केंद्रीय भूमि जल बोर्ड

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विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Parts Of Nadia District (9 Blocks), West Bengal (Karimpur - I, Karimpur - II, Tehatta - I, Tehatta - II, Kaliganj, Nakashipara, Chapra, Krishnaganj & Hanskhali Blocks) (Phase - II)

पूर्वी क्षेत्र, कोलकाता

Eastern Region, Kolkata

GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI

REPORT ON
AQUIFER MAPPING STUDIES IN PARTS OF NADIA DISTRICT (9 Blocks), WEST BENGAL

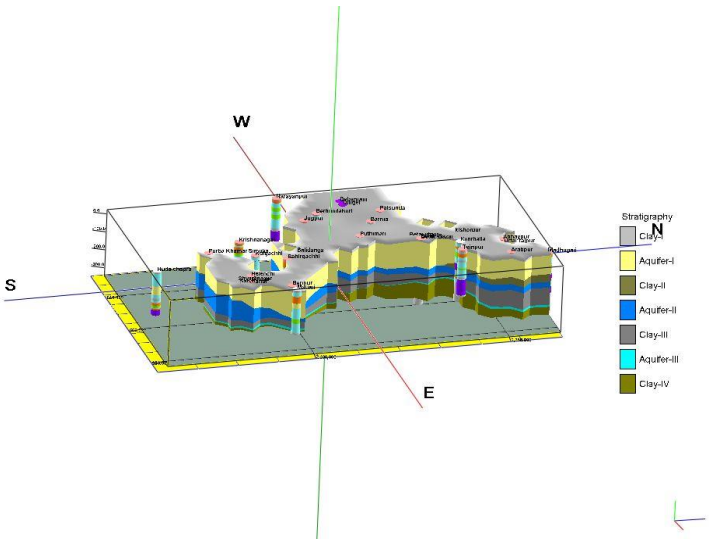
(Karimpur - I, Karimpur - II, Tehatta - I, Tehatta - II, Kaliganj, Nakashipara, Chapra, Krishnaganj & Hanskhali Blocks)

(PHASE - II)

(AAP 2016 - 2017)

By

D. Biswas, Scientist 'D'



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Eastern Region, Kolkata

SEPTEMBER 2019

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(PHASE - II)

(AAP 2016 - 2017)

CONTENTS

Part I

Aquifer Mapping Studies in parts of Nadia district (9 Blocks)

EXECUTIVE SUMMARY

Under the National Aquifer Mapping & Management Programme (NAQUIM), taken up by CGWB under XIIth Plan, 9 blocks of Nadia district in West Bengal, covering an area of approximately 2262 sq. km. were taken up by CGWB, ER, Kolkata during 2015-16 (extended to 2016-17). This report envisages the salient features of aquifer geometry, characteristics, ground water occurrences, availability, resource vis-a-vis quality etc. in respect of present scenario.

The broad objective of the study is to establish the geometry of underlying aquifer systems in horizontal and vertical domain and characterize them, so as to work out the developmental potential and prepare aquifer-wise management plan.

During the present study, there have been four major activity components viz.: (i) Data collection from different sources and compilation, (ii) Data gap analysis to ascertain requirement for further data generation, (iii) Data generation in respect of hydrogeological, geophysical, geochemical aspects, and (vi) Preparation of aquifer maps and management plan to achieve the primary objective.

The study area falls in northern part of Nadia district comprising 9 blocks namely- Karimpur I, Karimpur II, Tehatta I, Tehatta II, Kaliganj, Nakashipara, Chapra, Krishnaganj and Hanskhali; these blocks are located on the eastern side of Bhagirathi river. The study area is a part of Lower Ganga Alluvial Plains in the inter-fluvial belt of Ganga basin. Bhagirathi, Jalangi, Churni, etc forms the major drainage in the study area. The area partly falls in the Survey of India Degree Sheet nos. 79A and 79B and extends between North latitudes 23.240° and 24.132° and East longitudes 88.070° and 88.870°.

As per 2011 census, the total population of the study area (i.e. in 9 Blocks) is 21,21,105 which is about 41 % of the total population of Nadia district. The average population growth from 2001 to 2011 is about 12.25 %. The average annual rainfall in Nadia district from 2012-2016 is 1214.24 mm. However, the normal annual rainfall (1980-2016) is slightly higher at 1376 mm.

Ground water based irrigation is done by DTWs, STWs & Dug Wells, and cultural command area is 1267.93 sq. km. The surface water based irrigation is done by RLI and SFI and it's cultural command area is 88.60 sq. km. Total cultivable area in the area is 1584.68 sq. km. and the Cropping Intensity is 243%.

Principal crops in the area, are Paddy (Aus, Aman & Boro), Wheat, Maize, Gram, Pulses, Oil seeds (Mustard, Linseed), Fibers (Jute), Sugar-cane, Vegetables (Potato), etc.

Geomorphology, mainly represented by younger flood plain, is almost flat topography covered with numerous small rivers/ streams, meander scars, cut off/ abandoned channels, point bars, natural levees. Elevation ranges from 28.84 m above MSL (Mean Sea Level), near Jairampur, Karimpur block, to 5.1 m above MSL, near Hanskhali block.

Geologically, the area is underlain by a huge thickness of Recent to Sub-Recent Alluvium of the Ganga basin. Thick Gangetic alluvium of Quaternary Era constitutes the

sub - surface geology. These fluviatile sediments are composed of sand of various grades, silt, clay, gravel, kankar and their various admixtures deposited by the river Ganga and its tributaries. Sand is grey coloured and highly micaceous in nature and compositionally quartzo-feldspathic with some mafic minerals.

Hydrogeologically, 3 aquifer systems/ groups, separated by clay barriers of widely variable thickness, have been identified. The shallow aquifer system (say, Aquifer I Group) exists within a depth range of 5 m to 150 m, which extends up to 186 m at Betai in Tehatta I block; ground water in this aquifer system is mostly contaminated by arsenic in all the blocks. The next deeper aquifer system (Aquifer II Group) occurs broadly within 150 – 200 m in all the blocks; ground water in this aquifer system is found to be contaminated by arsenic sporadically, particularly in Tehatta I, Tehatta II, Kaliganj & Nakashipara blocks. The deepest one (Aquifer III Group) exists approximately within the depth range from 215 m to 295 m, as observed in Karimpur I & Karimpur II, Tehatta II and Kaliganj blocks; ground water in this aquifer system is in general fresh.

. The tube wells tapping the zones at shallow depth (Aquifer I) yield (Q) to the tune within 36 - 173 m^3/hr with Transmissivity (T) varying from 350 to 2700 m^2/day. In the tube wells tapping the intermediate zones, Aquifer- II, Q generally ranges from 29 to191 m^3/hr with T varying from 350 to 2700 m^2/day. Abstraction structures in the deeper aquifer, i.e. Aquifer III, yield between 36 and 86 m^3/hr. Pumping tests' data indicate that Storage co-efficient (S) ranges from 1.55×10^{-3} to 6.2×10^{-4} indicating confined condition for deeper aquifers. However, at many places the phreatic aquifers are under unconfined condition.

Monitoring data of hydrograph stations reveal that the pre-monsoon depth to water level (DTW) in shallow aquifer (Aquifer I) in this area ranges within 3 - 4 m bgl in a small patch of east-central part, covering parts of Karimpur II & Tehatta I blocks, and deepest within 7 - 8 m bgl in the west-central part, mainly in parts of Nakashipara block; and the same in deeper aquifer, Aquifer II is found to be shallow, ranging from 3 to 4 m bgl in the border area of Karimpur II & Tehatta I blocks, and deep, ranging from 9 to 10 m bgl in the west-central and south-western parts covering parts of Kaliganj & Hanskhali blocks.

Pre-monsoon water table map of Aquifer- I reveals ground water 'mounds' in the north-eastern & west-central parts of the area covering parts of Karimpur I, Karimpur II and Kaliganj blocks with a maximum elevation varying from 18 to 19 m above MSL and ground water 'troughs' occurring in the east-central & west-central parts covering parts of Chapra & Krishnaganj and Kaliganj blocks with maximum depression within 7 – 8 m above MSL. The regional direction of ground water flow is from north-west to south-east with variable gradients from 1:8000 to 1:1100 in different parts of the area.

Pre-monsoon water table map for deeper aquifer (Aquifer II) reveals the creation of ground water 'mounds' in the north-eastern & west-central parts of present area covering parts of Karimpur I, Tehatta- I, Nakashipara and Chapra blocks with a maximum elevation between 18 m and 19 m above MSL; and ground water 'troughs' occurring in the north-

western & south-western parts covering parts of Karimpur II and in the border of Krishnaganj & Hanskhali blocks with a maximum depression ranging between 7 m and 8 m above MSL. The local direction of ground water flow varies from place to place with variable gradients from 1:6000 to 1:1000.

Annual ground water flow has been estimated by Darcy's law using Q= TIL method. Block-wise flow of ground water in shallow unconfined aquifer and deeper semi-confined to confined aquifer systems have been presented in the Report.

Long term trend analysis reveals that there is a falling trend in some blocks (except a few) both during Pre-monsoon and Post-monsoon. Pre-monsoon falling trend of water level varies from 0.9 cm/year, in Hanskhali block to 16.4 cm/year, in Nakashipara block; Post-monsoon falling trend varies from 2.2 cm/year, in Nakashipara block) to 21.2 cm/year, in Tehatta I block.

Dynamic ground water resources of Aquifer I in the area under study have been estimated based on GEC (1997) methodology by CGWB and State Water Investigation Department (SWID) for the year as on 31.03.2013. The Net Ground Water Resource availability in the area comprising 9 blocks is computed to the tune of 1235.477 MCM and the Total Ground Water Draft for all uses is 1277.85 MCM. The average Stage of Development is 103.4 %. Based on the same estimation, out of nine blocks, two blocks – Nakashipara and Krishnaganj have been categorized as 'Safe' and other seven blocks are categorized as 'Semi-critical'.

Dynamic ground water resource of phreatic aquifer, Aquifer I, in the study area has also been estimated based on the Water Level Fluctuation Method for the year 2016 considering average Specific Yield of 20% and the same is found to be 422.237 MCM. The Dynamic ground water resources of deeper semi-confined to confined aquifer in the study area has also been estimated based on the average Storativity (considered as 1.55×10^{-3}) and average fluctuation of Water level (Pre monsoon minus post monsoon) of the present area and the same has been estimated to be 327.231 MCM.

Ground water occurring in shallow and deeper aquifers in the study area does not vary significantly, excepting sporadic contamination by arsenic. It is, in general, slightly alkaline and Ca-Mg- HCO3 type with electro-conductivity (EC) ranging between 280 and 1080 µS/cm. Chemical facies of shallow aquifer is generally $MgHCO_3$- $CaHCO_3$- $NaHCO_3$ Type, and that of deeper aquifer is in general $MgHCO_3$- $NaHCO_3$ Type. Sodium (Alkali) hazard of the ground water from both the shallow and deeper aquifers is very low and the Salinity hazard is 'Medium'.

Arsenic is the main contaminant in shallow and, at places, in intermediate Aquifer Groups in all 9 Blocks of present study area; sporadic arsenic in shallow aquifers beyond permissible limit (0.01 mg/l) has been encountered. A total population of 2121105 (Census 2011) in rural area, are within risk zone. Maximum concentration of arsenic in ground water has been observed to the tune of 1.18 mg/l at Mahisbathan in Karimpur II block.

In Part II, Aquifer Management Plan for Drinking and Irrigation has been dealt. Arsenic contamination in shallow aquifer is an important issue in present area. Arsenic free deeper aquifers, ranging from 200 to 300 m bgl, are potential with yield to the tune of 12.5 litre per second with drawdown of 6 m (approx), can cater to the need of rural water supply. Nos. of tube wells needed for supply of potable water in uncovered area have been estimated based on detail rational approach and cost estimate has been drawn for construction of those wells for implementation of PWSS in those parts.Tube wells should be constructed by tapping aquifers, separated from top arsenic contaminated aquifers by a persistent clay blanket above it and putting cement seal against clay layer in order to prevent the vertical percolation of arsenic contaminated water from the top contaminated aquifer. However, PHED, Government of West Bengal has been implementing different Short Term, Medium Term and Long Term measures to tackle the menace of ground water contamination by arsenic.

Paddy and Rabi vegetables are the important corps that are cultivated mainly by irrigation by ground water. There is regionally extensive unconfined upper aquifer system within depth of 150 m bgl in the area. This aquifer is highly potential and holds fresh water and can cater to the need of irrigation, agriculture and industries. There is urgent need for efficient management of the aquifer systems for sustenance of the tube wells due to huge declining of water level due to irrigation and also heavy withdrawal for drinking purpose in urban areas.

Based on the availability of ground water resources & its present status of development, block-wise availability of ground water for future Irrigation has been estimated; it reveals that only 4 blocks, eg. Hanskhali, Kaliganj, Nakashipara and Krishnaganj have nominal ground water available for future irrigation, whereas, no ground water is available in remaining 5 blocks.

Area suitable for artificial recharge is worked out based on post-monsoon depth to water level of more than 3m and showing long term falling trend of water level more than 0.20 m/year. Block-wise net surface water availability for recharge has been estimated after Dhruvanarayana, 1993, followed by source water allocation for suitable types of conservation & artificial recharge structures with feasible numbers and structure-wise cost estimate, have also been worked out for the study area. Considering the higher level of ground water development, categorization of block, suitable area for recharge, proposal for implementation of conservation and artificial recharge projects in the study area have been proposed. Percolation Tanks, Re-Excavation of Existing Tanks (REET) with Recharge Shafts, Injection Wells, Conservation Ponds in the rural area, and Roof-Top Rain Water Harvesting structures in urban areas are proposed structures in the present area.

To improve the ground water scenario in shallow aquifer, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be implemented. Water columns suggested in consultation with BCKV are as follows: rice - 0.8m, wheat - 0.2 - 0.35m, mustard - 0.2m, pulse - 0.08 - 0.12m, vegetable 0.12 - 0.16m, following micro-irrigation system. By decreasing area of Boro cultivation in summer and implementing micro-irrigation

techniques, huge draft of ground water could be avoided.

In Part II of the Report, block wise management plan of 9 blocks of Nadia district have been dealt separately by giving salient information of the block concerned, tabulating facts and figures of the aquifer(s), their disposition by 2D and 3D images, tabulating seasonal depth to water levels, analyzing long term water level trends, individual aquifer characteristics, viz. Discharge, Transmissivity, Storativity etc., aquifer-wise availability of ground water resources, eg. (dynamic and static), annual flow of ground water through the aquifer, chemical quality of ground water especially arsenic contamination & risk population. Under resource enhancement & management plan, suitable interventions for tapping proper aquifer have been proposed. Judicious use of irrigation water, eg. phase wise lessening of area of cultivation of 'Boro' rice, change in cropping pattern, use of low water requiring crops and use of micro-irrigation techniques have been strongly suggested. Finally, artificial recharge and rain water harvesting is suggested for specific structures; for this quantum of rain water for harvesting, has been estimated for individual blocks by applying 'Dhruvaarayana (1993)' method. The proposed conservation and / or recharge structures along with cost estimates have also been tabulated for all the blocks separately.

Part I

Aquifer Mapping Studies in parts of Nadia District (9 Blocks),

West Bengal

(Karimpur - I, Karimpur - II, Tehatta - I, Tehatta - II, Kaliganj, Nakashipara, Chapra, Krishnaganj & Hanskhali Blocks)

1. INTRODUCTION

Groundwater is one of the prime sources of fresh water contributing significantly for the survival of mankind. However, overexploitation, surface runoff, subsurface groundwater discharge have depleted the fresh groundwater availability considerably. Assessing the groundwater potential zone is extremely important for the protection of water quantity & quality, and the management of groundwater system. In this context, the National Aquifer Mapping & Management Programme (NAQUIM) has been taken up by CGWB under XIIth Plan. As per the Action Plan under NAQUIM, ground water management studies in 9 blocks of Nadia district in West Bengal, covering an area of approximately 2262 sq. km. was taken up by CGWB, ER, Kolkata during 2015-16-17. This report envisages the salient features of aquifer geometry, characteristics; ground water occurrences, availability, resource vis-a-vis quality etc. in present scenario.

1.1 Objective

The broad objective of the study is to establish the geometry of the underlying aquifer systems in horizontal and vertical domain and characterize them, so as to work out the development potential and prepare aquifer-wise management plan using ground water simulation model.

1.2 Scope of Study

The scope of the present study is broadly within the framework of National Aquifer Mapping & Management Programme (NAQUIM) being implemented by CGWB. There are four major activity components viz.: (i) Data collection / compilation (ii) Data gap analysis (iii) Data generation and (vi) Preparation of aquifer maps and management plan to achieve the primary objective. Data compilation included collection, and wherever required procurement, of all maps from concerned Agencies, such as the Survey of India, Geological Survey of India, State Governments etc., computerization and analyses of all acquired data, and preparation of a knowledge base. Identification of Data Gap included ascertaining requirement for further data generation in respect of hydrogeological, geophysical, chemical, hydrological, hydro-meteorological studies, etc. Data generation included those of hydrometeorology, chemical quality of ground water, litho-logs and aquifer parameters. Generation of ground water chemical quality data was accomplished by collection of water samples and their laboratory analyses for all major parameters, and some of the heavy metals. Additional data pertaining to sub-surface lithology and aquifer parameters were obtained through drilling of additional exploratory wells and slim holes, pumping tests at the drilling sites.

1.3 Approach and Methodology

An approach and methodology adopted to achieve the major objective have been shown below step-wise.

i) Compilation of existing data
ii) Identification of data gaps
iii) Data generation based on data gaps
iv) Preparation of thematic maps on GIS platform
v) Preparation of Rock-Works based 2D/3D maps
vi) Compilation of Block-wise Aquifer Maps and Management Plan

1.4 Location, Extent and Accessibility of the study area

The study area (Plate 1) comprising 9 blocks of northern Nadia district which is located on the eastern bank of Bhagirathi river, a tributary of river Ganga bordering with Bardhaman district in the west, and flanked by the western boundary of Bangladesh in the east, south-eastern boundary of Murshidabad district in the north-west, and some blocks of southern Nadia district in the south. The area extends between North latitudes 23.240° and 24.132° and East longitudes 88.070° and 88.870°. The study area partly falls in the Survey of India Degree Sheet nos. 79A and 79B. The study area forms part of Lower Ganga Alluvial Plains in the inter-fluvial belt of Ganga basin.

1.5 Administrative divisions and population

The study area comprises of 9 Blocks falling in 3 Sub-Divisions (in whole/ parts) covering an area of about 2262 sq. km, i.e., about 57.8 % total area of Nadia district. Details of administrative divisions are summarized in **Table- I**.

Table-I: Administrative divisions of the study area in parts of Nadia district

SI No.	Name of the Sub-Division	Name of the Block	No. of Gram Panchayats	No. of inhabited Villages	Geographic area (in sq.km.) (GIS based)
1.	Tehatta	Karimpur - I	8	65	212.27
2.	Tehatta	Karimpur – II	10	65	241.18
3.	Tehatta	Tehatta - I	11	55	258.30
4.	Tehatta	Tehatta – II	7	32	174.44
5.	Krishnanagar Sadar	Kaliganj	15	105	319.75
6.	Krishnanagar Sadar	Nakashipara	15	101	354.24
7.	Krishnanagar Sadar	Chapra	13	77	310.48
8.	Krishnanagar Sadar	Krishnaganj	7	52	159.55
9.	Ranaghat	Hanskhali	13	76	231.50
	TOTAL		99	1628	2261.71

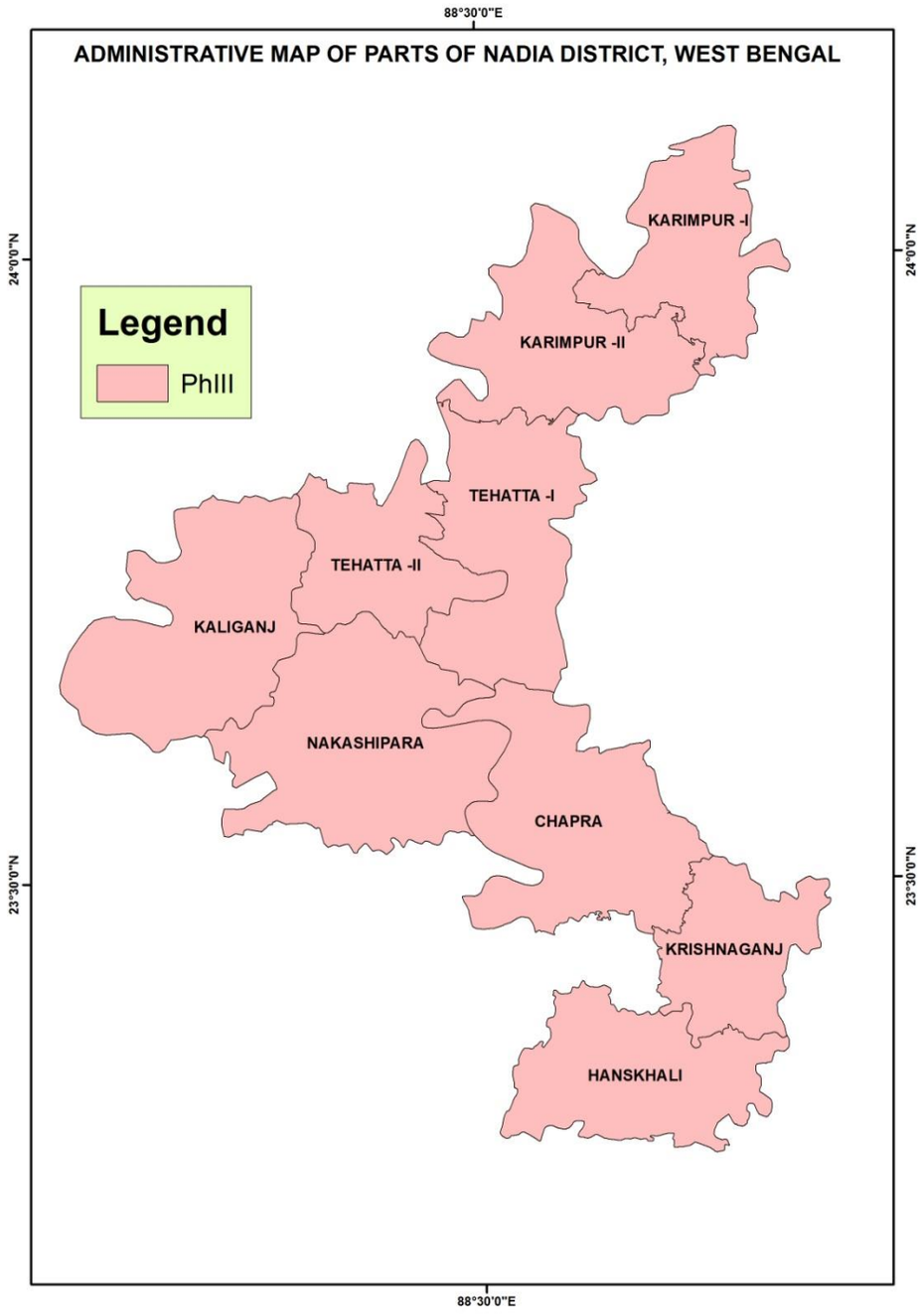


Plate-1

As per 2011 census, the total population of the study area (i.e. 9 Blocks) is 21,21,105 which is about 41 % of the total population of Nadia district. The average population growth from 2001 to 2011 is about 12.25 %. Block-wise male and female population in the study area is shown in **Table-II**.

Table-II: Block-wise Male and Female population

Block	Population (2011)		
	Male	Female	Total
Karimpur - I	83014	77881	160895
Karimpur – II	111488	105648	217136
Tehatta - I	125875	118447	244322
Tehatta – II	77299	73932	151231
Kaliganj	157234	148963	306197

Nakashipara	180990	171201	352191
Chapra	152575	143954	296529
Krishnganj	75573	71132	146705
Hanskhali	127576	118323	145899
Total	**10,91,624**	**10,29,481**	**21,21,105**

Source: District Statistical Handbook, 2013

The Administrative Map of the study area is shown in **Plate-1.**

1.6 Land-use and Cropping pattern

Irrigation plays an important role for crop production and intensity of crops. The area is having cultivable area of about 61% of the total geographical area. The cultivable land in the study area, about 35% is rain fed, and in the rest area crop production is solely dependent of surface water and ground water irrigation systems. Ground water irrigation is created by deep tube well and shallow tube wells. Irrigation by surface water is done through River lift irrigation, whereas irrigation by water conservation structures (tanks etc.) is covering an area of about 12% of the total irrigated area.

The details of land use pattern in each blocks is shown in the following **Table- III**.

Table-III: Block-wise details of Land-use pattern

Sl. No.	Name of the Block	Geographical Area (ha) (Agriculture-based)	Cultivable Area (ha)	Area Under Pasture and Orchard(ha)	Cultivable Waste Land (ha)	Forest Land (ha)	Home State Land (ha)	Remarks
1.	Karimpur-I	21580	12516	209	------	----	4631	Some Vested Land
2.	Karimpur-II	22440	13015	217	------	----	4712	Some Vested Land
3.	Tehatta-I	24960	15224	241	------	-----	5241	Some Vested Land
4.	Tehatta-II	17250	10212	167	-------	-----	3622	Some Vested Land
5.	Kaliganj	32000	20480	357	------	-----	6720	Some Vested Land
6.	Nakashipara	36090	23052	312	Nil	309	7525	Some Vested Land
7.	Chapra	30600	20002	287	-----	----	6426	Some Vested Land
8.	Krishnaganj	15160	9612	146	-----	215	3183	Some Vested Land
9.	Hanskhali	24630	13745	176	----	181	5085	Some Vested Land

The principal crops which are cultivated In this area, are :-

a) Paddy- Aus, Aman & Boro; Wheat, Maize etc.

b) Cereals- Gram and other Pulses

c) Oil seeds- Mustard, Linseed etc.

d) Fibers- Jute etc.

e) Miscellaneous- Sugar-cane, Potato etc.

The ground water based irrigation is done by DTWs, STWs and Dug Wells and the cultural command area is 1267.93 sq. km. The surface water based irrigation is done by RLI and SFI and the cultural command area is 88.60 sq. km. Total cultivable area in the area is 1584.68 sq. km. and the Cropping Intensity is 243%.

1.7 Urban areas

Urban areas in the study area include some of the Census Towns, viz., Karimpur, Chapra, Bagula, Majdia etc.

2. HYROMETEOROLOGY

The climate of the area is characterized by hot and humid climate with adequate rainfall mainly derived from south-west monsoon, which starts from mid-June and continue up to September. Generally, 85 percent of the rainfall is received during the monsoon period. Pre-monsoon showers are occasionally received in the month of March, April and May.

2.1 Rainfall

The average annual rainfall in Nadia district from 2012-2016 is 1214.24 mm. Rainfall amount is measured from 10 Rain gauge stations in different blocks. Rainfall data for a period of 5 years (2012-2016) have been recorded month-wise (**Table- IV**).

However, the normal annual rainfall (1980-2016) is slightly higher at 1376 mm. It is obvious that there is slight decrease in rainfall during the last 5 years.

A critical analysis of Rainfall v/s cropping pattern is shown in **Plate-2.**

Table-IV: Average monthly rainfall in Nadia for the period 2012 -16 (in mm)

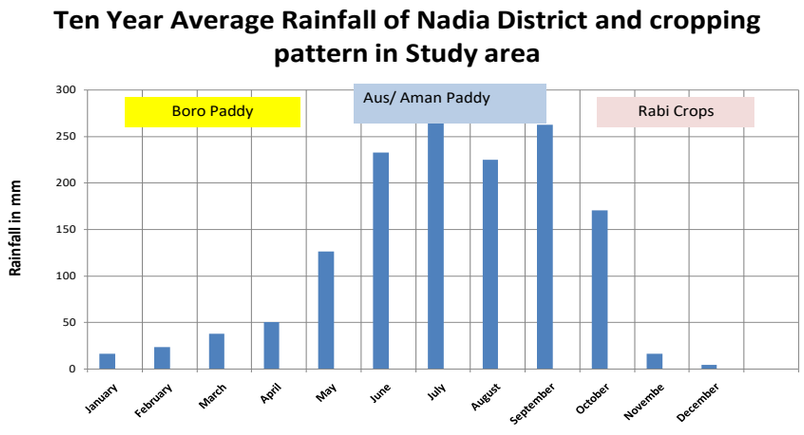
5 years Rainfall in Nadia district

Nadia	Year	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Nadia													
	2012	19.7	0.4	0.4	27.2	74.3	95.6	206.8	162.7	161.8	71.6	37.8	3.7
	2013	6.3	9.1	1.5	39.3	149.7	188.1	181.1	327	160.7	224.8	0	0.2
	2014	0.8	50.2	17.1	0	92	221.4	203.1	236.7	218.8	56.7	0	0
	2015	5.5	14.5	18.5	99.2	56.5	327.5	516.3	139.1	178.6	48	0	4.4
	2016	0.8	38.7	16.2	3.2	181.3	152.1	334.5	429.1	176.2	67.5	16.9	0
Average 5 yrs		**6.62**	**22.58**	**10.74**	**33.78**	**110.76**	**196.94**	**288.36**	**258.92**	**179.22**	**93.72**	**10.94**	**1.66**

Normal Rainfall 1443.8 mm
Normal monsoon Rainfall 955 mm

Plate- 2

Critical analysis of rainfall v/s cropping pattern



2.2 Temperature

The winter season sets in around middle of November when both maximum and minimum temperature begin to drop steadily and attain their respective lowest values in the month of January. The temperature starts rising in the month of February. May is the hottest month of the year.

3. PHYSIOGRAPHY

3.1 Geomorphology

The study area is an extensive alluvial plain possessing the characteristics of younger flood plain with almost flat topography covered with meander scars, cut off/ abandoned channels, point bars, natural levee type landforms. Elevation range from 28.84m above mean sea level (near Jairampur, Krimpur block) to 5.1m(near , Hanskhali block) above mean sea level. The slope of land is about 0.50 m per km from north to south. Numerous small rivers/ streams and abandoned channels cause interspersed throughout the area with a number of depressions meander scars, ox-bow lakes, point bars etc. Geomorphic unit is only Younger deltaic plain.

3.2 Drainage

The Ganga or the Padma along with its tributaries viz., Bhagirathi, Jalangi, Churni, Ichhamati etc forms the major drainage in the study area. All rivers and tributaries are perennial in nature. The Bhagirathi River flows along the western boundary of the study area from almost north-west to south-east direction. Jalangi river flows in almost central part of the area from NNE to SSW. The other tributaries are confined to the eastern part of the area flowing from north-east to south-west direction.

3.3 Soil Types

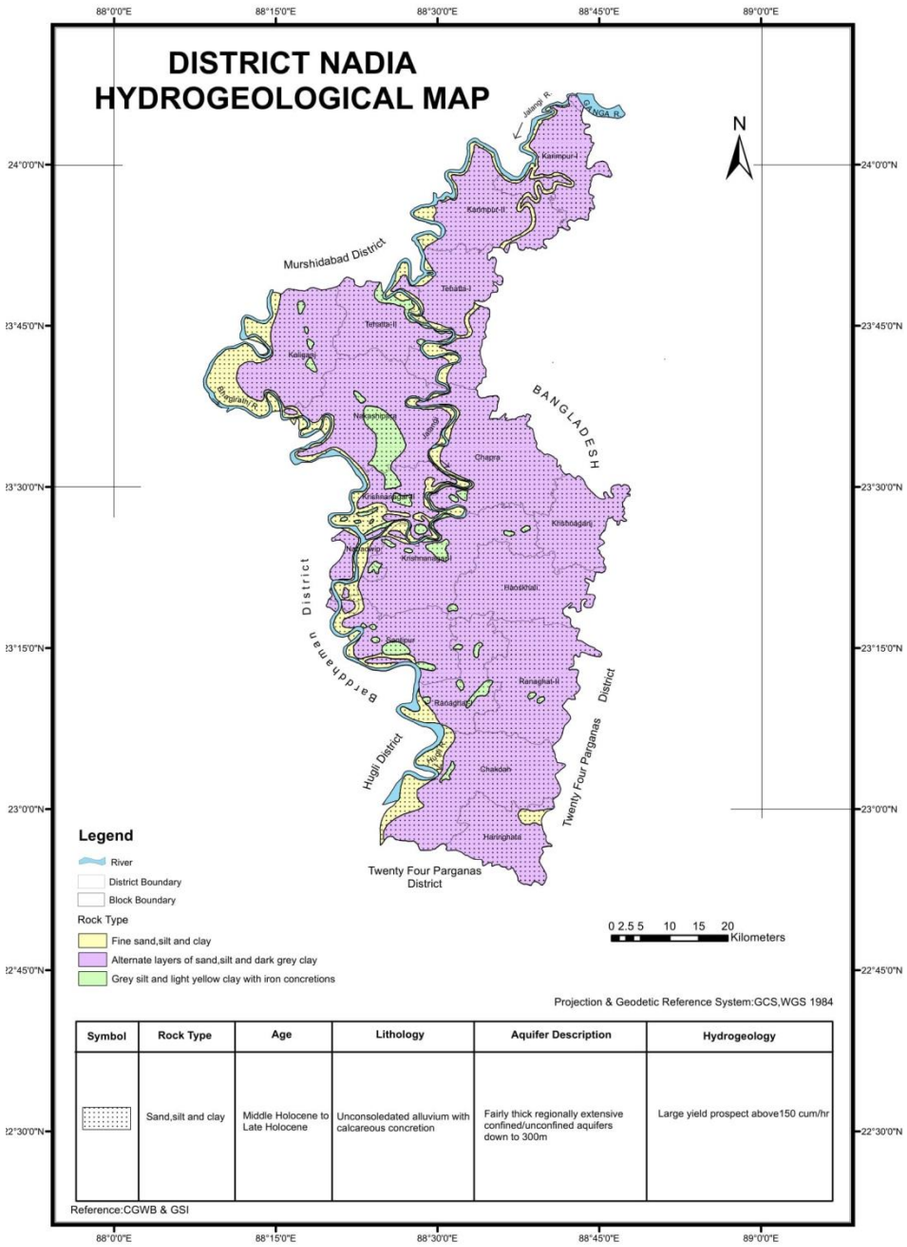
Entire area is covered by alluvial soil, and the parent material is Gangetic alluvium. Admixture of sand, silt and clay has given rise to three broad types of soil. Coarse Soil- formed by sand and loamy sand, Moderately Coarse Soil- formed by sandy and silty loams, and Moderately Fine Soil- formed by silt and clayee loams. Coarse Soil has got minimum distribution occurring mainly in Nakashipara block and other two types of soil have got more or less equal percentage of distribution in the area.

4. GEOLOGY AND HYDROGEOLOGY

4.1 General Geology

The area under study is covered by a huge thickness of Recent to Sub-Recent Alluvium of the Ganga Basin. Thick Gangetic alluvium of Quaternary age conceals the sub - surface geology. However, analysis of the tube wells reveals, fluviatile sediments in succession. The Recent fluviatile sediments are composed of sand of various grades, silt, clay, gravel and kankar and their various admixtures deposited by the river Ganga and its tributaries. Sand is grey coloured and highly micaceous in nature. Gravels are mainly composed of quartz, feldspar and mafic minerals.

The Geological/ Hydrogeological Map with drainage system of the area is shown in **Plate-3.**



Symbol	Rock Type	Age	Lithology	Aquifer Description	Hydrogeology
	Sand,silt and clay	Middle Holocene to Late Holocene	Unconsoledated alluvium with calcareous concretion	Fairly thick regionally extensive confined/unconfined aquifers down to 300m	Large yield prospect above150 cum/hr

Plate- 3

4.2 Hydrogeology

4.2.1 Sub-surface Geology:

The entire district is covered by thick alluvial formation composed of sand of different grades, silt and clay. The aquifers consist mostly of sand of different grades (coarse to fine). Gravel that is in general, the most important constituent of the aquifers, is not playing important role in this area. As it is observed in most of the boreholes, gravel is absent and it is present in very insignificant quantity. From the exploratory wells constructed by CGWB and State departments, it is observed that, in general three aquifer systems have been identified. The shallow aquifer (say, Aquifer- I) exists within a depth range of 5m to 150m, which extends up to 186m at Betai in Tehatta- I block. The next aquifer system (say, Aquifer- II) occurs broadly within the depth range of 150 to 200m and the deepest one (say, Aquifer- III) exists

approximately within the depth range of 215m to 295m. These aquifer groups are separated by clay barriers of widely variable thickness. In the study area, Block-wise the aquifer disposition is classified broadly and tabulated in **Table-V**.

The map showing the locations of the Exploratory Wells by CGWB/ State Govt. wells is presented in **Plate-3.** The 2D/3D views of the aquifer system in the study area are shown below as: - (a) Multi-log Plot of the Exploratory Wells in **Plate-4 & 5**; (b) Stratigraphic Fence & Model in **Plate-6 & 7**; (c) NW-SE Cross Section Index Map & Lithological Cross Section in **Plate-8 & 9 ; (d)** NE-SW Cross Section Index Map & Lithological Cross Section in **Plate-10 & 11 ;** (e) N-S Cross Section Index Map & Lithological Cross Section in **Plate-12 & 13;** (f) Lithological Panel diagram of the study area in **Plate-14.**

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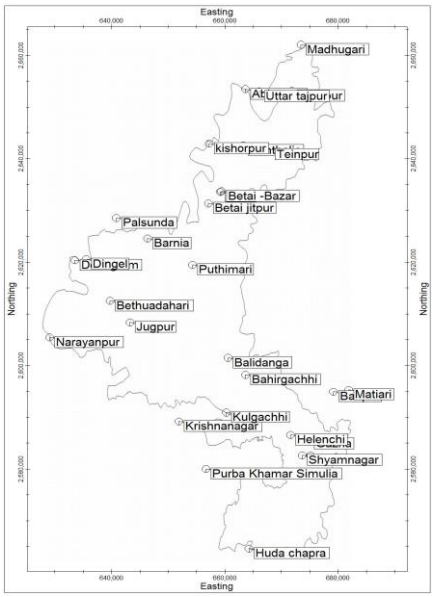
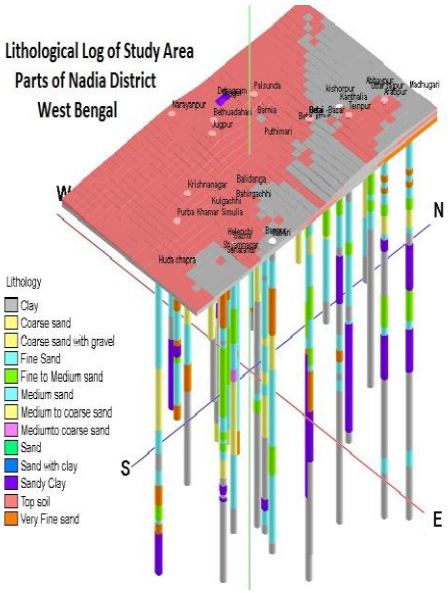
Table-V: Aquifer Disposition and its Quality in Study area in parts of Nadia district

Sr. No.	District	Block	Depth range of 1st aquifer (mbgl)	Quality	Depth range of 2nd Aquifer (mbgl)	Quality	Depth range of 3rd Aquifer (mbgl)	Quality	Remarks
1.	Nadia	Chapra	3-119	Arsenic	121-195	Fresh	-		
2.	Nadia	Hanskhali	3-27, 30-128	Arsenic	106-156	Fresh	-		
3.	Nadia	Kaliganj	19-50	Arsenic	56-110	Fresh/ Arsenic (sporadic)	254-270	Fresh	
4.	Nadia	Karimpur I	5-131	Arsenic	154-185	Fresh	282-294	Fresh	
5.	Nadia	Karimpur II	10-159	Arsenic	179-210	Fresh	215-224	Fresh	
6.	Nadia	Tehatta I	9-67, 2-186 (at Betai)	Arsenic	70-177	Fresh/ Arsenic (sporadic)	-		
7.	Nadia	Tehatta II	6-70	Arsenic	62-143	Fresh/ Arsenic (sporadic)	216-232	Fresh	
8.	Nadia	Nakashipara	6-62	Arsenic	69-156	Fresh/ Arsenic (sporadic)	-		
9.	Nadia	Krishnagan j	12-155	Arsenic	213-225	Fresh	-		

Plate-4

Location of Tube wells





Lithological Strip log in Parts of Nadia District, West Bengal

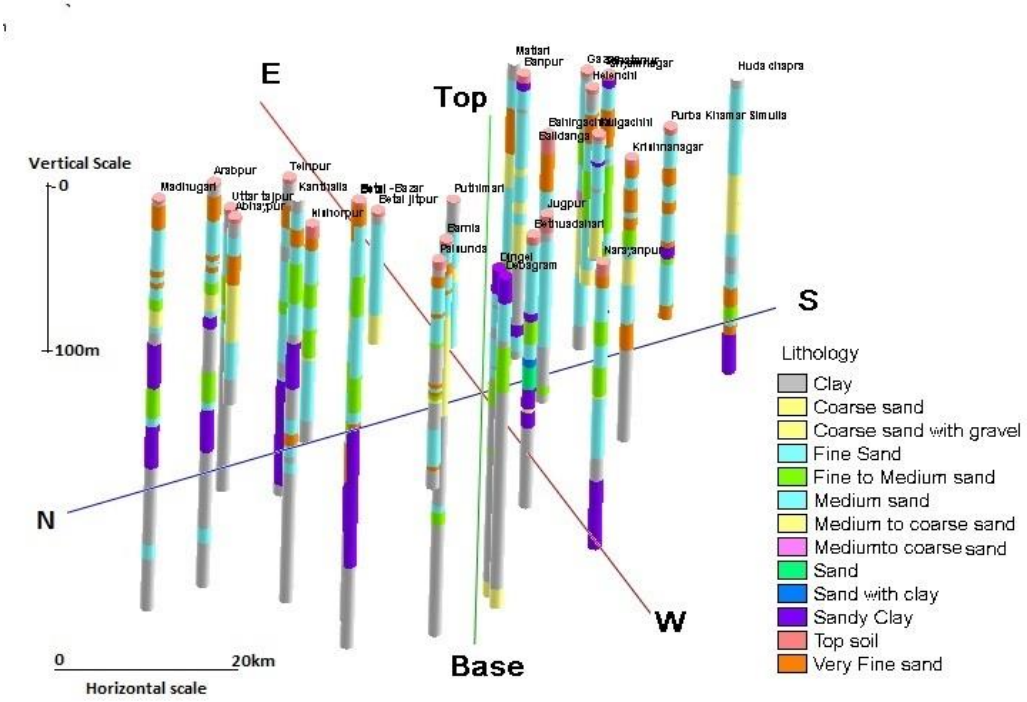


Plate-5

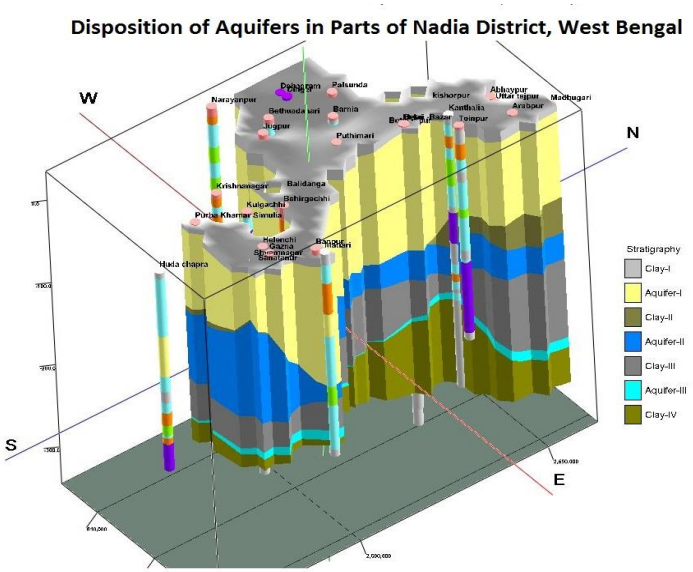


Plate- 6

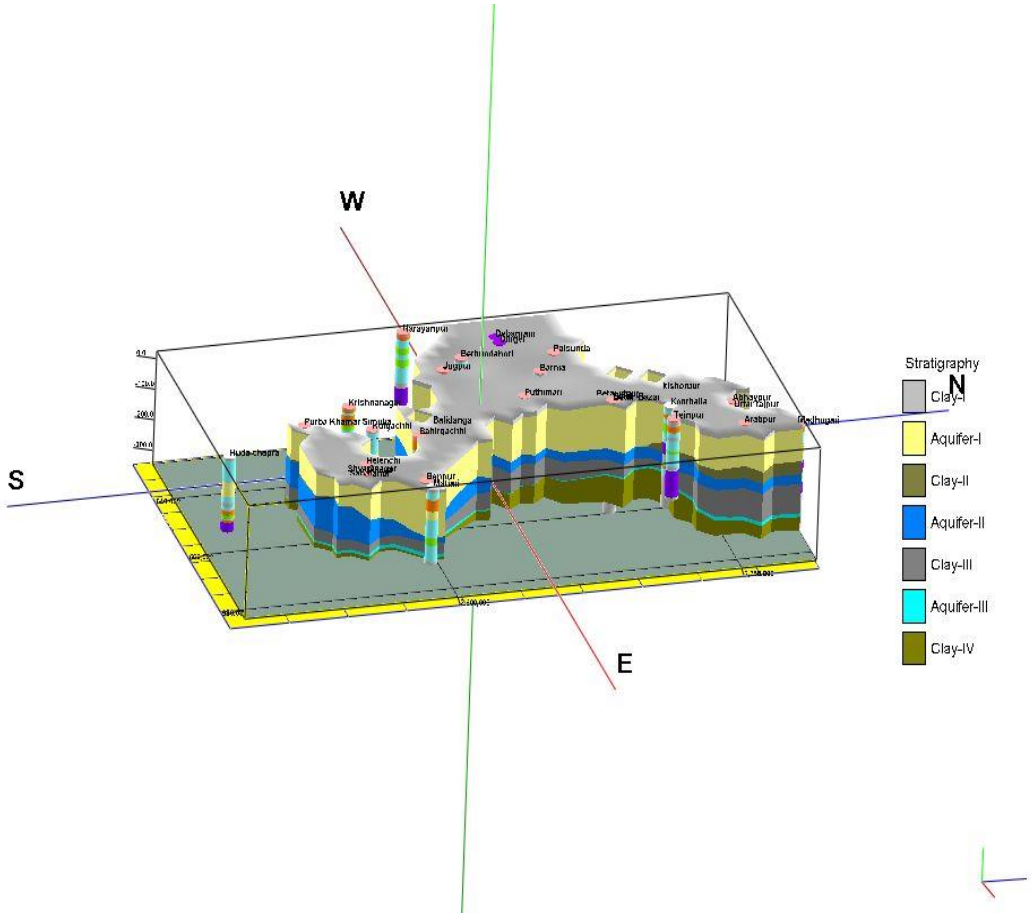


Plate- 7

NW-SE Cross-section Index Map in Nadia District

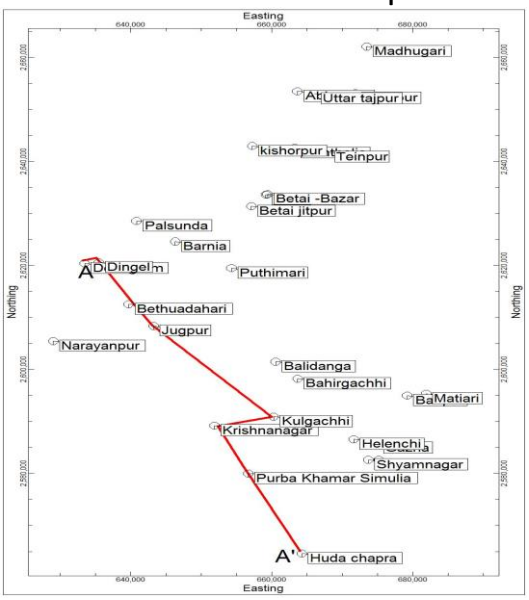


Plate-8

NW-SE Cross-section in Nadia District

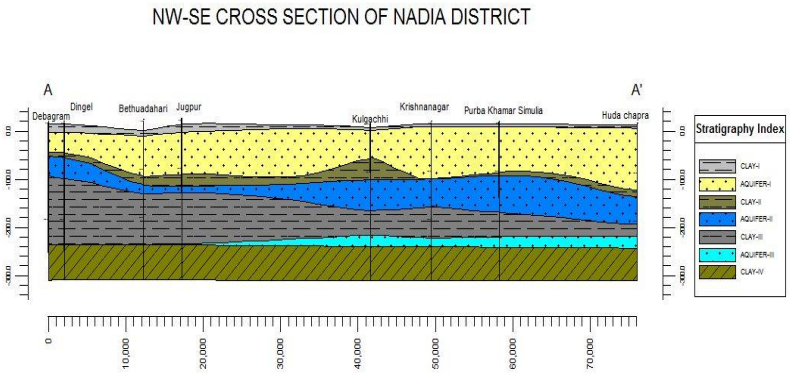


Plate- 9

NE-SW Cross-section Index map of Nadia District

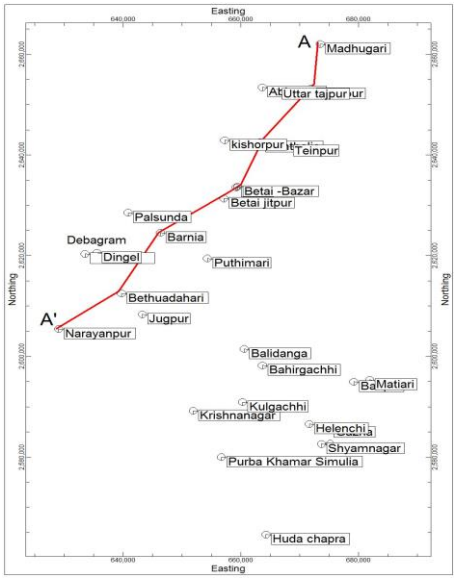


Plate- 10

NE-SW Cross-section of Nadia District

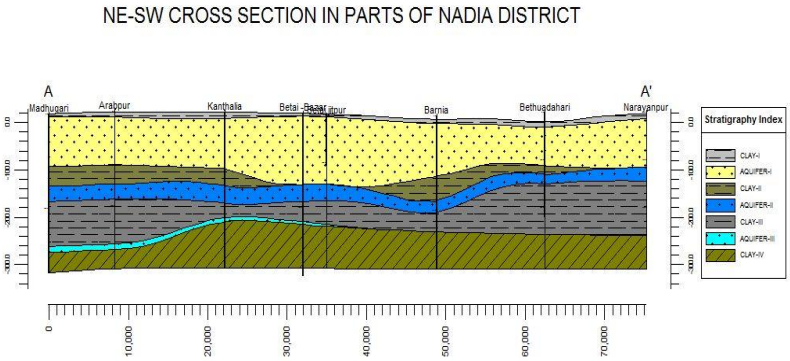


Plate- 11

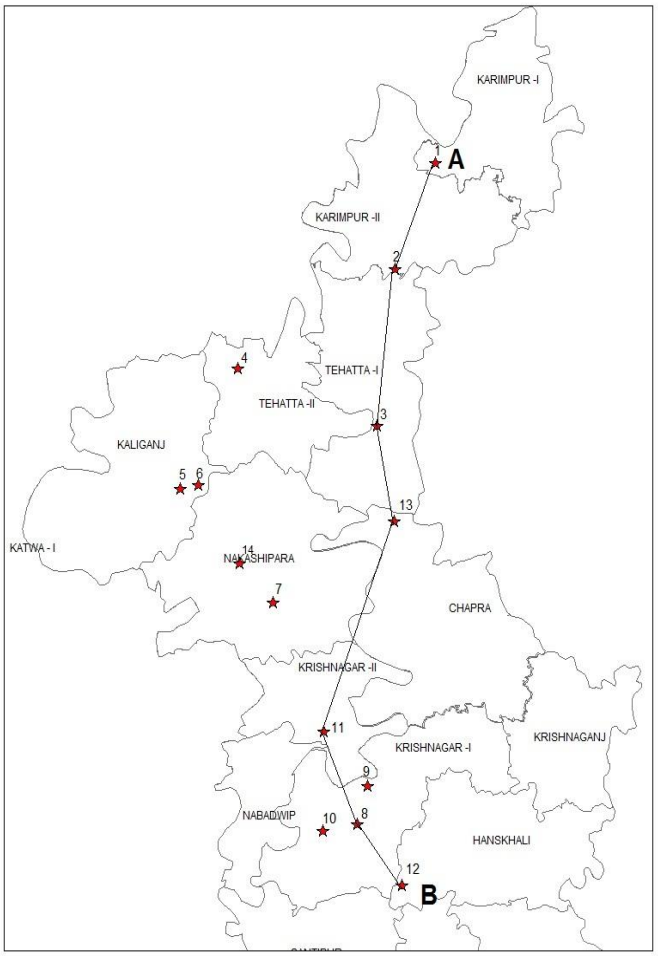

KARIMPUR -I
A
KARIMPUR -II
2
4
TEHATTA -I
TEHATTA -II
3
KALIGANJ
5
6
13
KATWA - I
14
NAKASHIPARA
7
CHAPRA
KRISHNAGAR -II
11
KRISHNAGAR -I
KRISHNAGANJ
9
NABADWIP
10
8
HANSKHALI
12
B

Plate- 12

SECTION ALONG A - B (NORTH - SOUTH) IN AQUIFER MAPPING AREA OF NADIA DISTRICT

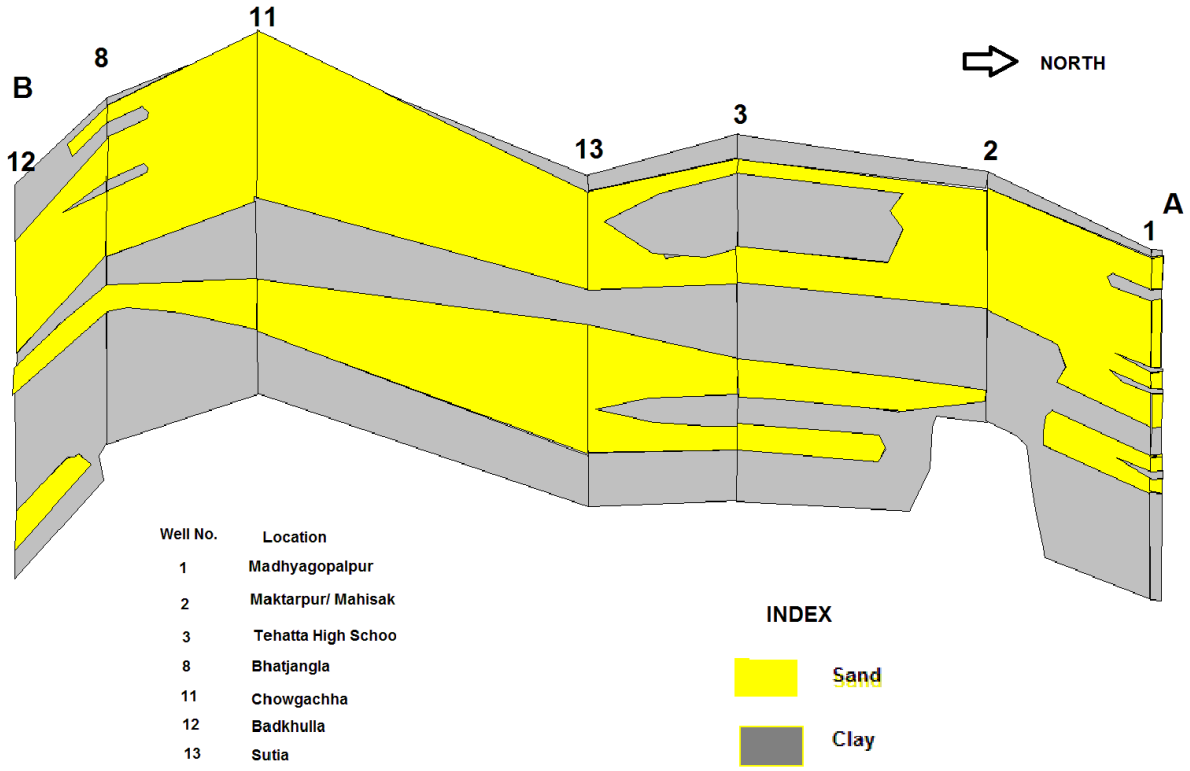


Plate- 13

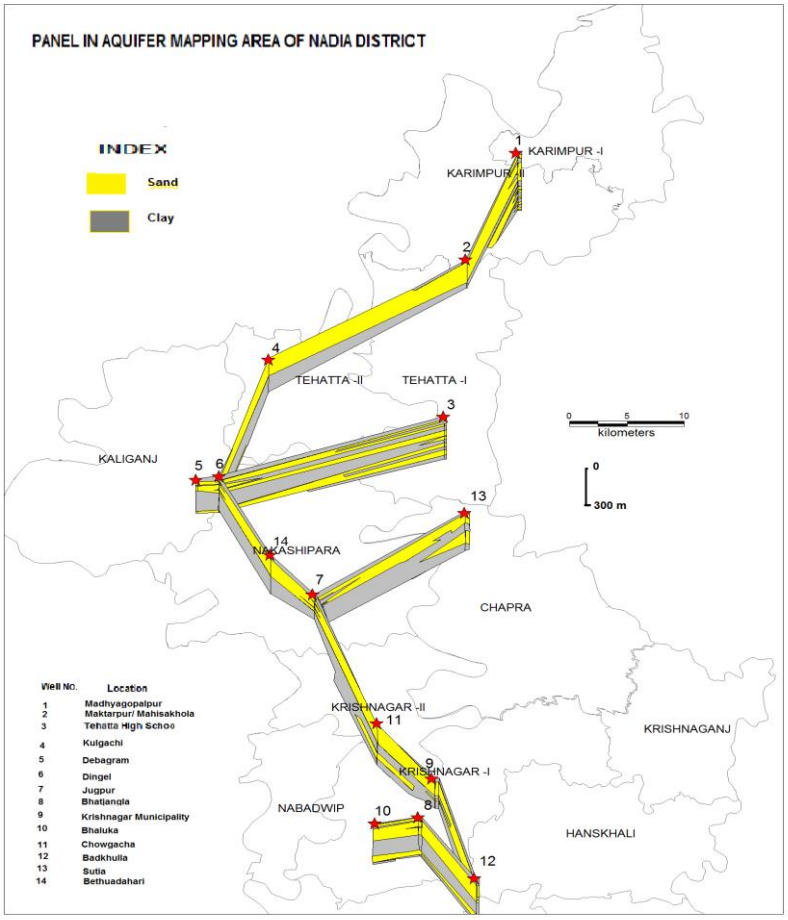


Plate- 14

4.2.2 Aquifer characteristics:

The tube wells tapping the zones at shallow depth (say Aquifer- I) are yielding discharge (Q) and it ranges from 36 to 173 m^3/hr and the Transmissivity (T) varies from 350 to 2700 m^2/d. The tube wells taping the intermediate zones (say Aquifer- II), Q generally ranges from 29 to191 m^3/hr and T varies from 350 to 2700 m^2/d. The deeper aquifer (say, Aquifer- III), yields ranging from 36 to 86 m^3/hr. The pumping tests data indicate that the value of Storage co-efficient (S) ranges from $1.55x10^{-3}$ to $6.2x10^{-4}$ indicating confined conditions for deeper aquifers. However, at many places the phreatic aquifers are under unconfined condition.

4.2.3 Ground Water Regime of Aquifers:

During detailed survey 114 numbers of almost uniformly distributed key observation wells have been established in the study area and in addition, 33 NHS falling in this area were considered for water level monitoring and water sample collection. These are mostly tube-wells and a few dug wells tapping the zones in different aquifer system representing Aquifer- I & II.

The pre-monsoon depth to water level (DTWL) map for **shallow aquifer** (**Plate-15**) in this area reveals that the water level is the shallowest (3 to 4 m bgl) in a small patch of east-central part of the area covering parts of Karimpur-II & Tehatta- I blocks; and is the deepest (7 to 8m bgl) in the west-central part of the area mainly in parts of Nakashipara block; and the same during post-monsoon period is the shallowest (2 to 3 m bgl) in parts of Nakashipara & Tehatta- I blocks; and the deepest (6 to 7 m bgl) in the west-central part of the area covering parts of Nakashipara & Kaliganj blocks.

The pre-monsoon depth to water level map for **deeper aquifer** (**Plate-17**) in this area reveals that the water level is the shallowest (3 to 4 m bgl) in a small patch in the border area of Karimpur-II & Tehatta- I blocks; and is the deepest (9 to 10 m bgl) in the west-central and south-western parts of the area covering parts of Kaliganj & Hanskhali blocks.

The water level during post-monsoon period is the shallowest (within 1 m bgl) in parts of Chapra & Nakashipara blocks; and the deepest (8 to 9 m bgl) in the west-central and north-eastern parts of the area covering parts of Kaliganj & Karimpur- I blocks.

Considering the elevation of the ground level and depth to water level monitored from the monitoring wells, **Water Table** maps with contours of 1 m intervals, were prepared for both the shallow (Aquifer- I) and deeper (Aquifer- II) aquifers.

The pre-monsoon water table map for **shallow aquifer** (**Plate-16**) reveal that, there

are ground water mounds in the north-eastern & west-central parts of the area covering parts of Karimpur- I & II and Kaliganj blocks with a maximum elevation of 18m to 19m amsl; and ground water troughs occur in the east-central & west-central parts of the area covering parts of Chapra & Krishnaganj and Kaliganj blocks with a maximum depression of 7m to 8m amsl. The regional direction of ground water flow is from north-west to south-east with variable gradients from 1:8000 to 1:1100 in different parts of the area.

The pre-monsoon water table map for **deeper aquifer** (**Plate-18**) reveals that, there are ground water mounds in the north-eastern & west-central parts of the area covering parts of Karimpur- I, Tehatta- I, Nakashipara and Chapra blocks with a maximum elevation of 18m to 19m amsl; and ground water troughs occur in the north-western & south-western parts of the area covering parts of Karimpur- II and in the border of Krishnaganj & Hanskhali blocks with a maximum depression of 7m to 8m amsl. The local direction of ground water flow varies place to place with variable gradients from 1:6000 to 1:1000 in different parts of the area as shown in **Table-19**.

The post-monsoon water table maps for both the **shallow & deeper aquifers** (**Plate-16 & 18**) reveal almost of the same nature as those of pre-monsoon period for both the aquifers separately.

Ground water flow has been calculated by Darcy's law using Q= TIL where Q is quantity of ground water flowing through the area, T is Transmissivity of the Aquifer , I is Hydraulic Gradient and L is maximum length of flow path perpendicular to flow direction.

In general ground water flow is from NW to SE within the area in shallow aquifer system; and at different directions in deeper aquifer system in this area, as deciphered by the Pre-monsoon Water Table maps. Block-wise the flow of ground water in the shallow unconfined aquifer system in approximation are shown in **Table-VI**, and that in deeper semi-confined to confined aquifer system is tabulated in **Table-VII**.

Depth to water level : Aquifer I

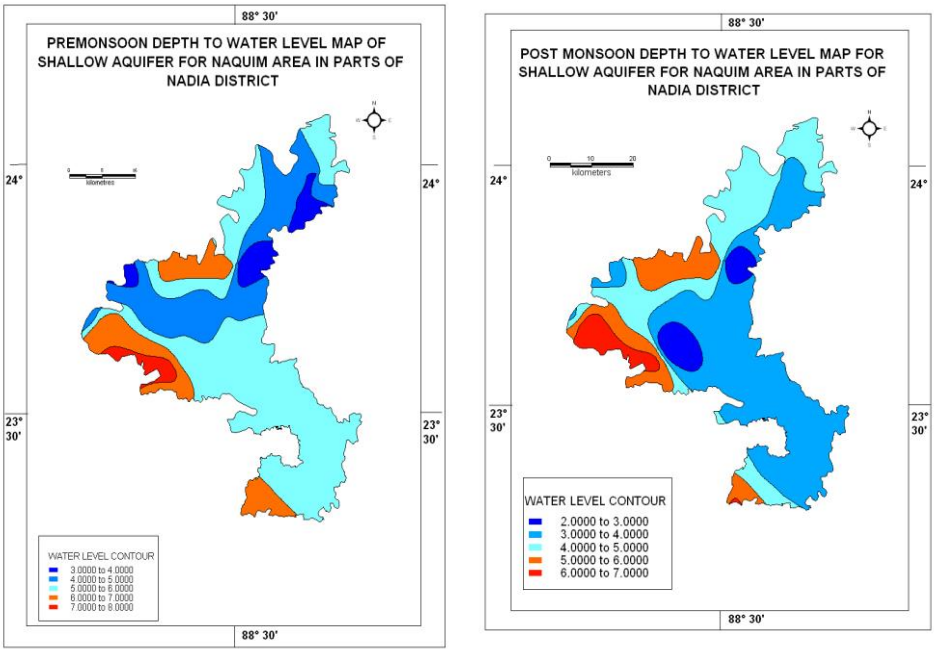


Plate- 15

Water Table: Aquifer I

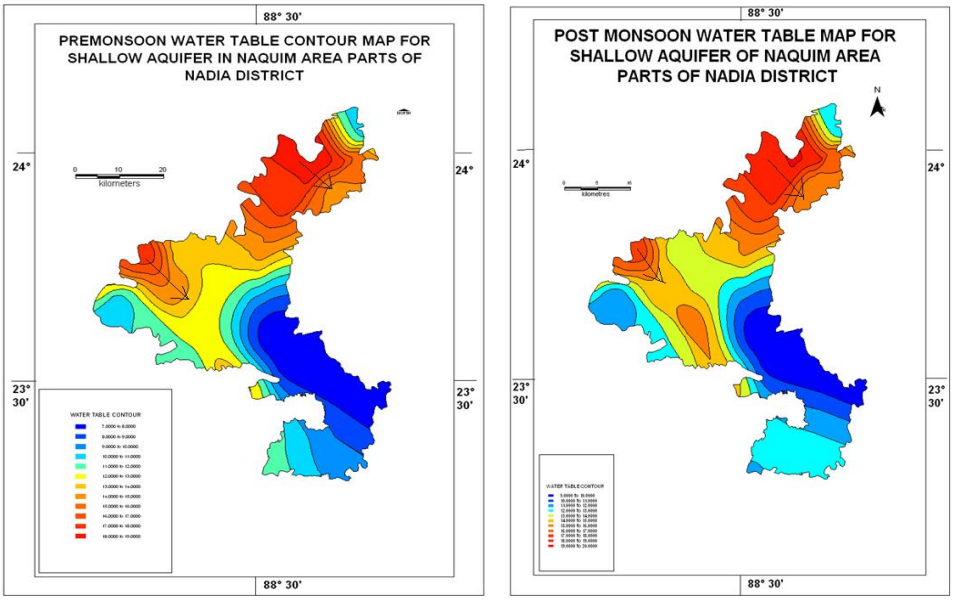


Plate- 16

Depth to water level : Aquifer II

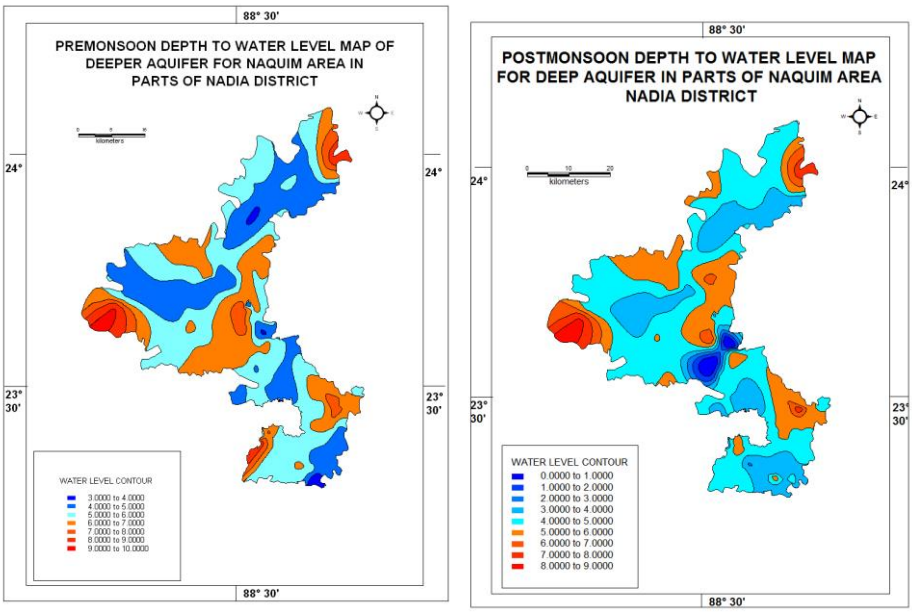


Plate- 17

Water Table: Aquifer II

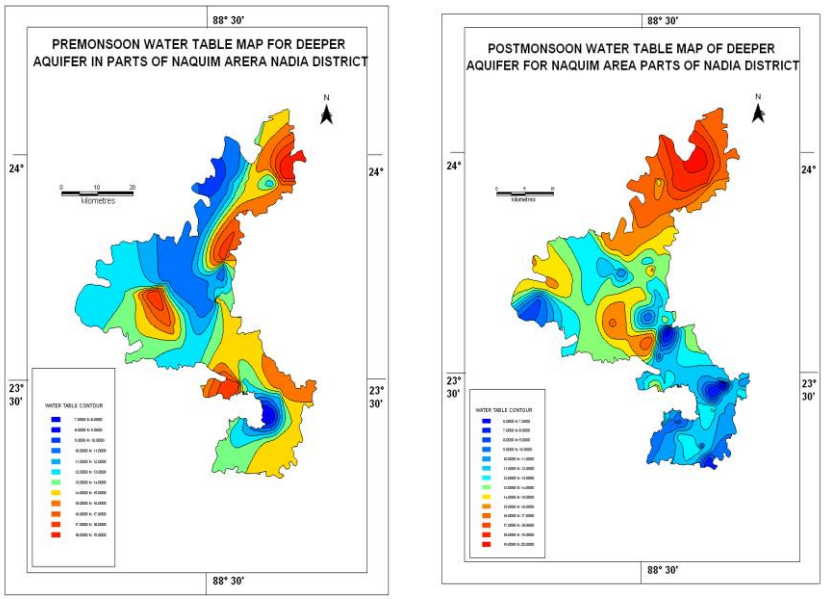


Plate- 18

Deeper Aquifer Water Table Contour Lines : Pre-monsoon & Post-monsoon

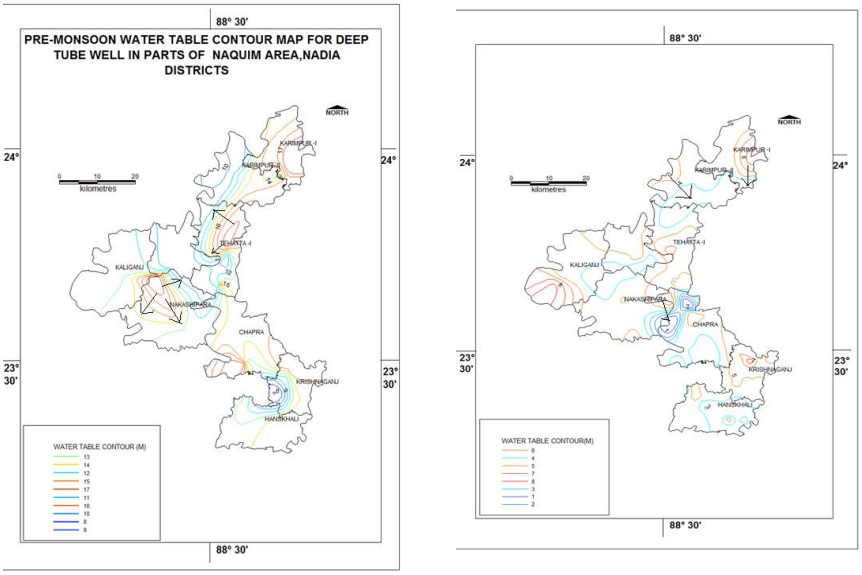


Plate- 19

Table-VI: Block-wise approximation of Ground Water Flow in Unconfined aquifer system in the Study area

Sr no.	District	Block	Flow direction	Average length of flow path across flow direction (m)	Hydraulic Gradient (I) (approx)	Average T of unconfined aquifer (approx) (m^2/d)	Quantity of Ground water Flow (approx) (m^3/day)
1	Nadia	Chapra	Mostly Easterly	14000	1:2000	4000	28000
2	Nadia	Hanskhali	Mostly North-easterly	13000	1:6000	4000	8700
3	Nadia	Kaliganj	Mostly South-easterly/ South-westerly	17000	1:3333	4000	20400
4	Nadia	Karimpur I	Mostly North-easterly	15000	1:1142	4000	52500
5	Nadia	Karimpur II	Mostly South-easterly	15000	1:2333	4000	25700
6	Nadia	Tehatta I	Mostly Southerly/ South-eastrly	11000	1:3000	4000	14700
7	Nadia	Tehatta II	Mostly South-easterly	13000	1:8000	4000	6500
8	Nadia	Nakashipara	Mostly Easterly	18000	1:2500	4000	28800
9	Nadia	Krishnagan j	Mostly North-easterly	13000	1:4000	4000	13000

Table-VII: Block-wise approximation of Ground Water Flow in Semi-confined to Confined aquifer system in the study area

Sr no.	District	Block	Flow direction	Average length of flow path across flow direction (m)	Hydraulic Gradient (I) (approx)	Average T of confined aquifer (m^2/d)	Quantity of Ground water Flow (approx) (m^3/day)
1	Nadia	Chapra	Mostly North/ North-easterly	18000	1:1500	3100	37200
2	Nadia	Hanskhali	Mostly North/ North-westerly	23000	1:1250	3300	60720
3	Nadia	Kaliganj	Mostly Westerly	20000	1:1750	2800	32000
4	Nadia	Karimpur I	Radial- outward (as centrally Gr. W. mound) Mostly Westerly/ South-westerly	18000	1:1666	2700	29160
5	Nadia	Karimpur II	Mostly Westerly	15000	1:2000	2800	21000
6	Nadia	Tehatta I	Radial- outward (as centrally Gr. W. mound) Mostly Westerly	13000	1:1166	2800	31200
7	Nadia	Tehatta II	Radial- inward (as centrally Gr. W. trough)	22000	1:6000	2950	10800
8	Nadia	Nakashipara	Radial- outward (as centrally Gr. W. mound) Mostly Southerly	17000	1:2500	2900	19720
9	Nadia	Krishnaganj	Radial- inward (as centrally Gr. W. trough) Mostly Westerly	15000	1:1000	3200	48000

4.2.4 Pre-monsoon & Post-monsoon long term trend analysis:

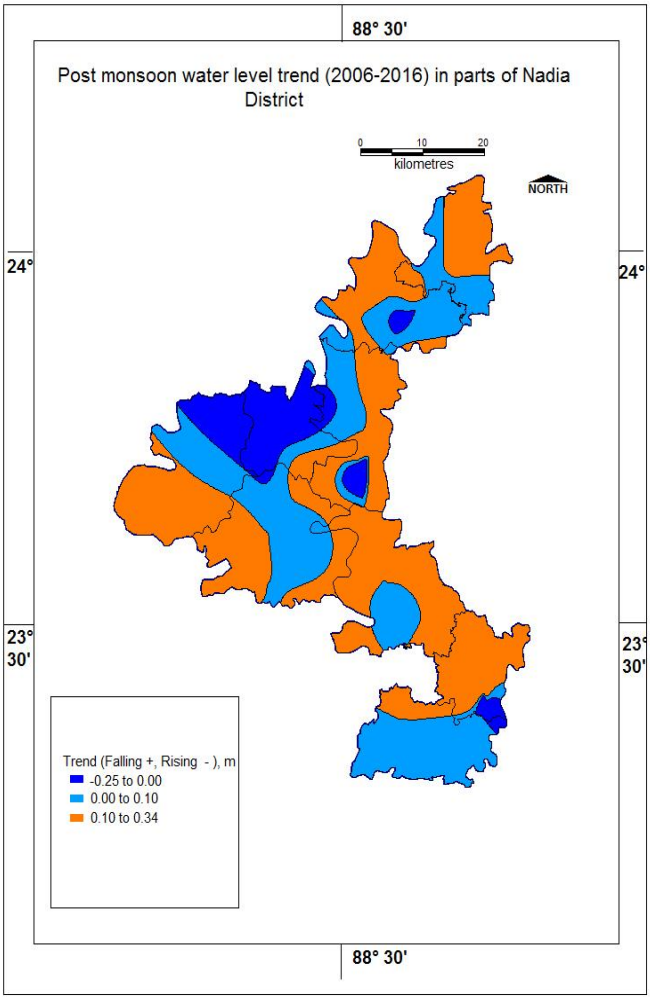
The long term trend analysis reveals that there is a falling trend in almost all the Blocks both during Pre-monsoon and Post-monsoon periods. The Pre-monsoon falling trend of water level varies from 0.9 cm/year (in Hanskhali block) to 16.4 cm/year (in Nakashipara block). The same during Post-monsoon varies from 2.2 cm/year (in Nakashipara block) to 21.2 cm/year (in Tehatta- I block). However, a few monitoring wells show slight rising trends during pre-monsoon period in Tehatta- I, Nakashipara and Krishnaganj blocks and during post-monsoon period in Krishnaganj block. Details of pre-monsoon and post-monsoon water level trend (from 1995 to 2011) in cm/year for individual Block is given in **Table-VIII**.

The map showing the Post-monsoon Water Level Trends (2006-2016) of the Aquifer-I in the study area **(Plate-20)** indicates slight rising trend of water level in the west-central part of the area.

Table-VIII: Block-wise Pre-monsoon and Post-monsoon average long term water level trends (2000 to 2016)

S.No.	Block	Location	Premonsoon Rise (meter/yr.)	Premonsoon Fall (meter/yr.)	Postmonsoon Rise (meter/yr.)	Postmonsoon Fall (meter/yr.)
1	Karimpur-I	Karimpur	0.009	-	-	0.088
		Murutia Pz	-	0.13	-	0.069
		Utr Kechuadanga	-	0.032	-	0.122
2	Karimpur-II	Gopalpur	-	0.016	-	0.149
		Mahisabathan	-	0.053	0.029	-
		Mahisbathan	0.084	-	-	0.156
		Narayanpur	-	0.015	-	0.104
		Thanapara	-	0.006	-	0.15
3	Tehatta-I	Betai Pz	-	0.079	-	0.212
		Karuigachhi	0.198	-	0.25	-
		Palassey Para	-	0.028	-	0.21
		Shyamnagar	0.074	-	-	0.217
		Tehatta Pz	0.07	-	-	0.238
4	Tehatta-II	Barnia	-	0.03	-	0.128
		Hanspukuria	-	0.03	-	0.064
		Kulgachhi	-	0.051	0.073	-
5	Kaliganj	Debagram pz	-	0.045	-	0.138
		Juranpur	-	0.056	-	0.154
6	Nakshipara	Birpur Pz	0.034	-	-	0.127
		Mayapur	-	0.007	-	0.047
		Muragacha	0.07	-	-	0.098
		Muragacha	0.165	-	-	0.022
		Nakasipara Pz	-	0.164	-	0.14
7	Chapra	Chapra Pz	-	0.087	-	0.065
		Fulkulmi Pz	-	0.063	-	0.109
		Hridaypurpz	-	0.045	-	0.144
8	Krishnaaganj	Banpur	0.019	-	0.13	-
		Banpur Pz	-	0.08	-	0.131
		Bhajan Ghat	-	0.065	0.043	-
		Gobindapur	0.027	-	-	0.344
9	Hanskhali	Badkulla	-	0.009	-	0.049
		Gajna	0.1	-	-	0.056
		Hanskhali Pz	-	0.013	-	0.099

Plate- 20



4.2.5 Ground Water Resources, Draft, SOD & Category:

The dynamic ground water resources of Aquifer –I in the area under study have been calculated on the basis of GEC (1997) methodology by CGWB and State Water Investigation Department (SWID) for the year as on 31.03.2013. The block wise computed data of dynamic ground water resources, as on 31st March 2013 is shown below in **Table-IX**.

The availability of GW resources for future uses with long term trends of ground water levels & its present status in study area are mentioned in **Table-X.**

Table-IX: Block wise dynamic ground water resources as on 31st March'11

SI. No.	Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Net ground water availability for future irrigation development (MCM)	Provision for domestic and industrial requirement supply upto next 25 years(MCM)
1.	Karimpur - I	119.2327	138.9490	116.54	Semi-critical	(-) 20.6156	3.8383
2.	Karimpur – II	133.2005	164.4156	123.43	Semi-critical	(-) 32.2506	4.4190
J.	Tehatta - I	138.3390	153.0598	110.64	Semi-critical	(-) 15.8940	5.0070
4.	Tehatta – II	98.6830	109.7564	111.22	Semi-critical	(-) 11.7969	3.0879
5.	Kaliganj	157.1135	145.7449	92.76	Semi-critical	9.7991	6.6984
6.	Nakashipara	185.5714	157.2051	84.71	**Safe**	26.5593	7.7121
7.	Chapra	182.2997	199.0758	109.20	Semi-critical	(-) 18.2449	6.2686
8.	Krishnganj	79.7440	69.9808	87.76	**Safe**	9.0438	3.0702
9.	Hanskhali	141.2931	139.6603	98.84	Semi-critical	0.2251	6.0080

Table-X: Availability of GW resources & its Present Status in Study area

Sr. No.	District	Block	Net GW availability in ham	Gross GW draft in Ham	SOD in %	Long term Water Level trend in Cm/Yr (Rising - & Falling +)		Category	GW available for Future GW use in ham
						Pre monsoon	Post monsoon		
1	Nadia	Chapra	18229.97	19907.58	109.20	4.56	11.47	Semi Critical	-
2	Nadia	Hanskhali	14129.31	13966.03	98.84	1.79	10.82	Semi Critical	22.51
3	Nadia	Kaliganj	15711.35	14574.49	92.76	3.64	10.39	Semi Critical	979.91
4	Nadia	Karimpur I	11923.27	13894.90	116.54	6.22	10.57	Semi Critical	-
5	Nadia	Karimpur II	13320.05	16441.56	123.43	3.00	9.09	Semi Critical	-
6	Nadia	Tehatta I	13833.90	15305.98	110.64	1.67	8.32	Semi Critical	-
7	Nadia	Tehatta II	9868.30	10975.64	111.22	-2.35	-3.06	Semi Critical	-
8	Nadia	Nakashipara	18557.14	15720.51	84.71	1.07	8.81	Safe	2655.93
9	Nadia	Krishnaganj	7974.40	6998.08	87.76	2.92	10.92	Safe	904.38
Study Area B in Total			**123547.7**	**127784.8**	**103.42**	**2.50**	**8.59**	**0**	**4562.73**

On the basis of ground water resource calculation (2013) and pre-monsoon & post-monsoon water level trends, out of nine blocks, two blocks – Nakashipara and Krishnaganj are 'Safe' and other seven blocks are categorized as 'Semi-critical'. The map showing the Category of Blocks is shown in **Plate-21.**

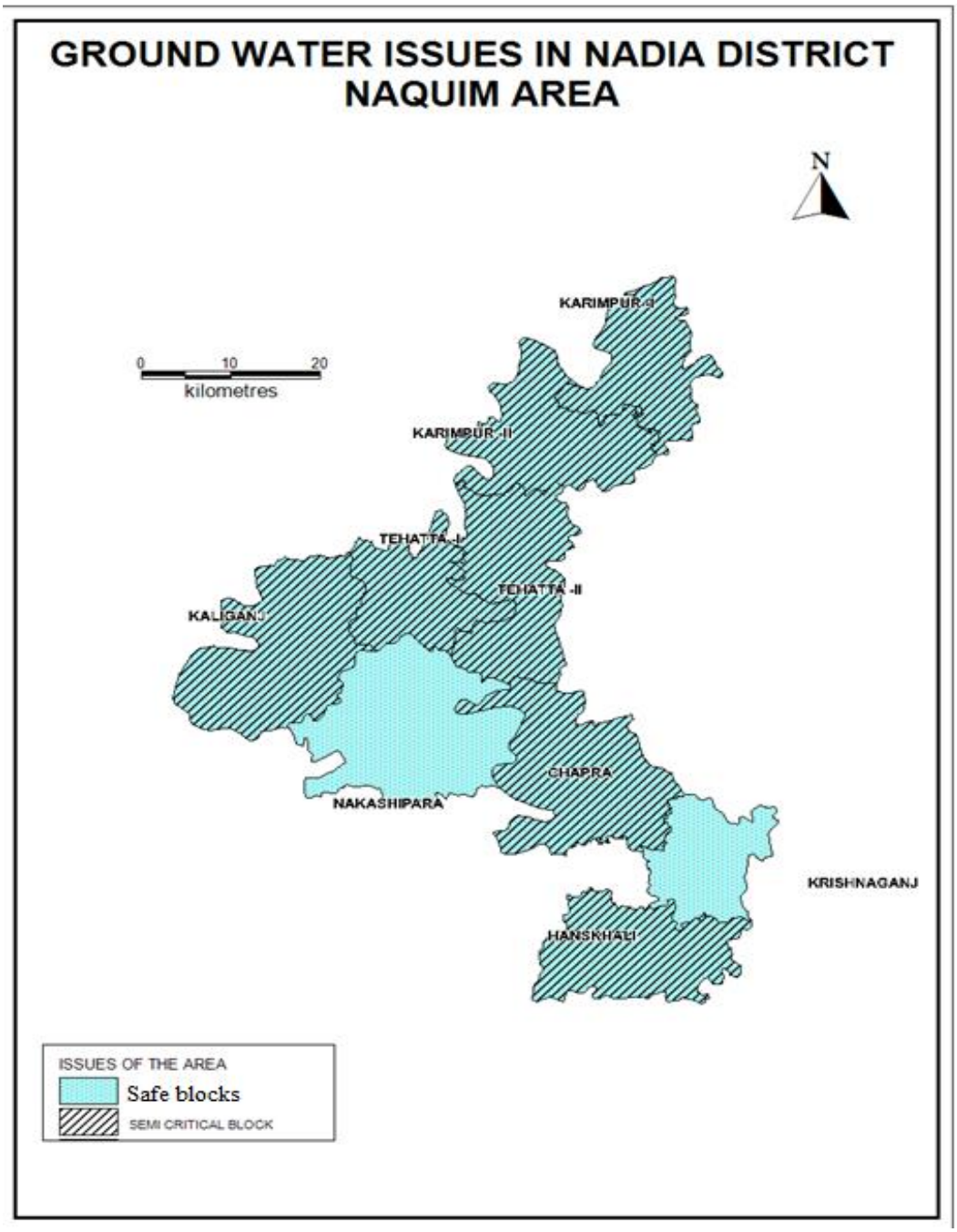


Plate- 21

The Static (In-storage) ground water resources of phreatic aquifer in the study area is estimated based on the average Specific Yield (considered as 20%) and the pre-monsoon saturated thickness of the phreatic aquifer. Block-wise the In-storage ground water resources are calculated and tabulated which is shown in **Table-XI**.

The Dynamic ground water resources of semi-confined to confined aquifer in the study area is estimated based on the average Storativity (considered as 1.55x 10^{-3}) and Average Fluctuation of Water level (Pre to post) in the area. Block-wise the Dynamic ground water resources are calculated and tabulated in **Table-XII**.

Table-XI: Block-wise in-storage ground water resources in Aquifer- I

Blockwise In-storage ground water resources in Aquifer I (phreatic)

Block	Block Area (sq km)	Average pre-monsoon depth to water level	Average Specific Yield	Average thickness of granular zones	Thickness of granular zone below pre-monsoon depth to water level	Volume of in-storage ground water resource (MCM)
Chapra	310.48	5.35	0.2	90	74.65	5256.4264
Hanskhali	231.5	5.58	0.2	55	74.42	2288.146
Kaliganj	319.75	6.7	0.2	80	73.3	4687.535
Karimpur I	212.27	5.81	0.2	60	74.19	2300.58226
Karimpur II	241.18	4.82	0.2	65	75.18	2902.84248
Krishnaganj	258.3	6.32	0.2	80	73.68	3806.3088
Nakashipara	174.44	5.64	0.2	70	74.36	2245.39168
Tehatta I	354.24	6.94	0.2	80	73.06	5176.15488
Tehatta II	159.55	5.29	0.2	80	74.71	2383.9961
Total						31047.3836

Table-XII: Change in storage in semi-confined to confined aquifer in study area (Pre to Post-monsoon, 2016)

Sr no.	District	Block	Area in ha	Average Fluctuation of Water level (Pre to post) in metre	Average Storativity of confined aquifer	Change in Storage in ham
1	Nadia	Chapra	31048	1.21	1.55×10^{-3}	58.230
2	Nadia	Hanskhali	23150	1.11	1.55×10^{-3}	39.829
3	Nadia	Kaliganj	31975	0.59	1.55×10^{-3}	29.241
4	Nadia	Karimpur I	21227	0.84	1.55×10^{-3}	27.637
5	Nadia	Karimpur II	24118	0.77	1.55×10^{-3}	28.785
6	Nadia	Tehatta I	25830	0.88	1.55×10^{-3}	35.232
7	Nadia	Tehatta II	17444	0.65	1.55×10^{-3}	17.575
8	Nadia	Nakashipara	35424	1.17	1.55×10^{-3}	64.241
9	Nadia	Krishnaganj	15955	1.07	1.55×10^{-3}	26.461
Total						**327.231**

5. HYDROCHEMISTRY

5.1 Quality of Shallow and Deeper Aquifer Water

Ground water samples were collected during pre-monsoon period from the National Hydrograph Stations falling in the study area and those have been analysed in the departmental Chemical Laboratory. Chemical quality of ground water occurring in shallow and deeper aquifers does not vary significantly, except arsenic concentration. The water, in general, is slightly alkaline. Water is Ca-Mg- HCO3 type.

5.2 General range of chemical parameter

The samples from the monitoring wells in the study area, were analysed in the CGWB Laboratory. From the analytical results, it is found that, pH of water, in general, varies between 8.31 and 8.50 indicating slightly Basic in nature, and EC ranges between 282.9 and 1077 µS/cm. The EC contour map **(Plate-22)** shows that, the ground water is mainly having less than 500 µS/cm in most of the part including the central portion. EC is higher than 500 µS/cm in parts of Karimpur- II, Tehatta- I & II, Krishnaganj and Hanskhali blocks. Concentrations of Na ranges from 10.8 to 100.4 mg/1. Cl is mostly in the range of 7.5 - 110 mg/1. Fluoride ranges from BDL – 1.08 mg/1, whereas Nitrate concentration ranges from 0.1 – 27.7 mg/1. Total hardness as CaC03 ranges from 105 - 275 mg/1. Block-wise Ranges of Chemical Parameters in Shallow aquifer is shown in **Table-XIII.**

The Chemical Facies in the Piper-Trilinear Diagram **(Plate-23)** shows that the ground water in shallow aquifers is in general $MgHCO^3$- $CaHCO^3$- $NaHCO^3$ Type, and that of deeper aquifer is in general $MgHCO^3$- $NaHCO^3$ Type.

The Wilcox Plot **(Plate-24)** indicates that the Sodium (Alkali) hazard of the ground water from both the shallow and deeper aquifers is very low and the Salinity hazard is in the 'Medium' category.

Table-XIII: Block-wise Ranges of Chemical Parameters in Shallow aquifer

(Samples from Monitoring Wells)

Block	Aquifer Type	As (mg/l)	pH	EC (Us/Cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO^3 (mg/l)	Total Hardness as $CaCo^3$ (mg/l)
Karimpur-I	I	0.003-0.332	8.37-8.44	282.9-759.3	10.8-84.2	20.0-72.5	BDL-1.5	0.1-27.0	150-225
Karimpur-II	I	0.002–0.008	8.33-8.50	398.8-1077	17.7-100.4	12.5-110	BDL-0.51	1.2-27.7	130- 275
Tehatta-I	I	0.0001-0.044	8.45-8.49	382.2-1032.0	10.9-90.4	12.5-47.5	BDL-0.42	BDL-1.7	115- 180
Tehatta-II	I	0.0002-0.076	8.37-8.46	328.6-701.4	15.9-48.1	12.5-25.0	BDL-0.39	BDL-0.7	130- 160
Kaliganj	I	0.002-0.082	8.35-8.46	347.2-550.4	17.0-89.0	20.0-37.5	0.04-0.70	BDL-0.9	125- 195
Nakashipara	I	0.0001-0.119	8.31-8.49	312.0-437.7	14.7-41.2	7.5-15.0	0.28-1.11	BDL-5.4	120- 155
Chapra	I	0.0002-0.034	8.32-8.50	292.8-507.6	17.7-37.4	10.0-50.0	BDL-1.08	BDL-2.8	130- 180
Krishnaganj	I	0.0003-0.019	8.32-8.48	295.9-464.5	16.0-49.2	10.0-22.5	BDL-0.82	BDL-0.5	105- 160
Hanskhali	I	0.0001-0.05	8.32-8.49	283-415.7	13.5-29.2	10-32.5	BDL-0.97	BDL-7.2	125-180

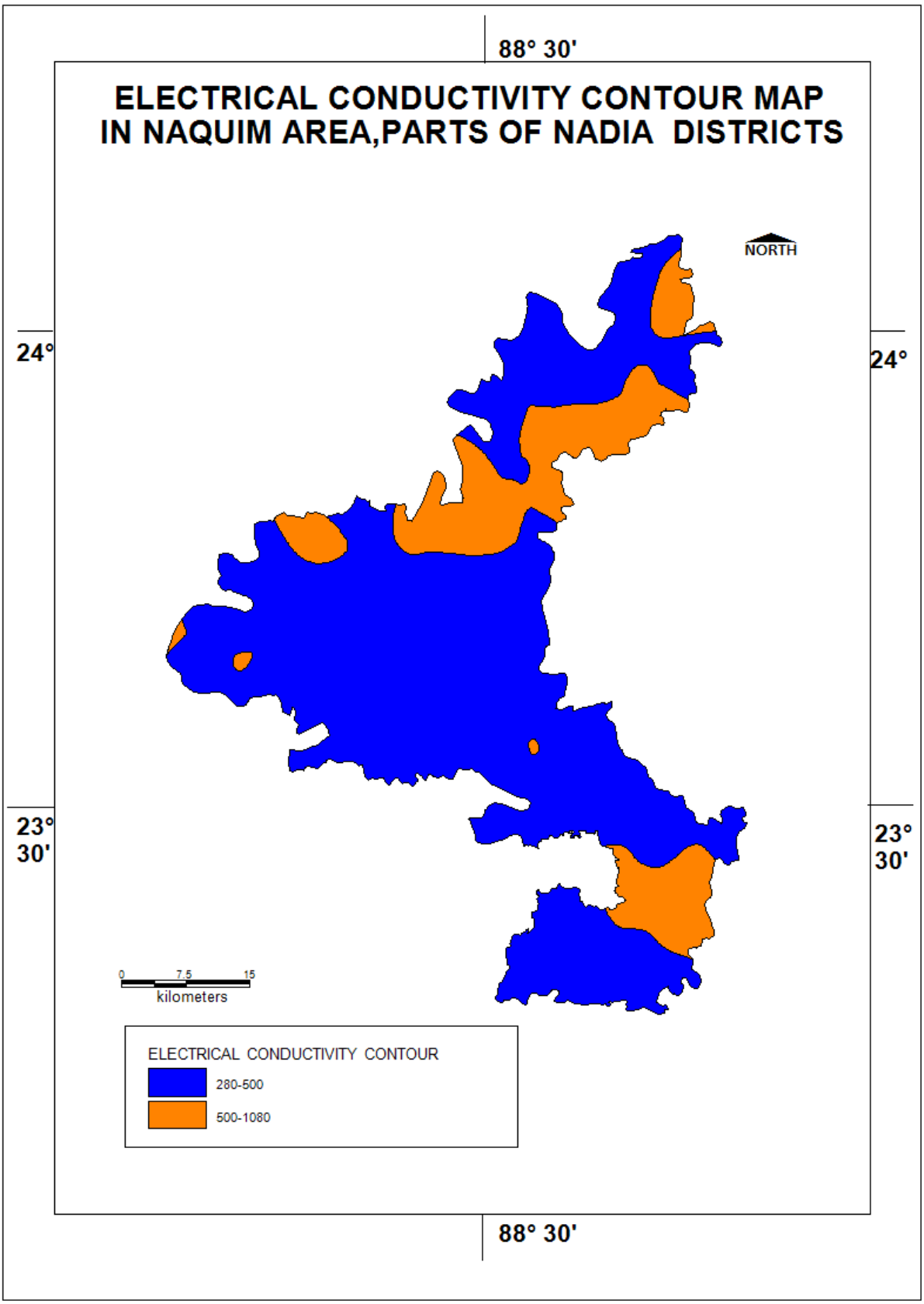
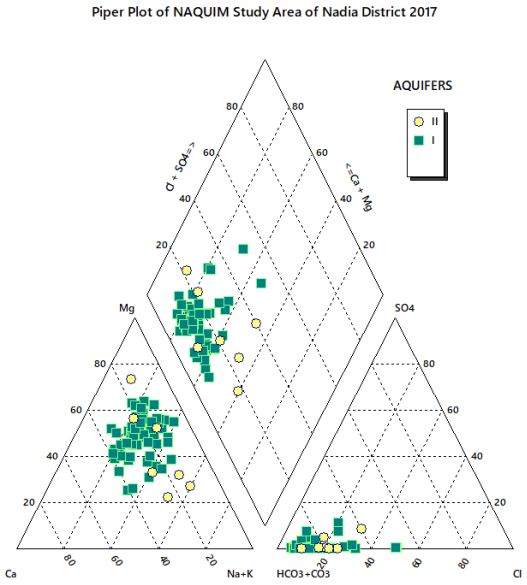

88° 30'
ELECTRICAL CONDUCTIVITY CONTOUR MAP
IN NAQUIM AREA,PARTS OF NADIA DISTRICTS
NORTH
24°
24°
23°
30'
23°
30'
0
7.5
15
kilometers
ELECTRICAL CONDUCTIVITY CONTOUR
280-500
500-1080
88° 30'

Plate- 22

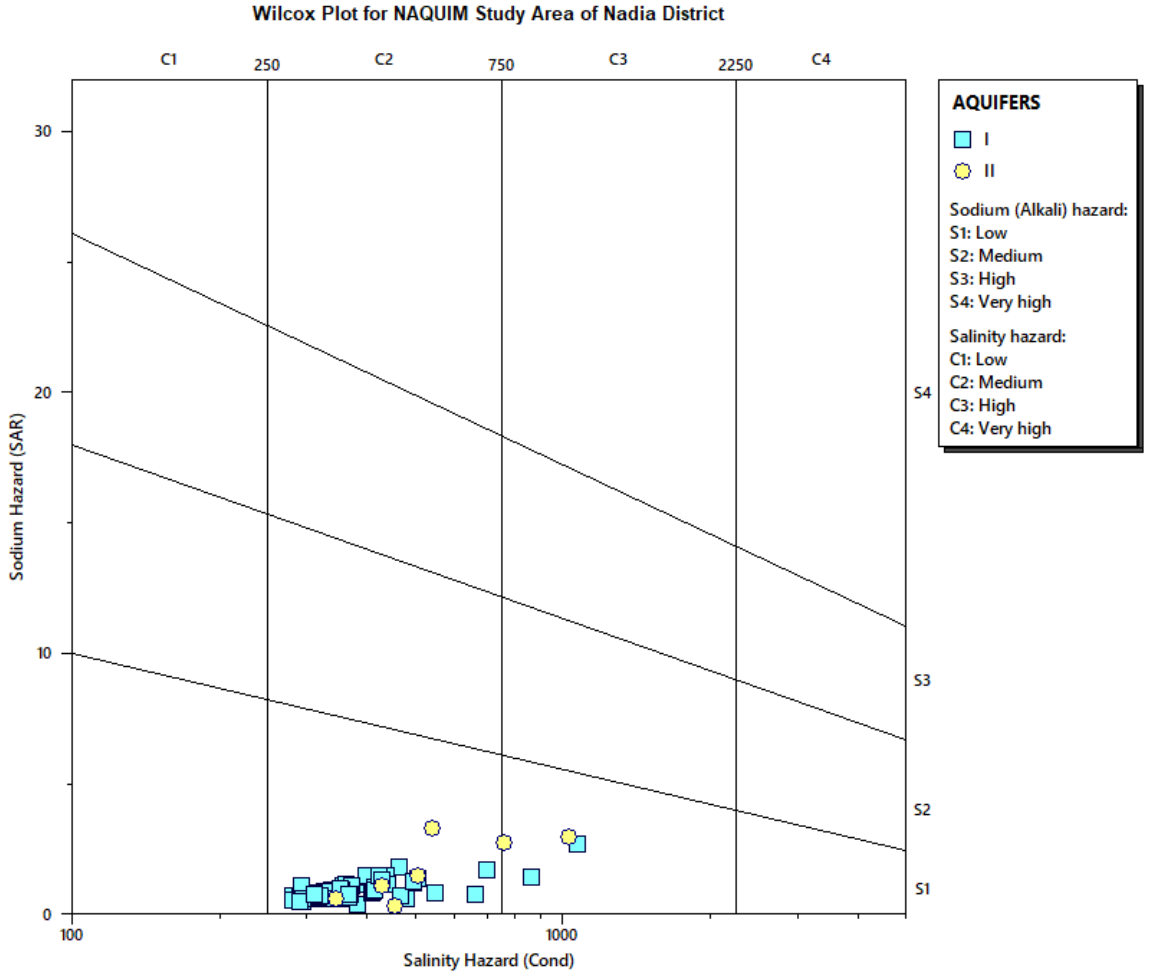
Chemical Facies of Ground Water in Nadia District



- **Type of ground water**
- **Aq- I: MgHCO3, CaHCO3, NaHCO3**
- **Aq-II : MgHCO3, NaHCO3**

Plate- 23

Plate- 24



5.3 Ground water pollution:

Arsenic is the main pollutant in the shallow and intermediate (at places) aquifer system in all the 9 Blocks in the study area. Sporadic occurrence of arsenic in shallow aquifers beyond permissible limit has been established in all the blocks of the district. The spot value of concentration of Arsenic in ground water in all the blocks in the study area is plotted and shown in **Plate-25**. A total population of 2121105 (as per 2011 Census) in rural area of the study area, are at risk zone. The maximum concentration of arsenic in ground water has been observed as 1.18 mg/l at Mahisbathan in Karimpur- II block. PHED has tested so far 15796 nos. of public hand pump tube wells in the area in their laboratories. From the chemical analysis results of the tube wells, it has been observed that 37% tube wells contain arsenic content in ground water in the range of 0.01 to 0.05 mg/l & 24% tube wells are having arsenic content >0.05 mg/l. The details are shown in **Table-XIV.**

Table-XIV: Status of Arsenic concentration in ground water in parts of Nadia district

Sl. No.	Name of arsenic affected block	No. of Tube well analysed	Arsenic Concentration (in mg/l)						
			< & =0.01		>0.01 & <=0.05		>0.05		Max.concentration
			%	No.	%	No.	%	No.	
1	Karimpur- I	1177	29.57	348	28.04	330	42.40	499	1.08
2	Karimpur- II	1697	26.34	447	27.64	469	45.96	780	0.93
3	Tehatta - I	1368	69.23	947	20.10	275	10.67	146	0.54
4	Tehatta -II	755	60.53	457	33.11	250	6.36	48	0.34
5	Kaliganj	2111	27.00	570	38.09	804	34.86	736	1.00
6	Nakashipara	2459	45.51	1119	40.42	994	14.07	346	0.56
7	Chapra	2230	34.80	776	52.83	1178	12.38	276	0.51
8	Krishnaganj	1737	39.21	681	37.94	659	22.86	397	0.77
9	Hanskhali	2262	34.92	790	39.48	893	25.46	576	0.53
TOTAL		**15796**	**40.79**	**6135**	**35.29**	**5852**	**23.89**	**3804**	

Water Quality (Arsenic content in ground water)

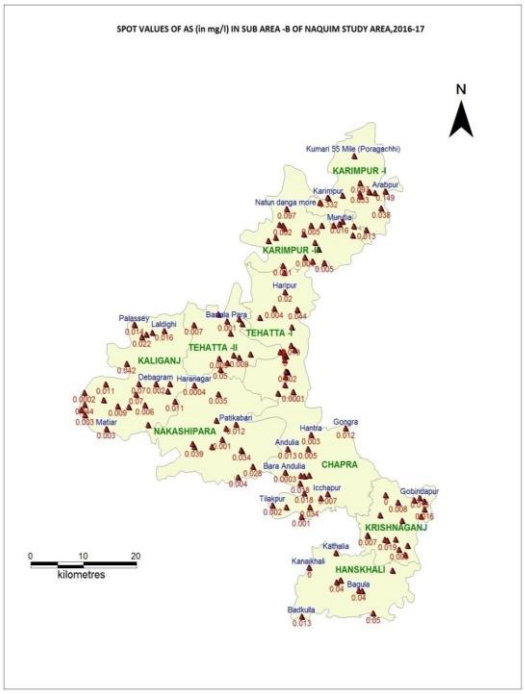


Plate- 25

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6. AQUIFER MANAGEMENT PLAN

6.1 Ground Water Management Plan for Drinking Purposes

The drinking water in all the 9 blocks of Nadia district (in study area B) is being supplied by PHED through surface water & ground water. The **Table-XV** showing below the block-wise status of Arsenic concentration in ground water and risk population in the area, reveals the Sporadic occurrence of arsenic above permissible limit are reported in all the 9 blocks.

Table-XV: Arsenic affected Blocks and Risk Population

Sr No.	District	Block (As affected)	No. of habitations in the risk zone where (Arsenic conc.>0.05 mg/l	No. of habitations in the risk zone (Arsenic conc. 0.01 to 0.05 mg/l)	Risk Population (2011) where Arsenic conc. >0.05 mg/l
1	Nadia	CHAPRA	63	40	296529
2		HANSKHALI	135	53	245899
3		KALIGANJ	192	96	306197
4		KARIMPUR - I	158	46	160895
5		KARIMPUR - II	138	19	217136
6		KRISHNAGANJ	136	69	146705
7		NAKASHIPARA	91	61	352191
8		TEHATTA - I	45	68	244322
9		TEHATTA - II	26	69	151231
Nadia Total			**984**	**521**	**2121105**

A total of 21,21,105 people (as per 2011 Census) of the blocks are at risk zone in the area.

Sporadic occurrence of arsenic in shallow aquifers has been established in all the blocks of the district. A total of 2121105 of people (as per 2011 Census) in rural area of the study area are at risk zone. The maximum concentration of arsenic in ground water has been observed as1.08 mg/l. PHED has tested so far 15796 nos. of public hand pump tube wells in this area in their laboratories. From the chemical analysis results of the tube wells, it has been observed that 37% tube wells contain arsenic content in ground water in the range of 0.01 to 0.05 mg/l & 24% tube wells are having arsenic content >0.05 mg/l.

As per the data of PHED, Govt. of West Bengal, about 85% of the rural risk population has been covered by water supply schemes. Only 15% rural population in the

study area in Karimpur I & II, Tehatta I & II, Hanskhali, Krishnaganj, Chapra blocks are to be covered by arsenic free water supply. Kaliganj and Nakashipara blocks are fully covered by State Authority.

6.1.1 Requirement of Wells:

As evidenced from the exploration arsenic free deeper aquifers ranging from 200 to 300 mbgl) are potential with a capacity to yield to the tune of 12.5 litre per second with drawdown of 6 m (approx) and can cater to the need of rural water supply. Considering human drinking and domestic demand of water @70 lpcd & projected population upto 2021 (considering decadal growth rate @ 21.09% following PHED guidelines and District Census 2011), the demand of water for human population as on 2021 has been calculated. Cattle population as on 2021 is estimated considering 0.19 per capita human population (district cattle population/ district human population), village population & 0.36 annual growth rate. Considering the cattle consumption @20 lpcd, water requirement for cattle has been calculated.

As per the ground Water Act, 2005 for arsenic affected areas, the extraction has been restricted to 45 m^3/hr (+/- 5%). Considering above guideline number of tube wells sizing of 250 mm X 150 mm with depth 300 mbgl has been calculated. Four observation wells, one for each block, are suggested for the blocks to monitor the impact of withdrawal of water from the tube wells on the water level. The tube wells should be constructed by tapping the aquifers which is separated from top arsenic contaminated aquifers by a persistent clay blanket. Provision for sealing the top arsenic contaminated aquifers with proper cement sealing against clay layer should be kept in order to prevent the vertical percolation of arsenic contaminated water from the top contaminated aquifer.

6.1.2 Mitigation Measures:

To supply safe Drinking Water to the affected blocks of the State a comprehensive Arsenic Master Plan was taken for implementation through various Short, Medium and Long Term measures by the State Government with assistance of Government of India. To combat the arsenic contamination in ground water, mitigation measures have been taken up by State Govt. by involving different NGOs, institutions etc., to provide arsenic free drinking water in the arsenic affected areas. Over the years, State Government has

undertaken number of steps to tackle the problem of arsenic contamination for ensuring safe drinking water to local habitants. Surface water supply scheme along with ground water based supply schemes are implemented in West Bengal by PHED, Govt. of West Bengal. A number of arsenic removal plants are also installed in the arsenic infested areas to remove arsenic from arsenic rich ground water as a short term measures. Sludge disposal from arsenic removal equipment is another problem for arsenic infested areas. But due to number of reasons, regarding operation, maintenance, social adaptability, lack of awareness among local people these efforts were not that much successful.

The technologies which are relevant to the ground water of West Bengal only have been classified as short, medium or long term remedial measures based on their nature. Since 1995 onwards PHED of Government of West Bengal has been implementing all possible mitigation measures by Engineering interventions .

Short Term : New Hand Pump Tube well tapping deeper Aquifer, Ring Well etc.

Medium Term : ATU with existing Hand Tube Well, ARP for existing PWSS , New large bore Tube Wells tapping deeper Aquifer, New Ground Water based PWSS.

Long Term : Surface Water based PWSS

Groundwater with arsenic contamination has been found mainly in the shallow aquifers. Deep aquifers, separated by thick clay layer of appropriate composition (which acts as an impervious layer between aquifer groups) may yield arsenic free fresh ground water. It was inferred from the isotopic studies carried out in West Bengal that in alluvial formations, there is no hydraulic connection between shallow and deep aquifers, when separated by an appropriate impervious layer. Central Ground Water Board, while carrying out extensive work on this aspect, has deciphered and delineated deep arsenic free aquifers in some parts of arsenic infested areas of West Bengal.

Exploration in the areas also reveals that the wells, constructed by tapping multiple aquifer system (tapping shallow and deep both aquifers), allows contamination from adjacent contaminated aquifers through annular space packed with gravel. At places the confining clays layers, silty in nature, act as semi-pervious, but under stressed condition (over pumping) arsenic contaminated water gets passage through these semi-confining layers and may contaminate safe aquifer water. In order to prevent such vertical percolation of contaminated

water, **CGWB has adopted cement sealing technique to separate deeper arsenic free aquifer from shallow arsenic rich aquifer.** Central Ground Water Board has already constructed tube wells in arsenic infested areas of West Bengal adopting cement sealing techniques and handed over to PHED, Govt. of West Bengal for supply of arsenic free water. Therefore construction of suitably designed tube well tapping arsenic free deeper aquifer in arsenic infested area is most suitable structure for supplying arsenic free water.

Based on the exploration data and need for water supply schemes, district wise feasibility of arsenic free abstraction structures is discussed below.

6.2 Ground Water Management Plan for Irrigation Purposes

The study area is basically under intensive irrigated agriculture by groundwater and also partly by surface water. Paddy and Rabi vegetables are the important corps cultivated by farmers in the region. In major part of the area farmers depend only on groundwater for cultivation of these crops during all seasons. Any reduction in the yield of the tube wells due to decline in groundwater shall adversely impact the production of the food grain. The study area has multilayer aquifer system where ground water occurs as regionally extensive unconfined conditions in upper aquifer system (say Aquifer- I & II) within depth of 150 mbgl (with local variation). This aquifer system is highly potential in nature, holds fresh water and caters to the need of irrigation, agriculture and industries. But in most of the places arsenic contamination in ground water occurs (>0.01mg/l) in a sporadic manner in Aquifer -I and Aquifer –II (at places), therefore it is not suitable for drinking purposes. The Aquifer System-III within depth of 280 mbgl (with slight variation in regional/ local level) occurs below the Aquifer System-I & II separated by clay bed with variable thickness. The ground water occurs under semi-confined to confined conditions and is in general arsenic free. As revealed by the Exploration, the Aquifer System-III within depth of 300 mbgl occurs below the Aquifer System-II separated by thick clay bed with variable thickness in northern Blocks (except Tehatta-I, where further exploration is required) of the study area, and is arsenic free. The ground water occurs under confined conditions in this aquifer system. The CGWB has constructed number of arsenic free wells tapping the Aquifer II & III groups using cement sealing techniques and handed over to PHED/ State Government departments for supply of arsenic free water. It is observed that ground water level is declining slowly in most of the area under irrigation and also in some of the wells in the urban areas. Therefore there is need for efficient management of these aquifer systems for sustenance of the tube wells tapping

Aquifer Systems– I, II as well as III.

Block-wise the availability of Ground Water Resources & its present status of Development of the aquifer system and, block-wise availability of land **for** future Irrigation in the study area are shown in the following **Tables-XVI & XVII**.

Table-XVI: Availability of GW resources & its present Status in the Study area

Sr. No.	District	Block	Net GW availability in ham	Gross GW draft in Ham	SOD in %	Long term Water Level trend in Cm/Yr (Rising - & Falling +)		Category	GW available for Future GW use in ham
						Pre monsoon	Post monsoon		
1	Nadia	Chapra	18229.97	19907.58	109.20	4.56	11.47	Semi Critical	-
2	Nadia	Hanskhali	14129.31	13966.03	98.84	1.79	10.82	Semi Critical	22.51
3	Nadia	Kaliganj	15711.35	14574.49	92.76	3.64	10.39	Semi Critical	979.91
4	Nadia	Karimpur I	11923.27	13894.90	116.54	6.22	10.57	Semi Critical	-
5	Nadia	Karimpur II	13320.05	16441.56	123.43	3.00	9.09	Semi Critical	-
6	Nadia	Tehatta I	13833.90	15305.98	110.64	1.67	8.32	Semi Critical	-
7	Nadia	Tehatta II	9868.30	10975.64	111.22	-2.35	-3.06	Semi Critical	-
8	Nadia	Nakashipara	18557.14	15720.51	84.71	1.07	8.81	Safe	2655.93
9	Nadia	Krishnaganj	7974.40	6998.08	87.76	2.92	10.92	Safe	904.38
Study Area B in Total			**123547.7**	**127784.8**	**103.42**	**2.50**	**8.59**	**0**	**4562.73**

Table-XVII: Availability of Land for Future Irrigation

Sr. No.	District	Block	Geographical area in ha	Cultivable area in ha	Net irrigated Command area (GW) in ha	Net irrigated Command area (SW) in ha	Net irrigated Command area (GW +SW) in ha	Net area available for Irrigation	Demand i.e Water required for Irrigation	GW available for Irrigation	Remarks
1	Nadia	Chapra	31048	21372	12149.15	1406.4	13555.55	7816.45		-	
2	Nadia	Hanskhali	23150	17580	27815.26	1371	29186.26	-11606.3	Nil	22.51	
3	Nadia	Kaliganj	31975	19169	12373.95	921.08	13295.03	5873.97		979.91	
4	Nadia	Karimpur I	21227	15217	13377.43	727.22	14104.65	1112.35		-	
5	Nadia	Karimpur II	24118	17168	18821.11	682.5	19503.61	-2335.61	Nil	-	
6	Nadia	Tehatta I	25830	19750	12236.54	949.29	13185.83	6564.17		-	
7	Nadia	Tehatta	17444	15250	9955.83	1042.6	10998.43	4251.57		-	

		II									
8	Nadia	Nakashi para	35424	23082	15441.4	731.53	16172.93	6909.07		2655.93	
9	Nadia	Krishna ganj	15955	9880	4622.06	1028.63	5650.69	4229.31		904.38	
	Study area in Nadia district		**226171**	**158468**	**126793**	**8860.25**	**135652.98**	**22815.02**		**4562.73**	

6.2.1 Desirable Management Interventions:

To formulate the proper Aquifer Management Plan, it is required to understand the ground water resources, its quality and proper scientific development. The study area is basically under intensive irrigated agriculture by groundwater and also partly by surface water. Paddy and Rabi vegetables are the important corps cultivated by farmers in the region. In major part of the area farmers depend only on groundwater for cultivation of these crops during all seasons. Any reduction in the yield of the tube wells due to decline in groundwater shall adversely impact the production of the food grain. Though the study area has multilayer aquifer system in which Aquifer-I & II (within depth of 150 m bgl) is highly potential in nature, holds suitable water and caters to the need of irrigation in agriculture and industries. Aquifer III (within depth of 160 to 300) occurs below the Aquifer II separated by clay bed. Aquifer III is not so much potential as Aquifer I & II. The urban agglomeration depends on aquifer II for their requirement. It is observed that ground water level is declining slowly in most of the area under irrigation and also in some of the wells in the urban areas. Therefore, there is need for efficient management of the aquifer systems for sustenance of the tube wells tapping Aquifer I as well as Aquifer II.

7. SCOPE OF ARTIFICIAL RECHARGE

Considering the administrative units (blocks or municipalities), average post monsoon water level and long term trend of ground water level, the area suitable for artificial recharge has been identified. The area suitable for recharge is arrived considering area having the post-monsoon depth to water level more than 3m and showing long term falling trend of water level more than 2cm/year.

a) Water levels more than 9m bgl with or without the falling trend with first priority.

b) Water levels between 6m and 9m bgl and with declining trend with second priority.

c) Area showing water levels between 6m and 9m bgl with no declining trend with third priority.

d) Areas showing water levels between 3m and 6m bgl and with declining trend with fourth priority.

However, area with 3m to 6m bgl post monsoon water level with no long term falling trend and area with 0 to 3m bgl of post monsoon water level has not been considered as feasible area for recharge.

Block-wise net surface water availability for recharge; source-water allocation for suitable types of artificial recharge structures; feasible numbers of various structures and structure-wise cost estimates were worked out for the study area, based on soil characteristic, land-slope, Runoff co efficient, rainfall data and long term trend, recommended by Dhruvanarayana, 1993.

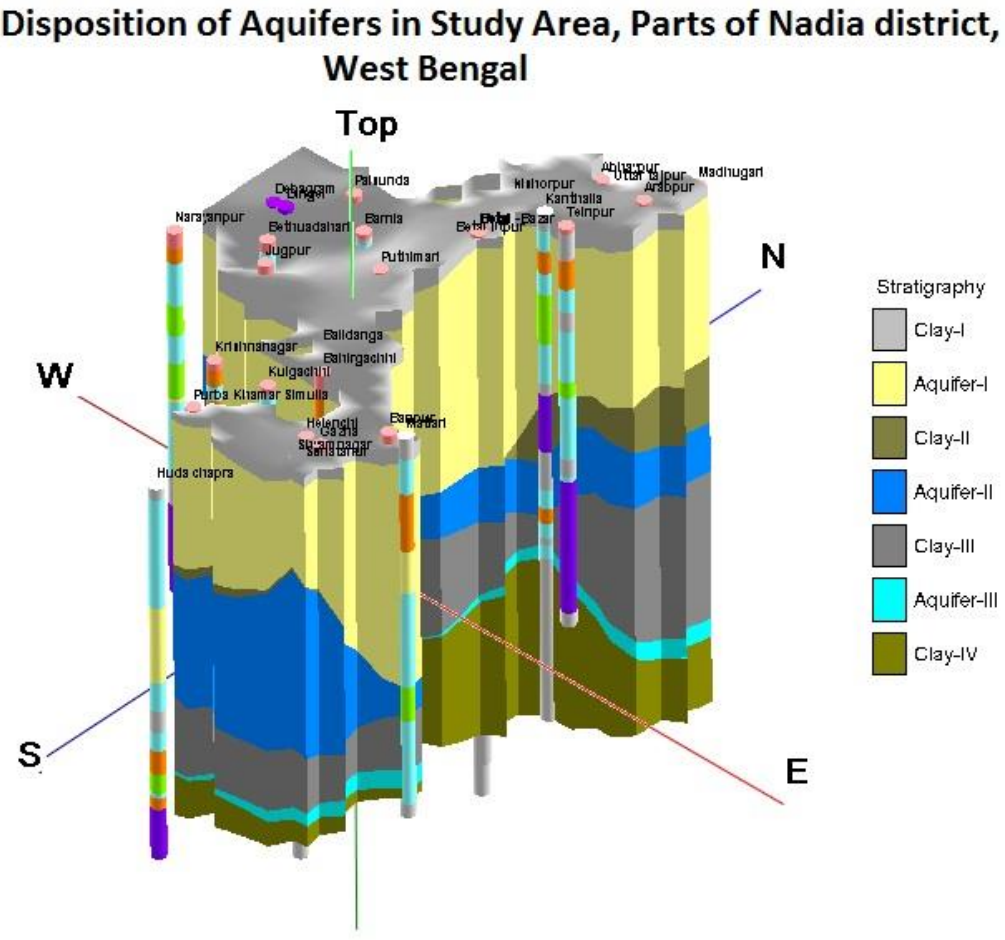
Considering the higher ground water development, categorization of the block as per the Ground Water Resource Assessment, 2013 and block/municipal level suitable area for recharge, priority may be assessed for implementation of artificial recharge projects in the study area. Percolation Tanks, Re-Excavation of Existing Tanks (REET) with Recharge Shafts, Injection Wells, Conservation Ponds in the rural area, and Roof-Top Rain Water Harvesting structures in the urban areas may be constructed as per the feasibility study.

N. B. - The Reports on “Data Gap Analysis”, “Geophysical Studies” and “Block-wise Ground Water Management Plan” of the concerned area are presented separately.

Part II

Block wise Aquifer Management Plan in parts of Nadia District (9 Blocks), West Bengal

(Karimpur - I, Karimpur - II, Tehatta - I, Tehatta - II, Kaliganj, Nakashipara, Chapra, Krishnaganj & Hanskhali Blocks)



1. KARIMPUR - I BLOCK

1.0 Salient Information

Block Name: **Karimpur - I**

Area (in sq km): **212.27**

District: **Nadia**

State: **West Bengal**

Population (as on 2011): **160895**

Table 1: Details of Population

Male	Female	Total
83014	77881	160895

1. Rainfall

Average annual rainfall (Nadia district) for the period 2012-2016 (in mm): 1214.24

Table 2: Details of Annual Rainfall since last five years (mm)

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Karimpur-I	1444	862.0	1287.8	1096.8	1408.1	1416.5

2. Agriculture & Irrigation

Total area in ha: 21227

Table 3: Details of Land use pattern

Sl. No	Name of the Block	Geographic Area (ha)	Cultivable Area (ha)	Area under pasture & orchard (ha)	Cultivable Waste Land(ha)	Forest Land (ha)	Home Stead Land (ha)
1.	**Karimpur-I**	**21227**	15217	209	(Negligible)	(Negligible)	4631

3. Aquifer Wise Ground Water Resource Availability & Extraction

Table 4: Details of aquifer wise resource availability and draft (in MCM)

Resource Availability	Aquifer I	Aquifer II	Aquifer III	Extraction (for Aquifer I)
Dynamic Resource	**119.23**	**-**	**-**	**138.95**
Static Resource	**2300.58**	**-**	**-**	**-**

4. Disposition of Principal Aquifer System

In Karimpur - I Block, three aquifer systems exist.

- The range of 1st aquifer is on an average from 5m to 131m but this is containing Arsenic.

- The range of 2nd aquifer is on an average from 154m to 185m, which is fresh and Arsenic free.
- The range of 3rd aquifer is 282 m to 294 m**,** which is also fresh and Arsenic free.

Table 5: Details of aquifer disposition depth range

	1st Aquifer	2nd aquifer	3rd aquifer
Karimpur- I	5-131 m	154-185 m	282-294 m

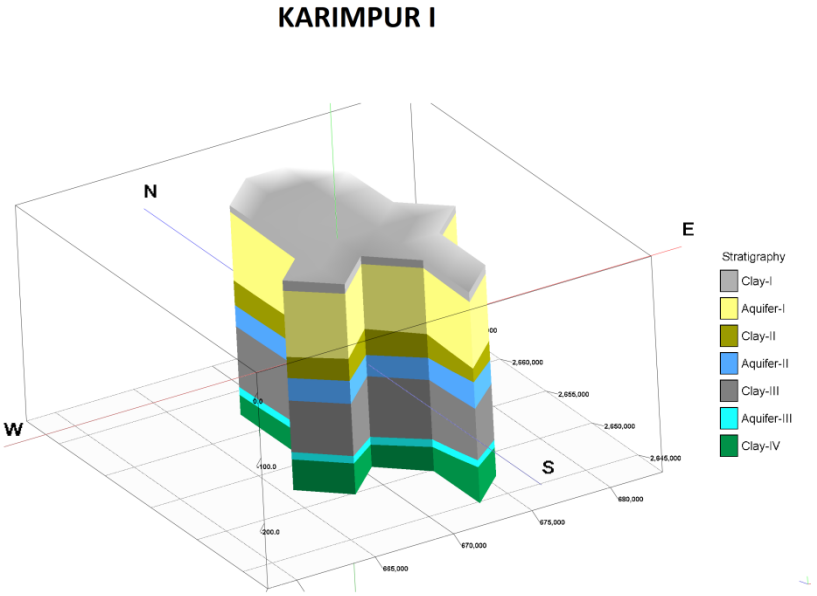
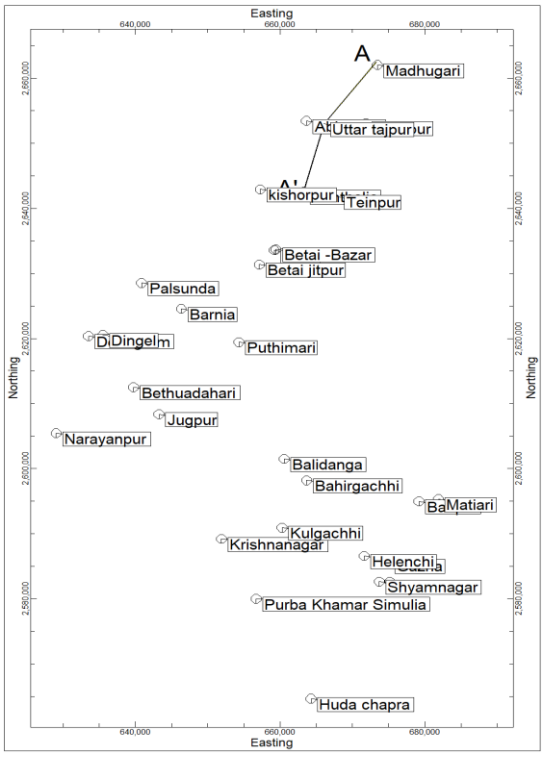


Fig.1: Aquifer disposition in Karimpur - I Block



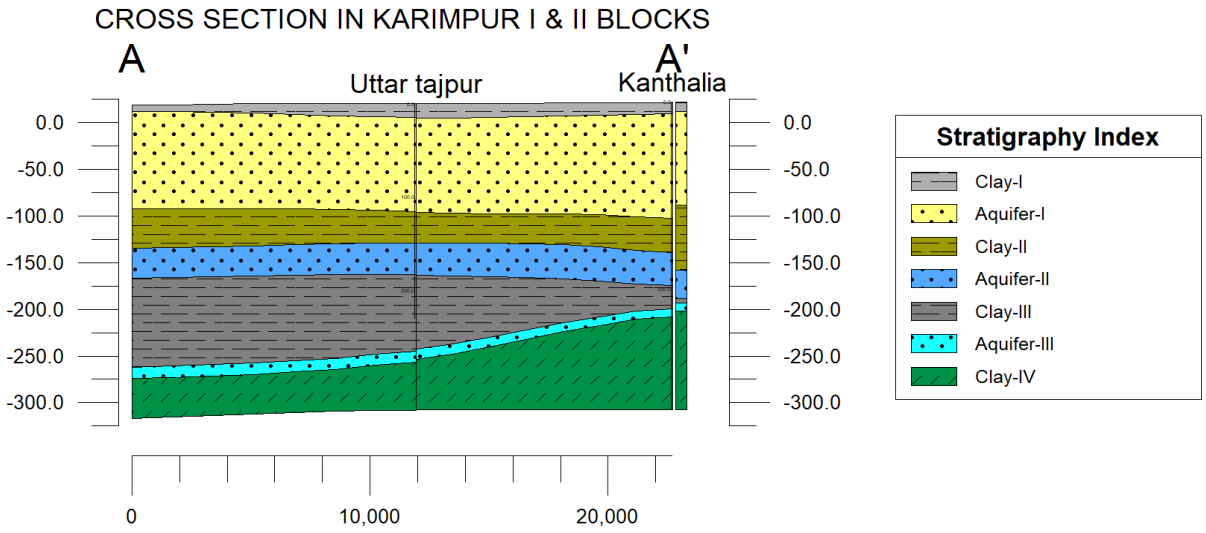


Fig.2: N- S Cross section of Karimpur - I & II (combined) Blocks

Table 6: Details of Aquifer Wise Water Level Ranges & Pre-monsoon and Post-monsoon long term water level trends (2006 to 2017)

Sl. No.	Block	Aquifer	Pre-monsoon Trend		Post-monsoon Trend	
			Rise (cm/year)	Fall (cm/year)	Rise (cm/year)	Fall (cm/year)
1.	Karimpur - I	I	-	6.22	-	10.57
		II	-	-	-	-
		III	-	-	-	-

Table 7: Aquifer wise (Maximum) thickness

Block	Area (sq km)	Thickness of the Granular Zone in 1st aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)	Thickness of the Granular Zone in 3rd aquifer (m)
Karimpur - I	212.27	126	35	15

Table 8: Aquifer-wise depth range and parameters (On the basis of CGWB exploration data)

Name of Block	1st Aquifer				2nd Aquifer				3rd Aquifer		
	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)
Karimpur - I	5 - 131	36	2700	-	150 - 185	29	-	-	280 - 295	-	-

5. **Ground Water Resource, Extraction, Contamination & Other Issues**

Resource Availability & Extraction: Dynamic ground water resources as on 31st March '13

Table 9: Availability of Ground Water resource

Block	Net ground Water availability (MCM)	Gross ground Water draft (MCM)	Stage of Development (%)	Category	Provision for domestic and industrial requirement supply upto 2035 years(MCM)
Karimpur - I	119.23	138.94	116.54	Semi-critical	3.84

6. Chemical Quality of Ground Water & Contamination

Average data of chemical parameters in the block based on the analysis from 8 to 10 monitoring wells are given below. For Arsenic data, 3 to 4 monitoring wells are considered, as analyzed by CGWB.

Table 10: Range of chemical parameter (based on CGWB Monitoring Wells data)

Block	Aquifer Type	As (mg/l)	pH	EC (Us/Cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO^3 (mg/l)	Total Hardness as $CaCo^3$ (mg/l)
Karimpur - I	**I**	**0.003-0.332**	**8.37-8.44**	**282.9-759.3**	**10.8-84.2**	**20.0-72.5**	**BDL-1.5**	**0.1-27.0**	**150-225**

Table 11: Arsenic Concentration (based on PHED hand pump data)

Name of arsenic affected block	No. of Tube well analysed	Arsenic Concentration (in mg/l)						
		<& =0.01		>0.01 &<=0.05		>0.05		Max. concentration
		%	No.	%	No.	%	No.	
Karimpur - I	1177	29.57	348	28.04	330	42.40	499	1.08

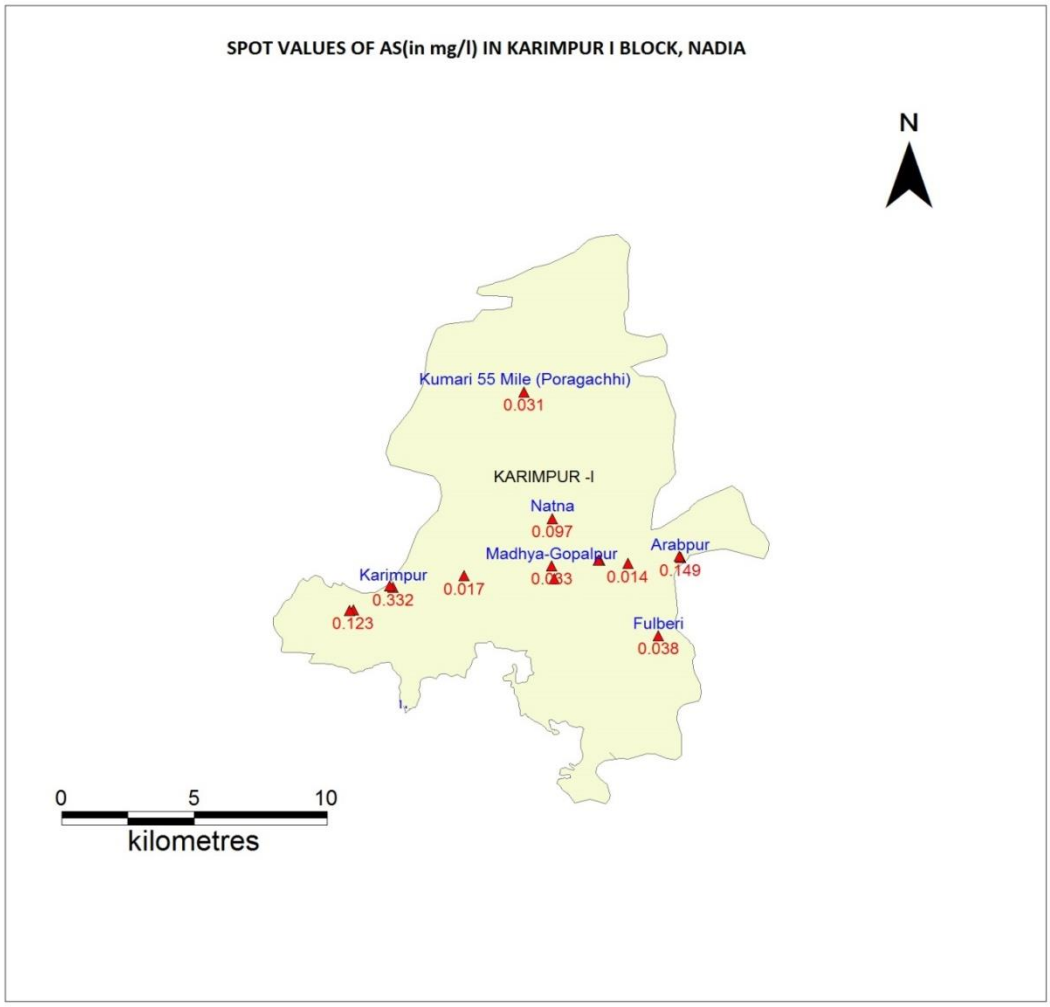


Fig. 3: Spot values of As in Karimpur – I Block, Nadia district

7. Ground Water Resource Enhancement & Management Plan

8.1 Ground Water Management Plan for drinking purposes

- As per the ground water policy, first priority of water is for drinking purpose.
- The Block is declared by the State Arsenic Task Force, as Arsenic affected.
- As per the Status of Rural Water Supply Schemes published by WBPHED a population of 5244 in 4 villages is under risk zone where no water supply scheme exists.
- On the basis of data available, 2 tube wells are required for catering four uncovered villages. Details of calculation are given below.
- The arsenic free aquifers in the depth span of 154m to 185m & 282m to 294m (comparatively less potential) may be exploited for the purpose.
- Arsenic free aquifer should be tapped with proper cement sealing. Arsenic removal plant may be installed before supply.
- Regular Field monitoring is necessary for Arsenic concentration in tube wells.

Table 12: Number and cost for construction of Tube wells in the uncovered villages calculated on the basis of projected population of Human and Cattle

Block	Projected population upto 2021 (considering growth 21.09% per decade as per Census 2011	Water required for drinking & domestic purposes @ 70 lpcd (in lpd)	Cattle Population (Considering 0.19 per capita human population) as on 2011	Cattle Population (Considering 0.36 annual growth rate) as on 2021	Water required for drinking & domestic purposes @ 20 lpcd (in lpd)	Total Water Required (in lpd)	Number of T. Ws	Cost of the tube well of 300 m depth (approx) & 10"x6" dia @ Rs. 25 lakhs (In lakh) as per EFC
Karimpur-I	6350	444500	7556	10276	205520	650020	**2**	**50**

8.2 Management Plan for Irrigation

Table 13: Availability of Land for Future Irrigation

Sr. No.	District	Block	Geographical area in ha	Cultivable area in ha	Net irrigated Command area (GW) in ha	Net irrigated Command area (SW) in ha	Net irrigated Command area (GW +SW) in ha	Net area available for Irrigation in ha	Demand i.e. Water required for irrigation in ham	GW available for future Irrigation in ham
1.	Nadia	Karimpur I	21227	15217	13377.43	727.22	14104.65	1112.35	-	-

- On the basis of the Ground Water Resource Assessment, the block is under Semi-critical condition and the Stage of Ground Water Development (SOD) is 116.54 %. Hence, irrigation by exploiting the unconfined aquifer is not advisable.
- As indicated in the above mentioned Table, ground water is not available for future irrigation in this block. Surface water bodies like streams, canals, ponds may be used for irrigation purposes for the available land.
- Irrigation by modern techniques like Sprinkler, Drip irrigation may be utilised. Crops consuming low amount of water should be cultivated.
- Conjunctive use of ground water and surface water may be applied for irrigation
- Artificial recharge is must in Arsenic affected zone for dilution of Arsenic concentration in unconfined aquifer for irrigation purpose also, so that there is no Arsenic contamination in food chain system.
- Regular monitoring of Arsenic concentration in crop is also necessary.
- R & D study is necessary in arsenic affected area so we can get new solutions in

future.

Table 14: Ground Water Management Plan for Irrigation in consultation with experts of Bidhan Chandra Krishi Vidyalaya (BCKV)

Block	Ground water availability(Ham,)	Quality	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Karimpur-I	-	As	wheat, rice, mustard, cabbage, cauliflower, brinjal, okra, lentil	wheat(0.3-0.35),rice(1.2-1.4),Vegetable(0.15-0.2),pulse(0.1-0.12)	wheat, mustard, lentil, flowers, vegetables	wheat(0.2-0.25),mustard(0.2),pulse(0.08-0.12),flowers(0.12-0.16)	Conjunctive use of fresh and contaminated water: 1:1 ratio/drip for vegetable, flowers

8.3 Management Plan for Industrial Purpose

The block is under Semi-critical condition and is mainly agriculture based rural area. There is a less chance for growing up of small scale industries. However, in near future, if any industry is coming up, the following steps should be considered.

- All industries proposing to draw ground water through energized means, need to obtain NOC for ground water withdrawal from the State Ground Water Authority (SGWA)
- All industries abstracting ground water > 500 m^3/day in the semi-critical assessment unit, have to implement mandatorily, artificial recharge measures, as per the norms.
- All the industries need to recharge 90 % of the quantum of ground water withdrawal.
- The Authority is to issue NOC for various uses and monitor its compliance. The NOC should be vested with the District Magistrate/ Deputy Commissioner/ State Ground Water Authority/ State Nodal Agency/ Central Ground Water Authority, as per details given in the guidelines of CGWA.

8. Special interventions for monitoring of Ground water situations in Semi-Critical Block

As per the GEC Norms for Semi-critical block, the following precautions should be taken before GW extraction.

- It is necessary to increase the density of observation wells in that unit for regular water level monitoring and thereby-
- The rainfall recharge during monsoon season by the water table fluctuation method can be estimated with greater accuracy.

- The trend of water table during pre- monsoon and post-monsoon intervals can be evaluated with greater accuracy.
- The trend of water table during pre- monsoon and post- monsoon intervals consequent to further groundwater development can be more effectively monitored.

9. Proposed Artificial Recharge Structures in the Study area:

Table 15: Space Available For Recharge and Proposed Interventions:

Name of Block	Geographical area in ha	Cultivable area in ha	Net irrigated area in ha	Area to be irrigated in ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in mbgl	Average Post monsoon WL in mbgl	Remarks for GW Management Plan
Karimpur- I	21227	15217	14104.65	1112.35	116.54	6.22	10.57	5.81	4.97	Block is under semi critical condition so Regular Monitoring of GW Regime should be made from time to time, Boro cultivation should be restricted

Table 16: Area suitable for recharge in the study area:

District	Block Name	**Block Area (in ha)**	**Area suitable for recharge(Considering area having DTW more than 3m in post-monsoon and showing 2cm/y falling trend)(in ha)**
Nadia	Karimpur-I	21227	**21227 (considering the average criteria)**

Table 17: Calculation of Surface runoff on the basis of Runoff co efficient from Dhruvanarayana, 1993 (Based on land slope, type of land and soil)

Block	Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana, 1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed)= Vnc Ham	60% of Vnc(considering e-flow)= Vf Ham
Karimpur I	0.955	21227	20271.785	0.5	Deep, poorly drained loamy soil	10135.8925	7601.919	3800.959688	2280.575813

Table 18: Details of Recharge structure in block calculated on the basis of soil characteristic, Slope, Rain fall data and Long term trend

Block (3)	Amount of water for artificial recharge and / or conservation (Ham) (4)	Source water allocation for Percolation Tank and REET with Recharge Shaft in Ham (5)	Source water allocation for REET with Recharge Shaft (Ham) : 50 % of Col. 5 (6)	Source water allocation for Percolation Tank (Ham): 50 % of Col. 5 (7)	Source water allocation for Injection Well (8)	Source water allocation for Conservation Pond in Ham (9)	Nos. of Conservation Pond @ 10 Ham per unit	Cost of conservation pond @ Rs 8 lakh per unit (12)	Nos. of Percolation tank suggested @ 50 Ham per unit (11)	Cost of Percolation tank @ Rs 8 lakh per unit (13)	Nos. of REET with recharge shaft @ 10 Ham per unit (11)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (12)	Nos. of injection Well @ 30 Ham per unit	Cost of injection Well @ Rs 25 lakh	Total Cost (in Lakh)
Karimpur I	2280.576	35% of Col. 4 i.e. 798.20 Ham	399.1	399.1	25 % of Col. 4 i.e. 570.14 Ham	40 % of Col. 4 i.e. 912.23 Ham	91	728	8	64	40	320	19	475	1587

2. KARIMPUR II BLOCK

1.0 Salient Information

Block Name: Karimpur II

Area (in sq km): **241.18**

District: **Nadia**

State: **West Bengal**

Population (as on 2011): 217136

Table 1.1 - Details of Population

Male	Female	Total
111488	105648	217136

Rainfall: Average annual rainfall (Nadia district) for the period 2012-2016 (in mm): 1214.24

Table 1.2 - Details of Annual Rainfall since last five years (mm)

Block	**District Normal**	**Actual (Annual)**				
		2012	**2013**	**2014**	**2015**	**2016**
Karimpur II	1444	862.0	1287.8	1096.8	1408.1	1416.5

Agriculture & Irrigation

Total area in ha: 24118

Table 1.3 - Details of Land use pattern of block

Sl. No	Name of the Block	Geographic Area (ha)	Cultivable Area (ha)	Area under pasture & orchard (ha)	Cultivable Waste Land(ha)	Forest Land (ha)	Home Stead Land (ha)
1.	**Karimpur-II**	**24118**	17168	217	(Negligible)	(Negligible)	4712

Aquifer Wise Ground Water Resource Availability & Extraction:

Table 1.4 - Details of aquifer wise resource availability and draft (in MCM) in Block

Resource Availability	Aquifer I	Aquifer II	Aquifer III	Extraction (for Aquifer I)
Dynamic Resource	**133.20**	**-**	**-**	**164.41**
Static Resource	**2902.84**	**-**	**-**	**-**

2.0 Disposition of Principal Aquifer System:

In Karimpur II Block, three aquifer systems exist.

- The average depth range of 1st aquifer is from 10m to 159m, but ground water in this contains Arsenic.
- The average depth range of 2nd aquifer is from 179m to 210m which is fresh and Arsenic free.
- The average depth range of 3rd aquifer is 215 m to 224 m, which is also fresh and Arsenic free.

Table 2.1 - Details of aquifer disposition depth range in the block

Karimpur-II	**1st Aquifer**	**2nd aquifer**	**3rd aquifer**
	10-159 m	**179-210 m**	**215-224 m**

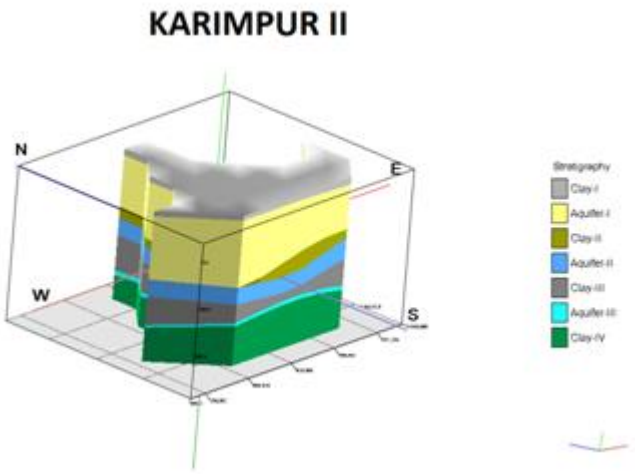


Fig 2.1 - Aquifer disposition in Karimpur II Block

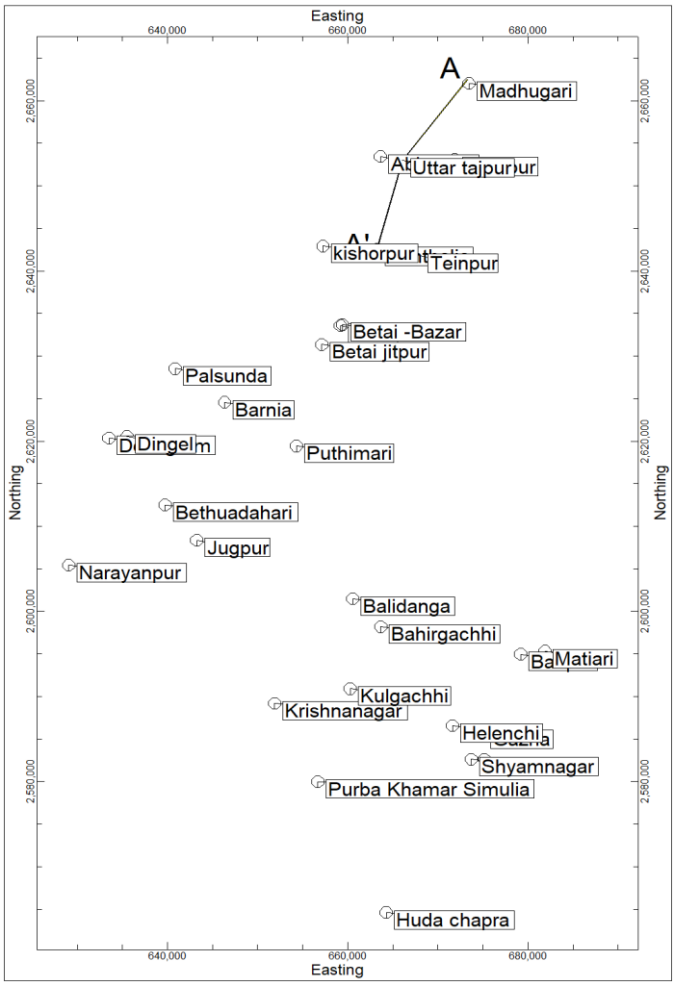


Fig 2.2 – Cross section index line in Karimpur II Block

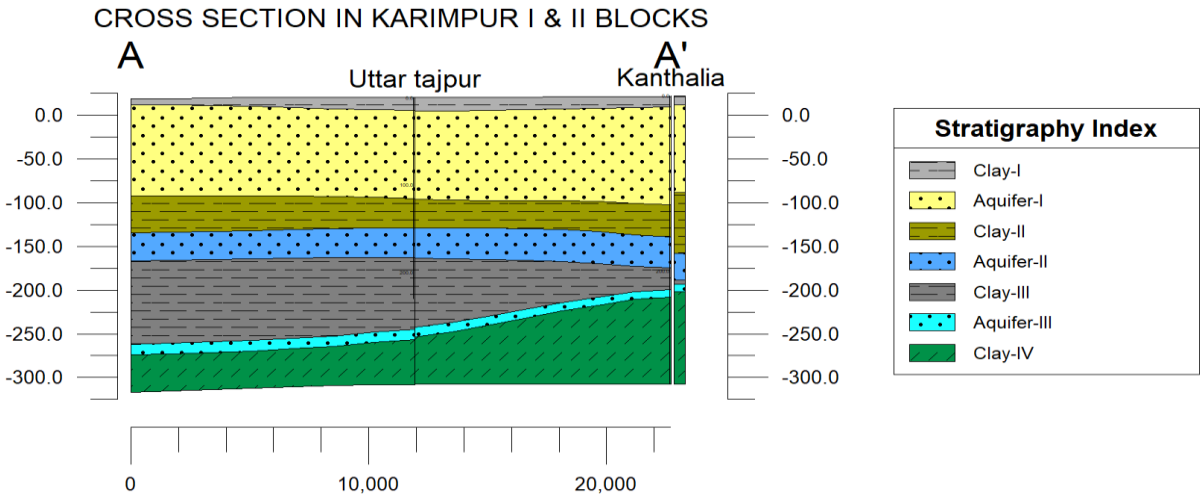


Fig 2.3 - Cross section of Karimpur II & nearby area

Table 2.2 - Aquifer Wise Water Level Ranges & Seasonal long term trends (2006 -17)

Sl. No.	Aquifer	Pre-monsoon			Post-monsoon		
		Depth to water level	Trend		Depth to water level	Trend	
			Rise (cm/year)	Fall (cm/year)		Rise (cm/year)	Fall (cm/year)
1.	I	3.84 – 4.87	-	3.00	3.37 – 4.24	-	9.09
2.	II	4.33 – 5.90	-	-	3.26 – 5.09	-	-

Table 2.3 - Aquifer wise (Maximum) thickness

Block	Area (sq km)	Thickness of the Granular Zone in 1st aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)	Thickness of the Granular Zone in 3rd aquifer (m)
Karimpur-II	241.18	149	31	9

Table 2.4 - Aquifer-wise depth range and parameters

Name of Block	1st Aquifer				2nd Aquifer				3rd Aquifer		
	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)
Karimpur-II	10 - 159	-	-	-	179 - 210	-	-	-	215 - 224	-	-

3.0 Ground Water Resource, Extraction, Contamination & Other Issues:

Resource Availability & Extraction: Dynamic ground water resources as on 31st March'13

Table 3.1 - Availability of Ground Water resource in Block

Block	Net ground Water availability (MCM)	Gross ground Water draft (MCM)	Stage of Development (%)	Category	Provision for domestic and industrial requirement supply up to 2035 years (MCM)
Karimpur II	133.20	164.41	123.43	Semi-critical	4.42

Chemical Quality of Ground Water & Contamination:

Average data of chemical parameters in the block based on the analysis from 8 to 10 monitoring wells are given below. For Arsenic data, 3 to 4 monitoring wells are considered.

Table 3.2 - Range of chemical parameter in the block

Block	Aquifer Type	As (mg/l)	pH	EC (µs/Cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Total Hardness as $CaCO_3$(mg/l)
Karimpur II	**I**	**0.002–0.008**	**8.33-8.50**	**398.8-1077**	**17.7-100.4**	**12.5-110**	**BDL-0.51**	**1.2-27.7**	**130- 275**

Table 3.3 - Arsenic Concentration in ground water in detail

Name of arsenic affected block	No. of Tube well analysed	Arsenic Concentration (in mg/l)						
		<& =0.01		>0.01 &<=0.05		>0.05		Max. concentration
		%	No.	%	No.	%	No.	
Karimpur II	1697	26.34	447	27.64	469	45.96	780	0.93

(Source – PHED, Govt. of West Bengal)

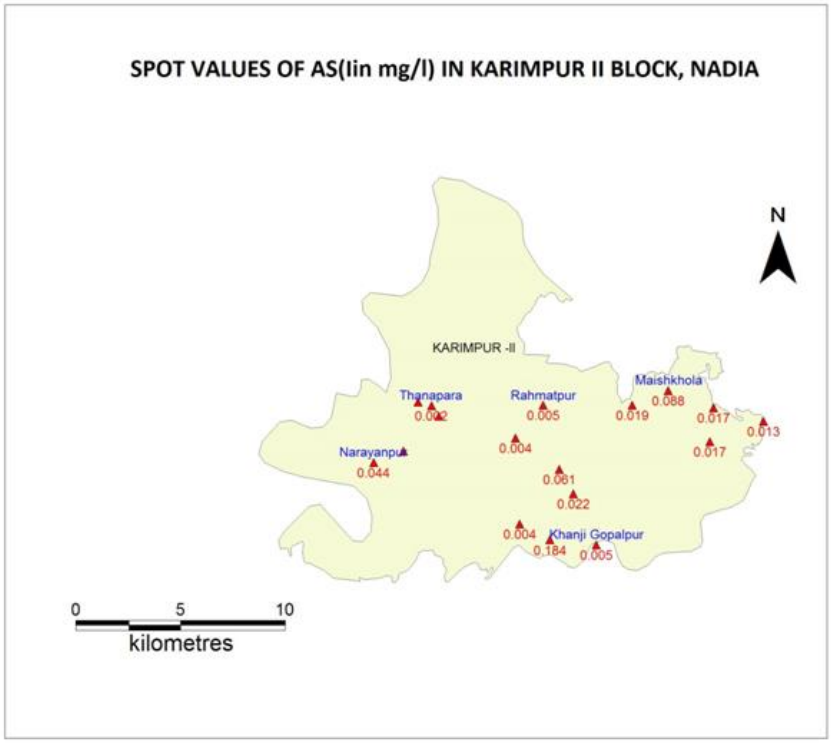


Fig. 3.1 – Spot values of Arsenic in ground water

4.0 Ground Water Resource Enhancement & Management Plan:

Ground Water Management Plan for Drinking purposes-

- As per the ground water policy, first priority of water is for drinking purpose.
- The Block is declared by the State Arsenic Task Force, as Arsenic affected.
- As per the Status of Rural Water Supply Schemes published by WBPHED a population of 63224 in 12 villages is under risk zone where no water supply scheme exists.
- On the basis of data available, 22 tube wells are required for catering twelve uncovered villages. Details of calculation are given below.
- The arsenic free aquifers in the depth span of 179m to 210m & 215m to 224m (comparatively less potential) may be exploited for the purpose.
- Arsenic free aquifer should be tapped with proper cement sealing. Arsenic removal plant may be installed before supply.
- Regular Field monitoring is necessary for Arsenic concentration in tube wells.

Table 4.1 – Nos & cost of Tube wells in the uncovered (projected) population of Human and Cattle

Block	Projected population upto 2021 (considering growth 21.09% per decade as per Census 2011	Water required for drinking & domestic purposes @ 70 lpcd (in lpd)	Cattle Population (Considering 0.19 per capita human population) as on 2011	Cattle Population (Considering 0.36 annual growth rate) as on 2021	Water required for drinking & domestic purposes @ 20 lpcd (in lpd)	Total Water Required (in lpd)	Number of T.Ws	Cost of the tube well of 300 m depth (approx) & 10"x6" dia @ Rs. 25 lakhs (In lakh) as per EFC
KarimpurII	76564	5359480	91111	123911	2478220	7837700	**22**	**550**

Management Plan for Irrigation

Table 4.2 - Availability of Land for Future Irrigation

Sr. No.	District	Block	Geographical area in ha	Cultivable area in ha	Net irrigated Command area (GW) in ha	Net irrigated Command area (SW) in ha	Net irrigated Command area (GW +SW) in ha	Net area available for Irrigation in ha	Demand i.e. Water required for Irrigation in ham	GW available for future Irrigation in ham	Remarks
2.	Nadia	Karimpur- II	24118	17168	18821.11	682.5	19503.61	-2335.61	Nil	-	

- On the basis of the Ground Water Resource Assessment, the block is under Semi-critical condition and the Stage of Ground Water Development (SOD) is 123.43 %. Hence, irrigation by exploiting the unconfined aquifer is not advisable.
- As indicated in the above mentioned Table, the net area for irrigation is not at all available, even over-irrigated. Hence, over-irrigation may be stopped and no further irrigation is suggested with ground water.
- Irrigation by modern techniques like Sprinkler, Drip irrigation may be utilised. Crops consuming low amount of water should be cultivated.
- Conjunctive use of ground water and surface water may be applied for irrigation
- Artificial recharge is advisable in Arsenic affected zone for dilution of Arsenic concentration in unconfined aquifer for irrigation purpose also, so that there is no Arsenic contamination in food chain system.
- Regular monitoring of Arsenic concentration in crop is also necessary.

- R & D study is necessary in arsenic affected area so we can get new solutions in future.

Table 4.3 - Ground Water Management Plan for Irrigation in consultation with experts of Bidhan Chandra Krishi Vidyalaya (BCKV)

Block	Ground water availability(Ham,)	Quality	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Karimpur-II	**-**	**As**	**wheat, rice, mustard, cabbage, cauliflower, brinjal, okra, lentil**	**Wheat (0.3-0.35), rice (1.2-1.4), Vegetable (0.15-0.2), pulse (0.1-0.12)**	**wheat, mustard, lentil, flowers, vegetables**	**Wheat (0.2-0.25), mustard (0.2), pulse (0.08-0.12), lowers (0.12-0.16)**	**Conjunctive use of fresh and contaminated water: 1:1 ratio/drip for vegetables, flowers**

Table 4.4 – Important points for Irrigation

Name of Block	Geographical area in ha	Cultivable area in ha	Net irrigated area in ha	Area to be irrigated in ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in mbgl	Average Post monsoon WL in mbgl	Remarks for GW Management Plan
Karimpur-II	24118	17168	19503.61	--2335.61	**123.43**	**3.00**	**9.09**	**4.82**	**4.00**	**Block is under semi critical condition so Regular Monitoring of GW Regime should be made from time to time, Boro cultivation should be restricted**

<u>Management Plan for Industrial Purpose</u>:

The block is under Semi-critical condition and is mainly agriculture based rural area. There is a less chance for growing up of small scale industries. However, in near future, if any industry is coming up, the following steps should be considered.

- All industries proposing to draw ground water through energized means, need to obtain NOC for ground water withdrawal from the State Ground Water Authority (SGWA)
- All industries abstracting ground water > 500 m^3/day in the semi-critical assessment unit, have to implement mandatorily, artificial recharge measures, as per the norms.
- All the industries need to recharge 90 % of the quantum of ground water withdrawal.

- The Authority is to issue NOC for various uses and monitor its compliance. The NOC should be vested with the District Magistrate/ Deputy Commissioner/ State Ground Water Authority/ State Nodal Agency/ Central Ground Water Authority, as per details given in the guidelines of CGWA.

Special interventions for monitoring of Ground water situations in Semi-Critical Block

As per the GEC Norms for Semi-critical block, the following precautions should be taken before GW extraction.

- It is necessary to increase the density of observation wells in that unit for regular water level monitoring and thereby-
- The rainfall recharge during monsoon season by the water table fluctuation method can be estimated with greater accuracy.
- The trend of water table during pre- monsoon and post-monsoon intervals can be evaluated with greater accuracy.
- The trend of water table during pre- monsoon and post- monsoon intervals consequent to further groundwater development can be more effectively monitored.

Artificial Recharge:

Table 4.5 - Area suitable for recharge in the study area:

District	Block Name	**Block Area (in ha)**	**Area suitable for recharge (Considering area having DTW more than 3m in post-monsoon and showing 20 cm/yr falling trend)(in ha)**
Nadia	Karimpur-II	24118	24118 **(considering the average criteria)**

Table 4.6 – Estimation of Surface runoff by Dhruvanarayana method, 1993 (Based on land slope, type of land and soil)

Block	Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed)= Vnc Ham	60% of Vnc(considering e-flow)= Vf Ham
Karimpur II	1.053	24118	25396.254	0.5	Deep, poorly drained loamy soil	12698.127	9523.5953	4761.7976	2857.078575

Table 4.7 – Possible Recharge & conservation structures using harvested run off in block based on soil characteristic, Slope, Rain fall data and Long term trend & cost estimate

Block (1)	Amount of water for artificial recharge and / or conservation (Ham) (2)	Source water allocation for Irrigation Cum Recharge Tank and REET with Recharge Shaft in Ham (3)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 3 (4)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 3 (5)	Source water allocation for Injection Well (6)	Source water allocation for Farm Pond in Ham (7)	Nos. of Farm Pond @ 10 Ham per unit (8)	Cost of Farm pond @ Rs 8 lakh per unit (9)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (10)	Cost of Irrigation Cum Recharge Tank @ Rs 8 lakh per unit (11)	Nos. of REET with recharge shaft @ 10 Ham per unit (12)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (13)	Nos. of injection Well @ 30 Ham per unit (14)	Cost of injection Well @ Rs 25 lakh (15)	Total Cost (16) (in Lakh)
Karimpur II	2857.0786	70 % of Col. 2 i.e. 1999.96 Ham	999.98	999.98	20 % of Col. 2 i.e. 571.42 Ham	10 % of Col. 2 i.e. 285.71 Ham	29	232	20	160	100	800	19	475	1667

REET with Recharge Shaft Re-excavation of existing tank with Recharge Shaft

3. TEHATTA I BLOCK

1.0 Salient Information

Block Name: Tehatta-I

Area (in sq km): **258.30**

District: **Nadia**

State: **West Bengal**

Population (as on 2011): 244322

Table 1.1 - Details of Population

Male	Female	Total
125875	118447	244322

Rainfall: Average annual rainfall (Nadia district) for the period 2012-2016 (in mm): 1214.24

Table 1.2 - Details of Annual Rainfall since last five years (mm)

Block	**District Normal**	**Actual (Annual)**				
		2012	**2013**	**2014**	**2015**	**2016**
Tehatta- I	1444	862.0	1287.8	1096.8	1408.1	1416.5

Agriculture & Irrigation

Total area in ha: 25830

Table 1.3 - -Details of Land use pattern of block

Sl. No	Name of the Block	Geographic Area (ha)	Cultivable Area (ha)	Area under pasture & orchard (ha)	Cultivable Waste Land(ha)	Forest Land (ha)	Home Stead Land (ha)
1.	**Tehatta- I**	**25830**	19750	241	(Negligible)	(Negligible)	5241

Aquifer Wise Ground Water Resource Availability & Extraction:

Table 1.4 - Aquifer wise resource availability and draft (in MCM) in Block

Resource Availability	Aquifer I	Aquifer II	Aquifer III	Extraction (for Aquifer I)
Dynamic Resource	**138.33**	**-**	**-**	**153.06**
Static Resource	**5176.15**	**-**	**-**	**-**

2.0 Disposition of Principal Aquifer System:

In Tehatta- I Block, two aquifer systems exist.

- The average depth range of 1st aquifer is from 9**m to 67m,** but this contains ground water which contains Arsenic.
- The average depth range of 2nd aquifer is from **70m to 177m** which is fresh and Arsenic free.

Table 2.1 - Details of aquifer disposition depth range in the block

Tehatta-I	**1st Aquifer**	**2nd aquifer**	**3rd aquifer**
	9-67 m	**70-177 m**	**-**

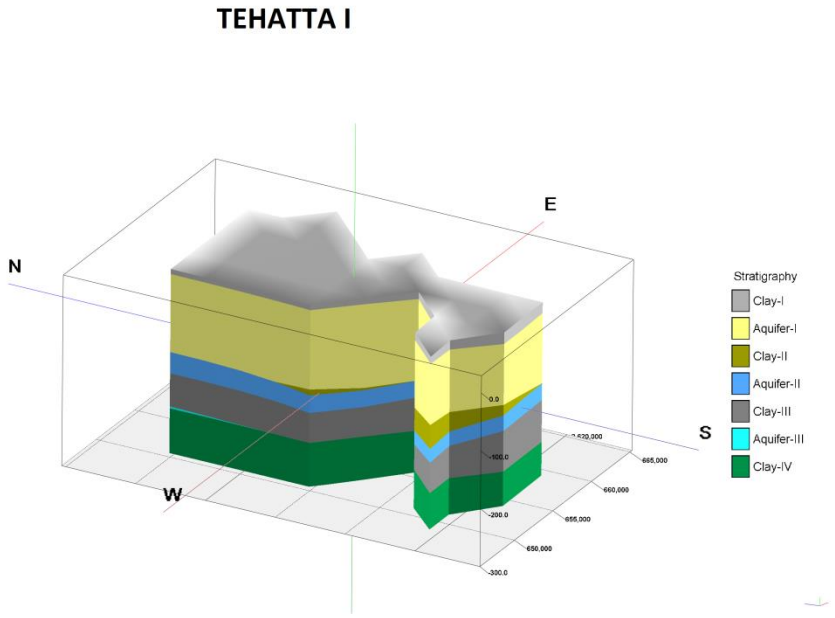


Fig 2.1 - Aquifer disposition in Tehatta-I Block

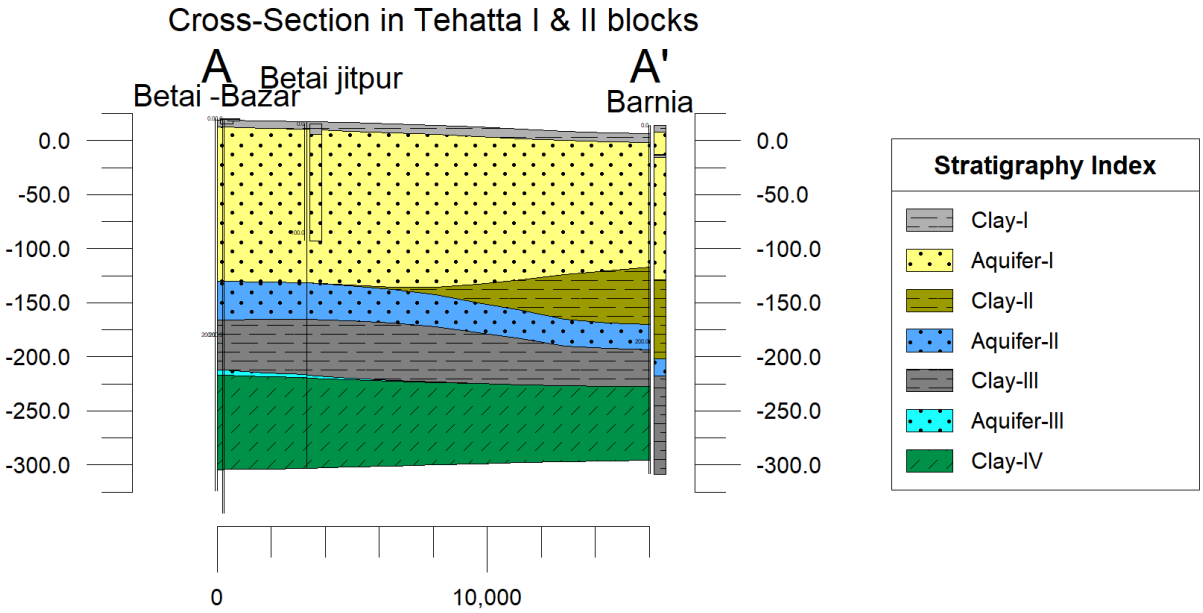


Fig- 2.2 - N- S Cross section of Tehatta I & Tehatta II (combined) Blocks

Table 2.2 - Aquifer Wise Water Level Ranges & Seasonal long term water level trends (2006 - 2017)

Sl. No.	Aquifer	Pre-monsoon			Post-monsoon		
		Depth to water level	Trend		Depth to water level	Trend	
			Rise (cm/year)	Fall (cm/year)		Rise (cm/year)	Fall (cm/year)
1.	I	3.30 – 6.37	-	1.67	2.56 – 5.57	-	8.32
2.	II	3.92 – 7.27	-	-	3.11 – 6.23	-	-

Table 2.3 - Aquifer wise (Maximum) thickness

Block	Area (sq km)	Thickness of the Granular Zone in 1st aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)
Tehatta-I	258.30	58	107

Table 2.4 - Aquifer-wise depth range and parameters

Name of Block	1st Aquifer				2nd Aquifer			
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	S
Tehatta-I	9 – 67; 2 - 186	-	-	-	70 - 177	-	-	-

3.0 Ground Water Resource, Extraction, Contamination & Other Issues:

Resource Availability & Extraction: Dynamic ground water resources as on 31st March 2013

Table 3.1 - Availability of Ground Water resource in Block

Block	Net ground Water availability (MCM)	Gross ground Water draft (MCM)	Stage of Development (%)	Category	Provision for domestic and industrial requirement supply up to 2035 years(MCM)
Tehatta-I	138.34	153.06	110.64	Semi-critical	5.01

Chemical Quality of Ground Water & Contamination:

Average data of chemical parameters in the block based on the analysis from 8 to 10 monitoring wells are given below. For Arsenic data, 3 to 4 monitoring wells are considered

Table 3.2 - -Range of chemical parameter in the block

Block	Aquifer Type	As (mg/l)	pH	EC (µs/Cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Total Hardness as $CaCO_3$(mg/l)
Tehatta I	**I**	**0.0001-0.044**	**8.45-8.49**	**382.2-1032.0**	**10.9-90.4**	**12.5-47.5**	**BDL-0.42**	**BDL- 1.7**	**115- 180**

Table 3.3 - Arsenic concentration (based on PHED hand pump data)

Name of arsenic affected block	No. of Tube well analysed	Arsenic Concentration (in mg/l)						
		<& =0.01		>0.01 &<=0.05		>0.05		Max. concentration
		%	No.	%	No.	%	No.	
Tehatta I	1368	69.23	947	20.10	275	10.67	146	0.54

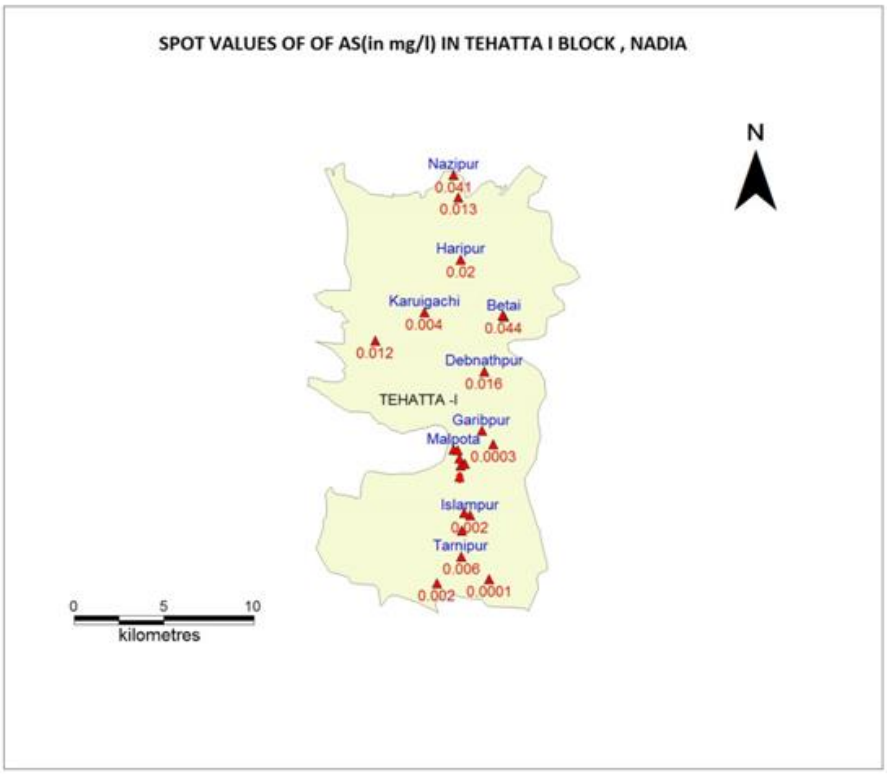


Fig. 3.1 – Spot values of Arsenic (mg/l) in block

4.0 Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for Drinking purposes-

- As per the ground water policy, first priority of water is for drinking purpose.
- The Block is declared by the State Arsenic Task Force, as Arsenic affected.
- As per the Status of Rural Water Supply Schemes published by WBPHED a population of 95511 in 23 villages is under risk zone where no water supply scheme exists.
- On the basis of data available, 24 tube wells are required for catering twenty-three uncovered villages. Details of calculation are given below.
- The arsenic free aquifers in the depth span of 70m to 177m (comparatively less potential) may be exploited for the purpose.
- Arsenic free aquifer should be tapped with proper cement sealing. Arsenic removal plant may be installed before supply.
- Regular Field monitoring is necessary for Arsenic concentration in tube wells.

Table 4.1 – Nos. & cost of Tube wells in the uncovered (projected) population of Human and Cattle

Block	Projected population upto 2021 (considering growth 21.09% per decade as per Census 2011	Water required for drinking & domestic purposes @ 70 lpcd (in lpd)	Cattle Population (Considering 0.19 per capita human population) as on 2011	Cattle Population (Considering 0.36 annual growth rate) as on 2021	Water required for drinking & domestic purposes @ 20 lpcd (in lpd)	Total Water Required (in lpd)	Number of T. Ws	Cost of the tube well of 300 m depth (approx) & 10"x6" dia @ Rs. 25 lakhs (In lakh) as per EFC
Tehatta I	**115664**	**8096480**	**19583**	**20300**	**406001**	**8502481**	**24**	**600**

Management Plan for Irrigation:

- On the basis of the Ground Water Resource Assessment, the block is under Semi-critical condition and the Stage of Ground Water Development (SOD) is 110.64 %. Hence, irrigation by exploiting the unconfined aquifer is not advisable.
- As indicated in the above mentioned Table, ground water is not available for future irrigation in this block. Surface water bodies like streams, canals, ponds may be used for irrigation purposes for the available land.
- Irrigation by modern techniques like Sprinkler, Drip irrigation may be utilised. Crops consuming low amount of water should be cultivated.
- Conjunctive use of ground water and surface water may be applied for irrigation
- Artificial recharge is advisable in Arsenic affected zone for dilution of Arsenic concentration in unconfined aquifer for irrigation purpose also, so that there is no Arsenic contamination in food chain system.
- Regular monitoring of Arsenic concentration in crop is also necessary.
- R & D study is necessary in arsenic affected area so we can get new solutions in future.

Table 4.2 - Availability of Land for Future Irrigation

Sr. No.	District	Block	Geographical area in ha	Cultivable area in ha	Net irrigated Command area (GW) in ha	Net irrigated Command area (SW) in ha	Net irrigated Command area (GW +SW) in ha	Net area available for Irrigation in ha	Demand i.e. Water required for Irrigation in ham	GW available for future Irrigation in ham	Remarks
3.	Nadia	Tehatta I	25830	19750	12236.54	949.29	13185.83	6564.17	-	-	-

Table 4.3 - Ground Water Management Plan for Irrigation in consultation with experts of Bidhan Chandra Krishi Vidyalaya (BCKV)

Block	Ground water availability(Ham,)	Quality	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Tehatta-I	-	As	wheat, rice, mustard, cabbage, cauliflower, brinjal, okra, lentil	Wheat (0.3-0.35), rice (1.2-1.4), Vegetable (0.15-0.2), pulse (0.1-0.12)	wheat, mustard, lentil, flowers, vegetables	Wheat (0.2-0.25), mustard (0.2), pulse (0.08-0.12), flowers (0.12-0.16)	Conjunctive use of fresh and contaminated water: 1:1 ratio/drip for vegetables, flowers

Table 4.4 – Important points for Future Irrigation

Name of Block	Geographical area in ha	Cultivable area in ha	Net irrigated area in ha	Area to be irrigated in ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in mbgl	Remarks for GW Management Plan
Tehatta-I	25830	19750	13185.83	6564.17	110.64	1.67	8.32	5.94	5.00	Block is under semi critical condition so Regular Monitoring of GW Regime should be made from time to time, Boro cultivation should be restricted

Management Plan for Industrial Purpose:

The block is under Semi-critical condition and is mainly agriculture based rural area. There is a less chance for growing up of small scale industries. However, in near future, if any industry is coming up, the following steps should be considered.

- All industries proposing to draw ground water through energized means, need to obtain NOC for ground water withdrawal from the State Ground Water Authority (SGWA)
- All industries abstracting ground water > 500 m^3/day in the semi-critical assessment unit, have to implement mandatorily, artificial recharge measures, as per the norms.
- All the industries need to recharge 90 % of the quantum of ground water withdrawal.

- The Authority is to issue NOC for various uses and monitor its compliance. The NOC should be vested with the District Magistrate/ Deputy Commissioner/ State Ground Water Authority/ State Nodal Agency/ Central Ground Water Authority, as per details given in the guidelines of CGWA.

Special interventions for monitoring of Ground water situations in Semi-Critical Block

As per the GEC Norms for Semi-critical block, the following precautions should be taken before GW extraction.

- It is necessary to increase the density of observation wells in that unit for regular water level monitoring and thereby-
- The rainfall recharge during monsoon season by the water table fluctuation method can be estimated with greater accuracy.
- The trend of water table during pre- monsoon and post-monsoon intervals can be evaluated with greater accuracy.
- The trend of water table during pre- monsoon and post- monsoon intervals consequent to further groundwater development can be more effectively monitored.

Artificial Recharge

Table 4.5 - Area suitable for recharge in the study area:

District	Block Name	**Block Area (in ha)**	**Area suitable for recharge(Considering area having DTW more than 3m in post-monsoon and showing 20 cm/y falling trend)(in ha)**
Nadia	Tehatta I	**25830**	**15830 (considering the average criteria)**

Table 4.6 – Estimation of Surface runoff by Dhruvanarayana method, 1993 (Based on land slope, type of land and soil)

Block	Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed)= Vnc Ham	60% of Vnc(considering e-flow)= Vf Ham
Tehatta- I	1.053	25830	27198.99	0.42	25 % Deep, poorly drained loamy soil, 25 % imperfectly drained fine & 50% moderately drained sandy soil	11423.5758	8567.6819	4283.8409	2570.304555

Table 4.7 - Possible Recharge & conservation structures using harvested run off in block based on soil characteristic, Slope, Rain fall data and Long term trend & cost estimate

Block (1)	Amount of water for artificial recharge and / or conservation (Ham) (2)	Source water allocation for Irrigation Cum Recharge Tank and REET with Recharge Shaft in Ham (3)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 3 (4)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 3 (5)	Source water allocation for Injection Well (6)	Source water allocation for Farm Pond in Ham (7)	Nos. of Farm Pond @ 10 Ham per unit (8)	Cost of Farm pond @ Rs 8 lakh per unit (9)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (10)	Cost of Irrigation Cum Recharge Tank @ Rs 8 lakh per unit (11)	Nos. of REET with recharge shaft @ 10 Ham per unit (12)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (13)	Nos. of injection Well @ 30 Ham per unit (14)	Cost of injection Well @ Rs 25 lakh (15)	Total Cost (16) (in Lakh)
Tehatta - i	2570.3046	70 % of Col. 2 i.e. 1799.21 Ham	899.61	899.61	20 % of Col. 2 i.e. 514.06 Ham	10 % of Col. 2 i.e. 257.04 Ham	26	208	18	144	90	270	17	425	1047

REET with Recharge Shaft Re-excavation of existing tank with Recharge Shaft

4. TEHATTA II BLOCK

1.0 Salient Information

Block Name: Tehatta- II

Area (in sq km): **174.44**

District: **Nadia**

State: **West Bengal**

Population (as on 2011): 151231

Table 1.1 - Details of Population

Male	Female	Total
77299	73932	151231

Rainfall: Average annual rainfall (Nadia district) for the period 2012-2016 (in mm): 1214.24

Table 1.2 - Details of Annual Rainfall since last five years (mm)

Block	**District Normal**	**Actual (Annual)**				
		2012	**2013**	**2014**	**2015**	**2016**
Tehatta-II	1444	862.0	1287.8	1096.8	1408.1	1416.5

Agriculture & Irrigation

Total area in ha: 17444

Table 1.3 - Details of Land use pattern of block

Sl. No	Name of the Block	Geographic Area (ha)	Cultivable Area (ha)	Area under pasture & orchard (ha)	Cultivable Waste Land(ha)	Forest Land (ha)	Home Stead Land (ha)
1.	**Tehatta-II**	**17444**	15250	167	(Negligible)	(Negligible)	3622

Aquifer Wise Ground Water Resource Availability & Extraction:

Table 1.4 - Details of aquifer wise resource availability and draft (in MCM) in Block

Resource Availability	Aquifer I	Aquifer II	Aquifer III	Extraction (for Aquifer I)
Dynamic Resource	**98.68**	**-**	**-**	**109.76**
Static Resource	**2383.99**	**-**	**-**	**-**

2.0 Disposition of Principal Aquifer System:

In Tehatta-II Block, three aquifer systems exist.

- The average depth range of 1st aquifer is from 6m to 70m but ground water in it is Arsenic bearing.
- The average depth range of 2nd aquifer is from 62m to 143m which is fresh and Arsenic free.
- The average depth range of 3rd aquifer is from 216m to 232 m, which is also fresh and Arsenic free.

Table 2.1 - Details of aquifer disposition depth range in the block

Tehatta-II	**1st Aquifer**	**2nd aquifer**	**3rd aquifer**
	6-70 m	**62-143 m**	**216-232 m**

TEHATTA II

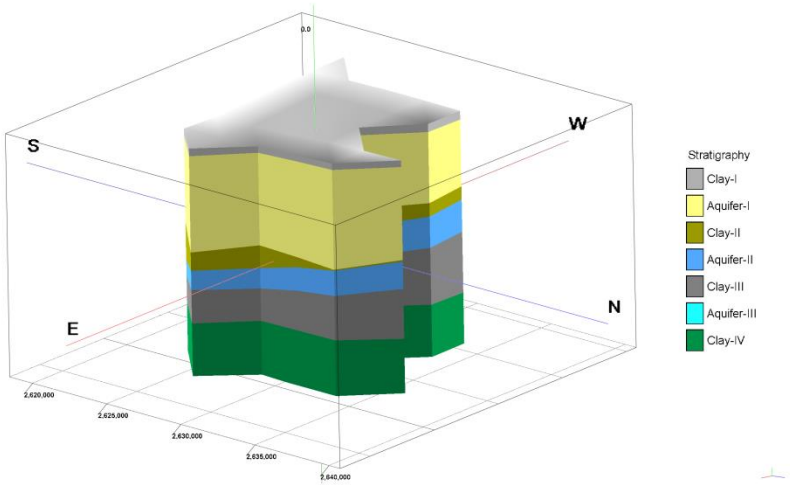


Fig 2.1 - Aquifer disposition in Tehatta II Block

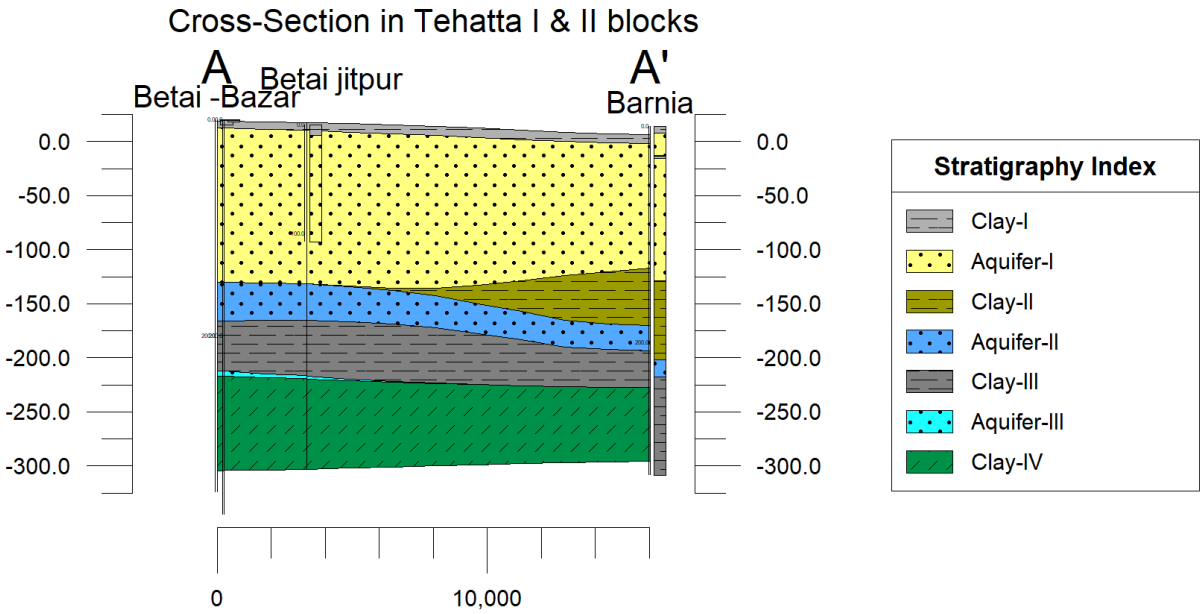


Fig 2.2 - N- S Cross section of Tehatta-I & II (combined) Blocks

Table 2.3 - Aquifer Wise Water Level Ranges & Seasonal long term water level trends (2006 to 2017)

Sl. No.	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		Depth to water level	Rise (cm/year)	Fall (cm/year)	Depth to water level	Rise (cm/year)	Fall (cm/year)
1.	I	4.03 – 4.55	- 2.35		3.21 – 3.75	-3.06	
2.	II	4.11 – 6.52	-	-	3.84 – 5.69	-	-

Table 2.4 - Aquifer wise (Maximum) thickness

Block	Area (sq km)	Thickness of the Granular Zone in 1st aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)	Thickness of the Granular Zone in 3rd aquifer (m)
Tehatta-II	174.44	64	81	16

Table 2.5 - Aquifer-wise depth range and parameters

Name of Block	1st Aquifer				2nd Aquifer				3rd Aquifer		
	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)
Tehatta-II	6 - 70	36	-	-	62 - 143	43	3000	-	216 - 232	-	-

3.0 Ground Water Resource, Extraction, Contamination & Other Issues:

Resource Availability & Extraction: Dynamic ground water resources as on 31st March 2013

Table 3.1 - Availability of Ground Water resource in Block

Block	Net ground Water availability (MCM)	Gross ground Water draft (MCM)	Stage of Development (%)	Category	Provision for domestic and industrial requirement supply up to 2035 years(MCM)
Tehatta-II	98.68	109.76	111.22	Semi-critical	3.09

Chemical Quality of Ground Water & Contamination:

Average data of chemical parameters in the block based on the analysis from 8 to 10 monitoring wells are given below. For Arsenic data, 3 to 4 monitoring wells are considered.

Table 3.2 - Range of chemical parameter in the block

Block	Aquifer Type	As (mg/l)	pH	EC (µs/Cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Total Hardness as $CaCO_3$(mg/l)
Tehatta-II	**I**	**0.0002-0.076**	**8.37-8.46**	**328.6-701.4**	**15.9-48.1**	**12.5-25.0**	**BDL-0.39**	**BDL-0.7**	**130- 160**

Table 3.3 - Arsenic Concentration (mg/l) in ground water

Name of arsenic affected block	No. of Tube well analysed	Arsenic Concentration (in mg/l)						
		<& =0.01		>0.01 &<=0.05		>0.05		Max. concentration
		%	No.	%	No.	%	No.	
Tehatta-II	755	60.53	457	33.11	250	6.36	48	0.34

(Source – PHED, Govt. of West Bengal)

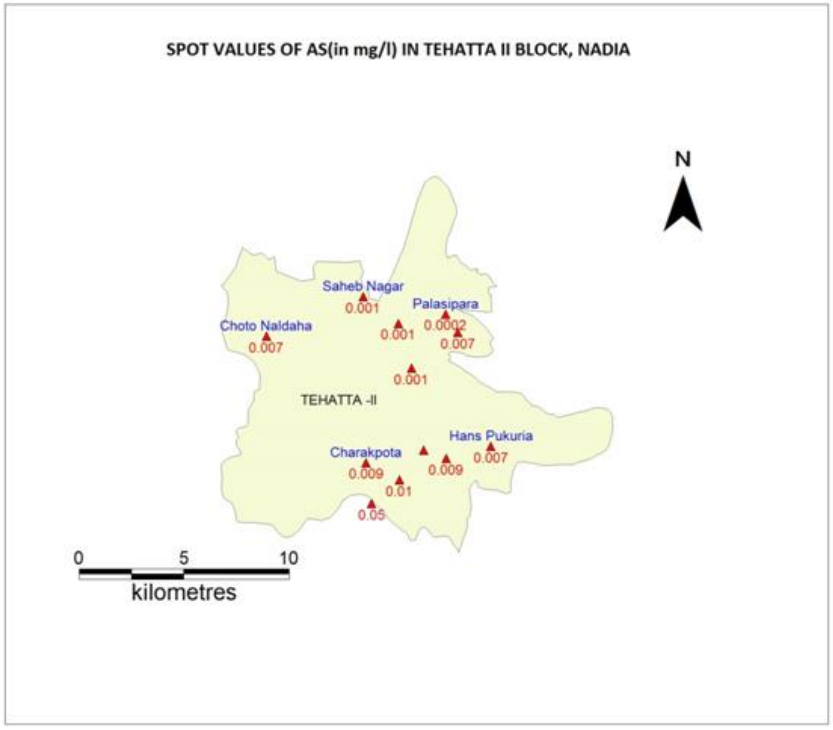


Fig. 3.1 – Spot values in ground water of shallow aquifer

4. Ground Water Resource Enhancement & Management Plan:

Ground Water Management Plan for Drinking purposes-

- As per the ground water policy, first priority of water is for drinking purposes.
- The Block is declared by the State Arsenic Task Force, as Arsenic affected.
- As per the Status of Rural Water Supply Schemes published by WBPHED a population of 25415 in 9 villages is under risk zone where no water supply scheme exists.
- On the basis of data available, 7 tube wells are required for catering nine uncovered villages. Details of calculation are given below.
- The arsenic free aquifers in the depth span of 62m to 143m (at places) & 216m to 232m (comparatively less potential) may be exploited for the purpose.
- Arsenic free aquifer should be tapped with proper cement sealing. Arsenic removal plant may be installed before supply.
- Regular Field monitoring is necessary for Arsenic concentration in tube wells.

Management Plan for Irrigation:

- On the basis of the Ground Water Resource Assessment, the block is under Semi-critical condition and the Stage of Ground Water Development (SOD) is 111.22 %. Hence, irrigation by exploiting the unconfined aquifer is not advisable.
- As indicated in the above mentioned Table, ground water is not available for future irrigation in this block. Surface water bodies like streams, canals, ponds may be used for irrigation purposes for the available land.
- Irrigation by modern techniques like Sprinkler, Drip irrigation may be utilised. Crops consuming low amount of water should be cultivated.
- Conjunctive use of ground water and surface water may be applied for irrigation
- Artificial recharge is advisable in Arsenic affected zone for dilution of Arsenic concentration in unconfined aquifer for irrigation purpose also, so that there is no Arsenic contamination in food chain system.
- .Regular monitoring of Arsenic concentration in crop is also necessary.
- R & D study is necessary in arsenic affected area so we can get new solutions in future.

Table 4.1 – Nos. & cost of Tube wells in uncovered (projected population) of Human and Cattle

Block	Projected population upto 2021 (considering growth 21.09% per decade as per Census 2011	Water required for drinking & domestic purposes @ 70 lpcd (in lpd)	Cattle Population (Considering 0.19 per capita human population) as on 2011	Cattle Population (Considering 0.36 annual growth rate) as on 2021	Water required for drinking & domestic purposes @ 20 lpcd (in lpd)	Total Water Required (in lpd)	Number of T. Ws	Cost of the tube well of 300 m depth (approx) & 10"x6" dia @ Rs. 25 lakhs (In lakh) as per EFC
Tehatta II	30778	2154460	5848	7953	159060	2313520	**7**	**175**

Table 4.2 - Availability of Land for Future Irrigation

Sr. No.	District	Block	Geographical area in ha	Cultivable area in ha	Net irrigated Command area (GW) in ha	Net irrigated Command area (SW) in ha	Net irrigated Command area (GW +SW) in ha	Net area available for Irrigation in ha	Demand i.e. Water required for Irrigation in ham	GW available for future Irrigation in ham	Remarks
1	Nadia	Tehatta II	17444	15250	9955.83	1042.6	10998.43	4251.57	-	-	-

Table 4.3 - Ground Water Management Plan for Irrigation in consultation with experts of Bidhan Chandra Krishi Vidyalaya (BCKV)

Block	**Ground water availability(Ham,)**	**Quality**	**Major crops/vegetables/ fruits/flowers currently in practice**	**Water column depth(m)**	**Crops suggested for better management(considering ground water quality & quantity)**	**Water column depth(m) recommended**	**Remarks e.g. Irrigation techniques etc**
Tehatta-II	**-**	**As**	**wheat, rice, mustard, cabbage, cauliflower, brinjal, okra, lentil**	**Wheat (0.3-0.35), rice (1.2-1.4), Vegetable (0.15-0.2), pulse (0.1-0.12)**	**wheat, mustard, lentil, flowers, vegetables**	**Wheat (0.2-0.25), mustard (0.2), pulse (0.08-0.12), flowers (0.12-0.16)**	**Conjunctive use of fresh and contaminated water: 1:1 ratio/drip for vegetables, flowers**

Table 4.4 – Important points for future irrigation

Name of Block	Geographical area in ha	Cultivable area in ha	Net irrigated area in ha	Area to be irrigated in ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in mbgl	Average Post monsoon WL in mbgl	Remarks for GW Management Plan
Tehatta-II	17444	15250	10998.43	4251.57	111.22	-2.35	-3.06	5.29	4.72	Block is under semi critical condition so Regular Monitoring of GW Regime should be made from time to time, Boro cultivation should be restricted

Management Plan for Industrial Purpose:

The block is under Semi-critical condition and is mainly agriculture based rural area. There is a less chance for growing up of small scale industries. However, in near future, if any industry is coming up, the following steps should be considered.

- All industries proposing to draw ground water through energized means, need to obtain NOC for ground water withdrawal from the State Ground Water Authority (SGWA)
- All industries abstracting ground water > 500 m^3/day in the semi-critical assessment unit, have to implement mandatorily, artificial recharge measures, as per the norms.
- All the industries need to recharge 90 % of the quantum of ground water withdrawal.
- The Authority is to issue NOC for various uses and monitor its compliance. The NOC should be vested with the District Magistrate/ Deputy Commissioner/ State Ground Water Authority/ State Nodal Agency/ Central Ground Water Authority, as per details given in the guidelines of CGWA.

Special interventions for monitoring of Ground water situations in Semi-Critical Block

As per the GEC Norms for Semi-critical block, the following precautions should be taken before GW extraction.

- It is necessary to increase the density of observation wells in that unit for regular water level monitoring and thereby-
- The rainfall recharge during monsoon season by the water table fluctuation method can be estimated with greater accuracy.
- The trend of water table during pre- monsoon and post-monsoon intervals can be evaluated with greater accuracy.

- The trend of water table during pre- monsoon and post- monsoon intervals consequent to further groundwater development can be more effectively monitored.

Artificial Recharge:

Table 4.5 - Area suitable for recharge in the study area:

District	Block Name	**Block Area (in ha)**	**Area suitable for recharge(Considering area having DTW more than 3m in post-monsoon and showing 2cm/y falling trend)(in ha)**
Nadia	Tehatta-II	**17444**	**Part (site specific) (considering the average criteria- as Rising WL Trend)**

Table 4.6 – Estimation of Surface runoff by Dhruvanarayana, 1993 method (Based on land slope, type of land and soil)

Block	Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed)= Vnc Ham	60% of Vnc(considering e-flow)= Vf Ham
Tehatta -ii	1.053	17444	18368.532	0.45	50 % imperfectly drained fine & 50% moderately drained sandy soil	8265.8394	6199.3796	3099.6898	1859.813865

Table 4.7 – Possible Recharge & conservation structures using harvested run off in block based on soil characteristic, Slope, Rain fall data and Long term trend & cost estimate

Block (1)	Amount of water for artificial recharge and / or conservation (Ham) (2)	Source water allocation for Irrigation Cum Recharge Tank and REET with Recharge Shaft in Ham (3)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 3 (4)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 3 (5)	Source water allocation for Injection Well (6)	Source water allocation for Farm Pond in Ham (7)	Nos. of Farm Pond @ 10 Ham per unit (8)	Cost of Farm pond @ Rs 8 lakh per unit (9)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (10)	Cost of Irrigation Cum Recharge Tank @ Rs 8 lakh per unit (11)	Nos. of REET with recharge shaft @ 10 Ham per unit (12)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (13)	Nos. of injection Well @ 30 Ham per unit (14)	Cost of injection Well @ Rs 25 lakh (15)	Total Cost (16) (in Lakh)
Tehatta - ii	1859.8139	70 % of Col. 2 i.e. 1301.87 Ham	650.94	650.94	20 % of Col. 2 i.e. 371.96 Ham	10 % of Col. 2 i.e. 185.98 Ham	19	152	13	104	65	520	12	300	1076

REET with Recharge Shaft Re-excavation of existing tank with Recharge Shaft

5. KALIGANJ BLOCK

1.0 Salient Information

Block Name: Kaliganj

Area (in sq km): **319.75**

District: **Nadia**

State: **West Bengal**

Population (as on 2011): 306197

Table 1.1 - Details of Population

Male	Female	Total
157234	148963	306197

Rainfall: Average annual rainfall (Nadia district) for the period 2012-2016 (in mm): 1214.24

Table 1.2 - Details of Annual Rainfall since last five years (mm)

Block	**District Normal**	**Actual (Annual)**				
		2012	**2013**	**2014**	**2015**	**2016**
Kaliganj	1444	862.0	1287.8	1096.8	1408.1	1416.5

Agriculture & Irrigation

Total area in ha: 31975

Table 1.3 - Details of Land use pattern of block

Sl. No	Name of the Block	Geographic Area (ha)	Cultivable Area (ha)	Area under pasture & orchard (ha)	Cultivable Waste Land(ha)	Forest Land (ha)	Home Stead Land (ha)
1.	**Kaliganj**	**31975**	19169	357	(Negligible)	(Negligible)	6720

Aquifer Wise Ground Water Resource Availability & Extraction:

Table 1.4 - Aquifer wise resource availability and draft (in MCM) in Block

Resource Availability	Aquifer I	Aquifer II	Aquifer III	Extraction (for Aquifer I)
Dynamic Resource	**157.11**	**-**	**-**	**145.74**
Static Resource	**4687.53**	**-**	**-**	**-**

2.0 Disposition of Principal Aquifer System:

In Kaliganj Block, three aquifer systems exist.

- The average depth range of 1st aquifer is from 19m to 50m, but sporadic occurrence of arsenic has been encountered in ground water of this aquifer.
- The average depth range of 2nd aquifer is from 56m to 110m which is fresh and Arsenic free (at places).
- The average depth range of 3rd aquifer is 254 m to 270 m, which is also fresh and Arsenic free.

Table 2.1 - Details of aquifer disposition depth range in the block

Kaliganj	**1st Aquifer**	**2nd aquifer**	**3rd aquifer**
	19-50 m	**56-110 m**	**254-270 m**

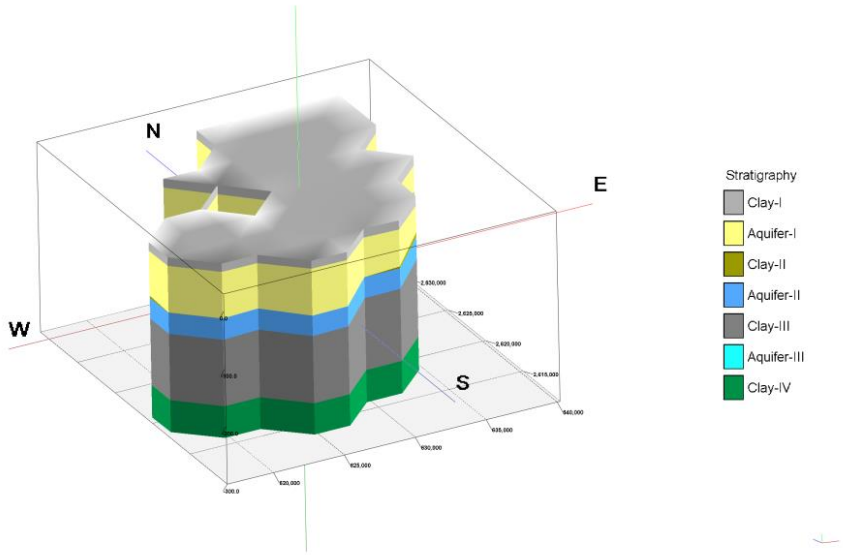


Fig 2.1 - Aquifer disposition in Kaliganj Block

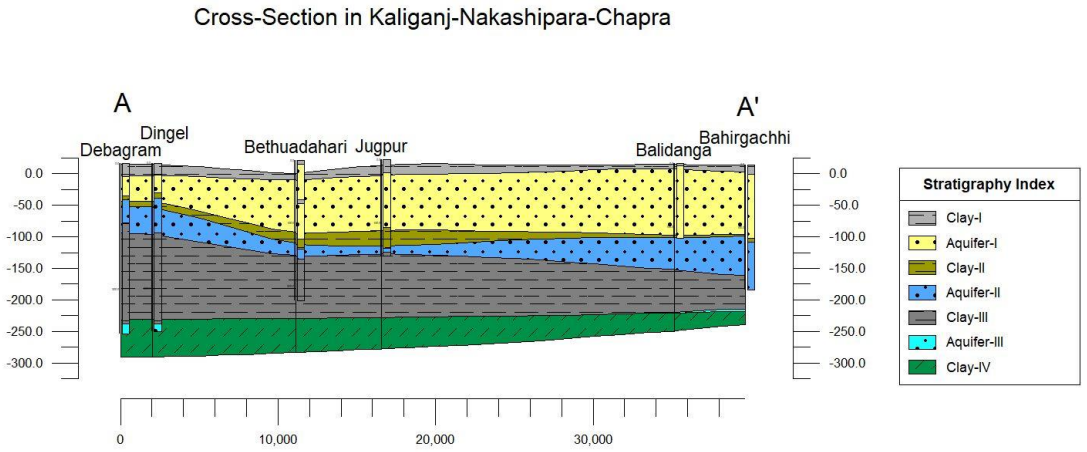


Fig 2.1 - N- S Cross section of Kaliganj, Nakashipara & Chapra (combined) Blocks

Table 2.2 - Aquifer Wise Water Level Ranges & Seasonal long term water level trends (2006 to 2017)

Sl. No.	Block	Aquifer	Pre-monsoon			Post-monsoon		
			Depth to water level	Trend		Depth to water level	Trend	
				Rise (cm/year)	Fall (cm/year)		Rise (cm/year)	Fall (cm/year)
1.	Kaliganj	I	3.76 – 6.76	-	3.64	3.62 – 6.28	-	10.39
2.	Kaliganj	II	4.79 – 9.10	-	-	4.14 – 8.21	-	-

Table 2.3 - Aquifer wise (Maximum) thickness

Block	Area (sq km)	Thickness of the Granular Zone in 1st aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)	Thickness of the Granular Zone in 3rd aquifer (m)
Kaliganj	319.75	31	54	16

Table 2.4 - Aquifer-wise depth range and parameters

Name of Block	1st Aquifer				2nd Aquifer				3rd Aquifer		
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)
Kaliganj	19 - 50	11	-	-	56 - 110	11 - 36	-	-	254 - 270	36	-

3. Ground Water Resource, Extraction, Contamination & Other Issues:

Resource Availability & Extraction: Dynamic ground water resources as on 31st March'13

Table 3.1 - Availability of Ground Water resource in Block

Block	Net ground Water availability (MCM)	Gross ground Water draft (MCM)	Stage of Development (%)	Category	Provision for domestic and industrial requirement supply up to 2035 years(MCM)
Kaliganj	157.11	145.74	92.76	Semi-critical	6.70

Chemical Quality of Ground Water & Contamination:

Average data of chemical parameters in the block based on the analysis from 8 to 10 monitoring wells are given below. For Arsenic data, 3 to 4 monitoring wells are considered.

Table 3.2 - Range of chemical parameter in the block (based on CGWB Monitoring Wells data)

Block	Aquifer Type	As (mg/l)	pH	EC (µs/Cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Total Hardness as $CaCO_3$(mg/l)
Kaliganj	**I**	**0.002-0.082**	**8.35-8.46**	**347.2-550.4**	**17.0-89.0**	**20.0-37.5**	**0.04-0.70**	**BDL-0.9**	**125- 195**

Table 3.3 - Arsenic Concentration in ground water of Tube wells

Name of arsenic affected block	No. of Tube well analysed	Arsenic Concentration (in mg/l)						
		<& =0.01		>0.01 &<=0.05		>0.05		Max. concentration
		%	No.	%	No.	%	No.	
Kaliganj	2111	27.00	570	38.09	804	34.86	736	1.00

(Source – PHED, Govt. of India)

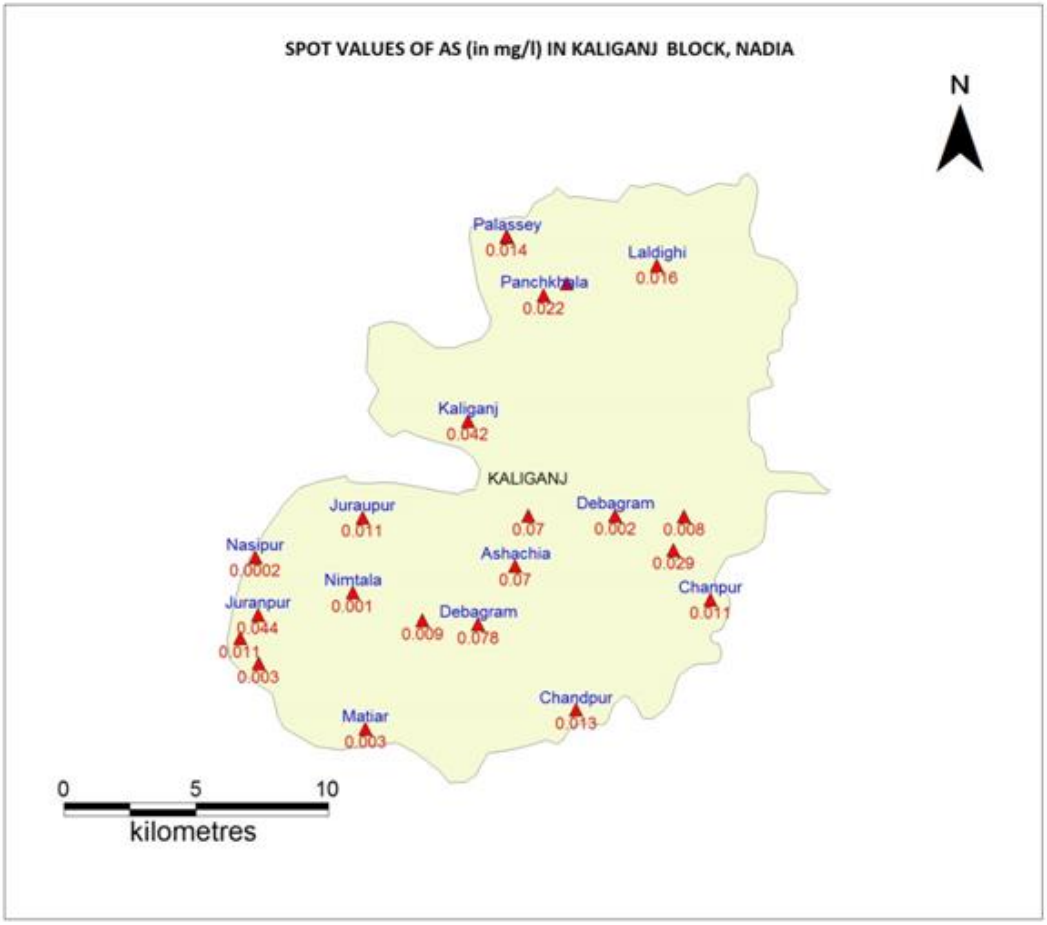


Fig. 3.1 – Spot values of arsenic (mg/l) in ground water

4.0 Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for Drinking purposes-

- As per the ground water policy, first priority of water is for drinking purpose.
- The Block is declared by the State Arsenic Task Force, as Arsenic affected.
- As per the Status of Rural Water Supply Schemes published by WBPHED, no population is remaining under Arsenic risk zone, as the area is fully covered by the State Water Supply System.
- It is suggested, regular field monitoring is necessary for Arsenic concentration in tube wells.

Management Plan for Irrigation:

Table 4.1 - Availability of Land for Future Irrigation

Sr. No.	District	Block	Geographical area in ha	Cultivable area in ha	Net irrigated Command area (GW) in ha	Net irrigated Command area (SW) in ha	Net irrigated Command area (GW +SW) in ha	Net area available for Irrigation in ha	Demand i.e. Water required for Irrigation in ham	GW available for future Irrigation in ham	Remarks
5.	Nadia	Kaliganj	31975	19169	12373.95	921.08	13295.03	5873.97		979.91	

- On the basis of the Ground Water Resource Assessment, the block is under Semi-critical condition and the Stage of Ground Water Development (SOD) is 92.76 %. Hence, irrigation by exploiting the unconfined aquifer is not advisable.
- As indicated in the above mentioned Table, about 980 ham of ground water is available for future irrigation for about 5874 ha of land available in this block. The available ground water may be used proportionately for Rabi and Boro paddy and other crops.
- Irrigation by modern techniques like Sprinkler, Drip irrigation may be utilised. Crops consuming low amount of water should be cultivated.
- Conjunctive use of ground water and surface water may be applied for irrigation
- Artificial recharge is advisable in Arsenic affected zone for dilution of Arsenic concentration in unconfined aquifer for irrigation purpose also, so that there is no Arsenic contamination in food chain system.
- Regular monitoring of Arsenic concentration in crop is also necessary.
- R & D study is necessary in arsenic affected area so we can get new solutions in future.

Table 4.2 - Ground Water Management Plan for Irrigation in consultation with experts of Bidhan Chandra Krishi Vidyalaya (BCKV)

Block	Ground water availability(Ham,)	Quality	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Kaliganj	979.91	As	wheat, rice, mustard, cabbage, cauliflower, brinjal, okra, lentil	Wheat (0.3-0.35), rice (1.2-1.4), Vegetable (0.15-0.2), pulse (0.1-0.12)	wheat, mustard, lentil, flowers, vegetables	Wheat 0.2-0.25), mustard (0.2), pulse (0.08-0.12), flowers (0.12-0.16)	Conjunctive use of fresh and contaminated water: 1:1 ratio/drip for vegetables, flowers

Table 4.3 - Availability of Land for Future Irrigation

Name of Block	Geographical area in ha	Cultivable area in ha	Net irrigated area in ha	Area to be irrigated in ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl	Remarks for GW Management Plan
Kaliganj	31975	19169	13295.03	5873.97	92.76	3.64	10.39	6.70	6.12	Block is under semi critical condition so Regular Monitoring of GW Regime should be made from time to time, Boro cultivation should be restricted

<u>Management Plan for Industrial Purpose</u>:

The block is under Semi-critical condition and is mainly agriculture based rural area. There is a less chance for growing up of small scale industries. However, in near future, if any industry is coming up, the following steps should be considered.

- All industries proposing to draw ground water through energized means, need to obtain NOC for ground water withdrawal from the State Ground Water Authority (SGWA)
- All industries abstracting ground water > 500 m^3/day in the semi-critical assessment unit, have to implement mandatorily, the artificial recharge measures, as per the norms.
- All the industries need to recharge 90 % of the quantum of ground water withdrawal.

- The Authority is to issue NOC for various uses and monitor its compliance. The NOC should be vested with the District Magistrate/ Deputy Commissioner/ State Ground Water Authority/ State Nodal Agency/ Central Ground Water Authority, as per details given in the guidelines of CGWA.

Special interventions for monitoring of Ground water situations in Semi-Critical Block

As per the GEC Norms for Semi-critical block, the following precautions should be taken before GW extraction.

- It is necessary to increase the density of observation wells in that unit for regular water level monitoring and thereby-
- The rainfall recharge during monsoon season by the water table fluctuation method can be estimated with greater accuracy.
- The trend of water table during pre- monsoon and post-monsoon intervals can be evaluated with greater accuracy.
- The trend of water table during pre- monsoon and post- monsoon intervals consequent to further groundwater development can be more effectively monitored.

Artificial Recharge :

Table 4.4 - Area suitable for recharge in the study area:

District	Block Name	**Block Area (in ha)**	**Area suitable for recharge(Considering area having DTW more than 3m in post-monsoon and showing 20 cm/y falling trend) (in ha)**
Nadia	Kaliganj	**31975**	**31975 (considering the average criteria)**

Table 4.5 – Estimation of Surface runoff by Dhruvanarayana, 1993 method (Based on land slope, type of land and soil)

Block	Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed) = Vnc Ham	60% of Vnc(considering e-flow)= Vf Ham
Kaliganj	1.053	31975	33669.675	0.35	20 %Deep, poorly & imperfectly drained loamy soil, 80% moderately drained sandy soil	11784.38625	8838.2897	4419.1448	2651.486906

Table 4.6 – Possible Recharge & conservation structures using harvested run off in block based on soil characteristic, Slope, Rain fall data and Long term trend & cost estimate

Block (1)	Amount of water for artificial recharge and / or conservation (Ham) (2)	Source water allocation for Irrigation Cum Recharge Tank and REET with Recharge Shaft in Ham (3)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 3 (4)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 3 (5)	Source water allocation for Injection Well (6)	Source water allocation for Farm Pond in Ham (7)	Nos. of Farm Pond @ 10 Ham per unit (8)	Cost of Farm pond @ Rs 8 lakh per unit (9)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (10)	Cost of Irrigation Cum Recharge Tank @ Rs 8 lakh per unit (11)	Nos. of REET with recharge shaft @ 10 Ham per unit (12)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (13)	Nos. of injection Well @ 30 Ham per unit (14)	Cost of injection Well @ Rs 25 lakh (15)	Total Cost (16) (in Lakh)
Kaliganj	2651.4869	70 % of Col. 2 i.e. 1856.04 Ham	928.02	928.02	20 % of Col. 2 i.e. 530.30 Ham	10 % of Col.2 i.e. 265.15 Ham	27	216	19	152	93	474	18	450	1292

REET with Recharge Shaft Re-excavation of existing tank with Recharge Shaft

6. NAKASHIPARA BLOCK

1.0 Salient Information

Block Name: Nakashipara

Area (in sq km): **354.24**

District: **Nadia**

State: **West Bengal**

Population (as on 2011): 352191

Table 1.1 - Details of Population

Male	Female	Total
180990	171201	352191

Rainfall: Average annual rainfall (Nadia district) for the period 2012-2016 (in mm): 1214.24

Table 1.2 - Details of Annual Rainfall since last five years (mm)

Block	**District Normal**	**Actual (Annual)**				
		2012	**2013**	**2014**	**2015**	**2016**
Nakashipara	1444	862.0	1287.8	1096.8	1408.1	1416.5

Agriculture & Irrigation

Total area in ha: 35424

Table 1.3 - Land use pattern of block

Sl. No	Name of the Block	Geographic Area (ha)	Cultivable Area (ha)	Area under pasture & orchard (ha)	Cultivable Waste Land(ha)	Forest Land (ha)	Home Stead Land (ha)
1.	**Nakashipara**	**35424**	23082	312	Nil	309	7525

Aquifer Wise Ground Water Resource Availability & Extraction:

Table 1.4 - Aquifer wise resource availability and draft (in MCM) in Block

Resource Availability	Aquifer I	Aquifer II	Aquifer III	Extraction (for Aquifer I)
Dynamic Resource	185.57	-	-	157.20
Static Resource	2245.39	-	-	-

2.0 Disposition of Principal Aquifer System:

In Nakashipara Block, two aquifer systems exist.

- The range of 1st aquifer is on an average from 6m to 62m but this is containing Arsenic.
- The range of 2nd aquifer is on an average from 69m to 156m which is fresh and Arsenic free (at places).

Table 2.1 - Aquifer disposition depth range in the block

Nakashipara	1st Aquifer	2nd aquifer	3rd aquifer
	6-62 m	69-156 m	-

NAKASHIPARA

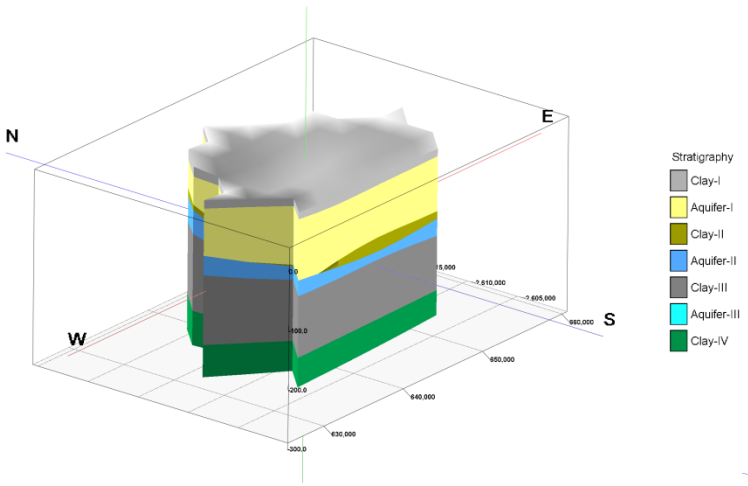


Fig 2.1 - Aquifer disposition in Nakashipara block

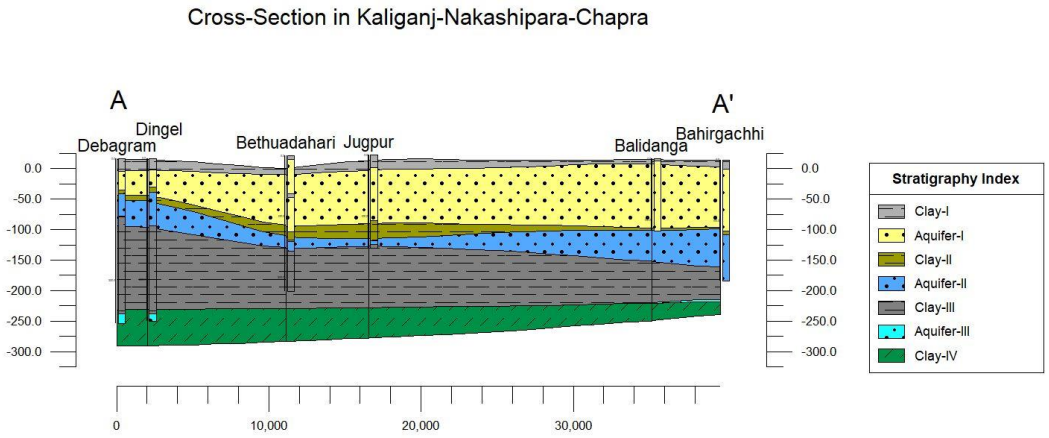


Fig 2.2 - N- S Cross section of Kaliganj, Nakashipara & Chapra (combined) Blocks

Table 2.2 - Aquifer Wise Water Level Ranges & Seasonal long term water level trends (2006 to 2017)

Sl. No.	Block	Aquifer	Pre-monsoon			Post-monsoon		
			Depth to water level	Trend		Depth to water level	Trend	
				Rise (cm/year)	Fall (cm/year)		Rise (cm/year)	Fall (cm/year)
1.	Nakashipara	I	4.41 – 5.61	-	1.07	2.04 – 4.26	-	8.81
2.	Nakashipara	II	4.15 – 6.41	-	-	3.22 – 5.11	-	-

Table 2.3 - Aquifer wise (Maximum) thickness

Block	Area (sq km)	Thickness of the Granular Zone in 1st aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)
Nakashipara	354.24	56	87

Table 2.4 - Aquifer-wise depth range and parameters

Name of Block	1st Aquifer				2nd Aquifer			
	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S
Nakashipara	6 - 62	173	350	-	69 - 156	191	1400	-

3.0 Ground Water Resource, Extraction, Contamination & Other Issues:

Resource Availability & Extraction: Dynamic ground water resources as on 31st March'13

Table 3.1 - Ground Water resource in Block

Block	Net ground Water availability (MCM)	Gross ground Water draft (MCM)	Stage of Development (%)	Category	Provision for domestic and industrial requirement supply up to 2035 years(MCM)
Nakashipara	185.57	157.20	84.71	Safe	7.71

Chemical Quality of Ground Water & Contamination:

Average data of chemical parameters in the block based on the analysis from 8 to 10 monitoring wells are given below. For Arsenic data, 3 to 4 monitoring wells are considered

Table 3.2 - Range of chemical parameter in the block

Block	Aquifer Type	As (mg/l)	pH	EC (µs/Cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Total Hardness as $CaCO_3$(mg/l)
Nakashipara	**I**	**0.0001-0.119**	**8.31-8.49**	**312.0-437.7**	**14.7-41.2**	**7.5-15.0**	**0.28-1.11**	**BDL-5.4**	**120- 155**

Table 3.3 - Arsenic Concentration in ground water of Tube wells

Name of arsenic affected block	No. of Tube well analysed	Arsenic Concentration (in mg/l)						
		<& =0.01		>0.01 &<=0.05		>0.05		Max. concentration
		%	No.	%	No.	%	No.	
Nakashipara	2459	45.51	1119	40.42	994	14.07	346	0.56

(Source – PHED, Govt. of West Bengal)

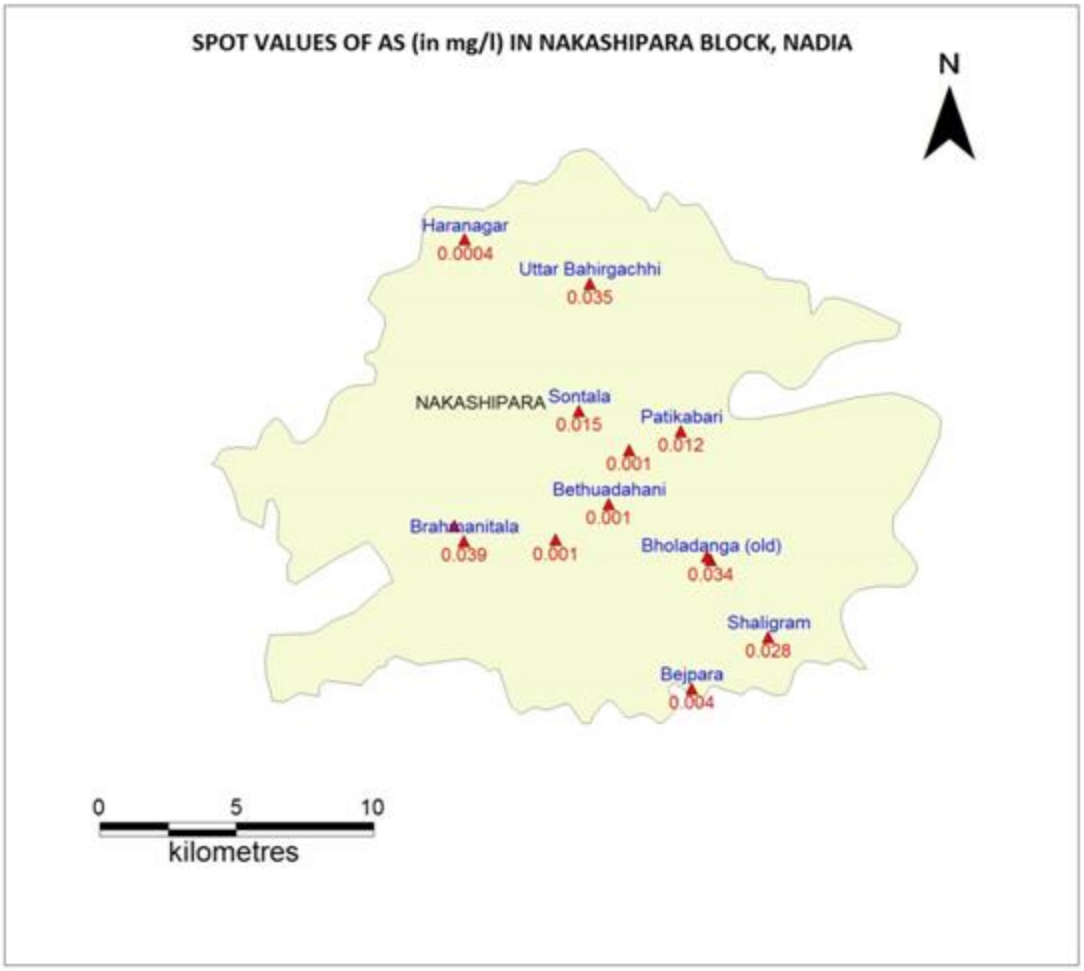


Fig. 3.1 – Spot values in ground water

4.0 Ground Water Resource Enhancement & Management Plan:

Ground Water Management Plan for Drinking purposes-

- As per the ground water policy, first priority of water is for drinking purpose.
- The Block is declared by the State Arsenic Task Force, as Arsenic affected.
- As per the Status of Rural Water Supply Schemes published by WBPHED, no population is remaining under Arsenic risk zone, as the area is fully covered by the State Water Supply System.
- It is suggested, regular field monitoring is necessary for Arsenic concentration in tube wells.

Management Plan for Irrigation:

Table 4.1 - Availability of Land for Future Irrigation

Sr. No.	District	Block	Geographical area in ha	Cultivable area in ha	Net irrigated Command area (GW) in ha	Net irrigated Command area (SW) in ha	Net irrigated Command area (GW +SW) in ha	Net area available for Irrigation in ha	Demand i.e. Water required for Irrigation in ham	GW available for future Irrigation in ham	Remarks
6.	Nadia	Nakashipara	35424	23082	15441.4	731.53	16172.93	6909.07	-	2655.93	-

- On the basis of the Ground Water Resource Assessment, the block is under Safe category and the Stage of Ground Water Development (SOD) is 84.71 %.
- As indicated in the above mentioned Table, about 2656 ham of ground water is available for future irrigation for about 6910 ha of land available in this block. The available ground water may be used proportionately for Rabi and Boro paddy and other crops
- Irrigation by modern techniques like Sprinkler, Drip irrigation may be utilised. Crops consuming low amount of water should be cultivated.
- Conjunctive use of ground water and surface water may be applied for irrigation
- Artificial recharge is advisable in Arsenic affected zone for dilution of Arsenic concentration in unconfined aquifer for irrigation purpose also, so that there is no Arsenic contamination in food chain system.
- .Regular monitoring of Arsenic concentration in crop is also necessary.
- R & D study is necessary in arsenic affected area so we can get new solutions in future.

Table 4.2 -Ground Water Management Plan for Irrigation in consultation with experts of Bidhan Chandra Krishi Vidyalaya (BCKV)

Block	Ground water availability(Ham,)	Quality	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Nakashipara	2655.93	As	wheat, rice, mustard, cabbage, cauliflower, brinjal, okra, lentil	Wheat (0.3-0.35), rice (1.2-1.4), Vegetable (0.15-0.2), pulse(0.1-0.12)	wheat, mustard, lentil, flowers, vegetables	Wheat (0.2-0.25), mustard (0.2), pulse (0.08-0.12), flowers(0.12-0.16)	Conjunctive use of fresh and contaminated water: 1:1 ratio/drip for vegetables, flowers

Table 4.3 – Important points for Future Irrigation

Name of Block	Geographical area in ha	Cultivable area in ha	Net irrigated area in ha	Area to be irrigated in ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl	Remarks for GW Management Plan
Nakasshipara	**35424**	23082	**16172.93**	**6909.07**	**84.71**	**1.07**	**8.81**	**5.64**	**4.47**	**Block is under Safe category, so regular monitoring of GW regime may be made from time to time. Boro cultivation may be encouraged to some extent.**

Management Plan for Industrial Purpose:

The block is under Safe category and is mainly agriculture based rural area. There is a less chance for growing up of small scale industries. However, in near future, if any industry is coming up, the following steps should be considered.

- All industries proposing to draw ground water through energized means, need to obtain NOC for ground water withdrawal from the State Ground Water Authority (SGWA)
- All industries abstracting ground water > 500 m^3/day in the semi-critical assessment unit, have to implement mandatorily, the artificial recharge measures, as per the norms.
- All the industries need to recharge 90 % of the quantum of ground water withdrawal.
- The Authority is to issue NOC for various uses and monitor its compliance. The NOC should be vested with the District Magistrate/ Deputy Commissioner/ State Ground Water Authority/ State Nodal Agency/ Central Ground Water Authority, as per details given in the guidelines of CGWA.

Artificial Recharge:

Table- Space Available For Recharge and Proposed Intervention

Table 4.4 - Area suitable for recharge in the study area:

District	Block Name	**Block Area (in ha)**	**Area suitable for recharge(Considering area having DTW more than 3m in post-monsoon and showing 20 cm/yr falling trend) (in ha)**
Nadia	Nakashipara	**35424**	**35424 (considering the average criteria)**

Table 4.5 – Estimation of Surface runoff by Dhruvanarayana, 1993 method (Based on land slope, type of land and soil)

Block	Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993 (Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed)= Vnc Ham	60% of Vnc(considering e-flow)= Vf Ham
Nakashipara	1.053	35424	37301.472	0.35	20 % Deep, poorly drained loamy soil, 80% moderately drained sandy soil	13055.5152	9791.6364	4895.8182	2937.49092

Table 4.6 – Possible Recharge & conservation structures using harvested run off in block based on soil characteristic, Slope, Rain fall data and Long term trend & cost estimate

Block (1)	Amount of water for artificial recharge and / or conservation (Ham) (2)	Source water allocation for Irrigation Cum Recharge Tank and REET with Recharge Shaft in Ham (3)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 3 (4)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 3 (5)	Source water allocation for Injection Well (6)	Source water allocation for Farm Pond in Ham (7)	Nos. of Farm Pond @ 10 Ham per unit (8)	Cost of Farm pond @ Rs 8 lakh per unit (9)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (10)	Cost of Irrigation Cum Recharge Tank @ Rs 8 lakh per unit (11)	Nos. of REET with recharge shaft @ 10 Ham per unit (12)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (13)	Nos. of injection Well @ 30 Ham per unit (14)	Cost of injection Well @ Rs 25 lakh (15)	Total Cost (16) (in Lakh)
Nakashipara	2937.4909	70 % of Col. 2 i.e. 2056.24 Ham	1028.12	1028.12	20 % of Col. 2 i.e. 588.48 Ham	10 % of Col.2 i.e. 293.75 Ham	29	232	21	168	103	824	20	500	1724

REET with Recharge Shaft Re-excavation of existing tank with Recharge Shaft

7. CHAPRA BLOCK

1.0 Salient Information

Block Name: Chapra

Area (in sq km): **310.48**

District: **Nadia**

State: **West Bengal**

Population (as on 2011): 296529

Table 1.1 - Details of Population

Male	Female	Total
152575	143954	296529

Rainfall: Average annual rainfall (Nadia district) for the period 2012-2016 (in mm): 1214.24

Table 1.2 - Annual Rainfall since last five years (mm)

Block	District Normal	Actual (Annual)				
		2012	**2013**	**2014**	**2015**	**2016**
Chapra	1444	862.0	1287.8	1096.8	1408.1	1416.5

Agriculture & Irrigation

Total area in ha: 31048

Table 1.3 - Details of Land use pattern of block

Sl. No	Name of the Block	Geographic Area (ha)	Cultivable Area (ha)	Area under pasture & orchard (ha)	Cultivable Waste Land(ha)	Forest Land (ha)	Home Stead Land (ha)
1.	**Chapra**	**31048**	21372	287	(Negligible)	(Negligible)	6426

Aquifer Wise Ground Water Resource Availability & Extraction:

Table 1.4 - Aquifer wise resource availability and draft (in MCM) in Block

Resource Availability	Aquifer I	Aquifer II	Aquifer III	Extraction (for Aquifer I)
Dynamic Resource	**182.30**	**-**	**-**	**199.07**
Static Resource	**5256.42**	**-**	**-**	**-**

2.0 Disposition of Principal Aquifer System:

In Chapra Block, two aquifer systems exist.

- The average depth range of 1st aquifer is from 3m to 119m but this contains Arsenic contaminated ground water.
- The average depth range of 2nd aquifer is on an average from 121m to 195m, which is fresh and Arsenic free.

Table 2.1 - Aquifer disposition depth range in the block

Chapra	**1st Aquifer**	**2nd aquifer**	**3rd aquifer**
	3-119 m	**121-195 m**	**-**

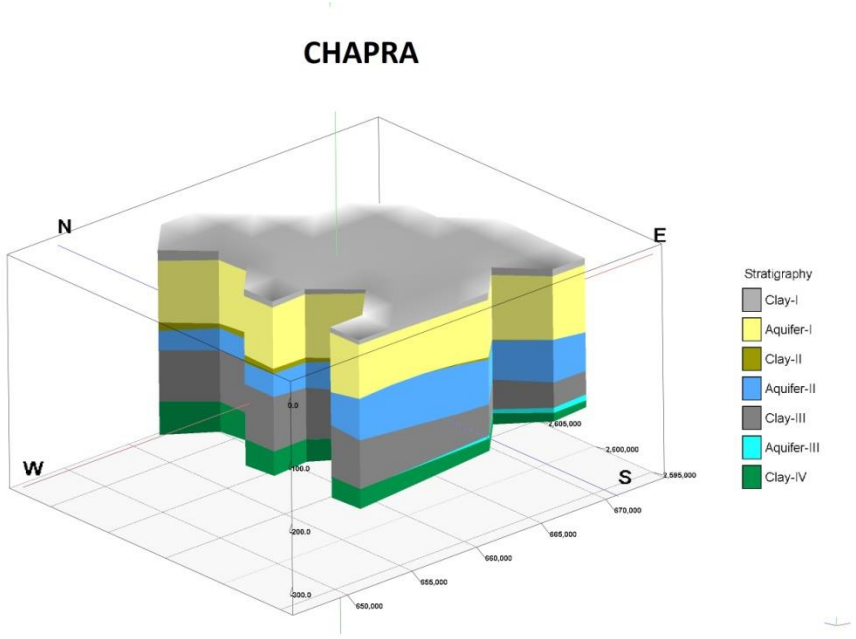


Fig 2.1 - Aquifer disposition in Chapra Block

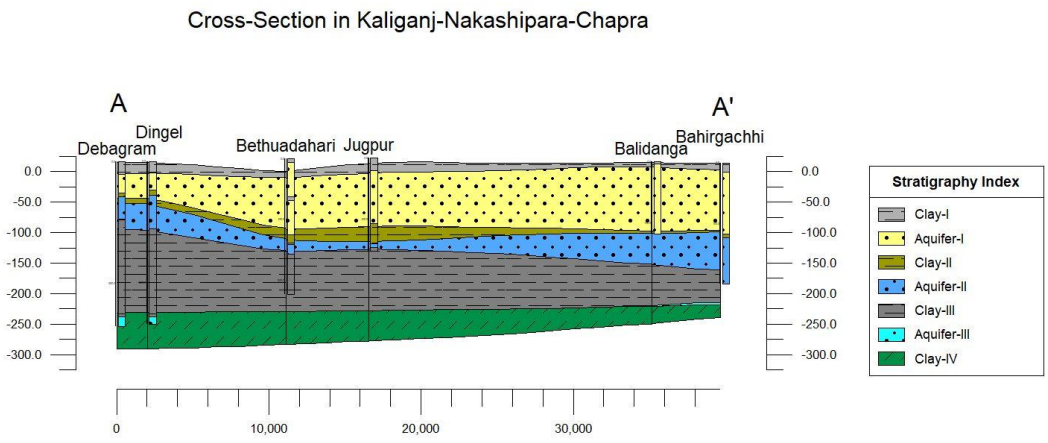


Fig 2.2 - N- S Cross section of Kaliganj, Nakashipara & Chapra Blocks (combined)

Table 2.2 - Aquifer Wise Water Level Ranges & Seasonal long term water level trends (2006 to 2017)

Sl. No.	Aquifer	Pre-monsoon			Post-monsoon		
		Depth to water level	Trend		Depth to water level	Trend	
			Rise (cm/year)	Fall (cm/year)		Rise (cm/year)	Fall (cm/year)
1.	I	5.02 – 5.78	-	4.56	3.11 – 3.63	-	11.47
2.	II	3.92 – 6.32	-	-	3.05 – 6.53	-	-

Table 2.3 - Aquifer wise (Maximum) thickness

Block	Area (sq km)	Thickness of the Granular Zone in 1st aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)
Chapra	310.48	116	74

Table 2.4 - Aquifer-wise depth range and parameters

Name of Block	1st Aquifer				2nd Aquifer			
	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S
Chapra	3 - 119	-	-	-	121 - 195	54	3017	6.23 x10^{-4}

3. Ground Water Resource, Extraction, Contamination & Other Issues:

Resource Availability & Extraction: Dynamic ground water resources as on 31st March'13

Table 3.1 - Availability of Ground Water resource in Block

Block	Net ground Water availability (MCM)	Gross ground Water draft (MCM)	Stage of Development (%)	Category	Provision for domestic and industrial requirement supply up to 2035 years (MCM)
Chapra	182.30	199.07	109.20	Semi-critical	6.27

Chemical Quality of Ground Water & Contamination:

Average data of chemical parameters in the block based on the analysis from 8 to 10 monitoring wells are given below. For Arsenic data, 3 to 4 monitoring wells are considered.

Table 3.2 - Range of chemical parameter in the block

Block	Aquifer Type	As (mg/l)	pH	EC (µs/Cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Total Hardness as $CaCO_3$(mg/l)
Chapra	I	0.0002-0.034	8.32-8.50	292.8-507.6	17.7-37.4	10.0-50.0	BDL-1.08	BDL-2.8	130- 180

Table 3.3 - Arsenic Concentration in ground water

Name of arsenic affected block	No. of Tube well analysed	Arsenic Concentration (in mg/l)						
		<& =0.01		>0.01 &<=0.05		>0.05		Max. concentration
		%	No.	%	No.	%	No.	
Chapra	2230	34.80	776	52.83	1178	12.38	276	0.51

(Source – PHED, Govt. of West Bengal)

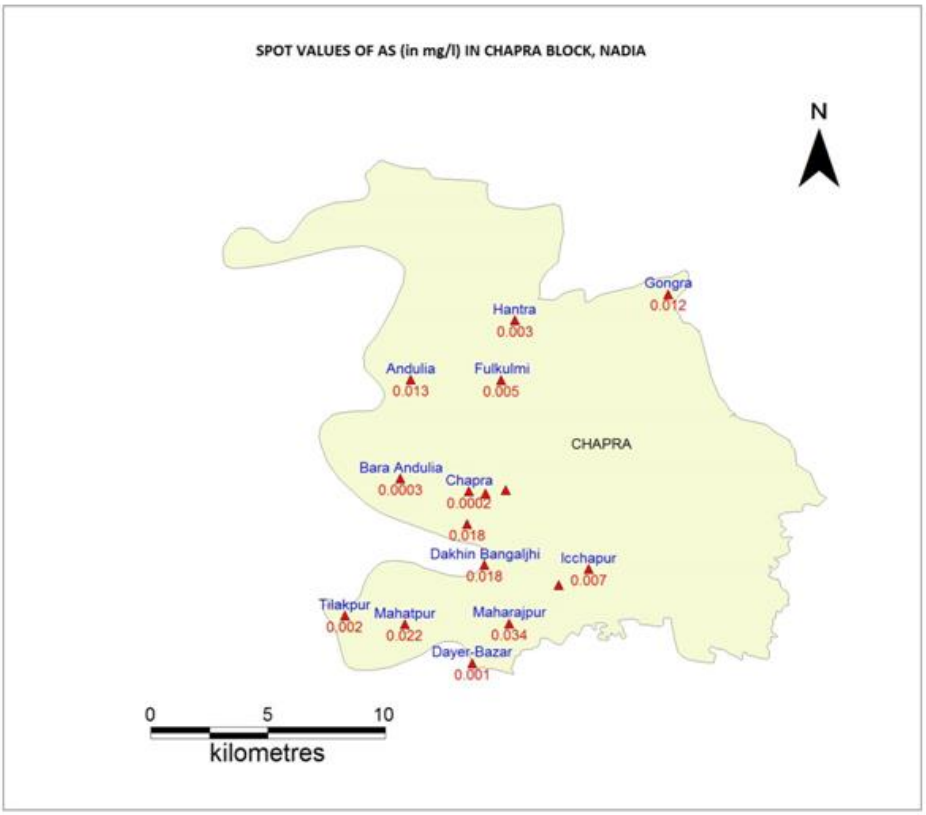


Fig. 3.1 – Spot values of As (mg/l) in ground water

4. Ground Water Resource Enhancement & Management Plan:

Ground Water Management Plan for Drinking purposes-

- As per the ground water policy, first priority of water is for drinking purpose.
- The Block is declared by the State Arsenic Task Force, as Arsenic affected.
- As per the Status of Rural Water Supply Schemes published by WBPHED a population of 44153 in 6 villages is under risk zone where no water supply scheme exists.
- On the basis of data available, 14 tube wells are required for catering six uncovered villages. Details of calculation are given below.
- The arsenic free aquifers in the depth span of 121m to 195m (comparatively less potential) may be exploited for the purpose.
- Arsenic free aquifer should be tapped with proper cement sealing. Arsenic removal plant may be installed before supply.
- Regular Field monitoring is necessary for Arsenic concentration in tube wells.

Table 4.1 – Nos. & cost of Tube wells in uncovered (projected population) of Human and Cattle

Block	Projected population upto 2021 (considering growth 21.09% per decade as per Census 2011	Water required for drinking & domestic purposes @ 70 lpcd (in lpd)	Cattle Population (Considering 0.19 per capita human population) as on 2011	Cattle Population (Considering 0.36 annual growth rate) as on 2021	Water required for drinking & domestic purposes @ 20 lpcd (in lpd)	Total Water Required (in lpd)	Number of T. Ws	Cost of the tube well of 300 m depth (approx) & 10"x6" dia @ Rs. 25 lakhs (In lakh) as per EFC
Chapra	53469	3742830	52546	71462	1429240	5172070	**14**	**350**

Management Plan for Irrigation:

Table 4.2 - Availability of Land for Future Irrigation

Sr. No.	District	Block	Geographical area in ha	Cultivable area in ha	Net irrigated Command area (GW) in ha	Net irrigated Command area (SW) in ha	Net irrigated Command area (GW +SW) in ha	Net area available for Irrigation in ha	Demand i.e. Water required for Irrigation in ham	GW available for future Irrigation in ham	Remarks
7.	Nadia	Chapra	31048	21372	12149.15	1406.4	13555.55	7816.45	-	-	-

- On the basis of the Ground Water Resource Assessment, the block is under Semi-critical condition and the Stage of Ground Water Development (SOD) is 109.20 %. Hence, irrigation by exploiting the unconfined aquifer is not advisable.
- As indicated in the above mentioned Table, ground water is not available for future irrigation in this block. Surface water bodies like streams, canals, ponds may be used for irrigation purposes for the available land.
- Irrigation by modern techniques like Sprinkler, Drip irrigation may be utilised. Crops consuming low amount of water should be cultivated.
- Conjunctive use of ground water and surface water may be applied for irrigation.
- Artificial recharge is advisable in Arsenic affected zone for dilution of Arsenic

concentration in unconfined aquifer for irrigation purpose also, so that there is no Arsenic contamination in food chain system.

- Regular monitoring of Arsenic concentration in crop is also necessary.
- R & D study is necessary in arsenic affected area so we can get new solutions in future.

Table 4.3 -Ground Water Management Plan for Irrigation in consultation with experts of Bidhan Chandra Krishi Vidyal aya (BCKV)

Block	Ground water availability(Ham,)	Quality	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Chapra	-	As	wheat, rice, mustard, cabbage, cauliflower, brinjal, okra, lentil	Wheat (0.3-0.35), rice (1.2-1.4), Vegetable (0.15-0.2), pulse(0.1-0.12)	wheat, mustard, lentil, flowers, vegetables	Wheat (0.2-0.25), mustard (0.2), pulse (0.08-0.12), flowers (0.12-0.16)	Conjunctive use of fresh and contaminated water: 1:1 ratio/drip for vegetables, flowers

Table 4.4 – Salient points for Future Irrigation

Name of Block	Geographical area in ha	Cultivable area in ha	Net irrigated area in ha	Area to be irrigated in ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl	Remarks for GW Management Plan
Chapra	31048	21372	135555	7816.45	109.20	4.56	11.47	5.35	4.33	Block is under semi critical condition so Regular Monitoring of GW Regime should be made from time to time, Boro cultivation should be restricted

<u>Management Plan for Industrial Purpose</u>:

The block is under Semi-critical condition and is mainly agriculture based rural area. There is a less chance for growing up of small scale industries. However, in near future, if any industry is coming up, the following steps should be considered.

- All industries proposing to draw ground water through energized means, need to obtain NOC for ground water withdrawal from the State Ground Water Authority (SGWA)

- All industries abstracting ground water > 500 m^3/day in the semi-critical assessment unit, have to implement mandatorily, the artificial recharge measures, as per the norms.
- All the industries need to recharge 90 % of the quantum of ground water withdrawal.
- The Authority is to issue NOC for various uses and monitor its compliance. The NOC should be vested with the District Magistrate/ Deputy Commissioner/ State Ground Water Authority/ State Nodal Agency/ Central Ground Water Authority, as per details given in the guidelines of CGWA.

Special interventions for monitoring of Ground water situations in Semi-Critical Block

As per the GEC Norms for Semi-critical block, the following precautions should be taken before GW extraction.

- It is necessary to increase the density of observation wells in that unit for regular water level monitoring and thereby-
- The rainfall recharge during monsoon season by the water table fluctuation method can be estimated with greater accuracy.
- The trend of water table during pre- monsoon and post-monsoon intervals can be evaluated with greater accuracy.
- The trend of water table during pre- monsoon and post- monsoon intervals consequent to further groundwater development can be more effectively monitored.

Artificial Recharge :

Table 4.5 - Area suitable for recharge in the study area:

District	Block Name	**Block Area (in ha)**	**Area suitable for recharge(Considering area having DTW more than 3m in post-monsoon and showing 20 cm/yr falling trend)(in ha)**
Nadia	Chapra	**31048**	**31048 (considering the average criteria)**

Table 4.6 – Estimation of Surface runoff by Dhruvanarayana, 1993 method (Based on land slope, type of land and soil)

Block	Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993 (Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed)= Vnc Ham	60% of Vnc(considering e-flow)= Vf Ham
Chapra	1.053	31048	32693.544	0.4	50 %Deep, poorly & imperfectly drained loamy soil, 50% moderately drained sandy soil	13077.4176	9808.0632	4904.0316	2942.41896

Table 4.7 – Possible Recharge & conservation structures using harvested run off in block based on soil characteristic, Slope, Rain fall data and Long term trend & cost estimate

Block (1)	Amount of water for artificial recharge and / or conservation (Ham) (2)	Source water allocation for Irrigation Cum Recharge Tank and REET with Recharge Shaft in Ham (3)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 3 (4)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 3 (5)	Source water allocation for Injection Well (6)	Source water allocation for Farm Pond in Ham (7)	Nos. of Farm Pond @ 10 Ham per unit (8)	Cost of Farm pond @ Rs 8 lakh per unit (9)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (10)	Cost of Irrigation Cum Recharge Tank @ Rs 8 lakh per unit (11)	Nos. of REET with recharge shaft @ 10 Ham per unit (12)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (13)	Nos. of injection Well @ 30 Ham per unit (14)	Cost of injection Well @ Rs 25 lakh (15)	Total Cost (16) (in Lakh)
Chapra	2942.419	70 % of Col. 2 i.e. 2056.24 Ham	1029.85	1029.85	20 % of Col. 2 i.e. 588.48 Ham	10 % of Col.2 i.e. 294.24 Ham	29	232	21	168	103	824	20	500	1724

REET with Recharge Shaft Re-excavation of existing tank with Recharge Shaft

8. KRISHNAGANJ BLOCK

1.0 Salient Information

Block Name: Krishnaganj

Area (in sq km): **159.55**

District: **Nadia**

State: **West Bengal**

Population (as on 2011): 146705

Table 1.1 - Details of Population

Male	Female	Total
75573	71132	146705

Rainfall: Average annual rainfall (Nadia district) for the period 2012-2016 (in mm): 1214.24

Table 1.2 - Annual Rainfall since last five years (mm)

Block	District Normal	Actual (Annual)				
		2012	**2013**	**2014**	**2015**	**2016**
Krishnaganj	1444	862.0	1287.8	1096.8	1408.1	1416.5

Agriculture & Irrigation

Total area in ha: 15955

Table 1.3 - Land use pattern of block

Sl. No	Name of the Block	Geographic Area (ha)	Cultivable Area (ha)	Area under pasture & orchard (ha)	Cultivable Waste Land(ha)	Forest Land (ha)	Home Stead Land (ha)
1.	**Krishnaganj**	**15955**	9880	146	(Negligible)	215	3183

Aquifer Wise Ground Water Resource Availability & Extraction

Table 1.4 - Aquifer wise resource availability and draft (in MCM) in Block

Resource Availability	Aquifer I	Aquifer II	Aquifer III	Extraction (for Aquifer I)
Dynamic Resource	**79.74**	**-**	**-**	**69.98**
Static Resource	**3806.31**	**-**	**-**	**-**

2.0 Disposition of Principal Aquifer System:

In Krishnaganj Block, three aquifer systems exist.

- The average depth range of 1st & 2nd aquifers together is from 12m to 155m but this is containing Arsenic; in fact the clay separating 1st & 2ndaquifer is thin, as explored by CGWB
- Aquifer I in this block is almost combined one of both 1st & 2nd aquifers in other blocks.
- The average depth range of 3rdaquifer is 213 m to 225 m, which is fresh and Arsenic free.

Table 2.1 - Aquifer disposition depth range in the block

Krishnaganj	**1st & 2nd Aquifer**	**3rd aquifer**
	12-155 m	**213-225 m**

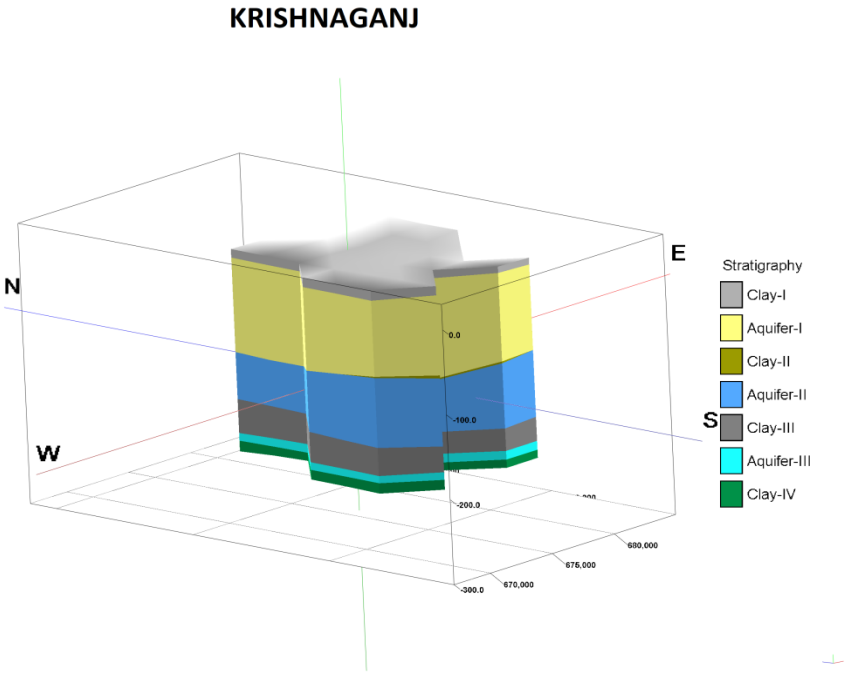


Fig 2.1 - Aquifer disposition in Krishnaganj Block

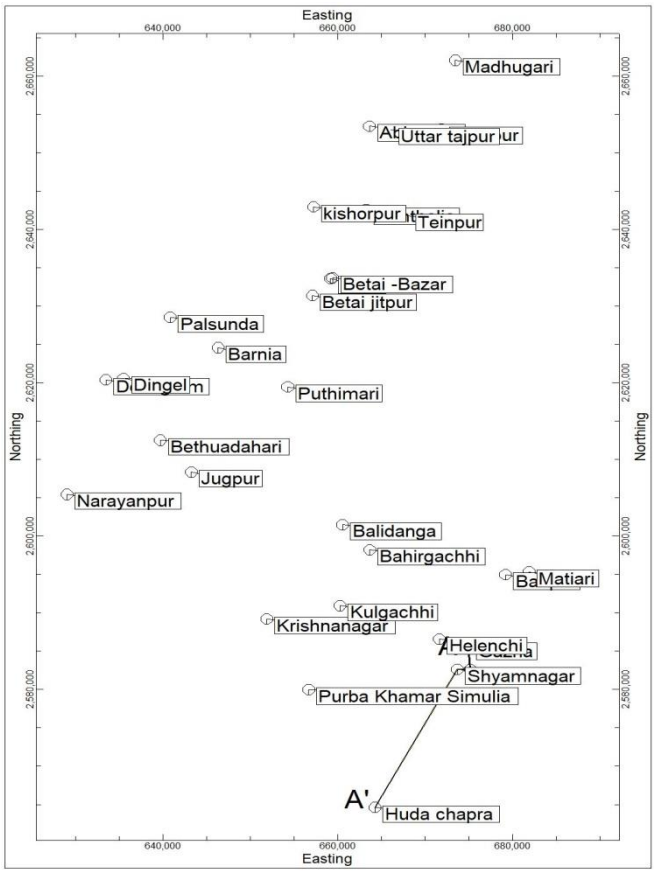


Fig 2.2 – Cross section index line in Krishnaganj Block

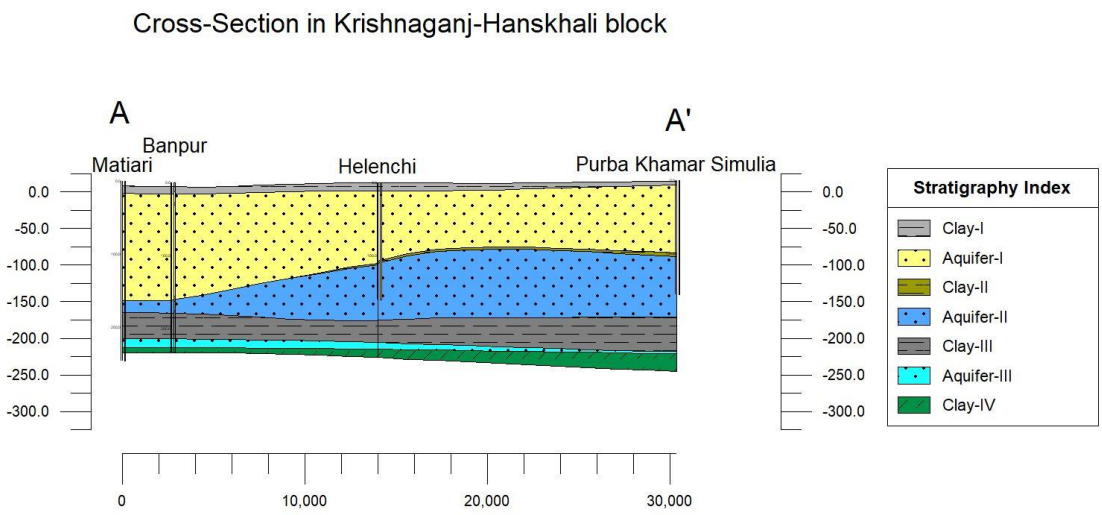


Fig 2.3 - Cross section of Krishnaganj & Hanskhali Blocks (combined)

Table 2. 2 - Aquifer Wise Water Level Ranges & Seasonal long term water level trends (2006 to 2017)

Sl. No.	Block	Aquifer	Pre-monsoon			Post-monsoon		
			Depth to water level (m bgl)	Trend		Depth to water level (m bgl)	Trend	
				Rise (cm/year)	Fall (cm/year)		Rise (cm/year)	Fall (cm/year)
1.	Krishnaganj	I & II	6.55 – 7.12	-	2.92	5.43 – 6.08	-	10.92
2.	Krishnaganj	III	4.83 – 7.84	-	-	4.16 – 7.32	-	-

Table 2.3 - Aquifer wise (Maximum) thickness

Block	Area (sq km)	Thickness of the Granular Zone in 1st & 2nd aquifer (m)	Thickness of the Granular Zone in 3rd aquifer (m)
Krishnaganj	159.55	143	12

Table 2.4 - Aquifer-wise depth range and parameters (On the basis of CGWB exploration data)

Name of Block	1st & 2nd Aquifer				3rd Aquifer			
	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	S
Krishnaganj	12 - 155	72		-	213 - 225	54 - 90	7030	$1.55x10^{-3}$

3.0 Ground Water Resource, Extraction, Contamination & Other Issues:

Resource Availability & Extraction: Dynamic ground water resources as on 31st March'13

Table 3.1 - Availability of Ground Water resource in Block

Block	Net ground Water availability (MCM)	Gross ground Water draft (MCM)	Stage of Development (%)	Category	Provision for domestic and industrial requirement supply up to 2035 years(MCM)
Krishnaganj	79.74	69.98	87.76	Safe	3.07

Chemical Quality of Ground Water & Contamination:

Average data of chemical parameters in the block based on the analysis from 8 to 10 monitoring wells are given below. For Arsenic data, 3 to 4 monitoring wells are considered.

Table 3.2 - Range of chemical parameter in the block

Block	Aquifer Type	As (mg/l)	pH	EC (µs/Cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Total Hardness as $CaCO_3$(mg/l)
Krishnaganj	I	0.0003-0.019	8.32-8.48	295.9-464.5	16.0-49.2	10.0-22.5	BDL-0.82	BDL-0.5	105- 160

Table 3.3 - Arsenic Concentration (mg/l) in ground water

Name of arsenic affected block	No. of Tube well analysed	Arsenic Concentration (in mg/l)						
		<& =0.01		>0.01 &<=0.05		>0.05		Max. concentration
		%	No.	%	No.	%	No.	
Krishnaganj	1737	39.21	681	37.94	659	22.86	397	0.77

(Source – PHED, Govt. of West Bengal)

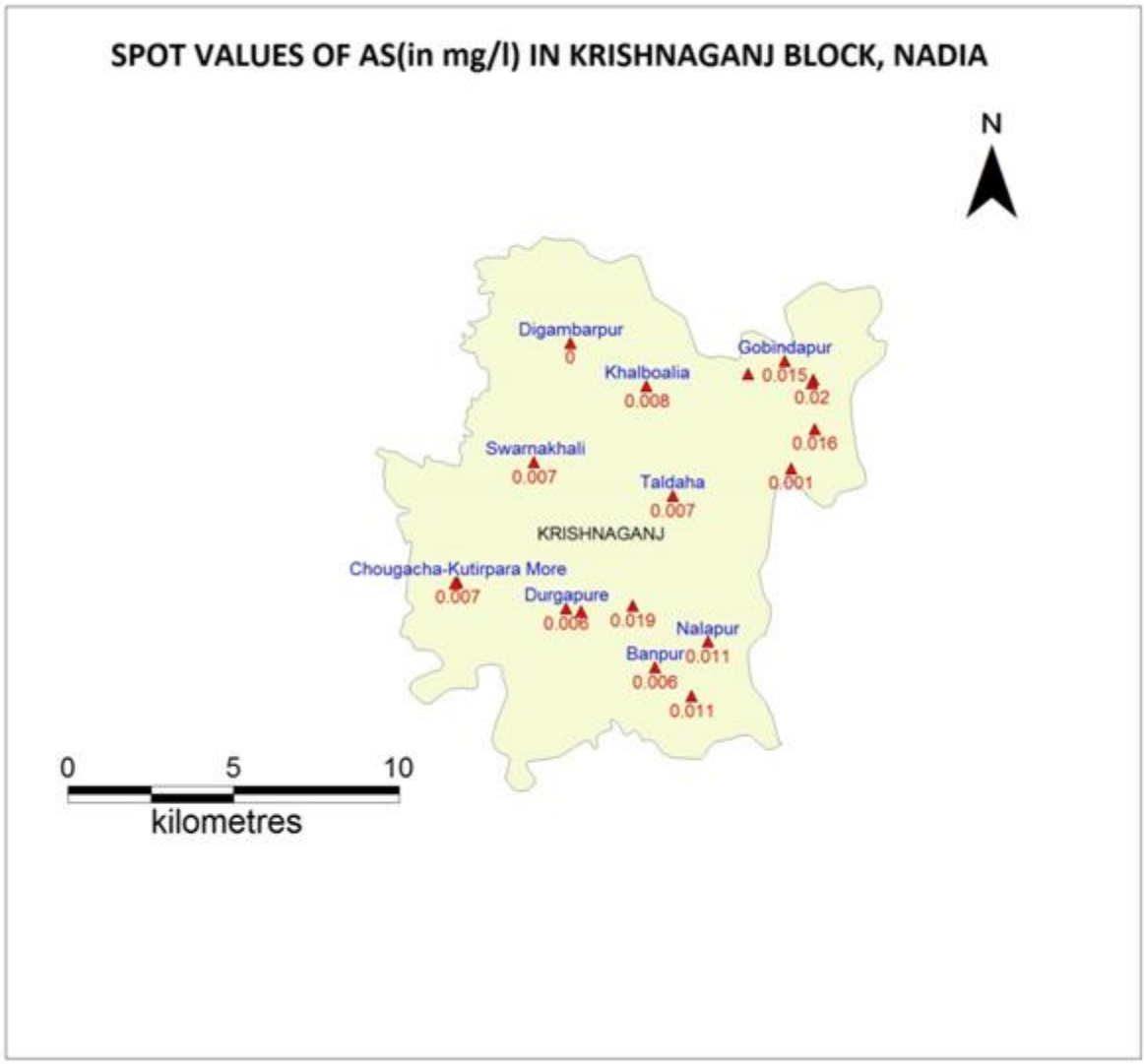


Fig. 3.1 – spot values of As (mg/l) in ground water

4. Ground Water Resource Enhancement & Management Plan:

Ground Water Management Plan for Drinking purposes-

- As per the ground water policy, first priority of water is for drinking purpose.
- The Block is declared by the State Arsenic Task Force, as Arsenic affected.
- As per the Status of Rural Water Supply Schemes published by WBPHED a population of 14523 in 5 villages is under risk zone where no water supply scheme exists.
- On the basis of data available, 4 tube wells are required for catering five uncovered villages. Details of calculation are given below.
- The arsenic free aquifers in the depth span of 213m to 225m (comparatively less potential) may be exploited for the purpose.

- Arsenic free aquifer should be tapped with proper cement sealing. Arsenic removal plant may be installed before supply.
- Regular Field monitoring is necessary for Arsenic concentration in tube wells.

Table 4.1 – Nos. & cost of Tube wells in uncovered (projected population) of Human and Cattle

Block	Projected population upto 2021 (considering growth 21.09% per decade as per Census 2011	Water required for drinking & domestic purposes @ 70 lpcd (in lpd)	Cattle Population (Considering 0.19 per capita human population) as on 2011	Cattle Population (Considering 0.36 annual growth rate) as on 2021	Water required for drinking & domestic purposes @ 20 lpcd (in lpd)	Total Water Required (in lpd)	Number of T. Ws	Cost of the tube well of 300 m depth (approx) & 10"x6" dia @ Rs. 25 lakhs (In lakh) as per EFC
Krishnaganj	**17587**	**1231090**	2977	**3086**	**61729**	**1292819**	**4**	**100**

Management Plan for Irrigation:

Table 4.2 - Availability of Land for Future Irrigation

Sr. No.	District	Block	Geographical area in ha	Cultivable area in ha	Net irrigated Command area (GW) in ha	Net irrigated Command area (SW) in ha	Net irrigated Command area (GW +SW) in ha	Net area available for Irrigation in ha	Demand i.e. Water required for Irrigation in ham	GW available for future Irrigation in ham	Remarks
8.	Nadia	Krishnaganj	15955	9880	4622.06	1028.63	5650.69	4229.31		904.38	

- On the basis of the Ground Water Resource Assessment, the block is under Safe category and the Stage of Ground Water Development (SOD) is 87.76 %.
- As indicated in the above mentioned Table, about 904 ham of ground water is available for future irrigation for about 4230 ha of land available in this block. The

available ground water may be used proportionately for Rabi and Boro paddy and other crops.

- Irrigation by modern techniques like Sprinkler, Drip irrigation may be utilised. Crops consuming low amount of water should be cultivated.
- Conjunctive use of ground water and surface water may be applied for irrigation
- Artificial recharge is advisable in Arsenic affected zone for dilution of Arsenic concentration in unconfined aquifer for irrigation purpose also so that, there is no Arsenic contamination in food chain system.
- Regular monitoring of Arsenic concentration in crop is also necessary.
- R & D study is necessary in arsenic affected area so we can get new solutions in future.

Table 4.3 - Ground Water Management Plan for Irrigation in consultation with experts of Bidhan Chandra Krishi Vidyalaya (BCKV)

Block	Ground water availability(Ham,)	Quality	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Krishnaganj	-	As	wheat, rice, mustard, cabbage, cauliflower, brinjal, okra, lentil	Wheat (0.3-0.35), rice (1.2-1.4), Vegetable (0.15-0.2), pulse (0.1-0.12)	wheat, mustard, lentil, flowers, vegetables	Wheat (0.2-0.25), mustard (0.2), pulse (0.08-0.12), flowers (0.12-0.16)	Conjunctive use of fresh and contaminated water: 1:1 ratio/drip for vegetables, flowers

<u>Management Plan for Industrial Purpose</u>:

The block is under Safe category and is mainly agriculture based rural area. There is a less chance for growing up of small scale industries. However, in near future, if any industry is coming up, the following steps should be considered.

- All industries proposing to draw ground water through energized means, need to obtain NOC for ground water withdrawal from the State Ground Water Authority (SGWA)
- All industries abstracting ground water > 500 m^3/day in the semi-critical assessment unit, have to implement mandatorily, the artificial recharge measures, as per the norms.
- All the industries need to recharge 90 % of the quantum of ground water withdrawal.

The Authority is to issue NOC for various uses and monitor its compliance. The NOC should be vested with the District Magistrate/ Deputy Commissioner/ State Ground Water

Authority/ State Nodal Agency/ Central Ground Water Authority, as per details given in the guidelines of CGWA.

Table 4.4 – Salient points for Future Irrigation

Name of Block	Geographical area in ha	Cultivable area in ha	Net irrigated area in ha	Area to be irrigated in ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl	Remarks for GW Management Plan
Krishnaganj	**15955**	9880	**5650 .69**	**4229.31**	**87.76**	**2.92**	**10.90**	**6.32**	**5.25**	**Block is under Safe category, so regular monitoring of GW regime may be made from time to time. Boro cultivation may be encouraged to some extent.**

Artificial Recharge

Table 4.5 - Area suitable for recharge in the study area:

District	Block Name	**Block Area (in ha)**	**Area suitable for recharge(Considering area having DTW more than 3m in post-monsoon and showing 20 cm/y falling trend)(in ha)**
Nadia	Krishnaganj	**15955**	**15955 (considering the average criteria)**

Table 4.6 – Estimation of Surface runoff by Dhruvanarayana, 1993 method (Based on land slope, type of land and soil)

Block	Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed)= Vnc Ham	60% of Vnc(considering e-flow)= Vf Ham (4)
Krishnaganj	1.053	15955	16800.615	0.38	30 %Deep, poorly drained loamy soil, 70% moderately drained sandy soil	6384.2337	4788.1753	2394.0876	1436.452583

Table 4.7 – Possible Recharge & conservation structures using harvested run off in block based on soil characteristic, Slope, Rain fall data and Long term trend & cost estimate

Block (1)	Amount of water for artificial recharge and / or conservation (Ham) (2)	Source water allocation for Irrigation Cum Recharge Tank and REET with Recharge Shaft in Ham (3)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 3 (4)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 3 (5)	Source water allocation for Injection Well (6)	Source water allocation for Farm Pond in Ham (7)	Nos. of Farm Pond @ 10 Ham per unit (8)	Cost of Farm pond @ Rs 8 lakh per unit (9)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (10)	Cost of Irrigation Cum Recharge Tank @ Rs 8 lakh per unit (11)	Nos. of REET with recharge shaft @ 10 Ham per unit (12)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (13)	Nos. of injection Well @ 30 Ham per unit (14)	Cost of injection Well @ Rs 25 lakh (15)	Total Cost (16) (in Lakh)
Krishnaganj	1436.4526	70 % of Col. 2 i.e. 1005.52 Ham	502.76	502.76	20 % of Col. 2 i.e. 287.29 Ham	10 % of Col.2 i.e. 143.65 Ham	14	112	10	80	50	400	10	250	842

REET with Recharge Shaft Re-excavation of existing tank with Recharge Shaft

9. HANSKHALI BLOCK

1.0 Salient Information

Block Name: Hanskhali

Area (in sq km): **231.50**

District: **Nadia**

State: **West Bengal**

Population (as on 2011): 245899

Table 1.1 - Details of Population

Male	Female	Total
127576	118323	245899

Rainfall: Average annual rainfall (Nadia district) for the period 2012-2016 (in mm): 1214.24

Table 1.2 - Annual Rainfall since last five years (mm)

Block	District Normal	Actual (Annual)				
		2012	**2013**	**2014**	**2015**	**2016**
Hanskhali	1444	862.0	1287.8	1096.8	1408.1	1416.5

Agriculture & Irrigation

Total area in ha: 23150

Table 1.3 - Land use pattern of block

Sl. No	Name of the Block	Geographic Area (ha)	Cultivable Area (ha)	Area under pasture & orchard (ha)	Cultivable Waste Land(ha)	Forest Land (ha)	Home Stead Land (ha)
1.	**Hanskhali**	**23150**	17580	176	(Negligible)	181	5085

Aquifer Wise Ground Water Resource Availability & Extraction:

Table 1.4 - Aquifer wise resource availability and draft (in MCM) in Block

Resource Availability	Aquifer I	Aquifer II	Aquifer III	Extraction (for Aquifer I)
Dynamic Resource	**141.29**	**-**	**-**	**139.66**
Static Resource	**2288.14**	**-**	**-**	**-**

2.0 Disposition of Principal Aquifer System:

In Hanskhali Block, three aquifer groups exist.

- 1st aquifer group occurs in general, ranging from 3m to 100 m which contains Arsenic contaminated ground water.
- The average depth range of 2nd aquifer group is from 126 to 156 m which is fresh and in general, Arsenic free except sporadic occurrence at places.
- The average depth range of 3rd aquifer is 205 m to 240 m, which is also fresh and Arsenic free.

Table 2.1 - Aquifer disposition depth range in the block

Hanskhali	**1st Aquifer Group**	**2nd Aquifer Group**	**3rd aquifer**
	3-100 m	**126-156 m**	**205-240 m**

HANSKHALI

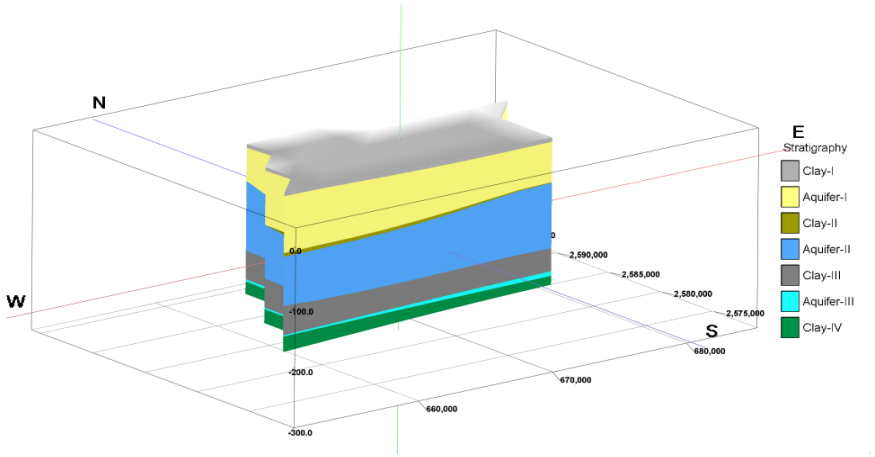


Fig 2.1 - Aquifer disposition in Hanskhali Block

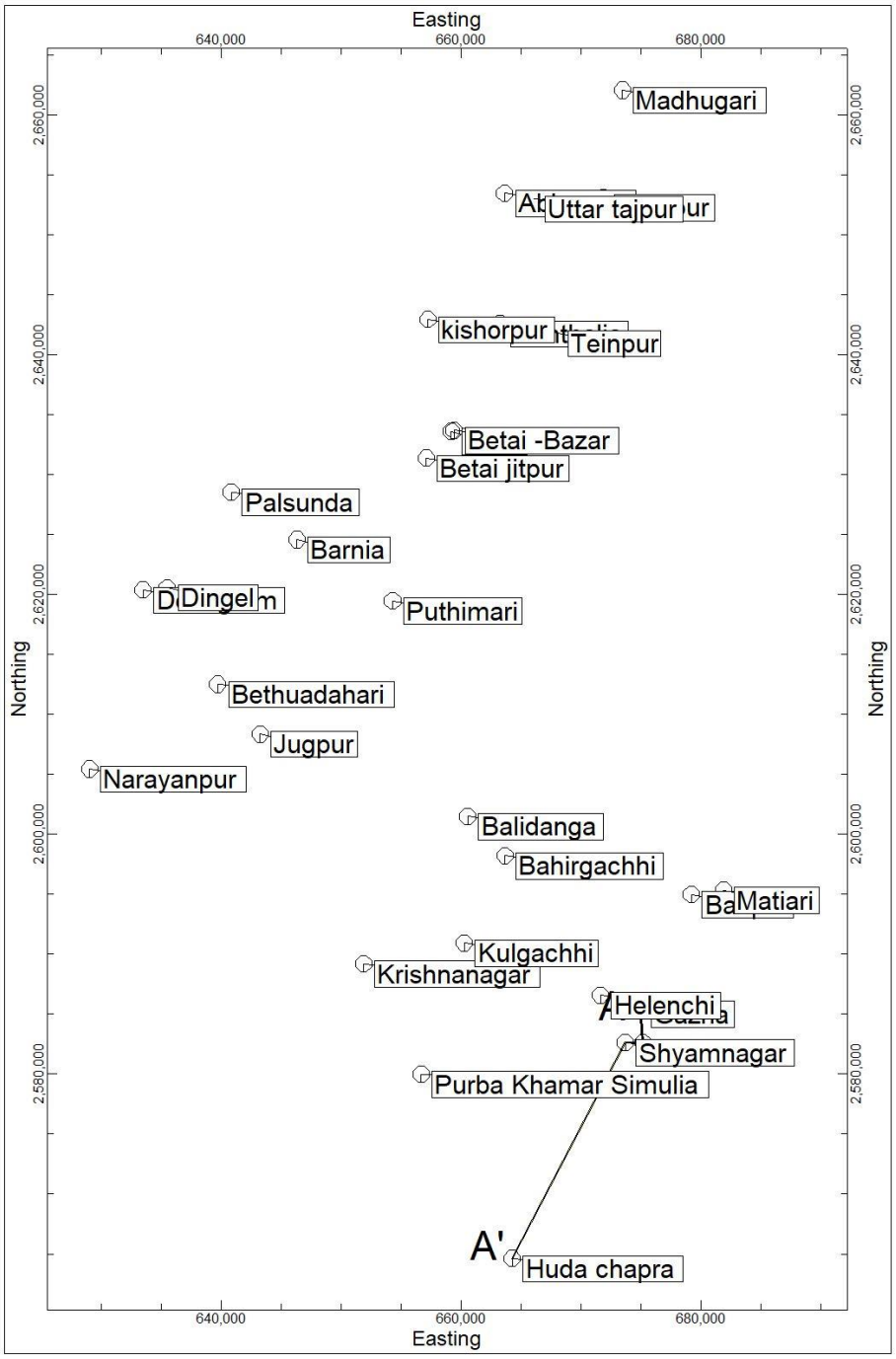


Fig. 2.2- Cross section index line

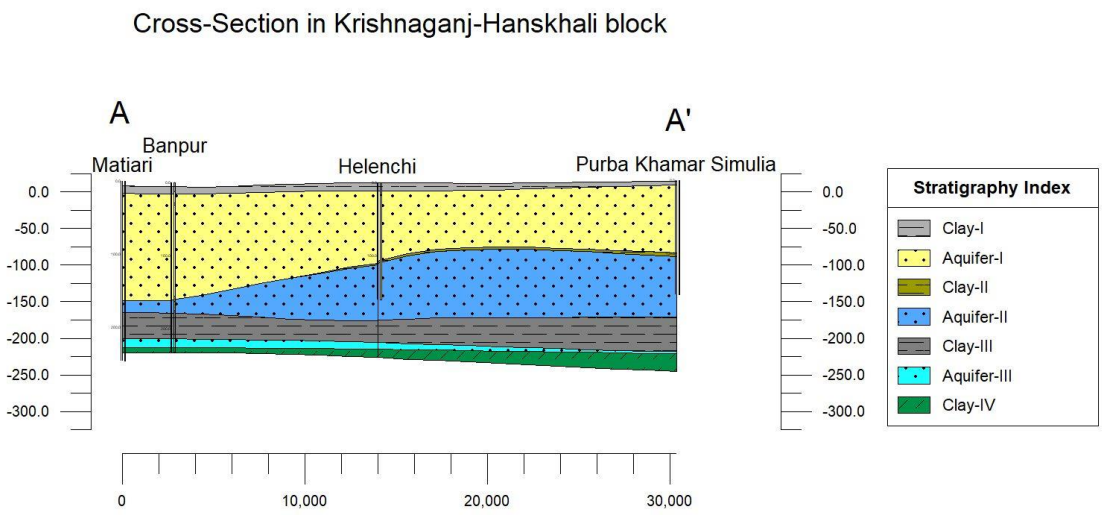


Fig 2.3 - Cross section of Krishnaganj & Hanskhali Blocks (combined)

Table 2.4 - Aquifer Wise Water Level Ranges & Seasonal long term water level trends (2006 to 2017)

Sl. No.	Aquifer	Pre-monsoon Trend			Post-monsoon		
		Depth to water level (m bgl)	Rise (cm/year)		Depth to water level (m bgl)	Trend	
			Rise (cm/year)	Fall (cm/year)		Rise (cm/year)	Fall (cm/year)
1.	I	5.85 – 6.93	-	1.79	4.90 – 6.03	-	10.82
2.	II	3.44 – 8.32	-	-	2.93 – 5.45	-	-

Table 2.5 - Aquifer wise (Maximum) thickness

Block	Area (sq km)	Thickness of the Granular Zone in 1st aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)	Thickness of the Granular Zone in 3rd aquifer (m)
Hanskhali	231.50	97	30	35

Table 2.6 - Aquifer-wise depth range and parameters

Name of Block	1st Aquifer				2nd Aquifer			
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	S	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	S
Hanskhali	3 - 100	72	3300	-	126-156	68	5207	-

3.0 Ground Water Resource, Extraction, Contamination & Other Issues:

Resource Availability & Extraction: Dynamic ground water resources as on 31st March'13

Table 3.1 - Availability of Ground Water resource in Block

Block	Net ground Water availability (MCM)	Gross ground Water draft (MCM)	Stage of Development (%)	Category	Provision for domestic and industrial requirement supply up to 2035 years (MCM)
Hanskhali	141.29	139.66	98.84	Semi-critical	6.01

Chemical Quality of Ground Water & Contamination:

Average data of chemical parameters in the block based on the analysis from 8 to 10 monitoring wells are given below. For Arsenic data, 3 to 4 monitoring wells are considered.

Table 3.2 - Range of chemical parameter in the block

Block	Aquifer Type	As (mg/l)	pH	EC (µs/Cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Total Hardness as $CaCO_3$(mg/l)
Hanskhali	I	0.0001-0.05	8.32-8.49	283-415.7	13.5-29.2	10-32.5	BDL-0.97	BDL-7.2	125-180

Table 3.3 - Arsenic Concentration in ground water

Name of arsenic affected block	No. of Tube well analysed	Arsenic Concentration (in mg/l)						
		<& =0.01		>0.01 &<=0.05		>0.05		Max. concentration
		%	No.	%	No.	%	No.	
Hanskhali	2262	34.92	790	39.48	893	25.46	576	0.53

(Source – PHED, Govt. of West Bengal)

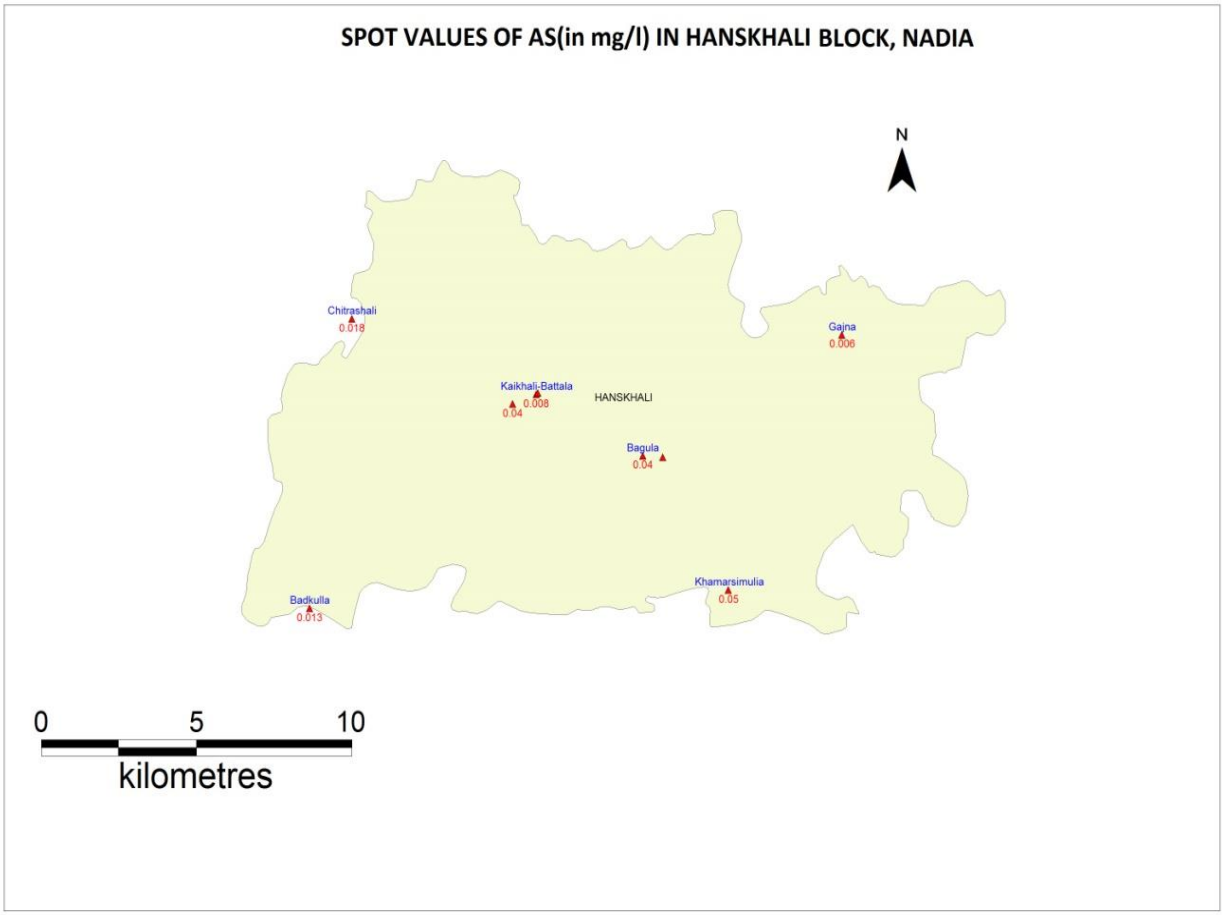


Fig. 3.1 – Spot values of arsenic (mg/l) in ground water

4.0 Ground Water Resource Enhancement & Management Plan:

Ground Water Management Plan for Drinking purposes-

- As per the ground water policy, first priority of water is for drinking purpose.
- The Block is declared by the State Arsenic Task Force, as Arsenic affected.
- As per the Status of Rural Water Supply Schemes published by WBPHED, a population of 55704 in 8 villages is under risk zone where no water supply scheme exists.
- On the basis of data available, 14 tube wells are required for catering eight uncovered villages. Details of calculation are given below.
- The arsenic free aquifers in the depth span of 126m to 156m & 205m to 240m (comparatively less potential) may be exploited for the purpose.

- Arsenic free aquifer should be tapped with proper cement sealing. Arsenic removal plant may be installed before supply.
- Regular Field monitoring is necessary for Arsenic concentration in tube wells.

Table 4.1 – Nos. & cost for construction of Tube wells in uncovered (projected) population of Human and Cattle

Block	Projected population upto 2021 (considering growth 21.09% per decade as per Census 2011	Water required for drinking & domestic purposes @ 70 lpcd (in lpd)	Cattle Population (Considering 0.19 per capita human population) as on 2011	Cattle Population (Considering 0.36 annual growth rate) as on 2021	Water required for drinking & domestic purposes @ 20 lpcd (in lpd)	Total Water Required (in lpd)	Number of T. Ws	Cost of the tube well of 300 m depth (approx) & 10"x6" dia @ Rs. 25 lakhs (In lakh) as per EFC
Hanskhali	67458	4722060	11421	11839	236783	4958843	**14**	**350**

Management Plan for Irrigation:

- On the basis of the Ground Water Resource Assessment, the block is under Semi-critical condition and the Stage of Ground Water Development (SOD) is 98.84 %. Hence, irrigation by exploiting the unconfined aquifer is not advisable.
- As indicated in the above mentioned Table, the net area for irrigation is not at all available, even over-irrigated. Hence, over-irrigation may be stopped and no further irrigation is suggested in this block. However, a quantum of about 22.5 ham of ground water which is available for future irrigation in this block, may be utilised for irrigation in adjacent water demanding block like Krishnaganj.
- Irrigation by modern techniques like Sprinkler, Drip irrigation may be utilised. Crops consuming low amount of water should be cultivated.
- Conjunctive use of ground water and surface water may be applied for irrigation
- Artificial recharge is advisable in Arsenic affected zone for dilution of Arsenic concentration in unconfined aquifer for irrigation purpose also, so that there is no Arsenic contamination in food chain system.
- .Regular monitoring of Arsenic concentration in crops is also necessary.
- R & D study is necessary in arsenic affected area so we can get new solutions in future.

Table 4.2 - Availability of Land for Future Irrigation

Sr. No.	District	Block	Geographical area in ha	Cultivable area in ha	Net irrigated Command area (GW) in ha	Net irrigated Command area (SW) in ha	Net irrigated Command area (GW +SW) in ha	Net area available for Irrigation in ha	Demand i.e. Water required for Irrigation in ham	GW available for future Irrigation in ham	Remarks
9.	Nadia	Hanskhali	23150	17580	27815.26	1371	29186.26	-11606.3	Nil	22.51	

Table 4.3 - Ground Water Management Plan for Irrigation in consultation with experts of Bidhan Chandra Krishi Vidyalaya (BCKV)

Block	**Ground water availability(Ham,)**	**Quality**	**Major crops/vegetables/ fruits/flowers currently in practice**	**Water column depth(m)**	**Crops suggested for better management(considering ground water quality & quantity)**	**Water column depth(m) recommended**	**Remarks e.g. Irrigation techniques etc**
Hanskhali	**22.51**	**As**	**wheat, rice, mustard, cabbage, cauliflower, brinjal, okra, lentil**	**Wheat (0.3-0.35), rice (1.2-1.4), Vegetable (0.15-0.2), pulse(0.1-0.12)**	**wheat, mustard, lentil, flowers, vegetables**	**Wheat (0.2-0.25), mustard (0.2), pulse (0.08-0.12), flowers (0.12-0.16)**	**Conjunctive use of fresh and contaminated water: 1:1 ratio/drip for vegetables, flowers**

Table 4.4 – Salient points for Future Irrigation

Name of Block	**Geographical area in ha**	**Cultivable area in ha**	**Net irrigated area in ha**	**Area to be irrigated in ha**	**SOD in %**	**Pre monsoon WL Trend 2016 in cm/yr**	**Post monsoon WL Trend 2016 in cm/yr**	**Average Pre monsoon WL in m bgl**	**Average Post monsoon WL in m bgl**	**Remarks for GW Management Plan**
Hanskhali	**23150**	17580	**29186.26**	**--11606.3**	**98.84**	**1.79**	**10.82**	**5.58**	**4.18**	**Block is under semi critical condition so Regular Monitoring of GW Regime should be made from time to time. Boro cultivation should be restricted**

Management Plan for Industrial Purpose:

The block is under Semi-critical condition and is mainly agriculture based rural area. There is a less chance for growing up of small scale industries. However, in near future, if any industry is coming up, the following steps should be considered.

- All industries proposing to draw ground water through energized means, need to obtain NOC for ground water withdrawal from the State Ground Water Authority (SGWA)
- All industries abstracting ground water > 500 m^3/day in the semi-critical assessment unit, have to implement mandatorily, the artificial recharge measures, as per the norms.
- All the industries need to recharge 90 % of the quantum of ground water withdrawal.
- The Authority is to issue NOC for various uses and monitor its compliance. The NOC should be vested with the District Magistrate/ Deputy Commissioner/ State Ground Water Authority/ State Nodal Agency/ Central Ground Water Authority, as per details given in the guidelines of CGWA.

Special interventions for monitoring of Ground water situations in Semi-Critical Block

As per the GEC Norms for Semi-critical block, the following precautions should be taken before GW extraction.

- It is necessary to increase the density of observation wells in that unit for regular water level monitoring and thereby-
- The rainfall recharge during monsoon season by the water table fluctuation method can be estimated with greater accuracy.
- The trend of water table during pre- monsoon and post-monsoon intervals can be evaluated with greater accuracy.
- The trend of water table during pre- monsoon and post- monsoon intervals consequent to further groundwater development can be more effectively monitored.

Artificial Recharge:

Table 4.5 - Area suitable for recharge in the study area:

District	Block Name	**Block Area (in ha)**	**Area suitable for recharge (Considering area having DTW more than 3m in post-monsoon and showing 20 cm/y falling trend) (in ha)**
Nadia	Hanskhali	**23150**	**23150 (considering the average criteria)**

Table 4.6 – Estimation of Surface runoff by Dhruvanarayana, 1993 method (Based on land slope, type of land and soil)

Block	Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed)= Vnc Ham	60% of Vnc(considering e-flow)= Vf Ham (4)
Hanskhali	1.053	23150	24376.95	0.4	50 %Deep, poorly drained loamy soil, 50% moderately drained sandy soil	9750.78	7313.085	3656.5425	2193.9255

Table 4.7 – Possible Recharge & conservation structures using harvested run off in block based on soil characteristic, Slope, Rain fall data and Long term trend & cost estimate

Block (1)	Amount of water for artificial recharge and / or conservation (Ham) (2)	Source water allocation for Irrigation Cum Recharge Tank and REET with Recharge Shaft in Ham (3)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 3 (4)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 3 (5)	Source water allocation for Injection Well (6)	Source water allocation for Farm Pond in Ham (7)	Nos. of Farm Pond @ 10 Ham per unit (8)	Cost of Farm pond @ Rs 8 lakh per unit (9)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (10)	Cost of Irrigation Cum Recharge Tank @ Rs 8 lakh per unit (11)	Nos. of REET with recharge shaft @ 10 Ham per unit (12)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (13)	Nos. of injection Well @ 30 Ham per unit (14)	Cost of injection Well @ Rs 25 lakh (15)	Total Cost (16) (in Lakh)
Hanskhali	2193.9255	70 % of Col. 2 i.e. 1535.75 Ham	767.88	767.88	20 % of Col. 2 i.e. 438.79 Ham	10 % of Col.2 i.e. 219.40 Ham	22	176	15	120	77	616	15	120	1032

REET with Recharge Shaft Re-excavation of existing tank with Recharge Shaft

Part III

Data Gap Analysis in parts of Nadia District

(9 Blocks), West Bengal

(Karimpur - I, Karimpur - II, Tehatta - I, Tehatta - II, Kaliganj, Nakashipara, Chapra, Krishnaganj & Hanskhali Blocks)

DATA GAP ANALYSIS FOR AQUIFER MAPPING PROGRAMME IN PARTS OF NADIA DISTRICT (9 BLOCKS), WEST BENGAL

Toposheet No.: 78 D/12

Quadrant No.	No. of additional EW required			No. of additional VES/TEM required			No. of additional water level monitoring stations required			No. of additional water quality stations required			Remarks
	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
2C	0	0	0	1	1	1	0	0	0	0	0	0	
3A	0	0	0	3	3	1	0	0	0	0	0	0	
3B	0	0	0	0	0	0	0	0	0	0	0	0	
3C	0	0	1	3	3	1	1	1	1	1	1	1	
Total	**0**	**0**	**1**	**7**	**7**	**3**	**1**	**1**	**1**	**1**	**1**	**1**	

Note:
No. of additional EW required- 1 (Aq-III: 1)
No. of additional VES/TEM required- 17 (Aq-I: 7, Aq-II: 7, Aq-III: 3)
No. of additional water level monitoring stations required -3 (Aq-I: 1, Aq-II: 1, Aq-III: 1)
No. of additional water quality stations required-3 (Aq-I: 1, Aq-II: 1, Aq-III: 1)

Fig-2

Toposheet No. 78 D/12 (parts) Exploratory Data adequacy for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Fig-2

Toposheet No. 78 D/12 Exploratory Data Gap Analysis for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	0	0	0

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	0	0	0

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	1	0	1

Toposheet No.: 79 A/1

Quadrant No.	**No. of additional EW required**			**No. of additional VES/TEM required**			**No. of additional water level monitoring stations required**			**No. of additional water quality stations required**			**Remarks**
	Aq-I	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	
3C	0	0	0	2	2	1	0	0	0	0	0	0	
Total	**0**	**0**	**0**	**2**	**2**	**1**	0	0	0	0	0	0	

Note: No. of Additional EW required- 0
No. of additional VES/TEM required- 5 (Aq-I: 2, Aq-II: 2, Aq-III: 1)
No. of additional water level monitoring stations required -0 (Aq-I: 0, Aq-II: 0, Aq-III: 0)
No. of additional water quality stations required-0 (Aq-I: 0, Aq-II: 0, Aq-III: 0)

Fig-2

Toposheet No. 79 A/1 (parts) Exploratory Data adequacy for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Fig-2

Toposheet No. 79 A/1 (parts) Exploratory Data Gap Analysis for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	0	0	0

Toposheet No.: 79A/5

Quadrant No.	No. of additional EW required			No. of additional VES/TEM required			No. of additional water level monitoring stations required			No. of additional water quality stations required			Remarks
	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
1C	0	0	0	1	1	1	0	0	0	0	0	0	
2C	0	0	0	2	2	1	0	0	0	0	0	0	
3A	0	0	1	2	2	1	0	1	1	0	1	1	
3B	0	0	0	3	3	1	0	1	1	0	1	1	
3C	0	0	0	3	3	1	0	0	1	0	0	1	
Total	**0**	**0**	**1**	**11**	**11**	**5**	**0**	**2**	**3**	**0**	**2**	**3**	

Note: No. of Additional EW required- 1 (Aq-III: 1)
No. of additional VES/TEM required- 27 (Aq-I: 11, Aq-II: 11, Aq-III: 5)
No. of additional water level monitoring stations required -5 (Aq-I: 0, Aq-II: 2, Aq-III: 3)
No. of additional water quality stations required-5 (Aq-I: 0, Aq-II: 2, Aq-III: 3)

Fig-2
Toposheet No. 79 A/5 (parts) Exploratory Data adequacy for Three Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Fig-2

Toposheet No. 79 A/5(parts) Exploratory Data Gap Analysis for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	1	0	1

Toposheet No.: 79A/2

Quadrant No.	No. of additional EW required			No. of additional VES/TEM required			No. of additional water level monitoring stations required			No. of additional water quality stations required			Remarks
	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
1C	0	0	0	2	2	1	0	1	1	0	1	1	
2C	0	0	0	2	2	1	0	1	1	0	1	1	
Total	**0**	**0**	**0**	**4**	**4**	**2**	**0**	**2**	**2**	**0**	**2**	**2**	

Note: No. of Additional EW required- 0
No. of additional VES/TEM required- 10 (Aq-I: 4, Aq-II: 4, Aq-III: 2)
No. of additional water level monitoring stations required - 4 (Aq-I: 0, Aq-II: 2, Aq-III: 2)
No. of additional water quality stations required-4 (Aq-I: 0, Aq-II: 2, Aq-III: 2)

<u>Toposheet No.: 79A/6</u>

Quadrant No.	No. of additional EW required			No. of additional VES/TEM required			No. of additional water level monitoring stations required			No. of additional water quality stations required			Remarks
	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
1A	0	0	1	1	1	1	0	1	1	0	1	1	
1B	0	0	0	1	1	1	1	1	1	1	1	1	
1C	0	0	1	1	1	1	0	0	1	0	0	1	
2A	0	0	0	1	1	1	0	1	1	0	1	1	
2B	0	1	1	2	2	1	0	1	1	0	1	1	
2C	0	0	0	1	1	1	0	1	1	0	1	1	
3A	0	0	0	1	1	1	0	0	0	0	0	0	
3B	0	0	0	1	1	1	0	0	1	0	0	1	
3C	0	0	1	1	1	1	1	1	1	1	1	1	
Total	**0**	**1**	**4**	**10**	**10**	**9**	**2**	**6**	**8**	**2**	**6**	**8**	

Note:

No. of Additional EW required- 5 (AQ-II: 1, AQ-III: 4)
2 OW for 2B
No. of additional VES/TEM required- 29 (Aq-I: 10, Aq-II: 10, Aq-III: 9)
No. of additional water level monitoring stations required -16 (Aq-I: 2, Aq-II: 6, Aq-III: 8)
No. of additional water quality stations required-16 (Aq-I: 2, Aq-II: 6, Aq-III: 8)

Fig-2

Toposheet No. 79 A/6 Exploratory Data adequacy for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	183-195	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Fig-2

Toposheet No. 79 A/6 Exploratory Data Gap Analysis for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	1	0	1

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	0	0	0

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	1	0	1

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	0	0	0

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	1	0	1
IIIrd	1	0	1

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	0	0	0

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	0	0	0

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	1	0	1

Toposheet No.: 79A/9

Quadrant No.	No. of additional EW required			No. of additional VES/TEM required			No. of additional water level monitoring stations required			No. of additional water quality stations required			Remark
	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
1A	0	0	1	2	2	1	0	1	1	0	1	1	
1B	0	0	0	2	2	1	0	1	0	0	1	0	
1C	0	0	0	2	2	1	0	1	1	0	1	1	
2A	0	0	0	2	2	1	1	1	1	1	1	1	
2B	1	1	1	2	2	1	0	1	1	0	1	1	
3A	0	0	1	2	2	1	0	1	1	0	1	1	
Total	**1**	**1**	**3**	**12**	**12**	**6**	**1**	**6**	**5**	**1**	**6**	**5**	

Note: No. of Additional EW required-5 (Aq-I: 1, AQ-II: 1, AQ-III: 3)
3 OW for 2B
No. of additional VES/TEM required- 30 (Aq-I: 12, Aq-II: 12, Aq-III: 6)
No. of additional water level monitoring stations required -12 (Aq-I: 1, Aq-II:6, Aq-III: 5)
No. of additional water quality stations required-12 (Aq-I: 1, Aq-II:6, Aq-III: 5)

Fig-2

Toposheet No. 79 A/9 Exploratory Data adequacy for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	NiL	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Fig-2

Toposheet No. 79 A/9 Exploratory Data Gap Analysis for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	1	0	1

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	1	0	1
IInd	1	0	1
IIIrd	1	0	1

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	1	0	1

Toposheet No.: 79A/10

Quadrant No.	No. of additional EW required			No. of additional VES/TEM required			No. of additional water level monitoring stations required			No. of additional water quality stations required			Remarks
	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
1A	0	0	0	2	2	1	0	1	1	0	1	1	
2A	1	1	1	2	2	1	0	1	1	0	1	1	
2B	0	0	0	1	1	1	0	0	0	0	0	0	
3A	0	0	0	2	2	1	0	0	1	0	0	1	
3B	0	0	0	2	2	1	0	1	1	0	0	0	
3C	0	0	1	1	1	1	0	0	0	0	1	1	
Total	**1**	**1**	**2**	**10**	**10**	**6**	**0**	**3**	**4**	**0**	**3**	**4**	

Note:
No. of Additional EW required-4 (Aq-I: 1, AQ-II: 1, AQ-III: 2)
3 OW for 2B
No. of additional VES/TEM required- 26 (Aq-I: 10, Aq-II: 10, Aq-III: 6)
No. of additional water level monitoring stations required -7 (Aq-I: 0, Aq-II: 3 Aq-III:4)
No. of additional water quality stations required-7(Aq-I: 0, Aq-II: 3 Aq-III:4)

Fig-2

Toposheet No. 79 A/10 Exploratory Data adequacy for Three Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	Depth Rnge	Aq. parameters	EC
I^st	Nil	Nil	Nil
II^nd	Nil	Nil	Nil
III^rd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
I^st	Nil	Nil	Nil
II^nd	Nil	Nil	Nil
III^rd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
I^st	Nil	Nil	Nil
II^nd	NiL	Nil	Nil
III^rd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
I^st	Nil	Nil	Nil
II^nd	Nil	Nil	Nil
III^rd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
I^st	Nil	Nil	Nil
II^nd	Nil	Nil	Nil
III^rd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
I^st	Nil	Nil	Nil
II^nd	Nil	Nil	Nil
III^rd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
I^st	Nil	Nil	Nil
II^nd	Nil	Nil	Nil
III^rd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
I^st	Nil	Nil	Nil
II^nd	Nil	Nil	Nil
III^rd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
I^st	Nil	Nil	Nil
II^nd	Nil	Nil	Nil
III^rd	Nil	Nil	Nil

Fig-2

Toposheet No. 79 A/10 Exploratory Data Gap Analysis for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	1	0	1
IInd	1	0	1
IIIrd	1	0	1

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	1	0	1

<u>Toposheet No.: 79A/11</u>

Quadrant No.	**No. of additional EW required**			**No. of additional VES/TEM required**			**No. of additional water level monitoring stations required**			**No. of additional water quality stations required**			**Remarks**
	Aq-I	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	
1A	0	0	0	1	1	1	1	1	1	1	1	1	
1B	0	0	0	1	2	1	0	0	1	0	0	1	
1C	0	0	1	1	2	1	0	0	1	0	0	1	
2A	0	0	0	1	1	1	1	1	1	1	1	1	
2B	1	1	1	1	2	1	0	1	1	0	1	1	
2C	0	0	0	1	1	1	0	0	1	0	0	1	
3A	0	0	0	1	1	1	0	1	1	0	1	1	
3B	0	0	0	1	1	1	0	1	1	0	1	1	
3C	0	0	1	1	1	1	0	1	1	0	1	1	
Total	**1**	**1**	**3**	**9**	**12**	**9**	**2**	**6**	**9**	**2**	**6**	**9**	

Note:
No. of Additional EW required-5 (Aq-I: 1, AQ-II: 1, AQ-III: 3)
3 OW for 2B
No. of additional VES/TEM required- 30 (Aq-I: 9, Aq-II: 12, Aq-III: 9)
No. of additional water level monitoring stations required -17 (Aq-I: 2, Aq-II: 6 Aq-III: 9)
No. of additional water quality stations required-17 (Aq-I: 2, Aq-II: 6 Aq-III: 9)

Fig-2

Toposheet No. 79 A/11 Exploratory Data adequacy for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	60-78	T=2966 m^2/day	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	NiL	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Aq. Gp.	Depth Rnge	Aq. parameters	EC
Ist	Nil	Nil	Nil
IInd	Nil	Nil	Nil
IIIrd	Nil	Nil	Nil

Fig-2

Toposheet No. 79 A/11 Exploratory Data Gap Analysis for <u>Three</u> Aquifer group system in Alluvial areas (quadrant wise)

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	1	0	1

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	1	0	1
IInd	1	0	1
IIIrd	1	0	1

Aq. Gp.	EW/OW/SH/PZ		
	Req	Exist	Gap
Ist	0	0	0
IInd	0	0	0
IIIrd	1	0	1

<u>Toposheet No.: 79A/15</u>

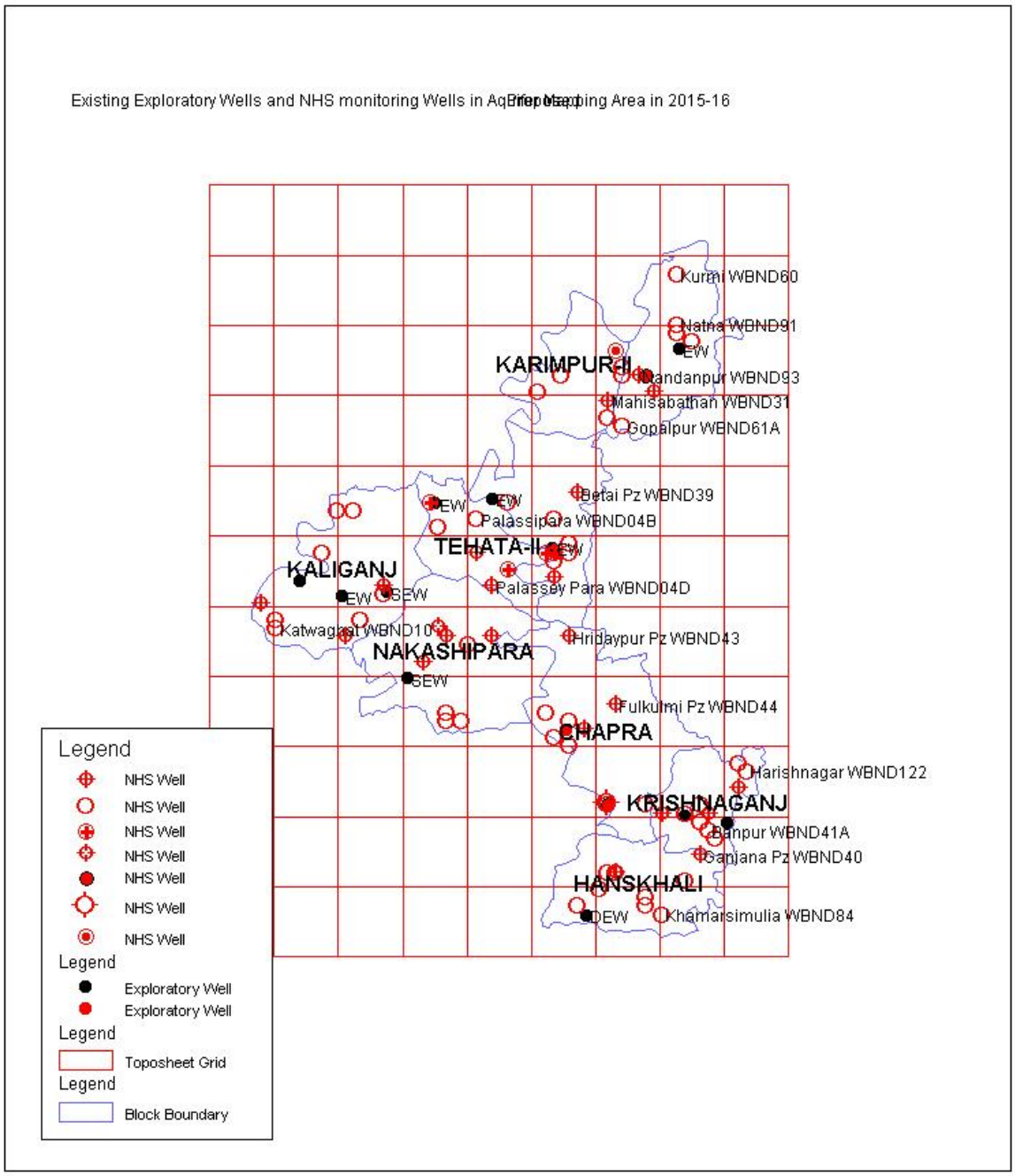
Quadrant No.	No. of additional EW required			No. of additional VES/TEM required			No. of additional water level monitoring stations required			No. of additional water quality stations required			Remarks
	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
1A	0	0	0	2	2	1	0	0	1	0	0	1	
2A	0	0	0	1	1	1	0	0	0	0	0	0	
Total	0	0	0	3	3	2	0	0	1	0	0	1	

Note:
No. of Additional EW required-0
No. of additional VES/TEM required- 8 (Aq-I:3, Aq-II: 3, Aq-III: 2)
No. of additional water level monitoring stations required -1(Aq-I:0, Aq-II: 0, Aq-III: 1)
No. of additional water quality stations required-1(Aq-I:0, Aq-II: 0, Aq-III: 1)

EXPLORATORY DATA COMPILATION IN PARTS OF NADIA (9 Blocks)

Topo No.	Quadrant no.	Block	Name of site	Agency	Depth of drilling	Aquifers tapped (mbgl)			Aquifer parameter									Aquifer water quality			Any other information
						Aq- I	Aq- II	Aq- III	Aq- I			Aq- II			Aq- III			Aq - I	Aq- II	Aq- III	
									K	T (m^2/d)	S	K	T	S	K	T	S				
79A/6	1A	Kaliganj	Debagram '58-'59	CGWB	269.86	33.75-76.41		254.50-268.50		3492.0	0.74x 10^{-3}										Shallow well-48.25 lps Deeper well-3.48 lps, DD-3.38 m
79A/6	1B		Dingel	CGWB	267.50			254.50-267.50												Pot able	Discharge-10 lps
79A/6	2B	Nakashipara	Jugpur	CGWB	152.40	20.40-106.70				1393.09											Discharge-53.46 lps
79A/2	1C		Juranpur 2001-02	CGWB	341.51		183-195													Pot able	Discharge-3.21 lps
79A/11	3A	Hanskhali	Badkulla (Suravisthan) $23^0$08'00" $88^0$31'39" 2002-03	CGWB	350.81	93-99, 118-127, 150-159		300-312, 318-324,330-333		3041										Pot able	Shallow well-19.17 lps, , SWL-4.166 mbgl, DD-2.47 m. Deeper well-4.13 lps, SWL-2.72 mbgl, DD-11.31 m Cement Sealing-261-264 mbgl
79A/11	1B	Tehatta-II	Kulgachi $23^0$25'50" $88^0$35'42" 2002-03	CGWB	230.91	60-78				2966.56											Discharge-13.33 lps DD-2.93 m SWL-1.75 mbgl RL to GL-13.139 mamsl.
79A/11	2C	Krishnaganj	Bhajanghat $23^0$22'51" $88^0$44'35" 2010/11-2011/12	CGWB	202.50			196-202, 216-222, 228-238, 244-250													Discharge-25 lps
79A/9	1C	Karimpur-I	Madhyagop	CGWB	319.35		113-														Discharge-

			alpur $23^0$58’15” $88^0$41’30” 2010/11-2011/12				119, 140-146, 209-215														5.23 lps (Comp.-10 lps)
79A/10	1A	Tehatta-I	Tehatta High School	CGWB	325.15			204-216, 219-225								2044.11					Discharge-9.56 lps
79A/5	3C	Tehatta-II	Palashipara 2010/11-2011/12	CGWB	325.05		95-107, 128-134, 171-177						395.54								Discharge-12 lps
79A/15	2A	Krishnaganj	Putikhali, $23^0$24’32.5” $88^0$45’9.9” 2010/11-2011/12	CGWB	325		146-152, 196-208,248-260,														Discharge-34.25 lps


Existing Exploratory Wells and NHS monitoring Wells in Aquifer Mapping Area in 2015-16
Kurmi WBND60
Natna WBND91
EW
KARIMPUR-II
Dandanpur WBND93
Mahisabathan WBND31
Gopalpur WBND61A
Betai Pz WBND39
EW
EW
Palassipara WBND04B
TEHATA-II
EW
KALIGANJ
Palassey Para WBND04D
EW
SEW
Katwagaal WBND10
Hridaypur Pz WBND43
NAKASHIPARA
SEW
Fulkumi Pz WBND44
CHAPRA
Harishnagar WBND122
KRISHNAGANJ
Banpur WBND41A
Ganjana Pz WBND40
HANSKHALI
DEW
Khamarsimulia WBND84
Legend
NHS Well
NHS Well
NHS Well
NHS Well
NHS Well
NHS Well
NHS Well
Legend
Exploratory Well
Exploratory Well
Legend
Toposheet Grid
Legend
Block Boundary