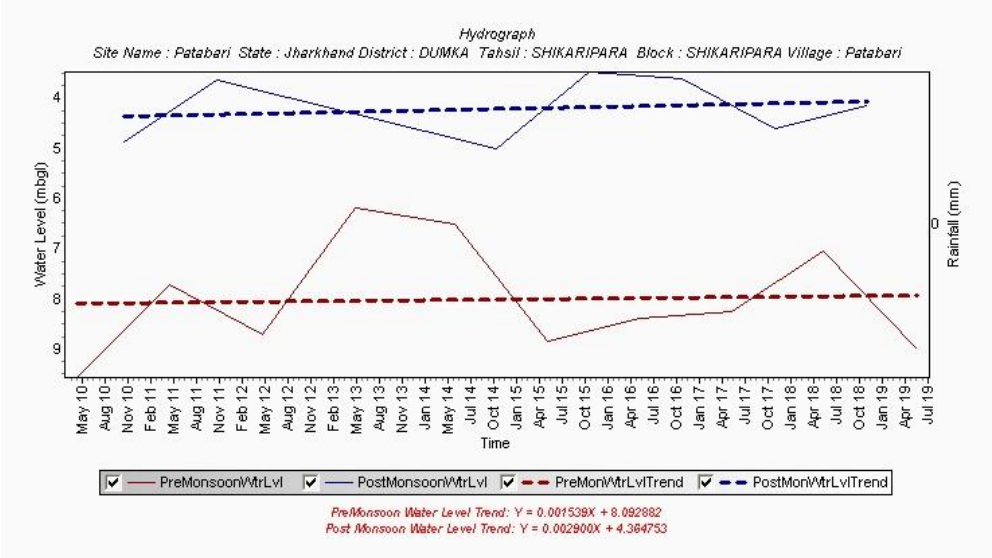


Figure – 12 (e): Hydrograph (2010-2019) of Patabari network station

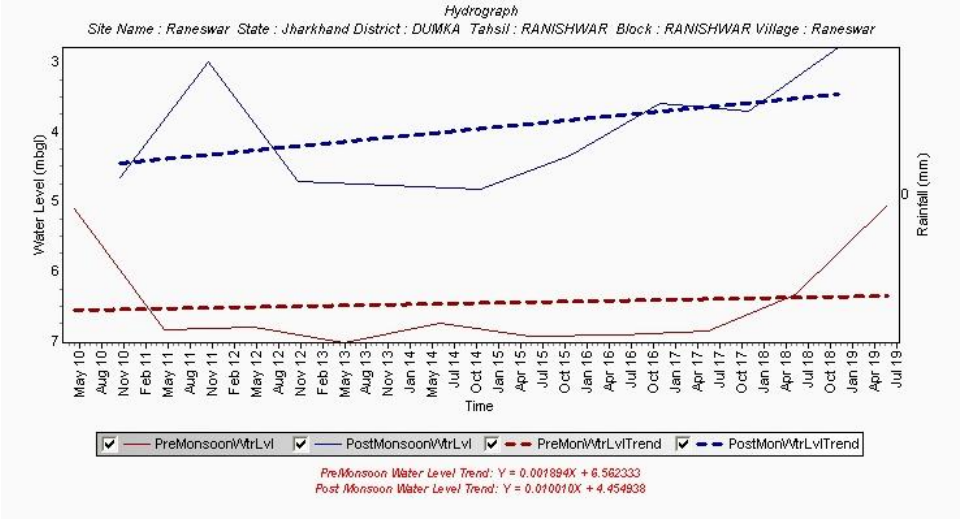


Figure – 12 (f): Hydrograph (2010-2019) of Raneshwar network station

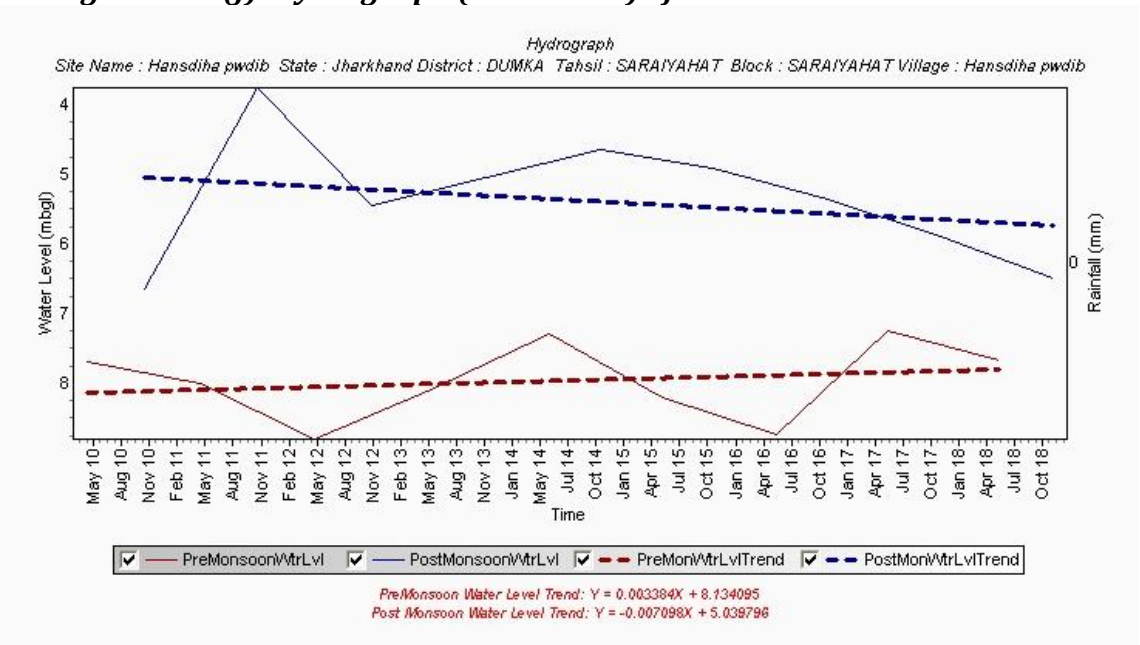


Figure –12 (g): Hydrograph (2010-2019) of Hansdiha network station

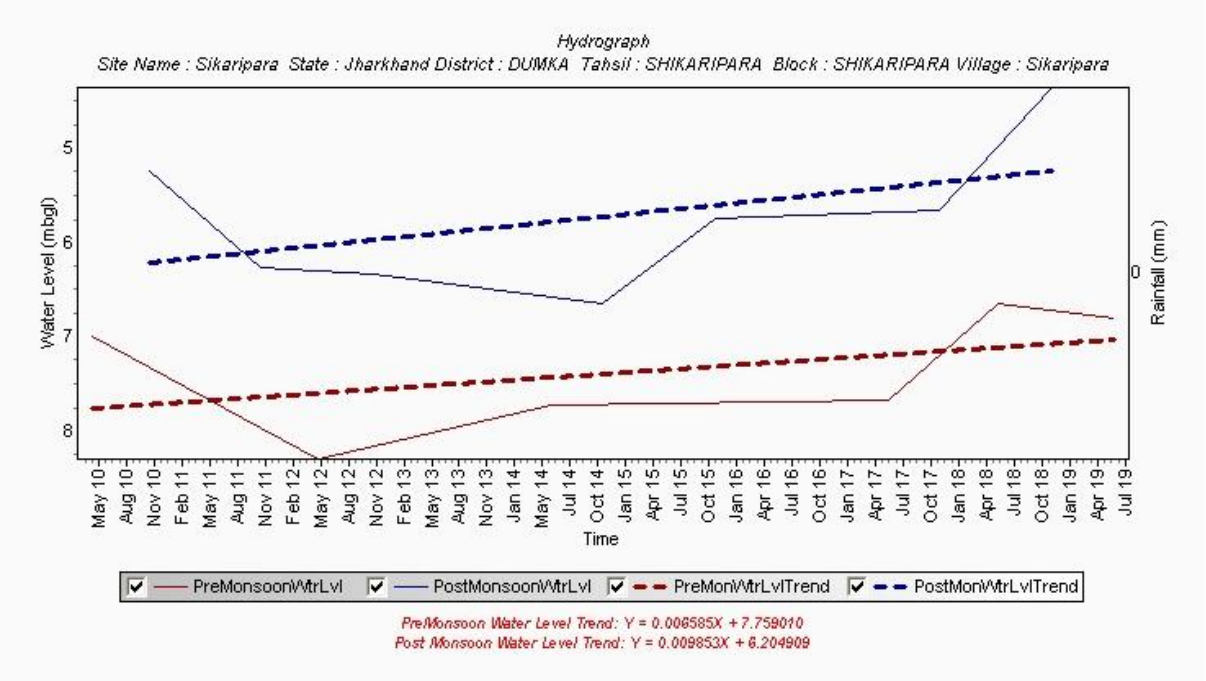


Figure – 12 (h): hydrograph (2010-2019) of Shikaripara network station

3.5 Ground Water Exploration: Toassess the potentiality of the deep fractured rock 31 exploratory wells and 18 observation wells were drilled in Dumka district by Central Ground Water Board. The drilling results have indicated that granite gneiss of different shades varying from grey to dark grey to pink, having course grained texture sometime porphyritic, are the most dominant rock types met in the area. In the bore wells upper weathered zones are cased and only the fractured zones are tapped in the uncased well. The details of the exploratory and observation wells drilled in Dumka district are presented in annexure – IV & V and available lithologs of these wells are represented in annexure – VII. Summary of success bore wells drilled by Central Ground Water Board in the district is given below in table – 12.

Table – 12: Summary of success bore wells drilled by CGWB in Dumka district

Location	Depth drilled (mbgl)	Fracture encountered between (mbgl)- Thin Zone	Discharge (m^3/hr)	T (m^2/day)	S
Shiv Pahar	159.00	151-153	35.4	107.8	0.00020
Kathikund	140.00	32-34, 39-40, 48-49, 58-60, 78-81, 100-103	26.40	29.50	0.00080
Raneshwar	200.00	50-52, 74-75, 117-118, 121-123, 132-134	17.82	41.00	0.00052
Basukinath	121.10	24-26, 42-43, 45-46, 61-63, 106-108	43.36	186.00	0.00025
Shikaripara	178.00	25-28, 56-60, 90-92, 160-163, 177-178	34.32	14.10	0.000073
Nishchintpur	87.62	23-24, 44-45, 54-58, 59-61, 84-87	19.35	14.04	0.00082
Masaliya	57.86	11-16, 36-37, 51-53, 57-58	66.49	174.04	0.023
Nawasar	92.24	11-14, 17-18, 37-39, 67-69, 90-91	32.94	19.66	0.0011
Nawadih	84.74	22-23, 28-29, 37-39, 45-54, 64-65, 79-84	76.80	--	--
Dalahi	177.20	33-34, 45-47, 98-100, 159-161, 162-163	22.56	--	--
Kurudih	138.00	93-94, 106-107, 114-115, 133-134, 137-138	31.20	--	--
Nonihat	94.00	37-39, 60-62, 66-71, 81-82, 93-94	81.00	--	--
Bedia	68.50	57-59	44.28	--	--
Chikania	202.70	176-177, 184-185	12.24	--	--
Mahura	153.90	114-115	14.04	--	--

From table–12, it is observed that one to seven sets of fractures have been encountered in the bore wells drilled in Dumka district. Based on morphotectonic analysis and exploratory drilling results, it confirms that the area has undergone several phases of tectonic deformations which lead to various sets of fractures, fissures, and faults etc which are ground water repositories. Various sets of fractures have been identified, on ground water point of view. The shallow aquifers upto the depth of 100m and deep fractured aquifer exist upto 185 mbgl within the explored depth of 200 m.

Based on Aquifer Parameters evaluation in the district, Transmissivityvalue of deep fractured aquifer is found to be between 14.04 to 186 m^2/day. High value of Transmissivity correlates to tensile fracture system. The Storage co-efficient value ranging from 7.30 x 10^{-5} to 2.30 x 10^{-2}which indicates semi-confined to confine aquifer system in the district.

3.6 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 29 dug wells and 32 representatives bore wells (hand pumps). The analytical results of water samples dug wells and hand pumps are given in Appendix- VIII and IX respectively. 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) and the bore well samples represent the Aquifer II (deeper zone) quality of ground water.

3.6.1 General range of chemical parameter of Aquifer-I in the area: - 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 too 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 tables 13.
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 H3O 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 7.24 to 8.47.

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 165 to 3449.

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 29.20 to 405.90 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 6.02 to 470 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 0.27 to 3.14 mg/l.

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 3 to 131 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 between 5.72 to 139.76 mg/l.

Calcium:In mineral form, it is found as Calcite, aragonite, gypsum, anhydrite, anorthite, diopside etc. The Calcium concentration ranges between 18 to 3.6 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 2.43 to 194.40 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 CaCO3)	-	Class
0- 60	-	Soft
61-120	-	Moderately hard
121-180	-	Hard
>180	-	Very Hard

In the study area, the total hardness value ranges from 70 to 1565 mg/l.

Table-13: Ranges of chemical constituents of Aquifer- I in Dumka district (dug wellsamples)

Chemical Constituents and quality parameters	**Granite Gneiss**	**Basalt**	**Sandstone**
pH	7.24 – 8.47	7.98 – 8.06	7.46 – 7.98

EC (micro siemens/cm at 25^0c)	187 - 3449	483 – 625	165 – 272
TDS (ppm)	121 - 2242	314 – 406	107 – 177
TH as $CaCo_3$ (ppm)	70 - 1565	230 – 275	70 – 85
Ca (ppm)	18 - 306	42 – 52	20 – 36
Mg (ppm)	2.43 – 194.40	30.38 – 35.24	4.86 – 6.08
Na (ppm)	9.49– 139.76	14.93 – 16.31	5.72 – 13.46
K (ppm)	0.43 – 9.32	0.44 – 0.87	1.12 – 1.24
HCO_3 (ppm)	29.20 – 405.90	123–141.45	47.35–61.50
Cl (ppm)	6.02 - 470	53 – 78.9	9 – 32.20
SO_4 (ppm)	3 - 131	34 – 49	4 – 19
NO_3 (ppm)	2.30 – 547	14.90 – 26.30	11.20 – 43.10
F (ppm)	0.33 – 3.14	0.27 – 0.28	0.32 – 0.39

The ground water of shallow aquifers in the area is alkaline in nature. On the perusal of table - 13, the pH value of the area is 7.24 – 8.47. The TDS value varies between 121 to 2242 mg/l in granite gneiss terrain. An overall value of Calcium and Magnesium varies between 18 to 306 mg/l and 2.43 to 194.40 mg/l in the area respectively. Nitrate concentration is observed between 2.30 to 547 mg/l while the Fluoride value found between 0.27 to 3.14 mg/l within the area.

3.6.1.1 Suitability of ground water of Aquifer – I (shallow aquifer) for drinking purposes: - The suitability of ground water for drinking purposes is determined 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 - 14.

Table - 14: 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	29 (100%)	Nil	Nil
TDS (ppm)	500	2000	21 (72.41%)	07 (24.14%)	01 (3.45%)
TH as $Caco_3$ (ppm)	200	600	11 (37.93%)	16 (55.17%)	02 (6.9%)
Ca (ppm)	75	200	24 (82.76%)	04 (13.79%)	01 (3.45%)
Mg (ppm)	30	100	17 (58.62%)	11(37.93 %)	01 (3.59%)
Cl (ppm)	250	1000	27 (93.10%)	02 (6.90%)	Nil
SO_4 (ppm)	200	400	29 (100%)	Nil	Nil
HCO_3 (ppm)	200	600	25 (86.21%)	04 (13.79%)	Nil
NO_3 (ppm)	45	No relaxation	18 (62.07%)	Nil	11(37.93%)
F (ppm)	1.0	1.5	23 (79.31%)	03 (10.34%)	03(10.34%)

The table- 14 indicates that all the water samples come under desirable to permissible category of Cl, SO_4 and HCO_3. The value of TDS, Ca, and Mg are observed beyond permissible limit in one sample of each. Similarly, the TH value is also found beyond permissible limit in

02 samples and F in 03 samples. Major concentration of Nitrate is found beyond permissible limit in 11 samples.

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

3.6.1.2.1: 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- 15: 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 %	09	31.03 %
2	Good	20 – 40 %	15	51.74 %
3	Permissible	40 – 60 %	05	17.23 %
4	Doubtful	30 – 80 %	Nil	Nil
5	Unsuitable	> 80 %	Nil	Nil

(Where all ions are expressed in epm)

On the perusal of table 15, 100 % of water samples of aquifer – I (dug wells) falling under excellent to permissible category.

3.6.1.2.2 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 16 which is showing that all the water samples (100%) of aquifer – I (dug wells) pertain to excellent class.

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

Sl No.	Water class	Type of Water	SAR Value	No. of samples falling	Percentage of samples
1	Excellent	Low sodium water	< 10	29 (100%)	Nil
2	Good	Medium sodium water	10 – 18	Nil	Nil
3	Fair	High sodium water	18 – 26	Nil	Nil
4	Poor	Very high sodium water	> 26	Nil	Nil

3.6.1.2.3 Residual sodium carbonate content (RSC): -Water containing Co_2 on way gets saturated with Co_2 and forms bicarbonates. The excess bicarbonate of Mg and Ca are precipitated out as carbonates. This produces impermeability to the top soil. Bicarbonate concentration of water has been suggested as additional criteria of suitability for irrigation water. Groundwater samples that had RSC indices of positive value imply that the cumulative concentration of CO_3^{2-} and HCO_3^{2-} is higher than the combined Ca^{2+} and Mg^{2+} concentrations. This would indicate that there is a residual carbonate to react with sodium, presenting sodium hazard to the soil when irrigated with such water. A negative value indicates no residual carbonate. Residual sodium carbonate is determined by using the formula –

$$RSC = (CO_3^{2-} + HCO_3^{2-}) + (Ca^{2+}) + (Mg^{2+}) \quad \ldots\ldots$$

(Where concentration is expressed in epm)

Table- 17: - Classification of ground water of Aquifer – I based on RSC value

Sl No.	RSC (mg/l)	Irrigational suitability	No. of samples falling	Percentage of samples
1	< 1.25	Safe for all type of crops	28	96.55 %
2	1.25 – 2.50	Safe for semi-tolerant to tolerant crops	01	3.45 %
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	Nil	Nil

(All the values are expressed in epm.)

On the perusal of table 17, about 96.55 % of water samples of aquifer - I are falling under safe for all type of crops category and about 3.45% of water sample (01 No.) falling under safe for semi- tolerant to tolerant crop. Classification of irrigation water modified Piper's diagram is shown below in figure – 13.

Classification of Ground water

The Piper diagram is used to categorize the type of water. It comprises of three parts: one diamondshaped 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.

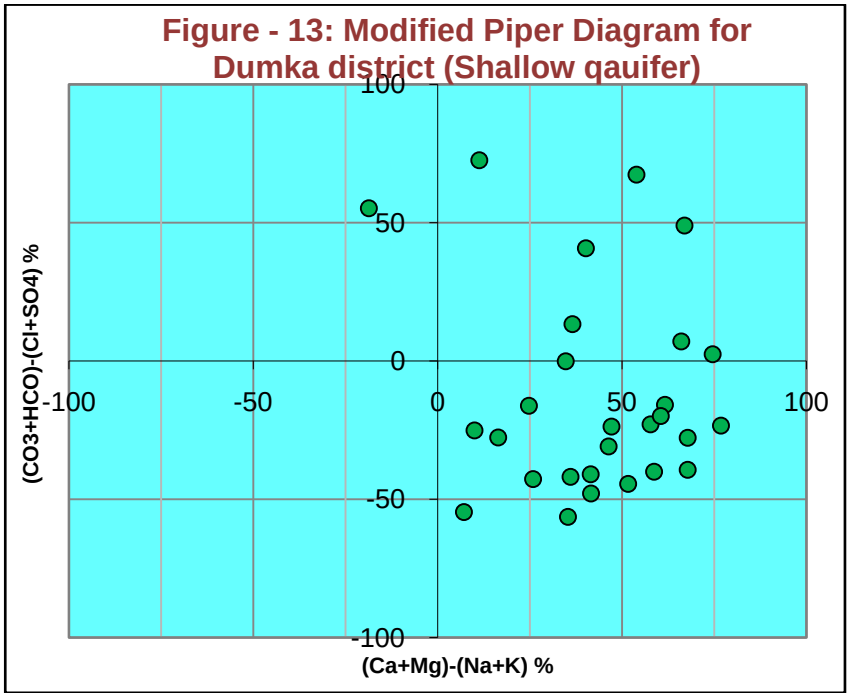
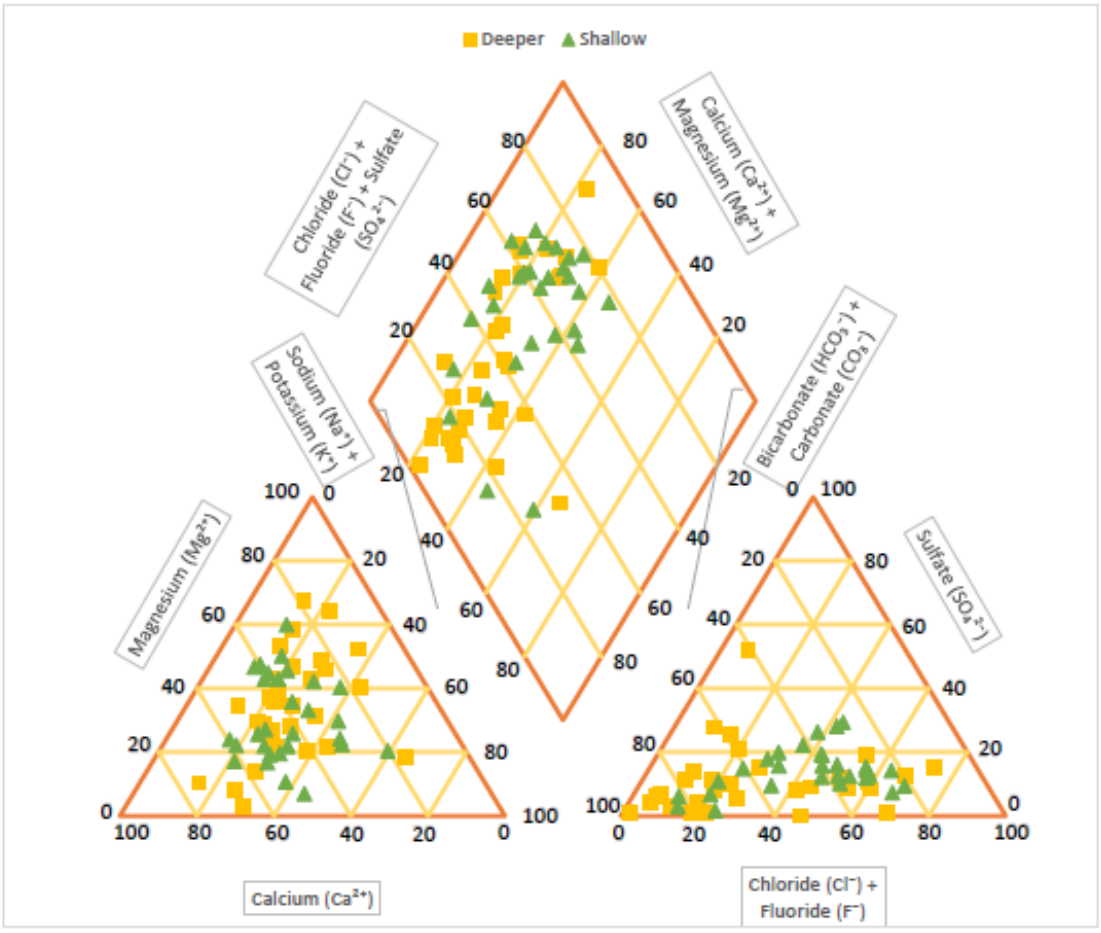


Figure - 13: Modified Piper Diagram for Dumka district (Shallow qauifer)



Interpretation of Chadha's modified Piper diagram,in shallow aquifer, 65% water sample belong to calcium–magnesium–chloride (Ca–Mg–Cl) type and only 28% water samples belong to calcium-bicarbonate (Ca-HCO3) type. Most of the samples from shallow and deeper aquifer fall in the region where alkaline earth's (Ca+Mg) exceed alkali metals (Na+K).

3.6.1.2.4 Suitability of ground water based on Electrical Conductivity (EC): - Wilcox 1948 suggested a water class classification for suitability of water for irrigation. The classification is given below as a table- 18.

Table - 18: - Classification of ground water of Aquifer - I based on electricalconductivity (EC)

Sl No.	Water Class	Rages of EC	No. of samples falling	Percentage of samples
1	Excellent	< 250	03	10.34 %
2	Good	250 – 750	18	62.07 %
3	Permissible	750 – 2250	07	24.14 %
4	Doubtful	2250 – 3000	01	3.45 %
5	Unsuitable	> 3000	Nil	Nil

On The perusal of table 18, about 10.34 % of samples falling under excellent class and 86.21 % of water samples of Aquifer – I (dug wells) falling under good to permissible water class. Rest about 3.45 % of water samples falling under doubtful water class.
EC maps of dug well samples i.e. Aquifer – I has been prepared and shown in figures- 14. The values for sodium percentage, SAR, RSC and EC of water samples Aquifer – I collected from dug wells are given in table – 19.

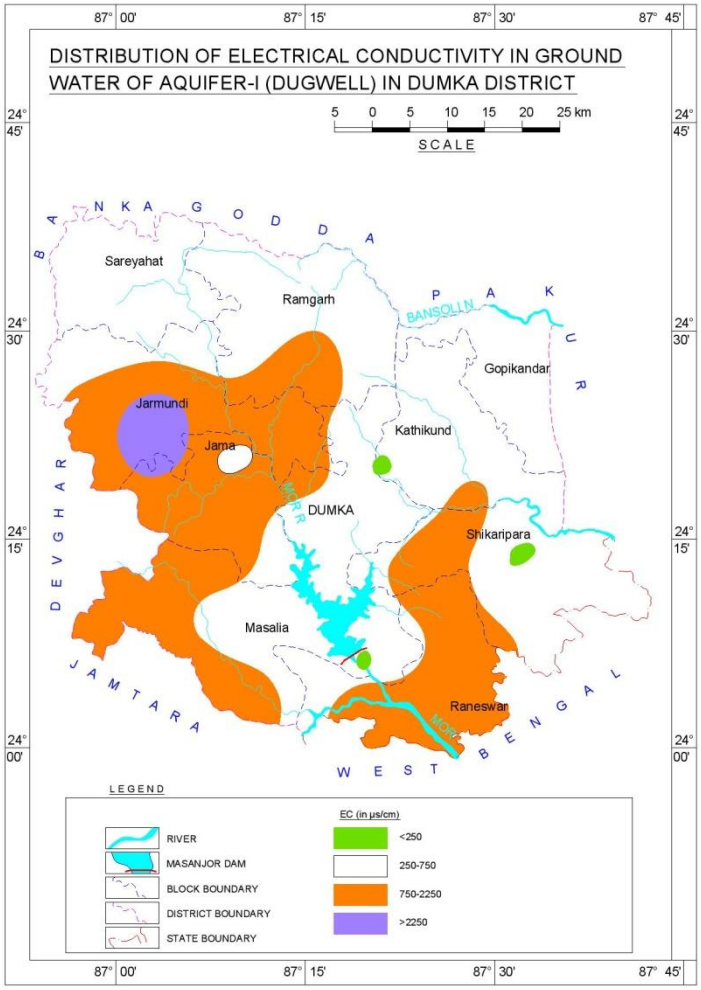


Figure- 14: EC map of Aquifer – I of Dumka district

Table - 19: Values of Sodium percentage, SAR, RSC and EC of water samples collected from Aquifer – I (Dug wells), Dumka district

Sr. No.	Village	Block	District	Na %	SAR	RSC	EC
1	Patabari	Shikaripara	Dumka	16.11	0.71	-4.98	853
2	Masanjor	Raneshwar	Dumka	23.04	0.51	-0.09	195
3	Raneshwar	Raneshwar	Dumka	37.06	2.47	-5.47	1455
4	Asanbani	Raneshwar	Dumka	46.44	2.84	-3.18	1128
5	Khirghata	Raneshwar	Dumka	32.35	1.42	-3.09	661
6	Masalia	Masalia	Dumka	19.17	0.59	-1.59	407
7	Domkata	Masalia	Dumka	24.16	1.16	-4.98	938
8	Tiliya Pahari	Masalia	Dumka	32.64	1.29	-1.38	601
9	Shikaripara	Shikaripara	Dumka	41.81	2.07	-2.08	749
10	Pokharia	Kathikund	Dumka	26.44	1.20	-3.18	827
11	Rampur	Shikaripara	Dumka	16.54	0.30	-0.39	165
12	Kathikund	Kathikund	Dumka	37.63	1.38	-1.58	575
13	Gopikandar	Gopikandar	Dumka	21.15	0.55	-1.52	272
14	Durgapur	Gopikandar	Dumka	11.58	0.43	-3.48	625
15	Digal Kharauni	Gopikandar	Dumka	12.74	0.43	-2.28	483
16	Amba	Kathikund	Dumka	31.74	0.49	-0.39	187
17	Doom	Dumka	Dumka	20.67	0.78	-3.19	603
18	Jawari	Ramgarh	Dumka	29.19	1.25	-3.29	670
19	Dumka	Dumka	Dumka	29.90	0.75	-0.39	298
20	Chapodia	Dumka	Dumka	16.98	0.63	-2.48	580
21	Bara Palasi	Jama	Dumka	31.98	2.34	-8.56	1957

22	Nonihat	Jarmundi	Dumka	29.27	0.81	-1.39	299
23	Dighi	Saraiyahat	Dumka	59.34	2.72	1.43	454
24	Beldaha	Jarmundi	Dumka	44.38	1.36	0.62	296
25	Kusmah	Jarmundi	Dumka	26.85	1.06	-2.38	643
26	Jarmundi	Jarmundi	Dumka	16.09	1.47	-24.34	3449
27	Jama	Jama	Dumka	19.75	0.71	-2.58	606
28	Chikania	Jama	Dumka	45.03	3.14	-2.96	1436
29	Dhadhakia	Dumka	Dumka	13.28	0.52	-5.09	302

3.6.2 General range of chemical parameter of Aquifer - II in the area: - The variation range of the concentration in ppm of different chemical constituents and quality parameters of Aquifer - II (hand pumps samples) represented in tables 20.

Table- 20: Ranges of chemical constituents of Aquifer - II in Dumka district (hand pump samples)

Chemical Constituents and quality parameters	**Granite gneiss**	**Basalt**	**Sandstone**
pH	7.34 – 8.35	7.95 – 8.11	8.06 – 8.15
EC (micro siemens/cm at 25^0c)	170 – 1295	210 - 513	432 – 541
TDS (ppm)	119 – 907	147 - 359	302 – 359
TH as $CaCo_3$ (ppm)	75 – 465	75 - 155	150 – 175
Ca (ppm)	16 – 116	16 - 32	12 – 18
Mg (ppm)	1.21 – 83.83	6.07 – 18.22	25.51 – 35.23
Na (ppm)	8.13 – 89.28	15.50 – 38.22	20.77 – 39.95
K (ppm)	0.52 – 9.01	0.45 – 12.00	4.63 – 17.95
HCO_3 (ppm)	61.50-276.75	92.25 – 184.50	178.35 – 252.15
Cl (ppm)	3.08 – 201.50	14.80 – 35.30	3.21 – 17.06
SO_4 (ppm)	0 – 84	1 – 22	2 – 63
NO_3 (ppm)	2.10 – 115	15.30 – 22.10	2.90 – 12.60
F (ppm)	0 – 1.70	Nil	0.00 – 0.13

The ground water of aquifer - II in the area is alkaline in nature. On the perusal of table - 20, the pH value ranges 7.34 to 8.35 mg/l in granite gneiss terrain. Similarly, it varies from 7.95 to 8.11 mg/l and 8.06 to 8.15 mg/l in basaltic terrain and sandstone areas. The EC value ranges between 170 to 1295 mg/l in granite gneiss area while it varies from 210 to 513 mg/l in basaltic area. Overall in the district, the TDS value varies from 119 to 907 mg/l. and the total hardness ranges between 75 to 465 mg/l. Calcium and Magnesium values varies from 16 to 116 mg/l and 1 to 83.83 mg/l respectively. Similarly, the Nitrate value ranges from 2.10 to 115 mg/l while Fluoride value found between 0 to 1.70 mg/l.

3.6.2.1 Suitability of ground water of Aquifer – II (deeper aquifers) for drinking purposes: - To know the ground water quality of Aquifer - II, water samples were collected from bore wells (Hand pump). The number of water samples falling under various categories of permissible and desirable limits of various constituents and its percentage are given in table - 21.

Table - 21: Suitability of ground water of Aquifer- II for drinking purposes

Chemical	**Ranges Desirable**	**No. of**	**No. of**	**No. of**

constituents and quality parameters	Desirable limit	Permissible limits in the absence of alternate source	samples under desirable limits	samples under permissible limit	samples under excessive limits
pH	6.5 to 8.5	No relaxation	32 (100%)	Nil	Nil
TDS (ppm)	500	2000	25 (78.12%)	07 (21.88%)	Nil
TH as $Caco_3$ (ppm)	200	600	22 (68.75%)	10 (31.25%)	Nil
Ca (ppm)	75	200	28 (87.50%)	04 (12.50%)	Nil
Mg (ppm)	30	100	24 (75%)	08 (25%)	Nil
Cl (ppm)	250	1000	31 (96.88%)	01 (3.12%)	Nil
SO_4 (ppm)	200	400	32 (100%)	Nil	Nil
HCO_3 (ppm)	200	600	24 (75%)	08 (25%)	Nil
NO_3 (ppm)	45	No relaxation	20 (62.50%)	Nil	12 (37.50%)
F (ppm)	1.0	1.5	28 (87.50%)	02 (6.25%)	02 (6.25%)

On the perusal of table – 21, it is observed that about 100% ground water samples of aquifer – II falling under desirable limits to permissible limits category except Nitrate and Fluoride. The Fluoride value is found beyond permissible limit in 02 samples. Major concentration of Nitrate value is found beyond permissible limit in 12 samples.

3.6.2.2 Suitability of ground water of Aquifer – II for irrigation Purposes: 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.

3.6.2.2.1 Sodium Percentage classification: - Sodium content is usually expressed estimated using the formula –

Sodium percent $= \left(\frac{Na^+ + K^+}{Ca^{2+} + Mg^{2+}\, Na^+\, K^+}\right) * 100$ …….

Table- 22: Classification of ground water of Aquifer - II based on Na%

Sl No.	Water class or category	Sodium percent	No. of samples falling	Percentage of samples
1	Excellent	< 20 %	06	18.75%
2	Good	20 – 40 %	23	71.88%
3	Permissible	40 – 60 %	02	6.25%
4	Doubtful	30 – 80 %	01	3.12%
5	Unsuitable	> 80 %	Nil	Nil

(Where all ions are expressed in lpm or epm)

From table 22, about 18.75 % of water samples of aquifer – II falling in excellent water class. About 78.13 % of water samples falling under permissible to good water class. Only 3.12 % of water sample (01 No.) falling under doubtful category.

3.6.2.2.2 Sodium adsorption ratio (SAR): - The sodium adsorption ration is calculated from the ionic concentration of Sodium, calcium and magnesium according the following relationship:

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

Ground water classification into four classes based on SAR value is given in table- 23 which is showing that all the water samples (100%) of aquifer - II falling under excellent water class.

Table - 23: - Classification of ground water of Aquifer – II based on SAR value

Sl No.	Water class	Type of Water	SAR Value	No. of samples falling	Percentage of samples
1	Excellent	Low sodium water	< 10	32 (100%)	Nil
2	Good	Medium sodium water	10 – 18	Nil	Nil
3	Fair	High sodium water	18 – 26	Nil	Nil
4	Poor	Very high sodium water	> 26	Nil	Nil

(Where all ions expressed in lpm)

3.6.2.2.3 Residual sodium carbonate content (RSC): Residual sodium carbonate is determined by using the formula

$$RSC = (CO_3^{2-} + HCO_3^{2-}) + (Ca^{2+}) + (Mg^{2+}) \quad \ldots\ldots$$

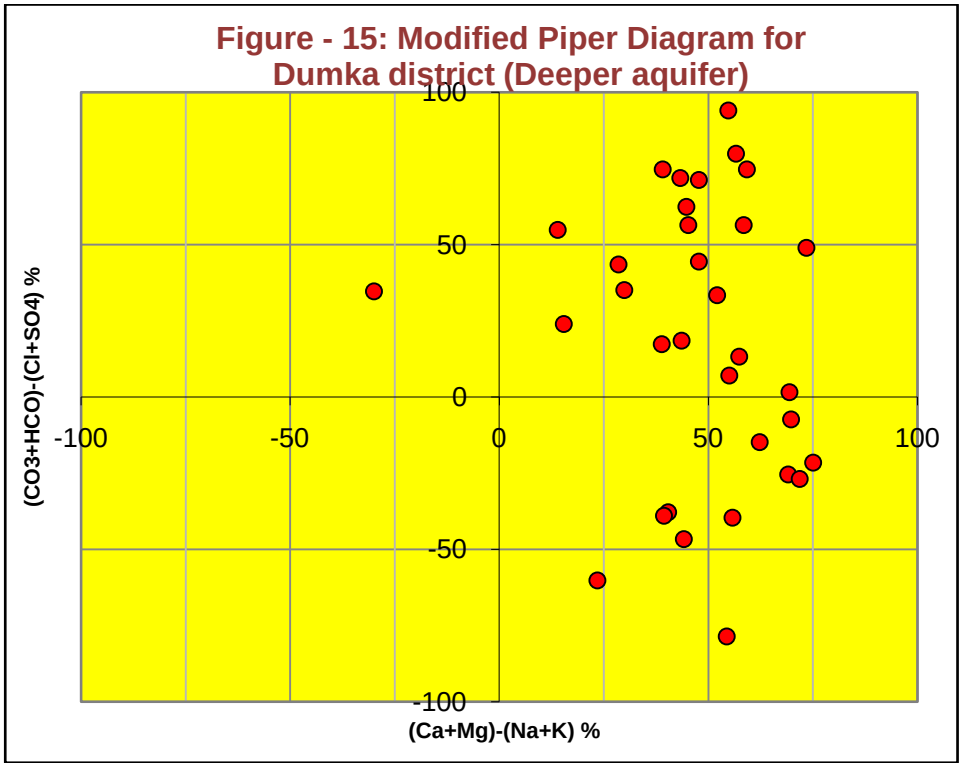
(Where concentration is expressed in epm)

Table - 24: - Classification of ground water of Aquifer – II based on RSC value

Sl No.	RSC (mg/l)	Irrigational suitability	No. of samples falling	Percentage of samples
1	< 1.25	Safe for all type of crops	31	96.88 %
2	1.25 – 2.50	Safe for semi-tolerant to tolerant crops	01	3.12 %
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	Nil	Nil

(All the values are expressed in lpm or epm)

On the perusal of table - 24, about 96.88 % of water samples of aquifer - II falling under safe for all type of crops category while about 3.12 % of water samples falling under safe for all type of crop category.Classification of irrigation watermodifiedPiper'sdiagram is shown below in figure – 15.



Interpretation of Chadha's modified Piper diagram revealed that 64% belong to calcium-bicarbonate (Ca-HCO3) hydrochemical facies and 33% water samples belong to calcium–magnesium–chloride (Ca–Mg–Cl) type of facies. This suggests that in the study area deeper aquifer is dominated by Ca-HCO3 type water.

3.6.2.2.4 Suitability of ground water based on Electrical Conductivity (EC): - Wilcox 1948 suggested a water class classification for suitability of water for irrigation. The classification is given below as a table - 25.

Table - 25: - Classification of ground water of Aquifer - II based on (EC)

Sl No.	Water Class	Rages of EC	No. of samples falling	% of samples
1	Excellent	< 250	04	12.50%
2	Good	250 – 750	21	65.63%
3	Permissible	750 – 2250	07	21.87%
4	Doubtful	2250 – 3000	Nil	Nil
5	Unsuitable	> 3000	Nil	Nil

On the perusal of table - 25, about 12.50 % of water samples aquifer - II falling under excellent water class. About 65.63% of water samples falling in good water class. Rest 21.87 % of water samples falling under permissible water class.
EC maps of dug well samples i.e. Aquifer – II has been prepared and shown in figures- 16. The values for sodium percentage, SAR, RSC and EC of water samples of Aquifer – II collected from hand pumps are given in table – 26.

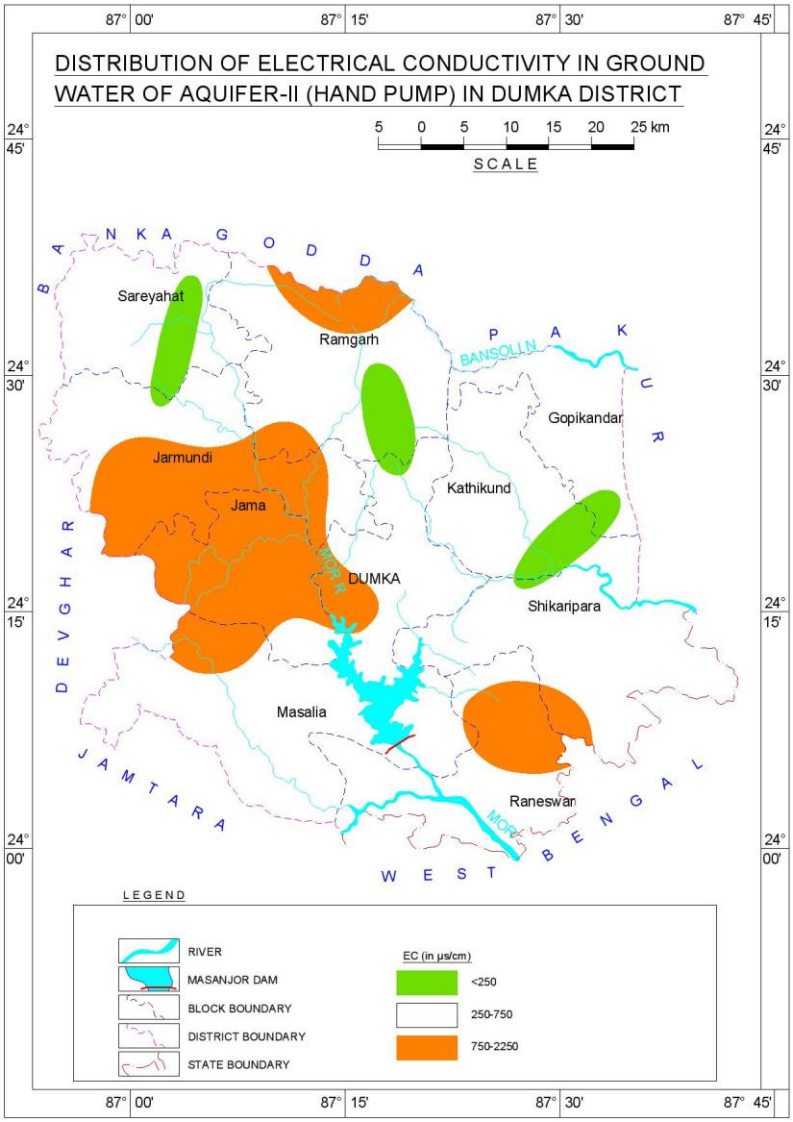


Figure – 16: EC map of Aquifer – II of Dumka district

Table - 26: Values of Sodium Percentage, SAR, RSC AND EC of water samples collected from Aquifer – II (Hand pumps), Dumka district

Sr. No.	Village	Block	District	Na %	SAR	RSC	EC
1	Patabari	Shikaripara	Dumka	28.18	1.23	-0.97	700
2	Masanjor	Raneshwar	Dumka	20.76	0.56	-0.28	281
3	Raneshwar	Raneshwar	Dumka	30.56	0.96	-0.48	366
4	Asanbani	Raneshwar	Dumka	15.46	0.73	-5.17	1098
5	Khirghata	Raneshwar	Dumka	23.93	0.76	-0.68	449
6	Masalia	Masalia	Dumka	35.73	1.60	0.24	608
7	Nipania	Masalia	Dumka	28.34	0.94	-0.08	471
8	Domkata	Masalia	Dumka	15.31	0.55	-2.68	632
9	Tiliya Pahari	Masalia	Dumka	30.46	1.04	0.73	449
10	Shikaripara	Shikaripara	Dumka	21.29	0.60	-0.88	352
11	Pokharia	Kathikund	Dumka	27.62	0.63	0.01	203
12	Rampur	Shikaripara	Dumka	42.27	1.42	-0.08	541
13	Kathikund	Kathikund	Dumka	27.38	0.99	0.64	567
14	Gopikandar	Gopikandar	Dumka	22.60	0.68	0.63	432
15	Durgapur	Gopikandar	Dumka	35.06	1.33	-0.07	513
16	Digal Kharauni	Gopikandar	Dumka	43.01	0.84	0.21	210
17	Amba	Kathikund	Dumka	13.27	0.32	-0.59	312

18	Doom	Dumka	Dumka	26.12	0.66	0.02	237
19	Jawari	Ramgarh	Dumka	20.39	0.41	-0.29	170
20	Ramgarh	Ramgarh	Dumka	29.80	1.44	-3.58	1018
21	Dumka	Dumka	Dumka	14.08	0.58	-4.77	1112
22	Chapodia	Dumka	Dumka	26.12	0.77	-0.58	314
23	Bara Palasi	Jama	Dumka	38.27	2.07	-4.29	1065
24	Nonihat	Jarmundi	Dumka	22.11	0.76	-2.49	545
25	Hansdiha	Saraiyahat	Dumka	18.84	0.40	-0.89	248
26	Dighi	Saraiyahat	Dumka	64.98	3.79	1.93	624
27	Beldaha	Jarmundi	Dumka	21.67	0.53	-0.08	233
28	Kusmah	Jarmundi	Dumka	15.12	0.42	-1.99	443
29	Jarmundi	Jarmundi	Dumka	22.81	1.25	-8.19	1295
30	Jama	Jama	Dumka	27.93	1.48	-4.98	974
31	Chikania	Jama	Dumka	30.30	1.68	-4.66	1193
32	Dhadhakia	Dumka	Dumka	22.48	0.77	-1.58	434

3.6.2.3 Geographical distribution and quantification with respect to ground water quality/ contamination:

The analyzed chemical data of groundwater samples (29 shallow aquifer samples and 32 deeper aquifer samples) were plotted on the Piper diagram. Interpretation of Piper diagram revealed that 64% belong to calcium-bicarbonate (Ca-HCO3) hydrochemical facies and 33% water samples belong to calcium–magnesium–chloride (Ca–Mg–Cl) type of facies. This suggests that in the study area deeper aquifer is dominated by Ca-HCO3 type water. On the other hand, in shallow aquifer, 65% water sample belong to calcium–magnesium–chloride (Ca–Mg–Cl) type and only 28% water samples belong to calcium-bicarbonate (Ca-HCO3) type. Most of the samples from shallow and deeper aquifer fall in the region where alkaline earth's (Ca+Mg) exceed alkali metals (Na+K).

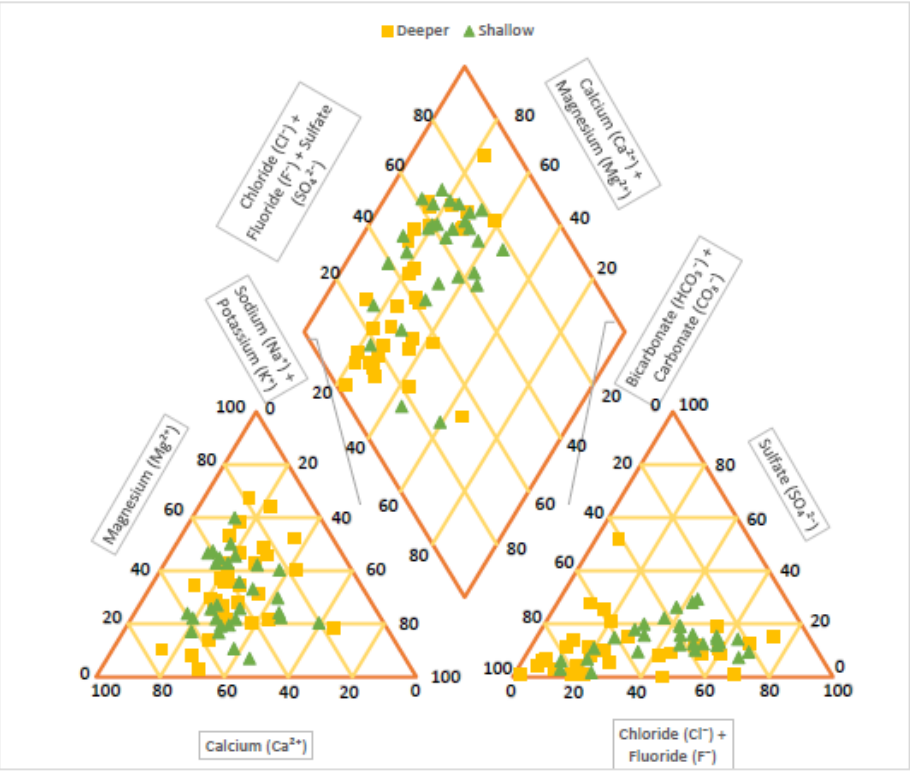


Figure – 17: Piper' diagram for shallow and deeper water samples of Dumka district

The physio-chemical parameters correlation matrices in shallow and deeper groundwater are given in tables 27 &28 respectively. In shallow water, significant positive relationships have been observed in following pairs of physico chemical parameters: TH–EC (r = 0.96), EC –Na (r = 0.84), EC–Ca (r = 0.95), EC–Cl (r = 0.96) and Cl – SO_4 (r = 0.81).In deeper water the correlation matrices show that various physio-chemical parameters pairs have significant positive correlations such as TH–EC (r = 0.86), EC –Na (r = 0.72), EC–Ca (r = 0.73),EC–Cl (r = 0.94) and EC – SO_4 (r = 0.69).

Table – 27: Correlation matrix (Shallow Aquifer)

	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F
pH	1												
Ec:	0.36	1											
TH	0.38	0.96	1										
Ca	0.36	0.95	0.97	1									
Mg	0.40	0.90	0.97	0.90	1								
Na	0.25	0.84	0.68	0.68	0.61	1							
K	0.27	0.33	0.34	0.42	0.26	0.26	1						
CO3	0.48	0.56	0.60	0.56	0.63	0.32	0.15	1					
HCO3	0.23	0.90	0.84	0.84	0.79	0.82	0.32	0.40	1				
Cl	0.34	0.96	0.89	0.88	0.83	0.88	0.28	0.49	0.82	1			
SO4	0.42	0.85	0.80	0.78	0.74	0.72	0.24	0.46	0.70	0.81	1		
NO3	0.36	0.90	0.95	0.94	0.92	0.56	0.36	0.62	0.77	0.80	0.68	1	
F	-0.13	-0.06	-0.13	-0.13	-0.12	0.10	-0.10	-0.15	0.20	-0.14	-0.14	-0.06	1

Table – 28: Correlation matrix (Deeper Aquifer)

	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F
pH	1												
Ec:	-0.49	1											
TH	-0.38	0.86	1										
Ca	-0.48	0.73	0.65	1									
Mg	-0.19	0.64	0.87	0.19	1								
Na	-0.39	0.72	0.46	0.45	0.31	1							
K	0.11	0.19	0.13	-0.06	0.20	0.10	1						
CO3	0.39	-0.14	-0.12	-0.07	-0.11	-0.20	-0.09	1					
HCO3	0.05	0.32	0.19	-0.12	0.33	0.37	0.12	-0.12	1				
Cl	-0.53	0.94	0.86	0.75	0.62	0.61	0.15	-0.13	0.03	1			
SO4	-0.39	0.69	0.60	0.43	0.50	0.53	0.21	-0.08	0.11	0.61	1		
NO3	-0.44	0.62	0.50	0.76	0.16	0.38	-0.14	-0.06	-0.18	0.61	0.42	1	

F	-0.02	-0.12	-0.11	-0.22	0.01	0.09	-0.20	-0.04	0.32	-0.28	0.14	-0.22	1

Gibb's Diagram

As it is obvious from Gibb's diagram, that weathering and mineralogical characteristics of bedrock and minerals are the major processes that are controlling hydrogeochemistry of the area in both aquifers. It is obvious from this diagram that elevated concentrations of Ca^{2+} and Na^{+} are resulting from dissolution of rock formation due to interaction between rock and percolated water in the aquifer matrix.

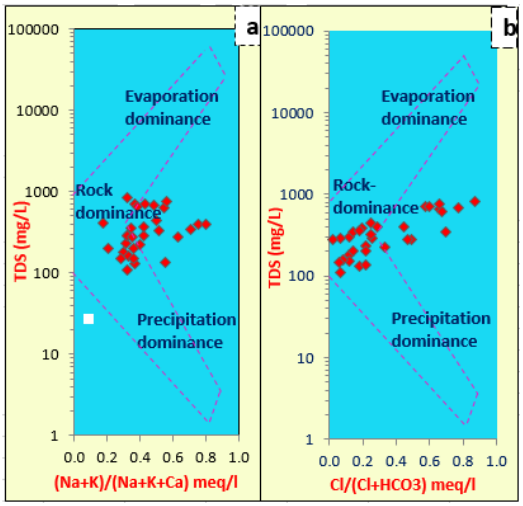


Figure – 18: Gibb's diagram for shallow aquifer

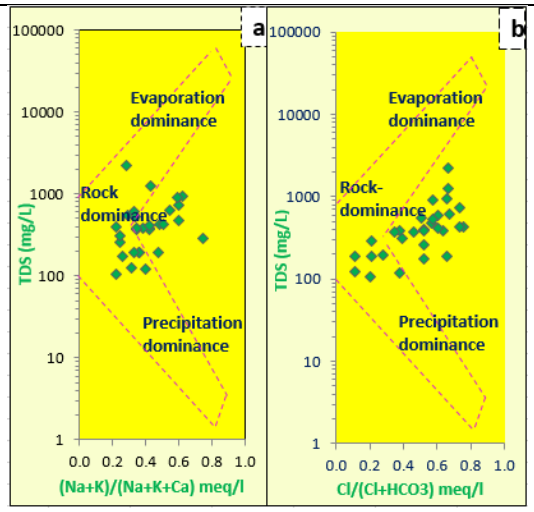


Figure – 19: Gibb' diagram for deeper aquifer

3.6.2.4. Uranium concentration in Ground Water

Uranium is a radioactive heavy metal which is broadly distributed throughout the earth's crust. The presence of Uranium in the ground water causes serious health hazards and is a matter of major concern. Total 18 samples were analysed for uranium concentration in Dumka district. Uranium concentrations in Dumka district were found to be in the range of BDL- 2.47 ppb , well below permissible limit of 30 ppb. . The detail results of chemical analysis for uranium are in Annexure-VI.

3.6.2.5. Geochemical studies results by other authors

- Mr Abhay Kumar Singh, Etal 2012, has concluded in his paper about the geochemistry of Dumka district which is as follows:-

The groundwater of the Dumka is generally faintly alkaline, fresh and soft to hard in nature. Hydrochemistry of the groundwater is dominated by Mg^{2+} and Ca^{2+} in cationic concentration and HCO_3^- and Cl^- in anionic abundance. In majority of the groundwater samples, concentrations of alkaline earth metal cations (Ca^{2+} Mg^{2+})exceed alkali metal cations (Na^+ + K^+) and HCO_3^- dominate over (SO_4^{2-} + Cl^-). Ca^{2+}–Mg^{2+}–HCO^- is the dominant hydrogeochemical facies. Water chemistry of the study area strongly reflects the dominance of weathering of rock forming minerals with secondary inputs from anthropogenic and atmospheric sources. Quality assessment for irrigation suitability shows that the groundwater of the area belongs excellent to good category and can be used for irrigation. However, high salinity and magnesium hazard value at few sites restricts the suitability of groundwater for agricultural purposes and demands special management plan.

- Dr S.K.Bera etal 2016 has analysed the ground water samples of deeper aquifer from exploratory wells at Shiv Pahar Dumka and found that The PMC value of Shiv Pahar Dumka deeper aquifer is 66+-0.2 and apparent radiocarbon age is 3340 BP

3.7 3-D and 2-D Aquifer Disposition: The 3-D map in hard rock area of the district showing spatial disposition and vertical extent of Aquifer-I indicating its depth of weathering while the Aquifer – II showing occurrence of fractured rock thickness is presented in **figures – 20&21**. Based on the drilling data of exploratory wells maximum thickness of Aquifer - I (weathered zone) in **hard rock area** is 25.0 m. The depth of Aquifer – II (fracture zone) ranges from 11.00 to 185.00 mbgl.

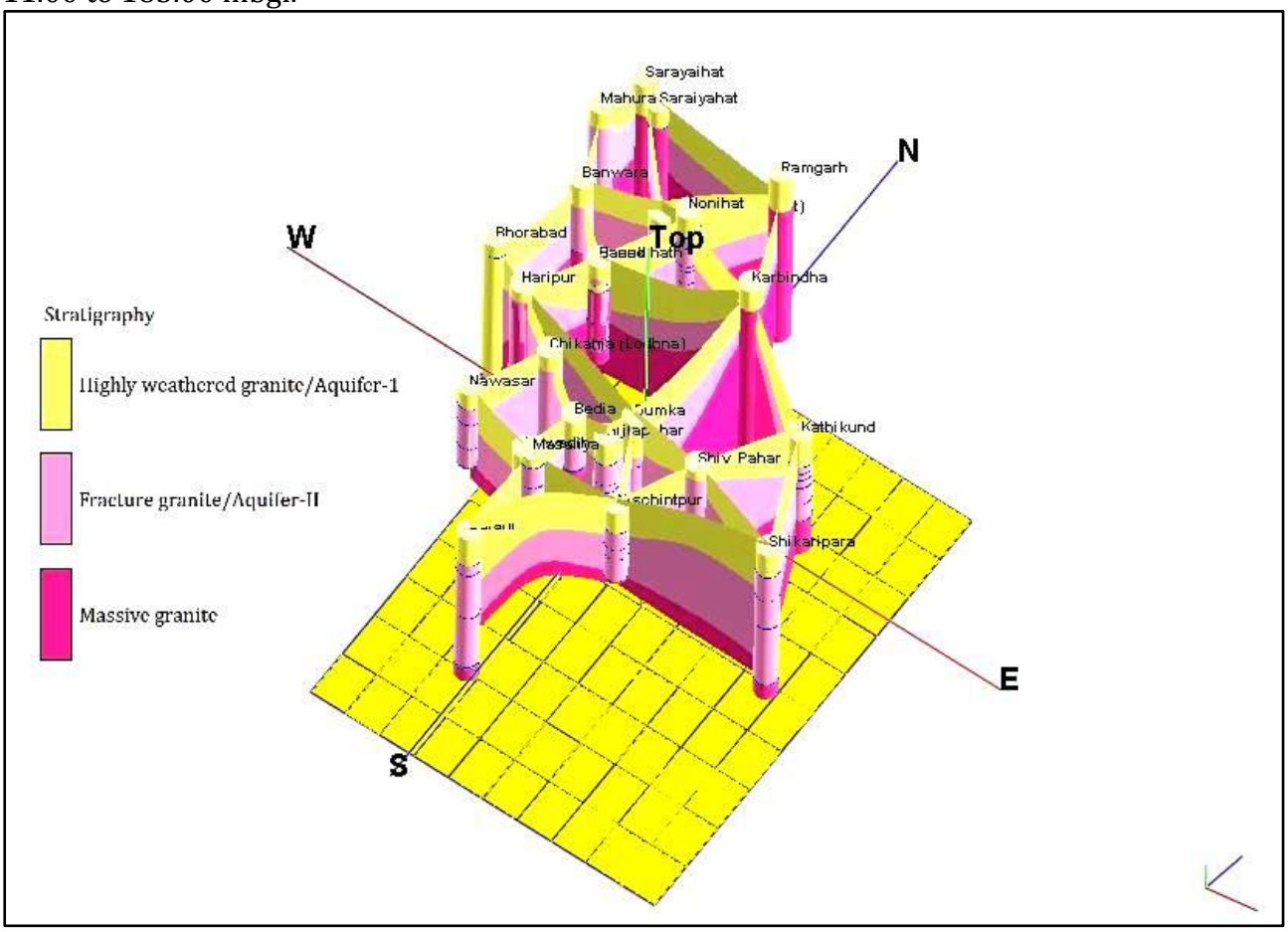


Figure – 20:3D subsurface lithological models with Aquifer Disposition in hard rock areas of Dumka district

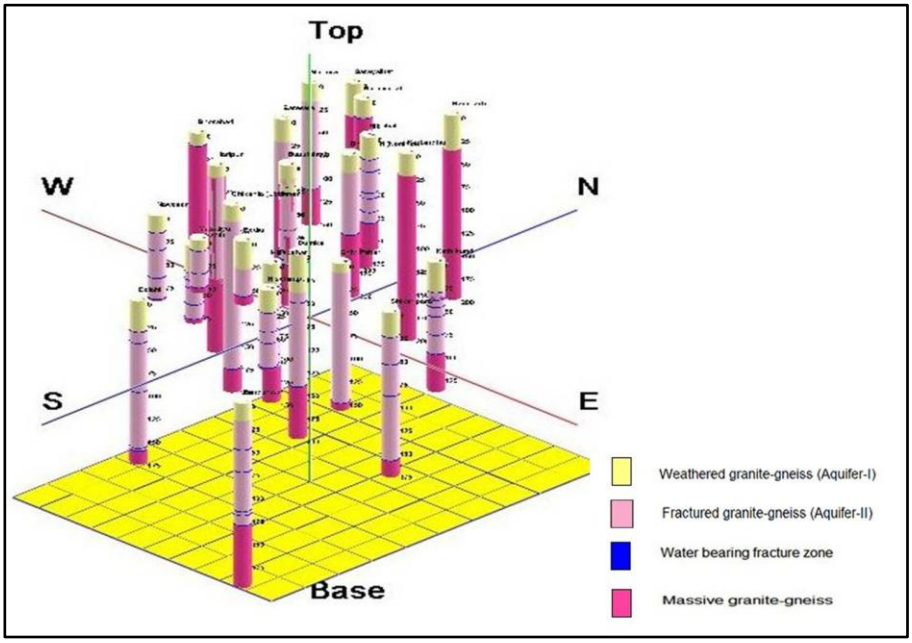


Figure – 21: Three dimensional strip-log of EW drilled in Dumka district

3.8 Hydrogeological Cross Section: To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. A-A' (northern part), B-B' (middle part) and C-C' (southern part) and D-D' representing NE-SW direction.

3.8.1Hydrogeological cross section A-A': Hydrogeological cross section A-A' represents the area in Northern - West portion district. The data of 4 exploratory wells i.e. Saraiyahat, Banwara, Haripur and Dalahi have been utilised. The Aquifer- I bottom depth ranges from 8-25 m representing weathered Granite Gneiss, while Aquifer-II ranges between12-164 m representing fractured Granite Gneiss. Generally 1- 6 fracture zones were encountered, with yield upto 6.27lps. Hydrogeological cross section of A-A' is shown in figure- 22 A &22 B.

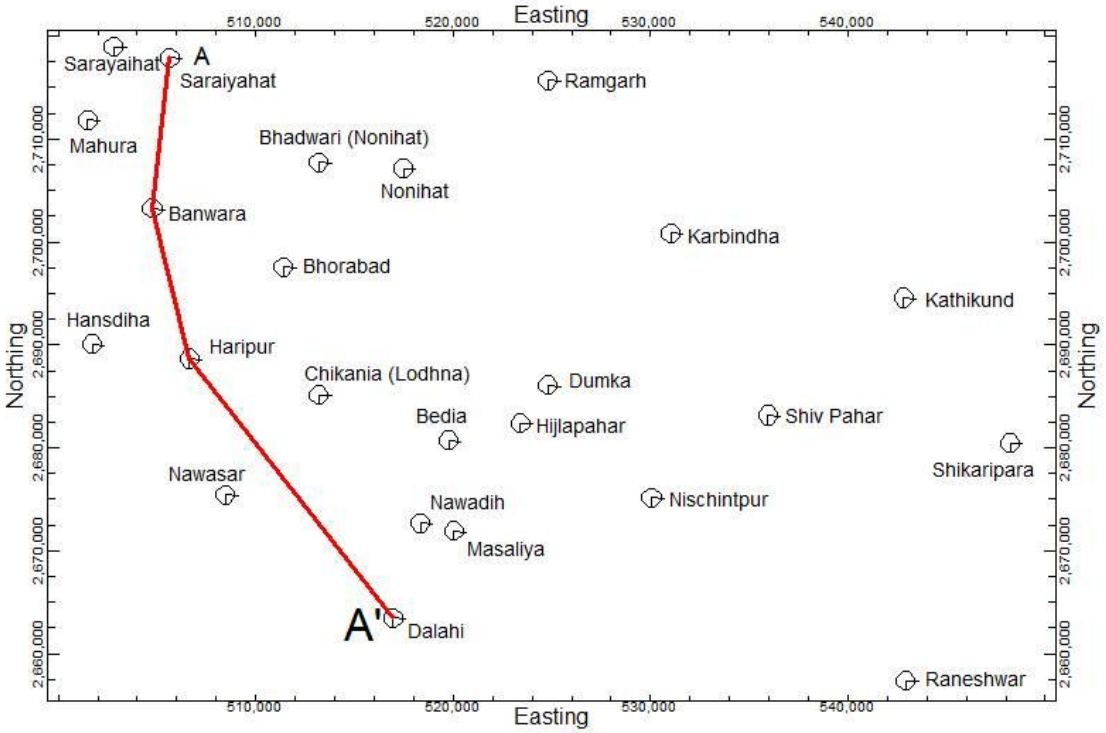


Figure – 22 A: Location map of cross section A – A'

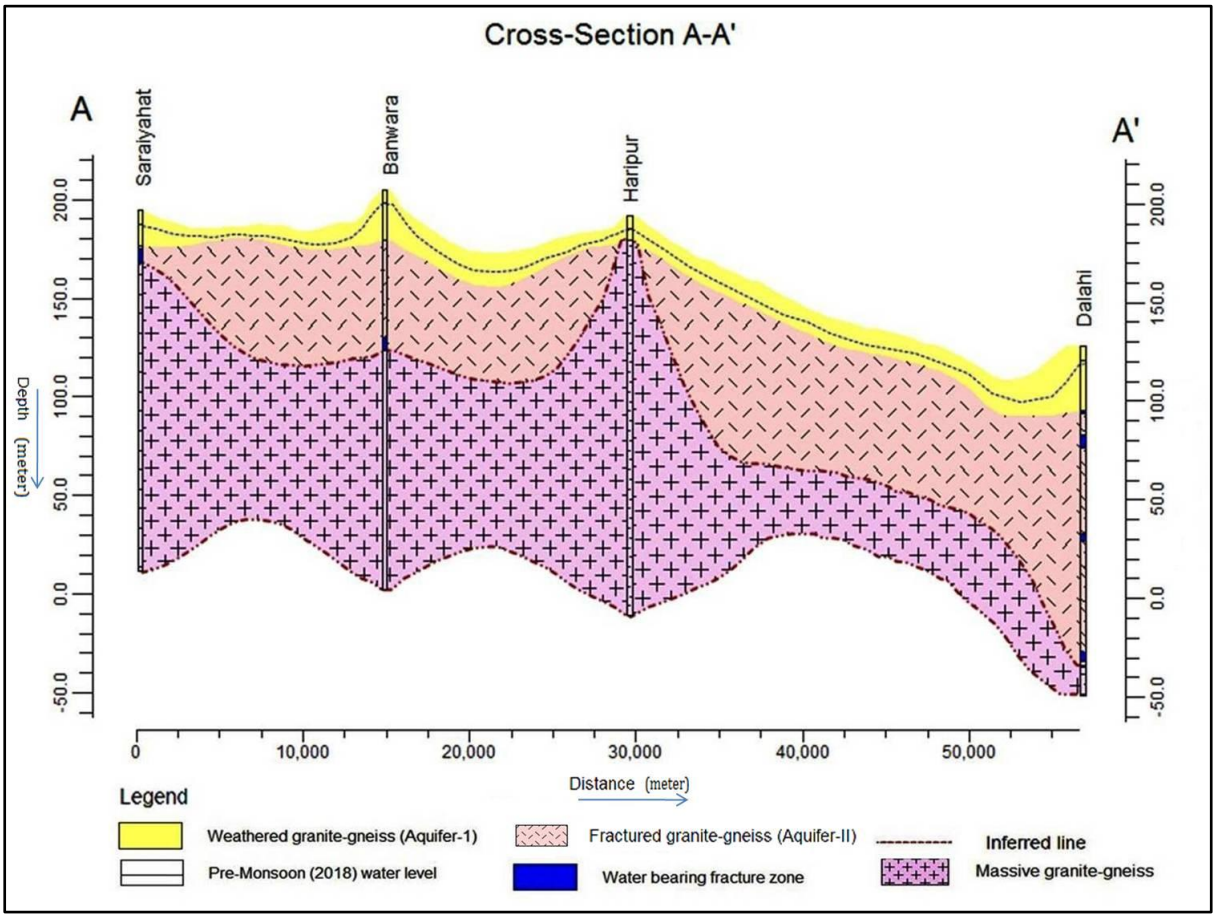


Figure – 22 B: Hydrogeological cross section along A – A'

3.8.2 Hydrogeological cross section B – B': Hydrogeological cross section B-B' represents the area in Northeren part of Dumka district. The data of 5 exploratory wells i.e. Mahura, Bhadwai, Nonihat, Karbindha and Kathikund have been utilised. The Aquifer- I bottom ranges between 16-23.5 m representing weathered Granite Gneiss, while Aquifer-II ranges from 24-115 m representing fractured Granite Gneiss. Due to the lack of fracture the Bhadwari and Karbindha exploratory wells become dry. Generally 1 - 7 fracture zones were encountered, with the well yield upto 22.5 lps. Hydrogeological cross section of B-B' is shown in figure - 23A and 23 B.

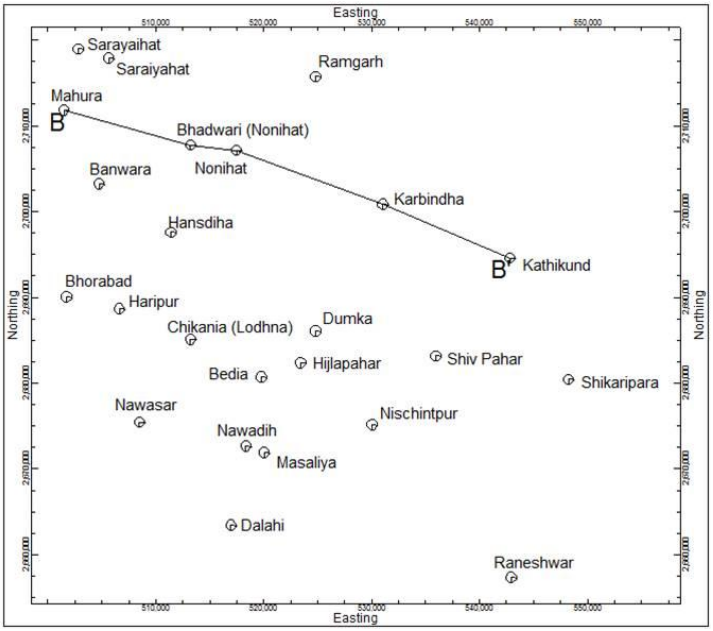


Figure – 23 A: Location map of cross section B – B'

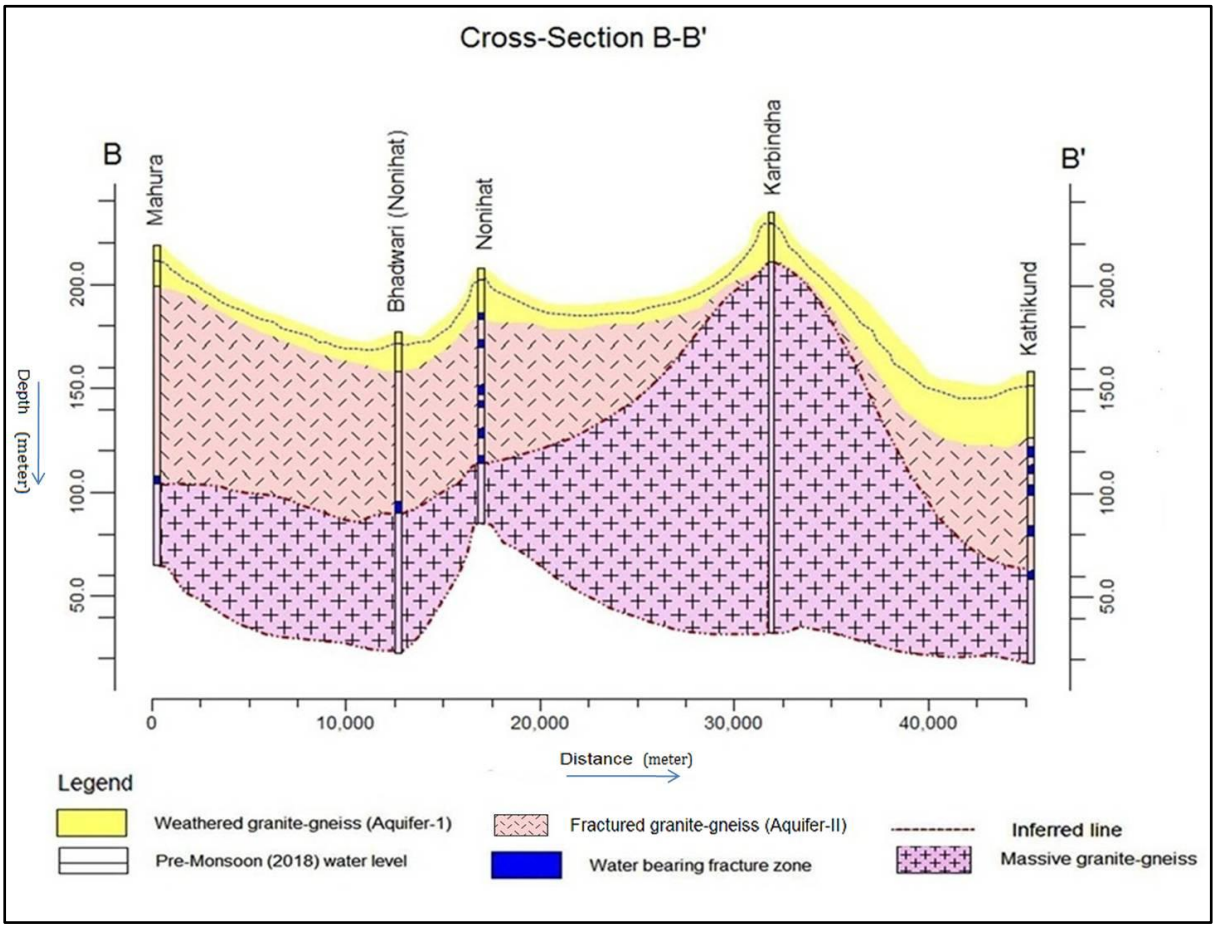


Figure – 23 B: Hydrogeological cross section along B – B'

3.8.3 Hydrogeological cross section C – C': Hydrogeological cross section C – C' represents the area in centra part of Dumka district. The data of 6 exploratory wells i.e. Bhorabad, Haripur, Chikania, Hijlapahar, Shivpahar and Shikaripara have been utilised. The Aquifer- I bottom ranges 8 - 21 m representing weathered Granite Gneiss, while Aquifer-II ranges from 13-185 m representing fractured Granite Gneiss. Generally 1-6 fracture zones were encountered with the well yield upto 9.84 lps. Hydrogeological cross section of C - C' is shown in figure- 24 A & 24 B.

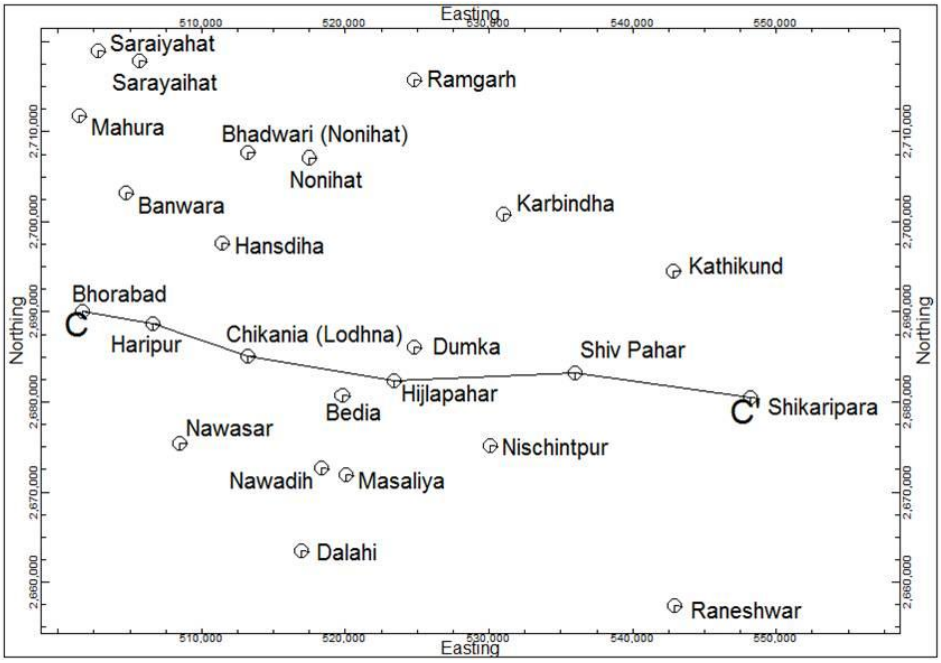


Figure – 24 A: Location map of cross section C – C'

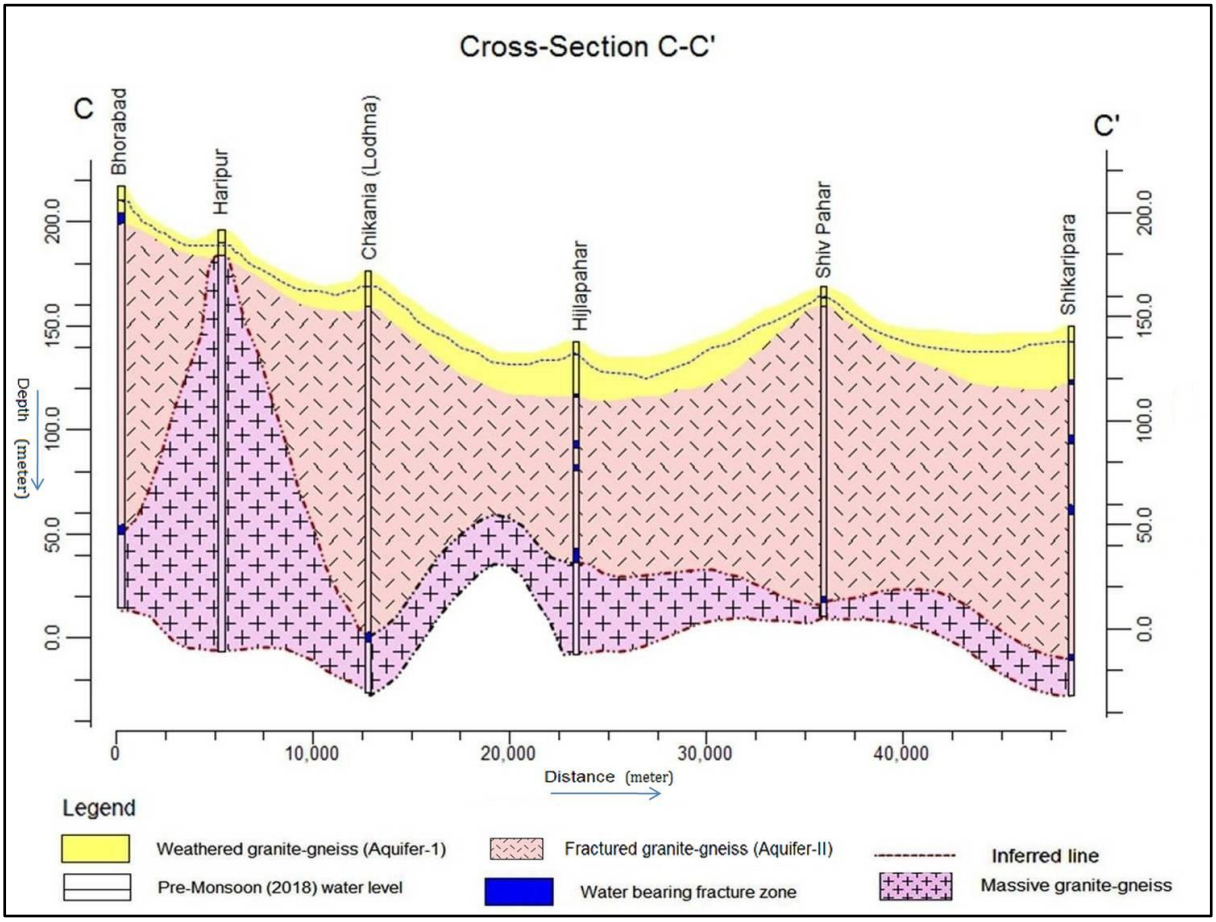


Figure – 24 B: Hydrogeological cross section along C – C'

3.8.4 Hydrogeological cross section D – D': Hydrogeological cross section D – D' represents the area in centra part of Dumka district. The data of 5 exploratory wells i.e. Karbindha, Dumka, Hijlapahar, Bedia and Nawadih have been utilised. The Aquifer- I bottom ranges 8-41 m representing weathered Granite Gneiss, while Aquifer-II ranges from 22- 145 m representing fractured Granite Gneiss. Generally 1- 6 fracture zones were encountered, with the well yield upto 21 lps. Hydrogeological cross section of D - D' is shown in figure- 25 A & 25 B.

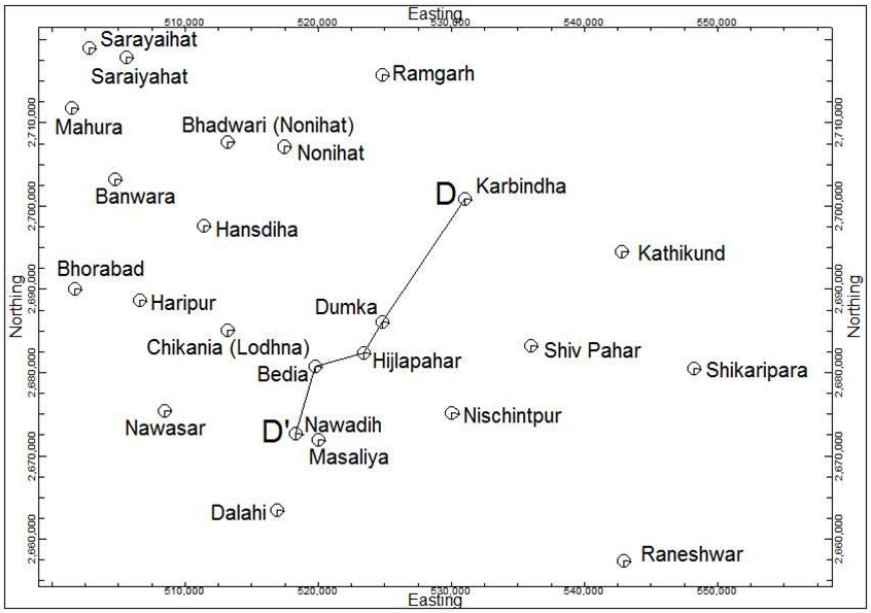


Figure – 25 A: Hydrogeological cross section along D – D'

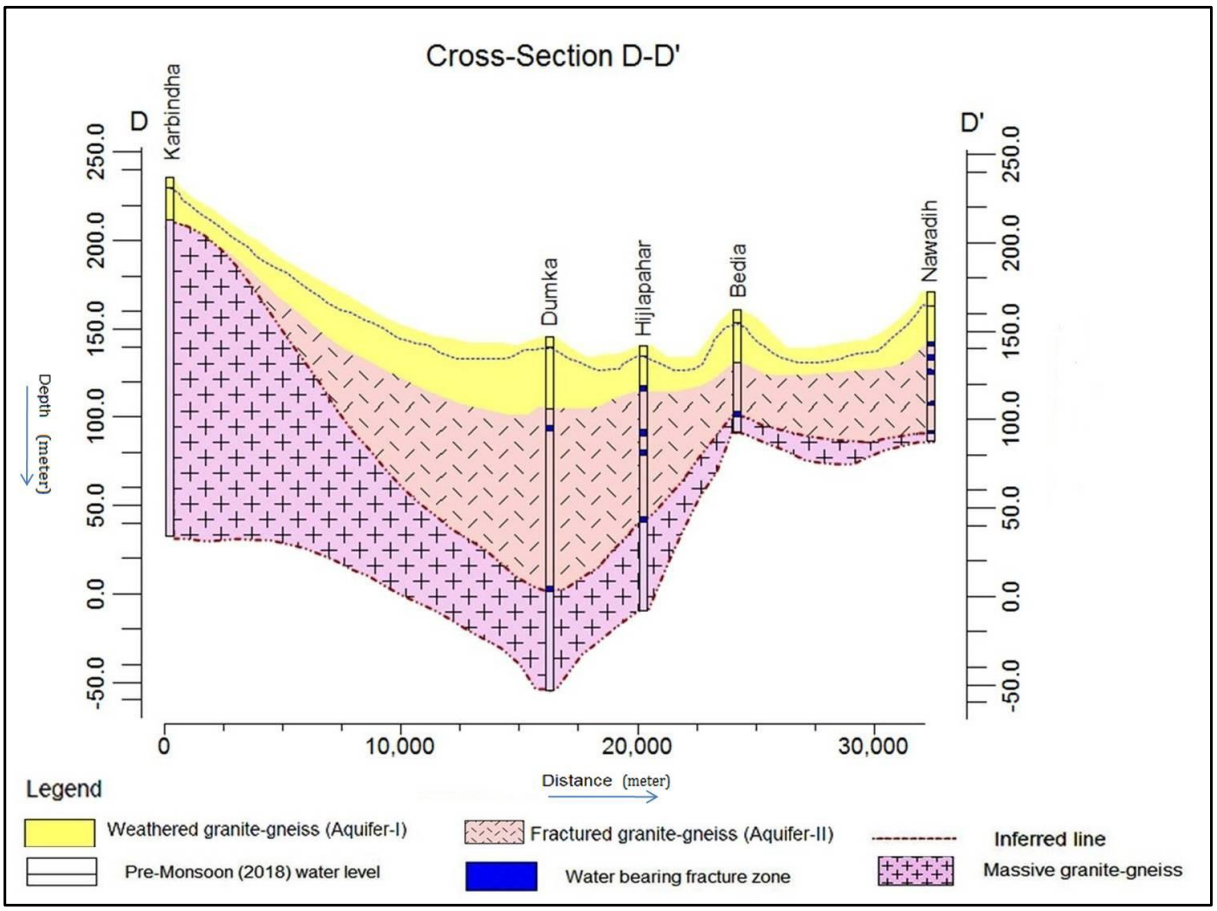


Figure – 25 B: Hydrogeological cross section along D – D'

Hydrogeological cross section of A-A' B-B', C-C', & D-D' shown in figure- 22B, 23B, 24B, 25B has been prepared based on exploratory well data of CGWB.The inferred imaginary line between fractured rock zone and massive rock zone depicted in Fig 22b,23b,23c &22d are also based on exploratory data. This is a regional model of hydrogeological cross setion. The heterogeneity of hard rock aquifer being high, the hydrogeological cross sections drawn by inferring the continuity of fracture zones in the second aquifer is tentative. Any additional data from the area in future may change the geometry of aquifer that can consider as well.

3.9 Aquifer Characteristics: - The sustainability of ground water Resources are better understood by the aquifer properties. The Table- 29 depicts the aquifer parameters details in Dumka district.The aquifer performance tests conducted at various exploratory wells reveal that aquifers can sustain to sufficient pumping hours and can give sustained yield with normal draw down. The transmissivity value ranges from 5-186 m2/day. Higher values of Transmissivity may be attributed to tensile nature or openness of fractures. The storativity value also varies from $2.3x10^{-2}$ to 7.3 x 10^{-5} , which shows that aquifers are under semi-confined to confined condition.

Table 29: Aquifer characteristics of Dumka district

Type of aquifer	Formation	Depth range of the aquifer (mbgl)	SWL (mbgl)		Thickness (m)	Yield m^3/hr	Aquifer parameter	
			Pre Monsoon (2018)	Post Monsoon (2018)			T (m^2/day)	Sy/S
Aquifer - I	Laterites/ Weathered Granite gneiss/Basalt	8-41	1.97 – 9.55	1.48 – 9.40	1 - 5	5-10	--	--
Aquifer - II	Fractured Granite gneiss/Fractured and Vesicular Basalt	11-185	--	--	0.50 – 7.00	Upto 81	5 - 186	0.000073 – 0.023

3.10 Thermal Spring studies: The hot springs of Dumka district was studied by Geological survey of India(2015-16) with the objective to monitoring of temperature and discharge to identify geothermal activity, water sampling for assessing quality of water and also isotope study in the area around known hot water springs. Following four hot springs of Dumka district were covered under the study-

1. Tantaloi hot spring
2. Barapalasi hot spring
3. Dalahi and Phulsahri hot springs
4. Sidpur, Mohanpur and Katwidongal hot springs

The salient features of different hot springs based on GSI(2016) study are as follows:-

1. Tantaloi Hot Spring: Tantaloi hot spring is located in Raneshwar block of Dumka district and lies at 24^0 02' 25" north latitudes and 87^0 17' 04" east longitudes falling in Toposheet No. 72P/8. It is 50 km away from district headquarter of Dumka, on Dumka – Suri road. The rocks around the Tantaloi hot spring are composed of gneisses and schists belonging to Chhota Nagpur Gneissic Complex (CGC) of Archean age. It includes granite gneiss, hornblend gneiss amphibolites and granitic rocks. The rocks are highly sheared, brecciated and mylonitised near hot spring. The studies have inferred the presence of two major sets of faults trending ENE-WSW and NNW-SSE. The emergence of hot spring is controlled by ENE-WSW fault.

The study of Pre and post monsoon geochemical results of Tantloi Spring show that thermal waters of the Tantaloi area are characterized by high Na, K, SO4 content and moderate Cl content and low Ca and Mg and HCO3 content. Broadly on piper plot, they cluster around

Na+K and Cl axes. Hence they can be grouped under Na-Cl type of water. They are Na-Cl saturated water indicative of geothermal origin. The HCO3- SO4- Cl diagram indicate thermal water to be of peripheral type of water while the Na-K-Mg diagram indicate thermal water to be partially equilibrated and mixed type affected by dilution. During pre monsoon, thermal waters show chloride affinity. The non thermal waters are characterized by low Na, K, Cl, SO4 content and high Ca, Mg and HCO3 content. Geochemically they are Ca-Mg-HCO3 type of water falling in metoric water type. It is observed that for Tantaloi geothermal manifestation area, the reservoir temperature varies from 119 to 121°C using quartz thermometers. Based on Na-K thermometers, the reservoir temperature varies from 127°C to 147°C.

2. **Barapalasi Hot Spring**: Barapalasi hot spring is located in Jama block of Dumka district and lies at 24^0 22' 36" north latitudes and 87^0 12' 12" east longitudes falling in Toposheet No. 72P/3. It is 20 km away from Dumka on Bhagalpur road, situated on the bank of Bhurbhuri River. The rocks near to Barapalasi geothermal manifestation are composed of gneisses and schists belonging to Chhota Nagpur Gneissic Complex (CGC) of Archean age. It includes granite gneiss, hormblende gneiss, amphibilites and granitic rocks. Near to thermal manifestation area, quartz vein has intruded parallel to foliation (Figure 26&27).

Fig.: 26Barapalasi hot spring Dumka,Jharkhand

Fig. : 27Garnet rich gneiss with quartz vein near Barapalasi

The geothermal manifestation is observed that several hot water sprouts with temperature ranging from 45.7^0 C to 64.7^0 C with cumulative discharge monitored 480 lit./min. The thermal waters of Barapalasi area are characterized by moderate Na, K, Cl, SO_4 and HCO_3 content and low Ca and Mg content. On Piper plot, they cluster around Na, Cl and HCO_3 axes. Hence they can be grouped under Na-Cl-HCO_3 type of water. Non thermal water are characterized by low Na, K and Cl, SO_4 content and high Ca, Mg and HCO_3 content. Geochemically they are Ca-Mg-HCO_3 type of water. No major geochemical variation is observed in thermal sources at Barapalasi area during post and pre monsoon period. It is also observed that for Barapalasi geothermal manifestation area, the reservoir temperature is around 105°C using quartz thermometers. Based on Na-K thermometers, the reservoir temperature varies from 117°C to 137°C.

3. Dalahi and Phulsahri hot springs

Dalahi hot spring is located in Masaliya block of Dumka district and lies at 24^0 05' 02" north latitudes and 87^0 09' 46" east longitudes falling in Toposheet No. 72P/4. It is 30 km away from Dumka on the Dumka – Nala road. The hot spring lies in Nunbil river course.The Phulsahri hot spring is also located in Masaliya block of Dumka district and lies at 24^0 04' 23" north latitudes and 87^0 10' 02" east longitudes falling in Toposheet No. 72P/4. It is 3-4 km away from Dalahi. The hot spring lies in Nunbil river course. The rocks around the Dalahi and Phulsahri hot spring are occupied by granite gneisses belonging to Chhota Nagpur Gneissic Complex (CGC) of Archean age. The rock is composed of quartz, feldspar, biotite and garnet.

The foliation has NW-SE trend with 60^0 dip towards north. At Phulsahri, amphibolites, pegmatite, quartz vein are present within granitic mass. These hot springs are structurally controlled as the contact between CGC and Gondwana is faulted and along the margin of these faults, thermal manifestations are seen. The thermal manifestation at Dalahi and Phulsahri is of low intensity.

Fig.:28DalahihotspringDumka, Jharkhand

Fig.:29 Phulsahri hot spring Dumka,Jharkhand

The geochemical results of the spring show that the thermal and non thermal waters of the Dalahi area are characterized by high Na, K, Cl SO4 content and low Ca, Mg and HCO3 content. On Piper plot, they cluster around Na, Cl and HCO3 axes. Hence they can be grouped under Na-Cl-HCO3 type of water. They are immature mixed/meteoric water. The HCO3- SO4- Cl diagram indicate thermal and non thermal water to be of peripheral type of water while the Na-K-Mg diagram indicate thermal water to be partially equilibrated and mixed type. The thermal and non thermal water of Phulsahri are characterized by low Na,K, and low to moderate Cl, SO4 content and high Ca, Mg and HCO3 content. Geochemically they are Ca-Mg-HCO3 type of water falling in metoric water type. It is also observed that for Dalahi and Phulsahri geothermal manifestation area, the reservoir temperature is around 100°C using quartz thermometers. Based on Na-K thermometers, the reservoir temperature varies from 163°C to 181°C

4. Katwidongal hot spring: Katwidongal hot spring is located in Gopikander block of Dumka district and lies at 24^0 25' 58" north latitudes and 87^0 27' 41" east longitudes falling in Toposheet No. 72P/7. It is located on Dumka – Garaipani (Dumka –Sahebganj road) - Bhuskidongal .The temperature of thermal spring water was observed 32.2^0 C with pH value of 8.2 and EC value of 540 µS/cm. Non thermal sources bear water temperature ranging from 21.4 to 24.6^0 C with pH value ranging from 7.9 to 8.3 and EC value varying from 60 to 150 µS/cm. The Thermal water is alkaline in nature with pH of 7.8. The major cations present in thermal water are Na, K, Ca, Mg and SiO_2 while major anions are HCO_3, Cl, SO_4 and F. Thermal water has TDS value of 248 with Na content of 24 ppm, K content of 4 ppm, Ca content of 62 ppm, Mg content of 21 ppm and SiO_2 content is 46ppm. It has Cl content of 5 ppm, SO_4 content of 2 ppm, HCO_3 content of 357 ppm and F content of 0.66 ppm. Non thermal water has TDS value 31 ppm with Na content of 3 ppm, K content of 2 ppm, Ca content of 7 ppm, Mg content of 2 ppm and SiO_2 content of 13 ppm. It has Cl content of 9 ppm, SO_4 content of 2 ppm, HCO_3 content of 37 ppm and F content of 1.60 ppm. The thermal and non thermal water of Katwidongal are characterized by low Na, K and low to moderate Cl, SO_4 content and high Ca, Mg and HCO_3 content. Geochemically they are Ca-Mg-HCO3 type of water.

4. GROUND WATER RESOURCE

Ground Water Resource of the area has been estimated block wise based on for base year as on March-2017. 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 the Ground water resources components, i.e., Replenishable ground water resources or Dynamic Ground Water Resources and In-storage Resources or Static Resources.The assessment of ground water includes assessment of dynamic and in-storage ground water resources, but the development planning should mainly depend on dynamic resource only as it gets replenished every year. Changes in static or in-storage resources reflect impacts of ground water mining. Such resources may not be replenishable annually and may be allowed to be extracted only during exigencies with proper recharge planning in the succeeding excess rainfall years.

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

The methodology for ground water resources estimation is based on the principle of water balance 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 details of Annually Replenishable or Dynamic Ground Water Resources of Dumka district is in Table-30.

Table-30:Dynamic Ground Water Resources of Dumka district (As on March -2017)

S.no.	Items	
1	Area in ha	371643
2	Annual Extractable Ground Water Recharge in ham	24335.31
3	Current Annual Ground Water Extraction for irrigation in ham	3690.75
4	Current Annual Ground Water Extraction for domestic in ham	2195.06
5	Current Annual Ground Water Extraction for industrial in ham	17.35
6	Current Annual Ground Water Extraction for All uses in ham	5903.15
7	Annual GW Allocation for for Domestic Use as on 2025 in ham	2195.08
8	Net Ground Water Availability for future use in ham	18432.14
9	Stage of Ground Water Development (%)	24.26

4.1.1 Recharge Component: During the monsoon season, the rainfall recharge is the main recharge parameter, which is estimated as the sum total of the change in storage and gross draft. The change in storage is computed by multiplying groundwater level fluctuation between pre and post monsoon periods with the area of assessment and specific yield. Monsoon recharge can be expressed as:-

$R = h \times Sy \times A + DG$

where,

h = rise in water level in the monsoon season, Sy = specific yield

A = area for computation of recharge, DG = gross ground water draft

The monsoon ground water recharge has two components- rainfall recharge and recharge from other sources. The other sources of groundwater recharge during monsoon season include seepage from canals, surface water irrigation, tanks and ponds, ground water

irrigation, and water conservation structures. During the non-monsoon season, rainfall recharge is computed by using Rainfall Infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-monsoon recharge.

The season wise assessment of recharge from various components such as rainfall and other sources was done and presented in table - 31 and figure - 30. The recharge from rainfall contributes maximum component 22916.01 ham during monsoon season and recharge from other sources is 459.81ham, whereas during non-monsoon season, recharge from rainfall is 1357.58 and the recharge from other sources is 1823.19 ham. The total annual ground water recharge is 26556.59 ham and total natural discharge is 2221.28 ham. Net ground water availability after natural discharge is estimated as 24335.31ham.

Table – 31: Recharge Components evaluated for Resource Estimation: Dumka District

Block	Recharge from rainfall during monsoon season (ham)	Recharge from other sources during monsoon season (ham)	Recharge from rainfall during non monsoon season (ham)	Recharge from other sources during non monsoon season (ham)	Total annual ground water recharge (ham)	Provision for natural discharges (ham)	Net annual ground water availability (ham)
Dumka	2159.78	59.39	292.13	235.92	2747.22	274.72	2472.50
Gopikandar	1770.36	31.82	76.58	126.33	2002.09	100.25	1904.84
Jama	2772.48	41.42	57.74	164.04	3035.68	151.78	2883.90
Jarmundi	1558.55	42.47	271.04	168.13	2040.19	204.02	1836.17
Kathikund	2157.73	29.85	15.34	118.05	2320.97	232.10	2088.87
Masaliya	2645.18	14.76	177.43	57.07	2894.44	289.44	2605.00
Ramgarh	3327.03	34.23	150.76	134.83	3646.85	182.34	3464.51
Raneshwar	1624.61	38.87	43.66	154.00	1861.14	186.11	1675.03
Saraiyahat	980.51	126.61	177.71	505.17	1790.00	179.00	1611.00
Shikaripara	3919.78	40.39	95.19	159.65	4215.01	421.50	3793.51
Total	**22916.0**	**459.81**	**1357.58**	**1823.19**	**26556.5**	**2221.28**	**24335.31**

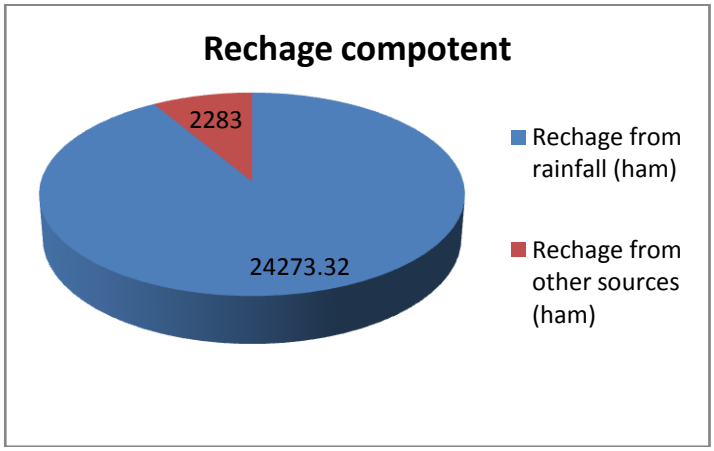


Figure – 30: Recharge from various sources

4.1.2 Ground Water Avaiability, Draft and Stage of GW development

The utilization of available ground water resources for various purposes is provided in table – 32 (As on 31st March 2017). The annual gross draft for all uses is estimated at 5903.15 ham with domestic sector being the major consumer having a draft of 2195.06 ham. The annual draft for irrigation use was estimated 3690.75ham. The allocation of net ground water

available for future irrigation is 24335.31ham. The stage of ground water development is low i.e., 24.26%.

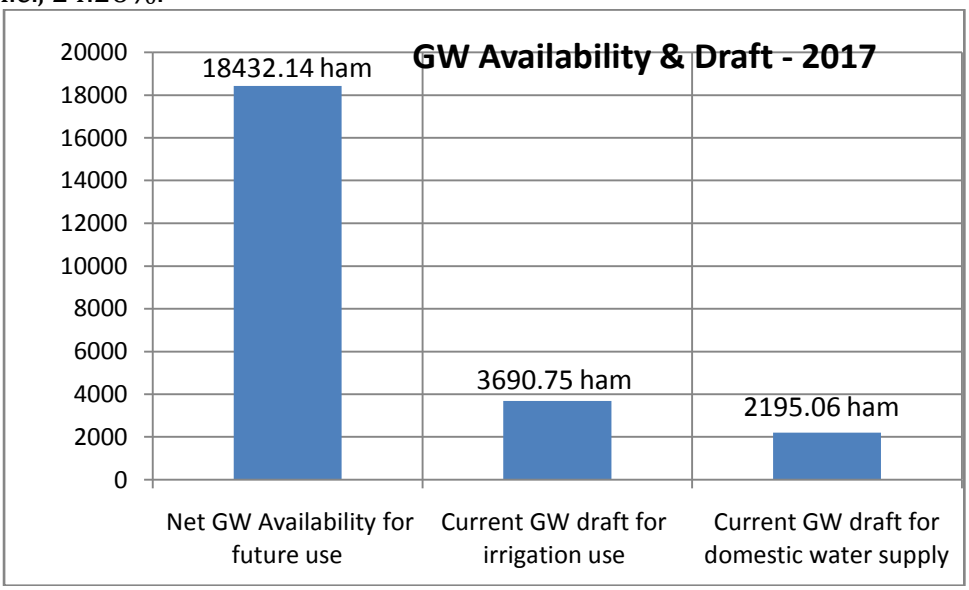


Figure – 31: Net GW Availability & Draft of Dumka district (2017)

Table – 32: Ground Water Resources Availability, Draft and Stage of GW Development (As on 31st March 2017)

Administrative Units	**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 (%)**
	(ham)	**(ham)**	**(ham)**	**(ham)**	**(ham)**	**(ham)**	**(%)**
Dumka	2472.50	457.75	372.77	17.34	847.86	1624.64	34.29
Gopikandar	1904.84	36.25	70.09	0.00	106.34	1798.49	5.58
Jama	2883.90	814.25	229.90	0.00	1044.15	1839.74	36.21
Jarmundi	1836.17	834.50	280.23	0.00	1114.73	721.44	60.71
Kathikund	2088.87	117.50	119.08	0.00	236.58	1852.29	11.33
Masalia	2605.00	278.25	207.56	0.00	485.81	2119.19	18.65
Ramgarh	3464.51	354.75	266.48	0.00	621.23	2843.28	17.93
Raneshwar	1675.03	60.75	169.42	0.00	230.17	1444.86	13.74
Saraiyahat	1611.00	481.25	260.45	0.00	741.70	869.30	46.04
Shikaripara	3793.51	255.50	219.07	0.00	474.57	3318.93	12.51
District Total	**24335.31**	**3690.75**	**2195.06**	**17.37**	**5903.15**	**18432.14**	**24.26**

4.2 Assessment of In-Storage Ground Water Resources or Static Ground Water Resources(Unconfined Aquifer i.e 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

For Aquifer I in hard rock area of Dumka district

AQUIFER I	
Area (A) (sqkm)	3716.02
Pre-monsoon (average) depth to water level (mbgl) (Z1)	6.82
Bottom of Unconfined Aquifer (mbgl) (Z2)	18.59
Specific yield (Sy)	2%
Saturated zone thickness (Z2-Z1) of aquifer (ST)	11.77
SGWR = A *(Z2 - Z1) * SY	874.75 mcm

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 water Resources 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) = 243.35 mcm +874.75 mcm = **1118.10** *mcm*

5. GROUND WATER RELATED ISSUES

Agriculture is the major occupation of the rural population of the Dumka district. About 93% population of the district is living in rural areas and depends on agriculture. Since the density of population is high there is acute pressure on land for agriculture use. But the land available for cultivation is limited because of rugged and hilly geomorphological set-up. The district of Dumka is mainly a dissected upland of ancient crystalline rocks which covers the major parts of this district uninterruptedly.

Ground water conditions in crystalline rocks are generally considering to be poor because of the absence of two basic parameters i.e. porosity and permeability which are essential for the occurrence and movement of ground water in any rock type. Weathering aided by joints and fractures breaks down the original composition and texture of rocks producing pore spaces, hence imparting the secondary porosity and permeability. So due to the development of these properties even crystalline rocks have become good conduit for the occurrence and movement of ground water. Dumka is one of the most underdeveloped district of Jharkhand especially in the field of irrigation infrastructure (major and medium). Ground water resources of this district have to be developed on priority basis for giving a thrust to the agriculture production of this tribal dominated district.

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 24.26%, based on Ground water resource assessment as on 2017. The Block wise stage of ground water development (SOD) of the district varies from 5.58 to 60.71 percent. Block wise stage of development of the district is shown in figure – 32.

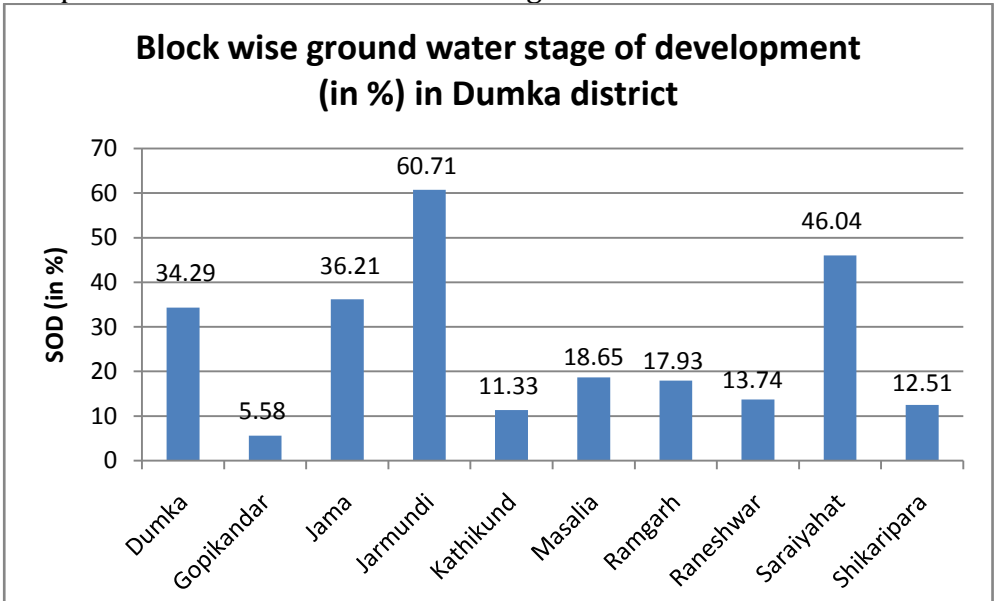


Figure - 32: GW stage of development in Dumka district

5.2 Low Ground Water Potential / Limited Aquifer Thickness / Sustainability: Central Ground Water Board has constructed 30 exploratory wells in hard area of the district. The percentage of success bore wells (more than 3 lps discharge) is 53% with 17% of dry wells. Average thickness of weathering is 20 m and fracture zone is limited only. Low to medium Transmissivity value observed which varies from 14.04 to 186 m^2/day of fractured aquifer. The yield of bore wells drilled in the area is classified and presented below in figure – 33.

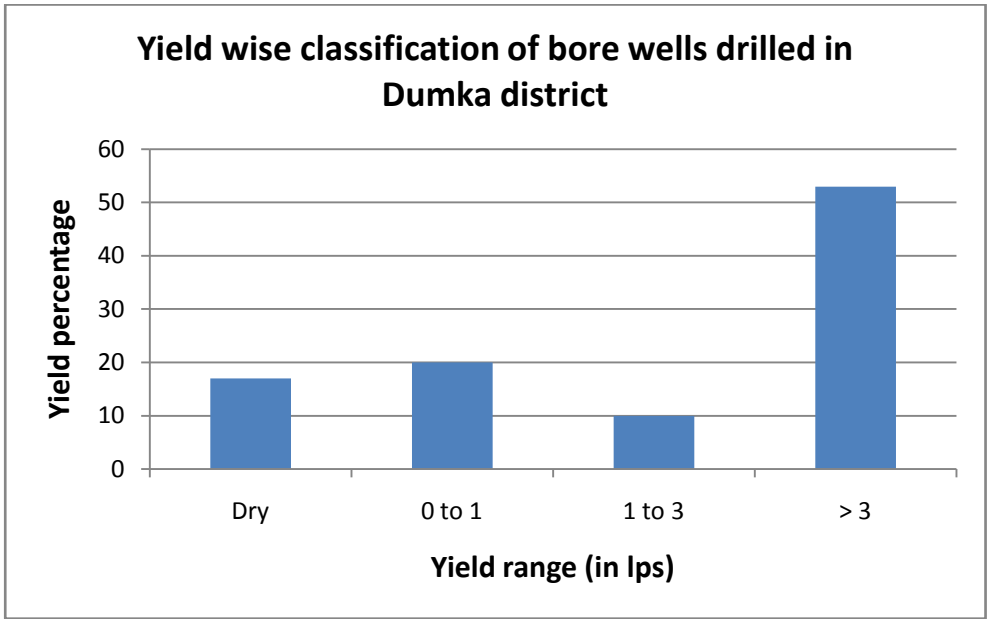


Figure – 33: Yield wise classification of bore wells drilled in Dumka district

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 11 samples of shallow aquifer (dug well) and 12 samples of deeper aquifer (hand pump). Similarly, Fluoride concentration is found beyond permissible limit in three samples of shallow aquifer and two samples of deeper aquifer. In addition, very high EC value 3449 µ S/cm has been observed in dug well sample existing at Jarmundi. Also total hardness (TH) value found beyond permissible limit in the samples of dug wells located at villages Bara Palashi (600 mg/l) and Jarmundi (1565 mg/l).

Location details of Nitrate and Fluoride concentration found beyond permissible limit are given in table 33 and 34 respectively and also represented in figure – 36.

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 as well as deeper aquifer about 37% water samples have 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 33.

Table – 33: Location details of Nitrate concentration found beyond permissible limit in ground water of Dumka district

Sr. No.	Village	Block	Nitrate value (mg/l)
1	2	3	4
1. Dug well samples			

1	Patabari	Shikaripara	86.7
2	Raneshwar	Raneshwar	83.5
3	Khirghata	Raneshwar	45.9
4	Domkata	Masalia	76.7
5	Tiliya Pahar	Jama	60.0
6	Pokharia	Kathikund	53.7
7	Bara Palashi	Jama	124.2
8	Kusmah	Jarmundi	48.3
9	Jarmundi	Jarmundi	547.0
10	Jama	Jama	80.6
11	Chikania	Jama	56.7
2. Hand pump samples			
1	Patabari	Shikaripara	47.2
2	Asanbani	Raneshwar	91.3
3	Khirghata	Raneshwar	50.0
4	Nipania	Masalia	55.3
5	Domkata	Masalia	115.0
6	Ramgarh	Ramgarh	53.8
7	Chapodia	Dumka	46.3
8	Bara Palashi	Jama	82.0
9	Kusmah	Jarmundi	71.1
10	Jarmundi	Jarmundi	114.0
11	Jama	Jama	65.0
12	Chikania	Jama	101.6

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. Natural sources are associated to the geological conditions of an area. Several rocks have fluoride bearing minerals like apatite, fluorite, biotite and hornblende. The weathering of these rocks and infiltration of rainfall through it increases fluoride concentration in groundwater. Anthropogenic sources of fluoride include agricultural fertilisers and combustion of coal. Phosphate fertilisers contribute to fluoride in irrigation lands. There are several methods available for the removal of fluoride from groundwater which is insitu or exsitu. To dilute the groundwater contaminated with fluoride, artificial recharge structures can be built in suitable places which will decrease its concentration. Rainwater harvesting through existing wells also will prove effective to reduce the groundwater fluoride concentration. Exsitu methods which are conventional treatment methods like adsorption, ion exchange, reverse osmosis etc can be practiced at community level or at households to reduce fluoride concentration before ingestion.

In shallow aquifer 10.34% samples have F concentration more than the desirable limit of 1mg/l while 6.25% water samples of deeper aquifer exceed the permissible limit of 1mg/l. Location details of F concentration found beyond permissible limit is given in table 34 and sample wise Fluoride concentration is shown in figure 34 and figure 35 for shallow and deeper aquifer respectively.

Table – 34: Location details of Fluoride concentration found beyond permissible limit in ground water of Dumka district

Sr. No.	Village	Block	Fluoride value (mg/l)
1. Dug well samples			

1	Tiliya Pahari	Jama	1.69
2	Dighi	Saraiyahat	3.14
3	Beldaha	Jarmundi	1.57
2. Hand pump samples			
1	Masalia	Masalia	1.53
2	Hansdiha	Saraiyahat	1.70

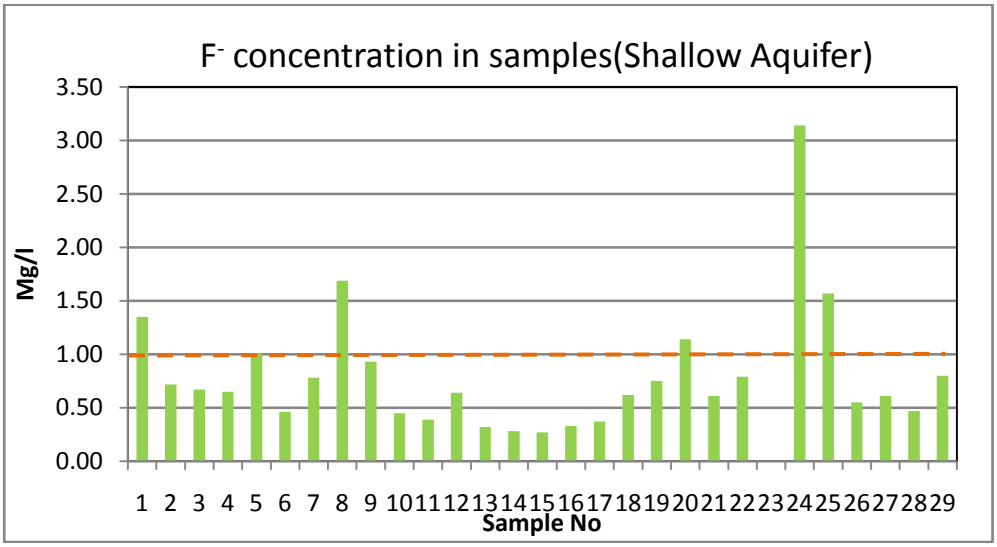


Figure – 34: Sample wise Fluoride concentration of shallow aquifer in Dumka district.

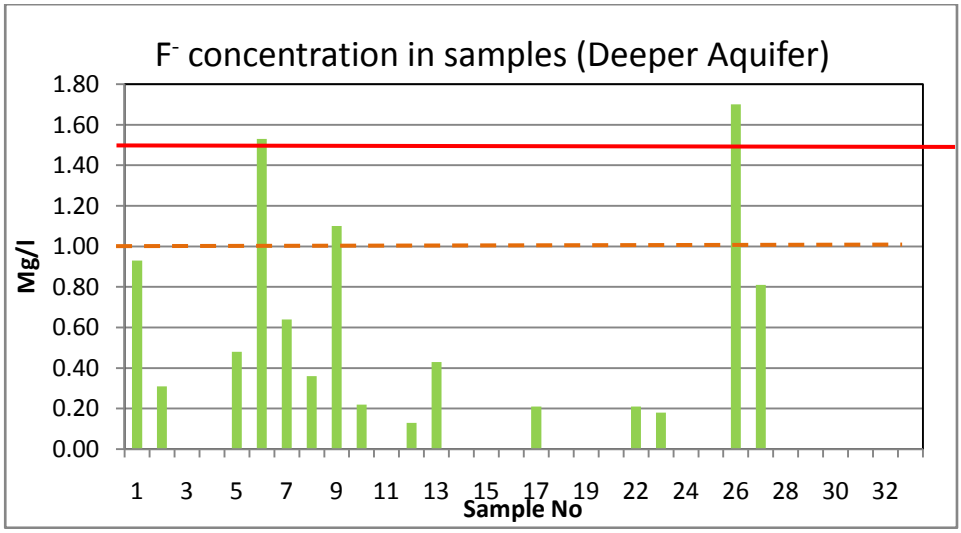


Figure – 35: sample wise Fluoride concentration of deeper aquifer in Dumka district

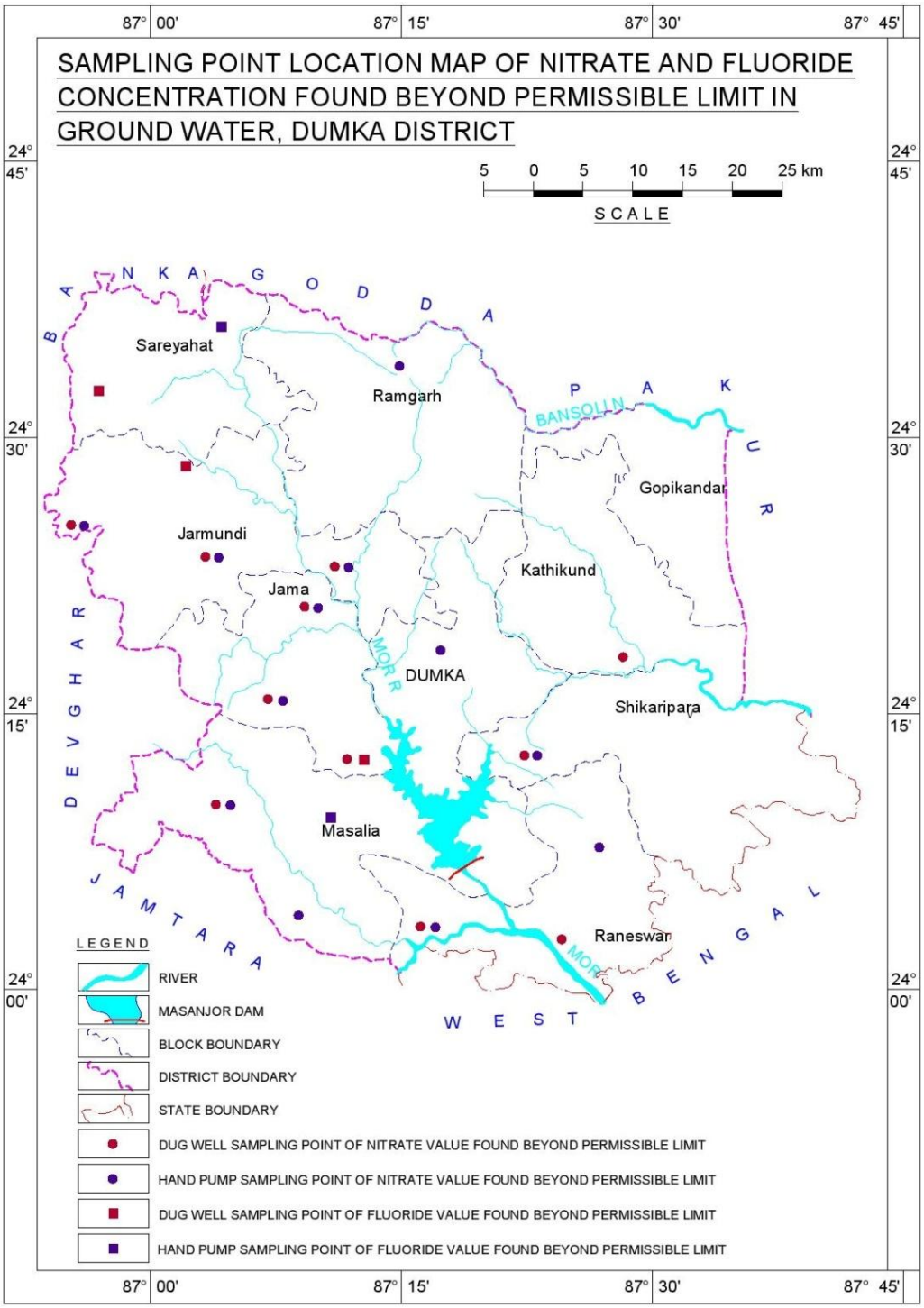


Figure – 36: Location map of NO_3 and F concentration found beyond permissible limit in ground water, Dumka district.

5.3.3 Water Contamination inventories by Jal Jeevan Mission

Under the Jal Jeevan Mission programme, Department of Drinking Water Sanitation, Ministry of Jalshakti, Govt of India has undertaken water quality analysis in Dumka district. The results show that out of 8442 water samples tested, 8226 samples were found to be not contaminated, however contamination for Iron, Flouride, Nitrate, Others, Bacterioiogical, Multiple contamination found in 106, 37,12,8,30 & 30 samples respectively(Annexure-XI).

6. MANAGEMENT STRATEGIES

As discussed in previous chapter, the major ground water related issue in the Dumka 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 24.26% to 70%. Total 71681 dug wells of 10-15 m depth are recommended to be constructed in feasible areas. Similarly, 11947 shallow depth bore wells (60 - 90 m depth) are also recommended to be drilled in feasible areas. Proposed number of abstraction structure based on SOD 70% with future irrigation potential & unit draft (Dugwell-0.2 ha, BW- 1.2 ha) is given below in tables–35& 36.

Table –35: Future Irrigation Potential & Proposed number of Abstraction Structures based on SOD 70%

District	Net GW Availability for Future Irrigation Development	future irrigation potential available (ha) considering (Δ) 0.45m	70% of future irrigation potential to be created (ha)	Proposed number of ground water structure (Dug wells)	Proposed number of ground water structure (BW)
Dumka	1624.64	3610.31	2527.22	6318	1053
Gopikandar	1798.49	3996.64	2797.65	6994	1166
Jama	1839.74	4088.31	2861.82	7155	1192
Jarmundi	721.44	1603.20	1122.24	2806	468
Kathikund	1852.29	4116.20	2881.34	7203	1201
Masalia	2119.19	4709.31	3296.52	8241	1374
Ramgarh	2843.28	6318.40	4422.88	11057	1843
Raneshwar	1444.86	3210.80	2247.56	5619	936
Saraiyahat	869.30	1931.78	1352.24	3381	563
Shikaripara	3318.93	7375.40	5162.78	12907	2151
Total	**18432.16**	**40960.36**	**28672.25**	**71681**	**11947**

BW = Bore well

This will bring an additional area of 28672 ha under assured iirigation. 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 further ground water development to achieve 100% utilization.

6.2 Supply Side Interventions:

At present as per Ground Water Resource Estimation 2017, the stage of ground water development is very low i.e., 24.26 % and all the block of the district comes under safe category. However in some parts of the district long term declining trend has been noticed. Therefore, the ground water development should also be coupled with ground water augmentation, so that there is no stress on ground water regime of the area. The supply side interventions 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 as well as dilution of ground water contamination such as Nitrate and Fluoride observed in the district. The implementation of

water conservation through artificial recharge measures will have a positive impact on drinking water sources of the area. It will ensure that the wells don't go dry during summer/lean/stress period in the areas of implementation and sufficient ground water availability is there in the wells even during the summer season. Thus not only the drinking and domestic water sources will be strengthened but additional irrigation potential can be created through artificial recharge structures.

6.2.1Artificial recharge to Ground Water 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 9 m bgl in the district has been considered for identifying the area. 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 are in Table- 36.

Table – 36 Artificial recharge structures feasible in Dumka district.

Volume of unsaturated zone available for recharge (MCM	Total volume of Available Water for Recharge (MCM)	Proposed numbers of recharge structures (No's)			
		Percolation Tank	NalaBund/ Check dam / Gully Plug	RTRWH	
				300 to 1000 sq. m. roof area	More than 1000 sq. m. roof area
82.28	136.58	363	2276	5954	313

6.2.2Initiatives by Minor Irrigation, Govtof Jharkhand

Numbers of check dam have been constructed by Minor Irrigation Division, Dumka for creating additional irrigation potential in the district. Block wise number of check dam is given below in table – 37.

Table–37: Block wise number of check dam constructed by Minor Irrigation Division, Dumka

Sr. No.	Block	No. of check dam
1	Dumka	12
2	Jama	11
3	Jarmundi	27
4	Saraiyahat	19
5	Ramgarh	43
6	Gopikandar	08
7	Kathikund	10
8	Shikaripara	07
9	Raneshwar	11
10	Masalia	16

(Source: Executive Engineer, Minor Irrigation Division, Dumka)

In addition, renovation work of medium irrigation projects was carried out by Minor Irrigation Division, Dumka for creating additional irrigation potential. Till date from 2005, 25 numbers of medium irrigation projects have been renovated. Details of medium irrigation projects renovated in the district till date are given below in table – 38.

Table – 38: Details of medium irrigation projects renovated in the district (from 2005)

Sr. No.	Block	Name of project
1	Raneshwar	Renovation of Nimbani medium irrigation project
2	Masalia	Renovation of Ajmeri Bara dam medium irrigation project
3	Masalia	Renovation of Modi dam medium irrigation project
4	Saraiyahat	Renovation Budhwa dam medium irrigation project
5	Raneshwar	Renovation of Nagalbhanga medium irrigation project
6	Dumka	Renovation of Guhiyajori medium irrigation project
7	Masalia	Renovation of Kulhariya medium irrigation project
8	Ramgarh	Renovation of Dumarjor medium irrigation project
9	Raneshwar	Renovation of Saheb dam medium irrigation project
10	Ramgarh	Renovation of Aurtara medium irrigation project
11	Ramgarh	Renovation of Gidhwana medium irrigation project
12	Raneshwar	Renovation of Ranikhas medium irrigation project
13	Shikaripara	Renovation of Dhaka medium irrigation project
14	Saraiyahat	Renovation of Asnaha medium irrigation project
15	Masalia	Renovation of Khairbani medium irrigation project
16	Masalia	Renovation of Jhiluwa medium irrigation project
17	Raneshwar	Renovation of Bhuski dam medium irrigation project
18	Raneshwar	Renovation of Kadma dam medium irrigation project
19	Ramgarh	Renovation of Manager dam medium irrigation project
20	Kathkund	Renovation of Baliya dam medium irrigation project
21	Shikaripara	Renovation of Durgapur medium irrigation project
22	Jama	Renovation of Chhailapathar medium irrigation project
23	Dumka	Renovation of Jhiktiya medium irrigation project
24	Jarmundi	Renovation of Banwara medium irrigation project
25	Dumka	Renovation of Haripur medium irrigation project

(Source: Executive Engineer, Minor Irrigation Division, Dumka)

6.2.3Initiatives by MANREGA Govt of Jharkhand

Govt of Jharkhand has constructed different water conservation and artificial recharge structures in the district under different rural development programmes viz. MANREGA, watershed development programme etc.

A Case study of Dumka district: Government of Jharkhand has constructed several numbers of water conservation and artificial recharge structures in Sikitiya Grampanchayat which is located in Jama block of Dumka district. There are 21 villages in Sikitiya Grampanchayat. After implementing the water conservation and artificial recharge, the Panchayat has changed in its agriculture pattern. Now with an increase in net sown area, there is a marked shift in cropping pattern from monocropping to double or multiple cropping specially in areas of operation. The integrated approach adopted under the RIDF- NABARD watershed programme has led to the overall recharge of ground water level coupled with easy availability of water for irrigation purpose. With construction of water conservation structures like dams, ponds, dovas etc hitherto wasteland has now been converted into fertile agriculture land. This has resulted in substantial increase in income level of the farmers who are now moving towards commercialization of agriculture farming. Now, farmers are not migrating to urban areas in search of jobs even in lean season. To them various soil moisture conservation measures like Trench cum Bund (TCB), Deep Contour Trenches (DCT), Water Absorption Trench (WAT), check dams created at various areas are now providing water availability agriculture purpose. Some achievements of Sikitiya Panchayat in water sector are as follows –

1. No. of water bodies revived: Ponds – 18, TCB/WAT – 260 ha.
2. Innovative practices for ground water management: TCB – 260 ha.
3. No. of new pond created and capacity in CUM: New pond – 18, in storage capacity 3852 CUM.

4. Total benefits accrued: With the help of programme like TCB, DCT, WAT, Check dams, ponds nearly 500 to 1000 peoples are benefited with their agriculture activities.

Photographs of some water conservation and artificial recharge structures of Sikitia Panchayat of Jama block, Dumka district is given below –

Construction of Trench cum Bund (TCB)

Construction of soak pit

Construction of check dam

Construction of check dam

Construction of TCB and Dova

Construction of pond

6.3 Demand Side Interventions

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

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

6.4 Ground water management strategy for Nitrate and Fluoride affected areas: Nitrate and Fluoride contamination occurring in granite gneiss of Shikaripara, Raneshwar, Masalia, Kathikund, Saraiyahat, Jama 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 Flouride removal should be in hand of local peoples, so that peoples will keep the proper maintenance of machines and equipments.

6.5 Water stress aspect against future demand (2025, 2030): Demand of water is increasing day by day against the increasing population. The detail demographic particular of the Dumka district and water requirement for domestic purpose is worked out for the year 2025 and 2030 is presented in table – 39& 40.

Table – 39: Detail demographic particular of Dumka district

Population as per census				**Projected population as per current growth ratio**			
2001		2011		2025		2030	
Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
59118	1047403	90178	1231264	167222	1557500	203785	1688261

Table - 40: Requirement of water for domestic use

Water requirement (assuming 90 litres per day per person for rural population and 130 litres per day per person for urban population)			
2025		2030	
Urban	Rural	Urban	Rural

21738860	140175000	26492050	151943490
Total 161913860 litres per day		Total 178435540 litres per day	

On perusal of table – 41, the requirement of water will be 174697180 litres per day in 2030. The demand of water is increasing due to highly increasing of population.

6.5.1 Urban water supply: There are two urban areas existing in the district namely Dumka urban area and Bashukinath urban area (including Jarmundi town). Dumka Nagar Nigam supplied 8.5 to 9.5 MLD water for Dumka urban area from intake well located at Baski Chak (near Masanjor Dam) through Kurwa treatment plant. Similarly, 1.8 MLD water supplied to Bashukinath urban area by Drinking Water & Sanitation Department, Dumka.

6.5.2 Rural water supply: Drinking Water & Sanitation Department (DWSD), Dumka has constructed large numbers of bore wells to solve the water scarcity problem of the rural area of the district. In addition, numbers of small rural water supply schemes have been implemented by the Drinking Water & Sanitation Department, Dumka in rural area. Block wise number of rural water supply schemes is give below in table – 41.

Table – 41: Block wise number of Rural Water Supply Schemes of Dumka district

Block	**Water supply schemes**							
	RWSS	**MRWSS/ MRPWSS**	**SVS**	**PWSS**	**Solar based MRPWSS**	**Solar with HYDT**	**Other scheme**	**Total**
Dumka	21	2	2	3	0	0	2	30
Gopikandar	9	3	4	2	42	9	7	76
Jama	18	2	0	9	0	0	16	45
Jarmundi	26	8	0	0	0	0	0	34
Kathikund	10	3	7	10	18	11	14	73
Masaiya	14	0	0	4	0	0	0	18
Ramgarh	19	43	0	8	0	0	10	80
Raneshwar	31	3	0	1	18	0	25	78
Saraiyahat	12	0	0	4	0	0	7	23
Shikaripara	23	4	2	23	46	0	4	102
Total	183	68	15	64	124	20	85	559

(Source: NRDWP site – https://indiawater.gov.in, IMIS Report section, Ground/ surface Water Based Schemes, vide letter No. 173, dated 09.03.2019, SE, DWSD, Dumka)

RWSS = Rural Water Supply Schemes
MWSS = Mini Water Supply Schemes
MRPWSS = Mini Rural Pipe Water Supply Schemes
PWSS = Pipe Water Supply Schemes
HYDT = High Yielding Tube well
SVS = Single Village Schemes

7.0 Sum-up

- The district of Dumka covering the north – eastern parts of Jharkhand state was curved out of the old Santhal Pargana district by the Act of Government of Bihar in 1982. Dumka district spans over an area of 3716 sq. Km covering 10 administrtaive blocks.

- Anthropologically the Dumka is one of the most diverse district of Jharkhand owing to the variety of aboriginal tribes inhabitating this district. Santhals, Paharies are the dominant races followed by Bhuiyas, Khetwas, Oraon and Mahto's in a small numerical strength.

- Broadly, the district may be divided into three distinct physiographic units viz. , the hilly area, the undulating terrain, peneplained flat country and valleys.The general elevation of the area is between 150 m to 640 m amsl. The prominent hills are Rajmahal hills, Ramgarh hills, Karakata and Sapchala hills. Among the loftiest peaks are Mahuagachi (528 m), Korcho hills (640 m), Karakata (210 m). The general slope of the district is from North West to South East.

- They experience sub-tropical to sub-humid climate with average annual rainfall 1043.67 mm. The mean monthly temperature range from 40^0C in winter to 46^0C in summer.

- Dumka district is highly dissected with river of varying magnitude. The Brahmani, the Bansloi, the Mor and their numerous tributaries form the main drainage of the district. They are ephemeral in character forming dendritic pattern.

- Aquifer Mapping Study was carried in Dumka district falling in 10 blocks through data gap analysis, data generated in-house, data acquired from State/Central Govt. departments. All the available data were integrated to prepare aquifer maps and aquifer management plans of the district.

- Geologically the district of Dumka is mainly underlain by Archaean crystalline rocks which are highly deformed and metamorphosed. However, in the eastern part of the district Upper Gondwana represented by Dubrajpur sandstone are exposed in the form of strip running in roughly NW-SE direction and is overlapped by Rajmahal traps. Narrow, discontinuous alluvial patches particularly in granitic areas are found along major streams.

- In general in fissured formations, discharge of well has been found in the range of 1.0-81 m^3/hr. Overall in the district the major potential fractures zones are found upto 100m. First potential fracture zone encountered in the district widely varies from 13-185 m.

- Ground water occurs in 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 m^3/hr in laterites/weathered Granite-Gneiss/Weathered basalt.

- The Chotanagpur granite-gneiss, belonging to Precabmrian age and Rajmahal traps constitutes the group of Fissured formation hydrogeological units and to some extent Gondwana sandstones as an Aquifer-II i.e Deeper Aquifer in the area. The Potential

fractured deeper aquifers(Aquifer-II) in the district have been observed upto 185 mbgl with the yield potential upto 81 m^3/hr.

- The analysis of aquifer parameters in the district shows that the transmissivity value ranges from 14-186 m2/day. Higher values of Transmissivity may be attributed to tensile nature or openness of fractures. The storativity value also varies from $2.3x10^{-2}$ to 7.3×10^{-5}, which shows that aquifers are under semi-confined to confined condition.

- Ground Water quality is generally potable, except few patches. Similarly, Nitrate value found beyond permissible limit in 11 dug well samples and 12 samples of hand pump. Also Fluoride value has been observed beyond permissible limit in 3 samples of dug well 2 samples of bore well (hand pump). Purification/filtration of Nitrate and Fluoride may also be adopted.

- Based on Ground water Resources estimation 2017, the stage of ground water development in Dumka district is 24.26% and the entire block comes under safe category. Therefore there is sufficient scope for further ground water development.

- Three major ground water related issues in Dumka district are low ground water development, low ground water potential and nitrate/ fluoride contamination in the area.

- Ground Water Management strategy suggested are construction of 71681 dug wells and 11947 shallow bore wells in the feasible areas in the district to enhance the overall ground water development to 70%. This would bring a additional area of 28672 has under assured irrigation.

- To suggest a sustainable ground water management plan there are two options-Supply Side Management Options(local water harvesting techniques) & Demand Side Management Options (real water-savings)

- The supply side interventions envisages construction of 2276 nos of Check Dam/Nala bund-, 363 nos of Percolation Tank and 6267 nos building RTRWH 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. Thus not only the drinking and domestic water sources will be strengthened but additional irrigation potential can be created through artificial recharge structures.

- The demand side intervention envisages the real water savings. The main demand side interventions may be i)Promote improved irrigation technologies (drip or sprinkler irrigation, etc.), ii)Crop choice management and diversification (promote less intensive crops like pulses and horticulture),
  iii) Promoting treated municipal waste water for irrigation and construction use,
  iv)Managing energy and irrigation nexus (provide quality power supply when needed through separate feeders, high voltage distribution lines, solar pumps, etc.)
  The government should encourage and provide incentive the use of drip irrigation and sprinkler system.

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Annexure - I

ANNUAL RAINFALL DATA OF DUMKA DISTRICT (2008 TO 2018)

Block: Dumka (2008 – 2018)
Average Annual Rainfall (mm): 1351.07
Standard deviation: 515.03
Coefficient of variation (in %): 38.12

Year	Annual rainfall (mm)	Departure %	Category
2008	1507.6	11.59	Normal
2009	1115.5	- 17.44	Normal
2010	999.2	- 26.04	Moderate
2011	1226.0	- 9.26	Normal
2012	1153.2	- 14.65	Normal
2014	987.0	- 26.95	Moderate
2015	1814.4	34.29	Excess
2016	1502.4	11.20	Normal
2017	2506.0	85.48	Excess
2018	699.4	- 48.23	Moderate

Block: Jama (2008 – 2018)
Average Annual Rainfall (mm): 776.12
Standard deviation: 256.02
Coefficient of variation (in %): 32.99

Year	Annual rainfall (mm)	Departure %	Category
2008	1273.9	64.00	Excess
2009	762.5	- 1.75	Normal
2010	580.9	- 25.15	Moderate
2011	822.6	5.99	Normal
2012	643.5	- 17.09	Normal
2014	666.9	- 14.02	Normal
2015	780.9	0.62	Normal
2016	878.4	13.18	Normal
2017	1022.8	31.78	Excess
2018	328.8	- 57.63	Severe

Block: Jarmundi (2008 – 2018)
Average Annual Rainfall (mm): 1196.22
Standard deviation: 191.68
Coefficient of variation (in %): 16.02

Year	Annual rainfall (mm)	Departure %	Category
2008	1361.9	13.85	Normal
2009	1104.8	- 7.64	Normal
2010	1035.2	- 13.46	Normal
2011	1106.4	- 7.51	Normal
2012	1085.4	- 9.26	Normal
2014	1344.4	12.39	Normal
2015	1275.0	6.59	Normal
2016	1411.0	17.95	Normal
2017	1404.0	17.37	Normal

2018	834.1	- 30.27	Moderate

Block: Saraiyahat (2008 – 2018)
Average Annual Rainfall (mm): 1270.81
Standard deviation: 391.93
Coefficient of variation (in %): 30.84

Year	**Annual rainfall (mm)**	**Departure %**	**Category**
2008	1359.6	6.99	Normal
2009	1975.0	55.41	Excess
2010	794.1	- 37.51	Moderate
2011	1161.0	- 8.64	Normal
2012	865.6	- 31.89	Moderate
2014	868.8	- 31.63	Moderate
2015	1463.6	15.17	Normal
2016	1467.6	15.49	Normal
2017	1704.6	34.13	Excess
2018	1048.2	- 17.52	Normal

Block: Ramgarh (2008 – 2018)
Average Annual Rainfall (mm): 999.86
Standard deviation: 314.48
Coefficient of variation (in %): 31.45

Year	**Annual rainfall (mm)**	**Departure %**	**Category**
2008	1700.9	70.11	Excess
2009	795.6	- 20.43	Normal
2010	670.1	- 32.98	Moderate
2011	971.8	- 2.81	Normal
2012	704.4	- 29.55	Moderate
2014	1348.0	34.82	Excess
2015	1039.4	3.95	Normal
2016	899.0	- 10.09	Normal
2017	1031.2	3.13	Normal
2018	838.2	- 16.17	Noderate

Block: Gopikandar (2008 – 2018)
Average Annual Rainfall (mm): 934.88
Standard deviation: 242.19
Coefficient of variation (in %): 25.91

Year	**Annual rainfall (mm)**	**Departure %**	**Category**
2008	1255.1	34.25	Excess
2009	1134.4	21.34	Normal
2010	659.0	- 29.51	Moderate
2011	875.5	- 6.35	Normal
2012	823.7	- 11.89	Normal
2014	961.6	2.86	Normal
2015	1192.7	27.58	Excess
2016	920.7	- 1.52	Normal
2017	1052.1	12.54	Normal
2018	474.0	- 49.30	Moderate

Block: Kathikund (2008 – 2018)
Average Annual Rainfall (mm): 855.02
Standard deviation: 404.63
Coefficient of variation (in %): 47.32

Year	Annual rainfall (mm)	Departure %	Category
2008	1264.1	47.84	Excess
2009	978.7	14.47	Normal
2010	1077.8	26.06	Excess
2011	1485.6	73.75	Excess
2012	1162.2	35.93	Excess
2014	437.7	- 48.81	Moderate
2015	791.9	- 7.38	Normal
2016	538.8	- 36.98	Moderate
2017	592.6	- 30.69	Moderate
2018	220.8	- 74.18	Severe

Block: Shikaripara (2008 – 2018)
Average Annual Rainfall(mm): 869.34
Standard deviation: 190.66
Coefficient of variation (in %): 21.93

Year	Annual rainfall (mm)	Departure %	Category
2008	1087.0	25.04	Excess
2009	1074.6	23.61	Normal
2010	897.5	3.24	Normal
2011	977.5	12.44	Normal
2012	684.5	- 21.26	Normal
2014	495.5	- 43.00	Moderate
2015	906.6	4.29	Normal
2016	978.0	12.50	Normal
2017	913.0	5.02	Normal
2018	679.2	- 21.87	Normal

Block: Raneshwar (2008 – 2018)
Average Annual Rainfall (mm): 1125.38
Standard deviation: 260.82
Coefficient of variation (in %): 23.18

Year	Annual rainfall (mm)	Departure %	Category
2008	1285.0	14.18	Normal
2009	948.0	- 15.76	Normal
2010	880.4	- 21.77	Normal
2011	1564.7	39.04	Excess
2012	1038.6	- 7.71	Normal
2014	1066.8	- 5.21	Normal

2015	1517.1	34.81	Excess
2016	1205.8	7.15	Normal
2017	922.3	- 18.05	Normal
2018	825.1	- 26.68	Moderate

Block: Masalia (2008 – 2018)
Average Annual Rainfall (mm): 1058.00
Standard deviation: 203.69
Coefficient of variation (in %): 19.25

Year	**Annual rainfall (mm)**	**Departure %**	**Category**
2008	1265.0	19.57	Normal
2009	960.1	- 9.25	Normal
2010	1062.2	0.40	Normal
2011	1149.6	8.66	Normal
2012	893.3	- 15.57	Normal
2014	930.8	- 12.02	Normal
2015	1076.9	1.79	Normal
2016	1485.8	40.43	Excess
2017	981.0	- 7.28	Normal
2018	775.2	- 26.73	Moderate

Annexure - II

DETAILS OF KEY WELLS ESTABLISHED FOR NATIONAL AQUIFER MAPPING STUDY OF DUMKA DISTRICT, 2018 –19

Well No.	Village	Block	Owner	Location	Co-ordinates	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Diameter (m.)
1	Patabari	Shikaripara	Govt.	Near chowk post at tri-junction of Dumka-Shikaripara - Masanjore	24^0 12’ 52” 87^0 22’ 10”	Dug well	Granite Gneiss	Rope & bucket	0.61	9.71	2.25
2	Masanjor	Raneshwar	Govt.	In front of Police station, east of metal road	24^0 06’ 21” 87^0 18’ 45”	Dug well	Granite Gneiss	Rope & bucket	0.70	6.46	1.75
3	Raneshwar	Raneshwar	Govt.	Adjacent to main gate of block office	24^0 02’ 44” 87^0 24’ 38”	Dug well	Granite Gneiss	Rope & bucket	0.50	9.50	2.00
4	Asanbani	Raneshwar	Govt.	Near house of Shri Mithu Kewat, RHS of Raneshwar – Shikaripara road	24^0 07’ 49” 87^0 26’ 51”	Dug well	Granite Gneiss	Rope & bucket	0.67	8.33	1.15
5	Khir Ghata	Raneshwar	Govt.	LHS of Raneshwar – Masalia road near house of Shri K. Rai.	24^0 03’ 24” 87^0 16’ 06”	Dug well	Granite Gneiss	Rope & bucket	0.55	8.02	2.00
6	Masalia	Masalia	Govt.	In back side of block office	24^0 09’ 21” 87^0 10’ 48”	Dug well	Granite Gneiss	Rope & bucket	0.55	8.05	1.50
7	Nipania	Masalia	Shri Kishnu Mahto	Near house of owner, LHS of Masalia – Nala road.	24^0 04’ 03” 87^0 08’ 58”	Dug well	Granite Gneiss	Rope & bucket	0.58	10.12	2.10
8	Domkata	Masalia	Govt.	LHS of Dumka – Fatehpur road.	24^0 10’ 05” 87^0 03’ 55”	Dug well	Granite Gneiss	Rope & bucket	0.50	8.65	3.10
9	Tiliya Pahari	Jama	Shri Nipen Tudu	Near house of owner, LHS of Dumka – Fatehpur road.	24^0 13’ 05” 87^0 12’ 02”	Dug well	Granite Gneiss	Rope & bucket	0.72	10.13	3.20
10	Shikaripara	Shikaripara	Mission school	Within Mission school compound	24^0 14’ 15” 87^0 28’ 02”	Dug well	Granite Gneiss	Rope & bucket	0.85	8.65	1.90
11	Pokharia (Amgachi)	Kathikund	Md. Asuruddin Miyan	Near house of owner, RHS of Shikaripara – Kathikund road.	24^0 18’ 02” 87^0 28’ 16”	Dug well	Granite Gneiss	Rope & bucket	0.59	8.36	1.85
12	Rampur	Shikaripara	Govt.	LHS of road near Hanuman temple	24^0 14’ 04” 87^0 32’ 00”	Dug well	Sandstone	Rope & bucket	0.40	9.30	2.90
13	Kathikund	Kathikund	Govt.	Within the Debinath temple compound opposite to IB	24^0 21’ 29” 87^0 25’ 34”	Dug well	Granite Gneiss	Rope & bucket	1.01	9.00	1.57
14	Gopikandar	Gopikandar	Govt.	Within Paharia Balak Awasiya Vidyalaya campus	24^0 25’ 26” 87^0 28’ 57”	Dug well	Sandstone	Rope & bucket	0.50	10.75	1.81
15	Durgapur	Gopikandar	Govt.	Near house of Shri Nimba	24^0 29’ 31”	Dug	Rajmahal	Rope	0.59	9.16	1.85

Well No.	Village	Block	Owner	Location	Co-ordinates	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Diameter (m.)
				Lal, opposite to hotel.	87⁰ 32’ 19”	well	Trap	&bucke t			
16	Digal Kharauni	Gopikandar	Govt.	LHS of Gopikandar – Pakuria road.	24⁰ 21’ 53” 87⁰ 33’ 16”	Dug well	Rajmahal Trap	Rope & bucket	0.73	6.47	3.50
17	Amba	Kathikund	Shri Girish Mirdha	NHO owner, LHS ofv Kathikund – Dumka road, leading to viilage road	24⁰ 20’ 16” 87⁰ 21’ 06”	Dug well	Granite Gneiss	Rope & bucket	0.53	6.18	1.60
18	Doom	Dumka	Shri Laxman Mandal	NHO owner, RHS of Dumka – Ramgarh road.	24⁰ 24’ 27” 87⁰ 18’ 13”	Dug well	Granite Gneiss	Rope & bucket	0.25	6.85	1.58
19	Jawari (Kusumdih)	Ramgarh	Govt.	LHS of Dumka – ramgar road, near Sidhu – Kanhu vidyapith, Jawari	24⁰ 30’ 03” 87⁰ 17’ 14”	Dug well	Granite Gneiss	Rope & bucket	0.55	7.00	3.15
20	Ramgarh	Ramgarh	Govt.	Opp. police station within temple premises	24⁰ 33’ 50” 87⁰ 14’ 54”	Dug well	Granite Gneiss	Rope & bucket	0.50	7.30	2.05
21	Hat Gambhariya	Ramgarh	Govt.	Near middle school	24⁰ 34’ 10” 87⁰ 11’ 05”	Dug well	Granite Gneiss	Rope & bucket	0.45	1015	1.90
22	Dumka	Dumka	Govt.	In Dumka – Bhagalpur road, in front of mosque	24⁰ 16’ 00” 87⁰ 15’ 00”	Dug well	Granite Gneiss	Rope & bucket	0.55	9.45	2.10
23	Chapodia	Dumka	Shri Akhil Dev Riu	Near house of owner, LHS of Dumka – Pakur road, 08 km from Dumka	24⁰ 18’ 25” 87⁰ 17’ 15”	Dug well	Granite Gneiss	Rope & bucket	0.50	8.40	3.25
24	Bara Palashi	Jama	Shri Manoranjan Marandi	NHO owner, RHS of dumka – Hansdiha road near temple	24⁰ 23’ 00” 87⁰ 11’ 00”	Dug well	Granite Gneiss	Rope & bucket	0.53	9.37	1.83
25	Nonihat	Jarmundi	Govt.	Within the compound (back side) of pair of temple, RHS of Dumka – Hansdiha road.	24⁰ 28’ 10” 87⁰ 07’ 31”	Dug well	Granite Gneiss	Rope & bucket	0.70	4.80	2.05
26	Hansdiha	Sarayahat	Govt.	Within the compound of D.B. IB.	24⁰ 36’ 00” 87⁰ 04’ 15”	Dug well	Granite Gneiss	Rope & bucket	0.60	8.96	1.46
27	Dighi (Bhalua more)	Sarayahat	Shri Rajendra Hazra	Near Bamb Bamb tent & light house	24⁰ 32’ 34” 86⁰ 56’ 54”	Dug well	Granite Gneiss	Rope & bucket	0.24	7.46	3.70
28	Beldaha	Jarmundi	Govt.	Near Naga Baba Mandir	24⁰ 28’ 22” 87⁰ 02’ 02”	Dug well	Granite Gneiss	Rope & bucket	0.38	10.13	2.15
29	Kusmah	Jarmundi	Shri Sachin	NHO owner LHS of Dumka	24⁰ 25’ 17”	Dug	Granite	Rope &	0.57	8.13	2.15

Well No.	Village	Block	Owner	Location	Co-ordinates	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Diameter (m.)
			Kumar Singh	– Devghar road.	86^0 55’ 15”	well	Gneiss	bucket			
30	Jarmundi	Jarmundi	Govt.	Within the compound of district board IB	24^0 23’ 35” 87^0 03’ 12”	Dug well	Granite Gneiss	Rope & bucket	0.60	9.44	1.21
31	Jama	Jama	Govt.	Within the compound of Jama police station (back side)	24^0 20’ 50” 87^0 09’ 10”	Dug well	Granite Gneiss	Rope & bucket	0.35	11.72	3.00
32	Chikania	Jama	Govt.	NHO Shri Teju Mirdha, LSH of Palajori – Jama road.	24^0 15’ 50” 87^0 07’ 00”	Dug well	Granite Gneiss	Rope & bucket	0.60	8.52	1.50
33	Dhadhakiya	Dumka	Radha – Govind temple trust	Northern part of Radha – Govind temple.	24^0 12’ 39” 87^0 17’ 12”	Dug well	Granite Gneiss	Rope & bucket	0.77	9.13	3.10
34	Kusum Ghata	Masalia	Shri Umakant Yadav	LHS of Masalia – Ranibahal road	24^0 04’ 57” 87^0 10’ 52”	Dug well	Granite Gneiss	Rope & bucket	0.82	9.75	1.57
35	Mahadevgarh	Saraiyahat	Shri Shiv Shakti Modi	LHS of Hansdiha – Bhagalpur road, Near house of owner	24^0 38’ 15” 87^0 03’ 55”	Dug well	Granite Gneiss	Rope & bucket	0.43	8.27	1.95
36	Mohra More (Sumeda)	Saraiyahat	Shri Shankar Hazra	Well is located at tri-junction of Mohra More (Sumeda)	24^0 31’ 20” 87^0 00’ 56”	Dug well	Granite Gneiss	Rope & bucket	0.40	7.60	1.85
37	Manka Chak	Jama	Govt.	9 km. from Dumka on Dumka – Palajori road (LHS) near electric pole and house of Shri Paltan Hembrom	24^0 16’ 28” 87^0 10’ 14”	Dug well	Granite Gneiss	Rope & bucket	0.70	8.85	1.55

Annexure - III

WATER LEVEL DATA OF KEY WELLS OF NATIONAL AQUIFER MAPPING STUDY AREA OF DUMKA DISTRICT, JHARKHAND, 2018 –19

Well No.	Village	Block	Water level (mbgl)			
			May 2018	August 2018	November 2018	January 2019
1	Patabari	Shikaripara	7.03	3.86	4.17	6.44
2	Masanjor	Raneshwar	3.00	1.95	1.48	2.24
3	Raneshwar	Raneshwar	6.34	2.01	2.80	3.88
4	Asanbani	Raneshwar	6.44	2.11	3.52	4.07
5	Khir Ghata	Raneshwar	7.33	3.19	3.95	5.59
6	Masalia	Masalia	4.88	2.66	3.76	4.79
7	Nipania	Masalia	9.55	7.25	7.42	8.05
8	Domkata	Masalia	7.41	5.25	5.75	7.35
9	Tiliya Pahari	Jama	5.11	2.13	2.92	4.82
10	Shikaripara	Shikaripara	6.65	3.36	4.35	6.04
11	Pokharia (Amgachi)	Kathikund	8.00	4.80	5.05	5.78
12	Rampur	Shikaripara	9.20	5.29	8.21	8.88
13	Kathikund	Kathikund	6.28	4.70	5.00	6.24
14	Gopikandar	Gopikandar	9.09	6.29	6.25	7.67
15	Durgapur	Gopikandar	7.84	4.76	4.40	5.15
16	Digal Kharauni	Gopikandar	4.97	1.07	1.35	2.05
17	Amba	Kathikund	5.51	5.34	5.37	6.23
18	Doom	Dumka	5.89	4.84	5.09	8.35
19	Jawari (Kusumdih)	Ramgarh	4.25	2.45	3.04	4.36
20	Ramgarh	Ramgarh	6.88	2.86	3.10	5.27
21	Hat Gambhariya	Ramgarh	Dry	9.15	9.40	Dry
22	Dumka	Dumka	4.03	3.69	3.55	4.30
23	Chapodia	Dumka	6.11	5.04	4.76	5.91
24	Bara Palashi	Jama	7.07	5.78	6.08	7.01
25	Nonihat	Jarmundi	1.97	1.29	1.62	1.94
26	Hansdiha	Saraiyahat	7.67	6.17	6.48	7.70

Well No.	Village	Block	Water level (mbgl)			
			May 2018	August 2018	November 2018	January 2019
27	Dighi (Bhalua more)	Saraiyahat	7.12	5.20	6.29	7.01
28	Beldaha	Jarmundi	9.12	7.69	7.65	8.92
29	Kusmah	Jarmundi	7.36	6.58	6.97	7.83
30	Jarmundi	Jarmundi	7.93	5.11	5.11	7.24
31	Jama	Jama	8.56	8.03	8.23	9.65
32	Chikania	Jama	8.08	6.86	5.95	8.03
33	Dhadhakiya	Dumka	7.03	4.06	5.10	7.14
34	Kusum Ghata	Masalia	8.77	4.45	5.45	7.78
35	Mahadevgarh	Saraiyahat	7.80	6.57	6.51	7.92
36	Samhuta (Mohra More)	Saraiyahat	7.05	4.92	4.76	6.25
37	Manka Chak	Jama	8.25	7.76	7.05	8.24

Annexure-IV

DETAILS OF WELL CONSTRUCTED IN HARD FORMATION OF DUMKA DISTRICT, JHARKHAND (upto 2017-18)

Sl. No.	Location with coordinates	Block	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered	Fractures Encountered (mbgl)- Thin zone between		Aquifer	Static water level (mbgl)	Dis-charge (lps)	D.D. (m)	T (m^2/d)	S
							From	To						
1	2	3	5	6	7	8	9	10	11	12	13	14	15	16
1.	Hijlapahar EW 24^0 15' 15" 87^0 13' 50"	Dumka	150	150	8.00	8.00	22.00 47.00 56.00 92.00 112.00	25.00 50.00 59.00 99.00 113.00	Fractured granite gneiss (F.G.N.)	5.36	2.05	--	--	--
2.	Shiv Pahar EW 24^0 15' 40" 87^0 21' 15"	Dumka	159.00	159.00	9.20	9.20	151.00	153.00	Fractured granite gneiss (F.G.N.)	25.45	9.84	14.91	107.8	0.00020
3.	Nischintpur EW 24^0 11' 20" 87^0 17' 45"	Dumka	87.62	87.62	12.50	12.50	23.66 44.99 54.14 55.14 57.14 59.00 84.00	24.78 45.50 54.75 56.00 58.00 61.76 87.62	F.G.N F.G.N F.G.N F.G.N F.G.N F.G.N F.G.N	8.25	5.38	17.68	14.04	0.00082
4.	Dumka EW 24^0 17' 15" 87^0 14' 40"	Dumka	200.00	200.00	41.00	41.20	52.00 143.60	52.90 144.60	F.G.N F.G.N	14.83	3.10	26.67	5.0	--
5.	Kathikund EW 24^0 21' 50" 87^0 25' 20"	Kathikund	140.00	140.00	15.82	15.82	19.04 32.28 39.90 48.52 58.14 78.08 99.24	21.04 34.28 40.93 49.52 60.14 81.00 103.86	F.G.N F.G.N F.G.N F.G.N F.G.N F.G.N F.G.N	9.96	7.35	12.04	29.50	0.00080
6.	Raneshwar EW	Raneshwar	200.00	200.00	18.50	18.50	50.50 74.36	52.50 75.36	F.G.N F.G.N	5.18	4.95	20.55	41.00	0.00052

Sl. No.	Location with coordinates	Block	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered	Fractures Encountered (mbgl)- Thin zone between		Aquifer	Static water level (mbgl)	Dis-charge (lps)	D.D. (m)	T (m^2/d)	S
							From	To						
1	2	3	5	6	7	8	9	10	11	12	13	14	15	16
	24^0 01' 40" 87^0 25' 20"						117.08 121.08 132.32	118.08 123.70 134.36	F.G.N F.G.N F.G.N					
7.	Jarmundi EW 24^0 23' 30" 87^0 04' 45"	Jarmundi	200.00	200.00	18.50	18.50				Abandoned				
8.	Basukinath EW 24^0 23' 30" 87^0 06' 45"	Jarmundi	121.10	121.10	15.03	15.03	23.66 41.90 44.90 61.76 106.48	26.66 42.90 46.52 62.76 107.48	F.G.N	3.55	12.04	14.70	186.00	0.00025
9.	Hansdiha EW 24^0 23' 30" 87^0 06' 45"	Saraiyahat	115.00	115.00	13.00	13.00	31.00 33.00 70.00 92.00 102.00 106.00	32.00 36.00 71.00 93.00 103.00 107.00	F.G.N F.G.N F.G.N F.G.N F.G.N F.G.N	4.36	9.53	--	--	--
10.	Saraiyahat EW 24^0 34' 30" 87^0 03' 20"	Saraiyahat	183.00	183.00	18.00	18.00	20.00	22.00	F.G.N	3.91	1.20	--	--	--
11.	Sarayaihat EW 24^0 35' 05" 87^0 01' 40"	Sarayaihat	200.00	200.00	36.60	36.60	--	--	--	--	Dry	--	--	--
12.	Shikaripara EW 24^0 14' 10" 87^0 28' 30"	Shikaripara	178.00	178.00	21.00	21.00	25.00 56.00 90.00 160.00 177.00	28.00 60.00 92.00 163.00 178.00	F.G.N F.G.N F.G.N F.G.N F.G.N	4.93	9.53	20.05	14.10	0.000073
13.	Jama EW	Jama	135.34	135.34	9.00	9.00	13.00	14.00	Fractured granite	5.36	0.37	Abandoned		

Sl. No.	Location with coordinates	Block	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered	Fractures Encountered (mbgl)- Thin zone between		Aquifer	Static water level (mbgl)	Dis-charge (lps)	D.D. (m)	T (m^2/d)	S
							From	To						
1	2	3	5	6	7	8	9	10	11	12	13	14	15	16
	24^0 21' 50" 87^0 10' 10"								gneiss (F.G.N.)					
14.	Masaliya EW 24^0 09' 35" 87^0 11' 50"	Masaliya	57.86	57.86	9.00	9.00	11.04 36.00 51.24 56.86	15.66 37.00 53.86 57.86	F.G.N F.G.N F.G.N F.G.N	3.90	18.49	10.25	174.04	0.023
15.	Nawasar EW 24^0 11' 30" 87^0 05' 00"	Masaliya	92.24	92.24	8.00	8.00	11.42 13.42 17.04 37.28 67.76 90.00	12.42 14.42 18.00 38.90 69.38 91.00	F.G.N F.G.N F.G.N F.G.N F.G.N F.G.N	5.31	9.15	18.61	19.66	0.0011
16.	Nawadih EW 24^0 10' 00" 87^0 10' 50"	Masaliya	84.74	84.74	15.50	15.50	22.16 28.78 37.40 45.00 63.80 79.12	23.78 29.78 39.02 54.26 65.88 84.74	F.G.N F.G.N F.G.N F.G.N F.G.N F.G.N	6.75	21.34	--	--	--
17.	Dalahi EW 24^0 05' 00" 87^0 10' 00"	Masaliya	177.2	177.2	12.00	12.00	33.48 45.00 98.34 159.30 162.92	34.48 46.60 99.66 160.93 163.92	F.G.N F.G.N F.G.N F.G.N F.G.N	1.05	6.27	--	--	--
18.	Karudih EW 24^0 21' 30" 87^0 34' 20"	Gopikandar	138.00	138.00	16.00	16.00	93.00 106.00 114.00 133.00 137.00	93.50 107.00 115.00 134.00 138.00	Fractured Basalt(FB)	1.50 magl	8.67	--	--	--
19.	Ramgarh EW 24^0 33' 19" 87^0 14' 42"	Ramgarh	200.00	200.00	38.00	38.25	--	--	--	--	Dry	--	--	--

Sl. No.	Location with coordinates	Block	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered	Fractures Encountered (mbgl)- Thin zone between		Aquifer	Static water level (mbgl)	Dis-charge (lps)	D.D. (m)	T (m^2/d)	S
							From	To						
1	2	3	5	6	7	8	9	10	11	12	13	14	15	16
20.	Nonihat EW 24^0 28' 40" 87^0 10' 21"	Ramgarh	94.00	94.00	23.00	23.00	24.00 37.00 60.00 66.00 81.00 93.00	26.00 39.00 62.00 71.00 82.00 94.00	F.G.N F.G.N F.G.N F.G.N F.G.N F.G.N	--	22.50	--	--	--
21.	Raneshwar EW - 1 24^0 01' 40" 87^0 25' 21"	Raneshwar	191.39	191.39	16.50	16.50	--	--	--	--	0.35	Abandoned		
22.	Raneshwar EW - 2 24^0 01' 40" 87^0 25' 22"	Raneshwar	191.39	191.39	23.70	23.70	--	--	--	--	0.35	Abandoned		

F.B. = Fractured Basalt

Annexure - V

DETAILS OF WELL CONSTRUCTED IN HARD FORMATION OF DUMKA DISTRICT, JHARKHAND DURING 2018-19

Sl. No.	Location with coordinates	Block	District	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered with dia. (m)	Fractures Encountered between (mbgl)- Thin zone		Aquifer	SWL (mbgl)	Dis-charge (lps)	D.D. (m)	T (m^2/d)	S
								From	To						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Banwara EW 24^0 26' 34" 87^0 02' 49"	Jarmundi	Dumka	202.70	202.70	25.00	25.00 (7" dia.)	80.00	80.50	Slightly fractured Granite gneiss	--	0.14	--	--	--
2	Bhorabad EW - I 24^0 19' 25" 87^0 01' 01"	Jarmundi	Dumka	202.70	202.70	10.00	10..50 (7" dia.)	13.00 166.0	13.50 167.0	Jointed, fractured Granite gneiss	1.62	2.20	--	--	--
3	Bhorabad EW - II	Jarmundi	Dumka	202.70	202.70	17.50	17..50 (7" dia.)	19.00	20.00	--	--	< 0.14	--	--	--
4	Haripur EW 24^0 18' 40" 87^0 03' 55"	Jarmundi	Dumka	202.70	202.70	11.50	11..50 (7" dia.)	--	--	--	--	Dry	--	--	--
5	Bedia-EW 24^0 14' 21" 87^0 11' 41"	Jama	Dumka	68.50	68.50	30.00	30.00 (7" dia.)	57.00	59.00	Fractured Granite gneiss	5.80	12.30	--	--	--
6	Bedia -OW	Jama	Dumka	74.60	74.60	30.00	30.20 (7" dia.)	66.00	68.00	Fractured Granite gneiss	--	12.30	--	--	--
7	Chikania (Lodhna) EW 24^0 16' 44" 87^0 07' 48"	Jama	Dumka	202.70	202.70	16.50	16.50 (7" dia.)	176.5 184.0	177.0 185.0	Fractured Granite gneiss	--	3.40	--	--	--
8	Karbindha	Ramgarh	Dumka	202.7	202.7	23.50	24.20	--	--	--	--	Dry	--	--	--

Sl. No.	Location with coordinates	Block	District	Depth drilled (m)	Depth of Well (m)	Thickness of weathering (m)	Length of casing lowered with dia. (m)	Fractures Encountered between (mbgl)- Thin zone		Aquifer	SWL (mbgl)	Dis-charge (lps)	D.D. (m)	T (m^2/d)	S
								From	To						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	EW 24^0 25' 15" 87^0 18' 22"			0	0		(7" dia.)								
9	Bhadwari (Nonihat) EW 24^0 29' 00" 87^0 07' 49"	Ramgarh	Dumka	153.50	153.50	19.50	19.00 (7" dia.)	86.00	86.50	Jointed Granite gneiss	--	< 0.14	--	--	--
10	Mahura EW 24^0 31' 13" 87^0 00' 53"	Saraiyahat	Dumka	153.90	153.90	18.50	19.20 (7" dia.)	114.00	115.00	Fractured Granite gneiss	17.95	3.90	--	--	--
11	Mahura OW	Saraiyahat	Dumka	153.90	153.90	18.50	19.20 (7" dia.)	112.00	112.50	Slightly fractured granite gneiss	--	0.38	--	--	--

Annexure – VI

DATA OF SOIL INFILTRATION TEST CARRIED OUT IN DUMKA DISTRICT

Unique ID: SIT/DK-1	Mahura
Date	03/03/2019
Location	Adarsh Unch Vidyalaya, Mahura
Block	Saraiyahat
District	Dumka
Latitude	24^0 31' 13"
Longitude	87^0 00' 53"
Initial Water level (mm)	172
Geology	Granite Gneiss
Final infiltration rate (mm/hr)	55.2

Sr.No.	**Clock time**	**Time interval (min.)**	**Cumulative time (min.)**	**Water level depth (mm)**	**Infiltered water depth (mm)**	**Infiltration rate (mm/min.)**	**Infiltration rate (mm/hr)**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	12.02	2	2	167	5	2.5	150
2	12.04	2	4	160	12	3.0	180
3	12.06	2	6	158	14	2.33	140
4	12.08	2	8	155	17	2.13	128
5	12.10	2	10	152	20	2.00	120
6	12.13	3	13	148	24	1.87	112.2
7	12.16	3	16	144	28	1.75	105.0
8	12.19	3	19	140	32	1.68	100.8
9	12.22	3	22	137	35	1.59	95.4
10	12.25	3	25	135	37	1.48	88.8
11	12.28	3	28	132	40	1.43	85.8
12	12.31	3	31	129	43	1.39	83.4
13	12.34	3	34	125	47	1.38	82.8
14	12.37	3	37	122	50	1.35	81.0
15	12.40	3	40	119	53	1.33	79.8
16	12.45	5	45	115	57	1.27	76.2
17	12.50	5	50	110	62	1.24	74.4
18	12.55	5	55	105	67	1.22	73.2
19	13.00	5	60	100	72	1.20	72.0
20	13.05	5	65	98	74	1.14	68.4
21	13.10	5	70	95	77	1.10	66.0
22	13.15	5	75	92	80	1.07	64.2
23	13.20	5	80	88	84	1.05	63.0
24	13.25	5	85	84	88	1.03	61.8
25	13.30	5	90	80	92	1.02	61.2
26	13.35	5	95	76	96	1.01	60.6
27	13.40	5	100	72	100	1.00	60.0
28	13.45	5	105	69	103	0.98	58.8
29	13.50	5	110	66	106	0.96	57.6
30	13.55	5	115	63	109	0.95	57.0

31	14.00	5	120	60	112	0.93	55.8
32	14.05	5	125	57	115	0.92	55.2

DATA OF SOIL INFILTRATION TEST

Unique ID: SIT/DK- 2	Jama
Date	03/03/2019
Location	Opposite to Govt. middle school (boys) on Jama – Palajori road.
Block	Jama
District	Dumka
Latitude	24^0 20' 37"
Longitude	87^0 08' 51"
Initial Water level (mm)	153
Geology	Granite Gneiss
Final infiltration rate (mm/hr)	27.60

Sr.No.	**Clock time**	**Time interval (min.)**	**Cumulative time (min.)**	**Water level depth (mm)**	**Infiltered water depth (mm)**	**Infiltration rate (mm/min.)**	**Infiltration rate (mm/hr)**
1	15.02	2	2	137	16	8.00	480
2	15.04	2	4	134	19	4.75	285
3	15.06	2	6	132	21	3.50	210
4	15.08	2	8	131	22	2.75	165
5	15.10	2	10	130	23	2.30	138
6	15.15	5	15	128	25	1.67	100.20
7	15.20	5	20	126	27	1.35	81.00
8	15.25	5	25	124	29	1.16	69.60
9	15.30	5	30	123	30	1.00	60.00
10	15.35	5	35	122	31	0.89	53.40
11	15.40	5	40	120	33	0.83	49.80
12	15.45	5	45	119	34	0.76	45.60
13	15.50	5	50	118	35	0.70	42.00
14	15.55	5	55	117	36	0.65	39.00
15	16.00	5	60	115	38	0.63	37.80
16	16.05	5	65	114	39	0.60	36.00
17	16.10	5	70	113	40	0.57	34.2
18	16.15	5	75	112	41	0.55	33.00
19	16.20	5	80	111	42	0.53	31.80
20	16.25	5	85	110	43	0.51	30.60
21	16.30	5	90	109	44	0.49	29.40
22	16.35	5	95	108	45	0.47	28.20
23	16.40	5	100	107	46	0.46	27.60

DATA OF SOIL INFILTRATION TEST

Unique ID: SIT/DK- 3	Nonihat (Bhadwari)
Date	04/03/2019
Location	Within the premises of Primary Health Centre
Block	Ramgarh
District	Dumka

Latitude	24^0 29’ 00”
Longitude	87^0 07’ 49”
Initial Water level (mm)	168
Geology	Granite Gneiss
Final infiltration rate (mm/hr)	14.40

Sr.No.	**Clock time**	**Time interval (min.)**	**Cumulative time (min.)**	**Water level depth (mm)**	**Infiltered water depth (mm)**	**Infiltration rate (mm/min.)**	**Infiltration rate (mm/hr)**
1	09.02	2	2	163	5	2.50	150
2	09.04	2	4	162	6	1.50	90
3	09.06	2	6	160	8	1.33	79.8
4	09.08	2	8	159	9	1.13	67.8
5	09.10	2	10	158	10	1.00	60.0
6	09.15	5	15	157	11	0.73	43.8
7	09.20	5	20	156	12	0.60	36.0
8	09.25	5	25	155	13	0.52	31.2
9	09.30	5	30	154	14	0.47	28.2
10	09.35	5	35	154	14	0.40	24.0
11	09.40	5	40	153	15	0.38	22.8
12	09.45	5	45	152	16	0.36	21.6
13	09.50	5	50	151	17	0.34	20.4
14	10.00	10	60	150	18	0.30	18.0
15	10.10	10	70	149	19	0.27	16.2
16	10.20	10	80	147	21	0.26	15.6
17	10.30	10	90	145	23	0.25	15.0
18	10.40	10	100	144	24	0.24	14.4

Annexure-VII

LITHOLOG OF SOME OF THE BOREWELL CONSTRUCTED BY CGWB

LITHOLOG

Unique ID: 1	EW
Village	Raneshwar
Block	Raneshwar
District	Dumka
Latitude	24^0 01' 40"
Longitude	87^0 25' 20"
Drilled Depth (mbgl)	150.00
Casing depth (m bgl)	18.50
SWL(m bgl)	5.18
Discharge (m^3/hr)	17.82
Date / Year	September 1989

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	18.50	18.50	Granite gneiss – highly weathered
18.50	22.02	3.52	Granite gneiss – compact hard
22.02	25.64	3.62	Granite gneiss – highly fractured, dark grey
25.64	29.64	4.00	Amphibolite – fracture zone between 26.64 – 27.64
29.64	35.26	5.62	Granite gneiss – compact hard
35.26	38.88	3.62	Granite gneiss – slightly fractured
38.88	40.88	2.00	Granite gneiss with predominating feldspar
40.88	42.88	2.00	Granite gneiss – compact
42.88	44.88	2.00	Quartzite slightly fractured, grey
44.88	46.50	1.62	Granite gneiss – compact hard
46.50	50.50	4.00	Granite gneiss – slightly fractured with pink and white quartz
50.50	52.50	2.00	Granite gneiss – highly fractured with quartz veins
52.50	54.12	1.62	Granite gneiss – compact hard
54.12	59.12	5.00	Biotite (Amphibolite) Schist with quartz
59.12	60.12	1.00	Granite gneiss with little pink feldspar
60.12	70.36	10.24	Granite gneiss – compact hard, slightly fractured Amphibolite with quartzite
70.36	74.36	4.00	Granite gneiss with little feldspar (pink)
74.36	75.36	1.00	Granite gneiss (pink) – fractured
75.36	79.98	4.62	Granite gneiss – slightly fractured
79.98	80.98	1.00	Quartz vein
80.98	82.98	2.00	Granite gneiss – compact
82.98	83.98	1.00	Granite gneiss (pink), predominating
83.98	89.60	5.62	Amphibolite slightly fractured
89.60	102.84	13.24	Granite gneiss (pink) – fractured slightly predominating quartz
102.84	105.84	3.00	Granite gneiss - slightly fractured predominating with colourless pink quartz
105.84	107.46	1.62	Quartz vein colourless and pink quartz

107.46	113.46	6.00	Granite gneiss – slightly fractured
113.46	117.08	3.68	Amphibolite – massive
117.08	118.08	1.00	Biotite Mica Schist (Ambhibolite) – highly fractured
118.08	119.08	1.00	Granite gneiss – slightness pink feldspar
119.08	121.08	2.00	Amphibolite, massive
121.08	128.70	7.62	Granite gneiss – slightly fractured, predominating with quartz
128.70	130.32	1.62	Granite gneiss, compact hard
130.32	134.32	4.00	Granite gneiss, fractured with pink feldspar & quartz
134.32	138.94	4.62	Granite gneiss with pre Rozy & colourless quartz & little feldspar
138.94	139.94	1.00	Quartz feldspathic vein
139.94	142.94	3.00	Granite gneiss predominating with quartz
142.94	146.56	3.62	Quartz vein (Rozy colour)
146.56	150.00	3.44	Granite gneiss into predominating with quartz & feldspar

LITHOLOG

Unique ID: 2	EW
Village	Shikaripara
Block	Shikaripara
District	Dumka
Latitude	24^0 14’ 10”
Longitude	87^0 28’ 30”
Drilled Depth (mbgl)	178.00
Casing depth (m bgl)	21.00
SWL(m bgl)	4.93
Discharge (m^3/hr)	34.32
Date / Year	May 1990

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	7.00	7.00	Lateritic soil
7.00	14.00	7.00	Granite gneiss – highly weathered
14.00	22.00	8.00	Granite gneiss – partly weathered and fractured
22.00	25.00	3.00	Granite gneiss – little weathered soft grey
25.00	32.00	7.00	Granite gneiss – slightly fractured
32.00	56.00	24.00	Granite gneiss – hard
56.00	60.00	4.00	Granite gneiss (pink) – fractured little grey variety
60.00	78.00	18.00	Granite gneiss – compact, grey
78.00	90.00	12.00	Amphibolite
90.00	92.00	2.00	Granite gneiss (pink) – fractured
92.00	132.00	40.00	Amphibolite
132.00	160.00	28.00	Granite gneiss – grey
160.00	163.00	3.00	Amphibolite, fractured
163.00	177.00	14.00	Granite gneiss – hard, compact grey
177.00	178.00	1.00	Granite gneiss – fractured grey

LITHOLOG

Unique ID: 3	EW
Village	Hansdiha
Block	Hansdiha
District	Dumka
Latitude	24^0 35' 30"
Longitude	87^0 05' 15"
Drilled Depth (mbgl)	115.00
Casing depth (m bgl)	13.00
SWL(m bgl)	4.36
Discharge (m^3/hr)	34.32
Date / Year	March 1990

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	2.00	2.00	Clay – light yellow sticky
2.00	5.00	3.00	Clay brownish, lateritic mixed with rounded to sub rounded pebbles of ferruginous material (transported)
5.00	7.00	2.00	Clay – yellow aluminous mixed with quartz feldspathic minerals – gneissic
7.00	10.00	3.00	Clay – light yellow buff coloured mixed with quartz feldspathic mineral gneissic
10.00	13.00	3.00	Clay – light brown mixed with gravel shaped quartz and feldspar
13.00	16.00	3.00	Clay – light buff to grey colour mixed with quartz and feldspar
16.00	30.00	14.00	Granite gneiss – massive with chips of potassic feldspar reddish brown in colour
30.00	33.00	3.00	Granite – fractured with biotite & potassic mineral
33.00	35.00	2.00	Granite – poorly fractured, complex of reddish brown colour
35.00	39.00	4.00	Granite – highly fractured rock of pink coloured
39.00	45.00	6.00	Granite – massive to poorly pink rock complex
45.00	47.00	2.00	Granite – fractured pink rock
47.00	55.00	8.00	Granite – massive to poorly fractured pink rock
55.00	57.00	2.00	Granite – fractured highly pink
57.00	65.00	8.00	Granite – poorly to moderate fractured pink
65.00	68.00	3.00	Granite, highly fractured pink
68.00	70.00	2.00	Granite, massive to poorly fractured
70.00	71.00	1.00	Granite – highly fractured pink with leach biotite flakes – potassic feldspar
71.00	82.00	11.00	Granite – fractured rocks with more percentage of biotite
82.00	83.00	1.00	Granite – highly fractured with more percentage of biotite
83.00	89.00	6.00	Granite – moderate fractured rock
89.00	94.00	5.00	Granite – highly fractured rock
94.00	101.00	7.00	Granite – massive powdered pink
101.00	105.00	3.00	Granite – highly fractured pink with biotite mineral in excess
105.00	115.00	10.00	Granite – fractured moderately to poorly mixed with powdered pink rock more percentage of biotite

LITHOLOG

Unique ID: 4	EW
Village	Basukinath
Block	Jarmundi
District	Dumka
Latitude	24^0 23' 30"
Longitude	87^0 06' 45"
Drilled Depth (mbgl)	121.10
Casing depth (m bgl)	15.03
SWL(m bgl)	3.55
Discharge (m^3/hr)	43.36
Date / Year	January 1990

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	11.42	11.42	Surface soil – lateritic, yellowish brown and sand
11.42	15.04	3.62	Granite gneiss – weathered
15.04	21.04	6.00	Granite gneiss – compact hard, grey
21.04	23.66	2.62	Granite gneiss – slightly fractured associated with quartz vein
23.66	26.66	3.00	Granite gneiss, highly fractured, pink fractured wide open
26.66	29.66	3.00	Amphibolite, compact hard
29.66	32.28	2.62	Granite gneiss, pink, hard, compact
32.28	35.28	3.00	Granite gneiss – grey associated with quartz veins feldspar pink
35.28	41.90	6.62	Biotite schist hard associated with quartz veins
41.90	42.90	1.00	Granite gneiss – slightly fractured grey with quartz vein
42.90	44.90	2.00	Granite gneiss, grey, hard compact
44.90	46.52	1.62	Granite gneiss, pink with slightly fractured
46.52	47.52	1.00	Amphibolite, hard compact
47.52	48.52	1.00	Granite gneiss, pink, compact
48.52	61.76	13.24	Granite gneiss, grey associated with quartz veins
61.76	62.76	1.00	Granite gneiss, grey, slightly fractured
62.76	69.38	6.62	Granite gneiss, pink, hard, compact associated with quartz vein
69.38	70.38	1.00	Biotite chist associated with quartz veins
70.38	75.38	5.00	Granite gneiss, pink, hard compact
75.38	87.62	12.24	Granite gneiss, grey, compact, hard
87.62	94.24	6.62	Biotite schist associated with quartz vein
94.24	96.24	2.00	Granite gneiss, pink, hard minimum
96.24	98.24	2.00	Granite gneiss, grey, hard maximum
98.24	106.48	8.24	Granite gneiss, pink, associated with quartz vein
106.48	107.48	1.00	Granite gneiss – slightly fractured, pink
107.48	115.10	7.62	Granite – pink, slightly fractured
115.10	116.10	1.00	Amphibolite, highly fractured with open intruded with quartz vein
116.10	118.10	2.00	Quartz, slightly fractured pink

118.10	119.10	1.00	Granite gneiss, pink highly fractured associated with quartz vein
119.10	121.10	2.00	Granite gneiss, slightly fractured with pink variety dominating

LITHOLOG

Unique ID: 5	EW
Village	Kathikund
Block	Kathikund
District	Dumka
Latitude	24^0 21' 50"
Longitude	87^0 25' 20"
Drilled Depth (mbgl)	140.00
Casing depth (m bgl)	15.82
SWL(m bgl)	9.96
Discharge (m^3/hr)	26.4
Date / Year	November 1989

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	4.00	4.00	Lateritic soil
4.00	15.04	11.04	Granite gneiss, weathered
15.04	16.04	1.00	Pegmatite veins, highly fractured with pink and colourless feldspar dominating
16.04	19.04	3.00	Granite gneiss, massive
19.04	23.66	4.62	Granite gneiss, fractured
23.66	24.66	1.00	Mica schist, massive, compact
24.66	31.28	6.62	Mica schist, fractured
31.28	32.28	1.00	Mica schist, garnetiferous
32.28	37.28	5.00	Mica schist (fractured), garnetiferous
37.28	39.90	2.62	Mica schist, massive
39.90	40.90	1.00	Mica schist, slightly fractured
40.90	42.90	2.00	Granite gneiss
42.90	48.52	5.62	Mica schist, compact, hard slightly fractured
48.52	49.52	1.00	Mica schist, garnetiferous, fractured
49.52	56.14	6.62	Mica schist, compact, slightly fractured
56.14	58.14	2.00	Mica schist, garnetiferous, massive
58.14	60.14	2.00	Mica schist, fractured garnetiferous with quartz vein
60.14	64.76	4.62	Mica schist, fractured
64.76	65.76	1.00	Mica schist, slightly fractured
65.76	67.76	2.00	Granite gneiss, hard compact massive
67.76	69.38	1.62	Mica schist, slightly fractured
69.38	72.38	3.00	Granite gneiss, pink
72.38	78.00	5.62	Mica schist, slightly fractured
78.00	81.00	3.00	Granite gneiss, slightly fractured
81.00	82.00	1.00	Mica schist

82.00	84.62	2.62	Granite gneiss
84.62	86.62	2.00	Mica schist, compact, hard
86.62	89.62	3.00	Granite gneiss with pink feldspar
89.62	92.24	2.62	Mica schist, slightly fractured
92.24	101.86	9.62	Granite gneiss, massive hard (slightly fractured)
101.86	102.86	1.00	Mica schist, compact hard
102.86	103.86	1.00	Granite gneiss, slightly fractured
103.86	105.86	2.00	Mica schist, compact
105.86	107.48	1.62	Granite gneiss, compact, hard, Mica schist
107.48	118.10	10.62	Granite gneiss, hard compact
118.10	119.10	1.00	Mica schist, with quartz vein
119.10	121.10	2.00	Granite gneiss, hard, compact
121.10	124.72	3.62	Mica schist with granite
124.72	127.72	3.00	Granite gneiss, pink, hard compact
127.72	132.34	4.62	Mica schist, slightly fractured
132.34	140.00	7.66	Granite gneiss, hard compact

LITHOLOG

Unique ID: 6	EW
Village	Jarmundi
Block	Jarmundi
District	Dumka
Latitude	24^0 23’ 30”
Longitude	87^0 06’ 45”
Drilled Depth (mbgl)	141.96
Casing depth (m bgl)	18.50
SWL(m bgl)	--
Discharge (lps)	Dry
Date / Year	1989

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	23.66	2.66	Gneiss, highly weathered
23.66	32.28	8.62	Granite gneiss, partially weathered
32.28	41.90	9.62	Granite gneiss (pink), little hard
41.90	42.90	1.00	Gneiss, grey quite
42.90	48.52	5.62	Granite gneiss, pink
48.52	61.76	13.24	Granite gneiss, grey
61.76	63.76	2.00	Granite gneiss, biotite
63.76	73.38	9.62	Granite gneiss, grey
73.38	83.00	9.62	Amphibolite, compact
83.00	85.62	2.62	Gneiss, grey
85.62	88.62	3.00	Amphibolite
88.62	96.24	7.62	Biotite schist
96.24	97.24	1.00	Granite gneiss, pink
97.24	102.86	5.62	Biotite schist
102.86	133.34	30.48	Granite gneiss, hard

133.34	135.34	2.00	Biotite schist
135.34	141.96	6.62	Granite gneiss

LITHOLOG

Unique ID: 7	EW
Village	Shiv Pahar
Block	Dumka
District	Dumka
Latitude	24^0 15' 40"
Longitude	87^0 21' 15"
Drilled Depth (mbgl)	98.00
Casing depth (m bgl)	9.2
SWL(m bgl)	25.45
Discharge (m^3/hr)	35.4
Date / Year	December 1989

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	6.00	6.00	Granite gneiss, highly weathered
6.00	11.00	5.00	Granite gneiss, partially weathered brecciated
11.00	21.00	10.00	Granite gneiss, slightly fractured
21.00	29.00	8.00	Granite gneiss, hard compact
29.00	33.00	4.00	Granite gneiss, highly brecciated, hard
33.00	49.00	16.00	Granite gneiss, brecciated, hard
49.00	53.00	4.00	Granite gneiss, hard, compact, brecciated
53.00	56.00	3.00	Granite gneiss, partially weathered, brecciated
56.00	70.00	14.00	Granite gneiss, hard, compact, highly brecciated
70.00	90.00	20.00	Granite gneiss, slightly fractured, brecciated, distinct brecciation
90.00	93.00	3.00	Granite gneiss, brecciated, associated with quartz veins
93.00	98.00	5.00	Granite gneiss, compact, hard

LITHOLOG

Unique ID: 8	EW
Village	Hijla Pahar
Block	Dumka
District	Dumka
Latitude	24^0 15' 15"
Longitude	87^0 13' 50"
Drilled Depth (mbgl)	122.00
Casing depth (m bgl)	8.00
SWL(m bgl)	5.36
Discharge (m^3/hr)	7.38
Date / Year	August 1989

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		

0.00	3.00	300	Surface soil, sandy yellowish
3.00	7.00	4.00	Granite, highly weathered with calcareous nodules
7.00	13.00	6.00	Granite gneiss, massive
13.00	16.00	3.00	Granite, fractured grayish with weathered gneisses
16.00	22.00	6.00	Granite gneiss, massive, compact
22.00	25.00	3.00	Granite gneiss, slightly fractured
25.00	47.00	22.00	Granite gneiss, massive, compact, grey
47.00	50.00	3.00	Granite gneiss, slightly fractured
50.00	56.00	6.00	Granite gneiss, massive, compact
56.00	59.00	3.00	Granite gneiss, fractured
59.00	67.00	8.00	Granite gneiss, massive, compact
67.00	80.00	13.00	Granite gneiss, slightly fractured
80.00	92.00	12.00	Granite gneiss, massive, compact
92.00	98.00	6.00	Granite gneiss, slightly fractured
98.00	110.00	12.00	Granite gneiss, massive, compact
110.00	113.00	3.00	Granite gneiss, fractured
113.00	122.00	9.00	Granite gneiss, massive

LITHOLOG

Unique ID: 9	EW
Village	Banwara
Block	Jarmundi
District	Dumka
Latitude	$24^0$26’ 34”
Longitude	$87^0$02’ 49”
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	25.00
SWL(m bgl)	5.16
Discharge (m^3/hr)	0.50
Date / Year	July 2018

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	19.50	19.50	Top soil, yellowish blown in colour, sticky nature
19.50	24.50	5.00	Granite gneiss – weathered
24.50	44.00	19.50	Granite gneiss – white in colour, predominating with quartz and feldspar
44.00	50.00	6.00	Granite gneiss – grey in colour, predominating with biotite
50.00	68.50	18.50	Granite gneiss – white to pink in colour, predominating with quartz (white) and feldspar (pink)
68.50	74.50	6.00	Granite gneiss – grey in colour, predominating with biotite
74.50	80.00	5.50	Granite gneiss – white in colour, predominating with quartz and feldspar
80.00	80.50	0.50	Slightly fracture granite gneiss
80.50	123.50	43.00	Granite gneiss – white in colour, predominating with quartz and feldspar
123.50	202.70	79.20	Granite gneiss – grey in colour, predominating with biotite

LITHOLOG

Unique ID: 10	EW
Village	Bhorabad
Block	Jarmundi
District	Dumka
Latitude	24^{0}19’ 25”
Longitude	87^{0}01’ 01”
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	10.50
SWL(m bgl)	1.39
Discharge (m^3/hr)	7.92
Date / Year	August 2018

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	4.50	4.50	Top soil, yellowish blown in colour, sticky nature
4.5	10.00	5.50	Slightly weathered granite gneiss
10.00	13.00	3.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
13.00	13.50	0.50	Fractured granite gneiss
13.50	39.50	26.00	Granite gneiss – white in colour, predominating with quartz and feldspar
39.50	60.00	20.50	Granite gneiss – grey in colour, predominating with biotite, hard & compact
60.00	93.00	33.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
93.00	115.00	22.00	Granite gneiss – grey in colour, predominating with biotite, hard & compact
115.00	166.00	51.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
166.00	167.00	1.00	Fracture granite gneiss
167.00	181.50	14.50	Granite gneiss – grey in colour, predominating with biotite, hard & compact
181.50	202.70	21.20	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact

LITHOLOG

Unique ID: 11	EW
Village	Haripur
Block	Jarmundi
District	Dumka
Latitude	24^{0}18’ 40”
Longitude	87^{0}03’ 55”
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	11.50
SWL(m bgl)	--

Discharge (m^3/hr)	Dry
Date / Year	November 2018

Depth range (m bgl)		Thickness (m)	Litholog
From	To		
0.00	4.00	4.00	Top soil, yellowish blown in colour, sticky nature
4.00	11.00	7.00	Slightly weathered granite gneiss
11.00	44.50	33.50	Granite gneiss – grey in colour, predominating with biotite, hard & compact
44.50	59.00	14.50	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
59.00	83.50	24.50	Granite gneiss – grey in colour, predominating with biotite, hard & compact
83.50	88.50	5.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
88.50	120.50	32.00	Granite gneiss – grey in colour, predominating with biotite, hard & compact
120.50	132.50	12.00	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
132.50	150.50	18.00	Granite gneiss – grey in colour, predominating with biotite, hard & compact
150.50	157.00	6.50	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact
157.00	191.00	34.00	Granite gneiss – grey in colour, predominating with biotite, hard & compact
191.00	202.70	11.70	Granite gneiss – white in colour, predominating with quartz and feldspar, hard & compact

LITHOLOG

Unique ID: 12	EW
Village	Bedia
Block	Jama
District	Dumka
Latitude	$24^0$14’ 21”
Longitude	$87^0$11’ 41”
Drilled Depth (mbgl)	68.50
Casing depth (m bgl)	30.00
SWL(m bgl)	5.80
Discharge (m^3/hr)	44.28
Date / Year	November 2018

Depth range (m bgl)		Thickness (m)	Litholog
From	To		
0.00	29.50	29.50	Top soil, yellowish blown in colour, sticky nature
29.50	38.00	8.50	Granite gneiss – slightly weathered

38.00	44.00	6.00	Granite gneiss – grey in colour, predominating with biotite
44.00	50.00	6.00	Granite gneiss – light pink in colour, predominating with feldspar
50.00	57.00	7.00	Granite gneiss – grey in colour, predominating with biotite
57.00	59.00	2.00	Fractured granite gneiss

LITHOLOG

Unique ID: 13	OW
Village	Bedia
Block	Jama
District	Dumka
Latitude	$24^0$14’ 21”
Longitude	$87^0$11’ 41”
Drilled Depth (mbgl)	74.60
Casing depth (m bgl)	30.20
SWL(m bgl)	6.10
Discharge (m^3/hr)	12.24
Date / Year	November 2018

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	30.00	30.00	Top soil, yellowish blown in colour, sticky nature
30.00	32.00	2.00	Granite gneiss – grey in colour, predominating with biotite
32.00	41.00	9.00	Granite gneiss – light pink in colour, predominating with feldspar
41.00	47.00	6.00	Granite gneiss – grey in colour, predominating with biotite
47.00	50.00	3.00	Granite gneiss – light pink in colour, predominating with feldspar
50.00	56.00	6.00	Granite gneiss – grey in colour, predominating with biotite
56.00	66.00	2.00	Granite gneiss – light pink in colour, predominating with feldspar
66.00	68.00	2.00	Fractured granite gneiss
68.00	74.60	6.60	Granite gneiss – grey in colour, predominating with biotite

LITHOLOG

Unique ID: 14	EW
Village	Chikania (Lodhna)
Block	Jama
District	Dumka
Latitude	$24^0$16’ 44”
Longitude	$87^0$07’ 48”
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	16.50
SWL(m bgl)	--
Discharge (m^3/hr)	12.24
Date / Year	January 2019

Depth range (m bgl)		Thickness (m)	Litholog
From	To		
0.00	14.90	14.90	Top soil, yellowish blown in colour, sticky nature
14.90	16.50	1.60	Granite gneiss – weathered
16.50	47.20	30.70	Granite gneiss – grey in colour, predominating with biotite
47.20	53.30	6.10	Granite gneiss – white in colour, predominating with quartz
53.30	157.00	103.70	Granite gneiss – grey in colour, predominating with biotite
157.00	160.00	3.00	Granite gneiss – white to pink in colour, predominating with quartz (white) feldspar (pink)
160.00	176.50	16.50	Granite gneiss – white in colour, predominating with quartz
176.50	177.00	0.50	Slightly fractured granite gneiss
177.00	184.00	7.00	Granite gneiss – grey in colour, predominating with biotite
184.00	185.00	1.00	Fractured granite gneiss
185.00	202.70	17.70	Granite gneiss – grey in colour, predominating with biotite

LITHOLOG

Unique ID: 15	EW
Village	Karbindha
Block	Ramgarh
District	Dumka
Latitude	$24^0$25’ 15”
Longitude	$87^0$18’ 22”
Drilled Depth (mbgl)	202.70
Casing depth (m bgl)	24.20
SWL(m bgl)	--
Discharge (m^3/hr)	Dry
Date / Year	January 2019

Depth range (m bgl)		Thickness (m)	Litholog
From	To		
0.00	13.50	13.50	Top soil, yellowish blown in colour, sticky nature
13.50	23.50	10.00	Granite gneiss – slightly weathered
23.50	90.00	66.50	Granite gneiss – white in colour, predominating with quartz and feldspar
90.00	96.00	6.00	Granite gneiss – light pink in colour, predominating with feldspar
96.00	202.70	106.70	Granite gneiss – grey in colour, predominating with biotite

LITHOLOG

Unique ID: 16	EW
Village	Mahura
Block	Saraiyahat
District	Dumka
Latitude	24^{0}31’ 13”
Longitude	87^{0}00’ 53”
Drilled Depth (mbgl)	153.90
Casing depth (m bgl)	19.20
SWL(m bgl)	17.95
Discharge (m^3/hr)	14.04
Date / Year	February 2019

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	0.50	0.50	Top soil
0.50	18.50	18.00	Weathered granite gneiss
18.50	86.00	67.50	Granite gneiss – grey in colour, predominating with biotite
86.00	90.00	4.00	Granite gneiss – white in colour, predominating with quartz and feldspar
90.00	114.00	24.00	Granite gneiss – grey in colour, predominating with biotite
114.00	115.00	1.00	Fractured granite gneiss
115.00	123.50	8.50	Granite gneiss – light pink in colour, predominating with feldspar
123.50	129.50	6.00	Granite gneiss – grey in colour, predominating with biotite
129.50	135.50	6.00	Granite gneiss – light pink in colour, predominating with feldspar
135.50	153.90	18.40	Granite gneiss – grey in colour, predominating with biotite

LITHOLOG

Unique ID: 17	OW
Village	Mahura
Block	Saraiyahat
District	Dumka
Latitude	24^{0}31’ 13”
Longitude	87^{0}00’ 53”
Drilled Depth (mbgl)	153.90
Casing depth (m bgl)	19.20
SWL(m bgl)	--
Discharge (m^3/hr)	1.37
Date / Year	February 2019

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	0.50	0.50	Top soil

0.50	19.00	18.50	Weathered granite gneiss
19.00	53.00	34.00	Granite gneiss – white in colour, predominating with quartz and feldspar
53.00	74.50	21.50	Granite gneiss – grey in colour, predominating with biotite
74.50	86.50	12.00	Granite gneiss – white in colour, predominating with quartz and feldspar
86.50	99.00	12.50	Granite gneiss – grey in colour, predominating with biotite
99.00	112.00	13.00	Granite gneiss – white in colour, predominating with quartz and feldspar
112.00	112.50	0.50	Fractured granite gneiss
112.50	153.90	41.40	Granite gneiss – white in colour, predominating with quartz and feldspar

LITHOLOG

Unique ID: 18	EW
Village	Bhadwari (Nonihat)
Block	Ramgarh
District	Dumka
Latitude	$24^0$29’ 00”
Longitude	$87^0$07’ 49”
Drilled Depth (mbgl)	153.50
Casing depth (m bgl)	19.00
SWL(m bgl)	--
Discharge (m^3/hr)	0.50
Date / Year	February 2019

Depth range (m bgl)		**Thickness (m)**	**Litholog**
From	**To**		
0.00	13.00	3.00	Top soil
13.00	19.00	6.00	Slightly weathered granite gneiss
19.00	28.50	9.50	Granite gneiss – grey in colour, predominating with biotite
28.50	44.00	15.50	Granite gneiss – white in colour, predominating with quartz and feldspar
44.00	86.50	42.50	Granite gneiss – grey in colour, predominating with biotite
86.50	102.00	15.50	Granite gneiss – white in colour, predominating with quartz and feldspar
102.00	138.00	36.00	Granite gneiss – grey in colour, predominating with biotite
138.00	153.50	15.50	Granite gneiss – white in colour, predominating with quartz and feldspar

Annexure - VIII

WATER QUALITY DATA OF AQUIFER - I (DUG WELL SAMPLES) OF AQUIFER MAPPING STUDY AREA OF DUMKA DISTRICT

Sr. No.	Village	Block	District	Latitude & Longitude	Depth (mbgl)	Aqui-fer Type	pH	EC (µS/ cm)	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F
									← Mg / l →										
1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	Patabari	Shikaripara	Dumka	24⁰ 12’ 52” 87⁰ 22’ 10”	7.03	W.G.G	8.21	853	554	365	68	47.39	31.29	1.60	141.45	85.1	82	86.7	1.35
2	Masanjor	Raneshwar	Dumka	24⁰ 06’ 21” 87⁰ 18’ 45”	3.00	W.G.G	7.97	195	127	90	20	6.07	10.07	0.43	86.10	6.02	5	3.50	0.72
3	Raneshwar	Raneshwar	Dumka	24⁰ 02’ 44” 87⁰ 24’ 38”	6.34	W.G.G	7.93	1455	946	445	64	69.26	119.9	1.01	209.10	237	89	83.50	0.67
4	Asanbani	Raneshwar	Dumka	24⁰ 07’ 49” 87⁰ 26’ 51”	6.44	W.G.G	7.95	1128	733	395	64	27.95	108.3	2.45	141.45	229	70	40.6	0.65
5	Khirghata	Raneshwar	Dumka	24⁰ 03’ 24” 87⁰ 16’ 06”	7.33	W.G.G	8.23	661	430	225	46	26.73	49.14	0.60	86.10	158	30	45.9	1.01
6	Masalia	Masalia	Dumka	24⁰ 09’ 21” 87⁰ 10’ 48”	4.88	W.G.G	7.98	407	265	165	48	10.94	17.43	0.97	104.55	66.1	24	19.4	0.46
7	Domkata	Masalia	Dumka	24⁰ 10’ 05” 87⁰ 03’ 55”	7.41	W.G.G	8.27	938	610	375	90	30.37	49.99	2.21	123.00	110	103	76.7	0.78
8	Tiliya Pahari	Masalia	Dumka	24⁰ 13’ 05” 87⁰ 12’ 02”	5.11	W.G.G	8.15	601	391	185	50	14.58	40.40	1.42	141.45	49	45	60.0	1.69
9	Shikaripara	Shikaripara	Dumka	24⁰ 14’ 15” 87⁰ 28’ 02”	6.65	W.G.G	8.14	749	487	215	42	26.73	69.87	2.01	135.30	104	47	39.8	0.93
10	Pokharia	Kathikund	Dumka	24⁰ 18’ 02” 87⁰ 28’ 16”	8.00	W.G.G	8.17	827	538	285	80	20.66	46.44	1.17	153.75	121	32	53.7	0.45
11	Rampur	Shikaripara	Dumka	24⁰ 14’ 04” 87⁰ 32’ 00”	9.20	Sand-stone	7.46	165	107	70	20	4.86	5.72	1.12	61.50	9	4	11.2	0.39
12	Kathikund	Kathikund	Dumka	24⁰ 21’ 29” 87⁰ 25’ 34”	6.28	W.G.G	8.17	575	374	175	58	7.29	41.90	11.34	116.85	57.9	49	38.4	0.64
13	Gopikandar	Gopikandar	Dumka	24⁰ 25’ 26” 87⁰ 28’ 57”	9.09	Sand-stone	7.98	272	177	85	36	6.08	13.46	1.24	47.35	30.2	19	43.1	0.32
14	Durgapur	Gopikandar	Dumka	24⁰ 29’ 31” 87⁰ 32’ 19”	7.84	W.B.	8.06	625	406	275	52	35.24	16.31	0.44	123.00	78.9	49	26.3	0.28
15	Digal Kharauni	Gopikandar	Dumka	24⁰ 21’ 53” 87⁰ 33’ 16”	4.97	W.B.	7.98	483	314	230	42	30.38	14.93	0.87	141.45	53	34	14.9	0.27
16	Amba	Kathikund	Dumka	24⁰ 20’ 16” 87⁰ 21’ 06”	5.51	W.G.G	8.30	187	121	70	20	4.86	9.49	9.32	61.50	21.27	8	9.5	0.33
17	Doom	Dumka	Dumka	24⁰ 24’ 27” 87⁰ 18’ 13”	5.89	W.G.G	8.47	603	392	235	40	32.81	27.47	1.17	73.80	74.7	68	27.5	0.37

Sr. No.	Village	Block	District	Latitude & Longitude	Depth (mbgl)	Aqui-fer Type	pH	EC (µS/ cm)	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F
									← Mg / l →										
1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
18	Jawari	Ramgarh	Dumka	24⁰ 30’ 03” 87⁰ 17’ 14”	4.25	W.G.G	8.33	670	436	235	38	34.02	43.90	1.13	79.93	128	19	43.9	0.62
19	Dumka	Dumka	Dumka	24⁰ 16’ 00” 87⁰ 15’ 00”	4.03	W.G.G	8.25	298	194	107	32	6.08	17.58	5.14	104.55	16.1	13	17.6	0.75
20	Chapodia	Dumka	Dumka	24⁰ 18’ 25” 87⁰ 17’ 15”	6.11	W.G.G	7.94	580	377	265	42	38.88	23.57	2.31	172.20	53.13	46	31.5	1.14
21	Bara Palasi	Jama	Dumka	24⁰ 23’ 00” 87⁰ 11’ 00”	7.07	W.G.G	8.08	1957	1272	660	164	60.75	138.4	7.24	282.90	329	99	124.2	0.61
22	Nonihat	Jarmundi	Dumka	24⁰ 28’ 10” 87⁰ 07’ 31”	1.97	W.G.G	7.88	299	194	110	32	7.29	19.64	2.20	49.20	54.3	19	3.1	0.79
23	Dighi	Saraiyahat	Dumka	24⁰ 32’ 34” 86⁰ 56’ 54”	7.12	W.G.G	8.10	454	295	90	18	10.94	59.31	1.88	196.80	30.50	3	21	3.14
24	Beldaha	Jarmundi	Dumka	24⁰ 28’ 22” 87⁰ 02’ 02”	9.12	W.G.G	7.24	296	192	80	28	2.43	28.02	2.28	135.30	9.7	4	3.8	1.57
25	Kusmah	Jarmundi	Dumka	24⁰ 25’ 17” 86⁰ 55’ 15”	7.36	W.G.G	7.97	643	418	215	44	25.52	35.62	1.14	116.85	104	33	48.3	0.55
26	Jarmundi	Jarmundi	Dumka	24⁰ 23’ 35” 87⁰ 03’ 12”	7.93	W.G.G	8.47	3449	2242	1565	306	194.40	133.3	7.93	405.90	470	131	547	0.61
27	Jama	Jama	Dumka	24⁰ 20’ 50” 87⁰ 09’ 10”	8.56	W.G.G	8.18	606	394	225	42	29.16	24.60	1.47	116.85	74.8	36	80.6	0.47
28	Chikania	Jama	Dumka	24⁰ 15’ 50” 87⁰ 07’ 00”	8.08	W.G.G	8.33	1436	933	375	84	40.10	139.8	2.60	270.60	215	73	56.7	0.80
29	Dhadhakia	Dumka	Dumka	24⁰ 12’ 39” 87⁰ 17’ 12”	7.03	W.G.G	8.27	302	196	340	42	57.11	22.01	3.29	104.55	23.3	20	2.3	0.54

Annexure – IX

WATER QUALITY DATA OF AQUIFER II (HAND PUMP SAMPLES) OF AQUIFER MAPPING STUDY AREA OF DUMKA DISTRICT

Sr. No.	Village	Block	District	Latitude	Aqui-fer Type	pH	EC (µS/ cm)	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F
								← Mg / l →										
1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Patabari	Shikaripara	Dumka	24⁰ 12’ 52” 87⁰ 22’ 10”	F.G.G	7.53	700	490	250	40	36.45	44.58	0.93	246.00	47.9	68	47.2	1.07
2	Masanjor	Raneshwar	Dumka	24⁰ 06’ 21” 87⁰ 18’ 45”	F.G.G	7.80	281	197	120	30	10.93	13.99	0.80	129.15	10	15	5.0	0.31
3	Raneshwar	Raneshwar	Dumka	24⁰ 02’ 44” 87⁰ 24’ 38”	F.G.G	7.87	366	256	125	48	1.21	24.61	1.17	123.00	19.5	42	37.8	0.00
4	Asanbani	Raneshwar	Dumka	24⁰ 07’ 49” 87⁰ 26’ 51”	F.G.G	7.80	1098	769	450	56	75.33	35.58	3.87	233.70	185	59	91.3	0.00
5	Khirghata	Raneshwar	Dumka	24⁰ 03’ 24” 87⁰ 16’ 06”	F.G.G	7.93	449	314	150	40	12.15	21.35	0.60	141.45	28.5	17	50.0	0.48
6	Masalia	Masalia	Dumka	24⁰ 09’ 21” 87⁰ 10’ 48”	F.G.G	7.95	608	426	215	16	42.52	54.09	1.51	276.75	38.1	34	21.7	1.53
7	Nipania	Masalia	Dumka	24⁰ 04’ 03” 87⁰ 08’ 58”	F.G.G	7.97	471	330	155	50	7.29	26.85	2.29	184.50	14.1	5	55.3	0.64
8	Domkata	Masalia	Dumka	24⁰ 10’ 05” 87⁰ 03’ 55”	F.G.G	7.95	632	442	245	86	7.29	19.73	1.10	135.30	63.9	17	115	0.36
9	Tiliya Pahari	Masalia	Dumka	24⁰ 13’ 05” 87⁰ 12’ 02”	F.G.G	8.03	449	314	150	36	14.58	29.28	1.59	227.55	8.92	14	2.1	1.10
10	Shikaripara	Shikaripara	Dumka	24⁰ 14’ 15” 87⁰ 28’ 02”	F.G.G	7.97	352	246	135	22	19.44	15.93	1.48	110.70	32.3	23	40.7	0.22
11	Pokharia	Kathikund	Dumka	24⁰ 18’ 02” 87⁰ 28’ 16”	F.G.G	7.96	203	142	75	20	6.07	12.58	0.99	92.25	12	1	21.4	0.00
12	Rampur	Shikaripara	Dumka	24⁰ 14’ 04” 87⁰ 32’ 00”	Sand-stone	8.17	541	379	150	18	25.51	39.95	17.95	178.35	17.06	63	12.6	0.13
13	Kathikund	Kathikund	Dumka	24⁰ 21’ 29” 87⁰ 25’ 34”	F.G.G	8.05	567	397	190	40	21.87	31.27	2.85	270.60	34.6	12	3.5	0.43
14	Gopikandar	Gopikandar	Dumka	24⁰ 25’ 26” 87⁰ 28’ 57”	Sand-stone	8.06	432	302	175	12	35.23	20.77	4.63	252.15	3.21	2	2.9	0.00
15	Durgapur	Gopikandar	Dumka	24⁰ 29’ 31” 87⁰ 32’ 19”	F.B.	7.95	513	359	155	32	18.22	38.22	0.45	184.50	35.3	22	22.1	0.00
16	Digal Kharauni	Gopikandar	Dumka	24⁰ 21’ 53” 87⁰ 33’ 16”	F.B.	8.11	210	147	75	16	6.07	15.50	12.00	92.25	14.8	1	15.3	0.00
17	Amba	Kathikund	Dumka	24⁰ 20’ 16” 87⁰ 21’ 06”	F.G.G	8.35	312	218	125	30	12.15	8.13	1.13	110.70	10.63	17	26.2	0.21

Sr. No.	Village	Block	District	Latitude	Aqui-fer Type	pH	EC (µS/ cm)	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F
								← Mg / l →										
1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	18	19	20
18	Doom	Dumka	Dumka	24⁰ 24’ 27” 87⁰ 18’ 13”	F.G.G	8.13	237	166	95	34	2.43	14.88	0.97	116.85	9.3	3	5.9	0.00
19	Jawari	Ramgarh	Dumka	24⁰ 30’ 03” 87⁰ 17’ 14”	F.G.G	8.06	170	119	75	16	8.50	8.13	1.20	73.80	3.15	4	22.6	0.00
20	Ramgarh	Ramgarh	Dumka	24⁰ 33’ 50” 87⁰ 14’ 54”	F.G.G	7.74	1018	713	325	90	24.30	59.60	6.58	178.35	201.5	38	53.8	0.00
21	Dumka	Dumka	Dumka	24⁰ 16’ 00” 87⁰ 15’ 00”	F.G.G	7.86	1112	778	450	38	83.83	27.87	9.01	246.00	214	46	15.7	0.21
22	Chapodia	Dumka	Dumka	24⁰ 18’ 25” 87⁰ 17’ 15”	F.G.G	7.74	314	220	125	32	10.93	19.79	0.90	117.00	18.6	10	46.3	0.18
23	Bara Palasi	Jama	Dumka	24⁰ 23’ 00” 87⁰ 11’ 00”	F.G.G	7.34	1065	746	300	80	24.30	82.35	5.45	104.55	207	51	82.0	0.00
24	Nonihat	Jarmundi	Dumka	24⁰ 28’ 10” 87⁰ 07’ 31”	F.G.G	7.58	545	382	195	42	21.87	24.53	1.58	86.10	114	2	32.6	0.00
25	Hansdiha	Saraiyahat	Dumka	24⁰ 36’ 00” 87⁰ 04’ 15”	F.G.G	7.84	248	174	95	18	12.15	9.02	1.91	61.50	3.08	61	11.2	1.70
26	Dighi	Saraiyahat	Dumka	24⁰ 32’ 34” 86⁰ 56’ 54”	F.G.G	8.07	624	437	105	20	13.36	89.28	0.52	246.00	57.2	16	35.4	0.81
27	Beldaha	Jarmundi	Dumka	24⁰ 28’ 22” 87⁰ 02’ 02”	F.G.G	8.16	233	163	100	20	12.15	12.18	0.93	117.00	4.3	5	12.3	0.00
28	Kusmah	Jarmundi	Dumka	24⁰ 25’ 17” 86⁰ 55’ 15”	F.G.G	7.92	443	310	175	26	26.73	12.91	2.42	92.25	51.6	14	71.1	0.00
29	Jarmundi	Jarmundi	Dumka	24⁰ 23’ 35” 87⁰ 03’ 12”	F.G.G	7.81	1295	907	465	116	42.52	62.24	1.62	67.65	272	77	114.0	0.00
30	Jama	Jama	Dumka	24⁰ 20’ 50” 87⁰ 09’ 10”	F.G.G	7.93	974	682	370	48	60.75	65.29	1.12	147.60	174	84	65	0.00
31	Chikania	Jama	Dumka	24⁰ 15’ 50” 87⁰ 07’ 00”	F.G.G	7.93	1193	835	380	52	60.75	75.16	1.37	179.10	201	49	101.6	0.00
32	Dhadhakia	Dumka	Dumka	24⁰ 12’ 39” 87⁰ 17’ 12”	F.G.G	8.10	434	304	185	40	20.65	24.15	0.89	129.15	62.2	0	9.0	0.00

Annexure - X

INTERPRETED RESULT OF VES IN DUMKA DISTRICT

Sr. No.	Block	Village	Location	VES No.	Resistivity values for individual layers					Thickness of the individual layer (in m)				Thickness of overburden	Expected fracture zones (mbgl)
					P_1	P_2	P_3	P_4	P_5	h_1	h_2	h_3	h_4		
	2	3	4	5	6	7	8	9		10	11	12	13	14	15
1	Dumka	Hijla Paharpur	Hijla Paharpur	10A	110	16.5	315	V.H		1.2	3.6	19.2	--	24.00	60 - 100
2	Dumka	-do-	-do-	10B	120	18	120	V.H		1.15	3.1	14	--	18.25	
3	Dumka	-do-	-do-	10C	140	21	98	V.H		1.15	3.2	12.6	--	16.95	
4	Dumka	-do-	-do-	10D	125	18.75	240	V.H		1.2	3.6	31.5	--	36.30	
5	Dumka	Kurua	Kurua	9A	47	164.5	V.H	--		3.8	8.7	--	--	12.50	70 - 100
6	Dumka	-do-	-do-	9B	54	189.0	V.H	--		3.9	15.0	--	--	18.90	
7	Dumka	-do-	-do-	9C	47	164.5	V.H	--		3.3	11.55	--	--	14.85	
8	Dumka	-do-	-do-	9D	48	168.0	V.H	--		4.1	9.4	--	--	13.50	
9	Dumka	Shivpahar	Shivpahar	3A	51	76.5	H	--		2.3	15	--	--	17.30	
10	Dumka	-do-	-do-	3B	52	65	H	--		2.2	16.5	--	--	18.70	70 - 100
11	Dumka	-do-	-do-	3C	52	65	H	--		2.8	16.2	--	--	19.00	
12	Dumka	-do-	-do-	3D	52	65	H	--		2.4	14.4	--	--	16.80	
13	Dumka	Dumka	Police line	6A	148	22.2	V.H	--		1.2	5.4	--	--	6.6	
14	Dumka	-do-	-do-	6B	150	22.5	V.H	--		1.18	4.0	--	--	5.2	
15	Dumka	-do-	-do-	6C	165	16.5	V.H	--		1.2	3.0	--	--	4.2	40 - 80
16	Dumka	-do-	-do-	6D	118	17.7	V.H	--		1.45	5.4	--	--	6.9	
17	Sikaripara	Patabari	Patabari	8A	100	30	H	--		1.3	6.5	--	--	7.8	20 - 40
18	Sikaripara	-do-	-do-	8B	72	28.8	V.H	--		1.25	7.5	--	--	8.8	
19	Sikaripara	-do-	-do-	8C	69	20.7	H	--		1.3	5.0	--	--	6.3	70 - 100
20	Sikaripara	-do-	-do-	8D	64	25.6	V.H	--		1.3	6.5	--	--	7.8	
21	Kathikund	Kathikund	Block campus	7A	260	104	325	107	H	1.28	2.56	4.56	13.1	21.5	20 - 40
22	Kathikund	-do-	-do-	7B	285	114	225	90	VH	1.3	1.9	2.8	9.6	15.6	
23	Kathikund	-do-	-do-	7C	285	85.5	187	85	H	1.2	1.6	8.6	9.6	21.1	60 - 80
24	Kathikund	-do-	-do-	7D	230	69	210	95	H	1.3	1.6	7.4	11.5	20.5	
25	Kathikund	-do-	Police station	2A	112	33.6	308	VH		1.2	2.6	10.3	--	14.2	50 - 80
	Kathikund	-do-	-do-	2B	94	329	V.H	--		3.4	15.0	--	--	18.4	

Sr. No.	Block	Village	Location	VES No.	Resistivity values for individual layers					Thickness of the individual layer (in m)				Thickness of overburden	Expected fracture zones (mbgl)
					P_1	P_2	P_3	P_4	P_5	h_1	h_2	h_3	h_4		
	2	3	4	5	6	7	8	9		10	11	12	13	14	15
27	Raneswar	Raneswar	Raneswar	1A	54	16.2	154	V.H		1.3	3.1	41.2	--	45.6	
28	Raneswar	-do-	-do-	1B	72	21.6	182	V.H		1.25	4.9	38.4	--	44.6	60 - 100
29	Raneswa	-do-	-do-	1C	49	19.6	161	V.H		1.2	3.4	32.6	--	37.2	
30	Raneswar	-do-	-do-	1D	64	19.2	87.5	V.H		1.2	2.6	40.0	--	43.8	
31	Masaliya	Datiarpur	Back side of Muthu Murmu house	1	95	38	380	--		1.3	5.6	--	--	6.9	--
32	Masaliya	-do-	Near Gobinath Murmu house	2	250	75	V.H	--		1.4	9.0	--	--	10.0	--
33	Masaliya	Masaliya	Near Lakhi Roy's house	3	26	182	950	--		3.8	34.2	--	--	3.8	25 - 30
34	Masaliya	-do-	Near Anand Nath house	4	26	182	950	--		3.8	34.2	--	--	3.8	
35	Masaliya	-do-	Back side of veterinary hospital	5	18	180	280	--		4.0	60.0	--	--	4.0	40-100
36	Masaliya	-do-	Back side of veterinary hospital	6	18	180	280			4.0	60	-	-	4.0	
37	Masaliya	-do-	Back side of veterinary hospital	7	18	180	230			4.0	60	-	-	4.0	
38	Masaliya	-do-	Back side of veterinary hospital	8	18	180	280			4.0	60	-	-	4.0	
39	Masaliya	Kendghate	Near Pool	9	68	238	900	--	-	2.3	16.1	--	--	2.3	
40	Masaliya	-do-	Near Gopal Nath's house	10	70	28	224	750	-	1.2	3.6	30.6	--	5.0	15 - 30
41	Masaliya	Dankata	In front of Te Tutu's house	11	80	32	400	V.H	-	1.4	3.2	21.07	--	4.6	
42	Masaliya	Dankata	In front of Titutu's	12	80	32	400	V.H	-	1.4	3.2	21.07	--	4.6	

Sr. No.	Block	Village	Location	VES No.	Resistivity values for individual layers					Thickness of the individual layer (in m)				Thickness of overburden	Expected fracture zones (mbgl)
					P_1	P_2	P_3	P_4	P_5	h_1	h_2	h_3	h_4		
	2	3	4	5	6	7	8	9		10	11	12	13	14	15
			house												
43	Masaliya	Nepania	Near hand pump	13	17	V.H	--	--		4.5	--	--	--	4.50	
44	Masaliya	Nepania	Back side of school	14	155	78	14	V.H		1.2	2.66	13.65	--	17.3	20 - 25
45	Masaliya	Chanddih	Near Shiva's land	15	43	34	175	--		1.2	6.84	33.6	--	8.0	10 - 40
46	Masaliya	Haripur	Middle of village	16	90	27	V.H	--		1.2	4.8	--	--	6.0	
47	Masaliya	Mankchak	Near Gopal Titutu house	17	165	50	175	V.H		1.3	2.34	31.5	--	3.6	15 - 30
48	Masaliya	Shikarpur	In front of Kurbakama Singh's house	18	150	225	V.H	--		4.2	16.8	--	--	4.2	
49	Masaliya	Bhangahir	Near Pool	19	73	V.H	--	--		6.2	--	--	--	6.2	
50	Masaliya	Paharpur	East side of village	20	52	V.H	--	--		5.5	--	--	--	5.5	
51	Masaliya	Paharpur	Near Ajit Layak's house	21	52	V.H	-								
52	Masaliya	Kusbedia	Near culvert	22	40	600	--	--		4.2	--	--	--	4.2	
53	Masaliya	Kusbeda	Midd of village	23	40	600	-	-	-	6.5	-			6.5	
54	Masaliya	Dudhani	North of play ground	24	185	V.H	--	--		6.5	--	--	--	6.5	
55	Masaliya	-do-	-do-	25	185	V.H	--	--		6.5	-	--	--	6.5	
56	Masaliya	Shampur	Near Mango Tree	26	17	34	210		--	3.2	17.6			20.8	50-60
57	Masaliya	-do-	-do-	27	17	34	210	--	--	3.2	17.6	--	--	20.8	
58	Masaliya	-do-	South side of village	28	25	88	504	--	--	2.2	15.2	--	--	17.6	15 - 30
59	Masaliya	Lakhibad	South of Pool	29	420	84	672	--	--	1.7	11.2	--	--	12.9	30 - 50
60	Masaliya	Tilabad	East of Pool	30	15	75	V.H	--	--	2.4	10.8	--	--	13.2	15 - 25
61	Masaliya	Banead	Near Mutchi's land	31	102	V.H	--	--	--	3.7	--	--	--	3.7	
62	Masaliya	Jamead	Near Hari	32	33	165	V.H	--	--	2.3	32.2	--	--	2.3	15 - 30

Sr. No.	Block	Village	Location	VES No.	Resistivity values for individual layers					Thickness of the individual layer (in m)				Thickness of overburden	Expected fracture zones (mbgl)
					P_1	P_2	P_3	P_4	P_5	h_1	h_2	h_3	h_4		
	2	3	4	5	6	7	8	9		10	11	12	13	14	15
			Tutu's land												
63	Masaliya	Dalahi	Near Arun Das land	33	50	350	V.H	--	--	6.0	54.0	--	--	6.0	20-100
64	Masaliya	-do-	-do-	34	50	350	V.H	--	--	6.0	54.0	--	--	6.0	
65	Masaliya	-do-	-do-	35	50	350	V.H	--	--	6.0	54.0	--	--	6.0	20 – 100
66	Masaliya	-do-	-do-	36	50	350	V.H	--	--	6.0	54.0	--	--	6.0	
67	Masaliya	-do-	-do-	37	50	350	V.H	--	--	6.0	54.0	--	--	6.0	
68	Masaliya	Nawasar	In front of Primary school	38	65	52	138	V.H	--	1.8	10.3	55.34	--	10.0	50-80
69	Masaliya	-do-	-do-	39	65	52	138	V.H	--	1.8	10.3	55.34	--	10.0	
70	Masaliya	-do-	-do-	40	65	52	138	V.H	--	1.8	10.3	55.3	--	10.0	50 - 80
71	Masaliya	-do-	-do-	41	65	52	138	V.H	--	1.8	10.3	55.3	--	10.0	
72	Masaliya	Chapria Bara	Near Sulai Sarun land	42	820	246	V.H	--	--	1.2	14.4	--	--	15.0	
73	Masaliya	-do-	Near primary school	43	56	196	V.H	--	--	4.0	20.0	--	--	4.0	
74	Masaliya	Jamjuri	Near Kali temple	44	29	73	930	--	--	2.9	23.2	--	--	3.0	
75	Ramgarh	Bhadwari	Bhadwari	1	55	45	V.H	--	--	1.4	7.62	--	--	9.05	70-80 100-110
76	Ramgarh	Bhadwari	Bhadwari	2	85.8	55	175	545	--	1.76	4.89	20	--	26.65	60-75 90-100
77	Ramgarh	Bhadwari	Bhadwari	3	60	45	556	--	--	0.85	12.1	--	--	12.95	--
78	Ramgarh	Karbindha	Karbindha	1	135	69	515	--	--	2.09	23.8	--	--	25.89	45-55
79	Ramgarh	Karbindha	Karbindha	2	245	65	455	--	--	1.32	22.3	--	--	23.60	55-65
80	Ramgarh	Karbindha	Karbindha	3	205	58	105	775	--	1.15	8.69	28.53	--	38.37	55-70
81	Jama	Chikaniya	Chikaniya	1	125	75	188	V.H	--	0.95	4.15	12.85	--	17.95	70-80
82	Jama	Chikaniya	Chikaniya	2	165	80	235	858	--	1.23	4.77	7.95	--	13.95	80-100
83	Jama	Bedia	Bedia	1	54.10	18	125	239	--	1.29	4.12	7.5	--	12.91	120-140
84	Jama	Bedia	Bedia	2	125	21	60	345	--	1.19	5.8	23.5	--	30.50	140-160

Sr. No.	Block	Village	Location	VES No.	Resistivity values for individual layers					Thickness of the individual layer (in m)				Thickness of overburden	Expected fracture zones (mbgl)
					P_1	P_2	P_3	P_4	P_5	h_1	h_2	h_3	h_4		
	2	3	4	5	6	7	8	9		10	11	12	13	14	15
85	Jama	Bedia	Bedia	3	105	21	52	V.H	--	0.9	7.88	30.1	--	39.90	160-180
86	Gopikandar	Barapathar	Barapathar	1	208	19	505	--	--	3.5	11.5	--	--	14.0	110-120
87	Saraiyahat	Mahura	Mahura	1	425	92	V.H	--	--	1.45	14.0	--	--	15.45	100-120
88	Saraiyahat	Mahura	Mahura	2	120	33	V.H	--	--	1.62	8.74	--	--	10.34	80-100
89	Saraiyahat	Mahura	Mahura	3	125	36	V.H	--	--	0.75	7.51	--	--	8.26	50.65

Annexure-XI

BLOCK WISE WATER CONTAMINATION SOURCES IN DUMKA DISTRICTDISTRICT– DUMKASTATE - JHARKHAND

S.No.	Block	Total Sources Tested	Tested Sources Not Found Contami-nated	Nos. of Sources with Single Chemical Contaminants						Nos. of Sources with Bacteriological Contaminants	Nos. of Sources with Multiple Contaminants	Nos. of Sources with Other Contami-nants
				Iron	Fluoride	Salinity	Nitrate	Arsenic	Other	Faecal Coliform		
1	Dumka	1233	1189	16	5	0	3	0	2	10	11	0
2	Gopikandar	400	377	4	8	0	3	0	0	4	5	0
3	Jama	1069	1060	1	5	0	0	0	6	1	1	0
4	Jarmundi	1114	1089	16	3	0	3	0	0	2	1	0
5	Kathikund	581	566	5	4	0	0	0	0	2	4	0
6	Masalia	546	530	7	3	0	1	0	0	0	0	0
7	Ramgarh	664	660	3	0	0	0	0	0	1	1	0
8	Raneshwer	802	762	34	4	0	1	0	0	2	0	0
9	Saraiyahat	1029	1016	7	3	0	0	0	0	2	1	0
10	Sikaripara	1004	977	13	2	0	1	0	0	6	6	0
	Total	**8442**	**8226**	**106**	**37**	**0**	**12**	**0**	**8**	**30**	**30**	**0**

Source: Jal Jeevan Mission, DODWS, Ministry of Jal Shakti

Annexure-XII

Results of Ground Water Samples for Uranium(ppb) in Dumka District				
Sample no.	**Block**	**Well Name**	**Type of Well**	**Uranium Concentration (ppb)**
1	**Dumka**	**Dumka**	**D/W**	**0.03**
2	**Jama**	**Chikania**	**HP**	**2.47**
3	**Dumka**	**Dumka**	**D/W**	**0.75**
4	**Ramgarh**	**Ramgarh**	**HP**	**0.34**
5	**Gopikandar**	**Gopikandar**	**D/W**	**BDL**
6	**Saraiyahat**	**Saraiyahat**	**D/W**	**BDL**
7	**Jama**	**Jama**	**D/W**	**0.13**
8	**Jarmundi**	**Jarmundi**	**D/W**	**0.22**
9	**Kathikund**	**Kathikund**	**D/W**	**0.12**
10	**Masalia**	**Masalia**	**HP**	**0.30**
11	**Raneshwar**	**Raneshwar**	**D/W**	**BDL**
12	**Jharmundi**	**Jharmundi**	**D/W**	**0.03**
13	**Jama**	**Jama**	**D/W**	**0.97**
14	**Sikaripara**	**Pattabari**	**D/W**	**0.18**
15	**Raneswar**	**Raneswar**	**HP**	**0.35**
16	**Shikaripara**	**Shikaripara**	**D/W**	**0.09**
17	**Dumka**	**Dhadhakia (Dumka)**	**D/W**	**0.42**
18	**Ramgarh**	**Ramgarh**	**D/W**	**0.05**