केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report

on

AQUIFER MAPPING

Parts of Begusarai, Bhagalpur, Khagaria, Munger and Lakhisarai Districts, Bihar Districts, Bihar

मध्य पूर्वी क्षेत्र, पटना

Mid-eastern Region, Patna

Report

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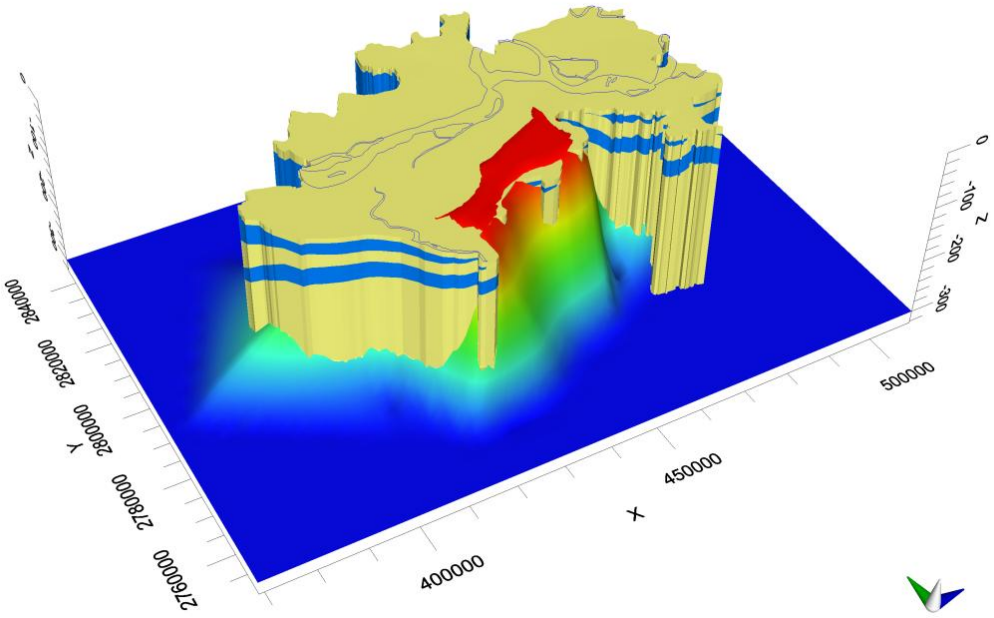
Aquifer mapping in parts of Begusarai, Bhagalpur, Khagaria, Munger and Lakhisarai Districts, Bihar (NAQUIM Phase - III)



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CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION
GOVERNMENT OF INDIA
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August 2017

Report
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Aquifer mapping in parts of Begusarai, Bhagalpur, Khagaria, Munger and Lakhisarai Districts, Bihar (NAQUIM Phase-III)

Principal Contributors

Under Guidance of

A. K. Agrawal
Regional Director

Hydrogeologist

Dr. Indranil Roy, Scientist C

(Nodal Officer)

Dr. Rakesh Singh, Scientist B

Sh. S.S. Purty, Scientist B

Sh. C.K.Gogoi, Scientist B

Sh. Anish Kumar, Scientist B

Dr. Fakhre Alam, Sr. Tech. Astt.

Geophysist

Dr.Subrato Das, Scientist B

Sh. P. Raghavender, Sr.Tech. Astt.

Sh. Somaru Ram, Sr.Tech. Astt

Chemist

Sh. Suresh Kumar, Asst. Chemist

Sushri. Supriya Singh, Sr. Tech. Astt.

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CHAPTER - I

INTRODUCTION

1. Introduction

Under the phase III of National Aquifer Mapping programme (NAQUIM), a total of 17 blocks falling in Begusarai, Bhagalpur, Khagaria, Lakhisarai and Munger districts have been taken up for detailed hydrogeological survey and preparation of Aquifer Management plan. In the study, hydrogeological survey, geophysical investigations and groundwater quality studies have been undertaken and the data generated have been used in conjunction with the existing data available for the area in preparation of the aquifer maps and formulation of the aquifer management plan.

1.1 Objective and Scope

The project envisages detailed characterisation of the aquifers by integrating the available data pertaining to lithology, groundwater geophysics, groundwater quality with the newly generated data during the course of National Aquifer Mapping programme. The generation of the fresh data under the NAQUIM has been made on the basis of the data gaps identified. Phase wise National Aquifer Mapping Area (NAQUIM) is given in Fig. 1.1.

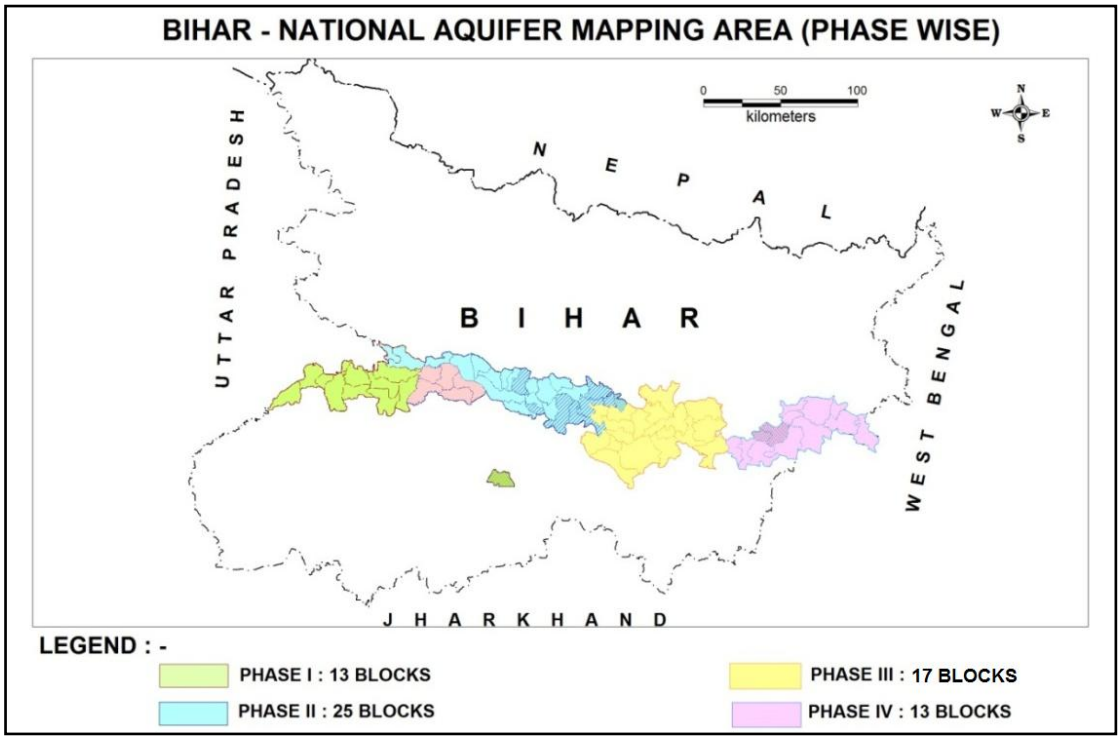


Fig. 1.1 Area to be covered under NAQUIM in different phases

Attempt has also been made to generate a conceptual model of the area for depicting the aquifer in 3-D using Visual Modflow Pro Software. Block wise map of phase III is given in Fig. 1.2.

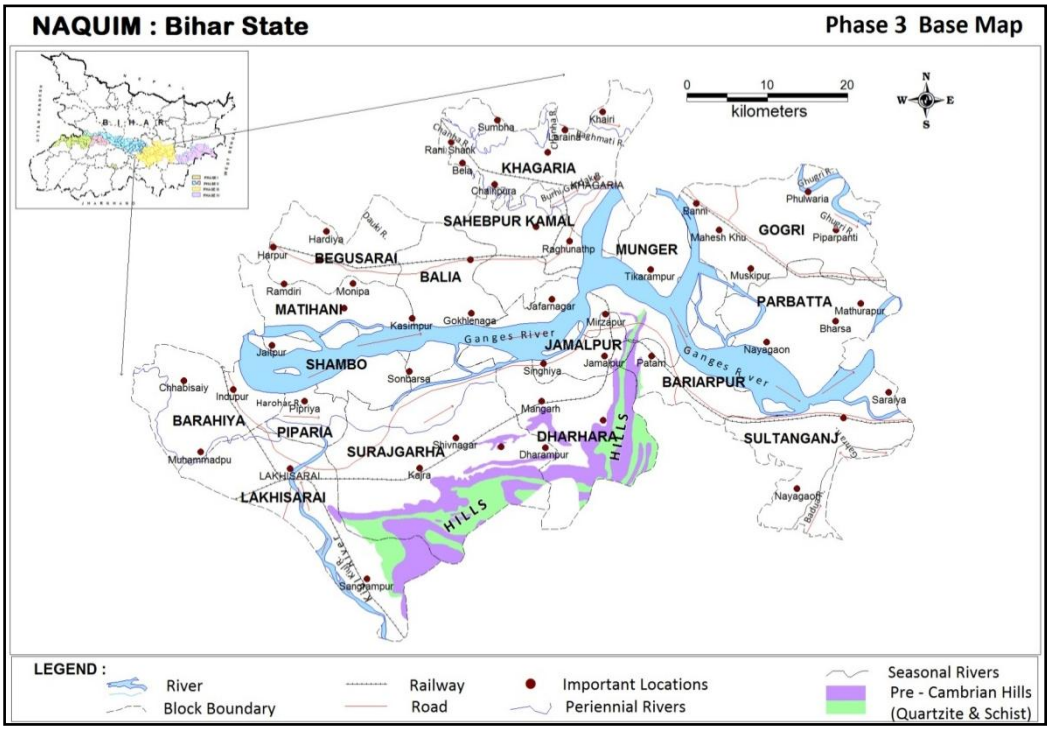


Fig. 1.2 Block-wise Map of NAQUIM Phase III Area

1.2 Approach and Methodology

Work plan for aquifer mapping envisage compilation, integration, validation and analysis of the existing database at one platform with a view to generate various thematic maps like land use and land cover map, geomorphology maps, geology, hydrogeology etc using GIS and geo-scientific softwares. Data were collected from all concerned agencies for preparing the status of data gap. Greater attention was paid on activities that required generation of additional data to fill the identified gap.

1.3 Area Details

NAQUIM Phase III area of Bihar state covers the aquifers in the Ganga stem part and spreads over the districts of Begusarai and Khagaria at the northern bank of Ganges and Bhagalpur, Lakhisarai and Munger districts in the southern banks of the Ganges. A total of 17 blocks have been covered during this phase. The study area spreads over 3473 Sq Kms covering 17 administrative blocks. The area lies between N latitudes 25.6242 and 24.9866 and E longitudes 85.8961 and 86.87772 falling in Survey of India toposheet nos 72G/15, 16, 72/K 3, 4, 6, 7, 8, 10, 11, 12, 14, 15, 16 and 72L/1. The location of the study area is shown in Fig. 1.3. The population density of the study

area is 1088 person per sq. km. The salient demographic details of the administrative blocks falling in the area are given in Table 1.1.

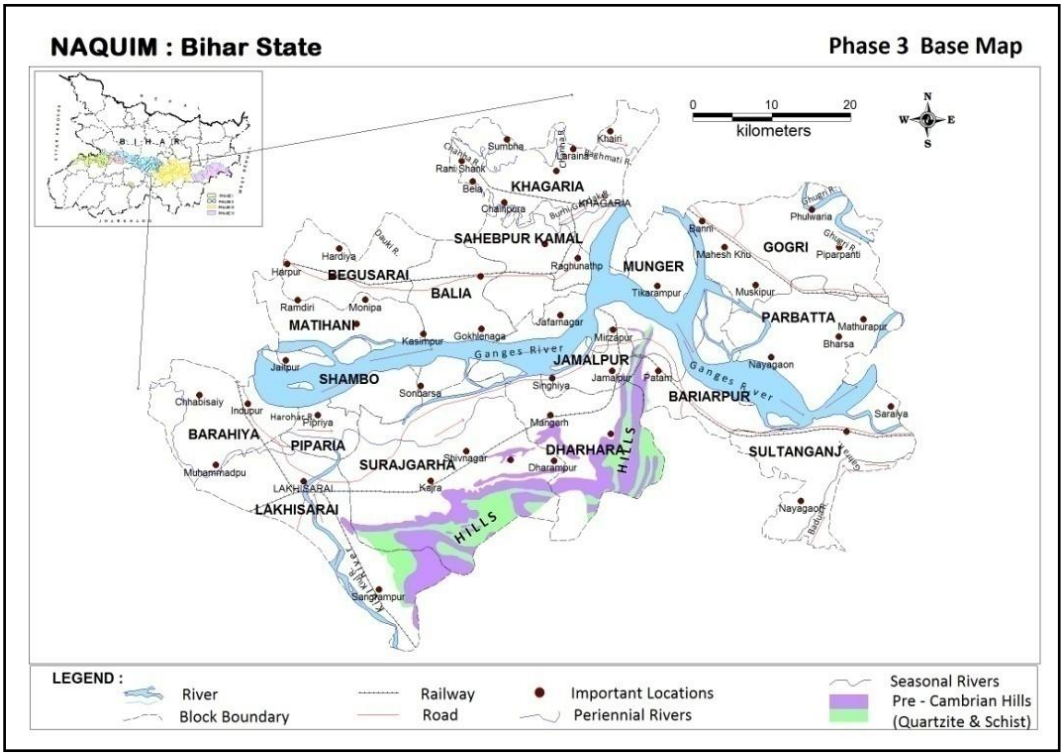


Fig. 1.3: Base Map of the Study Area

Table 1.1 Demographic details of the administrative blocks falling under NAQUIM area

District	Block	Total Area (sq. km.)	Rural Population	Urban Population	Total Population
Begusarai	Balia	149	134628	47550	182178
	Begusarai	222	278625	261384	540009
	Matihani	177	152725	0	152725
	Sahebpur Kamal	144	194172	0	194172
	Shamho	66	30777	0	30777
Bhagalpur	Sultanganj	219	195109	52892	248001
Khagaria	Gogri	250	279017	37753	316770
	Khagaria	262	331952	49406	381358
	Parbatta	241	244066	0	244066
Lakhisarai	Barahiya	241	85945	43032	128977
	Lakhisarai	283	121216	99979	221195
	Piparia	58	51496	0	51496
	Surajgarha	390	290998	0	290998
Munger	Bariarpur	161	104437	4922	109359
	Dharhara	283	131753	0	131753
	Jamalpur	85	102896	105434	208330
	Munger	242	134089	213303	347392

(as per 2011 census)

1.4 Brief Description

NAQUIM phase III area of Bihar stretches from Begusarai in west to Bhagalpur in east covering parts of five districts and 17 blocks. The phase 3 area is traversed by approximately 82 km long stretch of river Ganga forming the axial drainage. The area is characterized by highly fertile alluvial plain. The soil type is loamy to coarse grained. During heavy monsoons, part of the area on the southern bank of the river Ganga gets flooded and remains water logged for months, locally called as *tal* areas.

1.4.1 Data Availability

Central Ground Water Board has carried out hydrogeological surveys and groundwater exploration in the area. Ground water regime monitoring has carried out hydrogeological surveys and groundwater exploration in the area. Ground water regime monitoring is carried out on a regular basis. The data available from the earlier surveys have been compiled and data gap analysis has been carried out for working out the need for additional data generation in the study area.

1.4.2 Data Adequacy and Data Gap Analysis and Data Generation

As per existing data availability data gap analysis was done. On the basis of this data gap analysis, fresh data were generated. All the data gap analysis is done on the basis of area of the blocks under study. Some of the requirement in the area has been reworked considering homogeneity in aquifers for fresh data to be generated (Table 1.2, 1.3, 1.4).

Table 1.2 Water level monitoring data of Phase- III

District	Block	Requirement reworked considering homogeneity in aquifers	Data Availability	Data Gap	Data Generated
Begusarai	Balia	23	2	21	23
	Begusarai				
	Matihani				
	Shamho				
	Sahebpur Kamal				
Bhagalpur	Sultanganj	11	1	10	11
Khagaria	Gogri	18	1	17	18
	Khagaria				
	Parbatta				
Lakhisarai	Barahiya	35	3	32	33
	Lakhisarai				
	Pipariya				
	Surajgarha				
Munger	Bariyarpur	26	4	22	26
	Dharhara				
	Jamalpur				
	Munger				

Table 1.3 Groundwater quality data of Phase- III

District	Block	Requirement reworked considering homogeneity in aquifers	Data Availability	Data Gap	Data Generated
Begusarai	Balia	38	37	01	38
	Begusarai				
	Matihani				
	Shamho				
	Sahebpur Kamal				
Bhagalpur	Sultanganj	9	0	0	09
Khagaria	Gogri	10	11	0	10
	Khagaria				
	Parbatta				
Lakhisarai	Barahiya	34	14	20	34
	Lakhisarai				
	Pipariya				
	Surajgarha				
Munger	Bariyarpur	26	9	15	26
	Dharhara				
	Jamalpur				
	Munger				

Table 1.4 Geophysical data (VES) of Phase- III

District	Block	Requirement reworked considering homogeneity in aquifers	Data Availability	Data Gap	Data Generated
Begusarai	Balia	30	0	30	22
	Begusarai				
	Matihani				
	Shamho				
	Sahebpur Kamal				
Bhagalpur	Sultanganj	8	0	8	1
Khagaria	Gogri	29	0	29	13
	Khagaria				
	Parbatta				
Lakhisarai	Barahiya	31	0	31	0
	Lakhisarai				
	Pipariya				
	Surajgarha				
Munger	Bariyarpur	26	0	26	19
	Dharhara				
	Jamalpur				
	Munger				

1.4.3 Rainfall - Spatial and Temporal Distribution

The area experiences a humid sub-tropical climate. The monsoon season initiates by the third week of June and continues till the end of September. There is slight rainfall in October but November and December are quite dry. The rainy season receives Southwest monsoon and accounts for about 90% of the total rainfall. The area receives an average normal monsoon rainfall of about ~1100 mm/year.

1.4.4 Physiographic Setup

NAQUIM Phase 3 areas cover central part of Bihar State. The area comprises of fertile alluvial plains separated in two parts north and south by river Ganga. The surface for the part located on the northern bank of the River Ganga shows a general slope towards the south-east while for the part located on the southern flank of the Ganges, the general slope is towards north-east. The area has a major part as islands in the course of Ganga River, locally called as *Diyaras*. These diyaras comprises some of the blocks of phase 3 such as Shambo, Matihani, Balia, Khagaria, Munger, Jamalpur, Bariarpur, Parbatta, Sultanganj, Barhaia, Piparia blocks and has good demographic settlements with agriculture as the main occupation. Natural levees occur all along southern bank of river Ganga. In the south of the natural levee system, there is a vast stretch of backwaters known as the *Tal* lands. These *tals* remain submerged from mid June to mid October during monsoon period with a standing water column of 1 to 3 m. After cessation of monsoon, commonly 15th October onwards, when the water level recedes in Ganga River, these *tal areas* drain out their water in to the Ganga River.The area is characterized by extremely fertile flat land which is highly prone to floods during the monsoon season. Annual flood sequence generally deposit silt layer in the area which increase its fertility.

1.4.5 Physiography / DEM

The elevation in the area ranges from 29 to 62m above mean sea level. Broadly the area has flat topography (Fig 1.4).

1.4.6 Geomorphology

Study area forms part of the Middle Ganga Plain and physiographically it represents a monotonous flat topography. The land surface for the part located on the northern bank of the River Ganga shows a general slope towards the south-east while for the part located on the southern flank of the Ganges, the general slope is towards north-east.The area is drained by rivers Ganga, Gandak and their tributaries (Fig. 1.4).The west-east flow of the River Ganga forms the axial drainage of the area. The River Ganga forms the levee or upland all along its southern bank. In the south of the natural levee of the Ganga, there is a vast stretch of backwaters known as the *Tal* lands.

The area is characterized by fertile flat land which is highly prone to floods during the monsoon season. This is due to silt deposited from the river Ganges almost every year. The alluvium deposits covering the entire region are of Quaternary period. The geomorphological map of the area (based on NRSA) is produced in Fig. 1.5.

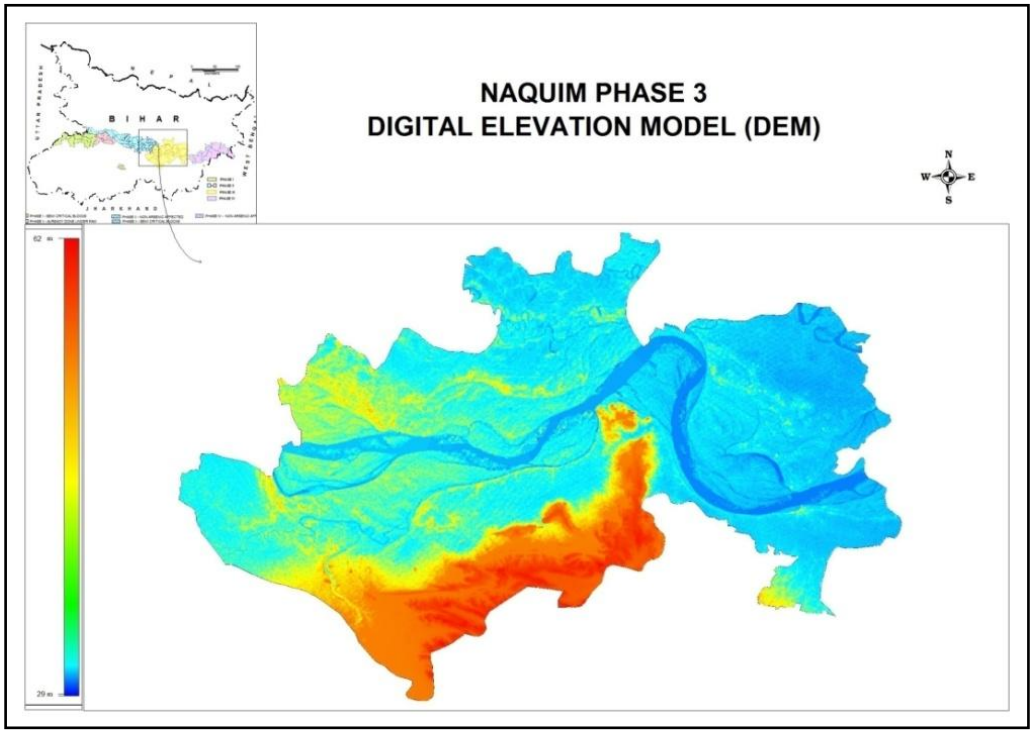


Fig. 1.4 Digital Elevation Model (DEM) of the Study Area

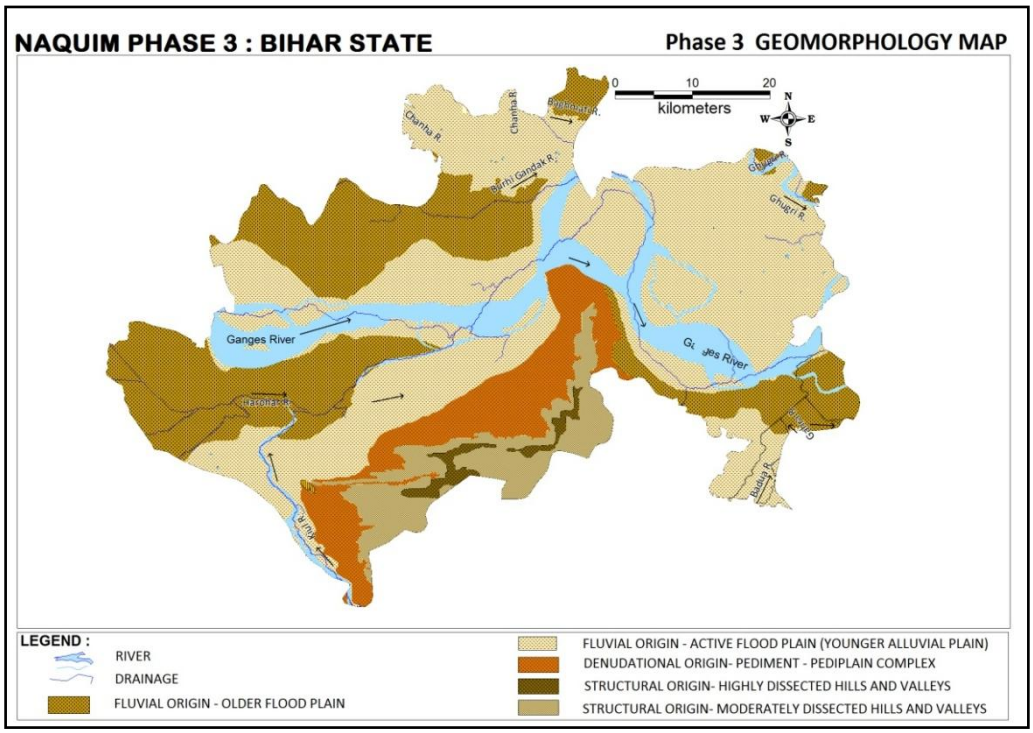


Fig. 1.5 Geomorphological Map

1.4.7 Land-use Pattern

Land use and land cover have direct linkage to the water demand of any area. Majority of land use statistics were collected from the reports of the Agriculture Department, Government of Bihar (2009), provides district wise information. Total geographical area of Begusarai, Khagaria, Lakhisarai, Munger and Bhagalpur district is 8,59,865 hectares, out of which net sown area is 4,37,725 hectares. The net sown area constitutes nearly 51% of the total geographical area. The principal source of assured irrigation is by wells and tube wells, which together account for about 90% of the total irrigation. The cropping intensity of the five districts as a whole has been found to be 132.58%, however, Begusarai and Khagaria districts have higher cropping intensity of 147 and 140 % respectively (Table 1.5). During the study, the land-use land cover map of the area falling under Phase 3 has been prepared based on the NRSA data. The land-use land-cover map based on the NRSA data is produced as under in Fig. 1.6.

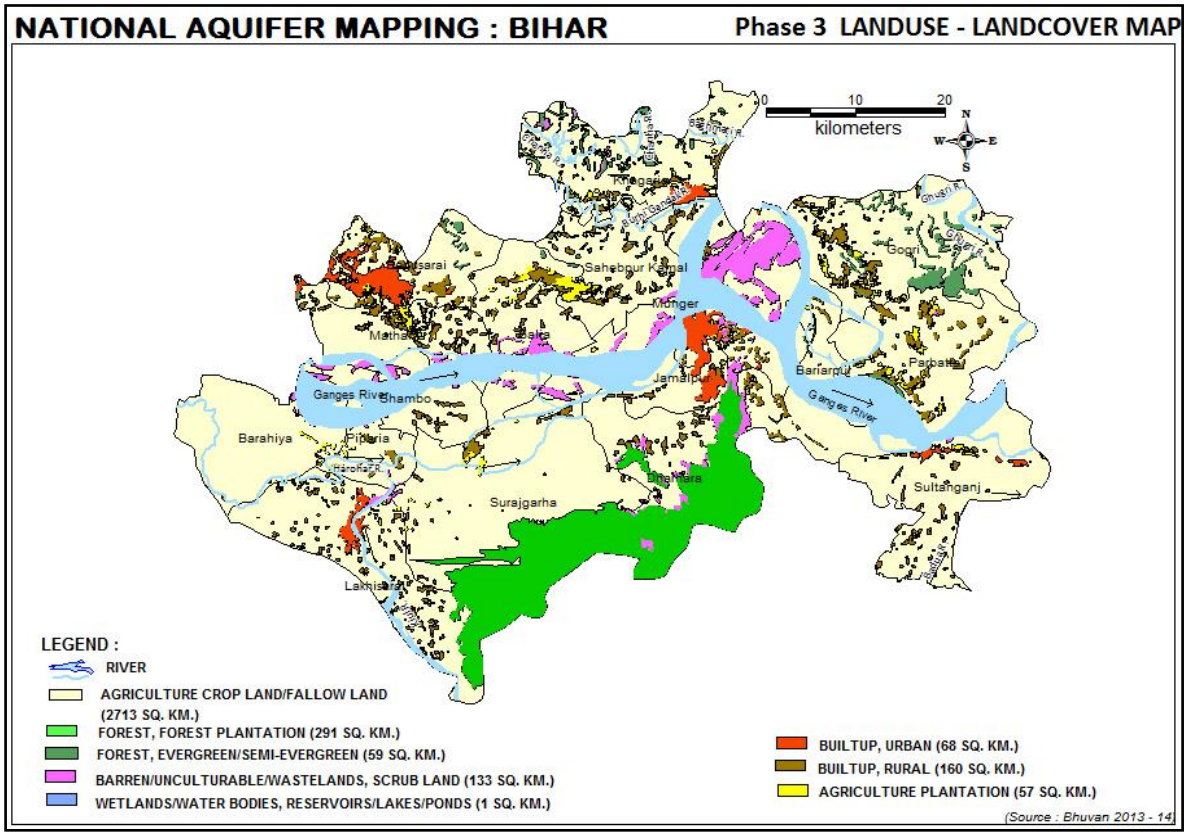


Fig. 1.6 Land-use & Land-cover Map

1.4.8 Soil

Area falling on the north of the River Ganga covering Begusarai and Khagaria districts, falls under the Agro-climatic zone I and II and is characterised by sandy loam, loam and clay loam soils with pH range of 6.5-8.4. The areas on the south bank of River Ganga covering Lakhisarai, Munger and Bhagalpur district falls under the agroclimatic zone IIIA and is characterised by sandy loam, clay loam, loam and clayey soil with pH range of 6.8 - 8. The soils under the influence of Burhi Gandak river are mostly calcareous having different amount of lime content in them. The soils in general, except those of the *diara* lands and *Tal* lands, are moderately well drained to somewhat poorly drained.

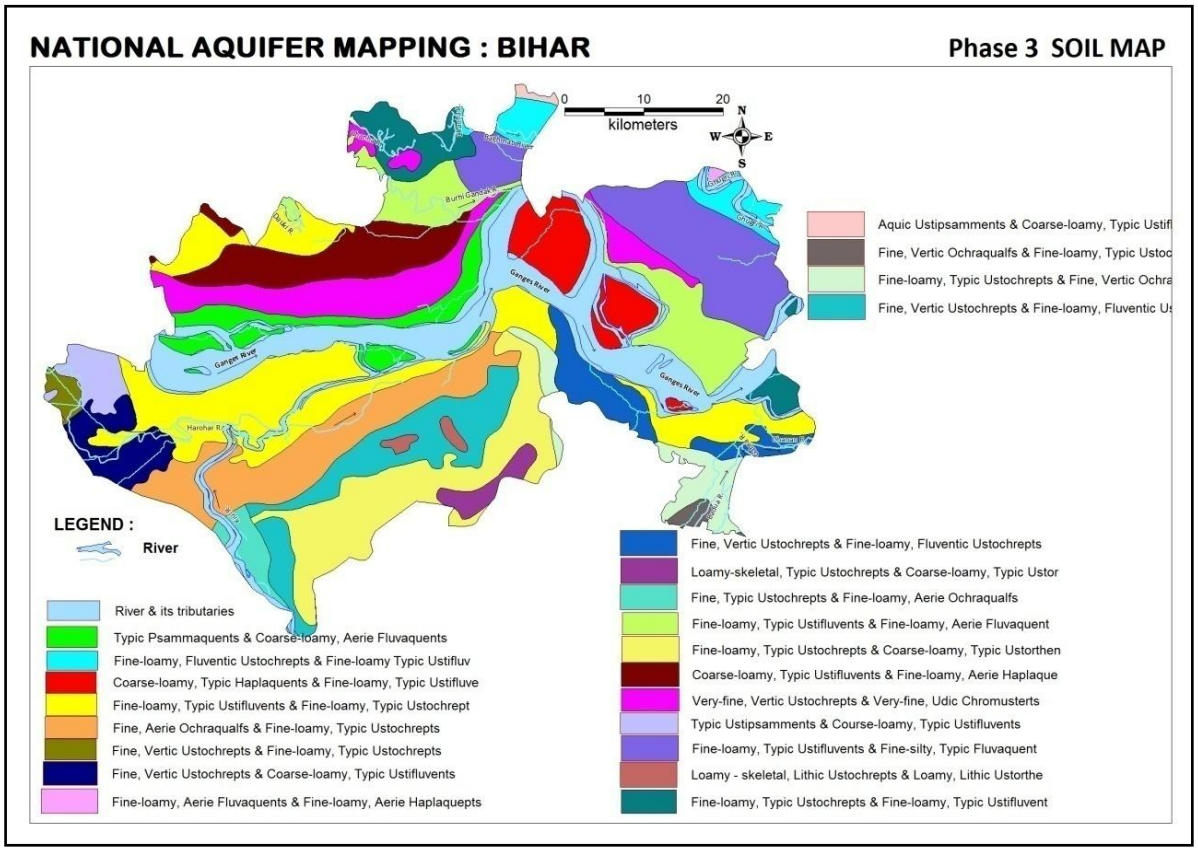


Fig. 1.7 Soil Map of the Study Area

Table 1.5 Block-wise Land-use Land-cover Data (in Sq. km.)

District	Block	Area	Net Cropped Area	Cropping Intensity	Gross Cropped Area	Irrigation Intensity	Gross Irrigated Area	Dependency on GW Irrigation
Begusarai	Ballia	149	105.80	147.47%	156.03	60.99%	95.16	99%
	Begusarai	222	129.08		190.36		116.10	
	Matihani	177	125.86		185.61		113.20	
	Sahebpur Kamal	144	102.80		151.59		92.46	
	Shambo	66	51.23		75.55		46.08	
Bhagalpur	Sultanganj	219	153.67	125.00%	192.09	27.45%	52.73	92%
Khagaria	Gogri	250	168.97	140.77%	237.86	63.31%	150.59	100%
	Khagaria	262	173.28		243.93		154.43	
	Parbatta	241	170.35		239.80		151.82	
Lakhisarai	Barahiya	241	177.45	136.52%	242.26	28.70%	69.53	75%
	Lakhisarai	283	165.70		226.21		64.92	
	Piparia	58	40.88		55.80		16.02	
	Surajgarha	390	208.01		283.97		81.50	
Munger	Bariarpur	161	85.80	113.15%	97.08	17.47%	16.96	50%
	Dharhara	283	71.51		80.92		14.14	
	Jamalpur	85	41.19		46.61		8.14	
	Munger	242	100.41		113.61		19.85	

(*Source: Bihar Statistical Hand Book, 2014*)

Table 1.6: Land-use pattern of districts under Phase III (*in hectares)*

Sl. No.	Name of District	Geograp-hical Area	Forest Area	Land put to Non-agriculturable use				Barren Uncultur-able Area	Permanent Pastures & Grazing Land	Land under Misc. Tree crop& Groves not included in net area sown	Culturable Waste Land	Fallow Land			Total Non-Agricult ural Land	Net Sown Area (3-16)	Total Cropped Area	Area Sown more than once
				Land Area	Water		Total (5+ 6+7)					Other Fallow Land	Current Fallow land	Total				
					Parenial	Temporary												
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
1	**Begusarai**	187828	0	29890	7668	3959	41517	17961	15	3651	40	852	6489	7341	70525	117303	179056	61753
2	**Bhagalpur**	254300	78	53849	6564	9690	70103	22403	632	6705	2284	4979	20806	25785	127990	126310	157887	31577
3	**Lakhisarai**	128602	13445	8742	1200	4611	14553	7009	54	298	705	6351	31627	37978	74042	54560	81726	27166
4	**Khagaria**	149342	0	18990	7715	4243	30948	13593	219	3064	629	2219	6175	8394	56847	92495	130606	38111
5	**Munger**	139793	28524	20380	5836	5225	31441	11436	203	572	944	1953	17663	19616	92736	47057	58781	11724
	Total	**859865**	**42047**	**131851**	**28983**	**27728**	**188562**	**72402**	**1123**	**14290**	**4602**	**16354**	**82760**	**99114**	**422140**	**437725**	**608056**	**170331**

Source: Directorate of Statistics Evaluation

1.4.9 Hydrology and Drainage

Ganga River forms the main drainage of the area. River Budhi Gandak flowing from north meets River Ganga in the western part of the study area. Part of study area in Begusarai district falls in the *doab* region between the Ganga and the Burhi - Gandak. The other rivers in the area are the Baghmati flowing in NW direction, Ghugri in NE, Kiul, Harohar and Sakri in SW and Channan in SE direction. Marshes and swamps locally known as *Chaurs* are common in the area. The general slope of the land is towards south east and the rivers on reaching Ganga traverse eastward for a long distance before they meet river Ganga. The area is full of streams with abandoned dead channels of Kosi river, which changes course frequently forming small lakes and shallow marshes.

1.4.10 Agriculture

Agriculture is the mainstay of the population in the area. The northern part (located on the northern bank of the River Ganga) of the area falling in Begusarai and Khagaria districts fall in the Agroclimatic zone I & II while the southern part (located south of the River Ganga) falls in the agroclimatic zone IIIA. The cropping pattern of the Zone I, II and IIIA is discussed under the head cropping patterns.

1.4.11 Irrigation

Tube well is the main source of irrigation in the area. Irrigation through tubewell accounts for more than 97% of the total irrigated area in Begusarai and Khagaria districts.

1.4.12 Cropping Patterns

Begusarai and Khagaria on the northern bank of river Ganga falls under the Agroclimatic Zone I & II and Lakhisarai, Munger and Bhagalpur district, located on south of the River Ganga, falls under Agroclimatic Zone III. The following cropping sequence is commonly practised in those areas.

Zone – I: Rice – Wheat, Rice – Rai, Rice – Sweet Potato, Rice – Maize (Rabi), Maize – Wheat, Maize – Sweet Potato, Maize – Rai, Rice – Lentil, Rice-linseed;

Zone – II: Rice – Wheat – Moong;

Zone – III: Rice – Wheat, Rice – Gram, Rice – Lentil, Rice – Rai

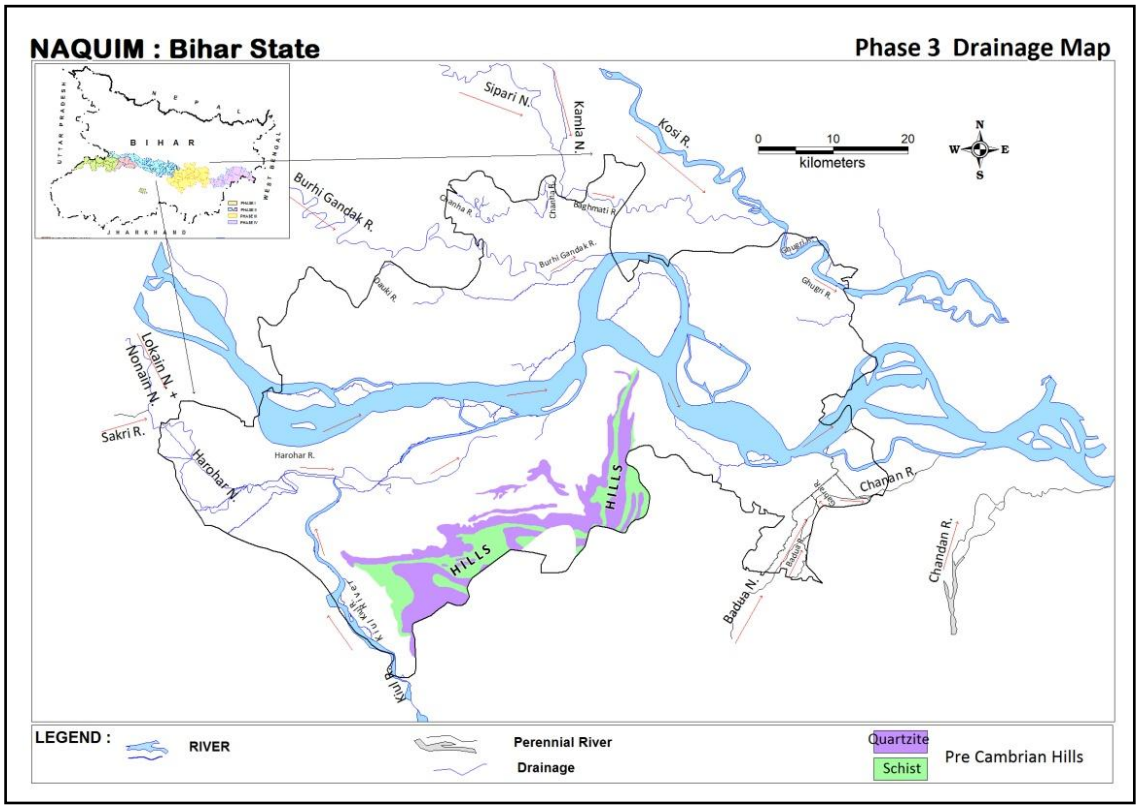


Fig. 1.8 Drainage Map of the Study Area

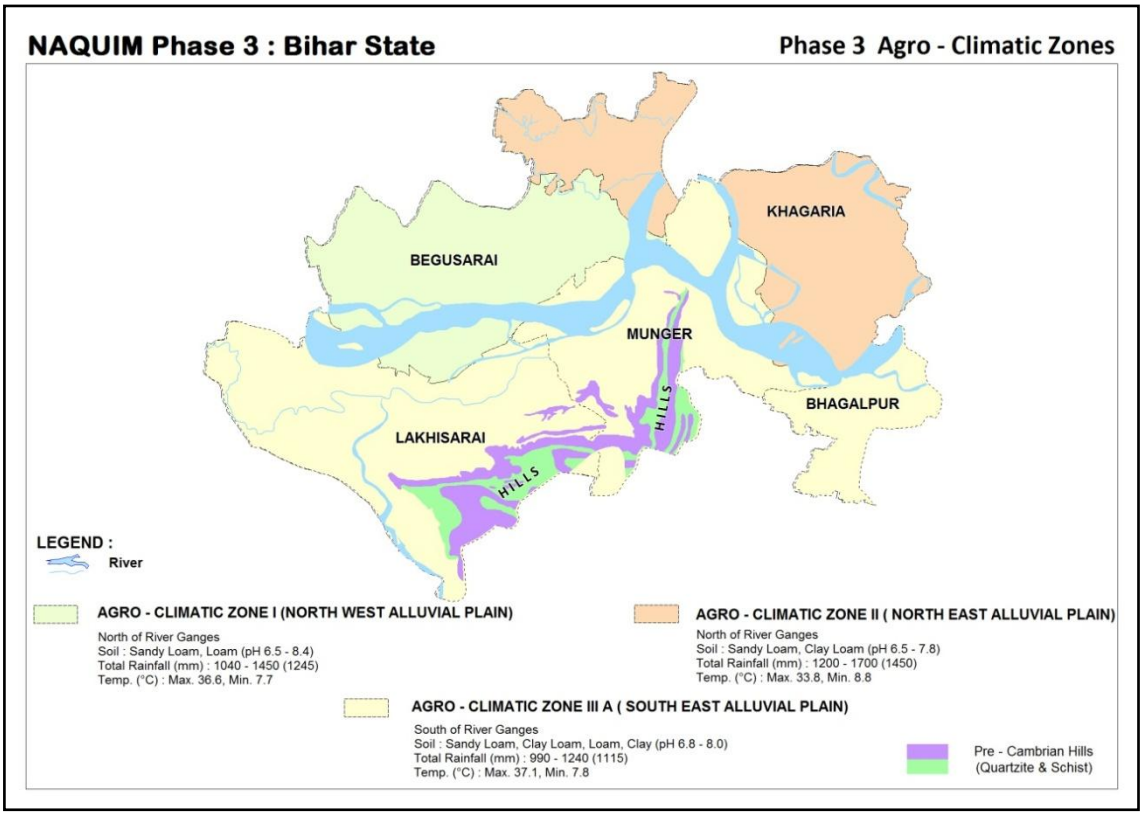


Fig. 1.9 Agro-climatic Map of the Study Area

1.4.13 Prevailing Water Conservation / Recharge Practices

A large part of the area remains seasonally water logged. In the northern part of the Ganga, these areas are locally known as *Chaurs* and remain seasonally water logged from July to February. In the south part on the natural levee of the Ganga, there is a vast stretch of backwaters known as the *Tal* lands. These *tals* remain submerged under 1 to 3 m of water column from mid June to mid October during monsoon period. These water bodies act as indirect sources of ground water recharge in the area.

1.5 Climate

Climate records available from the IMD database indicate that the area enjoys a typical subtropical climate. The summer season in the area begins from the middle of March when hot westerly winds, locally called as *Loo*, begins to blow during the day. The months of April and May are hottest with peak summer temperatures shooting up to 44 – 45°C. The summer season continues up to mid June. The winter season begins from November month and lasts till the beginning of March. January is the coldest month when the temperature comes down to as low as 4-5˚C. The monsoon season initiates by the third week of June and continues till the end of September. There is slight rainfall in October but November and December are quite dry. The rainy season receives Southwest monsoon and accounts for about 90% of the total rainfall. The area receives an average normal monsoon rainfall of about 1100 mm/year.

1.6 Geology

The area forms a part of the Gangetic plain underlain by immensely thick alluvial deposits comprising sediments (sand, gravel and clay) of Quaternary age deposited unconformably over the Precambrian basement. The alluvial deposits are characteristically divided into *Older and Younger Alluvium.*

Younger Alluvium: The Younger Alluvium is in general light coloured and poor in calcareous matter. It contains lenticular beds of sand and gravel and peat beds. The geological map of the area is shown in the Fig. 1.9.

Older Alluvium: The Older Alluvium (called *Bhangar* in the Ganges valley) forms slightly elevated terraces, generally above the flood level. These are dark coloured and in general are rich in concretion and nodules of impure calcium carbonate, locally known known as '*kankar*', of various shapes and sizes.

The southernmost part of phase 3 area is represented by rocky upland with ridges and ravines. Quartzite and Schist comprise the uplands. Areas under Phase III are located in the axial part

of Middle Ganga Plain occupying the central part of the Ganga Basin. The Ganga basin is an active foreland basin formed in response to the uplift of Himalaya due to collision of the Indian and the Asian plate. The Middle Ganga Plain lies between the Munger-Saharsa ridge in the east and Faizabad ridge in the west exhibiting an asymmetrical sediment wedge, with thickness varying from less than a meter in basin margin areas with Peninsular craton to more than 5 km near the Himalayan orogen. The area forms a part of the Gangetic plains underlain by immensely thick alluvial deposits. Delineation of aquifer geometry based on the available data reveals presence of a thick pile of alluvial sediments of Quaternary age comprising various grades of clay, silt and sand which constitutes the ground water reservoir.

The sands brought and deposited by the Ganga are grey, micaceous and rich in ferromagnesian minerals and occupy the topmost horizon along the course of the river up to a few kilometres south of it constituting the newer alluvium consisting of clay, kankars, fine to coarse grained sands, gravels and pebbles at depths.

1.7 Sub-Surface Lithological Information

Assessment of the subsurface configuration of aquifer, based on the available data, reveals presence of a thick pile of alluvial sediments of Quaternary age comprising various grades of clay, silt and sand. A pervasive layer of clay mixed sand constitutes the top of the succession.

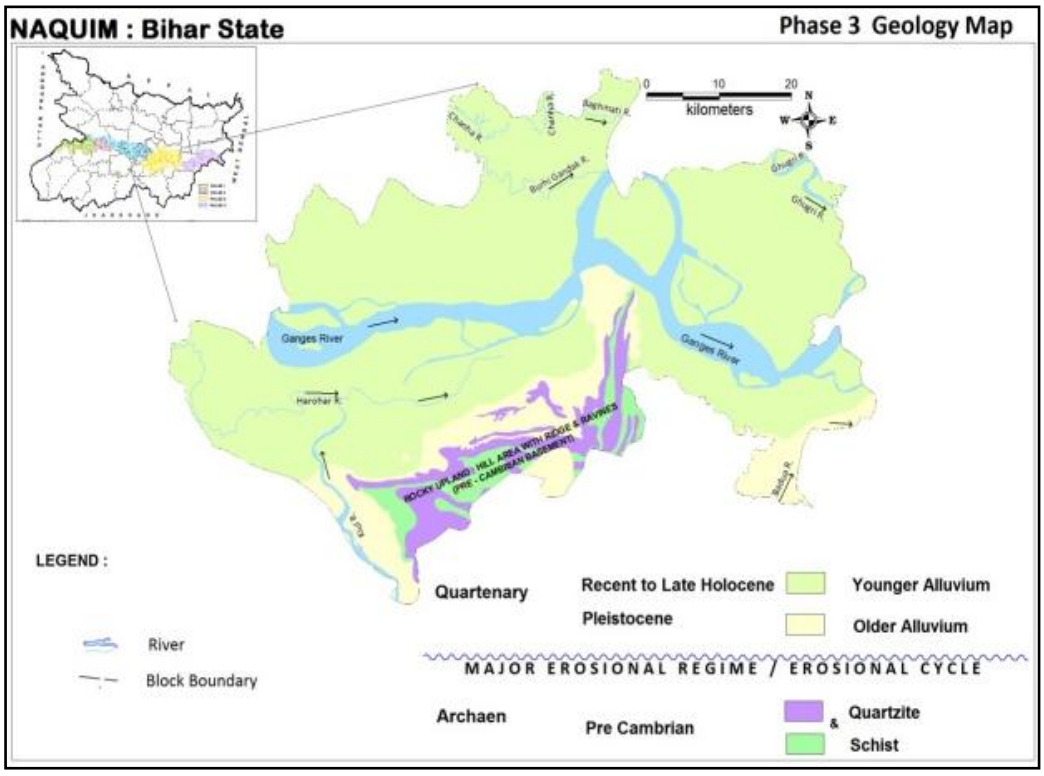


Fig. 1.9 Geological Map of the Area *(Source: GSI)*

CHAPTER - II

DATA COLLECTION AND GENERATION

2.1 Hydrogeology

NAQUIM Phase III area forms a part of the Gangetic plains which are underlain by immensely thick alluvial deposits. Assessment of the subsurface configuration of aquifer, based on the available data, reveals presence of a thick pile of alluvial sediments of Quaternary age comprising various grades of clay, silt and sand. A pervasive layer of clay mixed sand constitutes the top of the succession. The presence of kankar and fine sand makes this clay layer semi pervious. The area is characterized by occurrence of fairly thick sands of various grades forming prolific aquifers.

Available data indicate presence of two aquifer system up to 200 mbgl The deeper aquifer is made up of fine to medium grained sand often grading to gravelly sand at the bottom. The northern part of Ganga river is having thick clay layer at the bottom whereas southern part of the Ganga river is underlain by a Pre Cambrian basement.

2.1.1 Water Level, Pumping Tests

Water Level

Ground water monitoring had been carried out at 102 locations in the area in the year 2015-16 & 2016-17 (**Annexure - I**).The depth to water level representing the phreatic aquifer has been prepared for pre and post monsoon season. DTWL map of the area shows that majority of the area has water level of 5 – 10 m bgl in pre monsoon and 2 – 5 m bgl in post monsoon. In some parts, the water level is confined to 2 – 5 m bgl both in pre and post monsoon.The water level in fewareas ofMatihani, Balia, Sahebpur Kamal and Lakhisarai block recedes to more than 10 m bgl in pre monsson season whereas in post monsoon it is confined to 2 – 5 m bgl. The depth to water level map of the study area for the pre-and post-monsoon period is given below.

Pumping tests

Pumping test data of CGWB wells (Table 2.1) indicates that the transmissivity value of the aquifer is found to be 698 m^3/day. The storativity has been found to be 4.5 x 10^{-4} indicating that the deeper aquifer remains in semi-confined to confined condition.

Table 2.1: CGWB Exploratory Well Details

Sl. No.	Location	Block	Depth Drilled (mbgl)	Depth range of tapped Granular zones (m)	Discharge (m3/hr)	Draw-down (m)	Transmissivity (m3/day)	Storativity
1	**HERU DIARA/ MUNGER SADAR**	**Munger**	116.95	57.6-061.6, 63.6-075.6, 90.6-091.6, 96.8-099.8, 105.9-109.0, 111.0-114.0	160.7	8.33	697.88	$4.5X10^{-4}$
2	**BARIARPUR**	**Bariarpur**	126.5	-	10	-	-	-
4	**SOJHIGHAT HOSPITAL**	**Munger**	88	-	77.4	-	-	-
5	**KABIRMATH KHAIRA**	**Munger**	99.1	-	-	-	-	-
6	**ASHOKDHAM/ Lakhisara**	**Lakhisarai**	116.6	-	120	-	-	-
7	**GUNSAGAR**	**Lakhisarai**	119.75	-	15.84	12.05	13.1	

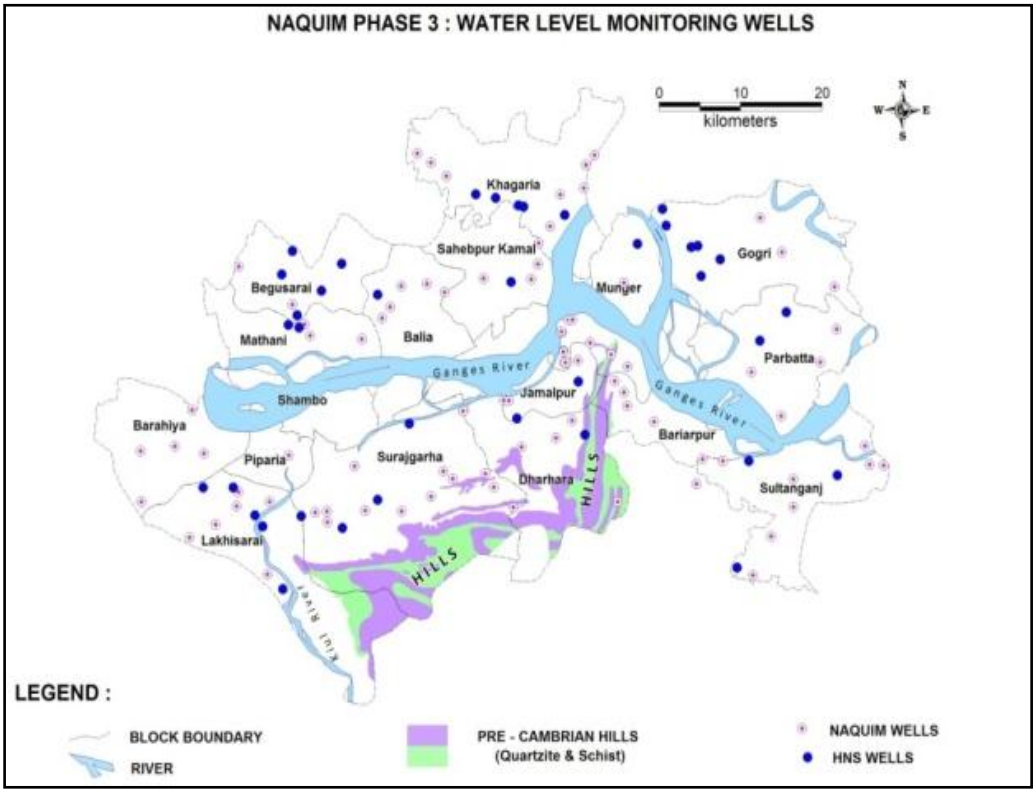
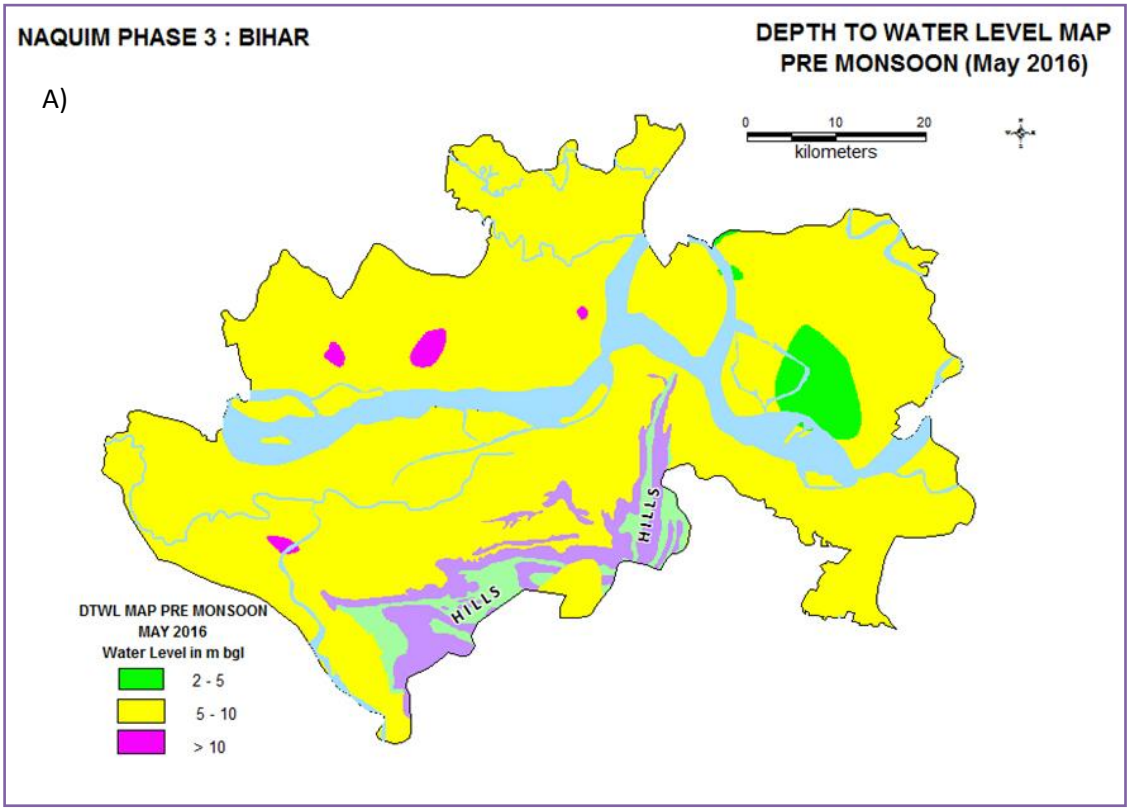


Fig. 2.1 Locations of Water Level Monitoring Stations



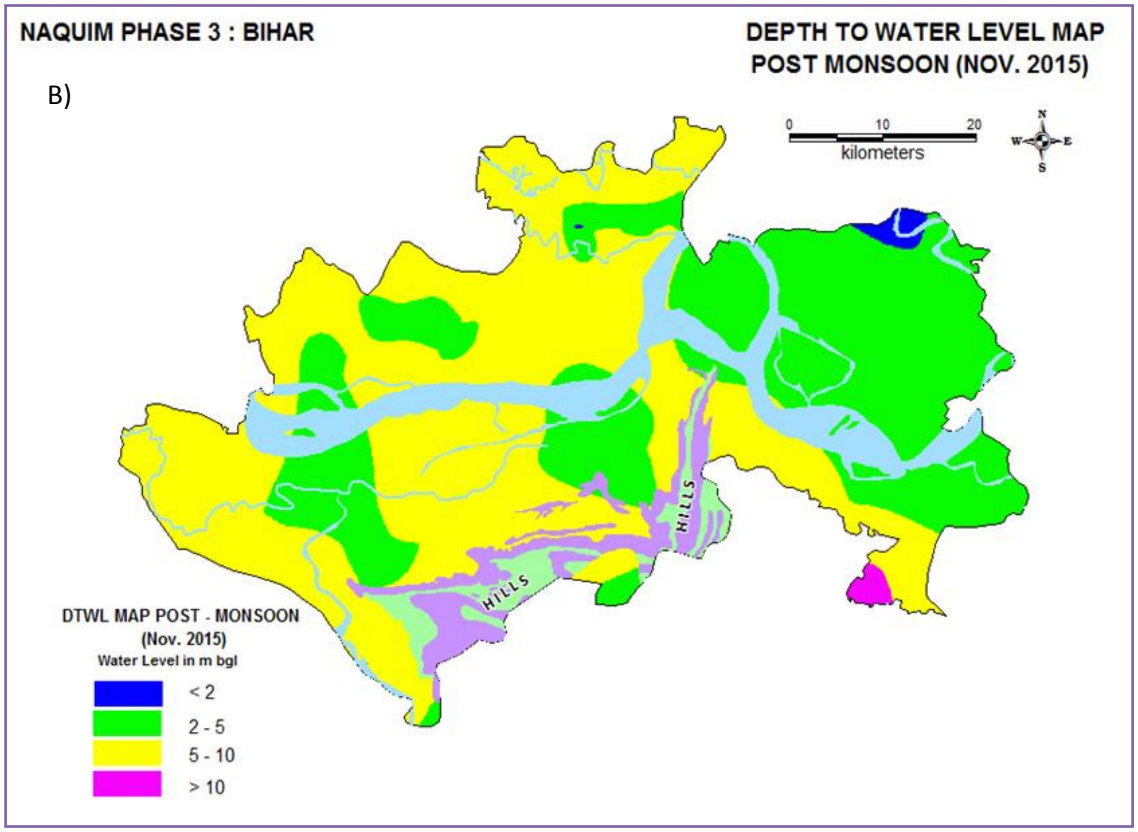


Fig 2.2 Depth to water level Maps A) Pre-monsoon (May, 2016), and B) Post-monsoon (Nov., 2015)

2.2 Hydrogeochemical Investigation

2.2.1 Water Quality Sampling, Number of Samples and Analysis Mechanism

Groundwater quality of an area is a function of physical and chemical parameters that are greatly influenced by geological formations and anthropogenic activities. Quality of ground water is as much demanding as its quantity. Suitability of ground water for drinking and irrigational purpose is important for its safe and effective use. The state of Bihar is mainly dependent on ground water for the domestic and irrigation demand. The pressure on ground water is considerable to meet urban and rural water requirements as well as the irrigation requirements in the semi-urban and rural areas. The concentration of the major ions and other dissolved ions in ground water are function of the availability of the constituents in the aquifer matrices and their solubility. Rocks, through which water circulate, are composed of minerals and amorphous solids, which in turn are composed of chemical elements that greatly affect the ground water quality.

To study the groundwater chemistry of different aquifer present in the area, a total no. of 119 groundwater samples were collected from different aquifers during different time periods for analysis of major parameters. Water samples were collected and stored in 01 litre capacity clean plastic bottles. Before collection of samples, bottles were properly washed and were rinsed by the water to be sampled. The tubewells were pumped for sufficient duration before collecting ground water sample so that the stagnant water, if any, is completely removed from storage within the well assembly.

These water samples were analysed in chemical laboratory of CGWB MER-Patna, and PHED, Govt. of Bihar. Besides these, available historical data of chemical analysis of ground water were also studied to have an understanding of ground water chemistry of the area. Analytical results of ground water samples are given in **Annexure II**.

Classification of Groundwater

In order to understand the chemical characteristics of the groundwater in the study area, analytical results were plotted in Piper trilinear diagram (Piper 1944), USSL, Durov and Ludwig Langelier plot using AquaChem software (Fig. 2.3). Plot on Piper diagram show that groundwater of the area may be classified in to various chemical types. The dominant water types are of Ca-Mg-HCO_3. The Ca–Mg-HCO_3 water is primarily a result of dissolution of carbonate minerals, and the origin of water is mainly due to rainfall-derived recharge, whereby surface water charged with atmospheric and biogenic CO_2 infiltrates into the subsurface. Few of the samples are rich in Na-K which may be due to usage of fertilizers. Low Cl & SO_4 content indicate low residence time. Mixed Ca-Mg-Cl and Ca-Na-HCO_3 water type indicate mineral dissolution and recharge of fresh water. NaCl water type

suggest the mixing of high salinity water caused from surface contamination sources such as irrigation return flow, domestic waste water, and septic tank effluents, with existing water followed by ion exchange reactions. 62% of the sample indicates Ca-HCO_3 type, 17% are Mixed Ca-Mg-Cl type, 16% sample show mixed Ca-Na-HCO_3 type and 5% are NaCl type water. It indicates that groundwater of the study area is suitable for drinking purposes based on major element geochemistry. USSL diagram (Fig. 2.3 D) indicates that groundwater of the study area is suitable for irrigation purposes. However, salinity problem in the area is moderate to high.

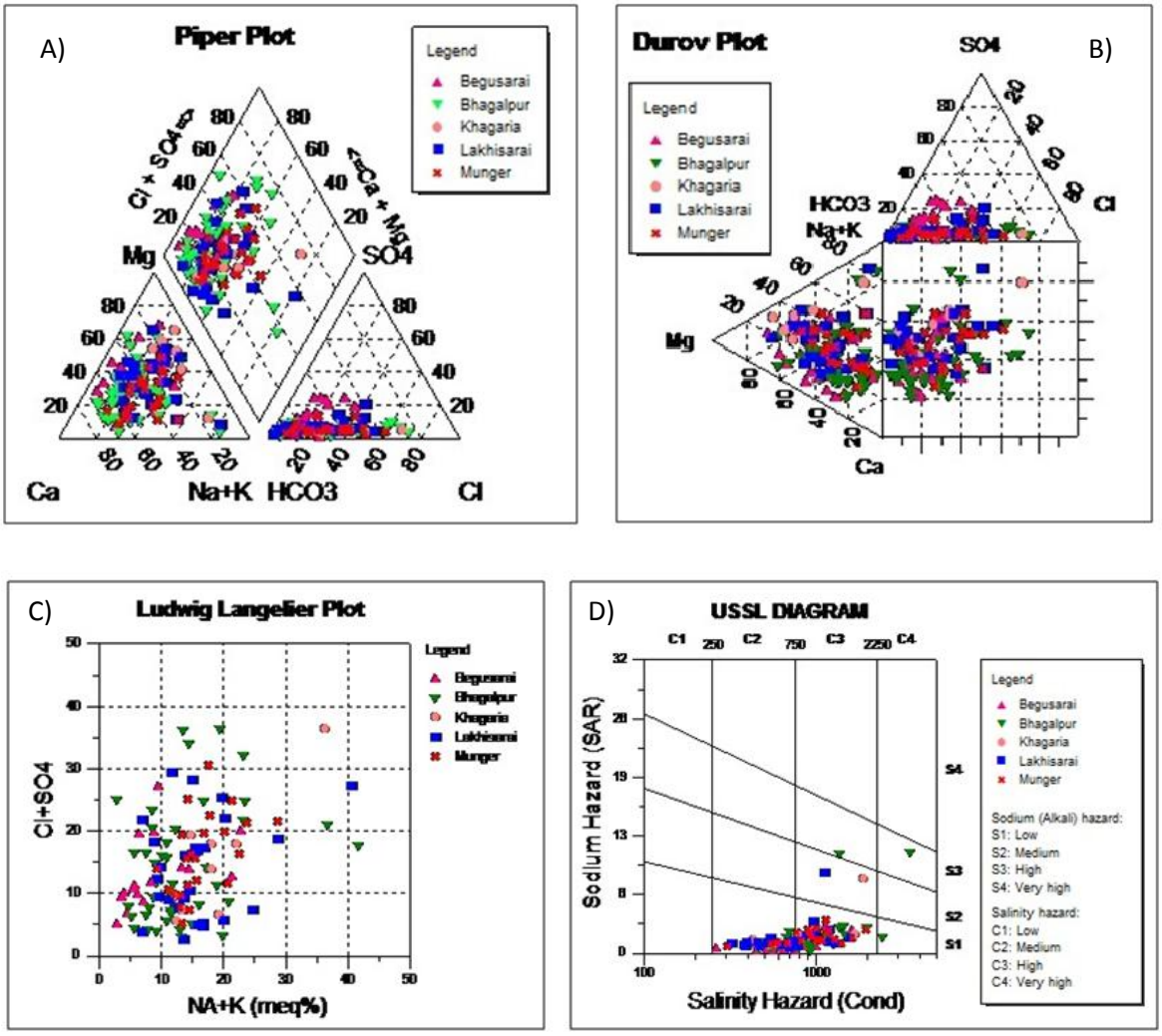


Fig. 2.3 Geochemical plots A) Piper, B) Durov, C) Ludwig Langelier and D) USSL of analysed Groundwater Samples

Ground Water Quality Problem in the Watershed

Major ground water quality problem of the study area was high arsenic (As) level (>50 ppb), which is greater than the permissible limit considered for drinking water as reported by PHED, Govt. of Bihar and through analysis of Ground water sample by CGWB from the area. Arsenic concentrations of the study area are given in **Annexure - IIIA & B**.

2.3 Geophysical Investigation

2.3.1 Location, Number, Analytical Techniques

Fifty four (54) surface electrical resistivity investigation (VES) were carried out by CGWB within the study area. The field data were interpreted with the help of empirical curves (Master curves) based on curve matching technique and computer based software. On the basis of interpreted results, geoelectrical sections have been prepared and vertical and horizontal disposition of granular zones of various grades are analysed within the investigated area.

Surface geophysical survey:

A total of 54 VES sounding were carried out within the aquifer mapping area. The VES were performed in the field and the data were interpreted with computer and manual processes.

Instruments used

During the surface resistivity investigation a CRM Auto C resistivity meter (manufactured by Anvic Systems, India) was used. The instrument measures potential differences between two potential electrodes when current is sent through two current electrodes and there by apparent resistivity is calculated automatically by the instrument.

All the curves are interpreted with the help of partial curve matching technique and also by the resistivity sounding interpretation software. The interpreted data is correlated with the available borehole information near by the survey area and utilised resistivity range with respect to lithology is given below. Interpreted VES results are tabulated in **Annexure-VI**.

Table 2.2: Resistivity range and lithology

Resistivity Range (Ω-m)	Lithology
9 -15	Clay
14-30	Sand mixed with little Clay
16 -25	Fine Sand
30 -50	Medium to Coarse Sand
60-200	Coarse Sand mixed with Gravel / Kankar
200-500	Unsaturated Sand

Ω-m = ohm metre

2.4 Exploratory Drilling - State Govt., CGWB and Private Wells

2.4.1 Number, Location, Depths, Well Design

Sub-surface lithological information (down to 200 mbgl) from the available drilling records of exploratory well of CGWB have been tabulated in Table 2.2A. Location of CGWB exploratory wells are given in Fig. 2.4. Corresponding lithologs are given in **Annexure - V**.

Table 2.2A Location Details of Wells Drilled by CGWB

Sl. No.	Location/Block	Longitude	Latitude	Depth Drilled (mbgl)
1	Herudiara / Munger Sadar	86.4747	25.3619	116.95
2	Bariarpur	86.5427	25.3052	126.5
3	Kasturba Waterworks	86.477	25.3731	69
4	Sojhighat Hospital	86.4658	25.3764	88
5	Kabirmath Khaira	86.4853	25.3875	99.1
6	Ashokdham / Lakhisara	86.0125	25.2047	116.6
7	Gunsagar	86.174	25.0643	119.75
8	Akbarnagar	86.83333	25.23333	177

In addition to the CGWB data, lithologs of 28 borewells from other sources have also been collected, the locations details of which are given in Table 2.2B. The lithologs of these wells are given in **Annexure-VI**. These lithologs are available mainly up to 100m except few (Akbarnagar, Asarganj, Bachhauta, Bhadas, Jahangira, Mahesi, Police Training Centre, Rasonk, Sultanganj and Tetrabad) and hence providing most of the lithological information up to 100m bgl only.

Table 2.2B Details of Wells Drilled by Agencies other than CGWB

Sl. No.	Location	Block	District	Longitude	Latitude	Depth Drilled (m bgl)
1	Akbarnagar	Sultanganj	Bhagalpur	86.83333	25.23333	177
2	Asarganj	Sultanganj	Bhagalpur	86.68333	25.13333	115.5
3	Babhan Gawan	Khagaria	Khagaria	86.39300	25.54570	85.4
4	Bachhauta	Khagaria	Khagaria	86.45610	25.54260	103.7
5	Bhadas	Khagaria	Khagaria	86.42970	25.55150	135.4
6	Darhi	Khagaria	Khagaria	86.41740	25.51170	85.4
7	Daulatpur	Jamalpur	Munger	86.49540	25.32530	24.5
8	Dumaria	Parbatta	Khagaria	86.69380	25.30200	69.81
9	Fatehpur	Gogri	Khagaria	86.67890	25.39960	79.57
10	Harinmar	Parbatta	Khagaria	86.61280	25.38490	94.51
11	Inglish Timarpur	Parbatta	Khagaria	86.67390	25.35810	97.56
12	Jahangira	Khagaria	Khagaria	86.36870	25.52070	128.35

Sl. No.	Location	Block	District	Longitude	Latitude	Depth Drilled (m bgl)
13	Jhajhra	Parbatta	Khagaria	86.77070	25.39470	91.46
14	Mahesi	Sultanganj	Bhagalpur	86.80000	25.25000	198.4
15	Malia	Gogri	Khagaria	86.67870	25.42130	79.3
16	Marar	Khagaria	Khagaria	86.50520	25.59090	97.6
17	Mehsauri	Khagaria	Khagaria	86.50880	25.53030	95
18	Nayagaon	Parbatta	Khagaria	86.69490	25.32820	83
19	Pairdominia	Sultanganj	Bhagalpur	86.84583	25.22273	101
20	Police training centre	Bariarpur	Munger	86.60694	25.27267	147
21	Rahimpur	Parbatta	Khagaria	86.69160	25.31500	80
22	Rasonk	Khagaria	Khagaria	86.50140	25.55910	141
23	Ratan	Gogri	Khagaria	86.64240	25.44500	91.8
24	Saurh	Parbatta	Khagaria	86.81480	25.31920	85.36
25	Sher Chakla	Gogri	Khagaria	86.70700	25.38780	91.5
26	Sondiha	Gogri	Khagaria	86.73030	25.40150	91.46
27	Sultanganj	Sultanganj	Bhagalpur	86.74333	25.24028	157.95
28	Tetarabad	Khagaria	Khagaria	86.36200	25.49580	103.7

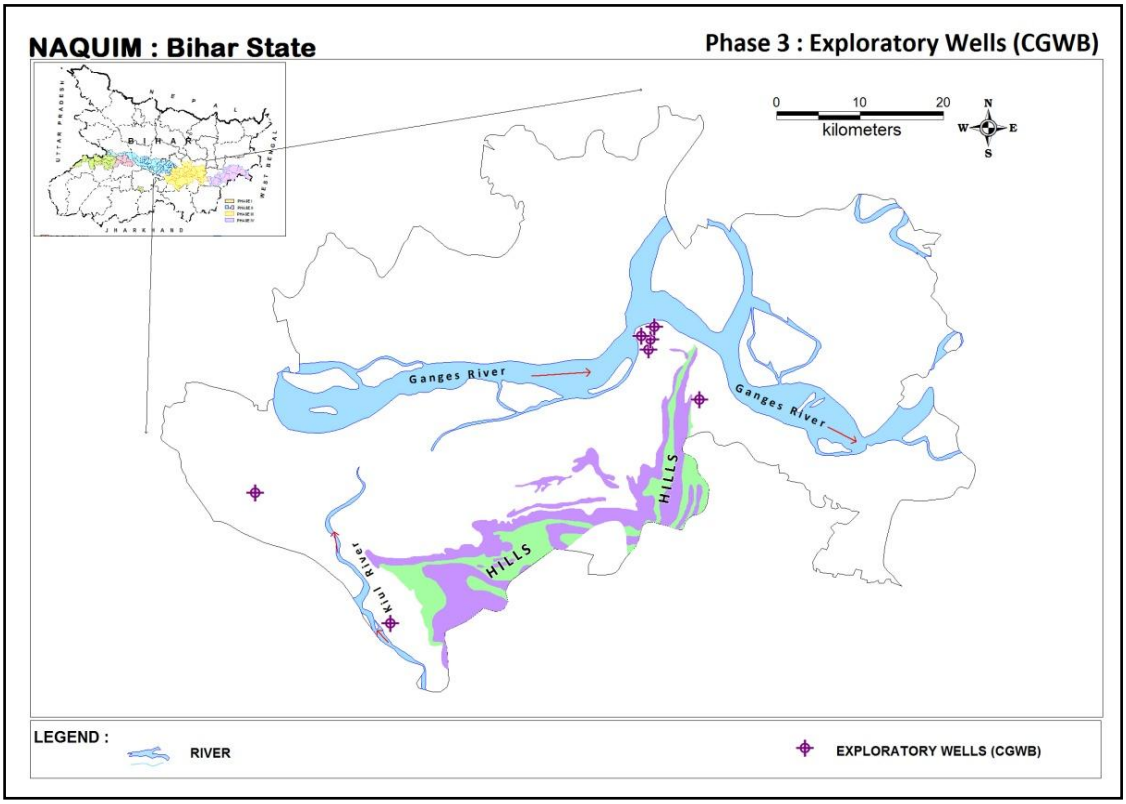


Fig 2.4 Locations of CGWB Exploratory Wells

CHAPTER - III

GENERATION OF AQUIFER MAP

3.1 Aquifer Disposition

Study area is located in the central axial part of Middle Ganga Plain occupying the central part of the Ganga Basin. The area forms a part of the Gangetic plains underlain by immensely thick alluvial deposits of Quaternary age comprising various grades of clay, silt and sand which constitutes the ground water reservoir.

3.1.1 Aquifer disposition in the area

Aquifer disposition of the Phase III area has been studied through prepared sections and fence diagrams based on the lithological information obtained through exploratory drilling undertaken by CGWB in conjunction with the available lithological logs of tubewells constructed by State Government agencies along with interpreted records from VES survey. Based on those studies, detailed aquifer geometry on regional scale has been established in the study area. Principal aquifers in the area have been delineated by grouping the fine to medium sand, coarse sand and gravelly sand as aquifers.

In contrast to earlier works of NAQUIM in Phase I and Phase II area, Phase III area shows distinct variation in aquifer disposition in north bank of River Ganga. In Phase I and Phase II areas, a distinct two aquifer system is present. However, in Phase III area, the existing clay layer occurring at a depth of 60-80 m at western margin of the study area, suddenly cease to exist as per available data. Hence the aquifer system becomes a mono-aquifer system. Moreover, the area being a prolific aquifer, with water level commonly within 5m, also does not have many deep wells with common depth of boring restricted within 80-100 m. Based on available drilling data several panel diagrams have been prepared (Fig. 3.1, Fig. 3.2 and Fig 3.3). These drilling data show that mono-aquifer system is continuing down to at least 100 m depth with a thin clay layer at the top. However, the sand horizon has gradation in sand size which continued regionally. Combining these panel diagrams, a generalised fence diagram has been prepared for the entire Phase III area and given in Fig. 3.4. For detailed understanding, 055 nos. vertical electrical sounding survey (VES) have been carried out. Results of VES survey has been compiled to prepare a fence diagram (Fig. 3.5) for the area down to a depth of 300 m. The results indicate that the same sand sequence is continuing down to a depth of 300 m. However, considering limitations of such VES survey, in a monolithic sequence, reliable interpretation depth of investigation may be considered down to 270-275 m.

Study on the nature of the sand indicates that the sequence may be part of the distal facies of alluvial fan sequence. Hence it may be the buried part of the Koshi megafan located in the north - eastern part of the area. However, this is also to be kept in mind that the area is bounded by several NE-SW trending faults like Munger Fault, Begusarai Fault *etc.* arranged in *en-echlon* pattern. These faults may also generate graben -related sequences due to their movements in geological past. In this situation the clay layer may be encountered at greater depth. Further study is needed in this direction.

On the other hand, south bank of River Ganga present entirely different sequence. The distinct two aquifer system, as present in Phase I and Phase II areas, continued its existence. However, the sequence has risen to shallower depth compared to its eastern counterpart. The 1st aquifer occurs within 30 m depth followed by a 20 m thick clay horizon. The 2nd aquifer starts at a depth range of 50-70 m and continue for another 20-30 m followed by clay. At the eastern margin of the study area, hardrock of Chotanagpur Gneissic Complex and Kharagpur Formation occurs at depth more than 200 m. However, only after short distance from the eastern boundary, the hardrock sequence rises within 120-150 m depth and gradually rises at shallower depth towards west and finally gets exposed at surface as Munger Hill Range. Toward Munger hill, the aquifer gradually thins out and finally abates against hardrock exposures of Munger Hills. On the western flank of Munger hills, aquifer is scanty and thin lying within clayey matrix. However, away from the hill range, two-aquifer system again continues.

A generalised and regional scale 3D hydro-stratigraphic model of the area has been prepared which provide a clear understanding about of the spatial variation of aquifer disposition in the area. The 3D model is given in Fig. 3.6.

3.1.2 Aquifer Characterizations

Characterization of aquifer down to 300 mbgl in the study area have been arrived at by convergence of the observations from the study of the different lithological sections, fence diagrams, geoelectrical sections, sections based on e-logs and overall lithological model of the area. All these figures reveal that in contrast to Phase I and Phase II areas, in north bank of River Ganga, a thick pile of alluvial sediments with alternation of various grades of sand formed a mono-aquifer system within 300 m of investigated depth. On the other hand, in south bank of River Ganga, two-aquifer system of Phase I and Phase II areas continued its existence. Here, the aquifers are separated by a clayey aquitard layer of significant thickness. However, the sequence is invaded by Munger hill range.

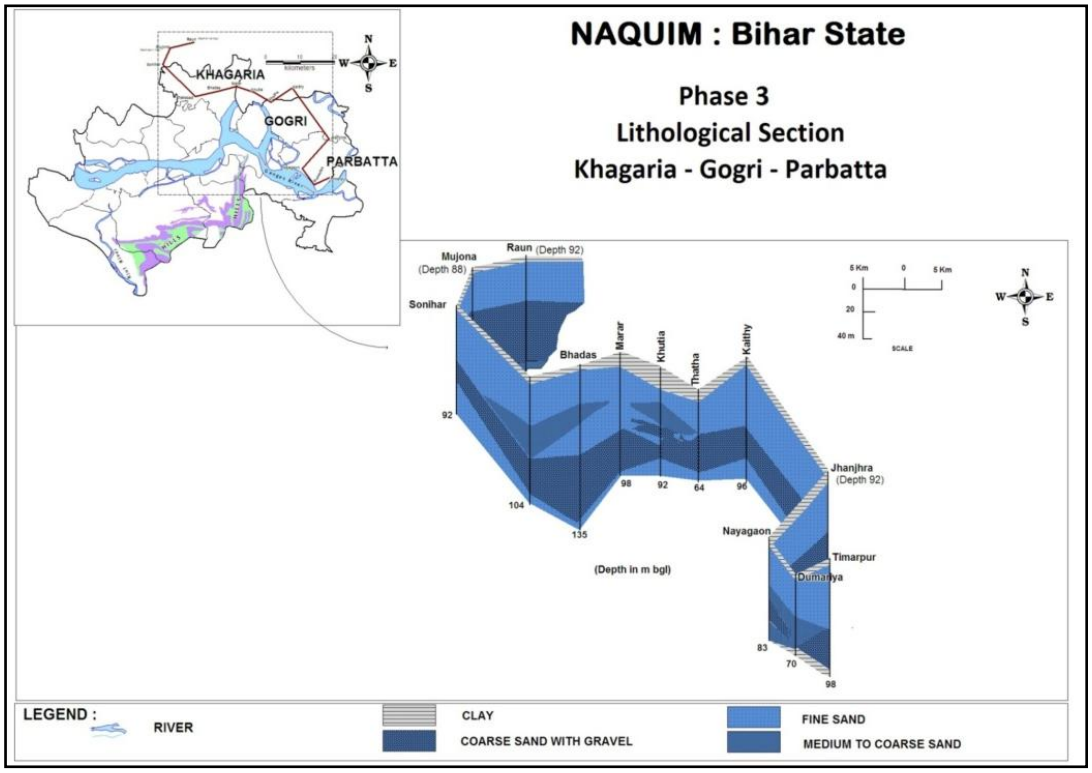


Fig 3.1: Hydrogeological section from Raun to Timarpur (in Khagaria – Gogri – Parbatta blocks)

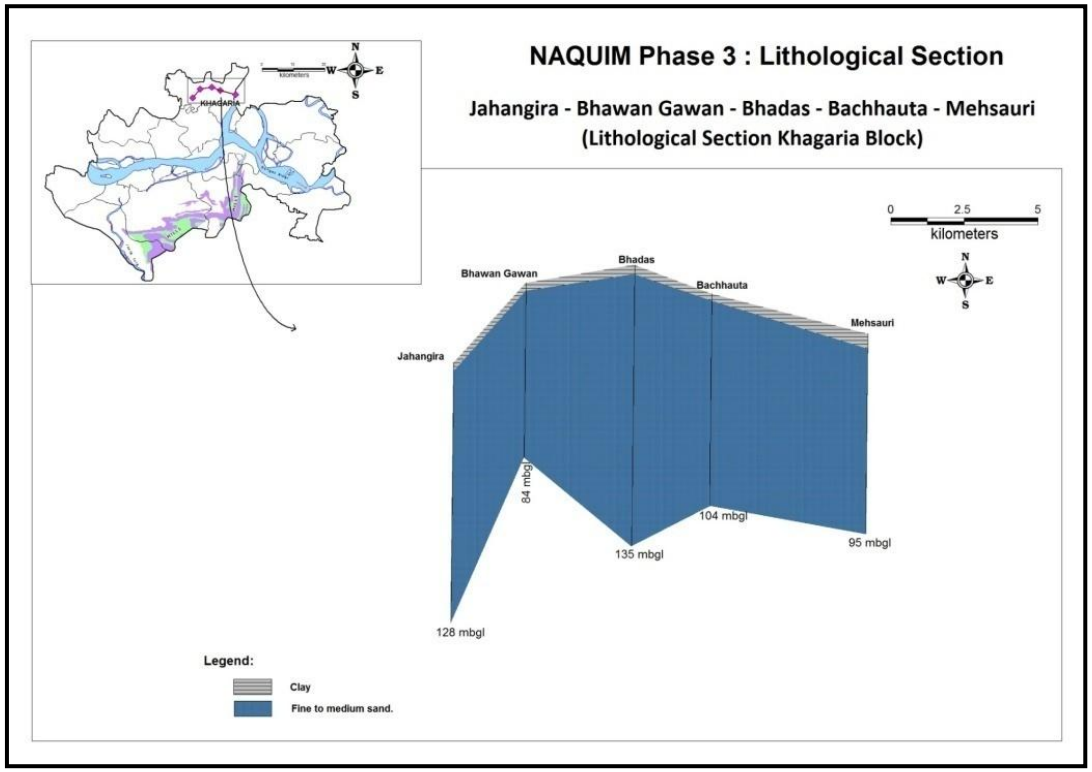


Fig 3.2: Hydrogeological section from Jahangira to Mehsauri (Khagaria block)

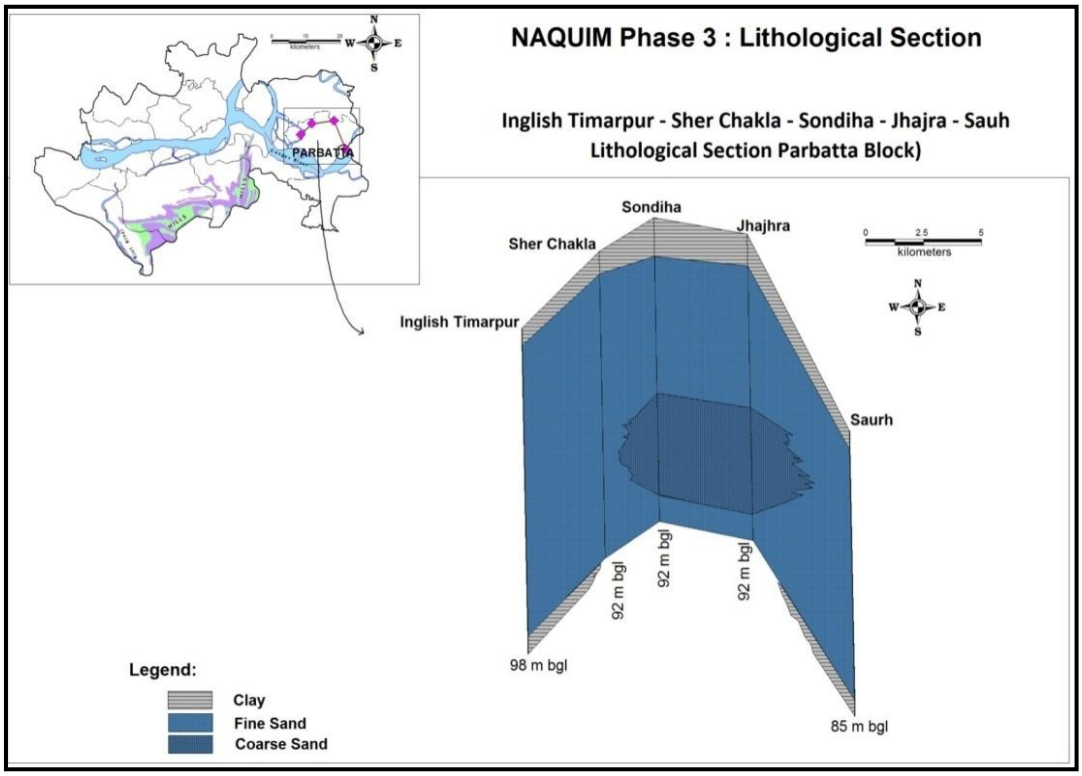


Fig 3.3: Hydrogeological Section (Parbatta Block)

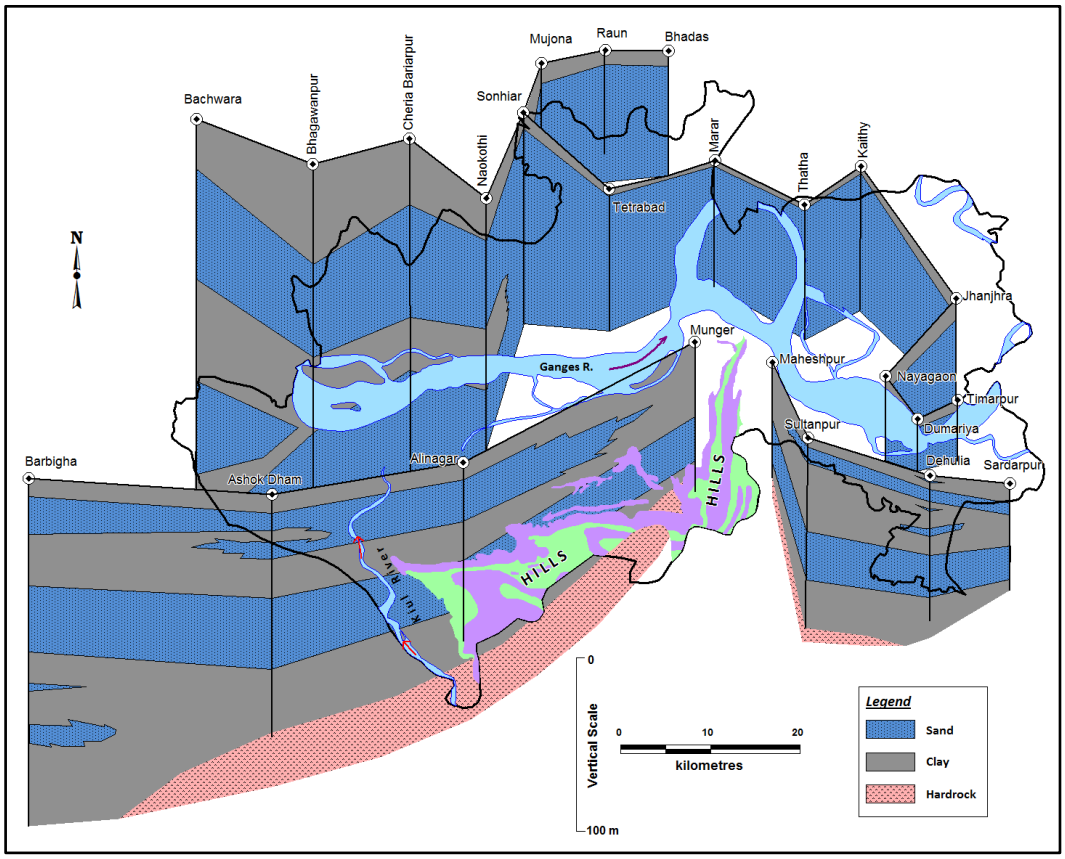


Fig. 3.4 Generalised Hydrogeological Panel diagram of Phase III Area

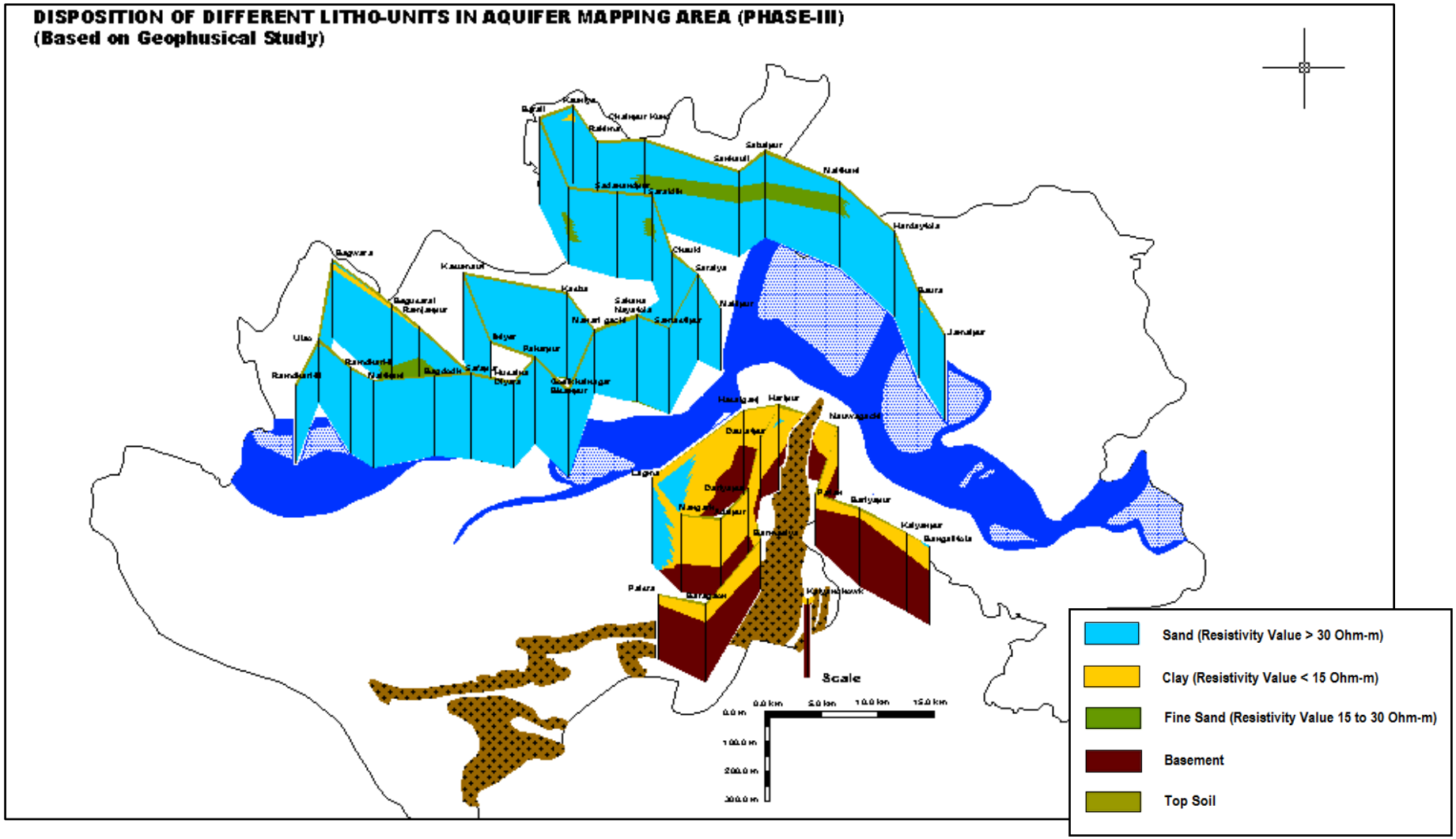


Fig. 3.5 Lithological Panel Diagram of Phase III Area based on VES data

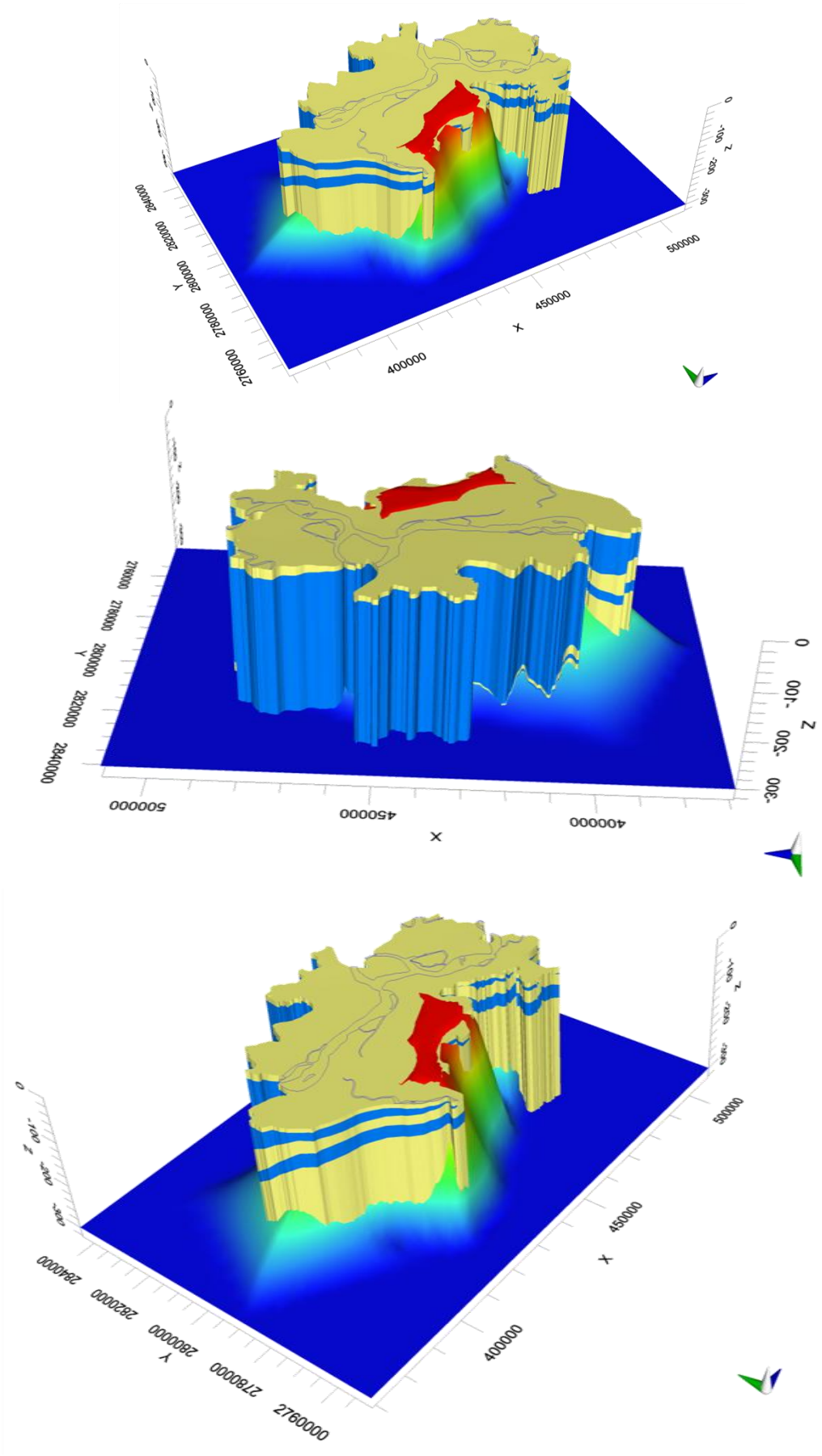


Fig. 3.6 Generated 3D hydro-stratigraphic Model of the Phase III Area

3.1.3 Aquifer Hydraulic Characteristics

CGWB has drilled very few wells in the area. Hence there is a general paucity of data. Pumping test data of CGWB wells have been analysed to arrive at the hydraulic characteristics of the aquifers. Data of wells constructed by State Government indicate that shallow tubewells tapping aquifer (within 110 m bgl) can yield up to 215 m^3/hr for a drawdown of 2- 5 m. Salient characteristics of the exploratory wells drilled by CGWB in the area is given in Table 2.1. Perusal of these data reveals significant potentiality of the aquifer of the area as transmissivity value of the aquifer is 698 m^3/d. The storativity in south bank area has been found to be 4.5 x 10^{-4} indicating that the deeper aquifer is in semi-confined to confined condition. District-wise yield potential has been tabulated in Table 3.1.

Table 3.1 District-wise summary of Yield Potential

District	Type of Wells	Expected Discharge (LPM)	Recommended Depth (m)	Diameter of Well	Type of Rig needed
Begusarai	Dug well	60-100	10-20	2.5-3.5 m	Manual
	Tube well	150-200	100-150	6 inch	Rotary
Bhagalpur	Dug well	60-100	10-15	2.5-3.5 m	Manual
	Tube well	100-200	100-200	6 inch	Rotary
	Bore well	100-300	100-150	4 inch	DTH
Khagaria	Dug well	60-100	10-15	2.5-3.5 m	Manual
	Tube well	100-500	100-150	6 inch	Rotary
Lakhisarai	Dug well	80-100	10-15	2.5-3.5 m	Manual
	Tube well	100-500	100-150	6 inch	Rotary
	Bore well	100-300	100-150	4 inch	DTH
Munger	Dug well	60-100	10-15	2.5-3.5 m	Manual
	Tube well	100-500	100-150	6 inch	Rotary
	Bore well	100-300	100-150	4 inch	DTH

CHAPTER - IV

GROUND WATER RESOURCES

4.1 Dynamic Ground Water Resources

Dynamic ground water resources of the 17 blocks of Begusarai, Khagaria, Lakhisarai, Munger and Bhagalpur district, has been assessed, as on March 2013, given in **Annexure V**. A summary of same is given in Table 4.1.

Table 4.1 Summary of Dynamic Groundwater Resource Assessment in the Area (as on 31st march, 2013)

	Dynamic GW Resource
	(in BCM)
Total Ground Water Recharge	**1.00**
Provision for Natural Ground Water Discharge	**0.09**
Net Ground Water Availability	**0.91**
Gross Ground Water Draft for All Uses	**0.32**
Current Annual GW Draft for Irrigation	**0.25**
Current Annual GW Draft for Domestic and Industrial uses	***0.07***
Stage of G.W. Development (%)	***35.78 %***
Annual Allocation of GW for Domestic & Industrial Water Supply for 2035	**0.02**
Net GW Availability for 'Future Irrigation Use'	**0.63**

Overall stage of groundwater development (SOD) in the area is 36.49% and all the blocks have been categorised under *safe* category on the basis of the status of ground water utilisation. The SOD in the phase 3 area varies between 15% and 75%. Lowest stage of groundwater development is 14.85% in Bariarpur block (Munger District) and the highest is 74.6 % in Shamho block (Begusarai District). Though there is a significantly variation in spatial distribution of SOD exists, average SOD in the area is about 35%. This indicates that in most of the area groundwater use is low and significant scope of further development exists particularly in north bank areas.

Of present groundwater use, main use is in agriculture consuming about 28% of groundwater. On the other hand, domestic and industrial use consumes about 8% of ground water. If the recharge aspect is looked into, 82% recharge takes place due to rainfall and rest 18% from other sources. Of rainfall induced recharge, 86% takes place during monsoon season and rest 14% during non-monsoon season.

4.2 Static Ground Water Resources

In the present exercise, attempt has been made to estimate the availability of the Static / In storage ground water resource in the shallow aquifer. The exercise has been carried out block-wise. For the purpose, aquifer thickness in south bank has been considered as per conceptual model. For blocks located in north bank of river Ganga, thickness down to 200 m has been considered as indicated by geophysical survey data. The availability of the static ground water resource in Aquifer-I, considering an average specific yield of 10 %, has been worked out as 32.43 BCM in the area. The block wise estimated static resource in Aquifer-I is given in Table 4.2.

Table 4.2 Block-wise Estimated Total Resource in Aquifer I

Sl. No.	Blocks	Area (in Sq Km)	Thickness of Aq. 1 (m)	Sp. Yield (%)	Resource (BCM)
1	Balia	149	192.56	0.1	2.869
2	Begusarai	222	191.67	0.1	4.255
3	Matihani	177	191.56	0.1	3.391
4	Shamho	66	193.33	0.1	1.276
5	Sahebpur Kamal	144	192.70	0.1	2.775
6	Sultanganj	219	21.94	0.1	0.480
7	Gogari	250	193.37	0.1	4.834
8	Khagaria	262	193.67	0.1	5.074
9	Parbatta	241	192.60	0.1	4.642
10	Barahia	241	16.58	0.1	0.400
11	Lakhisarai	283	11.28	0.1	0.319
12	Piparia	58	14.86	0.1	0.086
13	Surajgarha	390	10.40	0.1	0.406
14	Bariarpur	161	22.94	0.1	0.369
15	Dharhara	283	29.88	0.1	0.846
16	Jamalpur	85	21.44	0.1	0.182
17	Munger	242	9.50	0.1	0.230
	TOTAL				**32.43**

4.3 Ground Water Resource of Deeper Aquifer

The availability of the ground water resource in the second aquifer has been computed. Considering presence of 2nd aquifer system only in south bank of River Ganga, the resource has been computed. Storativity value of 4.5 x 10^{-4} with an average aquifer thickness of 35 m over an area of 1962 Sq. km. has been worked out to be in the tune of 30.9 MCM i.e. 0.31 BCM.

4.4 Rejected Recharge in Unconfined Aquifer

In parts of the study area, an attempt was made to find out the volume of rejected recharge. For the purpose, DWL map for the month of Aug. 2015 (Fig. 4.1) was prepared so to find out the part with lowest water level, considering it will not take any further water thereby resulting in water logging. Thus, this surplus water can be considered as rejected recharge. It was found that around 72 sq. km. area of Khagaria and Munger district has the lowest water level in the month of august 2015.

District	Water Logged Area (Sq. Km)
Khagaria	37
Munger	35
Total =	**72**

Apart from DTWL map, other factors which were considered for calculation of rejected recharge are

1) Soil moisture
2) Added volume of water in the aquifer
3) Volume of Rainfall
4) Infiltration of Rainfall

Relationship of various parameters in Khagaria and Munger blocks are shown in Fig. 4.2. It was found that in the district of Khagria, the volume of rejected recharge was found to be 3.48 MCM and in Munger district it was 3.19 MCM (Table 4.3). In Khagaria district, it is observed that post July, the volume of rejected recharge increased significantly whereas in Munger it was with moderate rate. This indicate rainfall-recharge response is faster in Khagaria area. The graph of change in volume of rejected recharge over time (Fig. 4.3), show that with the increase in rainfall volume, amount of infiltration decreases, thereby increasing the rejected recharge (run off).

Table 4.3 Volume of Rejected Recharge (in MCM)

District	July	August	September	Annual Total
Khagaria	0.67	0.78	3.48	4.93
Munger	0.44	2.68	3.19	6.31
			Grand Total	**11.24**

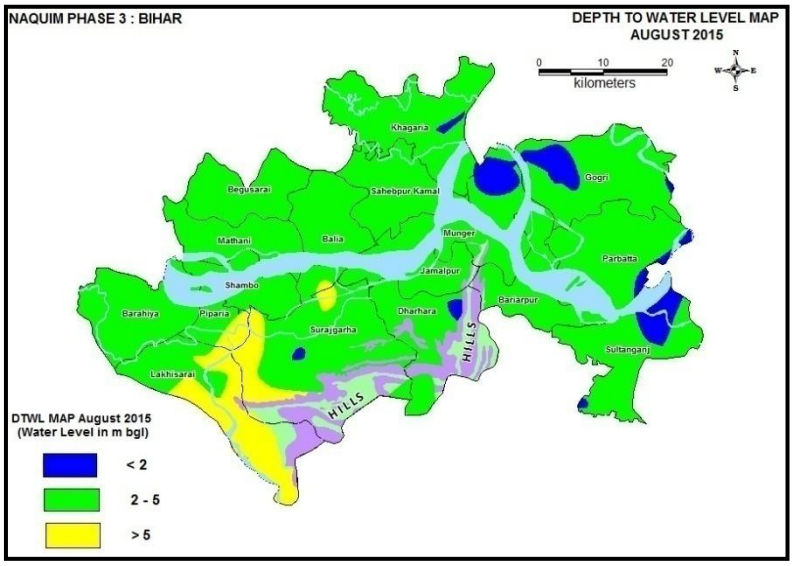


Fig. 4.1 DWL Map showing areas with Rejected Recharge

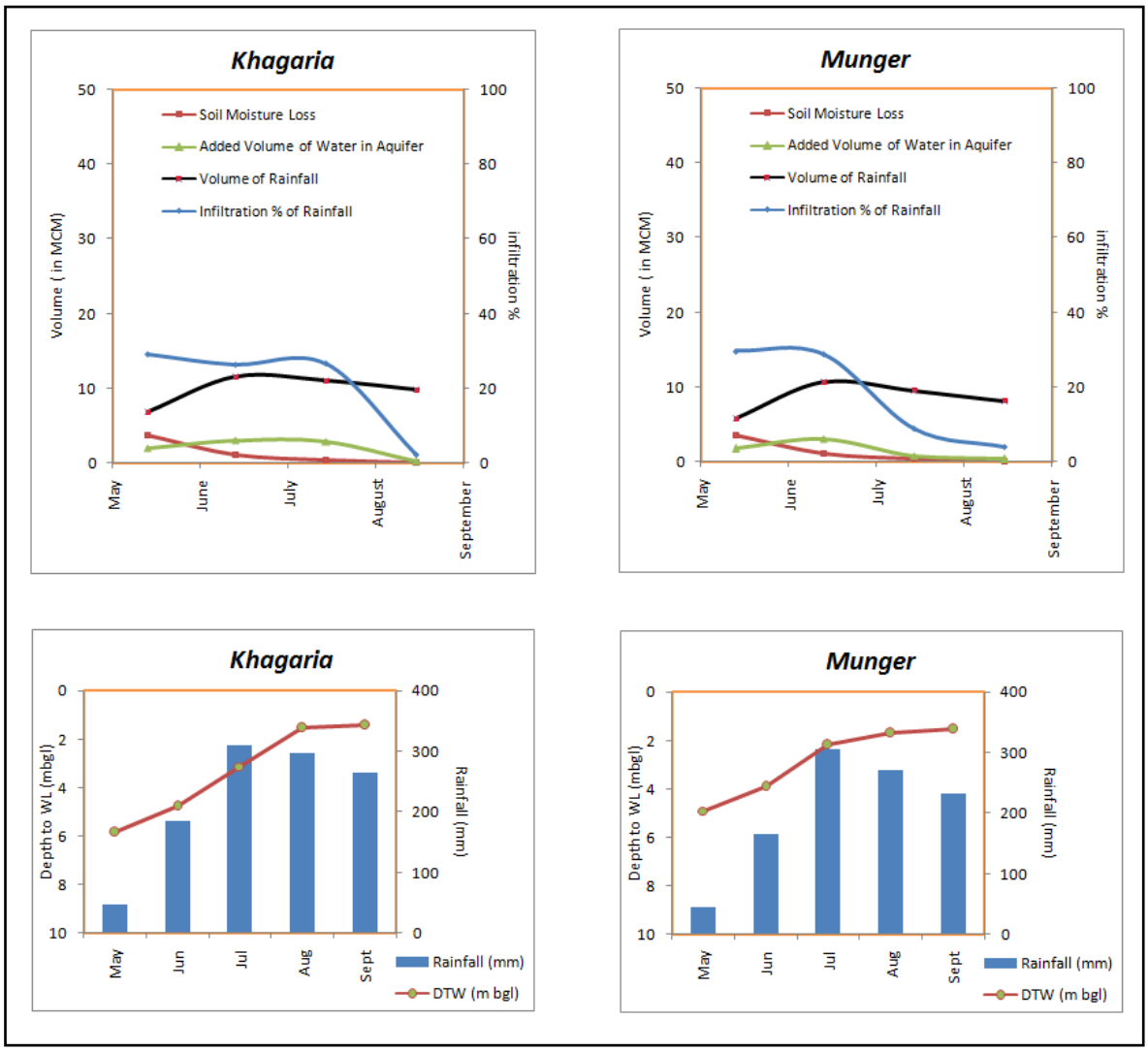


Fig 4.2 Relationship of Various Parameters in Khagaria and Munger Blocks

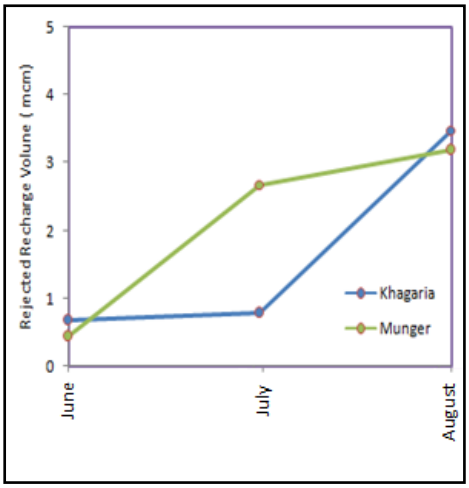


Fig. 4.3 Change in Volume of Rejected Recharge over Time

4.5 Groundwater Mass-Balance in the Area

Groundwater resource is computed as groundwater present in an area at any point of time without considering the lateral flow. However, groundwater is in continuous flow. Hence, a significant amount of groundwater moves laterally through an area which does not get reflected in computed resource estimates. To understand the inflow and outflow condition of Phase - III area, a sector-wise flow analysis (Fig. 4.4 and Table 4.4) has been carried out. Results indicate that 292.4 BCM of water passes through the area and ultimately gets discharged in River Ganga and a surplus of 1.8 BCM of water is present within top aquifer of the area as a remaining balance of Inflow-Outflow which gets manifested by prolonged water logging in the area.

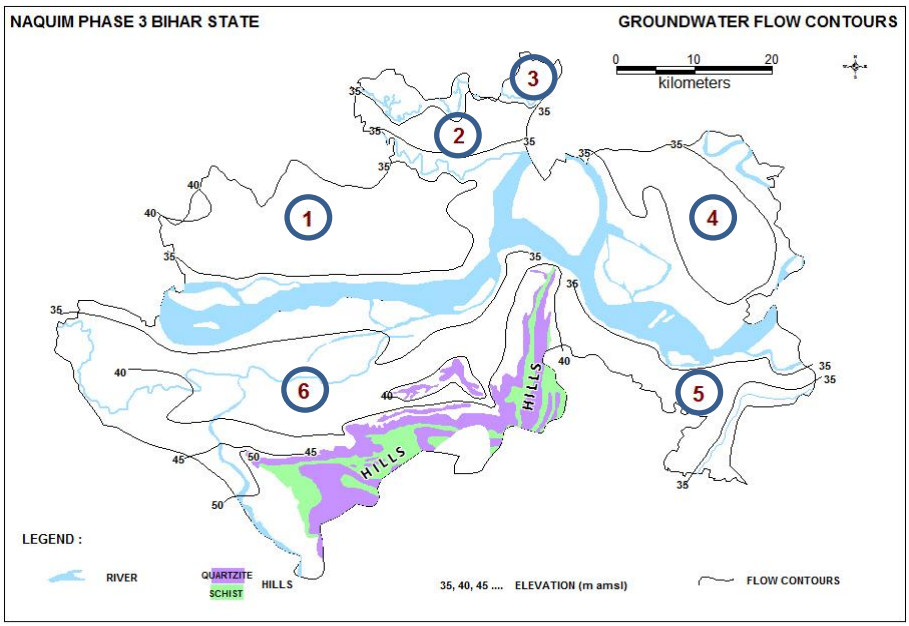


Fig. 4.4 Sector-wise Groundwater Flow Contours in Phase III Area

Table 4.4 Inflow & Outflow of Groundwater in Phase - III Area

Flow Type	Sector	Transmissivity (m^2/d)	Head Difference (m)	Distance (Km)	Length of boundary across which flow is taking place (Km)	Total Volume (BCM)
Inflow	**Sector 1**	3000	4	33.86	56.21	19.9
	Sector 2	3000	3	2.74	7.05	23.1
	Sector 3	3000	4	4.26	45.03	126.8
	Sector 4	3000	3	25.73	17.63	6.1
	Sector 5	1500	4	10.89	58.87	32.4
	Sector 6	1500	10	15.01	85.91	85.9
Outflow	**North bank**	3000	0.5	1	135.89	203.8
	South bank	1500	0.5	1	118.1	88.6

4.6 Additional Extraction Potential of Unconfined Aquifer

Considering the prolific nature of the aquifers in the study area, it is apparent that significant scope of groundwater development exists in the Phase-III area specifically for those areas located at northern bank of the River Ganga. Even only tapping the dynamic resource, up to a stage of development of 70% *i.e.* within *Safe* limit, 311.96 MCM of groundwater is available for development in Phase III area. Numbers of additional shallow tube wells that can be constructed in different blocks considering the above criteria are computed and given in Table 4.5.

Table 4.5 Feasible Numbers of Additional Shallow Tubewells in Phase III Area

Administrative Units	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for All Uses	Net GW Availability for Future Irrigation Development	Existing Stage of Ground Water Development (%)	Agriculture land (ha)	No. of already existing STW's	TW command area (ha)	No. of Tubewells feasible	Additional no. of TW feasible Based on available GW Resource upto 70% SOD (nos.)
Balia	4878.58	3536.84	1876.98	72.50	13680	1429	3	4560	**0**
Begusarai	8057.47	4323.17	4495.67	53.65	9894	1613	3	3298	**547**
Matihani	4949.50	783.38	4345.50	15.83	11490	215	3	3830	**1301**
Shamho	2327.38	1736.25	702.58	74.60	9838	801	3	3279	**0**
Sahebpur Kamal	4030.01	1082.61	3180.01	26.86	13580	359	3	4527	**828**
Sultanganj	5943.31	973.72	5212.81	16.38	21560	471	3	7187	**2384**
Gogri	9101.72	3955.57	5787.92	43.46	22810	1420	3	7603	**1052**
Khagaria	7972.98	1726.92	6693.58	21.66	21990	478	3	7330	**1660**
Parbatta	8278.36	4773.38	3960.16	57.66	21790	1780	3	7263	**460**
Barahia	6782.01	1397.47	5733.81	20.61	18980	696	3	6327	**2373**
Lakhisarai*	5530.57	2266.57	3553.37	40.98	20750	1334	3	6917	**1126**
Piparia	1653.99	732.00	984.99	44.26	5922	463	3	1974	**309**
Surajgarha*	4121.43	890.13	3354.63	21.60	31160	475	3	10387	**1410**
Bariarpur*	3861.81	573.35	3414.81	14.85	14140	254	3	4713	**1612**
Dharhara	7954.56	2002.43	6154.66	25.17	9762	937	3	3254	**2729**
Jamalpur	1933.62	917.90	1207.82	47.47	5672	404	3	1891	**289**
Munger *	3124.69	712.23	2594.69	22.79	18280	272	3	6093	**1074**

TW Command area considered as 3 ha

(Based upon Groundwater Resource Estimation of Bihar, 2013, CGWB and MI Census 2006)

**Only in Alluvial Part*

CHAPTER - V

GROUND WATER RELATED ISSUES

5.1 Identification of issues

The major groundwater issue in the study area is of arsenic contamination which has been reported from 16 out of 17 blocks of the study area. Detailed investigations carried out by CGWB have established that, where exists, the deeper aquifer is free from arsenic contamination.

5.2 Major Ground Water Issues

Major groundwater issues are mentioned below:

1. Arsenic contamination

Arsenic contamination has been reported to from 16 out of 17 blocks of the study area. This situation put a population of about 3.75 million at risk of health hazard related to arsenic, who are directly or indirectly dependent on groundwater of the area.

a) In North bank of River Ganga, arsenic infestation in mono-aquifer system puts the residents without any alternative groundwater source;

b) In south bank of River Ganga, two-aquifer system exists. The shallow aquifer is arsenic contaminated in its uppermost part where as deeper aquifer is arsenic safe. Important management challenge lies in the protection of the deeper aquifer from any possible threats of cross-contamination.

2. Prolonged seasonal water logging of *tal* areas

Prolonged seasonal water-logging hinders agricultural productivity in Rabi season. If the area can be cleared at an early date, farmers will be immensely benefitted.

a) About 950 Sq. Km area of entire Phase III area gets seasonally water logged;

b) Main area affected is Mokama Group of *Tal*;

c) Period of Water logging is June to October.

d) Delayed drainage in *tal* areas impacts the agricultural productivity in Rabi season

CHAPTER - VI

MANAGEMENT STRATEGIES

In order to address the problem of groundwater development in the area, i.e. in one hand tackling the problem of Arsenic contamination area and to ensure safe water supply in the affected villages, on the other hand to enhance agricultural productivity in the area, a suitable management strategy is needed. The strategy should be such that groundwater resource should be optimally utilised ensuring equitability and sustainability. In the course of the study, it is clearly understood that one uniform plan for the entire area cannot be prepared based on people's livelihood, land-use pattern and severity of the problem. Moreover, the results of the study indicate that even the nature of the aquifer system in north and south bank of Ganga is not similar. With this background, a broad framework of management strategy is prepared, recognising that the outlined strategy has to be suitably modified based on area specific manifestation of the problems.

6.1 Arsenic Contamination in Groundwater

Arsenic contamination of groundwater is the most important issue in the study area. It has been reported from the 16 out of the 17 blocks (source PHED, Govt. of Bihar) of the study area. The area hold a population of about 3.75 million. As this population is directly or indirectly dependent on groundwater of the area, the situation puts the entire population at risk of health hazard related to arsenic. Investigations carried out by CGWB, indicate that, in South bank of the River Ganga, where two-aquifer system exists, 2^{nd} aquifer occurring below the 1^{st} aquifer and separated from it by an aquitard layer is free from arsenic contamination. In North bank of River Ganga, where it is principally a mono-aquifer system, arsenic contamination has been reported from upper part of the aquifer. Hence, to mitigate the problem, separate strategy has to be formulated for North and South bank of River Ganga.

A) North Bank of River Ganga

In North bank of River Ganga, in contrast to aquifer disposition at eastern margin, the aquifer system becomes a mono-aquifer system with a thin clay layer at the top. Based on available drilling data and VES survey, sand sequence is continuing down to a depth of 275 m. However, the sand horizon has gradation in sand size which continues regionally.

The situation poses a unique problem in terms of Arsenic contamination. The area does not have any alternate groundwater source which is arsenic free. At present the contamination problem is restricted within only top-part of the aquifer. This is due to the prolific nature of the aquifer with

water level commonly within 5m and not having many deep wells. Commonly depth of tubewell is restricted within 30-40 m with maximum depth of 80-100 m. This indicates that only the top part of the aquifer has been developed so far. However, there is a fair possibility that with gradual increase in development of deeper part of the aquifer, arsenic will be reported from the deeper parts also, as the entire sequence is under single hydrodynamic regime.

With this situation, construction of arsenic free arsenic free tubewell is not possible. Hence, restriction on depth of construction of tubewells is the only viable solution at present with only exception for drinking water supply tubewells. The restriction may be continued till the deeper (> 300m) parts of the aquifer are explored and alternative arsenic free groundwater source is found out. In addition, all drinking water supply tubewells should be planned to be fitted with arsenic removal plant with frequent check on water quality. Conjunctive use may be encouraged in the area towards irrigational practices. In this context, implementation of the solar photovoltaic groundwater pumping system with grounded tank for water storage developed for eastern India by ICAR (Rahman and Bhatt, 2015). This technique has several advantages and the occurrence of shallow water level condition in the study area makes it more relevant. In addition to reduction in reliance on the fossil fuels for groundwater pumping, the model may also be tested for the reduction in the arsenic load upon surface storage before being fed for irrigation.

B) South Bank of River Ganga

In South bank of River Ganga, distinct two aquifer system is present. However, the sequence has risen to shallower depth compared to its eastern counterpart. The 1st aquifer occurs within 30 m depth followed by a 20 m thick clay horizon. The 2nd aquifer starts at a depth range of 50-70 m and continue for another 20-30 m followed by clay. Hardrock of Chotanagpur Gneissic Complex and Kharagpur Formation may occur at depth less than 200 m. Of this, arsenic contamination has been reported from top aquifer. At existing hydrodynamic condition, the deeper aquifer has a higher piezometric head than the shallow aquifer. This upward pressure restricts downward migration of arsenic laden groundwater from shallow aquifer by creating a hydrodynamic barrier and keeps the deeper aquifer arsenic free.

At present, a strong tendency towards deepening of tubewells tapping deeper aquifer has been currently developed in the area to get Arsenic – free water. However, this situation is posing a unique problem in implementation of the projects. Enhanced large scale pumping of deeper aquifer may result in changing the hydrodynamic balance of the entire aquifer system. With continued pumping, the piezometric head of deeper aquifer will gradually reduce and when it become lower than that of shallow aquifer, the hydrodynamic barrier will cease to exist and downward migration of arsenic laden water may start. This situation indicates that with time, the second aquifer will also

become arsenic affected with continued pumping. Besides this, reduced discharge of wells in the area due to interference of cone of depression may also occur in the future.

To address the concern towards sustainable development of deeper aquifer, the deeper aquifer should be only exploited for drinking water supply purpose and the tubewells should be designed for optimal discharge and maximally spaced. Distance-drawdown analyses of nearby areas in same aquifer system indicate that tubewells tapping deeper aquifer should be designed for a maximum discharge of 50m^3/hr only and the radial distance between two such pumping schemes should be kept at a minimum of 3 Km.

6.2 Proposed Design of Arsenic Free Wells in Duel-Aquifer System

Development of deeper aquifer should be made through properly designed wells which must be sealed from the overlying contaminated aquifers through cement sealing. The cement sealing is applied to a suitably thick intervening clay layer separating the arsenic contaminated aquifer from arsenic free aquifer. This cement seal prevents seeping of contaminated water through the annular space which is filled with gravels. A schematic design is presented as under (fig. 6.1).

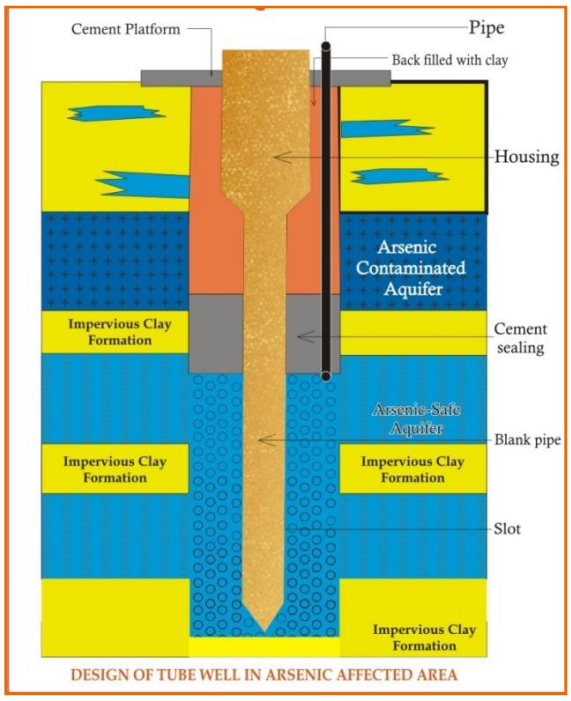


Fig. 6.1: Schematic Design of Tube Well with Cement Seal for Arsenic Affected Areas

6.3 Early Reclamation of Agricultural Lands in *Tal* Areas

Typically the *tal* areas gets inundated with the onset of monsoon. The water starts receding from late-September and the areas get drained completely by late-December. Hence, the land is available to the farmer for agriculture only after mid-December. Soils of these areas are grey in colour, medium-heavy to heavy in texture and very poor in drainage. With this soil type and very late availability of the land, mostly Rabi crops like lentil, lathyrus, and grams are grown. Cropping is not possible during Kharif season due to submergence of the areas.

Rabi cultivation in those areas is based on the residual moisture of the land freed from submergence. However, there is ample possibility for increasing the productivity and yield of these crops. Agricutural production statistics indicates that in the study area, represented mainly be Mokama group of *tal*, cropped area under lentil (Masoor) is maximum followed by gram. However, if the land becomes available to the farmer at an early date, gram crop production can be enhanced due to early sowing. When the drainage is delayed beyond 15th October, *rabi* sowing is delayed and the crops suffer due to loss of moisture during their maturity stage and lack of irrigation facility. Considering an average depth of standing water column in inundated area is 0.5 – 1 m, reclamation of about 5% of the *tal* land is feasible through construction of groundwater recharge shaft. Considering the local hydrogeological situation, 1 recharge shaft per hectare is needed.

Recharge shafts of 2 m diameter, filled with granular materials may be constructed in the field down to about 7m of depth (variable in the range of 5 - 10 m depending on thickness of clay layer). Detailed design of the recharge shaft is given in Fig. 6.2. The structure will accelerate the vertical drainage and recharge to groundwater which is impeded because of the clayey nature of the soil. Such a recharge shaft has potential for clearing 1 ha of land in ~20 days considering an average inundation of 0.5 m in the area. Cost of construction of such recharge shaft has been estimated as about Rs. 50,000/- each without considering the cost of land. Considering average productivity of Maize is 8000 Kg/ha in the area and current market value at Rs 11.75/Kg (*i.e.* Rs. 1175/- per quintal), annual productivity value from 1 ha may be estimated at Rs 94,000/-. Hence, benefit exceeds cost in a single year.

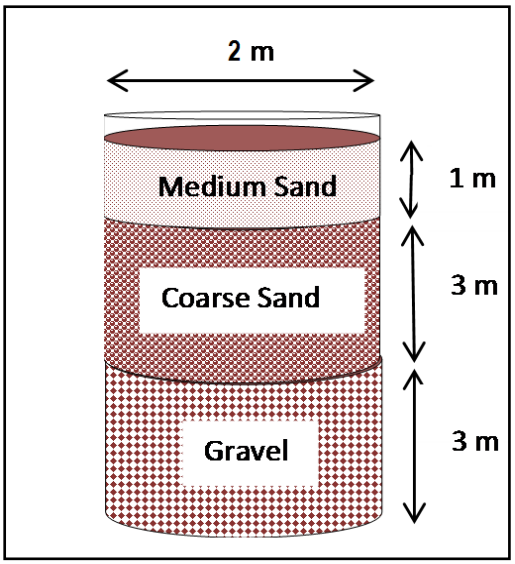


Fig. 6.2 Schematic Design of Recharge Shaft for Accelerated Vertical Recharge in *Tal* Areas

Fig. 6.3 Field Implementation of Recharge Shaft

Annexure - I

Details of Keywells established in Study Area with Water Level

Sl. No.	Location	Block	District	Long	Lat	Elev. (m)	Dia (m)	Depth of Well (mbmp)	Initial Water Level July 2015 (mbgl)	W.L. Nov. 2015 (mbgl)	W.L. MAY 2016 (mbgl)
1.	Badi Balia	Balia	Begusarai	86.2754	25.4189	45.5	3.1	11	7.9	5.56	7
2.	Bariarpur	Balia	Begusarai	86.2618	25.3973	44	1.5	8.9	6.4	4.54	10.7
3.	Choti Balia	Balia	Begusarai	86.3068	25.4207	47.4	0	10.5	8.2	5.45	10
4.	Lakhminia	Balia	Begusarai	86.3284	25.4122	44.6	3	10.3	7.2	5.8	8.42
5.	Pokharia	Balia	Begusarai	86.2464	25.4100	44.7	2.20	8.83	5.97	3.41	6.68
6.	Rahatpur	Balia	Begusarai	86.2519	25.3858	44.6	1.7	8.86	6.5	4.6	10.7
7.	Barieghu	Begusarai	Begusarai	86.1424	25.3999	46.2	1.75	10	6.7	5.95	9.57
8.	Gopalpur	Begusarai	Begusarai	86.2028	25.4417	42	1.45	8.95	6.15	5.40	6.8
9.	Haridia	Begusarai	Begusarai	86.1422	25.4547	43.9	2.56	8.00	5.90	5.17	6.48
10.	Harpur	Begusarai	Begusarai	86.0770	25.4389	47.8	1.2	7.5	5.55	5.32	7.45
11.	Kaithma	Begusarai	Begusarai	86.1481	25.3886	49.2	0.80	10.00	7.84	6.81	9.42
12.	Lakho	Begusarai	Begusarai	86.1778	25.4139	45.9	1.86	12.00	6.49	4.47	7.43
13.	Matihani	Maithani	Begusarai	86.1292	25.4306	45.3	1.72	9.37	6.17	6.36	9.3
14.	Badalpura	Maithani	Begusarai	86.1573	25.3793	50.3	1.85	8.2	7.23	6	11.85
15.	Badalpura	Maithani	Begusarai	86.1506	25.3764	46.5	1.84	12.00	5.82	6.96	11.3
16.	Begusarai fc_ib	Maithani	Begusarai	86.1375	25.3792	47	2.02	7.00	5.77	4.88	6.2
17.	Dariarpur	Maithani	Begusarai	86.2274	25.3646	46	1.75	10.8	5.8	5.73	8.75
18.	Thaua chawk	Maithani	Begusarai	86.1638	25.3682	48.5	2.1	10.37	5.66	5.52	10
19.	Bintoli	Sahebpur Kamal	Begusarai	86.4097	25.4228	41.6	1.40	8.50	5.82	6.99	8.4
20.	Heera tola	Sahebpur Kamal	Begusarai	86.4432	25.4626	42.9	2	10.1	8.5	6.44	9.82
21.	New Jafar Nagar	Sahebpur Kamal	Begusarai	86.3757	25.4264	44.7	2	8	5.5	5.87	7.68
22.	Raghunathpur	Sahebpur Kamal	Begusarai	86.4424	25.4412	41.4	1.8	8.7	7.45	6.67	8.5

Sl. No.	Location	Block	District	Long	Lat	Elev. (m)	Dia (m)	Depth of Well (mbmp)	Initial Water Level July 2015 (mbgl)	W.L. Nov. 2015 (mbgl)	W.L. MAY 2016 (mbgl)
23.	Sabdalpur	Sahebpur Kamal	Begusarai	86.4343	25.4257	43.4	1.7	10.4	7.35	7	10.3
24.	Akbarnagar stn	Sultanganj	Bhagalpur	86.8083	25.2250	37.4	1.20	12.20	4.37	3.12	5.28
25.	Gangti	Sultanganj	Bhagalpur	86.7546	25.2209	38.4	3	9.2	5.74	3.75	5.74
26.	Ghor ghat	Sultanganj	Bhagalpur	86.6437	25.2420	39.8	1.94	14.76	12.95	5.15	12.95
27.	Gouripur	Sultanganj	Bhagalpur	86.8756	25.2435	39.1	1.33	10.22	8.22	3.2	8.22
28.	Hario pani tanki (Akbarnagar)	Sultanganj	Bhagalpur	86.8477	25.2362	40.7	2.27	10.42	5.34	3.4	5.34
29.	Karharia (Kastkari)	Sultanganj	Bhagalpur	86.7050	25.1228	48.4	1.8	5.2	3.51		3.51
30.	Kathara	Sultanganj	Bhagalpur	86.7543	25.1927	38	1.67	12.6	3.86	5.6	3.86
31.	Sultanganj	Sultanganj	Bhagalpur	86.7000	25.2417	38.7	1.50	11.60	6.33	4.40	6.64
32.	Basantpur	Gogri	Khagaria	86.5883	25.5033	43.8	1.50	7.65	5.05	3.74	4.28
33.	Gandhinagar	Gogri	Khagaria	86.6650	25.4461	40.1	1.36	6.55	6.64	6.40	5.22
34.	Jamalpur	Gogri	Khagaria	86.6417	25.4292	43	1.80	12.10	7.60	4.90	6.3
35.	Maheshkhunt Lohiya Chowk	Gogri	Khagaria	86.5989	25.4806	47.8	1.42	7.80	4.98	3.82	7.25
36.	Maheshkhunt 1	Gogri	Khagaria	86.6375	25.4600	46.2	1.97	7.86	6.48	4.54	7.46
37.	Maheshkunt	Gogri	Khagaria	86.6294	25.4586	50.3	2.00	7.10	4.46	4.88	6.95
38.	Durgapur	Khagaria	Khagaria	86.4570	25.4798	44.8	2.5	8.2	7.23	6	9.3
39.	Gangaut	Khagaria	Khagaria	86.3667	25.5125	42	2.30	8.20	5.63	6.27	8
40.	Ismailpur	Khagaria	Khagaria	86.3906	25.5089	40.5	1.10	10.00	5.63	1.69	7.77
41.	Kasimpur	Khagaria	Khagaria	86.4183	25.5011	39.6	1.27	7.60	7.37	6.40	6.4
42.	Khagaria	Khagaria	Khagaria	86.4750	25.4917	43	1.71	10.47	8.29	6.40	7.77
43.	Labhgaon	Khagaria	Khagaria	86.4250	25.5000	39.4	1.50	8.93	6.44	5.20	8.4
44.	Ranko	Khagaria	Khagaria	86.4983	25.5190	45.4	2.7	7.49	4.9	4.57	7.27
45.	Rasaunk	Khagaria	Khagaria	86.5115	25.5529	44.8	2.8	10.5	8.36	8.1	8.79

Sl. No.	Location	Block	District	Long	Lat	Elev. (m)	Dia (m)	Depth of Well (mbmp)	Initial Water Level July 2015 (mbgl)	W.L. Nov. 2015 (mbgl)	W.L. MAY 2016 (mbgl)
46.	Sabalpur	Khagaria	Khagaria	86.5013	25.5427	43.3	1.45	8.1	4.87	3.88	7.43
47.	Sonhauli	Khagaria	Khagaria	86.4699	25.5121	44.2	1.5	9.9	7.1	4.1	8.77
48.	Dewri	Parbatta	Khagaria	86.7136	25.3628	42.3	1.13	15.00	4.68	3.21	3.24
49.	Mohaddipur	Parbatta	Khagaria	86.7461	25.3919	48.5	1.80	8.90	4.81	3.44	7.25
50.	Aijini Ghat	Barahiya	Lakhisarai	85.9580	25.1982	43.1	1.85	9.23	6.95	6	6.95
51.	Baroan taal	Barahiya	Lakhisarai	85.9985	25.2549	46.9	2.4	8.02	5.06	6.2	5.06
52.	Amhara	Lakhisarai	Lakhisarai	86.0488	25.1747	46.3	2.4	9.93	7.96	7.3	7.96
53.	Ashok dham	Lakhisarai	Lakhisarai	86.0742	25.1935	46.2	3.07	11.05	9.833		9.83
54.	Barhaiya	Lakhisarai	Lakhisarai	86.0333	25.2125	44.6	1.40	9.80	8.40	7.96	8.99
55.	Bichala tola	Lakhisarai	Lakhisarai	86.0766	25.2080	50.9	1.95	6.21	4.22	3.8	4.22
56.	Dariyapur	Lakhisarai	Lakhisarai	86.0703	25.2125	44	1.35	10.16	7.45	2.74	8.94
57.	Kiul_1	Lakhisarai	Lakhisarai	86.1042	25.1736	47.4	1.40	8.00	8.40	8.40	7.33
58.	Korizilla Bhagalpur	Lakhisarai	Lakhisarai	86.1144	25.1981	44	1.23	8.1	6.05	4.7	6.05
59.	Lakhisarai	Lakhisarai	Lakhisarai	86.1003	25.1833	44.6	1.90	11.65	7.88	7.02	11.52
60.	Mahsuana	Surajgarha	Lakhisarai	86.1118	25.1235	53.2	1.42	11.3	10.32	9.6	10.32
61.	Morma Basti	Surajgarha	Lakhisarai	86.0166	25.1615	46.7	1.97	11.2	10.04	9.2	10.04
62.	Saidpur	Surajgarha	Lakhisarai	86.1533	25.1833	44.2	1.83	11.70	7.40	4.48	9.36
63.	Surajgarha1	Surajgarha	Lakhisarai	86.1308	25.1086	43.3	1.74	10.81	8.15	5.60	8.42
64.	Olipur	Surajgarha	Lakhisarai	86.1381	25.2456	48.4	1.97	9.4	7.96	4.1	7.96
65.	Arma	Surajgarha	Lakhisarai	86.2464	25.2000	46	1.82	13.92	8.91	8.41	9.95
66.	Kajra2	Surajgarha	Lakhisarai	86.2033	25.1711	45.5	1.57	13.92	8.00	3.78	9.97
67.	Rishi Paharpur	Surajgarha	Lakhisarai	86.2850	25.2781	44.8	2.40	8.92	9.48	7.41	8.3
68.	Anandpur	Surajgarha	Lakhisarai	86.1848	25.1882	44.7	1.49	5.83	4.33	3	4.33
69.	Jagbada	Surajgarha	Lakhisarai	86.1850	25.1771	46	1.75	5.2	2.84	2.75	2.84
70.	Basauni (Jogapur)	Surajgarha	Lakhisarai	86.3780	25.2269	53.3	1.85	10.2	8.96	7.7	8.96

Sl. No.	Location	Block	District	Long	Lat	Elev. (m)	Dia (m)	Depth of Well (mbmp)	Initial Water Level July 2015 (mbgl)	W.L. Nov. 2015 (mbgl)	W.L. MAY 2016 (mbgl)
71.	Benipur	Surajgarha	Lakhisarai	86.3381	25.2216	50.5	1.34	10.92	10.01	8.85	10.01
72.	Borna	Surajgarha	Lakhisarai	86.1703	25.1871	44.7	1.04	9.72	8.74	4.75	8.74
73.	Ghoghi	Surajgarha	Lakhisarai	86.3116	25.2034	47.8	1.85	10	8.35	7	8.35
74.	Khaira Masaoni	Surajgarha	Lakhisarai	86.2755	25.1882	46.3	1.96	8.6	6.34	5.9	6.34
75.	Maheshpur	Surajgarha	Lakhisarai	86.3271	25.2294	41	1.42	12	9.42	8	9.42
76.	Manuchak	Surajgarha	Lakhisarai	86.2181	25.2346	48.4	0.9	10.32	7.6	6.95	7.6
77.	Pokhrama	Surajgarha	Lakhisarai	86.2312	25.1889	44.9	2.5	8.6	4.56	5.7	4.56
78.	Karhariya (south)	Bariyarpur	Munger	86.6361	25.2161	38.5	1.85	10.5	8.02		8.02
79.	Ithari	Bariyarpur	Munger	86.5476	25.3103	43.5	2.1	10.25	6.5	6	6.5
80.	Patam	Bariyarpur	Munger	86.5364	25.3216	47.1	1.45	12.12	9.64	6.13	9.64
81.	Mahdeva	Bariyarpur	Munger	86.5841	25.2798	39.9	1.86	12.24	11.56	10.2	11.56
82.	Ratanpur village	Bariyarpur	Munger	86.5515	25.2961	40.5	1.97	10.18	8.18	7	8.18
83.	Bariarpur	Dharhara	Munger	86.5000	25.2667	44.8	1.00	9.90	7.35	6.35	8.65
84.	Etwa/Dasarathpur	Dharhara	Munger	86.4644	25.2634	49.9	1.1	10.15	7.08	4.3	7.08
85.	Orabaicha	Dharhara	Munger	86.4220	25.2539	50.8	1.97	9.3	5.73	4.33	5.73
86.	Rasulpur	Dharhara	Munger	86.3534	25.2963	47.6	1.84	11.86	9.39	5.1	9.39
87.	Khutaha	Dharhara	Munger	86.5396	25.1982	141.3	2.56	9.2	7.8		7.8
88.	Paharpur	Dharhara	Munger	86.4842	25.2810	49.6	1.25	7.82	5.45	5.2	5.45
89.	Jamalpur1	Jamalpur	Munger	86.4917	25.3208	41.4	1.33	8.90	8.38	5.26	6.5
90.	Navlakha	Jamalpur	Munger	86.4912	25.3427	48.1	1.18	11.6	6.02	5.4	6.02
91.	Shivpur	Jamalpur	Munger	86.4006	25.3021	45.8	1.3	9.05	5.33	3.72	5.33
92.	Singhiya chawk	Jamalpur	Munger	86.4169	25.2833	44.7	1.96	17.45	5.00	3.45	5.61
93.	Singhiya punchara	Jamalpur	Munger	86.4068	25.3014	43.2	1.96	8.54	5.84	4.05	5.84
94.	Bhagat chowki	Munger	Munger	86.5520	25.3366	40.4	1.11	8.52	5.08	5.83	5.08
95.	Halimpur	Munger	Munger	86.4744	25.3409	47.9	2.73	9.3	7.47	6.79	7.47

Sl. No.	Location	Block	District	Long	Lat	Elev. (m)	Dia (m)	Depth of Well (mbmp)	Initial Water Level July 2015 (mbgl)	W.L. Nov. 2015 (mbgl)	W.L. MAY 2016 (mbgl)
96.	Chandisthan	Munger	Munger	86.4812	25.3923	42.5	2.14	11.2	9.52	7.4	9.52
97.	Hasanganj	Munger	Munger	86.4783	25.3403	48.7	1.24	15.33	9.82	7.39	9.82
98.	Herudiyara	Munger	Munger	86.4681	25.3528	42.6	1.32	10.59	9.02	6.9	9.02
99.	Nauagarhi	Munger	Munger	86.5319	25.3486	47	1.56	9.75	7.01	5.09	7.01
100.	Purabsarai	Munger	Munger	86.5639	25.4619	43.4	1.90	11.50	4.90	2.77	5.65
101.	Soji ghat	Munger	Munger	86.4668	25.3733	49	2.27	15.44	13.66	8.2	13.66
102.	Sutur Khana	Munger	Munger	86.5063	25.3608	56	2.25	22.5	21.52	9	21.52

Annexure - II

Chemical Analysis Results of Groundwater Samples from the Study Area

S. No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25°C	CO_3^-	HCO_3^-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO_4	SiO_2
1	Begusarai	Bhagwanpur	Dahia	85.0141	25.5384	TW	8.97	266	18	61	21	0.71	23	-bdl-	110	30	8	10	0.9	0.3	10.7
2	Begusarai	Bhagwanpur	Bhardiha	85.9879	25.5492	TW	8.6	526	24	183	21	0.47	28	2.7	210	54	18	18	1.7	0.1	11.1
3	Begusarai	Bhagwanpur	Garhuni	85.9598	25.5668	TW	8.9	446	27	134	21	1.17	23	-bdl-	125	36	8	22	35	-bdl-	7.5
4	Begusarai	Bhagwanpur	Manupur	85.9598	25.5926	TW	8.85	510	30	140	21	0.47	43	24.4	205	34	29	22	-bdl-	-bdl-	14
5	Begusarai	Bhagwanpur	Dohta	85.9897	25.5895	TW	8.1	1221	0	537	117	0.64	3	-bdl-	420	50	71	78	-bdl-	-bdl-	61
6	Begusarai	Bhagwanpur	Jagdishpur	86.0113	25.5794	TW	8.06	1270	0	354	163	1.4	111	-bdl-	490	32	98	52	-bdl-	0.22	11
7	Begusarai	Bhagwanpur	Sanjat (As)	86.0176	25.5970	TW	8.54	455	9	195	14	1	23	-bdl-	200	52	17	8	-bdl-	0.14	7.4
8	Begusarai	Bhagwanpur	Tajpur	86.0169	25.5714	TW	8.4	1154	12	384	74	1.14	116	-bdl-	300	52	41	114	1.9	-bdl-	9.1
9	Begusarai	Bhagwanpur	Narharpur(As)	86.0392	25.5731	TW	8.7	517	33	153	18	0.62	44	-bdl-	185	68	4	25	10.1	-bdl-	8.2
10	Begusarai	Bhagwanpur	Naula	86.0654	25.5581	TW	8.33	1625	18	677	135	1.2	36	-bdl-	525	40	102	130	-bdl-	0.2	14.8
11	Begusarai	Birpur	Pakdi	86.0932	25.5338	TW	8.72	857	15	293	64	0.71	78	-bdl-	385	48	64	25	1.1	0.14	11.8
12	Begusarai	Birpur	Parra(As)	86.0994	25.4952	TW	8.5	660	27	232	32	0.94	18	-bdl-	255	58	26	14	-bdl-	0.17	5.8
13	Begusarai	Birpur	Phulkari	86.1048	25.4860	TW	8.65	524	27	214	14	1.29	14	-bdl-	235	36	35	10	0.9	0.13	9.9
14	Begusarai	Birpur	Kajichak	86.1174	25.4689	TW	8.5	567	21	232	28	0.69	12	-bdl-	255	72	18	9	0.2	0.16	12.2
15	Begusarai	Naokothi	Rajaura	86.1469	25.4651	TW	8.55	634	18	256	25	1.14	33	-bdl-	280	84	17	16	0.9	0.41	13.8
16	Begusarai	Naokothi	Khamhar	86.1457	25.4827	TW	8.78	513	27	189	21	1.28	19	-bdl-	220	46	25	14	0.2	-bdl-	12
17	Begusarai	Naokothi	Mohanpur(As)	86.1318	25.5181	TW	8.37	758	27	439	14	0.71	24	-bdl-	400	84	46	11	-bdl-	-bdl-	12.5
18	Begusarai	Naokothi	Paharchak	86.1412	25.4426	TW	8.07	1010	0	488	46	0.29	17	-bdl-	425	96	44	32	0.6	-bdl-	13.2
19	Lakhisarai	Barhaiya	Barhaiya	86.01986	25.29022	TW		999	0	323	121	0.03	45	26.1	325	26	62	86			
19	Lakhisarai	Barhaiya	Barhaiya	86.01986	25.29022	TW													23.7	-bdl-	2.0
20	Lakhisarai	Barhaiya	Gangasarai	86.02878	25.26278	TW	7.76	979	0	366	89	nd	24	nd	325	38	55	60	13.2	-bdl-	3.9
21	Lakhisarai	Barhaiya	Pratappur	86.04708	25.24025	TW	7.89	796	0	220	35	-bdl-	14	29.8	220	42	28	23	1.4	-bdl-	2.5
22	Lakhisarai	Surajgarha	Rampur	86.14447	25.18400	TW	7.88	1575	0	299	223	-bdl-	19	31.2	450	44	82	78	18.7	-bdl-	5.5

S. No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25°C	CO_3^-	HCO_3^-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO_4	SiO_2
23	Lakhisarai	Surajgarha	Ratanpur	86.20381	25.20739	TW	7.98	1140	0	250	149	-bdl-	51	32.6	100	24	10	200	6.3	-bdl-	5.1
24	Lakhisarai	Surajgarha	Nista	86.22236	25.22797	TW	8.39	757	39	305	14	-bdl-	14	-bdl-	235	30	38	43	18.0	-bdl-	4.9
25	Lakhisarai	Surajgarha	Ramlagar	86.24506	25.25978	TW	8.04	870	0	336	18	-bdl-	19	-bdl-	155	34	17	53	30.3	-bdl-	5.9
26	Lakhisarai	Surajgarha	Abgil Ashimpur	86.26678	25.27131	TW	7.98	706	0	189	60	0.10	35	8.1	235	54	24	16	2.3	-bdl-	1.5
27	Lakhisarai	Surajgarha	Haiwatgnj	86.29714	25.27842	TW	8.08	627	0	305	25	0.01	20	14.4	245	52	28	29	6.8	-bdl-	5.5
28	Lakhisarai	Surajgarha	Medni Chowk	86.32625	25.28797	TW	7.82	1197	0	220	138	0.00	84	32.1	380	108	26	47	10.0	-bdl-	5.0
29	Lakhisarai	Surajgarha	Rasulpur	86.35608	25.29592	TW	8.13	582	0	293	25	0.07	17	-bdl-	215	48	23	35	3.8	-bdl-	6.7
30	Lakhisarai	Surajgarha	Kaswa Basauni	86.37792	25.22681	TW	8.57	396	21	171	21	0.32	10	-bdl-	185	40	20	19	1.8	-bdl-	7.1
31	Lakhisarai	Surajgarha	Abyapur	86.35972	25.22681	TW	8.02	984	0	317	99	-bdl-	15	4.2	175	54	10	100	16.6	-bdl-	7.6
32	Lakhisarai	Surajgarha	Benipur Kaswa	86.33842	25.22169	TW	8.19	1323	0	397	124	0.35	18	33.0	445	38	84	43	1.1	-bdl-	5.6
33	Lakhisarai	Surajgarha	Babua Bazar	86.31789	25.21144	TW	8.23	473	0	207	39	0.00	11	-bdl-	190	48	17	21	0.4	-bdl-	1.6
34	Lakhisarai	Surajgarha	Tali Bishunpur	86.28769	25.19486	TW	8.28	531	0	354	7	0.08	4	-bdl-	220	34	32	34	5.6	-bdl-	4.7
35	Lakhisarai	Surajgarha	Banshipur	86.26997	25.22089	TW	7.82	787	0	323	11	nd	10	-bdl-	190	46	18	40	7.0	-bdl-	5.8
36	Lakhisarai	Surajgarha	Konipar	86.27356	25.23011	TW	8.06	696	0	354	7	nd	12	-bdl-	265	50	34	20	0.4	-bdl-	5.4
37	Lakhisarai	Surajgarha	Manikpur	86.27319	25.23664	TW	8.19	705	0	317	35	nd	17	-bdl-	230	38	32	39	7.5	-bdl-	8.2
38	Lakhisarai	Surajgarha	Purana Sanaipur	86.25300	25.24289	TW	8.37	545	24	244	14	nd	9	-bdl-	170	46	13	48	6.0	-bdl-	6.2
39	Lakhisarai	Lakhisarai	Damodarpur	86.09506	25.14808	TW	8.18	516	0	256	25	nd	3	5.3	190	46	18	28	2.9	0.08	6.9
40	Lakhisarai	Lakhisarai	Khairi	86.10561	25.13658	TW	8.63	329	24	140	11	nd	1	-bdl-	130	18	20	25	3.8	-bdl-	7.7
41	Lakhisarai	Lakhisarai	Sondhi	86.11969	25.09300	TW	8.33	458	21	134	50	0.13	5	-bdl-	150	36	14	28	5.1	-bdl-	7.5
42	Lakhisarai	Lakhisarai	Beldadri	86.15694	25.07658	TW	8.5	400	0	146	39	nd	7	-bdl-	120	40	5	26	4.7	-bdl-	7.7
43	Lakhisarai	Lakhisarai	Makuna	86.08944	25.15589	TW	8.06	386	0	146	32	nd	10	-bdl-	120	38	6	20	2.3	1.45	6.3
44	Lakhisarai	Lakhisarai	Belgudar	86.07908	25.20478	TW	8.04	1202	0	354	188	0.26	31	1.9	350	64	46	103	5.6	-bdl-	2.7
45	Munger	Munger	Munger	86.46753	25.37522	TW	8.19	1036	0	311	82	0.06	14	32.9	300	38	49	52	9.6	-bdl-	0.3
46	Munger	Munger	Hirodiara	86.46508	25.34553	TW	7.91	1071	0	305	71	0.13	20	33.3	285	100	8	50	0.9	-bdl-	4.2
47	Munger	Munger	Kanchangarh	86.50989	25.35211	TW	8.13	585	0	262	21	-bdl-	20	-bdl-	180	38	20	27	3.6	-bdl-	0.4
48	Munger	Munger	Radiabadh	86.52644	25.34764	TW	8.21	546	0	244	25	0.25	14	7.5	190	50	16	27	1.1	-bdl-	0.0

S. No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25°C	CO_3^-	HCO_3^-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO_4	SiO_2
49	Munger	Munger	Nuwagarni	86.53736	25.34492	TW	8.02	1400	0	519	106	-bdl-	20	35.0	510	166	23	51	3.0	-bdl-	3.3
50	Munger	Jamalpur	Dakarnala	86.45939	25.33350	TW	8.16	595	0	323	28	-bdl-	4	-bdl-	215	46	24	38	3.8	-bdl-	4.3
51	Munger	Jamalpur	Farda	86.43686	25.31333	TW	7.91	681	0	348	18	-bdl-	6	-bdl-	220	48	24	34	4.7	-bdl-	6.6
52	Munger	Jamalpur	Saifai	86.49178	25.34089	TW	7.93	1960	0	342	316	-bdl-	19	32.7	510	80	74	124	2.0	-bdl-	5.4
53	Munger	Jamalpur	Singhiya Chowk	86.40689	25.30217	TW	7.89	1146	0	317	131	0.23	24	33.2	200	60	12	114	17.8	-bdl-	4.5
54	Munger	Dharhara	Shivkund Sarapatti	86.40517	25.29044	TW	8.13	928	27	299	117	0.21	18	-bdl-	310	48	46	66	11.0	-bdl-	4.9
55	Munger	Dharhara	Sunderpur	86.37033	25.30208	TW	8.54	1133	36	305	142	0.07	62	28.3	385	76	47	94	7.9	-bdl-	8.7
56	Munger	Dharhara	Baha Chowki	86.35808	25.29667	TW	8.63	895	0	360	64	0.33	50	-bdl-	245	34	38	86	9.3	-bdl-	5.5
57	Munger	Dharhara	Mongaon	86.41275	25.26289	TW	8.29	767	0	366	53	-bdl-	13	-bdl-	230	56	22	73	3.1	-bdl-	4.8
58	Munger	Dharhara	Darhara	86.41406	25.25722	TW	8.1	914	0	268	96	-bdl-	20	31.5	265	72	20	80	2.3	-bdl-	2.5
59	Munger	Dharhara	Aura Bagicha	86.42906	25.25794	TW	7.36	1196	0	281	170	-bdl-	4	32.0	300	80	24	94	15.1	-bdl-	2.9
60	Munger	Dharhara	Adalpur	86.44447	25.26019	TW	7.74	998	0	323	78	0.42	17	33.4	290	98	11	52	12.1	-bdl-	3.6
61	Munger	Dharhara	Ballan	86.46458	25.26408	TW	7.83	307	0	153	21	0.35	5.1	7.1	125	30	12	16	0.8	-bdl-	4.2
62	Munger	Bariarpur	Nimiya Tola	86.48006	25.27433	TW	7.51	1002	0	250	110	0.15	10	33.8	215	70	10	88	2.7	-bdl-	5.3
63	Munger	Bariarpur	Brahmsthan	86.57156	25.30083	TW	7.45	1634	0	482	170	0.30	19.0	35.7	505	156	28	80	7.3	-bdl-	8.0
64	Munger	Bariarpur	Neerpur	86.59242	25.27119	TW	7.79	1008	0	506	39	0.02	18.6	-bdl-	365	62	50	51	13.1	-bdl-	7.9
65	Munger	Bariarpur	Phulkia	86.43928	25.26119	TW	7.37	1284	0	244	142	-bdl-	21.3	35.9	340	112	14	61	1.2	-bdl-	6.3
66	Munger	Bariarpur	Kalyanpur	86.61436	25.25319	TW	7.81	675	0	262	39	0.04	10.7	21.7	195	58	12	33	5.0	-bdl-	2.6
67	Munger	Bariarpur	Ghor Ghat	86.63708	25.24456	TW	7.79	816	0	323	53	-bdl-	7.1	-bdl-	230	54	23	45	5.3	0.18	3.8
68	Bhagalpur	Sultanganj	Fatehpur	86.66681	25.22567	TW	7.65	1196	0	342	117	0.51	38.4	36.0	390	76	48	54	7.0	-bdl-	4.1
69	Bhagalpur	Sultanganj	Gangania	86.67569	25.23872	TW	7.73	897	0	250	71	0.78	3.9	34.3	265	92	8	33	1.9	-bdl-	7.5
70	Bhagalpur	Sultanganj	Jhangira	86.70742	25.24256	TW	7.7	847	0	262	35	0.06	17	33.3	185	62	7	48	6.3	-bdl-	7.2
71	Bhagalpur	Sultanganj	Dilgauri Modh	86.74706	25.24625	TW	7.56	1147	0	281	156	-bdl-	23	35.2	330	114	11	77	1.3	-bdl-	5.2
72	Bhagalpur	Sultanganj	Nawada	86.76258	25.24653	TW	7.7	548	0	293	11	0.09	7	18.7	235	58	22	19	1.7	-bdl-	4.1
73	Bhagalpur	Sultanganj	Tilak Nagar	86.76197	25.24033	TW	7.91	503	0	275	28	0.40	4	-bdl-	190	42	20	37	6.8	-bdl-	11.4
74	Bhagalpur	Sultanganj	Bhavnath Pur	86.86158	25.23556	TW	7.61	1277	0	305	96	0.30	19	36.6	370	82	40	42	9.1	-bdl-	5.9

Annexure – III A

Wells with elevated As level (10 – 50 ppb)

S. No.	District	Block	Villages/Location	Long	Lat	Source	As (10-50 ppb)
1	Begusarai	Barauni	Badalpur Chowk	86.0150	25.4501	TW	10
2	Begusarai	Matihani	Nayagaon	86.1930	25.3638	TW	47
3	Begusarai	Matihani	Balhapur	86.2262	25.3552	TW	13
4	Begusarai	Begusarai	Khatupur Morh	86.3336	25.6222	TW	24
5	Begusarai	Begusarai	Begusarai Durga Asthan	86.1389	25.4406	TW	22
6	Beguasarai	Beguasarai	Birkumar Chowk Begusarai	86.0709	25.4194	TW	15
7	Beguasarai	Beguasarai	Begusarai fc/ib	86.1375	25.3792	TW	21
8	Beguasarai	Beguasarai	Mohanpur usrai	86.1328	25.5075	TW	14
9	Basantpur	Chautham	Khagaria	86.5883	25.5033	TW	11
10	Khagaria	Gogri	Mushkipur Bhuri Atari	86.6768	25.4165	TW	42
11	Khagaria	Gogri	Chakla	86.7136	25.3996	TW	45
12	Khagaria	Gogri	Pitaunjhia (anganbari)	86.6968	25.4127	TW	33
13	Khagaria	Gogri	Gauchari	86.6834	25.4393	TW	14
14	Khagaria	Gogri	Gauchari basti	86.6846	25.4478	TW	14
15	Khagaria	Khagaria	Harijantola Choti Kothiya	86.6344	25.5728	TW	20
16	Khagaria	Khagaria	Kumar chakki	86.4168	25.3390	TW	25
17	Khagaria	Parbatta	Baisa	86.7185	25.3527	TW	13
18	Khagaria	Parbatta	Temtha	86.9664	25.3958	TW	31
19	Khagaria	Parbatta	Sirajpur	86.7606	25.3639	TW	23
20	Khagaria	Parbatta	Srirampur thuthe	86.8369	25.4636	TW	17
21	Khagaria	Sahebpur kamal	Pancbir bazar	86.3829	25.4093	TW	26
22	Khagaria	Sahebpur kamal	Bhaloria	86.4130	25.4036	TW	18
23	Lakhisarai	Surajgarha	Rampur	86.4178	25.1954	TW	50
24	Lakhisarai	Barhaiya	Tarfar	86.0192	25.2911	TW	16
25	Lakhisarai	Pipariya	Surji chak	86.1658	25.2138	TW	43

Annexure – III B

Wells with elevated As level (> 50 ppb)

S. No.	District	Block	Villages/Location	Long	Lat	Source	As (>50 ppb)
1	Bhagalpur	Birpur	Marwa	86.9222	25.3988	TW	140
2	Begusarai	Barauni	Bihat	86.0138	25.4574	TW	52
3	Begusarai	Sahebpur kamal	Gyantoli	86.4168	25.4114	TW	409
4	Begusarai	Sahebpur kamal	Phulmalik	86.4304	25.4168	TW	123
5	Khagaria	Gogri	Gandhi nagar	86.665	25.4461	TW	76
6	Khagaria	Gogri	Gogri hospital compound	86.6539	25.4222	TW	67
7	Khagaria	Gogri	Pitunjia	86.678	25.4001	TW	180
8	Khagaria	Parbatta	Mareia	86.7244	25.5425	TW	261
9	Khagaria	Parbatta	Aguania	86.7286	25.4608	TW	69

Annexure – IV

Summarised VES Results

Sr. No.	District	Block	Location	Long.	Lat.	Elev. (m)	AB (m)	r1	r2	r3	r4	r5	r6	h1	h2	h3	h4	h5	h6	H	Topo sheet No.
1	Begusarai	Begusarai	Olao	86.0974	25.4023	44	600	11	9506	9	49			1	0.3	4.66	190			195.96	72 K/3
2	Begusarai	Mathani	Ramdhiri-II	86.0978	25.3666	45.6	700	27	720	47				2.45	2.54	220				224.99	72 K/3
3	Begusarai	Mathani	Ramdhiri-I	86.1236	25.3797	44.9	800	140	1396	84	46			2.15	2.36	14.5	240			259.01	72 K/3
4	Begusarai	Mathani	Maithani	86.1520	25.3692	45.8	800	48	21	41				1.2	4.03	250				255.23	72 K/3
5	Begusarai	Mathani	Bagdodh	86.2111	25.3732	44.2	700	15	107	34	63			1.7	25.4	50.7	150			227.8	72 K/3
6	Begusarai	Begusarai	Bagwara	86.1112	25.4667	43	700	58	27	851	10	78		2.9	2.64	9.71	26.5	190		231.75	72 K/3
7	Begusarai	Mathani	Safapur	86.2345	25.3859	44.3	800	82	12	58	49			1.2	1.29	93.86	170			266.35	72 K/3
8	Begusarai	Begusarai	Ramjanpur	86.1976	25.4125	45	700	47	11	79	30			1.2	9	76.3	140			226.5	72 K/3
9	Begusarai	Balia	Inliyar	86.2543	25.4001	44.6	800	76	639	60				1	18.6	240				259.6	72 K/7
10	Begusarai	Balia	Kasba	86.3121	25.4380	42.3	800	17	64	44				3.82	9.87	250				263.69	72 K/7
11	Begusarai	Balia	Sadanadapur	86.2842	25.4007	42.6	800	71	509	64				1	18	240				259	72 K/7
12	Begusarai	Balia	Husain Diyara	86.2658	25.3683	44	800	109	534	59				1	35.8	220				256.8	72 K/7
13	Begusarai	Balia	Paharpur	86.2850	25.3880	43.4	800	39	243	48	70			1.2	21.4	74	160			256.6	72 K/7
14	Begusarai	Balia	Gokhelinagar Bishanpur	86.3110	25.3747	43.3	800	178	394	71				1	18.8	240				259.8	72 K/7
15	Begusarai	Begusarai	Kausamaut	86.2378	25.4535	43.5	800	11	116	48				1.2	9.6	250				260.8	72 K/3
16	Begusarai	Sahebpur kamal	Manarigachi	86.3439	25.4098	48.2	600	63	22	54				2.4	9.88	180				192.28	72 K/7
17	Begusarai	Sahebpur kamal	Samastipur	86.4046	25.4115	39.3	800	33	519	55				1.68	17.5	240				259.18	72 K/7
18	Begusarai	Sahebpur kamal	Sahana Nayatola	86.3720	25.4213	41.3	800	26	81	66				1.13	14.19	250				265.32	72 K/7
19	Begusarai	Begusarai	Begusarai	86.1585	25.4291	45.5	800	76	15	59	23			4.48	4.65	184				193.13	72 K/3
20	Begusarai	Sahebpur kamal	Chauki	86.4164	25.4673	39.9	800	51	18	42	54			2.31	1.58	47.46	200			251.35	72 K/7
21	Begusarai	Sahebpur kamal	Saraiya	86.4353	25.4534	40.7	800	111	449	72				2.24	13.1	250				265.34	72 K/7
22	Begusarai	Sahebpur kamal	Malhipur	86.4446	25.4266	45	600	32	210	7	41	90		1	0.86	2.17	57.9	130		191.93	72 K/7
23	Munger	Dharhara	Mangarh	86.4099	25.2652	40.9	350	3	8	14	8	167		1	13.9	68.8	77.6	38		199.3	72K/7

Sr. No.	District	Block	Location	Long.	Lat.	Elev. (m)	AB (m)	r1	r2	r3	r4	r5	r6	h1	h2	h3	h4	h5	h6	H	Topo sheet No.
24	Munger	Dharhara	Adalpur	86.4498	25.2617	43.3	350	37	3	13	10	101		1.2	1.23	24.5	126	47		199.93	72K/7
25	Munger	Dharhara	Dariyapur	86.4817	25.2858	48.3	350	14	12	7	140			2.5	40.3	105	52			199.8	72K/7
26	Munger	Sultangunj	Gangania	86.6671	25.2374	39.5	230	10	8	22				7.6	13.2	110				130.8	72K/12
27	Munger	Bariyarpur	Kalyanpur	86.6170	25.2503	38.3	350	12	10	160				2.4	86.4	111				199.8	72K/11
28	Munger	Bariyarpur	Bangalitola	86.6269	25.2402	37.5	350	3	81	9	1626			1.2	3.9	83	111			199.1	72K/12
29	Munger	Dharhara	Paisra	86.3895	25.2022	58.6	300	8	22	2	12	298		1.2	1.3	3.6	18.3	147		171.4	72K/8
30	Munger	Dharhara	Bangalwa	86.4379	25.1988	71.1	350	70	13	175				1.6	50.4	148				200	72K/8
31	Munger	Dharhara	Baurna	86.4507	25.2183	57.1	300	7	334	9	332			1.2	1.5	16.1	152			170.8	72K/8
32	Munger	Dharhara	Barmasiya	86.4781	25.2441	59.4	230	10	17	108				13.3	57.5	60				130.8	72K/8
33	Munger	Bariyarpur	Bariyapur	86.5709	25.2716	39	350	8	11	151				1	31.4	167				199.4	72K/11
34	Munger	Bariyarpur	Patam	86.5327	25.2914	49	300	22	10	169				1.4	73.5	96				170.9	72K/11
35	Munger	Bariyarpur	Nauwagarchi	86.5450	25.3303	43.7	300	9	12	154				1	112	58				171	72K/11
36	Munger	Dharhara	Kalayanchak	86.5234	25.1986	251.4	350	16	8	117				2.5	18.7	178				199.2	72K/12
37	Munger	Jamalpur	Faridpur	86.4675	25.3027	45	400	2	30	6	19	5	103	1.2	1.3	8.3	18.3	106	93	228.1	72K/7
38	Munger	Jamalpur	Daulatpur	86.4776	25.3254	46.2	300	11	4	12	4	126		3	1	55	70	42		171	72K/7
39	Munger	Jamalpur	Haripur	86.4944	25.3509	46.5	350	20	13	96	5	10	421	1.7	42.9	16.5	36	27.5	75	199.6	72K/7
40	Munger	Dharhara	Lagma	86.3899	25.3005	43.2	400	8	11	38				1	22.5	205				228.5	72K/7
41	Munger	Munger	Hasalganj	86.4710	25.3447	44.4	400	16	11	14	7	108		2	14	25.1	66.9	120		228	72K/7
42	Khagaria	Khagaria	Kauniya	86.3336	25.5847	38.8	350	51	17	174	14	164		3.6	2.9	14.4	30.2	27.3	148	226.4	72K/6
43	Khagaria	Khagaria	Rahima	86.3389	25.5553	38.4	400	29	67	33	96	2921		1.3	9.9	5.37	342			358.57	72K/6
44	Khagaria	Khagaria	Barial	86.3004	25.5763	38.2	400	16	72	182	61			2.2	42.3	25.9	23.7	134		228.1	72K/6
45	Khagaria	Khagaria	Belagunj	86.3185	25.5328	41.3	350	23	254	13	353	17	2956	2.7	3.1	6.7	27.4	83.7	76	199.6	72K/6
46	Khagaria	Khagaria	Sadanandpur	86.3617	25.5279	38.3	400	27	19	86				1	10.5	217				228.5	72K/6
47	Khagaria	Khagaria	Saraidih	86.4071	25.5163	39.7	400	14	49	229	67			2.2	32.7	21.8	171			227.7	72K/6
48	Khagaria	Khagaria	Chainpur kurd	86.3821	25.5579	38.6	400	39	188	31	168	51	2478	2.1	4	11	32.7	231		280.8	72K/6
49	Khagaria	Khagaria	Sanhauli	86.4768	25.5325	41.6	400	101	11	71	278	16	634	1	1.6	14.6	25.5	64.9	120	227.6	72K/6

Sr. No.	District	Block	Location	Long.	Lat.	Elev. (m)	AB (m)	r1	r2	r3	r4	r5	r6	h1	h2	h3	h4	h5	h6	H	Topo sheet No.
50	Khagaria	Khagaria	Sabalpur	86.4853	25.5484	38.1	400	11	50	250	24	641		2.1	20.5	35.1	103	67		227.7	72K/6
51	Khagaria	Mansi	Matihani	86.5613	25.5258	41.9	450	17	284	12	3865			17.6	27.9	72.5	139			257	72K/10
52	Khagaria	Gogri	Hardaytola	86.5977	25.4864	40.2	400	26	12	50				2	3.3	223				228.3	72K/11
53	Khagaria	Gogri	Baurna	86.6302	25.4373	38.1	400	21	7	16	329	10	1457	1	1.6	14	25.5	64.9	121	228	72K/11
54	Khagaria	Gogri	Jamalpur	86.6424	25.4054	39.7	400	37	59	19	50			3.3	5.1	3.84	216			228.24	72K/11

Annexure - V

National Aquifer Mapping (NAM) Exploration Details
(as per 12 point progress format in Aquifer Mapping manual)

Unique ID	1
Village	**Herudiara**
Taluka/Block	Munger
District	Munger
Toposheet No.	72K/7
Lat	25.3619
Long	86.4747
RL (m amsl)	52.6
Drilled Depth	116.95 mbgl
Casing	116.5
SWL (m bgl)	6.18 mbgl
Discharge (lps)	160.7
Date/Year	October-88

Depth range (m bgl)		Thickness (m)	Litholog
From	**To**		
0	57.60	57.60	Clay
57.60	61.60	4	Fine to medium sand
61.60	63.60	2	Clay
63.60	75.60	12	Fine to medium sand
75.60	90.60	15	Clay
90.60	91.60	1	Fine to medium sand
91.60	96.80	5.20	Clay
96.80	99.80	3	Fine to medium sand
99.80	105.90	6.1	Clay
105.90	109.00	3.1	Fine to medium sand
109.00	111.00	2	Clay
111.00	114.00	3	Fine to medium sand
114.00	116.95	2.95	Clay

Unique ID	2
Village	**Sultanganj**
Taluka/Block	Sultanganj
District	Begusarai
Toposheet No.	72K/12
Lat	25.24028
Long	86.74333
RL (m amsl)	41.7
Drilled Depth	157.95 m.b.g.l
Casing	
SWL (m bgl)	
Discharge (lps)	
Date/Year	

Depth range (m bgl)		Thickness (m)	Litholog
From	**To**		
0	10	10	Clay
10	15	5	Sand
15	78	63	Clay
78	109	31	Sand
109	138	29	Clay
138	150	12	Sand
150	157.95	7.95	Hard Rock

Unique ID	3
Village	**Akbarnagar**
Taluka/Block	Sultanganj
District	Bhagalpur
Toposheet No.	72K/16
Lat	25.23333
Long	86.83333
RL (m amsl)	39
Drilled Depth	
Casing	
SWL (m bgl)	
Discharge (lps)	
Date/Year	-

Depth range (m bgl)		Thickness (m)	Litholog
From	**To**		
0	92.3	92.3	Clay
92.3	156.7	64.4	Sand
156.7	163.1	6.4	Clay
163.1	176.1	13	Sand
176.1	177	0.9	Hard rock

Annexure – VII

Dynamic Ground Water Resources of Blocks under Phase III (as on 31st March, 2013)

Sl. No.	Blocks	Recharge from Rainfall during Monsoon season (ham)	Recharge from Rainfall during Non Monsoon season (ham)	Recharge from Other Sources during 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)	Existing Gross Ground Water Draft for irrigation (ham)	Existing Gross Ground water Draft for Domestic and Industrial Water Supply (ham)	Existing Gross Ground Water Draft for All Uses (ham)	Provision for Domestic and Industrial Requirement for Next 25 years (ham)	Net GW Availability for Future Irrigation Development (ham)	Stage of Ground Water Development (ham)	Category: Safe / Semi-critical/ Critical/ Over-exploited
1	Balia	3494.35	566.64	598.39	761.26	5420.64	542.06	4878.58	2894.60	642.24	3536.84	107.00	1876.98	72.50	Safe
2	Begusarai	5213.83	845.46	921.13	1972.32	8952.74	895.27	8057.47	3245.80	1077.37	4323.17	316.00	4495.67	53.65	Safe
3	Matihani	4148.26	672.67	156.06	522.45	5499.44	549.94	4949.50	514.00	269.38	783.38	90.00	4345.50	15.83	Safe
4	Shamho	1543.92	250.36	182.09	609.61	2585.98	258.60	2327.38	1606.80	129.45	1736.25	18.00	702.58	74.60	Safe
5	Sahebpur Kamal	3389.20	549.59	301.07	237.93	4477.79	447.78	4030.01	736.00	346.61	1082.61	114.00	3180.01	26.86	Safe
6	Sultanganj	5483.38	993.60	59.55	67.15	6603.68	660.37	5943.31	613.50	360.22	973.72	117.00	5212.81	16.38	Safe
7	Gogari	6491.88	1034.18	388.04	2198.92	10113.02	1011.30	9101.72	3128.80	826.77	3955.57	185.00	5787.92	43.46	Safe
8	Khagaria	6266.26	1083.97	156.36	886.02	8392.61	419.63	7972.98	1056.40	670.52	1726.92	223.00	6693.58	21.66	Safe
9	Parbatta	6251.46	995.88	292.63	1658.21	9198.18	919.82	8278.36	4175.20	598.18	4773.38	143.00	3960.16	57.66	Safe
10	Barahia	5918.51	832.62	552.22	232.22	7535.57	753.56	6782.01	976.20	421.27	1397.47	72.00	5733.81	20.61	Safe
11	Lakhisarai	4262.72	599.68	966.84	315.84	6145.08	614.51	5530.57	1871.20	395.37	2266.57	106.00	3553.37	40.98	Safe
12	Piparia	1433.59	201.68	135.25	67.25	1837.77	183.78	1653.99	650.00	82.00	732.00	19.00	984.99	44.26	Safe
13	Surajgarha	3237.67	455.48	702.61	183.61	4579.37	457.94	4121.43	714.80	175.33	890.13	52.00	3354.63	21.60	Safe
14	Bariarpur	3324.95	509.20	331.21	125.54	4290.90	429.09	3861.81	395.00	178.35	573.35	52.00	3414.81	14.85	Safe
15	Dharhara	6400.03	980.14	829.72	628.51	8838.40	883.84	7954.56	1732.90	269.53	2002.43	67.00	6154.66	25.17	Safe
16	Jamalpur	1528.44	234.08	233.13	152.82	2148.47	214.85	1933.62	639.80	278.10	917.90	86.00	1207.82	47.47	Safe
17	Munger	2158.91	385.73	526.91	217.60	3289.15	164.46	3124.69	446.00	266.23	712.23	84.00	2594.69	22.79	Safe

(Values in ham)

BLOCK WISE

AQUIFER MAPS AND MANAGEMENT PLANS

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2): **BALLIA**(149 sq. Km.)

District/ State: Begusarai/Bihar

Rainfall and Temperature

Normal annual rainfall of Begusarai district is 1104.9 mm of which 80.46% occurs during the monsoon season. The normal rainfall during monsoon season is 889.05 mm and during non-monsoon season is 213.35 mm.The variation of rainfall in this zone is from 1040 mm to 1450 mm and the temperature varies from 36.6 to 7.7˚C.

Agriculture and Irrigation

Ballia block falls in the Agro-climatic Zone I. The cropping sequence followed in this zone isRice – Wheat, Rice – Rai, Rice – Sweet Potato, Rice – Maize (Rabi), Maize – Wheat, Maize – Sweet Potato, Maize – Rai, Rice – Lentil, Rice-linseed. The soils in this zone are sandy loam, loam with pH in the range of 6.5 – 8.4. The gross irrigated area is 95.16sq .Km and ground water dependency is 99%.

Ground Water Resource Availability and Extraction

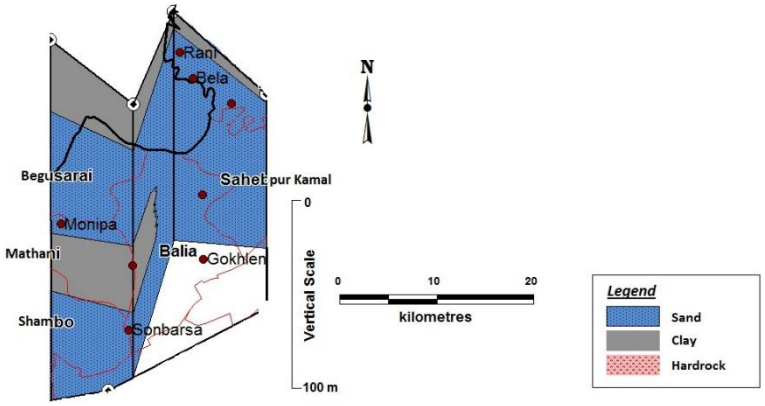
Dynamic ground water resource of Ballia Block has been assessed as 48.79 MCM. The gross ground water draft for all uses stands at 35.36 MCM. The stage of Development is 72.5%.

Water Level Behaviour

Depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In few parts of the block, the water level goes down below 10 mbgl. In post monsoon season,the depth to water level varies from 5 to 10 mbgl in some parts and 2 to 5 mbgl in some parts.

2. Aquifer Disposition

Mono-aquifer system has been observed in Ballia block. Section depicting the aquifer disposition is shown below.

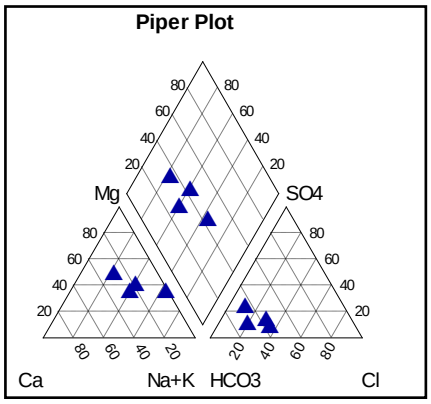


Ground Water Resource, Extraction, Contamination and Other Issues

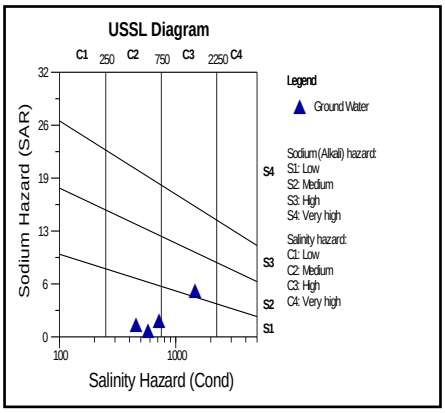
Sufficient scope exists for groundwater development in the block. However, Arsenic contamination of groundwater has been reported from the area. As the area is represented by mono-aquifer system down to investigated depth of 300m, there is no alternate groundwater source. Hence, groundwater development in the area should be done with caution. Though, deeper part of the aquifer is relatively arsenic free, with continued development sufficient chance exists for its getting contaminated. Hence, only the top part of the aquifer should be developed along with measures of conjunctive uses. Arsenic treatment plant may be installed for drinking water sources.

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper plot



USSL diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Other development of the aquifer is may be restricted within 30m.

Dynamic Ground Water Resource (as on 31st March, 2013)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non-Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non-Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Begusarai	Balia	3494.35	566.64	598.39	761.26	5420.64	542.06	4878.58	2894.60	642.24	3536.84	107.00	1876.98	72.50	Safe

Result of Chemical Analysis of Ground Water Samples

Sl. No.	District	Block	Location	Latitude	Longitude	pH	EC	TDS	TH	Ca	Mg	Na	K	CO3	HCO3	Cl
1	Begusarai	Balia	Pokharia	25.41	86.2464	7.76	495	321.75	225	22	41	12	1	0	262	18

(Source: NHS data)

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2): **BEGUSARAI**(222 Sq. Km.)

District/ State Begusarai/Bihar

Rainfall and Temperature

Normal annual rainfall of Begusarai district is 1104.9 mm of which 80.46% occurs during the monsoon season. The normal rainfall during monsoon season is 889.05 mm and during non-monsoon season is 213.35 mm.The variation of rainfall in this zone is from 1040 mm to 1450 mm and the temperature varies from 36.6 to 7.7˚C.

Agriculture and Irrigation

Begusarai block falls in the Agro-climatic Zone I. The cropping sequence followed in this zone isRice – Wheat, Rice – Rai, Rice – Sweet Potato, Rice – Maize (Rabi), Maize – Wheat, Maize – Sweet Potato, Maize – Rai, Rice – Lentil, Rice-linseed. The soils in this zone are sandy loam, loam with pH in the range of 6.5 – 8.4. The gross irrigated area is 116.10sq.Km and ground water dependency on irrigation is 99%.

Ground Water Resource Availability and Extraction

Dynamic ground water resource of Begusarai Block has been assessed as 80.57 MCM. The gross ground water draft for all uses stands at 43.23 MCM. The stage of Development is 53.65%.

Water Level Behaviour

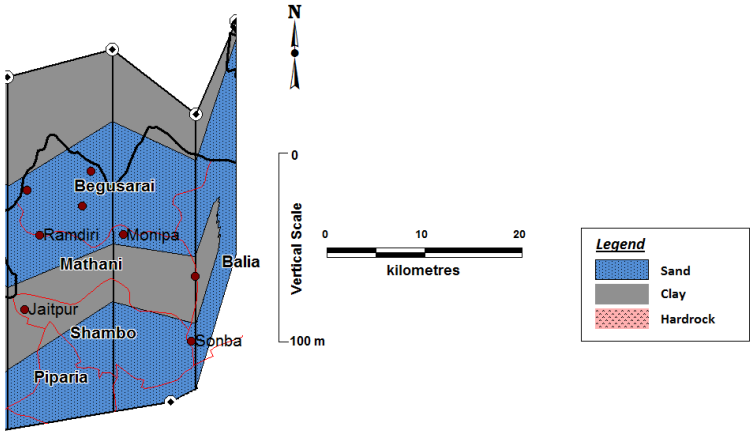
Depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from 5 to 10 mbgl in some parts and 2 to 5 mbgl in some.

2. Aquifer Disposition

Begusarai block is bestowed with mono- aquifer system. The section depicting the aquifer disposition is shown below.

Ground water resource, extraction, contamination and other issues

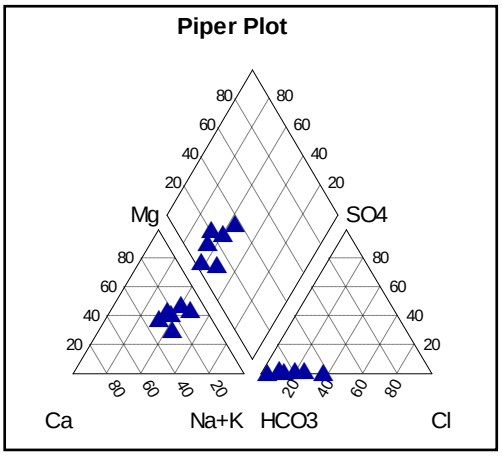
The overall stage of groundwater development in the Block is 53.65%. Sufficient scope exists for groundwater development in the block. However, Arsenic contamination of groundwater has been reported from the area. As the area is represented by mono-aquifer system down to investigated depth of 300m, there is no alternate groundwater source. Hence, groundwater development in the area should be done with caution. Though, deeper part of the aquifer is relatively arsenic free, with continued development sufficient chance exists for its getting contaminated. Hence, only the top part of the aquifer should be developed along with measures of conjunctive uses. Arsenic treatment plant may be installed for drinking water sources.



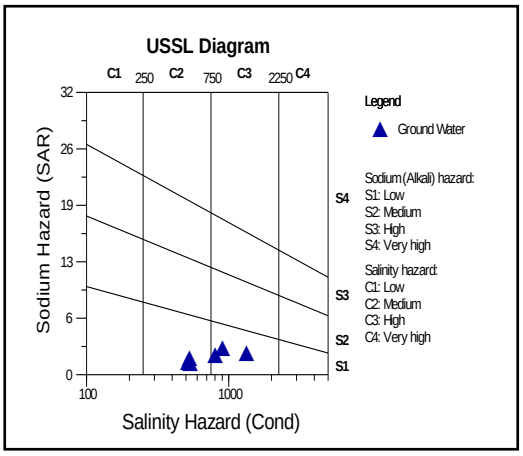
Aquifer Disposition Map

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper Plot



USSL diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Other development of the aquifer is may be restricted within 30m.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Begusarai	Begusarai	5213.83	845.46	921.13	1972.32	8952.74	895.27	8057.47	3245.80	1077.37	4323.17	316.00	4495.67	53.65	**Safe**

Result of Chemical Analysis of Ground Water Samples

Sl.	District	Block	Location	Latitude	Longitude	pH	EC	TDS	TH	Ca	Mg	Na	K	CO3	HCO3	Cl
1	Begusarai	Begusarai	Begusarai	25.4478	86.0278	8.6	1526	991.9	200	10	42	252	3	90	494	145
2	Begusarai	Begusarai	Gopalpur	25.4417	86.2028	7.94	1004	652.6	390	46	66	39	6	0	366	89
3	Begusarai	Begusarai	Haridia	25.4547	86.1422	7.61	878	570.7	220	24	38	88	6	0	299	106
4	Begusarai	Begusarai	Kaithma	25.3886	86.1481	7.6	543	352.95	240	20	46	19	1	0	317	11
5	Begusarai	Begusarai	Lakho	25.4139	86.1778	7.63	1191	774.15	325	28	61	117	1	0	427	149

(Source: NHS data)

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2): **MATIHANI** (177 Sq. km.)

District/ State: Begusarai/Bihar

Rainfall and Temperature

Normal annual rainfall of Begusarai district is 1104.9 mm of which 80.46% occurs during the monsoon season. The normal rainfall during monsoon season is 889.05 mm and during non-monsoon season is 213.35 mm.The variation of rainfall in this zone is from 1040 mm to 1450 mm and the temperature varies from 36.6 to 7.7˚C.

Agriculture and Irrigation

Matihani block falls in the Agro-climatic Zone I. The cropping sequence followed in this zone isRice – Wheat, Rice – Rai, Rice – Sweet Potato, Rice – Maize (Rabi), Maize – Wheat, Maize – Sweet Potato, Maize – Rai, Rice – Lentil, Rice-linseed. The soils in this zone are sandy loam, loam with pH in the range of 6.5 – 8.4. The gross irrigated area is 113.20sq.Km and dependency on ground water for irrigation is 99%.

Ground Water Resource Availability and Extraction

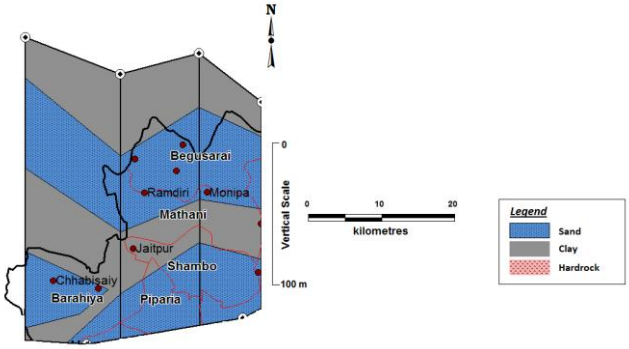
Dynamic ground water resource of Matihani Block has been assessed as 49.50 MCM. The gross ground water draft for all uses stands at 78.34 MCM. The stage of Development is 15.83%.

Water Level Behaviour

Depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from 5 to 10 mbgl in some parts and 2 to 5 mbgl in some parts.

2. Aquifer Disposition

Matihani block is bestowed with mono- aquifer system. The section depicting the aquifer disposition is shown below.

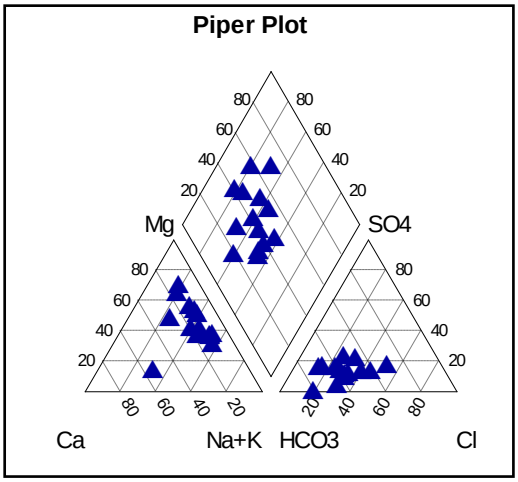


Ground Water Resource, Extraction, Contamination and Other Issues

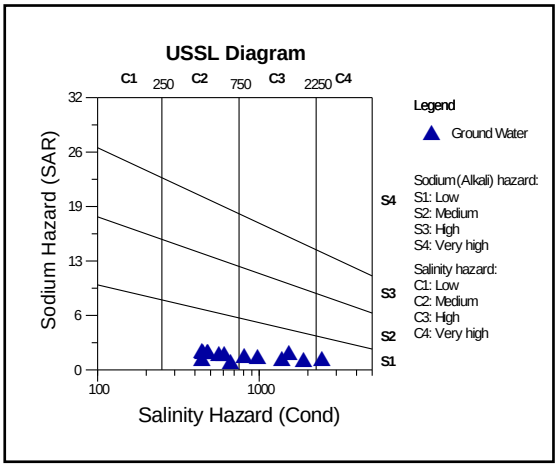
The overall stage of groundwater development in the Block is 15.83%. Sufficient scope exists for groundwater development in the block. However, Arsenic contamination of groundwater has been reported from the area. As the area is represented by mono-aquifer system down to investigated depth of 300m, there is no alternate groundwater source. Hence, groundwater development in the area should be done with caution. Though, deeper part of the aquifer is relatively arsenic free, with continued development sufficient chance exists for its getting contaminated. Hence, only the top part of the aquifer should be developed along with measures of conjunctive uses. Arsenic treatment plant may be installed for drinking water sources.

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper Plot



USSL diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Other development of the aquifer is may be restricted within 30m.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non-Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Begusarai	Matihani	4148.26	672.67	156.06	522.45	5499.44	549.94	4949.50	514.00	269.38	783.38	90.00	4345.50	15.83	Safe

Result of selpmaS retaW dnuorG fo sisylanA lacimehC

Sl. No.	District	Block	Location	Latitude	Longitude	pH	EC	TDS	TH	Ca	Mg	Na	K	CO3	HCO3	Cl
1	Begusarai	Matihani	Begusarai fc/ib	25.3792	86.1375	7.62	812	527.8	150	24	22	99	0	0	317	53
2	Begusarai	Matihani	Matihani	25.4306	86.1292	7.74	475	308.75	185	28	28	19	3	0	214	25

(Source: NHS data)

Block wise
Aquifer Maps and Management plans

1. Salient Information

Name of the Block and Area(in Km^2) **SAHEBPUR KAMAL**(144 Sq. km.)

District/ State Begusarai/Bihar

Rainfall and Temperature

Normal annual rainfall of Begusarai district is 1104.9 mm of which 80.46% occurs during the monsoon season. The normal rainfall during monsoon season is 889.05 mm and during non-monsoon season is 213.35 mm.The variation of rainfall in this zone is from 1040 mm to 1450 mm and the temperature varies from 36.6 to 7.7˚C.

Agriculture and Irrigation

Sahebpur kamalblock falls in the Agro-climatic Zone I. The cropping sequence followed in this zone isRice – Wheat, Rice – Rai, Rice – Sweet Potato, Rice – Maize (Rabi), Maize – Wheat, Maize – Sweet Potato, Maize – Rai, Rice – Lentil, Rice-linseed. The soils in this zone are sandy loam, loam with pH in the range of 6.5 – 8.4. The gross irrigated area is 92.46sq.Km and dependency on ground water for irrigation is 99%.

Ground Water Resource Availability and Extraction

Dynamic ground water resource of Sahebpur Kamal Block has been assessed as 40.30 MCM. The gross ground water draft for all uses stands at 10.83 MCM. The stage of Development is 26.86%.

Water Level Behaviour

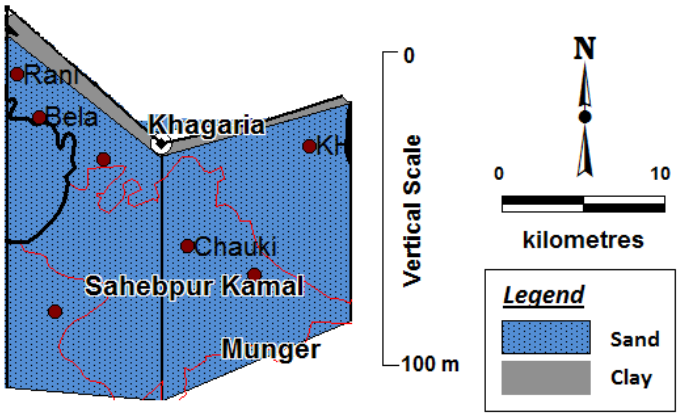
Depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In few parts of the block, the water level goes down below 10 mbgl. In post monsoon season,the depth to water level varies from 5 to 10 mbgl.

Ground Water Resource, Extraction, Contamination and Other Issues

The overall stage of groundwater development in the Block is 26.86%. Sufficient scope exists for groundwater development in the block. However, Arsenic contamination of groundwater has been reported from the area. As the area is represented by mono-aquifer system down to investigated depth of 300m, there is no alternate groundwater source. Hence, groundwater development in the area should be done with caution. Though, deeper part of the aquifer is relatively arsenic free, with continued development sufficient chance exists for its getting contaminated. Hence, only the top part of the aquifer should be developed along with measures of conjunctive uses. Arsenic treatment plant may be installed for drinking water sources.

2. Aquifer Disposition

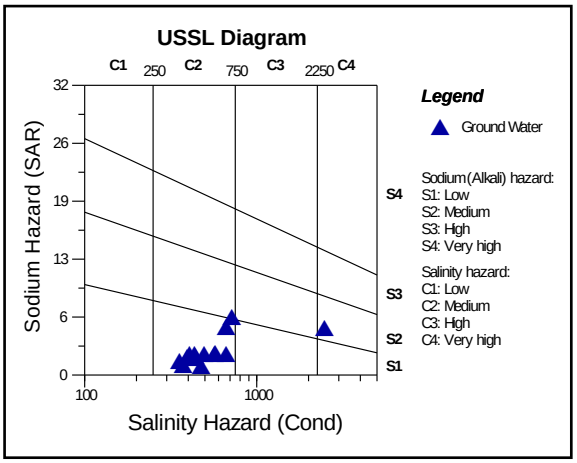
Area is bestowed with mono- aquifer system. The section depicting the aquifer disposition is shown below.



2D-aquifer disposition

Chemical Quality of Ground Water and Contamination

On the basis of USSL diagram suitable for irrigational purposes.



USSL diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Other development of the aquifer is may be restricted within 30m.

Table 1:Dynamic Ground Water Resource (as on 31st March, 2013)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non-Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Begusarai	Sahebpur Kamal	3389.20	549.59	301.07	237.93	4477.79	447.78	4030.01	736.00	346.61	1082.61	114.00	3180.01	26.86	Safe

Result of Chemical Analysis of Ground Water Samples

S.No	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25	HCO 3-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO4	SiO2
1	Begusarai	Naokothi	Rajaura	86.146	25.465	TW	8.55	634	256	25	1.14	33	0	280	84	17	16	0.9	0.41	13.8
2	Begusarai	Naokothi	Khamhar	86.145	25.482	TW	8.78	513	189	21	1.28	19	0	220	46	25	14	0.2	0	12
3	Begusarai	Naokothi	Mohanpur(As)	86.131	25.518	TW	8.37	758	439	14	0.71	24	0	400	84	46	11	0	0	12.5
4	Begusarai	Naokothi	Paharchak	86.141	25.442	TW	8.07	1010	488	46	0.29	17	0	425	96	44	32	0.6	0	13.2

(Data of nearby block)

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **SHAMHO** (66 Sq. Km.)

District/ State Begusarai/Bihar

Rainfall and Temperature

Normal annual rainfall of Begusarai district is 1104.9 mm of which 80.46% occurs during the monsoon season. The normal rainfall during monsoon season is 889.05 mm and during non-monsoon season is 213.35 mm.The variation of rainfall in this zone is from 1040 mm to 1450 mm and the temperature varies from 36.6 to 7.7˚C.

Agriculture and Irrigation

Shamho block falls in the Agro-climatic Zone I. The cropping sequence followed in this zone isRice – Wheat, Rice – Rai, Rice – Sweet Potato, Rice – Maize (Rabi), Maize – Wheat, Maize – Sweet Potato, Maize – Rai, Rice – Lentil, Rice-linseed. The soils in this zone are sandy loam, loam with pH in the range of 6.5 – 8.4.The gross irrigated area is 46.08sq.Km and dependency on ground water for irrigation is 99%.

Ground Water Resource Availability and Extraction

Dynamic ground water resource of Shamho Block has been assessed as 23.27 MCM. The gross ground water draft for all uses stands at 17.36 MCM. The stage of Development is 74.6%.

Water Level Behaviour

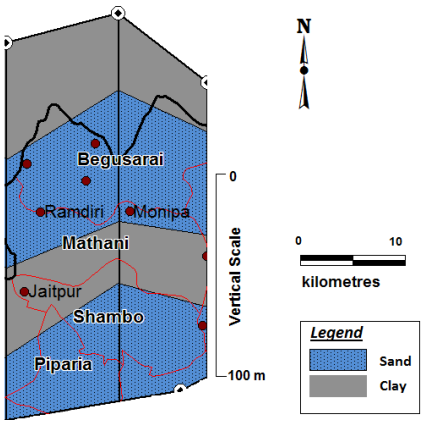
Depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In few parts of the block, the water level goes down below 10 mbgl. In post monsoon season,the depth to water level varies from 5 to 10 mbgl in some parts and 2 to 5 mbgl in some parts.

Ground Water Resource, Extraction, Contamination and Other Issues

The overall stage of groundwater development in the Block is 74.60%. Sufficient scope exists for groundwater development in the block. However, Arsenic contamination of groundwater has been reported from the area. As the area is represented by mono-aquifer system down to investigated depth of 300m, there is no alternate groundwater source. Hence, groundwater development in the area should be done with caution. Though, deeper part of the aquifer is relatively arsenic free, with continued development sufficient chance exists for its getting contaminated. Hence, only the top part of the aquifer should be developed along with measures of conjunctive uses. Arsenic treatment plant may be installed for drinking water sources.

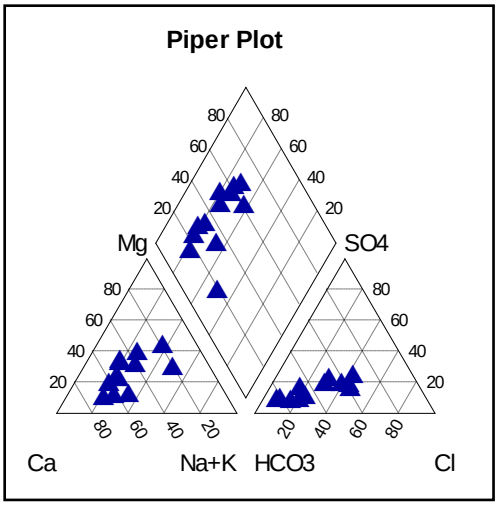
2. Aquifer Disposition

The area is bestowed with mono- aquifer system. The section depicting the aquifer disposition is shown below.

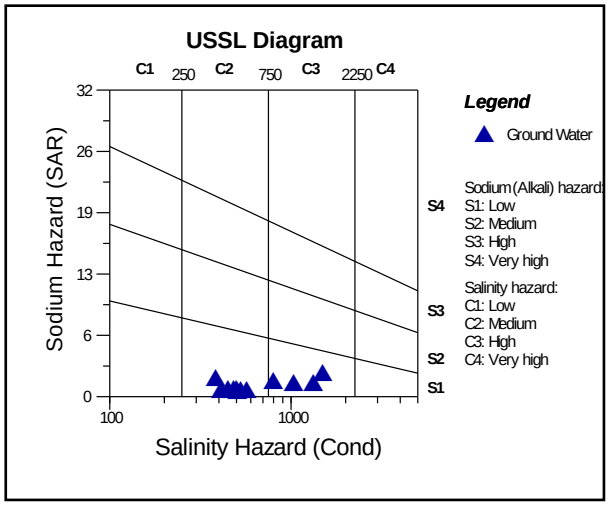


Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper Plot



USSL diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Other development of the aquifer is may be restricted within 30m.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Begusarai	Shamho	1543.92	250.36	182.09	609.61	2585.98	258.60	2327.38	1606.80	129.45	1736.25	18.00	702.58	74.60	Safe

Result of Chemical Analysis of Ground Water Samples

S.No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25	CO3-	HCO3-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO4	SiO2
1	Begusarai	Naokothi	Rajaura	86.1469	25.4651	TW	8.55	634	18	256	25	1.14	33	0	280	84	17	16	0.9	0.41	13.8
2	Begusarai	Naokothi	Khamhar	86.1457	25.4827	TW	8.78	513	27	189	21	1.28	19	0	220	46	25	14	0.2	0	12
3	Begusarai	Naokothi	Mohanpur(As)	86.1318	25.5181	TW	8.37	758	27	439	14	0.71	24	0	400	84	46	11	0	0	12.5
4	Begusarai	Naokothi	Paharchak	86.1412	25.4426	TW	8.07	1010	0	488	46	0.29	17	0	425	96	44	32	0.6	0	13.2

(Data of nearby block)

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **SULTANGANJ** (219 Sq. Km.)

District/ State Bhagalpur/Bihar

Rainfall and Temperature

Normal annual rainfall of Bhagalpur district is 1148.52 mm of which 82.48% occurs during the monsoon season. The normal rainfall during monsoon season is 947.38 mm and during non-monsoon season is 201.13 mm.The variation of rainfall in this zone is from 990 mm to 1240 mm and the temperature varies from 37.1 to 7.8˚C.

Agriculture and Irrigation

Sultanganj block falls in the Agro-climatic Zone IIIA. The cropping sequence followed in this zone isRice – Wheat, Rice – Gram, Rice – Lentil, Rice – Rai. The soils in this zone are sandy loam, clay loam, loam, clay with pH in the range of 6.8 – 8.0. The gross irrigated area is 52.73sq.Km and dependency on ground water for irrigation is 92%.

Ground Water Resource Availability and Extraction

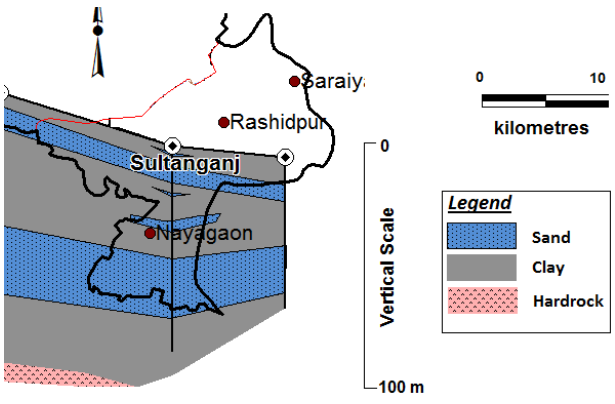
Dynamic ground water resource of Sultanganj Block has been assessed as 59.43 MCM. The gross ground water draft for all uses stands at 9.74 MCM. The stage of Development is 16.38%.

Water Level Behaviour

Depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from2 to 5 mbgl in northern and north eastern parts and 5 to 10 mbgl in southern and south western parts.

2. Aquifer Disposition

The area is bestowed with two- aquifer system. The section depicting the aquifer disposition is shown below.

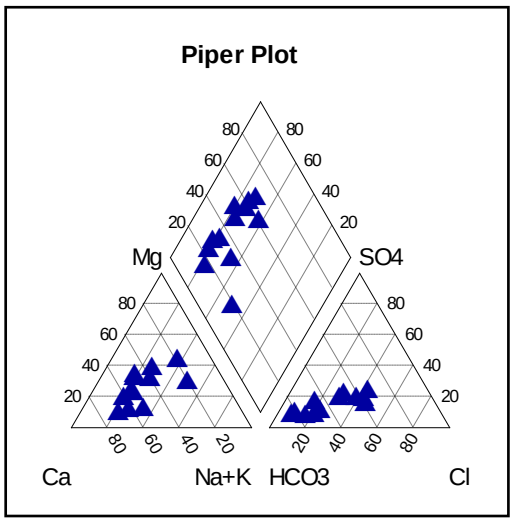


Ground Water Resource, Extraction, Contamination and Other Issues

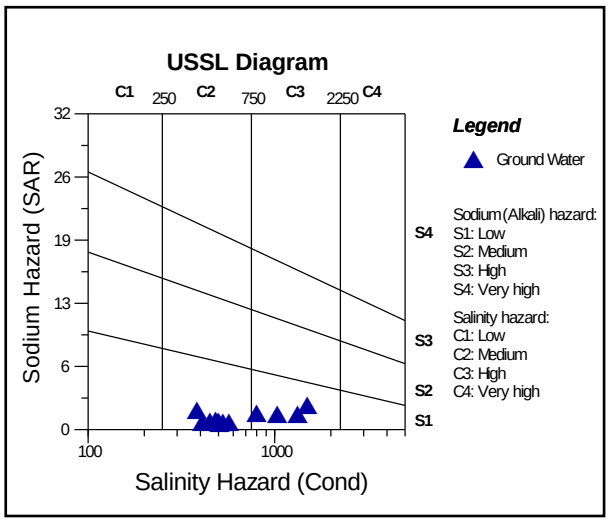
Overall stage of groundwater development in the Block is 16.38%. Sufficient scope exists for groundwater development in the block. Arsenic contamination of groundwater has been reported from the 1st aquifer in the younger alluvial belt down to the depth of 60m. Ground water exploration has revealed that the 2nd aquifer which is encountered below the clay layer separating the 1st and the 2nd aquifer is safe from arsenic contamination. The 2nd aquifer is thus recommended for community drinking water supply. Even in the 1st aquifer, the concentration of arsenic below the depth of 60 m has been found within the permissible limit; however, these are vulnerable to contamination with further groundwater development as they are part of the same contaminated aquifer. It is therefore recommended to develop the groundwater from the lower parts of the 1st aquifer only through hand-pumps. Energized extraction should be discouraged as this would accelerate the vertical mixing with the arsenic contaminated layers. The 2nd Aquifer is recommended only for extraction for drinking water supply.

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper Plot



USSL diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use the 2nd Aquifer solely for meeting the drinking water supply requirement. Necessary regulations to enforce this recommendation in the arsenic affected Blocks may be made so as to keep the 2nd aquifer safe from arsenic contamination.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non-Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Bhagalpur	Sultanganj	5483.38	993.60	59.55	67.15	6603.68	660.37	5943.31	613.50	360.22	973.72	117.00	5212.81	16.38	Safe

Result of Chemical Analysis of Ground Water Samples

S. N	District	Block	Location	Long	Lat	Source	pH	EC (µs) /cm at 25	$HCO3^-$	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	SiO2
1	Bhagalpur	Sultanganj	Fatehpur	86.667	25.226	TW	7.65	1196	342	117	0.51	38.4	36	390	76	48	54	7	4.1
2	Bhagalpur	Sultanganj	Gangania	86.676	25.239	TW	7.73	897	250	71	0.78	3.9	34	265	92	8	33	1.9	7.5
3	Bhagalpur	Sultanganj	Jhangira	86.707	25.243	TW	7.7	847	262	35	0.06	17	33	185	62	7	48	6.3	7.2
4	Bhagalpur	Sultanganj	DilgauriModh	86.747	25.246	TW	7.56	1147	281	156	nd	23	35	330	114	11	77	1.3	5.2
5	Bhagalpur	Sultanganj	Nawada	86.763	25.247	TW	7.7	548	293	11	0.09	7	19	235	58	22	19	1.7	4.1
6	Bhagalpur	Sultanganj	Tilak Nagar	86.762	25.24	TW	7.91	503	275	28	0.4	4	nd	190	42	20	37	6.8	11.4
7	Bhagalpur	Sultanganj	Bhavnathpur	86.862	25.236	TW	7.61	1277	305	96	0.3	19	37	370	82	40	42	9.1	5.9

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **GOGRI** (250 Sq. Km.)

District/ State Khagaria/Bihar

Rainfall and Temperature

The normal annual rainfall of Khagaria district is 1170.2 mm of which 83.95% occurs during the monsoon season. The normal rainfall during monsoon season is 982.4mm and during non-monsoon season is 187.8 mm.The variation of rainfall in this zone is from 1200 to 1700 mm and the temperature varies from 33.8 to 8.8˚C.

Agriculture and Irrigation

The block falls in the Agro-climatic Zone II. The cropping sequence followed in this zone isRice – Wheat – Moong. The soils in this zone are sandy loam, clayey loam with pH in the range of 6.5 – 7.8. The gross irrigated area 150.59 sq.Km and dependency on ground water for irrigation is100%.

Ground Water Resource Availability and Extraction

The dynamic ground water resource of Gogriblock has been assessed as 91.01 MCM. The gross ground water draft for all uses stands at 39.56 MCM. The stage of Development is 43.46%.

Water Level Behaviour

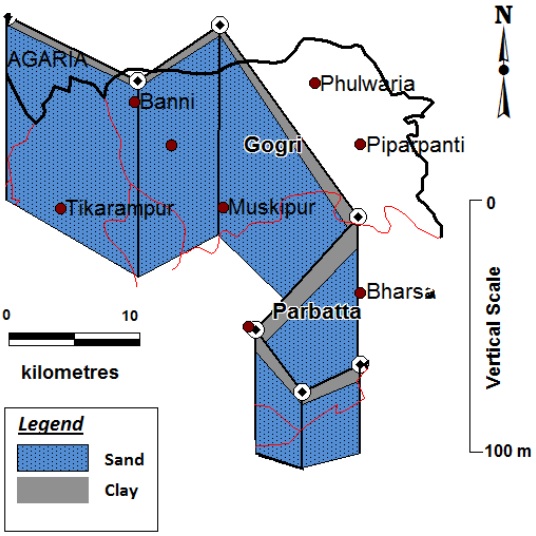
The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from2 to 5 mbgl and in northern parts it is less than 2 mbgl.

Ground Water Resource, Extraction, Contamination and Other Issues

The overall stage of groundwater development in the Block is 43.46%. Sufficient scope exists for groundwater development in the block. However, Arsenic contamination of groundwater has been reported from the area. As the area is represented by mono-aquifer system down to investigated depth of 300m, there is no alternate groundwater source. Hence, groundwater development in the area should be done with caution. Though, deeper part of the aquifer is relatively arsenic free, with continued development sufficient chance exists for its getting contaminated. Hence, only the top part of the aquifer should be developed along with measures of conjunctive uses. Arsenic treatment plant may be installed for drinking water sources.

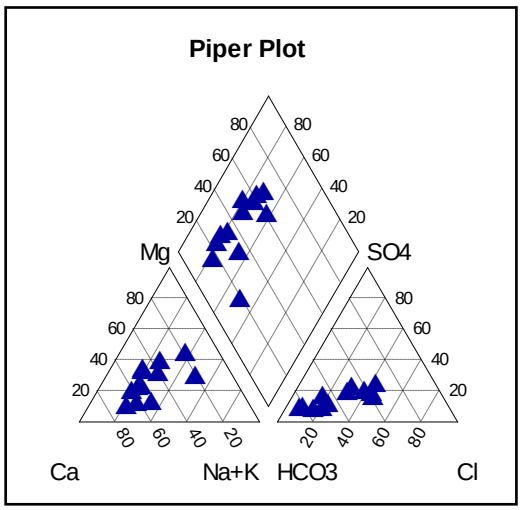
2. Aquifer Disposition

The area is bestowed with mono- aquifer system. The section depicting the aquifer disposition is shown below.

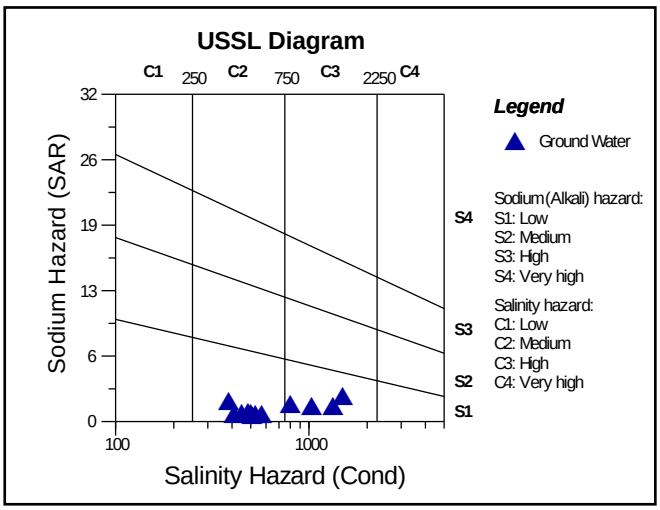


Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper Plot



USSL diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Other development of the aquifer is may be restricted within 30m.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
Khagaria	Gogri	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	Safe
		6491.88	1034.18	388.04	2198.92	10113.02	1011.30	9101.72	3128.80	826.77	3955.57	185.00	5787.92	43.46	

Result of Chemical Analysis of Ground Water Samples

Sl.	District	Block	Location	Latitude	Longitude	pH	EC	TDS	TH	Ca	Mg	Na	K	CO3	HCO3	Cl
1	Khagaria	Gogri	Gandhinagar	25.4461	86.665	7.64	1297	843.05	475	42	89	55	1	0	317	209
2	Khagaria	Gogri	Jamalpur	25.4292	86.6417	7.9	803	521.95	280	60	31	40	1	0	366	43
3	Khagaria	Gogri	Maheskhunt 1	25.46	86.6375	7.4	975	633.75	270	30	47	93	7	0	366	103
4	Khagaria	Gogri	Lohia chowk	25.481	86.59889	7.78	1893	1230.45	245	56	25	287	19	0	305	443
5	Khagaria	Gogri	Maheskunt	25.4583	86.6292	7.7	1675	1088.75	570	22	124	107	1	0	610	202

(Source: NHS data)

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2): **KHAGARIA** (262 Sq. Km.)

District/ State Khagaria/Bihar

Rainfall and Temperature

The normal annual rainfall of Khagaria district is 1170.2 mm of which 83.95% occurs during the monsoon season. The normal rainfall during monsoon season is 982.4 mm and during non-monsoon season is 187.8 mm.The variation of rainfall in this zone is from 1200 to 1700 mm and the temperature varies from 33.8 to 8.8˚C.

Agriculture and Irrigation

The block falls in the Agro-climatic Zone II. The cropping sequence followed in this zone isRice – Wheat – Moong. The soils in this zone are sandy loam, clayey loam with pH in the range of 6.5 – 7.8. The gross irrigated area is 154.43sq.Km and dependency on ground water for irrigation is 100%.

Ground Water Resource Availability and Extraction

The dynamic ground water resource of Khagariablock has been assessed as 79.72 MCM. The gross ground water draft for all uses stands at 17.26 MCM. The stage of Development is 21.66%.

Water Level Behaviour

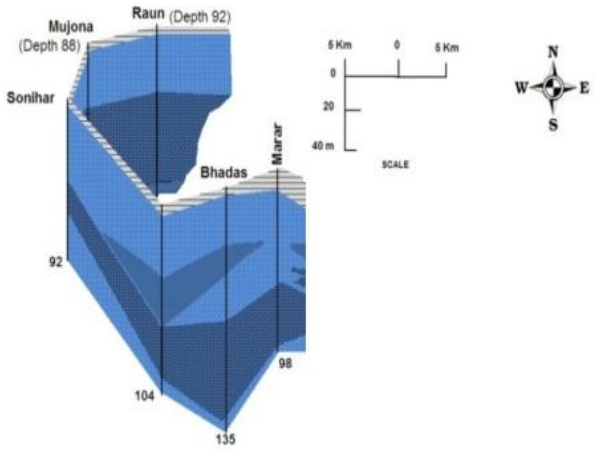
The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from5 to 10 mbglexcept in central part where it is between 2 to 5 mbgl.

Ground Water Resource, Extraction, Contamination and Other Issues

The overall stage of groundwater development in the Block is 21.66%. Sufficient scope exists for groundwater development in the block. However, Arsenic contamination of groundwater has been reported from the area. As the area is represented by mono-aquifer system down to investigated depth of 300m, there is no alternate groundwater source. Hence, groundwater development in the area should be done with caution. Though, deeper part of the aquifer is relatively arsenic free, with continued development sufficient chance exists for its getting contaminated. Hence, only the top part of the aquifer should be developed along with measures of conjunctive uses. Arsenic treatment plant may be installed for drinking water sources.

2. Aquifer Disposition

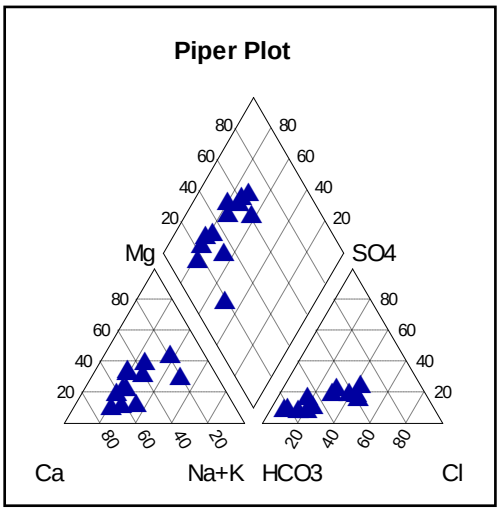
The area is bestowed with mono- aquifer system. The section depicting the aquifer disposition is shown below.



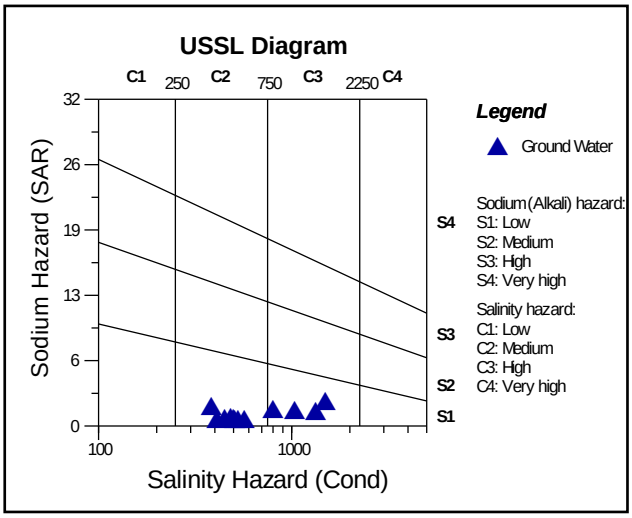
2D-aquifer disposition

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper Plot



USSL diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Other development of the aquifer is may be restricted within 30m.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

Sl. No.	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Khagaria	Khagaria	6266.26	1083.97	156.36	886.02	8392.61	419.63	7972.98	1056.40	670.52	1726.92	223.00	6693.58	21.66	Safe

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Sl.	District	Block	Location	Latitude	Longitude	pH	EC	TDS	TH	Ca	Mg	Na	K	CO3	HCO3	Cl
1	Khagaria	Khagaria	Gangaur	25.5125	86.3667	7.7	921	598.65	285	22	55	65	13	0	354	103
2	Khagaria	Khagaria	Ismailpur	25.5089	86.3906	7.7	537	349.05	210	26	35	27	2	0	268	28
3	Khagaria	Khagaria	Kasimpur	25.5011	86.4183	7.9	434	282.1	130	24	17	36	2	0	220	14
4	Khagaria	Khagaria	Khagaria	25.4917	86.475	7.9	811	527.15	280	36	46	70	4	0	384	74
5	Khagaria	Khagaria	Labhgaon	25.5	86.425	7.89	624	405.6	220	20	41	35	2	0	317	25

(Source: NHS Data)

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **PARBATTA**(241 Sq. Km.)

District/ State Khagaria/Bihar

Rainfall and Temperature

The normal annual rainfall of Khagaria district is 1170.2 mm of which 83.95% occurs during the monsoon season. The normal rainfall during monsoon season is 982.4 mm and during non-monsoon season is 187.8 mm.The variation of rainfall in this zone is from 1200 to 1700 mm and the temperature varies from 33.8 to 8.8˚C.

Agriculture and Irrigation

The block falls in the Agro-climatic Zone II. The cropping sequence followed in this zone isRice – Wheat – Moong. The soils in this zone are sandy loam, clayey loam with pH in the range of 6.5 – 7.8. The gross irrigated area is 151.82 Sq.Km and dependency on ground water for irrigation is 100%.

Ground Water Resource Availability and Extraction

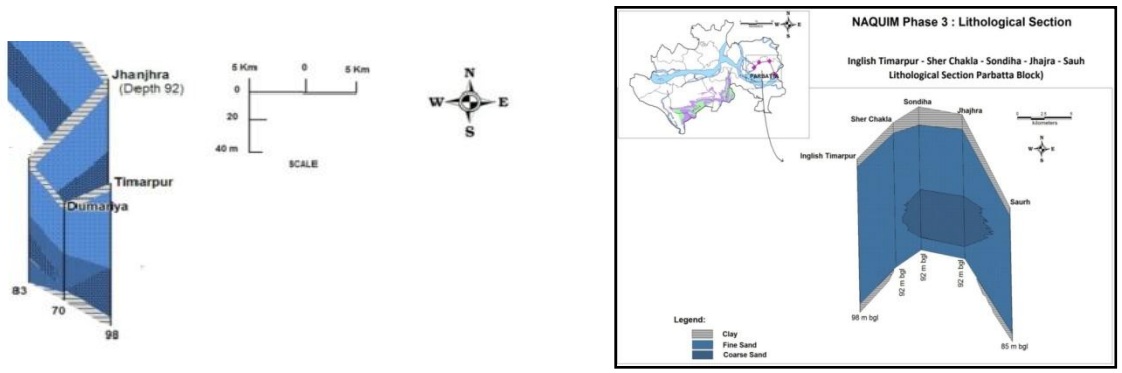
The dynamic ground water resource of Parbattablock has been assessed as 82.78 MCM. The gross ground water draft for all uses stands at 47.73MCM. The stage of Development is 57.66%.

Water Level Behaviour

The depth to water level varies from 5 to 10 mbgl during pre-monsoon season except for some parts with 2 to 5 mbgl water level. In post monsoon season,the depth to water level varies from2 to 5 mbgl.

2. Aquifer Disposition

The area is bestowed with mono- aquifer system. The section depicting the aquifer disposition is shown below.



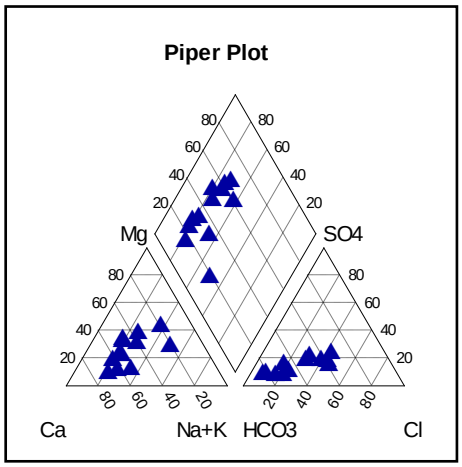
2D disposition of the aquifer

Ground Water Resource, Extraction, Contamination and Other Issues

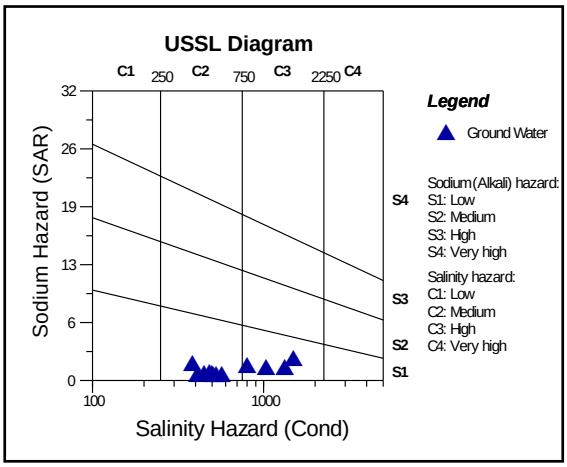
The overall stage of groundwater development in the Block is 57.66%. Sufficient scope exists for groundwater development in the block. However, Arsenic contamination of groundwater has been reported from the area. As the area is represented by mono-aquifer system down to investigated depth of 300m, there is no alternate groundwater source. Hence, groundwater development in the area should be done with caution. Though, deeper part of the aquifer is relatively arsenic free, with continued development sufficient chance exists for its getting contaminated. Hence, only the top part of the aquifer should be developed along with measures of conjunctive uses. Arsenic treatment plant may be installed for drinking water sources.

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper Plot



USSL Diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Other development of the aquifer is may be restricted within 30m.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Khagaria	Parbatta	6251.46	995.88	292.63	1658.21	9198.18	919.82	8278.36	4175.20	598.18che	4773.38	143.00	3960.16	57.66	Safe

Result of selpmaS retaW dnuorG fo sisylanA lacimehC

Sl. No.	District	Block	Location	Latitude	Longitude	pH	EC	TDS	TH	Ca	Mg	Na	K	CO3	HCO3	Cl
1	Khagaria	Parbatta	Dewri	25.3628	86.7136	7.49	1667	1083.55	350	28	67	111	63	0	427	199

(Source: NHS Data)

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **BARAHIA** (241 Sq. Km.)

District/ State Lakhisarai/Bihar

Rainfall and Temperature

The normal annual rainfall of Lakhisarai district is 1108.63 mm of which 83.89% occurs during the monsoon season. The normal rainfall during monsoon season is 930mm and during non-monsoon season is 178.63 mm.The variation of rainfall in this zone is from 990 mm to 1240 mm and the temperature varies from 37.1 to 7.8˚C.

Agriculture and Irrigation

The block falls in the Agro-climatic Zone IIIA. The cropping sequence followed in this zone isRice – Wheat, Rice – Gram, Rice – Lentil, Rice – Rai. The soils in this zone are sandy loam, clay loam, loam, clay with pH in the range of 6.8 – 8.0.The gross irrigated area is 69.53sq.Km and dependency on ground water irrigation is 75%.

Ground Water Resource Availability and Extraction

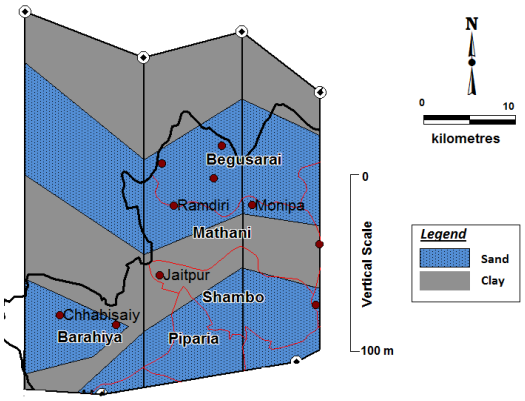
The dynamic ground water resource of Barahiablock has been assessed as 67.82 MCM. The gross ground water draft for all uses stands at 13.97MCM. The stage of Development is 20.61%.

Water Level Behaviour

The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from5 to 10 mbgl.

2. Aquifer Disposition

The area is bestowed with two- aquifer system. The section depicting the aquifer disposition is shown below.



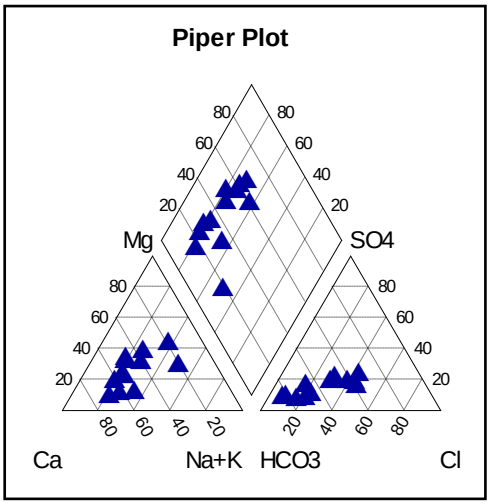
2D disposition of the aquifer

Ground Water Resource, Extraction, Contamination and Other Issues

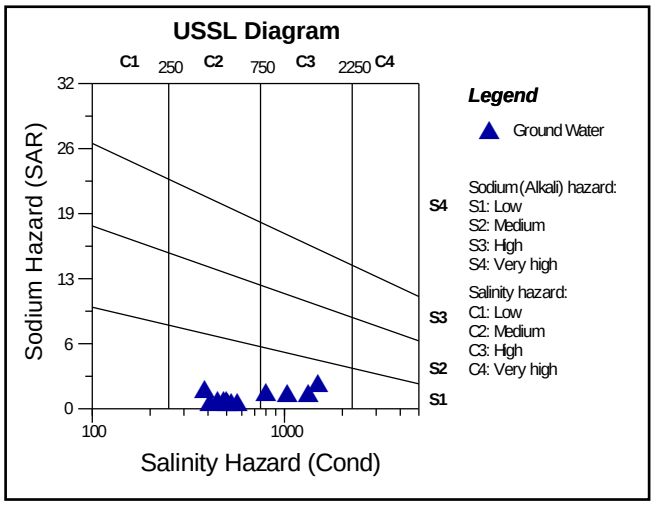
The overall stage of groundwater development in the Block is 20.61%. Sufficient scope exists for groundwater development in the block. Arsenic contamination of groundwater has been reported from the 1st aquifer in the younger alluvial belt down to the depth of 60m. Ground water exploration has revealed that the 2nd aquifer which is encountered below the clay layer separating the 1st and the 2nd aquifer is safe from arsenic contamination. The 2nd aquifer is thus recommended for community drinking water supply. Even in the 1st aquifer, the concentration of arsenic below the depth of 60 m has been found within the permissible limit; however, these are vulnerable to contamination with further groundwater development as they are part of the same contaminated aquifer. It is therefore recommended to develop the groundwater from the lower parts of the 1st aquifer only through hand-pumps. Energized extraction should be discouraged as this would accelerate the vertical mixing with the arsenic contaminated layers. The 2nd Aquifer is recommended only for extraction for drinking water supply.

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper Plot



USSL diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use the 2nd Aquifer solely for meeting the drinking water supply requirement. Necessary regulations to enforce this recommendation in the arsenic affected Blocks may be made so as to keep the 2nd aquifer safe from arsenic contamination.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Lakhisarai	Barahia	5918.51	832.62	552.22	232.22	7535.57	753.56	6782.01	976.20	421.27	1397.47	72.00	5733.81	20.61	Safe

Result of selpmaS retaW dnuorG fo sisylanA lacimehC

S.No.	Block	Location	Long	Lat	Source	pH	EC (µs) /cm at 25°c	CO3-	HCO3-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO4	SiO2
1	Barhaiya	Barhaiya	86.01986	25.29022	TW		999	nd	323	121	0.03	45	26.1	325	26	62	86			
2	Barhaiya	Barhaiya	86.01986	25.29022	TW													23.7	nd	2.0
3	Barhaiya	Gangasarai	86.02878	25.26278	TW	7.76	979	nd	366	89	nd	24	nd	325	38	55	60	13.2	nd	3.9
4	Barhaiya	Pratappur	86.04708	25.24025	TW	7.89	796	nd	220	35	nd	14	29.8	220	42	28	23	1.4	nd	2.5

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **LAKHISARAI** (283 Sq. Km.)

District/ State Lakhisarai/Bihar

Rainfall and Temperature

The normal annual rainfall of Lakhisarai district is 1108.63 mm of which 83.89% occurs during the monsoon season. The normal rainfall during monsoon season is 930 mm and during non-monsoon season is 178.63 mm.The variation of rainfall in this zone is from 990 mm to 1240 mm and the temperature varies from 37.1 to 7.8˚C.

Agriculture and Irrigation

The block falls in the Agro-climatic Zone IIIA. The cropping sequence followed in this zone isRice – Wheat, Rice – Gram, Rice – Lentil, Rice – Rai. The soils in this zone are sandy loam, clay loam, loam, clay with pH in the range of 6.8 – 8.0. The gross irrigated area 64.92 sq.Km and dependency on ground water for irrigation is 75%.

Ground Water Resource Availability and Extraction

The dynamic ground water resource of Lakhisarai block has been assessed as 55.30 MCM. The gross ground water draft for all uses stands at 22.66MCM. The stage of Development is 40.98 %.

Water Level Behaviour

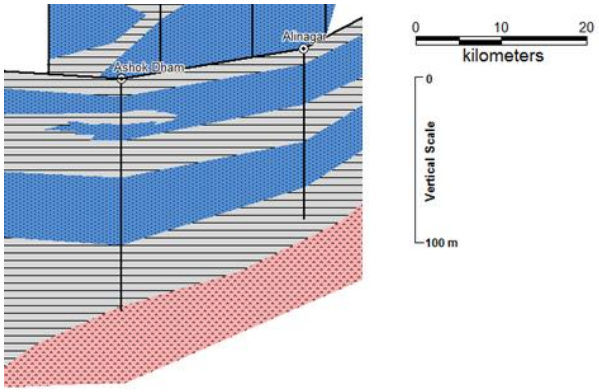
The depth to water level varies from 5 to 10 mbgl during pre-monsoon season except for very few areas where it goes beyond 10 mbgl. In post monsoon season,the depth to water level varies from5 to 10 mbgl and in some parts from 2 to 5 mbgl.

Ground Water Resource, Extraction, Contamination and Other Issues

The overall stage of groundwater development in the Block is 40.98%. Sufficient scope exists for groundwater development in the block. Arsenic contamination of groundwater has been reported from the 1st aquifer in the younger alluvial belt down to the depth of 60m. Ground water exploration has revealed that the 2nd aquifer which is encountered below the clay layer separating the 1st and the 2nd aquifer is safe from arsenic contamination. The 2nd aquifer is thus recommended for community drinking water supply. Even in the 1st aquifer, the concentration of arsenic below the depth of 60 m has been found within the permissible limit; however, these are vulnerable to contamination with further groundwater development as they are part of the same contaminated aquifer. It is therefore recommended to develop the groundwater from the lower parts of the 1st aquifer only through hand-pumps. Energized extraction should be discouraged as this would accelerate the vertical mixing with the arsenic contaminated layers. The 2nd Aquifer is recommended only for extraction for drinking water supply.

2. Aquifer Disposition

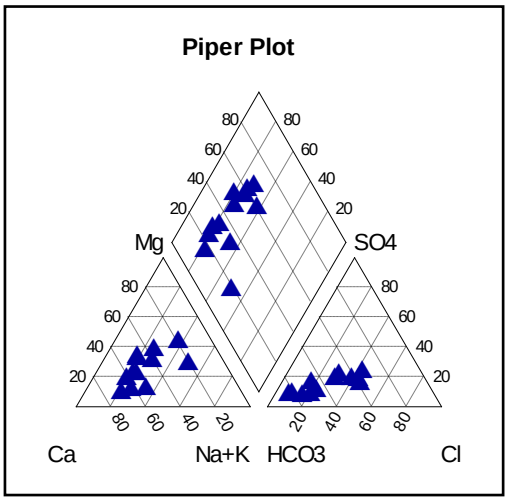
The area is bestowed with two- aquifer system. The section depicting the aquifer disposition is shown below.



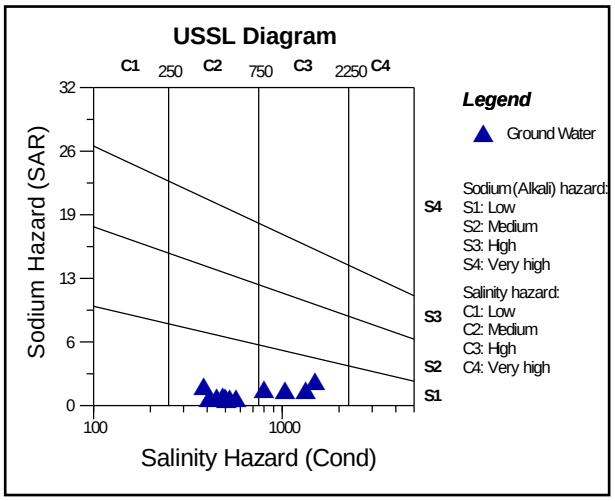
2D disposition of the aquifer

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper Plot



USSL diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use the 2nd Aquifer solely for meeting the drinking water supply requirement. Necessary regulations to enforce this recommendation in the arsenic affected Blocks may be made so as to keep the 2nd aquifer safe from arsenic contamination.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Blocks	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non-Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non-Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Lakhisarai	Lakhisarai	4262.72	599.68	966.84	315.84	6145.08	614.51	5530.57	1871.2	395.37	2266.57	106.0	3553.37	40.98	Safe

Result of Chemical Analysis of Ground Water Samples

S.No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25	CO3-	HCO3-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO4	SiO_2
1	Lakhisarai	Lakhisarai	Damodarpur	86.09506	25.14808	TW	8.18	516	nd	256	25	nd	3	5.3	190	46	18	28	2.9	0.08	6.9
2	Lakhisarai	Lakhisarai	Khairi	86.10561	25.13658	TW	8.63	329	24	140	11	nd	1	nd	130	18	20	25	3.8	nd	7.7
3	Lakhisarai	Lakhisarai	Sondhi	86.11969	25.09300	TW	8.33	458	21	134	50	0.13	5	nd	150	36	14	28	5.1	nd	7.5
4	Lakhisarai	Lakhisarai	Beldadri	86.15694	25.07658	TW	8.5	400	nd	146	39	nd	7	nd	120	40	5	26	4.7	nd	7.7
5	Lakhisarai	Lakhisarai	Makuna	86.08944	25.15589	TW	8.06	386	nd	146	32	nd	10	nd	120	38	6	20	2.3	1.45	6.3
6	Lakhisarai	Lakhisarai	Belgudar	86.07908	25.20478	TW	8.04	1202	nd	354	188	0.26	31	1.9	350	64	46	103	5.6	nd	2.7

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **PIPARIA**(58 Sq. Km.)

District / State Lakhisarai/Bihar

Rainfall and Temperature

The normal annual rainfall of Lakhisarai district is 1108.63 mm of which 83.89% occurs during the monsoon season. The normal rainfall during monsoon season is 930 mm and during non-monsoon season is 178.63 mm.The variation of rainfall in this zone is from 990 mm to 1240 mm and the temperature varies from 37.1 to 7.8˚C.

Agriculture and Irrigation

The block falls in the Agro-climatic Zone IIIA. The cropping sequence followed in this zone isRice – Wheat, Rice – Gram, Rice – Lentil, Rice – Rai. The soils in this zone are sandy loam, clay loam, loam, clay with pH in the range of 6.8 – 8.0. The gross irrigated area is 16.02 sq.Km and dependency on ground water for irrigation is 75%.

Ground Water Resource Availability and Extraction

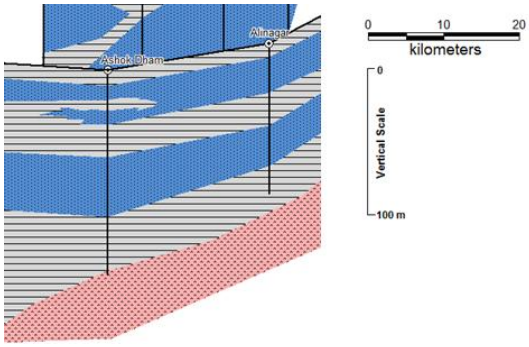
The dynamic ground water resource of Piparia block has been assessed as 16.53 MCM. The gross ground water draft for all uses stands at 7.32MCM. The stage of Development is 44.26%.

Water Level Behaviour

The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from2 to 5 mbgl.

2. Aquifer Disposition

The area is bestowed with two- aquifer system. The section depicting the aquifer disposition is shown below.



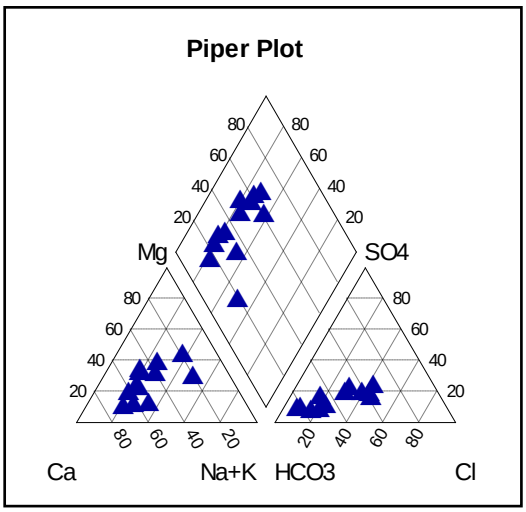
2D view of aquifer disposition

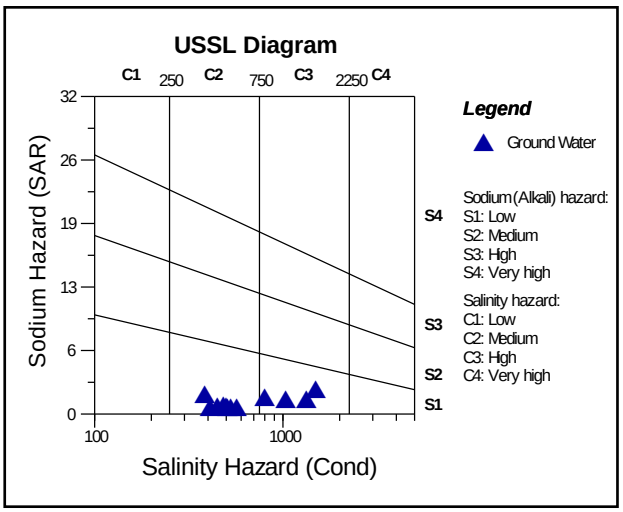
Ground Water Resource, Extraction, Contamination and Other Issues

The overall stage of groundwater development in the Block is 44.26%. Sufficient scope exists for groundwater development in the block. Arsenic contamination of groundwater has been reported from the 1st aquifer in the younger alluvial belt down to the depth of 60m. Ground water exploration has revealed that the 2nd aquifer which is encountered below the clay layer separating the 1st and the 2nd aquifer is safe from arsenic contamination. The 2nd aquifer is thus recommended for community drinking water supply. Even in the 1st aquifer, the concentration of arsenic below the depth of 60 m has been found within the permissible limit; however, these are vulnerable to contamination with further groundwater development as they are part of the same contaminated aquifer. It is therefore recommended to develop the groundwater from the lower parts of the 1st aquifer only through hand-pumps. Energized extraction should be discouraged as this would accelerate the vertical mixing with the arsenic contaminated layers. The 2nd Aquifer is recommended only for extraction for drinking water supply.

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.





Piper Plot **USSL diagram**

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use the 2nd Aquifer solely for meeting the drinking water supply requirement. Necessary regulations to enforce this recommendation in the arsenic affected Blocks may be made so as to keep the 2nd aquifer safe from arsenic contamination.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Blocks	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non-Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non-Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Lakhisarai	Piparia	1433.59	201.68	135.25	67.25	1837.77	183.78	1653.99	650.0	82.0	732.00	19.00	984.99	44.26	Safe

Result of Chemical Analysis of Ground Water Samples

S.No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25	CO3-	HCO3-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO4	SiO2
1	Lakhisarai	Lakhisarai	Damodarpur	86.09506	25.14808	TW	8.18	516	nd	256	25	nd	3	5.3	190	46	18	28	2.9	0.08	6.9
2	Lakhisarai	Lakhisarai	Khairi	86.10561	25.13658	TW	8.63	329	24	140	11	nd	1	nd	130	18	20	25	3.8	nd	7.7
3	Lakhisarai	Lakhisarai	Sondhi	86.11969	25.09300	TW	8.33	458	21	134	50	0.13	5	nd	150	36	14	28	5.1	nd	7.5
4	Lakhisarai	Lakhisarai	Beldadri	86.15694	25.07658	TW	8.5	400	nd	146	39	nd	7	nd	120	40	5	26	4.7	nd	7.7
5	Lakhisarai	Lakhisarai	Makuna	86.08944	25.15589	TW	8.06	386	nd	146	32	nd	10	nd	120	38	6	20	2.3	1.45	6.3
6	Lakhisarai	Lakhisarai	Belgudar	86.07908	25.20478	TW	8.04	1202	nd	354	188	0.26	31	1.9	350	64	46	103	5.6	nd	2.7

(Data of nearby block)

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **SURAJGARHA**(390 Sq. Km.)

District/ State Lakhisarai/Bihar

Rainfall

The normal annual rainfall of Lakhisarai district is 1108.63 mm of which 83.89% occurs during the monsoon season. The normal rainfall during monsoon season is 930 mm and during non-monsoon season is 178.63 mm.The variation of rainfall in this zone is from 990 mm to 1240 mm and the temperature varies from 37.1 to 7.8˚C.

Agriculture and Irrigation

The block falls in the Agro-climatic Zone IIIA. The cropping sequence followed in this zone isRice – Wheat, Rice – Gram, Rice – Lentil, Rice – Rai. The soils in this zone are sandy loam, clay loam, loam, clay with pH in the range of 6.8 – 8.0. The gross irrigated area 81.50 sq.Km and dependency on ground water for irrigation is 75%.

Ground Water Resource Availability and Extraction

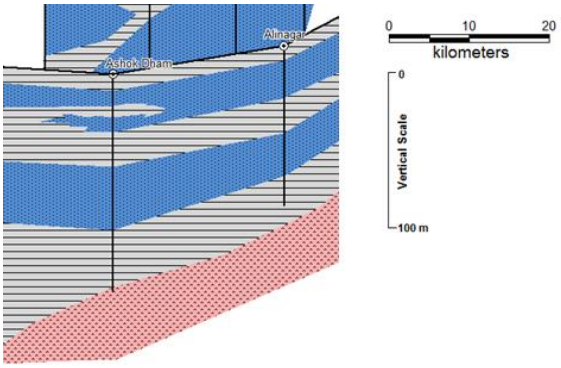
The dynamic ground water resource of Surajgarha block has been assessed as 41.21 MCM. The gross ground water draft for all uses stands at 8.90MCM. The stage of Development is 44.26 %.

Water Level Behaviour

The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from5 to 10 mbgl in most parts and in some parts 2 to 5 mbgl.

2. Aquifer Disposition

The area is bestowed with two- aquifer system. The section depicting the aquifer disposition is shown below.



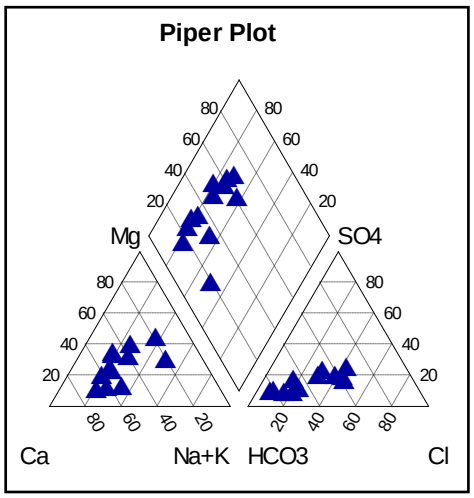
2D view of aquifer disposition

Ground Water Resource, Extraction, Contamination and Other Issues

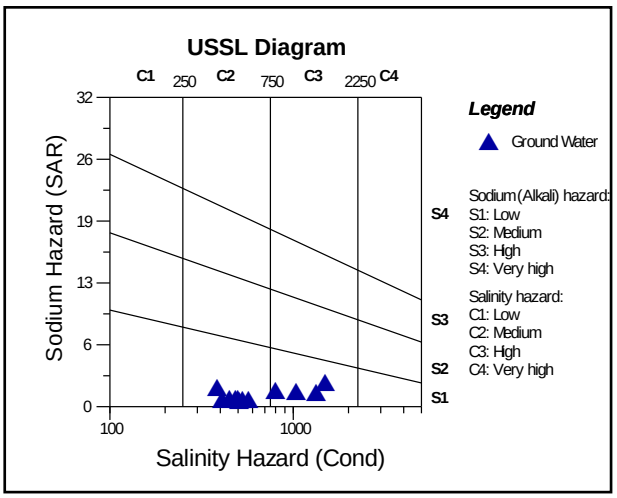
The overall stage of groundwater development in the Block is 21.60%. Sufficient scope exists for groundwater development in the block. Arsenic contamination of groundwater has been reported from the 1st aquifer in the younger alluvial belt down to the depth of 60m. Ground water exploration has revealed that the 2nd aquifer which is encountered below the clay layer separating the 1st and the 2nd aquifer is safe from arsenic contamination. The 2nd aquifer is thus recommended for community drinking water supply. Even in the 1st aquifer, the concentration of arsenic below the depth of 60 m has been found within the permissible limit; however, these are vulnerable to contamination with further groundwater development as they are part of the same contaminated aquifer. It is therefore recommended to develop the groundwater from the lower parts of the 1st aquifer only through hand-pumps. Energized extraction should be discouraged as this would accelerate the vertical mixing with the arsenic contaminated layers. The 2nd Aquifer is recommended only for extraction for drinking water supply.

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper Plot



USSL Diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use the 2nd Aquifer solely for meeting the drinking water supply requirement. Necessary regulations to enforce this recommendation in the arsenic affected Blocks may be made so as to keep the 2nd aquifer safe from arsenic contamination.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Blocks	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non-Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non-Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Lakhisarai	Surajgarha	3237.67	455.48	702.61	183.61	4579.37	457.94	4121.43	714.8	175.33	890.13	52.0	3354.63	21.6	Safe

Result of Chemical Analysis of Ground Water Samples

S.No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25	CO3-	HCO3-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO4	SiO2
1	Lakhisarai	Surajgarha	Rampur	86.14447	25.18400	TW	7.88	1575	nd	299	223	nd	19	31.2	450	44	82	78	18.7	nd	5.5
2	Lakhisarai	Surajgarha	Ratanpur	86.20381	25.20739	TW	7.98	1140	nd	250	149	nd	51	32.6	100	24	10	200	6.3	nd	5.1
3	Lakhisarai	Surajgarha	Nista	86.22236	25.22797	TW	8.39	757	39	305	14	nd	14	nd	235	30	38	43	18.0	nd	4.9
4	Lakhisarai	Surajgarha	Ramlagar	86.24506	25.25978	TW	8.04	870	nd	336	18	nd	19	nd	155	34	17	53	30.3	nd	5.9

S.No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25	CO3-	HCO3-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO4	SiO2
5	Lakhisarai	Surajgarha	AbgilAshimpur	86.26678	25.27131	TW	7.98	706	nd	189	60	0.10	35	8.1	235	54	24	16	2.3	nd	1.5
6	Lakhisarai	Surajgarha	Haiwatgnj	86.29714	25.27842	TW	8.08	627	nd	305	25	0.01	20	14.4	245	52	28	29	6.8	nd	5.5
7	Lakhisarai	Surajgarha	MedniChowk	86.32625	25.28797	TW	7.82	1197	nd	220	138	0.00	84	32.1	380	108	26	47	10.0	nd	5.0
8	Lakhisarai	Surajgarha	Rasulpur	86.35608	25.29592	TW	8.13	582	nd	293	25	0.07	17	nd	215	48	23	35	3.8	nd	6.7
9	Lakhisarai	Surajgarha	KaswaBasauni	86.37792	25.22681	TW	8.57	396	21	171	21	0.32	10	nd	185	40	20	19	1.8	nd	7.1
10	Lakhisarai	Surajgarha	Abyapur	86.35972	25.22681	TW	8.02	984	nd	317	99	nd	15	4.2	175	54	10	100	16.6	nd	7.6
11	Lakhisarai	Surajgarha	BenipurKaswa	86.33842	25.22169	TW	8.19	1323	nd	397	124	0.35	18	33.0	445	38	84	43	1.1	nd	5.6
12	Lakhisarai	Surajgarha	Babua Bazar	86.31789	25.21144	TW	8.23	473	nd	207	39	0.00	11	nd	190	48	17	21	0.4	nd	1.6
13	Lakhisarai	Surajgarha	TaliBishunpur	86.28769	25.19486	TW	8.28	531	nd	354	7	0.08	4	nd	220	34	32	34	5.6	nd	4.7
14	Lakhisarai	Surajgarha	Banshipur	86.26997	25.22089	TW	7.82	787	nd	323	11	nd	10	nd	190	46	18	40	7.0	nd	5.8
15	Lakhisarai	Surajgarha	Konipar	86.27356	25.23011	TW	8.06	696	nd	354	7	nd	12	nd	265	50	34	20	0.4	nd	5.4
16	Lakhisarai	Surajgarha	Manikpur	86.27319	25.23664	TW	8.19	705	nd	317	35	nd	17	nd	230	38	32	39	7.5	nd	8.2
17	Lakhisarai	Surajgarha	PuranaSanaipur	86.25300	25.24289	TW	8.37	545	24	244	14	nd	9	nd	170	46	13	48	6.0	nd	6.2

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **BARIARPUR** (161 Sq. Km.)

District/ State Munger/Bihar

Rainfall

The normal annual rainfall of Munger district is 1173.58 mm of which 82.72% occurs during the monsoon season. The normal rainfall during monsoon season is 970.75mm and during non-monsoon season is 202.83 mm.The variation of rainfall in this zone is from 990 mm to 1240 mm and the temperature varies from 37.1 to 7.8˚C.

Agriculture and Irrigation

The block falls in the Agro-climatic Zone IIIA. The cropping sequence followed in this zone isRice – Wheat, Rice – Gram, Rice – Lentil, Rice – Rai. The soils in this zone are sandy loam, clay loam, loam, clay with pH in the range of 6.8 – 8.0. The gross irrigated area is 16.96sq.Km and dependency on ground water for irrigation is 50%.

Ground Water Resource Availability and Extraction

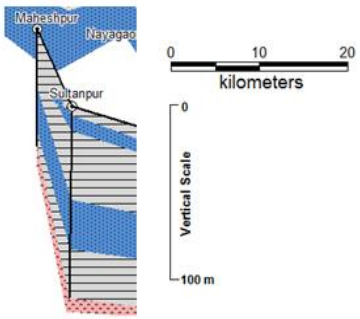
The dynamic ground water resource of Bariarpur block has been assessed as 38.61 MCM. The gross ground water draft for all uses stands at 5.73MCM. The stage of Development is 14.85%.

Water Level Behaviour

The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from5 to 10 mbgl in some parts and in some parts 2 to 5 mbgl.

2. Aquifer Disposition

The area is bestowed with two- aquifer system. The section depicting the aquifer disposition is shown below.



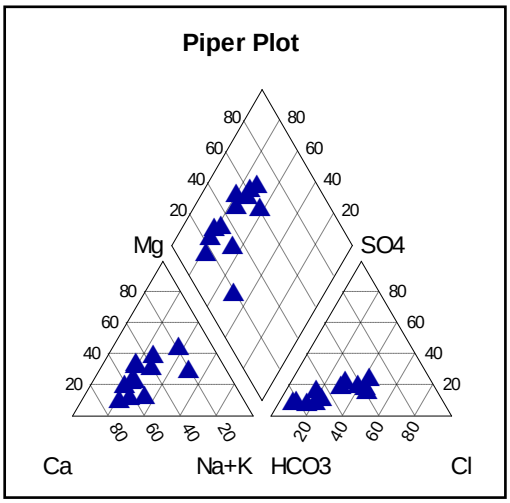
2D view of aquifer disposition

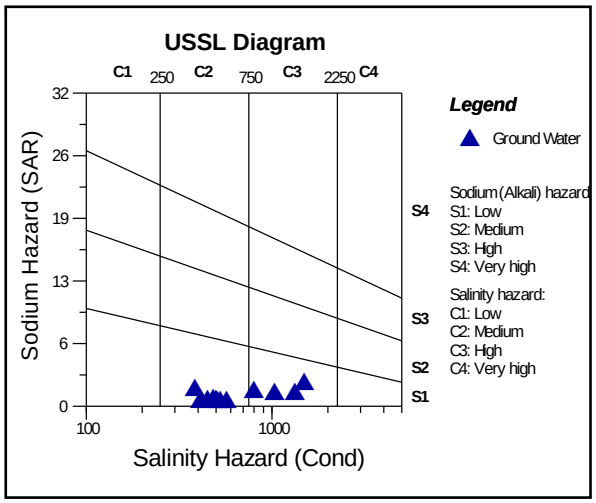
Ground Water Resource, Extraction, Contamination and Other Issues

The overall stage of groundwater development in the Block is 14.85%. Sufficient scope exists for groundwater development in the block. Arsenic contamination of groundwater has been reported from the 1st aquifer in the younger alluvial belt down to the depth of 60m. Ground water exploration has revealed that the 2nd aquifer which is encountered below the clay layer separating the 1st and the 2nd aquifer is safe from arsenic contamination. The 2nd aquifer is thus recommended for community drinking water supply. Even in the 1st aquifer, the concentration of arsenic below the depth of 60 m has been found within the permissible limit; however, these are vulnerable to contamination with further groundwater development as they are part of the same contaminated aquifer. It is therefore recommended to develop the groundwater from the lower parts of the 1st aquifer only through hand-pumps. Energized extraction should be discouraged as this would accelerate the vertical mixing with the arsenic contaminated layers. The 2nd Aquifer is recommended only for extraction for drinking water supply.

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.





Piper Plot **USSL Diagram**

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use the 2nd Aquifer solely for meeting the drinking water supply requirement. Necessary regulations to enforce this recommendation in the arsenic affected Blocks may be made so as to keep the 2nd aquifer safe from arsenic contamination.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Blocks	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non-Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non-Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Munger	Bariarpur	3324.95	509.2	331.21	125.54	4290.9	429.09	3861.81	395.0	178.35	573.35	52.00	3414.81	14.85	Safe

Result of Chemical Analysis of Ground Water Samples

S.No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25	CO3-	HCO3-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO4	SiO2
1	Munger	Bariarpur	NimiyaTola	86.48006	25.27433	TW	7.51	1002	nd	250	110	0.15	10	33.8	215	70	10	88	2.7	nd	5.3
2	Munger	Bariarpur	Brahmsthan	86.57156	25.30083	TW	7.45	1634	nd	482	170	0.30	19.0	35.7	505	156	28	80	7.3	nd	8.0
3	Munger	Bariarpur	Neerpur	86.59242	25.27119	TW	7.79	1008	nd	506	39	0.02	18.6	nd	365	62	50	51	13.1	nd	7.9
4	Munger	Bariarpur	Phulkia	86.43928	25.26119	TW	7.37	1284	nd	244	142	nd	21.3	35.9	340	112	14	61	1.2	nd	6.3
5	Munger	Bariarpur	Kalyanpur	86.61436	25.25319	TW	7.81	675	nd	262	39	0.04	10.7	21.7	195	58	12	33	5.0	nd	2.6
6	Munger	Bariarpur	GhorGhat	86.63708	25.24456	TW	7.79	816	nd	323	53	nd	7.1	nd	230	54	23	45	5.3	0.18	3.8

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **DHARHARA**(161 Sq. Km.)

District/ State Munger/Bihar

Rainfall and Temperature

The normal annual rainfall of Munger district is 1173.58 mm of which 82.72% occurs during the monsoon season. The normal rainfall during monsoon season is 970.75 mm and during non-monsoon season is 202.83 mm.The variation of rainfall in this zone is from 990 mm to 1240 mm and the temperature varies from 37.1 to 7.8˚C.

Agriculture and Irrigation

The block falls in the Agro-climatic Zone IIIA. The cropping sequence followed in this zone isRice – Wheat, Rice – Gram, Rice – Lentil, Rice – Rai. The soils in this zone are sandy loam, clay loam, loam, clay with pH in the range of 6.8 – 8.0. The gross irrigated area is 14.14sq.Km and dependency on ground water for irrigation is 50%.

Ground Water Resource Availability and Extraction

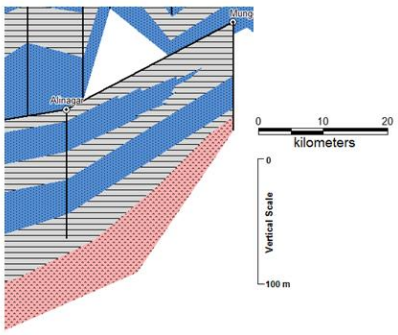
The dynamic ground water resource of Dharhara block has been assessed as 79.54 MCM. The gross ground water draft for all uses stands at 20.02MCM. The stage of Development is 25.17%.

Water Level Behaviour

The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from2 to 5 mbgl in some parts and in some parts 5 to 10 mbgl.

2. Aquifer Disposition

The area is bestowed with two-aquifer system. The section depicting the aquifer disposition is shown below.



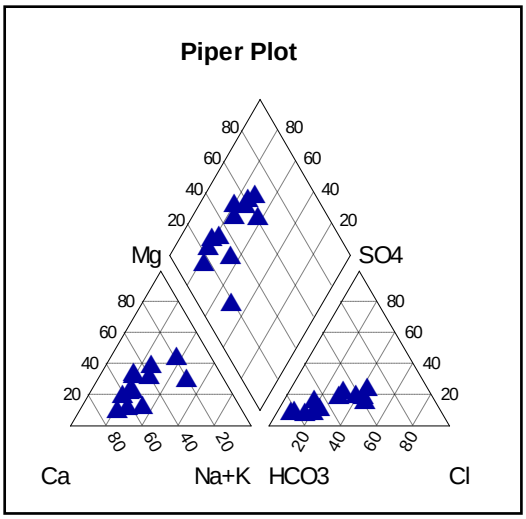
2D view of aquifer disposition

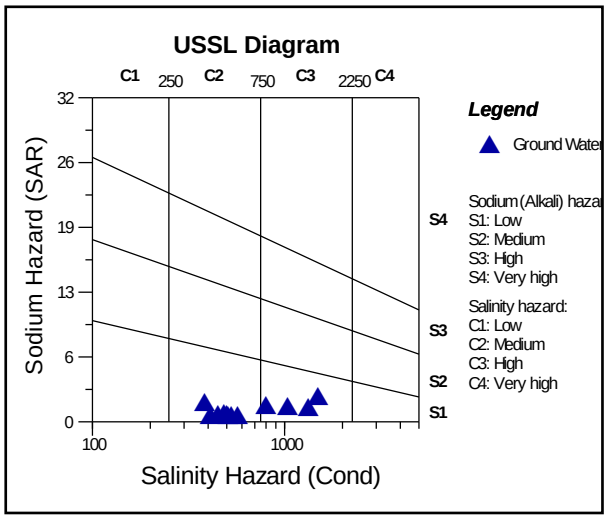
Ground Water Resource, Extraction, Contamination and Other Issues

The overall stage of groundwater development in the Block is 25.17%. Sufficient scope exists for groundwater development in the block. Arsenic contamination of groundwater has been reported from the 1st aquifer in the younger alluvial belt down to the depth of 60m. Ground water exploration has revealed that the 2nd aquifer which is encountered below the clay layer separating the 1st and the 2nd aquifer is safe from arsenic contamination. The 2nd aquifer is thus recommended for community drinking water supply. Even in the 1st aquifer, the concentration of arsenic below the depth of 60 m has been found within the permissible limit; however, these are vulnerable to contamination with further groundwater development as they are part of the same contaminated aquifer. It is therefore recommended to develop the groundwater from the lower parts of the 1st aquifer only through hand-pumps. Energized extraction should be discouraged as this would accelerate the vertical mixing with the arsenic contaminated layers. The 2nd Aquifer is recommended only for extraction for drinking water supply.

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.





Piper Plot **USSL diagram**

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use the 2nd Aquifer solely for meeting the drinking water supply requirement. Necessary regulations to enforce this recommendation in the arsenic affected Blocks may be made so as to keep the 2nd aquifer safe from arsenic contamination.

Dynamic Ground Water Resource (as on 31st March, 2013)

District	Blocks	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non-Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non-Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Munger	Dharhara	6400.03	980.14	829.72	628.51	8838.4	883.84	7954.56	1732.90	269.53	2002.43	67.00	6154.66	25.17	Safe

Result of Chemical Analysis of Ground Water Samples

Sl.No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25	CO3-	HCO3-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO4	SiO2
1	Munger	Dharhara	ShivkundSarapatti	86.40517	25.29044	TW	8.13	928	27	299	117	0.21	18	nd	310	48	46	66	11.0	nd	4.9
2	Munger	Dharhara	Sunderpur	86.37033	25.30208	TW	8.54	1133	36	305	142	0.07	62	28.3	385	76	47	94	7.9	nd	8.7
3	Munger	Dharhara	BahaChowki	86.35808	25.29667	TW	8.63	895	nd	360	64	0.33	50	nd	245	34	38	86	9.3	nd	5.5
4	Munger	Dharhara	Mongaon	86.41275	25.26289	TW	8.29	767	nd	366	53	nd	13	nd	230	56	22	73	3.1	nd	4.8
5	Munger	Dharhara	Darhara	86.41406	25.25722	TW	8.1	914	nd	268	96	nd	20	31.5	265	72	20	80	2.3	nd	2.5
6	Munger	Dharhara	Aura Bagicha	86.42906	25.25794	TW	7.36	1196	nd	281	170	nd	4	32.0	300	80	24	94	15.1	nd	2.9
7	Munger	Dharhara	Adalpur	86.44447	25.26019	TW	7.74	998	nd	323	78	0.42	17	33.4	290	98	11	52	12.1	nd	3.6
8	Munger	Dharhara	Ballan	86.46458	25.26408	TW	7.83	307	nd	153	21	0.35	5.1	7.1	125	30	12	16	0.8	nd	4.2

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **JAMALPUR**(85 Sq. Km.)

District/ State Munger/Bihar

Rainfall and Temperature

The normal annual rainfall of Munger district is 1173.58 mm of which 82.72% occurs during the monsoon season. The normal rainfall during monsoon season is 970.75 mm and during non-monsoon season is 202.83 mm.The variation of rainfall in this zone is from 990 mm to 1240 mm and the temperature varies from 37.1 to 7.8˚C.

Agriculture and Irrigation

The block falls in the Agro-climatic Zone IIIA. The cropping sequence followed in this zone isRice – Wheat, Rice – Gram, Rice – Lentil, Rice – Rai. The soils in this zone are sandy loam, clay loam, loam, clay with pH in the range of 6.8 – 8.0. The gross irrigated area is 8.14sq.Km and dependency on ground water for irrigation is 50%.

Ground Water Resource Availability and Extraction

The dynamic ground water resource of Jamalpur block has been assessed as19.33 MCM. The gross ground water draft for all uses stands at 9.17MCM. The stage of Development is 47.47%.

Water Level Behaviour

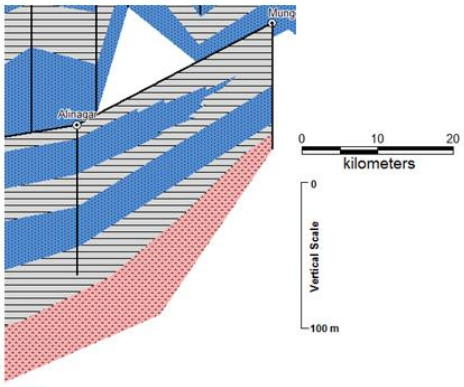
The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from2 to 5 mbgl in most parts and in some parts 5 to 10 mbgl.

Ground Water Resource, Extraction, Contamination and Other Issues

The overall stage of groundwater development in the Block is 47.47%. Sufficient scope exists for groundwater development in the block. Arsenic contamination of groundwater has been reported from the 1st aquifer in the younger alluvial belt down to the depth of 60m. Ground water exploration has revealed that the 2nd aquifer which is encountered below the clay layer separating the 1st and the 2nd aquifer is safe from arsenic contamination. The 2nd aquifer is thus recommended for community drinking water supply. Even in the 1st aquifer, the concentration of arsenic below the depth of 60 m has been found within the permissible limit; however, these are vulnerable to contamination with further groundwater development as they are part of the same contaminated aquifer. It is therefore recommended to develop the groundwater from the lower parts of the 1st aquifer only through hand-pumps. Energized extraction should be discouraged as this would accelerate the vertical mixing with the arsenic contaminated layers. The 2nd Aquifer is recommended only for extraction for drinking water supply.

2. Aquifer Disposition

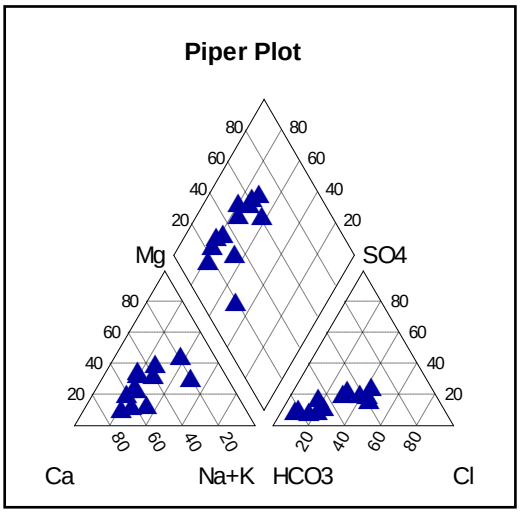
The area is bestowed with two- aquifer system. The section depicting the aquifer disposition is shown below.



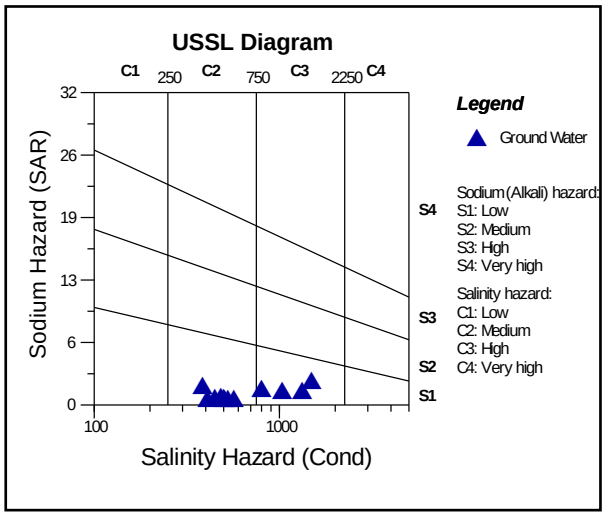
2D view of aquifer disposition

Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper plot



USSL diagram.

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use the 2nd Aquifer solely for meeting the drinking water supply requirement. Necessary regulations to enforce this recommendation in the arsenic affected Blocks may be made so as to keep the 2nd aquifer safe from arsenic contamination.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non-Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non-Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Munger	Jamalpur	1528.44	234.08	233.13	152.82	2148.47	214.85	1933.62	639.80	278.10	917.90	86.00	1207.82	47.47	Safe

Result of Chemical Analysis of Ground Water Samples

Sl.No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25	CO3-	HCO3-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO4	SiO2
1	Munger	Jamalpur	Dakarnala	86.45939	25.33350	TW	8.16	595	nd	323	28	nd	4	nd	215	46	24	38	3.8	nd	4.3
2	Munger	Jamalpur	Farda	86.43686	25.31333	TW	7.91	681	nd	348	18	nd	6	nd	220	48	24	34	4.7	nd	6.6
3	Munger	Jamalpur	Saifai	86.49178	25.34089	TW	7.93	1960	nd	342	316	nd	19	32.7	510	80	74	124	2.0	nd	5.4
4	Munger	Jamalpur	SinghiyaChowk	86.40689	25.30217	TW	7.89	1146	nd	317	131	0.23	24	33.2	200	60	12	114	17.8	nd	4.5

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block and Area(in Km^2) **MUNGER**(242 Sq. Km.)

District/ State Munger/Bihar

Rainfall

The normal annual rainfall of Munger district is 1173.58 mm of which 82.72% occurs during the monsoon season. The normal rainfall during monsoon season is 970.75 mm and during non-monsoon season is 202.83 mm.The variation of rainfall in this zone is from 990 mm to 1240 mm and the temperature varies from 37.1 to 7.8˚C.

Agriculture and Irrigation

The block falls in the Agro-climatic Zone IIIA. The cropping sequence followed in this zone isRice – Wheat, Rice – Gram, Rice – Lentil, Rice – Rai. The soils in this zone are sandy loam, clay loam, loam, clay with pH in the range of 6.8 – 8.0.

Ground Water Resource Availability and Extraction

The dynamic ground water resource of Munger block has been assessed as31.25 MCM. The gross ground water draft for all uses stands at 7.12MCM. The stage of Development is 22.79%.

Water Level Behaviour

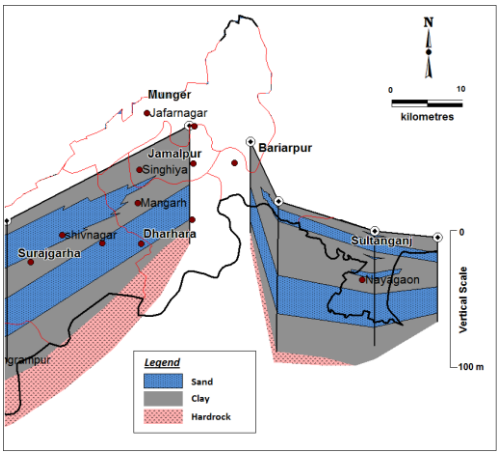
The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season,the depth to water level varies from2 to 5 mbgl in most parts and in few parts 5 to 10 mbgl.

Ground Water Resource, Extraction, Contamination and Other Issues

The overall stage of groundwater development in the Block is 22.79%. Sufficient scope exists for groundwater development in the block. Arsenic contamination of groundwater has been reported from the 1st aquifer in the younger alluvial belt down to the depth of 60m. Ground water exploration has revealed that the 2nd aquifer which is encountered below the clay layer separating the 1st and the 2nd aquifer is safe from arsenic contamination. The 2nd aquifer is thus recommended for community drinking water supply. Even in the 1st aquifer, the concentration of arsenic below the depth of 60 m has been found within the permissible limit; however, these are vulnerable to contamination with further groundwater development as they are part of the same contaminated aquifer. It is therefore recommended to develop the groundwater from the lower parts of the 1st aquifer only through hand-pumps. Energized extraction should be discouraged as this would accelerate the vertical mixing with the arsenic contaminated layers. The 2nd Aquifer is recommended only for extraction for drinking water supply.

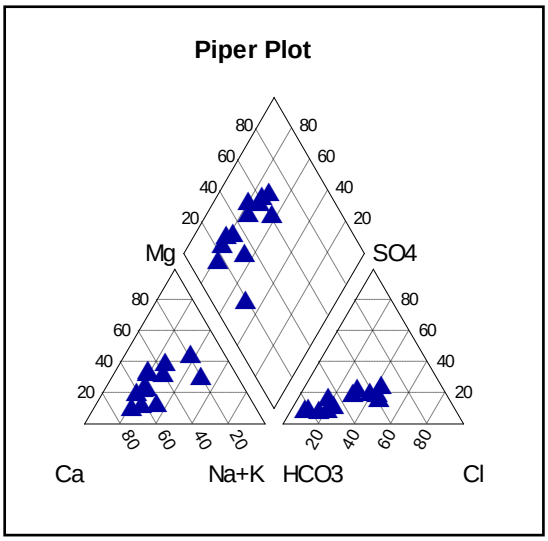
2. Aquifer Disposition

The area is bestowed with two- aquifer system. The section depicting the aquifer disposition is shown below.

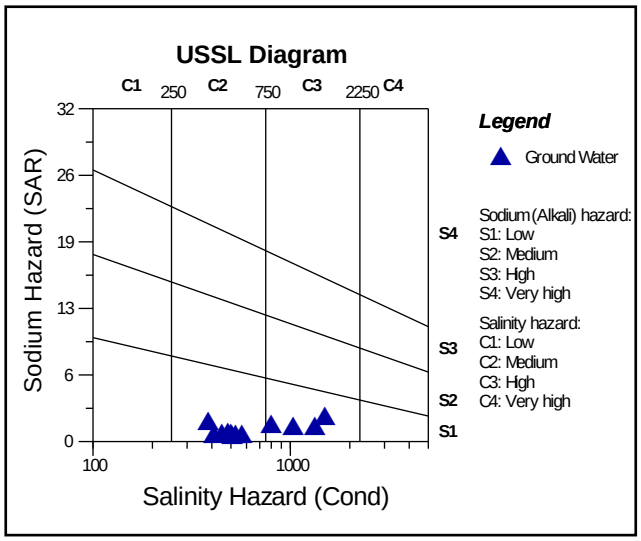


Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram groundwater of the block is potable and based on USSL diagram suitable for irrigational purposes.



Piper Plot



USSL diagram

3. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

4. Demand Side Interventions

In view of the issue of arsenic contamination, it is recommended to use the 2nd Aquifer solely for meeting the drinking water supply requirement. Necessary regulations to enforce this recommendation in the arsenic affected Blocks may be made so as to keep the 2nd aquifer safe from arsenic contamination.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2013)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non-Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non-Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Munger	Munger	2158.91	385.73	526.91	217.60	3289.15	164.46	3124.69	446.00	266.23	712.23	84.00	2594.69	22.79	Safe

Result of Chemical Analysis of Ground Water Samples

S.No.	District	Block	Village	Long	Lat	Source	pH	EC (µs) /cm at 25	CO3-	HCO3-	Cl^-	F	SO_4^{2-}	NO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	PO4	SiO2
1	Munger	Munger	Munger	86.46753	25.37522	TW	8.19	1036	nd	311	82	0.06	14	32.9	300	38	49	52	9.6	nd	0.3
2	Munger	Munger	Hirodiara	86.46508	25.34553	TW	7.91	1071	nd	305	71	0.13	20	33.3	285	100	8	50	0.9	nd	4.2
3	Munger	Munger	Kanchangarh	86.50989	25.35211	TW	8.13	585	nd	262	21	nd	20	nd	180	38	20	27	3.6	nd	0.4
4	Munger	Munger	Radiabadh	86.52644	25.34764	TW	8.21	546	nd	244	25	0.25	14	7.5	190	50	16	27	1.1	nd	0.0
5	Munger	Munger	Nuwagarni	86.53736	25.34492	TW	8.02	1400	nd	519	106	nd	20	35.0	510	166	23	51	3.0	nd	3.3