केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

PAKUR DISTRICT, JHARKHAND

राज्य एकक कार्यालय, रांची

State Unit Office, Ranchi

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

CONTRIBUTORS'

Principal Authors

Dr. Anukaran Kujur	:	Scientist-B
Dr. Sudhanshu Shekhar	:	Scientist-D
Atul Beck	:	Assistant Hydrogeologist

Supervision & Guidance

A.K.Agrawal	:	Regional Director
G. K. Roy	:	Officer-In- Charge

Hydrogeology, GIS maps and Management Plan

Dr. Sudhanshu Shekhar	:	Scientist-D
Dr. Anukaran Kujur	:	Scientist-B
Atul Beck	:	Assistant Hydrogeologist
Sunil Toppo	:	Scientist-B

Hydrogeological Data Acquisition and Groundwater Exploration

Dr. Anukaran Kujur	:	Scientist-B
Atul Beck	:	Assistant Hydrogeologist
Sunil Toppo	:	Scientist-B

Geophysics

B. K. Oraon	:	Scientist-D

Chemical Analysis

Suresh Kumar	:	Assistant (Chemist)

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

List of tables

List of figures

List of Annexure

(PART – I)

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

1. INTRODUCTION

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

During XII five year plan (2012-17) National Aquifer Mapping (NAQUIM) study was initiated by CGWB to carry out detailed hydrogeological investigation. The Aquifer Mapping programme has been continued till 2023 to cover whole country. The present study of Pakur district has been taken up in AAP 2018-19 as a part of NAQUIM Programme. The aquifer maps and management plans will be shared with the administration of Pakur district and other user agencies for its effective implementation.

1.1 Objective and Scope of the Study:

The major objectives of aquifer mapping are

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

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

The main activities under NAQUIM are as follows:

a). Identifying the aquifer geometry
b). Aquifer characteristics and their yield potential
c). Quality of water occurring at various depths
d). Aquifer wise assessment of ground water resources
e). Preparation of aquifer maps and
f). Formulate ground water management plan.

The demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and

implementable ground water management plan will provide a **"Road Map"** to systematically manage the ground water resources for equitable distribution across the spectrum

1.2 Approach and Methodology: The ongoing activities of NAQUIM include hydrogeological data acquisition supported by geophysical and hydro-chemical investigations supplemented with ground water exploration down to the depths of 200 meters in hard rocks and 300 meters in soft rocks.

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

Compilation of existing data (Central & State Govt.)

↓

Generation of different thematic layers

↓

Identification of Primary Aquifer

↓

Identification of data gaps

↓

Data generation (water level, exploration, geophysical,

hydrochemical, hydrogeological etc.

↓

Robust Aquifer Maps with 3D disposition

↓

Preparation of Aquifer Management Plan

↓

Capacity building in all aspects of ground water through IEC Activties

1.3 Area Details: The district Pakur was taken for aquifer mapping study during 2018-19. The district is spread over 1805 Sq. km of geographical area. Pakur district is situated in the north–eastern part of the Jharkhand state. It is bounded in the north by Sahebganj ditrict of Jharkhand state, in the east by West Bengal, in the south by Dumka district and West Bengal and in the west by Godda district. The district is situated between $24^0$49'45"and $24^0$14'00'North latitude and $87^0$24'00" and $87^0$55'00" East longitude. The district covers Survey of India toposheets nos. 72P/5, 72P/6, 72P/9, 72P/10, 72P/11, 72P/14 and 72P/15. The district has one sub-division i.e. Pakur and six blocks namely – Pakur, Maheshpur, Hiranpur, Amrapara, Littipara and Pakuria. (Fig. 1). Total population of the district is 900422 (as per census of 2011) with 832910 rural population and 67512 of urban population.
The location map of the study area is shown in figure – 1.

Table 1 Block area of Pakur district

Sr. No.	Block	Area in (Hectare)
1	Amrapara	27329
2	Hiranpur	16960
3	Litipara	41305
4	Maheshpur	44893
5	Pakur	22171
6	Pakuria	27901
Total		**180559**

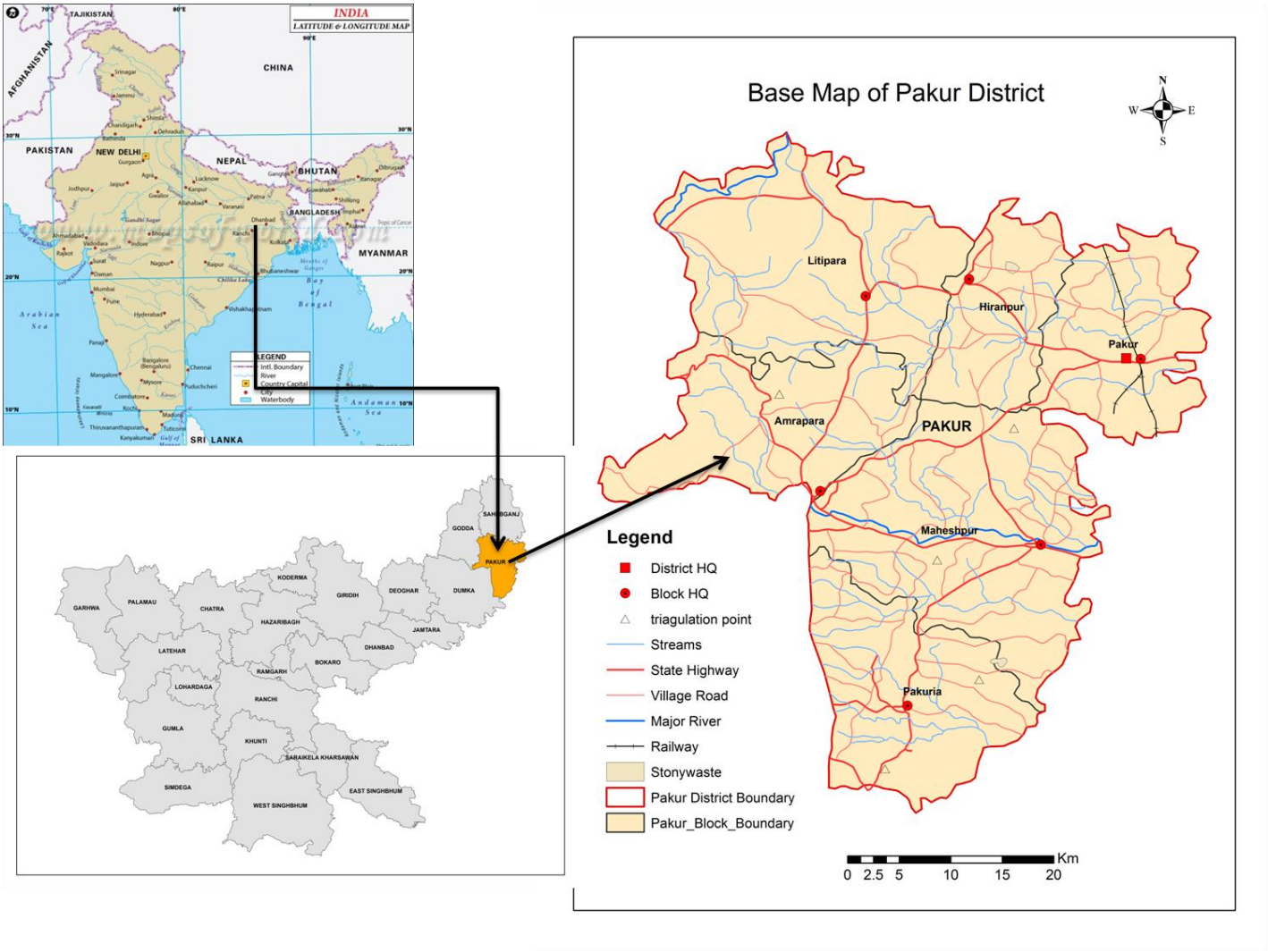


Figure 1: Location map of Pakur district

1.4 Data Availability, Data Adequacy and Data Gap Analysis

***1.4.1 Data Availability*:** Central Ground Water Board has carried out exploratory drilling in the district and drilled five exploratory and four observation wells by departmental rig during the year 1982-83. Similarly, seven exploratory wells and seven observation wells were drilled during AAP 2018-19. Five exploratory wells were drilled through outsourcing. Thus, at least two exploratory and one observation wells are to be drilled in each block to know the sub–surface geology, depth and thickness of water bearing formation with their yield and determining the different aquifer parameters because of complicated geological formation and variable lithology in the area.

In addition, thirteen numbers of permanent observation well (HNS) of Central Ground Water Board located in the district are being monitored for ground water regime and to assess the chemical quality of ground water.

***1.4.2 Data Adequacy and Data Gap Analysis*:** The available data of the Exploratory wells drilled by Central Ground Water Board, State Unit Office, Ranchi, geophysical survey carried out in the area, ground water monitoring stations and ground water quality stations monitored by Central Ground Water Board were compiled and analyzed for adequacy of the same for the aquifer mapping studies.

After taking into consideration, the available data of ground water exploration, geophysical survey, ground water monitoring and ground water quality, the data adequacy is compiled and the summarised details of required, existing and data gap of exploratory wells, ground water monitoring and ground water quality stations is given in table – 2.

Table – 2: Data adequacy and data gap analysis

Exploratory data			**Geophysical data**			**GW monitoring data**			**GW quality data**		
Req.	Exist.	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap
21	17	4	64	18	43	30	29	1	30	29	1

The data adequacy as discussed above indicates that the existing data is not sufficient for preparation of aquifer maps; hence data gap has been identified for Exploratory Wells, Geophysical Survey (VES), Ground Water Monitoring Wells and Ground Water Quality. Based on the data gap identification, the data generation activity was planned and completed in 2018-19.

1.5 Climate and Rainfall: The district is characterized by humid to sub-humid climate. During summer the hot spell prevails from March to middle of June. Rainy season starts from middle of June to middle & end of October. Winter starts from the middle of November and continues till the end of February. The district experiences hot weather from March to May, when the maximum temperature reaches upto 40^0c. December is the coldest month, when the minimum temperatures fall down to 4^0c.

The area receives rainfall by South-West monsoon. The normal average rainfall in the district is 1399 mm. The blockwise average monsoon rainfall (2008 to 2017) of the district varies from 1160.37 to 1535.90 mm. The rain fall data for the period of 2008 – 2017 has been analyzed for average annual monsoon rainfall, standard deviation and coefficient of variation which are given in table – 3. Based on available data, average monsoon rain fall map of the district has been prepared and presented in figure - 2.

Table – 3: Analytical data of monsoon rainfall (2008 – 2017) of Pakur district

Sr. No.	**Block**	**Average monsoon rainfall**	**Standard deviation**	**Coefficient of variation (%)**
1	Amrapara	1535.9	444.15	28.92
2	Hiranpur	1353.744	905.49	66.89
3	Litipara	1193.578	331.78	27.80
4	Maheshpur	1458.467	641.84	44.01
5	Pakur	1160.378	273.30	23.55
6	Pakuria	1454.844	279.27	19.20

1.6 Physiography: The area is characterized by undulating topography with hills and plain. Major part of the area is covered by basaltic terrain of Rajmahal hills. The general elevation of the hills and plateau varies from 70 to 371 m above MSL.

1.7 Geomorphology: The area is characterized by hilly undulating topography covered by lateritic soil and Rajmahal basaltic flows with flat valleys separated by topographic highs. Originally this elevated area existed as a more or less regular plateau formed of successive flows of basaltic traps. The main geomorphological features of the district are the rolling peneplain in the south with numerals remnants of ancient ridges and resistant lava plateau of Rajmahal. These plateaus rise above the general level and occupy major part of the district. The general elevation of the hills and plateau varies from 70 to 371 m above MSL. Digital elevation model (DEM) and Geomorphological of Pakur district is prepared and presented in figure – 2 and 3 respectively.

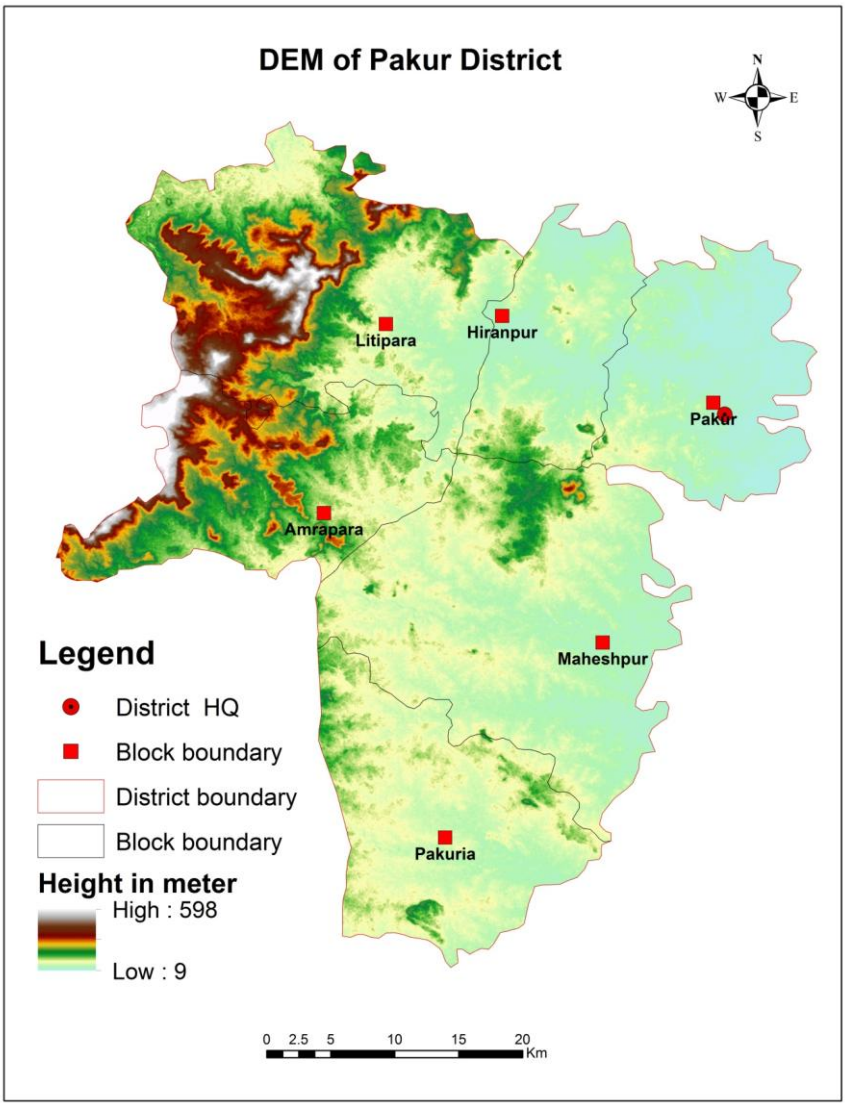


Figure – 2: Digital elevation model of Pakur district

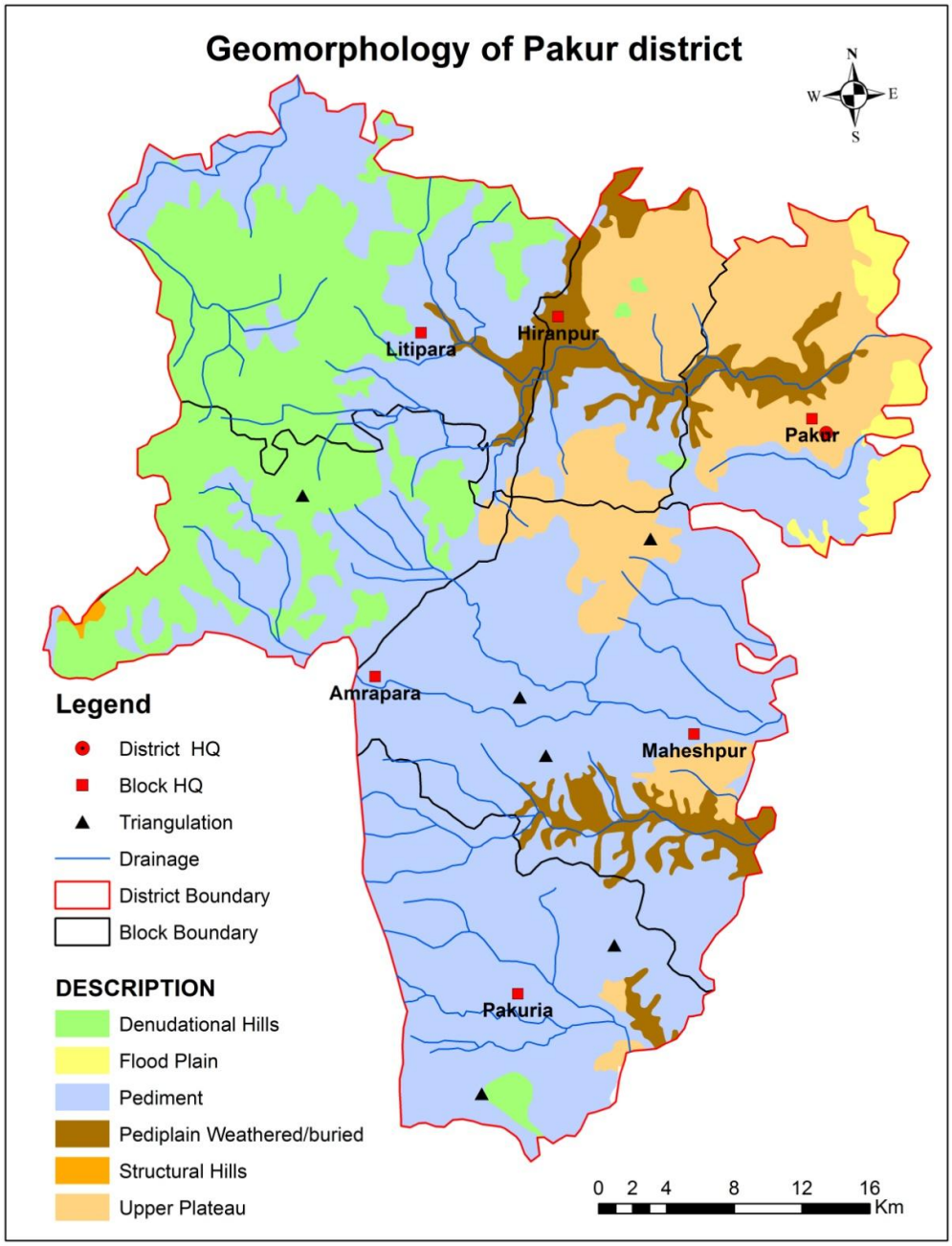


Figure – 3: Geomophology of Pakur district

1.8 Land Use: Geographical features play a major role in land use pattern of the district. The land use pattern data of the area for the year 2014-15 is given below in table 4. Land use map of the Pakur district has been prepared and shown in figure – 4.

Table: 4: Land use pattern of Pakur district (2014– 2015)

(Figures in Hactare.)

District	Total area (Hectare)	Forest land	Barren & non agricul-turable land	Cultiva-ble waste land	Permanent pastures & other grassing land	Land under miscella-neous Trees	Current fallow	Fallow land other than current fallow	Net area sown	Total cropped area
Pakur	180557	14583	27654	10735	6860	4165	41801	39255	35404	39957

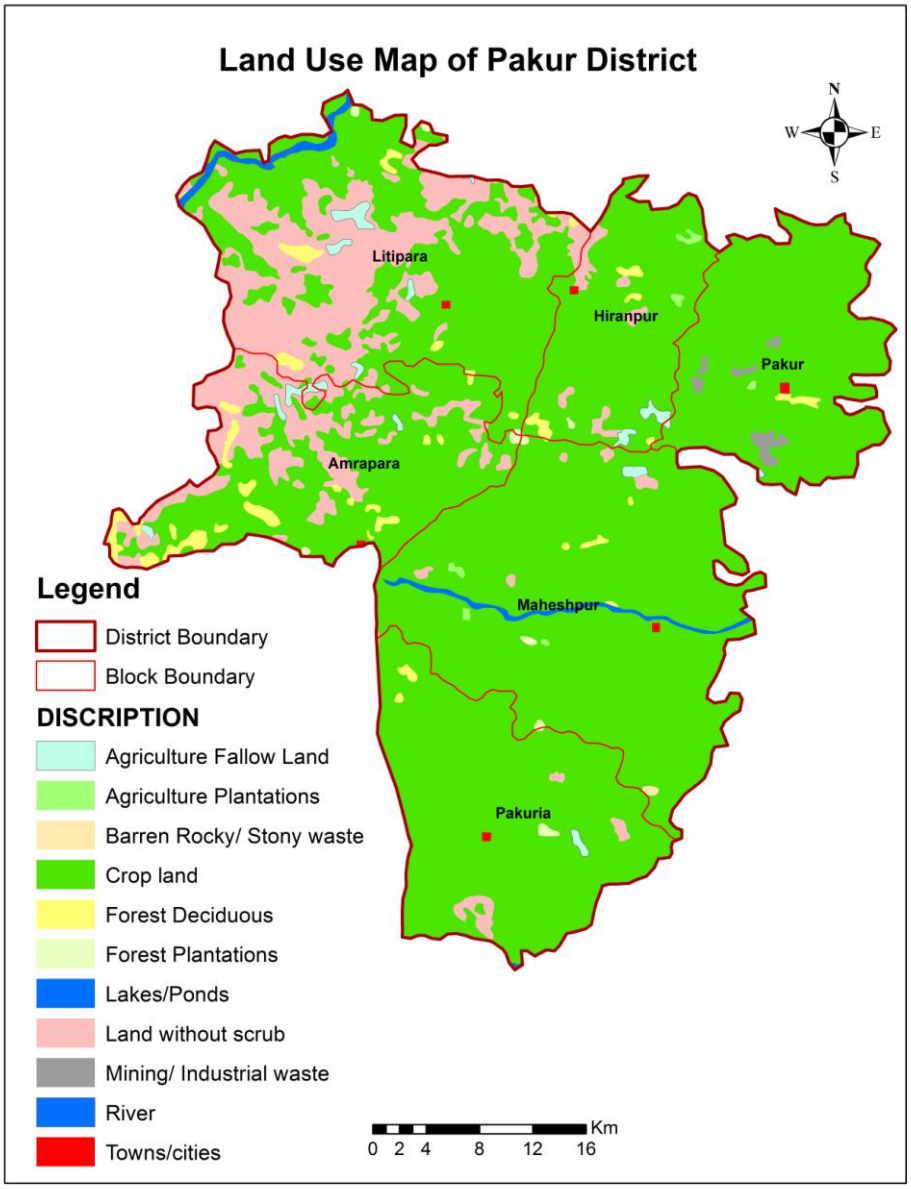


Figure – 4: Land Use Map of Pakur district

1.9 Soil: The area is characterized by the following type of soils –

(i) Rajmahal trap soil
(ii) Red soil
(iii) Eroded scarp soil
(iv) Foothill soils
(v) Tal soil
(vi) Alluvial soil

***1.9.1 Rajmahal trap soil*:** Soils derived from basaltic lava occurs in major part of the area. These soils, black in colour are very fertile and restricted to Rajmahal lava areas.

***1.9.2 Red Soil*:** Red soils are light to medium and are red to yellow and light gray in colour. These soils are mildly acidic in reaction and low in organic constituent. Dry crops and paddy grow in these soils.

***1.9.3 Eroded scarp soil*:** This type of soil occurs in transverse section of dissected, descending scarp land at various altitude of upland. This type of soil has poor fertility with shallow thickness.

***1.9.4 Foothill soil*:** Foothill soils occur in the eastern fringe of the area. The soil is deep and acidic in reaction. The soil is yellowish red in colour crops like maize, arhar etc. grow in these soils.

1.10 Drainage: The district is mainly drained by the river Bansloi, Brahmani, Torai and Gumani. All these rivers are seasonal in nature. All the rivers flow from west to east direction except river Gumani which flows from SW to NE direction. The drainage pattern of the district is dendritic. All the rivers are tributaries of river Ganga and are seasonal in nature. The river Ganges passes at a little distance away, along the north eastern boundary of the district.The drainage map of the area is shown in figure - 5.

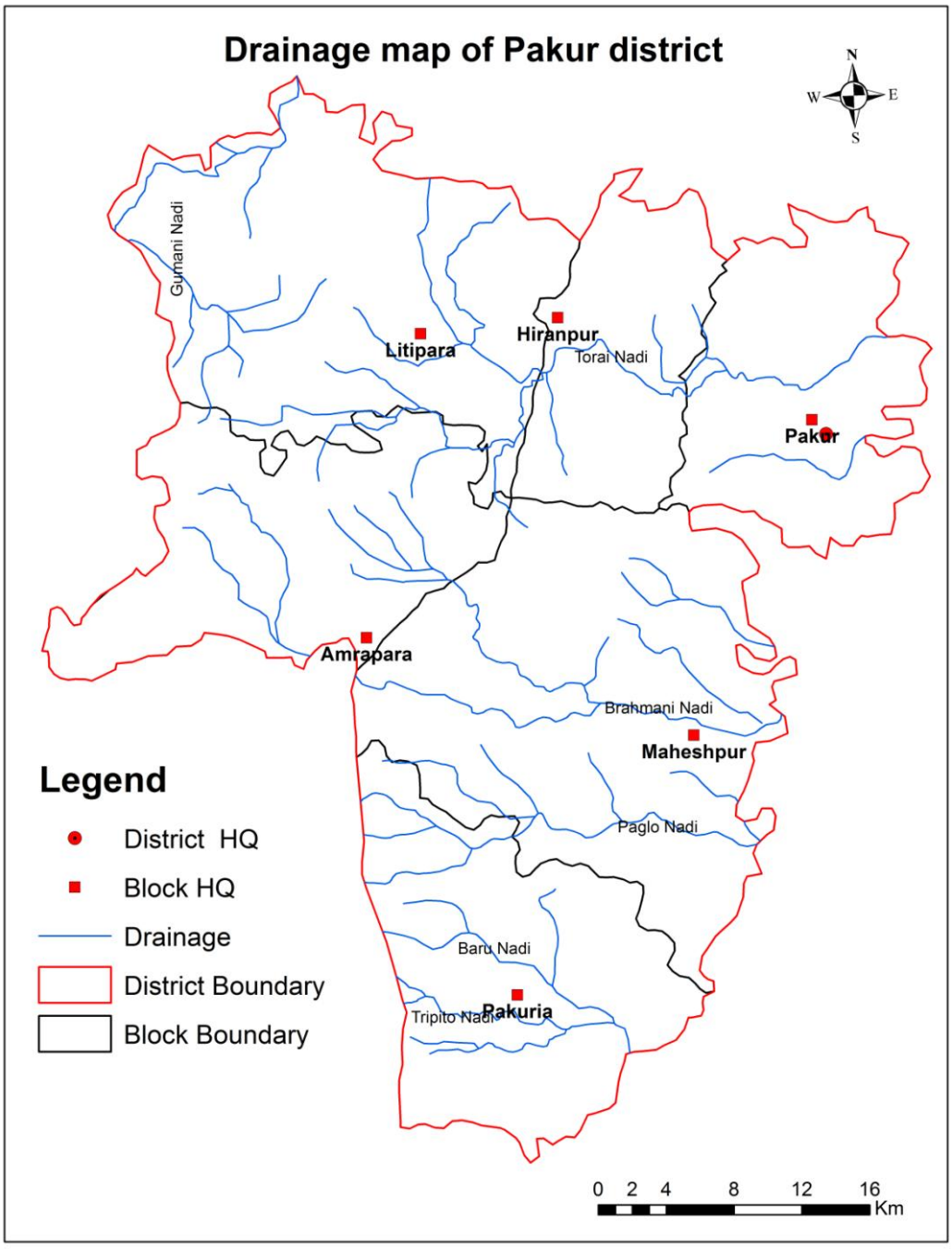


Figure – 5: Drainage Map of Pakur district

1.11 Agriculture and Irrigation Practice: The local population of the district mostly depends on agriculture and forestry for their sustenance. The agriculture activity of the area is solely dependent upon the monsoon rainfall. Paddy is the main crop of the district is Maize, Wheat, mustard, Pegion pea. Irrigational facilities are not adequate in this district. The most common source is the dug wells and ponds, but this is not a very dependable source of irrigation. The undulating nature of land makes it possible to store rain water by bunding. Apart from being dependent upon rains, these are by no means adequate. The result is that failure of rains invariably involves failure of crops except in small pockets. Minor irrigation structures like surface water tanks and ponds are the other source for irrigation. Available source wise irrigation for the 2013-14 is given in table - 5.

Table 5: Details of source wise irrigation of Pakur district (2013-14)

(Area in hectare)

Block	Surface water			Ground water			Other sources
	Canal	Tank	LI	DTW	STW	DW	
Amrapara			46	0	5	297	505
Hiranpur			29	0	23	309	307
Litipara			248	0	5	76	134
Maheshpur	1		109	34	11	358	513
Pakur			124	1	8	537	229
Pakuria	1		63	1	3	288	563
Total	**2**	**0**	**619**	**36**	**55**	**1865**	**2251**

1.12 Cropping Pattern: The major crops cultivated in the area are paddy, wheat, maize, gram, oil seeds, pulses and vegetable. The paddy is grown in all the three cropping season viz., Aghani, Bhadai and summer. Summer paddy is mainly cultivated in the low lying area along the river course where water is available for sufficient irrigation. Area under crop for the year 2015 – 16 of the district is presented in table - 6.

Table – 6: Cropping pattern of Pakur district

(Area in hectare)

Block	Major Crops				
	Paddy	Wheat	Gram	Maize	Pulses
Pakur	7924	1857	1927	1811	1287
Hiranpur	7526	1468	1040	1176	1031
Littipara	6478	659	1102	1203	939
Amrapara	6619	667	1134	1158	1085
Maheshpur	9529	1891	2058	2085	1474
Pakuria	7434	1632	1394	1502	1220
Total	**45510**	**8174**	**8655**	**8935**	**7036**

***1*.13. Hot springs**

There is a natural fountain of hot water at Sidpur, 8km from Pakuria Block HQ. There is no road linking to this spring. It is used by the Sapa Hore tribal people for religious purposes. The Sapa Hore are strict vegetarians. People of other communities come to bathe here as well.

2. DATA COLLECTION AND GENERATION

The primary Data such as water level, quality, geophysical data and exploration details were available with CGWB has been collected and utilised as baseline data. The Central Ground Water Board has established a network of observation wells under National Hydrograph Network programme to study the behavior of ground water level and quality of ground water in the district. To understand the sub-surface geology, identify the various water bearing horizons including their depth, thickness and compute the hydraulic characteristics such as transmissivity and storativity of the aquifers, exploratory drilling programme was carried out by Central Ground Water Board. For other inputs such as hydrometeorological, Landuse, cropping pattern etc were collected from concerned state and central govt departments and compiled.

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

i. Hydrogeological Data: Water level data of 18 no. key wells and 11 no. NHNS were monitored and compiled for Aquifer-I. Seven exploratory and 7 exploratory wells drilled in the district. Also conducted one numbers of soil infiltration tests.

ii. Hydrochemical Data: To evaluate the quality of ground water, 29 samples were collected from dug wells and 2 samples from hand pumps representing shallow aquifer (Aquifer – I).

***iii. Geophysical survey*:** 18 VES were carried out to identify the weathered zone resistivity and its thickness as wells as find out deeper fracture zone and different layer of basaltic formation.

***iv. Exploratory drilling*:** 12 exploratory and 11 observation wells drilled in hard rock area area of the district through departmental rigs. In addition to this 5 exploratory wells were also drilled in hard rock formation through outsourcing.

***v.* Hydrometeorological Data**: Last ten years (2008 – 2017) monsoon rainfall data for each of the block from the office of District Agriculture Department, Pakur.

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

2.2 Data Generation: After taking into consideration, the data available with CGWB on ground water monitoring wells (GWMW), ground water quality, geophysical survey and ground water exploration, the data adequacy was compiled and it indicated that exploratory drilling is required at least 4 locations of Litipara, Amrapar and Maheshpur blocks, geophysical survey (VES) are required in Maheshpur, Litipara, Pakur, Amrapara blocks. The requirement, availability and gap of major data inputs i.e., exploratory wells, geophysical data, ground water monitoring wells and ground water quality data are detailed in the table – 1.

***2.2.1 Ground water Monitoring Wells*:** 18 key wells were established to assess the ground water scenario of shallow aquifer (Aquifer-I) of the area. The depth of these dug well varies from 2.25 to 11.45 mbgl. Similarly, the diameters of key wells (dug wells) ranges from 1.00m to 4.80 m. During 2018, the pre monsoon (May) depth to water level in these wells was between 0.56 mbgl to 9.90 mbgl. The post monsoon depth to water level (Nov. 2018) in the dug wells ranges from 0.30 to 7.40 mbgl. A detail of key wells and water level data is presented in Annexure – I & II. Location of key wells and exploratory wells are shown in figure – 6.

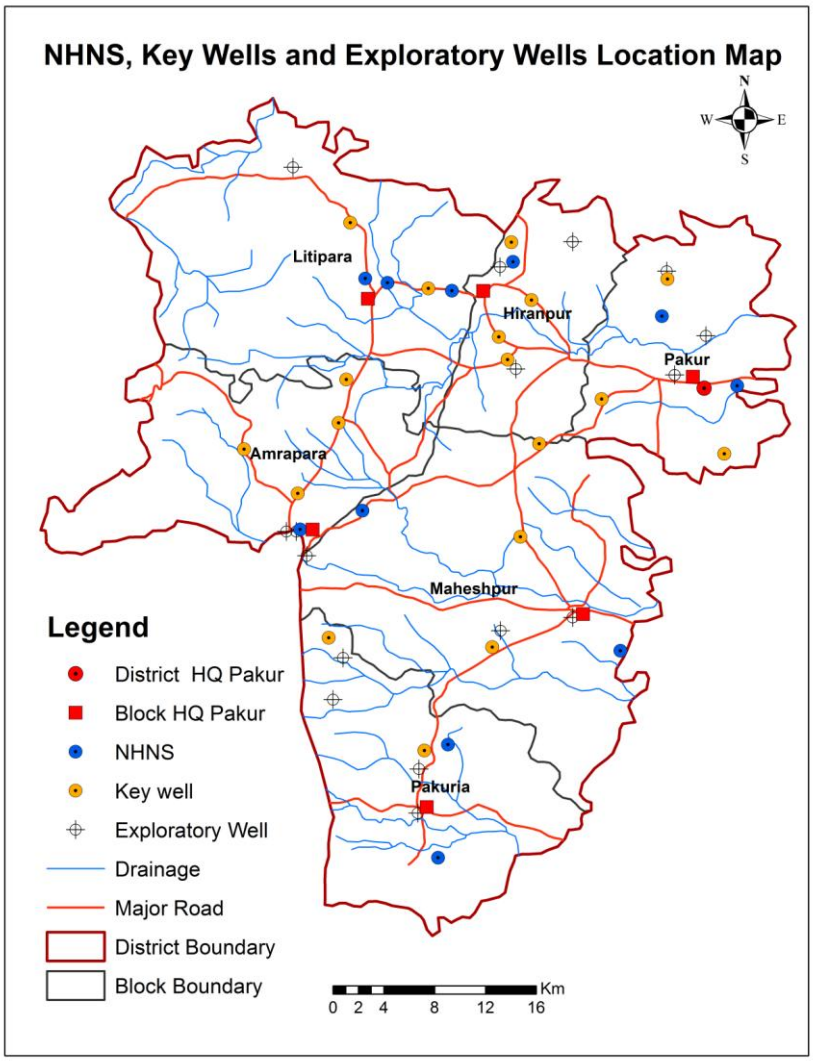


Figure – 6: Location of key wells and exploratory wells

2.2.2 Ground Water Exploration: On perusal of table- 1, exploratory drilling in Litipara, Amrapara and Maheshpur blocks is required. Accordingly additional data generation were undertaken in hard rock to assess the lithological disposition of shallow aquifer (Aquifer-I) and deeper aquifer (Aquifer-II). The details of exploratory and observation wells are given in Annexure-III.

2.2.3 Ground Water Quality: To assess the quality of ground water, 29 samples were collected for chemical quality analysis from dug wells representing Aquifer – I.

2.2.4 Geophysical Survey: 18 VES have been conducted in the district. Block wise number of VES conducted in Pakur district is given below in table –7.

Table –7: Block wise number of VES conducted in Pakur district

Year	Block	No. of VES
2018 - 19	Hiranpur	5
	Maheshpur	4
	Pakur	3
	Pakuria	6

***2.2.5 Soil Infiltration Test*:** To obtain the actual rate of infiltration of various soil cover and their impact on recharge to ground water, 1 infiltration tests has been conducted in the area. The data has been analyzed and the salient features of the infiltration tests are presented in table -8.

Table – 8: Salient features of the soil infiltration test

Sr. No.	Village	Block	Co-ordinates	Date	Formation	Initial water level (mm)	Final infiltration rate (mm/hr)
1	Patpahari	Pakuria	24.4111 87.5913	24/04/2019	Rajmahal Trap	165.1	2.75

***2.2.6 Pumping Test*:** For evaluating the well characteristics and for determining the hydraulic parameters of the aquifer- II, pumping tests (step drawdown test and aquifer performance test) of earliar data was available.

2.2.7 Micro Level Hydrogeological Data Acquisition

In addition to the Hydrograph Monitoring Wells, micro level hydrogeological data was also acquired for deciphering the sub-surface lithological disposition, water level scenario and other hydrogeological inputs such as weathered thickness etc., of shallow aquifer (Aquifer-I). Thus 18 wells in the district, were inventoried for micro level data acquisition. The details of dugwells inventoried for micro-level data acquisition are given in Annexure-II&III.

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

1. Drainage
2. Geomorphology
3. Elevation
4. Land use
5. Geology & structure

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

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

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

3.1 Geological Setup

Geologically major part of the area is represented by Rajmahal traps having huge thickness of basaltic lava flows with intercalated shales and Clays. The Rajmahal Traps extend with a north-south trend for more than 120 kms through the districts of Santhal Parganas in Jharkhand (Sahebganj, Pakur, Dumka) and Birbhum in West Bengal (GSI, 1989). It consists of long flat topped hills The basaltic lava flows of the Rajmahal Trap of middle Jurassic to lower cretaceous age occupy the major part of the district. It has been observed (GSI, 2006) that there are at least seven successive basaltic flows, each flow ranging in thickness between 20m and 75 m. Lithologically these traps are fine grained, amygdaloidal with quartz, agate and Chacedony filling, which on decomposition leave large exfoliated boulders. The weathering of these traps under favourable climatic conditions has resulted laterisation. These laterites form a wide spread cover over the underlying traps in the eastern part of the district. Rajmahal Traps are undererlain by Gondwana formations,represented by Dubrajpur Formation, and Barakar Formation. Rajmahal Traps are overlain by Laterites and Alluvium. A very small patch of older alluvium (comprising clay, silts and sand) and older flood plain deposits (comprising sand , silt and clay) occur in eastern part of the district. The general geological succession as encountered in Pakur district (As per GSI, 2006) is given below

Lithology	Formation	Group/Super Group	Age
Alternating layers of Sands, Silts and Clays, oxidised	Older Flood Plain deposits (Ganga-Kosi Formation)	Quaternary	Holocene
Khaki Green Clay with Brown silts and Sands highly oxidized	Older Alluvium		Late Pleistocene to Early Holocene
Laterite & Lateritic Soil			Cenozoic
Rajmahal Trap-Basalt/Inter-trappean beds-Chert	Rajmahal Trap		Upper Jurrasic to Cretaceous
Sandstone and shale	Dubrajpur Formation	Gondwana Super Group	Triassic to Jurassic
Silt stone, sandstone and carbonaceous shale with Coal seams	Barakar Formation		Permian
Unclassified Granite gneiss with enclaves of metamorphic/Granite-Gneiss and Migmatite	Chotanagpur Granite-Chotanagapur Gneissic Complex		Archean to proterozoic

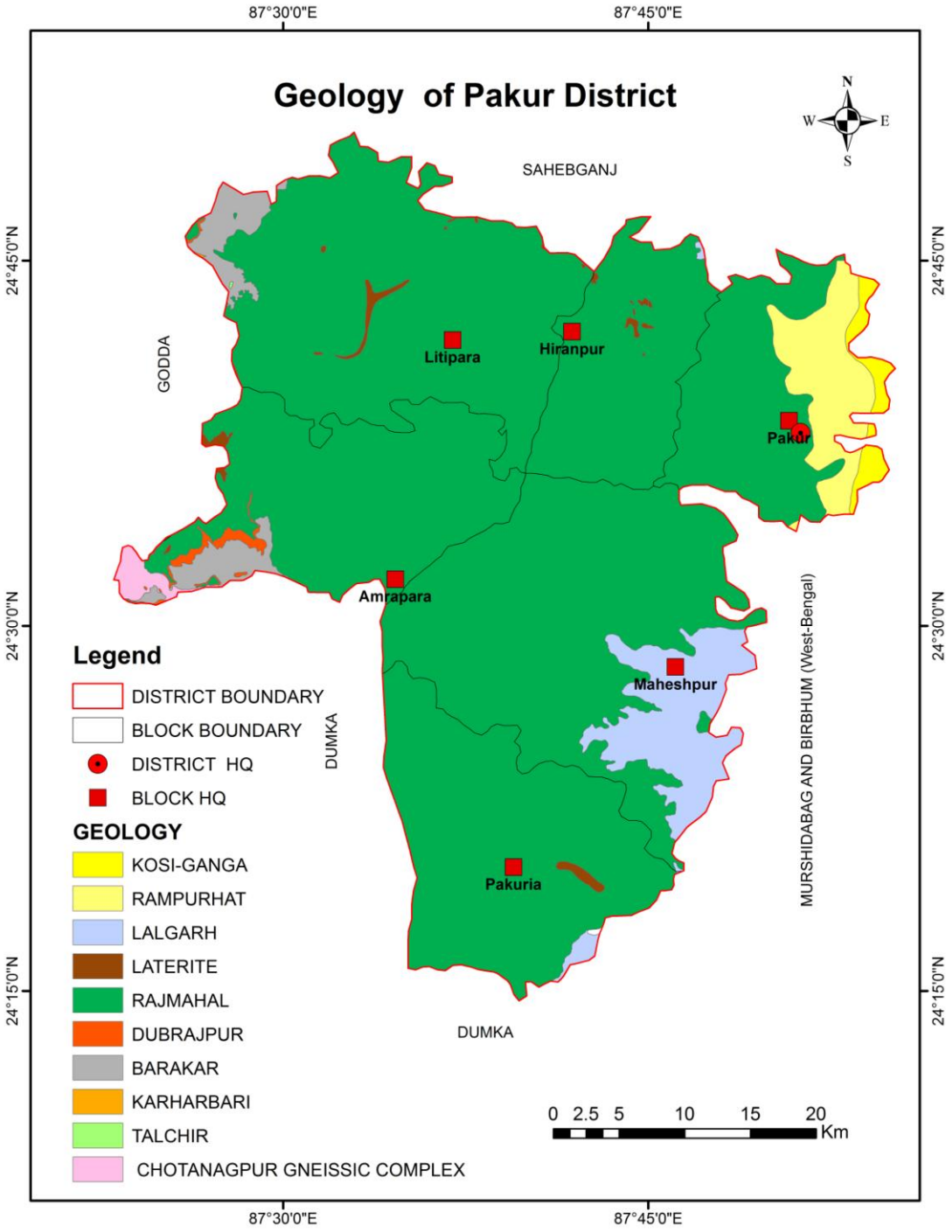


Figure – 7: Geological map of Pakur district

3.2 Hydrogeology: The occurrence and movement of ground water in the area is variable, which is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. The principal aquifer in the area is Basalt, where the occurrence and movement of ground water primarily depends on the degree of interconnection of secondary pores/voids developed by fracturing and weathering. Rajmahal Traps in the area constitutes number of basaltic flows separated by intertrappean beds which are often agillaceous and arenacious in nature. The intertrappean beds seperates two flows occurs as impermeable beds. The distinctive hydrogeological features of the basaltic rocks is the significant primary porosity in the form of vesicles, cracks etc. The secondary porosity is developed due to fracturing during cooling of lavas, tectonic disturbances followed by weathering etc. Laterites are mainly of insitu origin and

have formed by subaerial erosion of underlying basalts under favourable climatic condition. The study reveals that vesicular basalts, laterites, intertrappeans formation etc form suitable condition for ground water storage. The alluvium occurs in the northern and eastern boundary of the district, which is composed mainly of sand and sub ordinate clay.

Based on morpho-genetic, geological diversities and relative ground water potentialities of the aquifers, the district can be broadly divided into three Hydrogeological units: Consolidated or Fissured formations, Semi-Consolidated and unconsolidated or Porous formations .

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

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

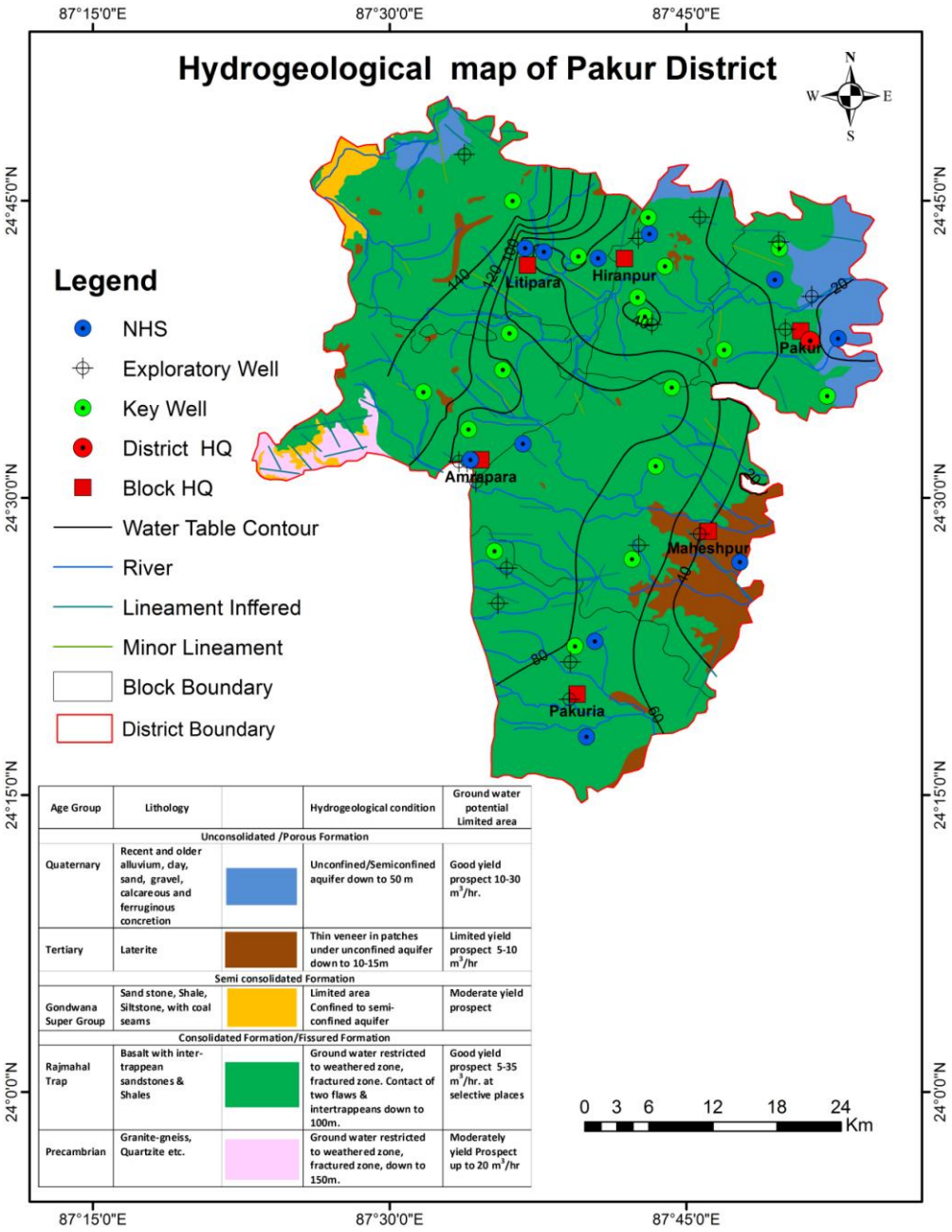


Figure – 8: Hydrogeology of Pakur district

3.2.1 Ground Water In Aquifer-I (Alluvium/Laterite/ Weathered Basalt)*:* Ground water occurs under phreatic/ unconfined to semi-confined conditions in Aquifer-I which is represented by Alluvium, Laterite, weathered Basalt. Potential aquifer exists at shallow to moderate depth upto 30m. Yield of the wells in Aquifer-I upto 10 m3/hr in Laterites/Weathered Basalt. In the shallow zones of weathered hard rock the depth of the dug wells varies from 10–15 mbgl. This zone should be developed either through large diameter open wells or shallow borewells of 30-50 m depth which permits draft upto 10 m^3/hr for domestic as well as irrigating small holdings of land. A very small patch of older alluvium (comprising clay, silts and sand) and older flood plain deposits (comprising sand , silt and clay) occur in eastern part of the district. Ground water occurs under unconfined to semi-confined condition down to 40-50m with the well yield upto 30 m3/hr.

3.2.2 Ground Water In Aquifer-II (Fractured Basalt): Ground water occurs under Semi-confined to confined condition in Aquifer-II represented by Fractured/Jointed /Vesicular Basalt upto the depth of 181.0m depth. The exploratory drlling in the district reveal that the vesicular basalts, intratrappean beds, contact zone of two volcanic eruptions etc in Rajmahal Traps form potential aquifer zones and can yield upto 36 m3/yr.The high yielding aquifers are generally encountered in fractures/joints between 40-140 depth, however in some cases deeper fractures were encountered between 178 -181 m, e.g at Teliyapokhar in Maheshpur block.

3.2.2.1 Potential Fractures in Aquifer-II: Number of boreholes has been constructed by CGWB in the district under groundwater exploration programme upto maximum depth of 200 m (Table-9). The borehole data reveals that, in general potential fractures are encountered between 40-140 m. Table-9 shows the Potential Fracture encountered during Ground Water Exploration in Dumka district

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

S. No.	Location	Block	Depth Drilled (m)	Potential Fracture Zone (m bgl)	Static Water Level (m bgl) at the time of drilling	Discharge (m^3/h) compressor	Major Lithology Encountered
1.	Brindawan-EW	Pakur	92.5	-	2.17	6.12(P)	Rajmahal Trap
2.	Sangrampur EW	Pakur	150	-	-	24.0	Rajmahal Trap
3.	Litipara EW	Litipara	98.35	12-13, 45-46,67-68, 71-72	11.36	9.24	Rajmahal Trap
4.	P. School Kadwa EW	Littipara	160	135.60-138.70	8.10	25.2	Rajmahal Trap
5.	P. School Kadwa OW	Littipara	160	135.60-138.70	8.10	25.2	Rajmahal Trap
6.	Amrapara-I - EW	Amrapara	98	-	1.55 agl	1.08	Rajmahal Trap
7.	Amrapara-II EW	Amrapara	150	-	-	10.0	Rajmahal Trap

S. No.	Location	Block	Depth Drilled (m)	Potential Fracture Zone (m bgl)	Static Water Level (m bgl) at the time of drilling	Discharge (m^3/h) compressor	Major Lithology Encountered
8.	Govt. Basic School, Amrapara EW	Amrapara	153.80	50.74-54.74	6	12.24	Rajmahal Trap and Gondwana
9.	Govt. Basic School, Amrapara OW	Amrapara	153.80	50.74-54.74	6	12.24	Rajmahal Trap and Gondwana
10.	Mohanpur EW	Hiranpur	150	-	-	12.0	Rajmahal Trap
11.	S.T. Residential High School Hiranpur EW	Hiranpur	75.50	49.80-52.80	7	15.84	Rajmahal Trap
12.	S.T. Residential High School Hiranpur OW	Hiranpur	50	42.70-46.80	7.10	20.16	Rajmahal Trap
13.	Pakuria EW	Pakuria	150			8.0	Rajmahal Trap
14.	Primary School Dumarsol EW	Pakuria	153.80	112-113	5	15.84	Rajmahal Trap
15.	Primary School Dumarsol OW	Pakuria	153.80	73.6-74.6	5	15.84	Rajmahal Trap
16.	U.M.School, Patpahari EW	Pakuria	153.80	71-72, 127-128	8	12.24	Rajmahal Trap
17.	U.M.School, Patpahari OW	Pakuria	153.80	71-72, 104-105	8	9.36	Rajmahal Trap
18.	U.H.School, Durgapur EW	Pakuria	74.60	53.30 - 56.30	4.2	36.72	Rajmahal Trap
19.	U.H.School, Durgapur OW	Pakuria	74.60	53.30 - 56.30	4.2	36.72	Rajmahal Trap
20.	Maheshpur EW	Maheshpur	150	-	-	12.0	Rajmahal Trap
21.	JNV, Teliyapokhar EW	Maheshpur	200	178.30 - 181.40	6	25.2	Rajmahal Trap
22.	JNV, Teliyapokhar OW	Maheshpur	200	178.30 - 181.40	6	25.2	Rajmahal Trap

P-Pumping discharge
Source: CGWB

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

- In general in fissured formations, discharge of well has been found in the range of 6-36 m^3/hr.
- Overall in the district the major potential fractures zones are found upto 140 m.
- At come places the potential fractures were encountered at very shallow level below 50 m with very high yielding wells. These potential fractures may be tensile in nature occurring at shallow level, which is found to be potential repository of ground water. Some of the exploratory wells encountered upto the depth of 60m which yielded high discharge eg Amrapara(12.24 m^3/hr), Hiranpur(15.84 m^3/hr), Durgapur(36.72 m^3/hr)
- Some of high yielding well where fractures were encountered between 70-130m depth are Dumarsol(15.84 m^3/hr) Patpahari(12.24 m3/hr) and Litipara(9.24 m3/hr)
- At some occasion potential deep seated fractures were also encountered beyond 130 m depth (130-181 m). The well has yielded copious amount of discharge e.g Kadwa(25.2 m^3/hr) and Teliapokhar(25.2 m^3/hr).

3.3 Geophysical survey: To identify the weathering thickness, depth of bed rock, fractures depth etc. 18 no. geophysical surveys have been carried out in district. The geophysical data was analyzed and interpreted VES result presented in table-9. A total of 18 VES were carried out at 18 locations in the district area of Pakur under aquifer mapping in Jharkhand state locationmap is prepared and presented in figure 9. The VES curves obtained in the area are A, H and HA types (Fig-10 & 11). Interpreted results of VES are given in (Table-9). Based on the results of 13 VES sites, it is observed that in Palkur district the surface soil thickness ranges from 0.75 to 3.0 m. The resistivity varies from 25 ohm-m to 445 ohm-m. The lateritic soil was deciphered at VES site 1, 2, 3, 9 and 17 in Pakur block. It is maximum at VES 4 in Teliya Pokhar site in Maheshpur block. The weathered zone (includes clay) in basaltic terrain extends maximum up 36.93 m depth and generally found within 32.30 m depth. The resistivity of weathered zone ranges 3.5 ohm-m to 85 ohm-m. The thickness of weathered zones vary from 4.25m to 36.9 m. The depth to bottom of weathered zone exceeds 12.5m except VES no. 10. The massive fractured basalt/semi weathered rock deciphered at 8 sites and the resistivity varies from 156 ohm-m to 310 ohm-m and their thickness vary from 1.45m to 53.40m. The depth to bottom have been deciphered at VES sites 6, 8 10 11, 12, 13, 14, 16. The massive rocks have been found very high resistivity in depth. The fractured zones have been delineated empirically (Table-10).

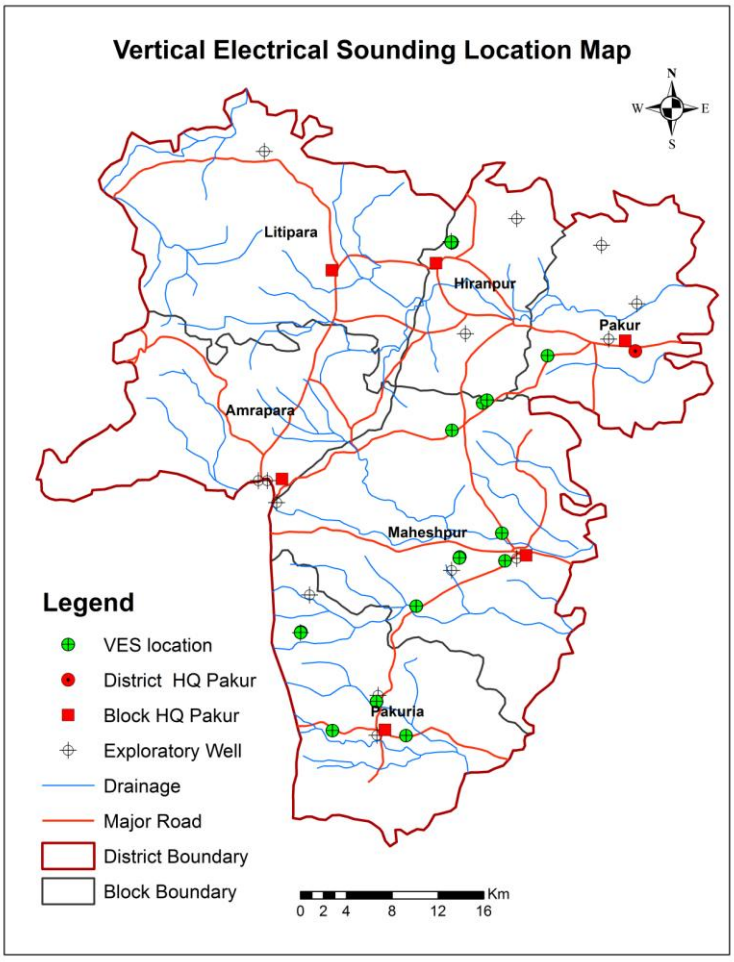


Figure – 9: Location of geophysical Survey map

Table-10: Interpreted results of VES data collected from Pakur district

VES No	Location	Block	Layer resistivity in ohm-m					Layer thickness in m				Total depth in m
			P1	P2	P3	P4	P5	h1	h2	h3	h4	
1	Hiranpur	Hiranpur	935	240	21.5	69	-	1.66	6.17	29.10	-	37.60
2	Hiranpur	Hiranpur	905	248	21.0	63.8	-	1.72	4.67	32.3	-	38.7
3	Hiranpur	Hiranpur	835	335	19.9	165		2.52	7.02	27.00		37.60
4	Tilaiya Pokhar	Maheshpur	305	85	385	-	-	7.16	24.10	-	-	31.30
5	Tilaiya Pokhar	Maheshpur	245	65	455	-	-	1.32	22.30	-	-	23.60
6	Pokhariya	Maheshpur	335	1825	2620	-	-	0.75	15	-	-	15.7
7	Shivatala	Pakur	445	7.5	195	-	-	2.62	11	-	-	13.5
8	Ban Pokhariya	Maheshpur	185	75	335	2035	-	1.07	4.25	14.10	-	19.4
9	Silampur	Maheshpur	570	378	52.5	300	-	1.23	3.53	8.83	-	13.6
10	Shahargram	Maheshpur	1555	310	2975	-	-	2.53	6.26	-	-	8.79
11	Chamarkhi	Maheshpur	895	105	14.5	4715	-	1.7	4.57	6.19	-	12.5
12	Patpahari	Pakuria	325	155	955	VH		0.75	1.45	39.4		41.60
13	Patpahari	Pakuria	85	175	545	1985	-	0.75	9.98	33.9	-	44.60
14	Patpahari	Pakuria	25	156	595	-	-	1.38	17.7	-	-	19.10
15	Haripur	Pakuria	156	9.5	125	-	-	1.77	14.5	-	-	16.30
16	Dumarsol	Pakuria	150	3.50	195	1585	-	2.19	3.95	26.5	-	32.64
17	Baman Pokhar	Maheshpur	120	335	5.80	2455	-	0.75	1.10	17.60	-	19.50
18	Balko	Pakuria	495	5537	28	112	-	0.75	0.194	24.6	-	25.50

REPRESENTATIVE VES CURVES OF PAKUR DISTRICT (JHARKHAND)

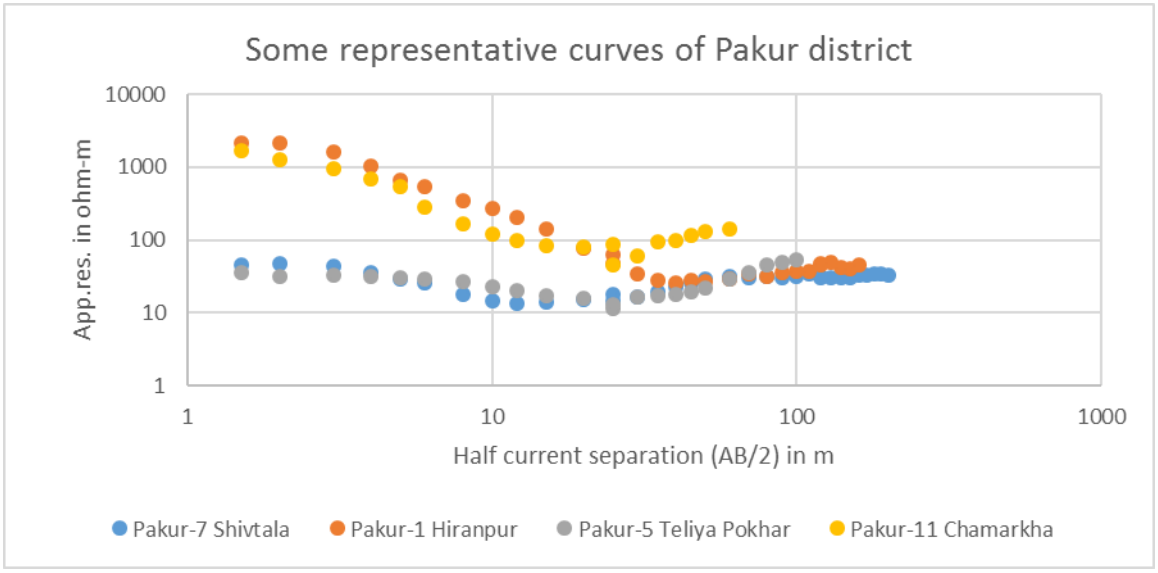


Figure-10 VES curve

REPRESENTATIVE VES CURVES OF PAKUR DISTRICT (JHARKHAND)

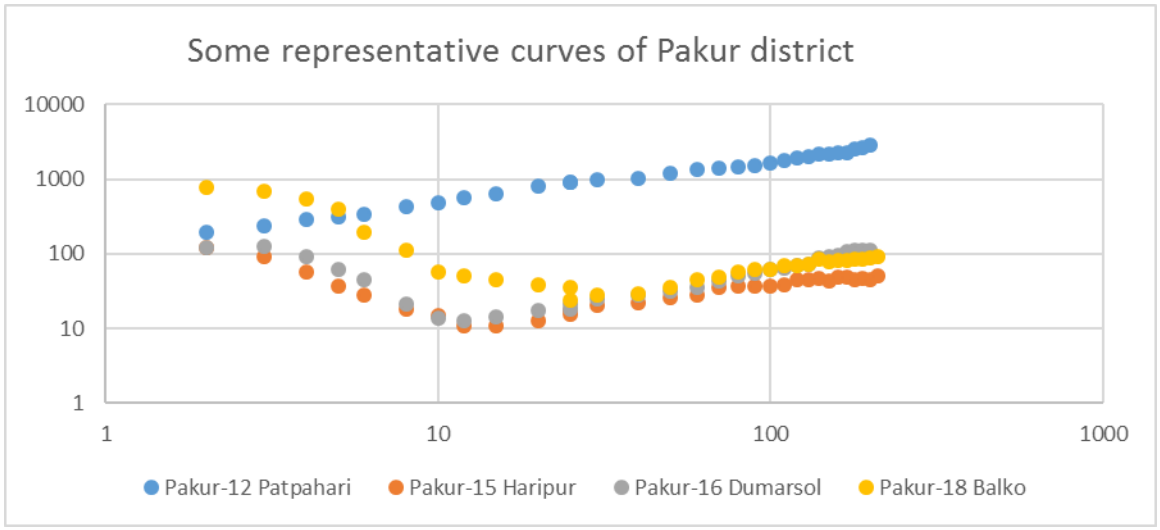


Figure-11 VES curve

Table -11:Details of weathered and semi weathered zones and possible presence of thin fractured zones, Pakur district

VES	Weathered zone			Semi-weathered zone			Fractured zone
	Resistivity (ohm.m)	Thickness (m)	Probable occurrence of weathered zone aquifer up to about (depth in m)	Resistivity (ohm.m)	Thickness (m)	Probable occurrence of semi weathered zone aquifer up to about (depth in m)	Probable occurrence of thin fractured zone aquifer in the depth range (m)
1	21.5	35.30	36.93	-	-	-	70-90, 100-120
2	21.0	30.3	38.7	-	-	-	60-80, 100-110
3	19.9	36.9	37.60	-	-	-	70-90
4	85	24.10	31.30	-	-	-	60-80
5	65	22.30	23.60	-	-	-	-
6	-	-	-	-	-	-	100-110
7	7.50	11.0	13.50	-		-	-
8	75	4.25	5.32	-	-	-	50-70
9	52.5	8.83	13.6	-	-	-	125-135
10	-	-	-	310	6.26	8.79	-
11	14.5	6.19	12.5	-	-	-	30-40
12	-	-	-	155	1.45	2.20	-
13	-	-	-	175	9.98	10.73	120-130
14	-	-	-	156	17.10	19.10	55-65
15	8.50	13.7	18.30	-	-	-	100-110
16	3.50	3.95	6.14	-	-	-	115-125
17	5.80	17.6	19.50	-	-		120-130
18	28	24.60	25.50	-	-	-	-

3.4 Ground water Dynamics

3.4.1 Water Level Scenario – Aquifer – I (Shallow Aquifer): water level scenario of shallow aquifer was generated by utilizing water level data of 29 monitoring wells representing shallow aquifer. The pre monsoon (May 2018) depth to water level monitored between 0.56 to 9.90 mbgl. Minimum water level was observed in Northwestern and southern parts of the district, while maximum water level was observed in Central and Eastern part of the district (parts of Hiranpur, Maheshpur and Pakur blocks). The post monsoon depth to water level (Nov. 2018) in the dug wells ranges from 0.30 to 7.40 mbgl. Northern and southern parts of the district observed minimum water level, while North-eastern and south eastern part of the district (parts of Maheshpur and Pakur blocks) observed maximum water level. Pre-monsoon and post monsoon average depth to water level were calculated 4.45 mbgl and 3.39 mbgl respectively. Pre and post monsoon depth to water level maps were prepared for the year 2018 and presented in figure – 12 & 13.

The water level monitored during pre and post monsoon period 2018 was used to compute the seasonal fluctuation. The seasonal water level fluctuation was observed between 0.08 to 5.55 m for the period between pre monsoon and post monsoon 2018.

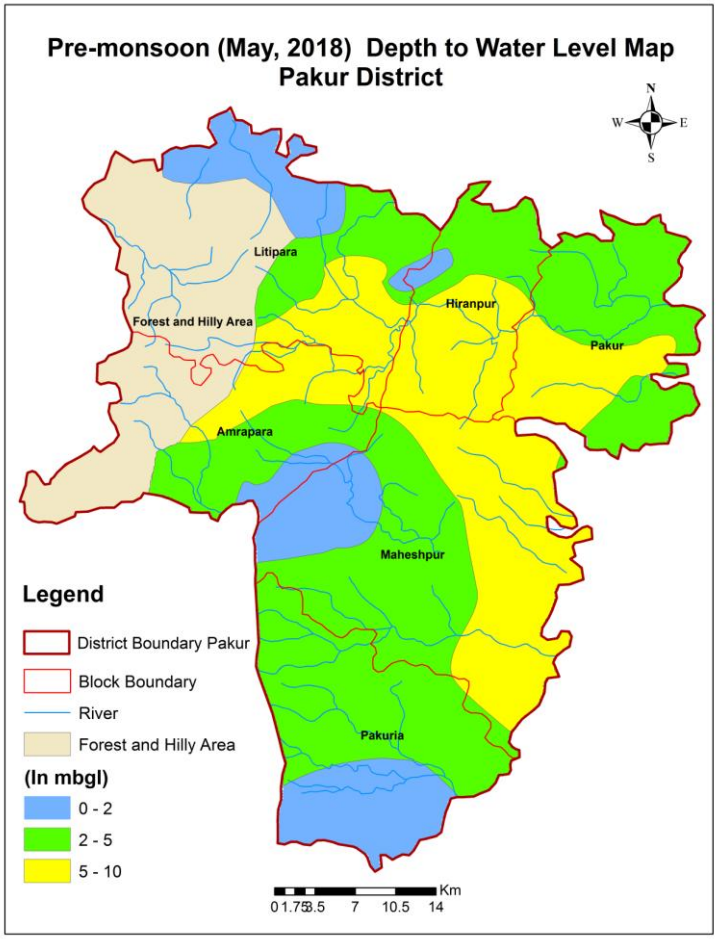


Figure – 12: Pre monsoon (May 2018) depth to water level map of Aquifer – I (shallow aquifer)

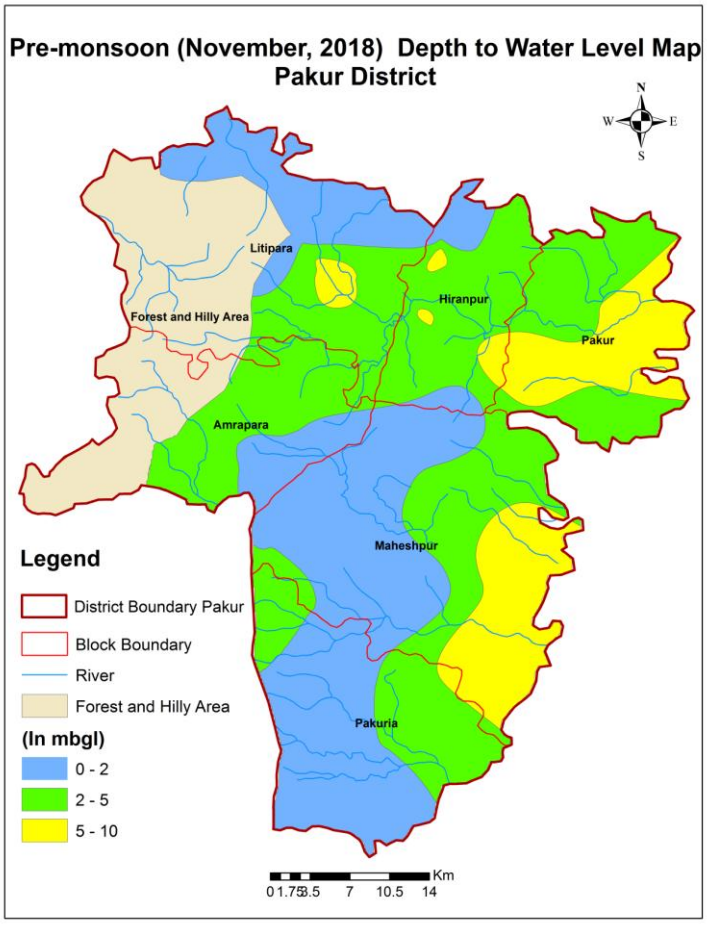


Figure – 13: Post monsoon (Nov. 2018) depth to water level map of Aquifer – I (shallow aquifer)

3.4.2 Long Term Water Level Trend (2010-2019): In order to study long term behavior of the water levels and also the effect of various developmental activities with time, the data for the period 2010-2019 have been computed and analyzed which is presented in table - 12. The pre monsoon water level trend analysis showing declining trend in 28% wells. The post monsoon water level is showing rising trend in 100% wells each. Annually water level trend is showing declining trends anout 28%.

Table – 12: Long term water level trend of Pakur district (2010 – 2019)

		Pre Monsoon		Post Monsoon		Annual	
Sl No.	Location	Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year)
1	Pakuria	0.4489	-	0.1185	-	0.0969	-
2	Salgapara	0.1596	-	0.1785	-	0.0596	-
3	Maheshpur2	0.0721	-		-	-	0.0173
4	Amrapara	0.2152	-	0.2152	-	0.1834	-
5	Pakur1	-	0.0321	0.2087	-	0.0801	-
6	Litipara	-	0.024	0.0347	-	-	0.0226
7	Hiranpur	0.1883	-	0.0455	-	0.1267	-

3.4.3 Hydrograph Analysis

Analysis of five (05) hydrograph network stations, were carried out using GEMS software (Fig-14 a-e) and analysed for the period from 2010-2019. It is observed that the long-term water level trends during pre and post-monsoon seasons are declining trend in two stations and rising trend in three places in shallow aquifer-I represented by dug wells.

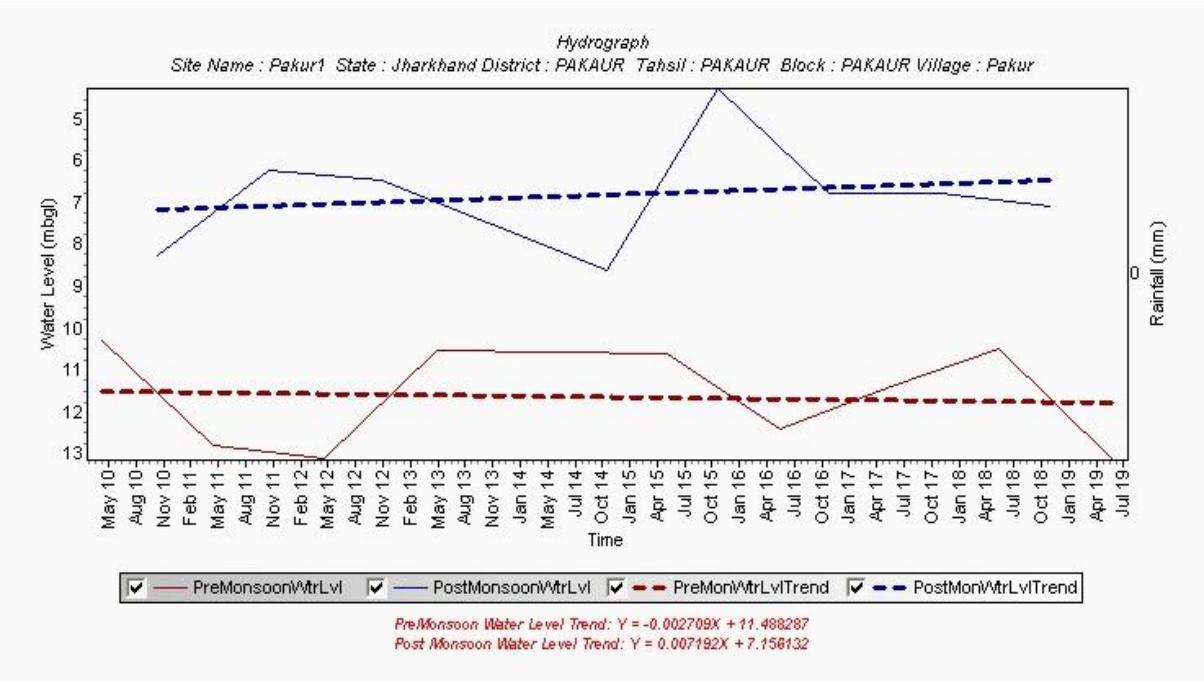


Fig 14a: Hydrograph (2010-2019), Pakur, Pakur block, Pakur district

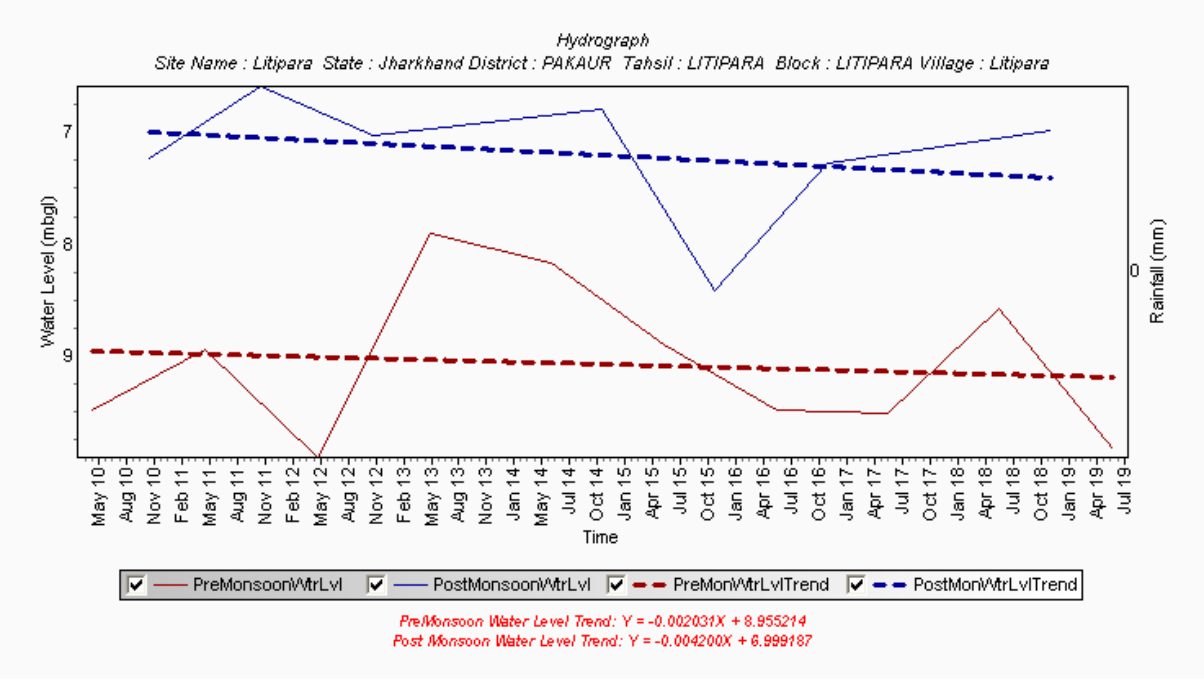


Fig-14b: Hydrograph (2010-2019), Litipara, Litipara block, Pakur district

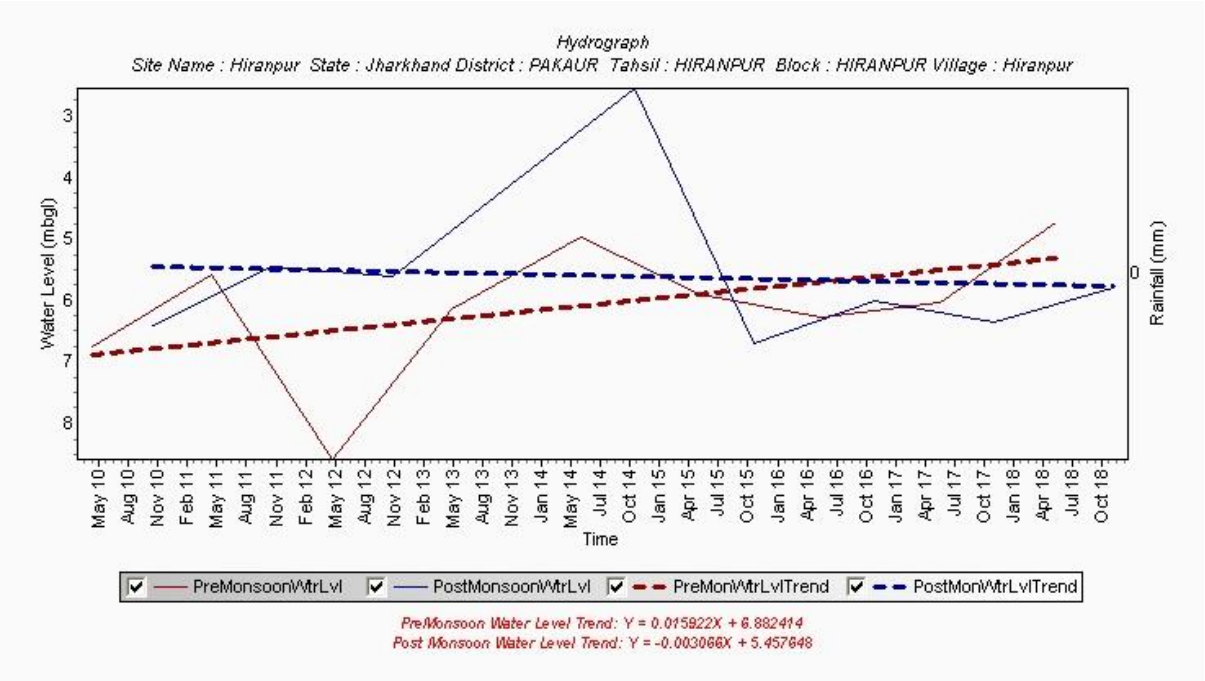


Fig 14c: Hydrograph (2010-2019), Hiranpur, Hiranpur block, Pakur district

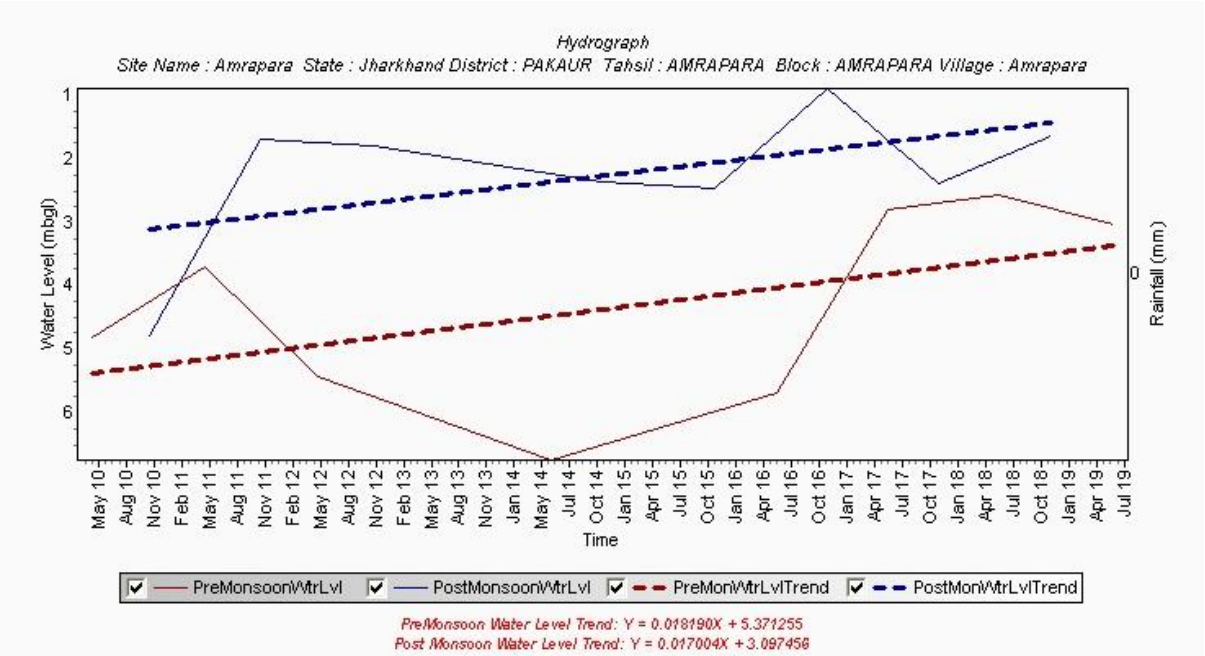


Fig 14 d: Hydrograph (2010-2019), Amrapara, Amrapara block, Pakur district

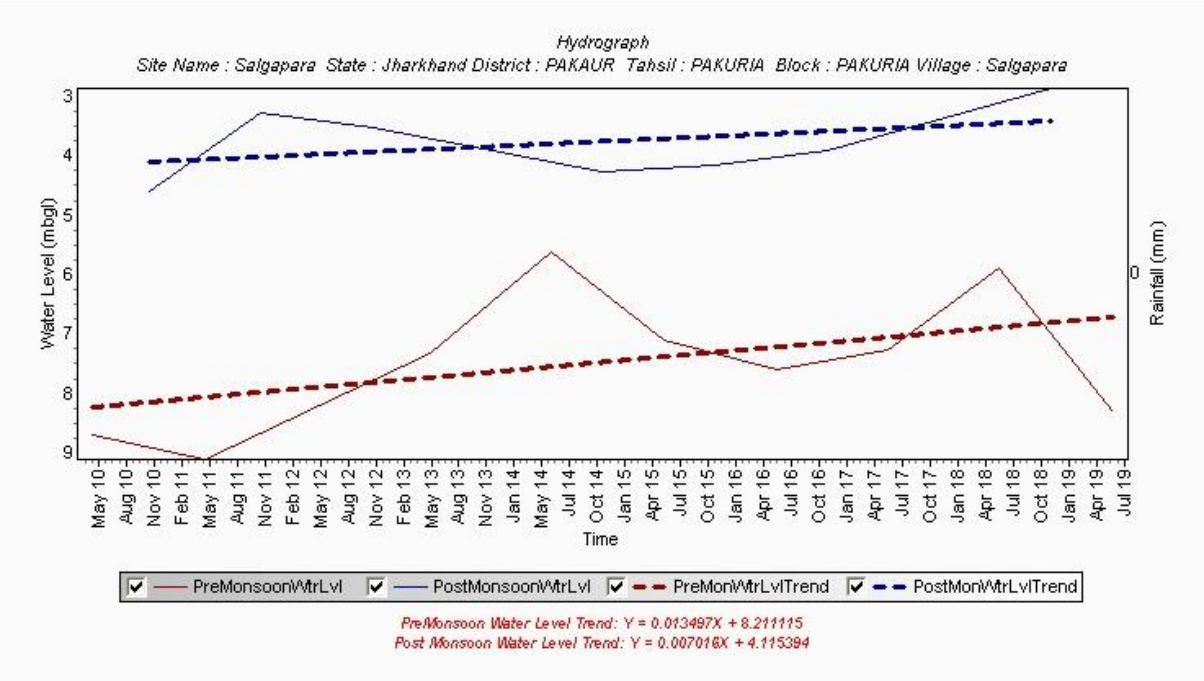


Fig 14 e: Hydrograph (2010-2019), Salgapara, Pakuria block, Pakur district

3.5 Ground Water Exploration: The exploratory data particularly includes the information on sub–surface geology, hydrogeological information and geometry of aquifer in Alluvium as well as in hard rocks. Based on exploration data, prepared litholog of EW & OW, identified the number of flow layer encountered within 200 m depth in basaltic formation Rajmahal trap and presented in table – 13. Drilling details of the exploratory and observation wells are presented in table 13 and also in Annexure-III Litholog of exploratory wells and observation wells are furnished in Annexure – IV.

Table – 13: Summary of bore wells drilled by CGWB in Pakur district

Location	Block	Depth drilled (mbgl)	Fracture encountered between (mbgl)	Discharge (m^3/hr)	T (m^2/day) and Storativity
Brindawan	Pakur	92.5	-	6.12(P)	T-29 m2/day, S- 6.10X10-5
Sangrampur	Pakur	150	-	24.0	-
Litipara	Litipara	98.35	12-13, 45-46,67-68, 71-72	9.24(P)	T-86.29 m2/day
P. School Kadwa	Litipara	160	135.60-138.70	25.2	-
Amrapara	Amrapara	150	-	10.0	T-26 m2/day
Govt. Basic School, Amrapara	Amrapara	153.80	50.74-54.74	12.24	-
Mohanpur	Hiranpur	150	-	12.0	-
S.T. Residential High School Hiranpur	Hiranpur	75.50	49.80-52.80	15.84	-
Pakuria	Pakuria	150		8.0	-
Primary School Dumarsol	Pakuria	153.80	112-113	15.84	-
U.M.School, Patpahari	Pakuria	153.80	71-72, 127-128	12.24	-

Location	Block	Depth drilled (mbgl)	Fracture encountered between (mbgl)	Discharge (m^3/hr)	T (m^2/day) and Storativity
U.H.School, Durgapur	Pakuria	74.60	53.30 -56.30	36.72	-
Maheshpur	Maheshpur	150	-	12.0	-
JNV, Teliyapokhar	Maheshpur	200	178.30 -181.40	25.2	-

3.6 Ground Water Quality:

The quality of water plays prominent role in promoting both the standards of agriculture production and human health. To evaluate the quality of ground water, samples have been collected from 18 dug wells The analytical results of water samples dug wells are given in annexure-V. The ground water samples were analyzed for major chemical constituents by using standard procedure at chemical laboratory in CGWB, MER, Patna. These samples have been considered to assess the chemical quality of ground water and its suitability for drinking and irrigational purposes. Since the samples are collected from the dug wells, they represent the quality of Aquifer I (phreatic/ shallow zone) of ground water.

3.6.1 General Range Of Chemical Parameters of Aquifer – I : -

Evaluation of ground water suitability in relation to its different purposes has been classified for drinking / domestic and irrigation. Water is very essential for life. Many a times it has raw consumption or indirectly (in food). Hence, it should be free from turbidity, odor, bacterial and poisonous contents and also chemically soft, low T.D.S value and other chemical constituents should range within low to tolerable limits. Excessive and longer use of water beyond these limits may endanger too many health problems. The variation range of the concentration in ppm of different chemical constituents and quality parameters of Aquifer I (dug wells samples) in tables 14.

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

Hydrogen ions activity:

It is expressed in terms of pH and shows the acidity & basicity of the solution. Natural water reacts with H+ & H- ions and forms H3O or ions. The recommended limit (6.5 to 8.5) by BIS, 2012 is base on taste, corrosion and scale formation criteria. The pH value in Aquifer-I ranges from7.13-8.40.

Electrical Conductivity:

Generally, the water's electrical conductivity increases in the dry periods because of evaporation and decreases in the rainy days because of the precipitation and also to the surface runoff flow into reservoir. The EC value in Aquifer-I ranges from 163-1338 micro siemens/cm at 25^0c

Carbonate & bicarbonate:

Naturally occurring carbondioxide is the foremost source of carbonate and bicarbonate ions in ground water along with the carbon cycle and carbonaceous rocks. Leaching of calcite or dolomite bearing rocks (mainly carbonate) is also a principal source of these ions at places. Carbonate content of the area is not detectable. The bicarbonate concentration ranges between 61.5-209.10 ppm

Chloride:
The chloride anions in a certain water environment are characterized by a high stability. Thus, the concentration of chlorides shows little change after long flow distance because the dissolution of chloride is greater in water and the reaction between Cl- and other ions in stratum is insignificant. The Chloride concentration ranges between 6.92-209.10 ppm

Fluoride:
Its low solubility in water makes it different form the rest of halogen family. Fluoride geochemistry is mainly governed by fluoride bearing minerals found in Chotanagpur Gneissic complex.The main sources are fluorite (CaF_2), fluorapatite & other minerals present in rocks contributing the ion in water. The Flouride concentration ranges between 0.15-1.14 ppm

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

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

The Sulphate value ranges between 2.10-89.43 ppm

Sodium:
Sources of sodium are halite, sea spray, brines and some silicates. Common sodic silicates include plagioclase. The only common sink for sodium is reverse ion exchange that occurs when highly saline waters come in contact with calcium rich clays.
The Sodium concentration ranges between 4.73-58.66 ppm.

Calcium: In mineral form, it is found as Calcite, aragonite, gypsum, anhydrite, anorthite, diopside etc. The Calcium concentration ranges between 14-116 ppm

Magnesium:
The most common source of large quantities of magnesium in natural waters is dolomite. Magnesium is also derived from the silicates olivine, pyroxene and amphibole. The main sink is montmomorillonite. The Magnesium concentration ranges between 8.5-48.60 ppm

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

Hardness range (mg/l CaCO3)	-	Class
0- 60	-	Soft
61-120	-	Moderately hard
121-180	-	Hard
>180	-	Very Hard

In the study area, the total hardness value ranges from 75-455 ppm.

The variation range of the concentration in ppm of different chemical constituents and quality parameters of Aquifer I (dug wells samples) in tables 13.

Table-14: Ranges of chemical constituents of Aquifer – I

Chemical Constituents and quality parameters	Aquifer – I (Dug well samples)
pH	7.13 – 8.40
EC (micro siemens/cm at 25^0c)	163 – 1338
TDS (ppm)	104.32 -856.32
TH as $CaCo_3$ (ppm)	75 – 455
Ca (ppm)	14 – 116
Mg (ppm)	8.5 – 48.60
Na (ppm)	4.73 – 58.66
K (ppm)	0.27 – 4.25
HCO_3 (ppm)	61.5 – 209.10
Cl (ppm)	6.92 – 209.10
SO_4 (ppm)	2.10 – 89.43
NO_3 (ppm)	1.90 – 158
F (ppm)	0.15 – 1.14

The ground water of Aquifer – I (shallow aquifers) in the area is alkaline in nature. On the perusal of table - 14, the pH value of the area is 7.13 – 8.40. The TDS value is varies between 104.32 -856.32 mg/l. Overall values of Calcium and Magnesium varies between 14 – 116 mg/l and 8.5 – 48.60 mg/l in the area respectively. Nitrate concentration is observed between 1.90 – 158 mg/l while the Fluoride value varies from 0.15 – 1.14 mg/l within the area.

3.6.1.1 Suitability Of Ground Water Of Aquifer–I For Drinking Purposes: - The suitability of ground water for drinking purposes is determine on the basis of drinking water specification adopted by the Bureau of India Standards IS 10500 – 91 Revised 2012 and approved by World Health Organization (WHO). The number of water samples falling under various categories of permissible and desirable limits of various constituents and its percentage are given in table – 15 in Aquifer – I.

Table-15: Suitability of ground water of Aquifer- I for drinking purposes

Chemical constituents and quality parameters	Ranges Desirable		No. of samples under desirable limits	No. of samples under permissible limit	No. of samples under excessive limits
	Desirable limit	Permissible limits in the absence of alternate source			
Ph	6.5 to 8.5	No relaxation	18 (100%)	Nil	Nil
TDS (ppm)	500	2000	18 (100%)	Nil	Nil
TH as $Caco_3$ (ppm)	200	600	18 (100%)	Nil	Nil
Ca (ppm)	75	200	18 (100%)	Nil	Nil
Mg (ppm)	30	100	18 (100%)	Nil	Nil
Cl (ppm)	250	1000	18 (100%)	Nil	Nil
SO_4 (ppm)	200	400	18 (100%)	Nil	Nil
HCO_3 (ppm)	200	600	18 (100%)	Nil	Nil
NO_3 (ppm)	45	No relaxation	15 (83.33%)	Nil	3 (16.67%)
F (ppm)	1.0	1.5	18 (100%)	Nil	Nil

The table- 15 indicates that all the water samples are falling in desirable to permissible category except Nitrate. The value of Nitrate is observed beyond permissible limit (> 45 mg/l) in 03 samples.

3.6.1.2 Suitability of Ground Water of Aquifer – I for Irrigation Purposes:

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

3.6.1.2.1 Classification of Irrigation Water Sodium Adsorption Ratio (SAR):-

The diagram illustrates the salinity and sodium hazards of irrigation water. It assumes that water is used under average conditions with respect to soil texture, drainage, infiltration rates, quantity of water used, climate and tolerance of crops. The diagram for the classification of irrigation water is based on salinity hazard i.e. Electrical Conductivity in µS/cm at 25º C versus the Sodium hazard i.e. Sodium Adsorption Ratio (SAR) for Aquifer-I has been classified.

The Sodium adsorption ratio (SAR) is an irrigation water quality parameter used in the management of sodium-affected soils. It is an indicator of the suitability of water for use in agricultural irrigation, as determined from the concentrations of the main alkaline and earth alkaline cations present in the water. In Pakur district all 18 water samples collected during the field falls in the (0-10) C1 category, ground water is excellent for irrigation.

Table:16 Sodium Adsorption Ratio

Sodium Hazards Class	SAR (meq/L)	Remarks	Study area quality
C1	0-10	Excellent	All (18 sample)
C2	10-20	Good	
C3	20-26	Doubtful	
C4	>26	Unsuitable	

3.6.1.2.2 Residual sodium carbonate (RSC) and Soluble Sodium Percent (SSP)

The potential for a sodium hazard and Residual sodium carbonate (RSC) are directly proportional, and much of the calcium and magnesium are precipitated out of solution when water is supplied to the soil. In study area all (18) water samples are good for irrigation based on Soluble Sodium Percentage (SSP) and Residual Sodium Carbonate (RSC)

Table: 17 Soluble Sodium Percent (SSP) and Residual sodium carbonate (RSC)

Parameter	Range	Water Class	Sample	Percentage
Soluble Sodium Percentage (SSP)	< 50	**Good**	**18**	**100**
	>50	Bad	0	0
Residual Sodium Carbonate (RSC)	**< 1.25**	**Good**	**18**	**100**
	1.25 – 2.50	Doubtful	0	0
	>2.50	Unsuitable	0	0

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

To better understanding the suitability of ground water for irrigation purpose chemical result of collected water samples have been analyzed and described the different water class based on Electrical Conductivity (EC) which is presented in table – 18. On The perusal of table 17, about 5% water samples are excellent 95 % of water samples of Aquifer – I (dug well) falling under good to permissible water class.

Table- 18: - Classification of ground water of Aquifer – I based on EC

Sl. No.	Water Class	Ranges of EC	No. of samples falling and their percentage
			Aquifer – I
1	Excellent	< 250	01 (5%)
2	Good	250 – 750	15 (84%)
3	Permissible	750 – 2250	02 (11%)
4	Unisuitable	>2250	00 (0%)

3.6.1.2.4 Piper Diagrame for Classification of Irrigation Water:-

Based on the major cation and major anion content in the water samples and plotting them in the trillinear diagram, hydrochemical facies could be identified. In Aquifer I cation chemistry out of 18 samples 15 samples are no dominant type 3 samples are Calcium dominant. In anion part 14 samples are Bicarbonate dominant, 1 sample is no dominant (mixed typed) and 3 samples are Chloride dominant. In the dimond part plotted chemical falling 14 samples are Magnesium bicarbonate type (Mg-HCO_3) and 4 samples are mixed type of Calcium chloride and Magnesium Bicarbonate. The Diamond part of the Piper Diagram reveals that most of the water samples fall in the hardness region. Figure 15 and 16 si given below.

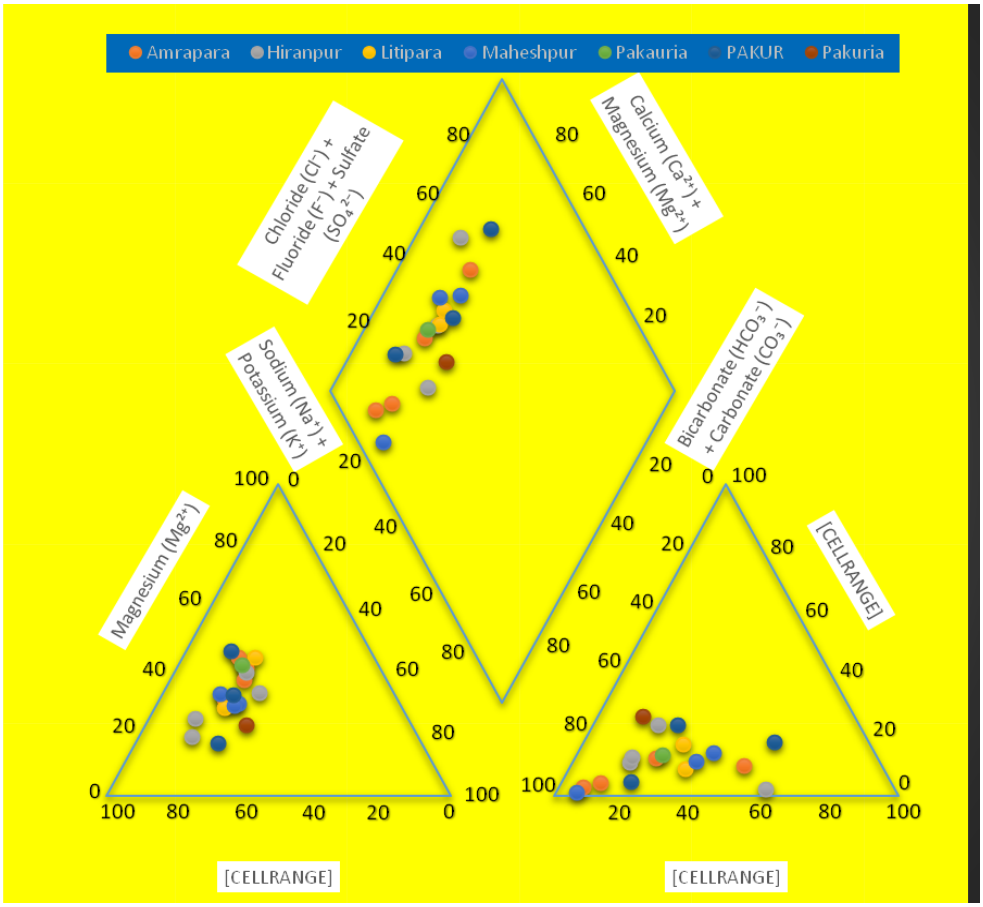


Figure:-15 Piper Diagrame for Aquifer – I

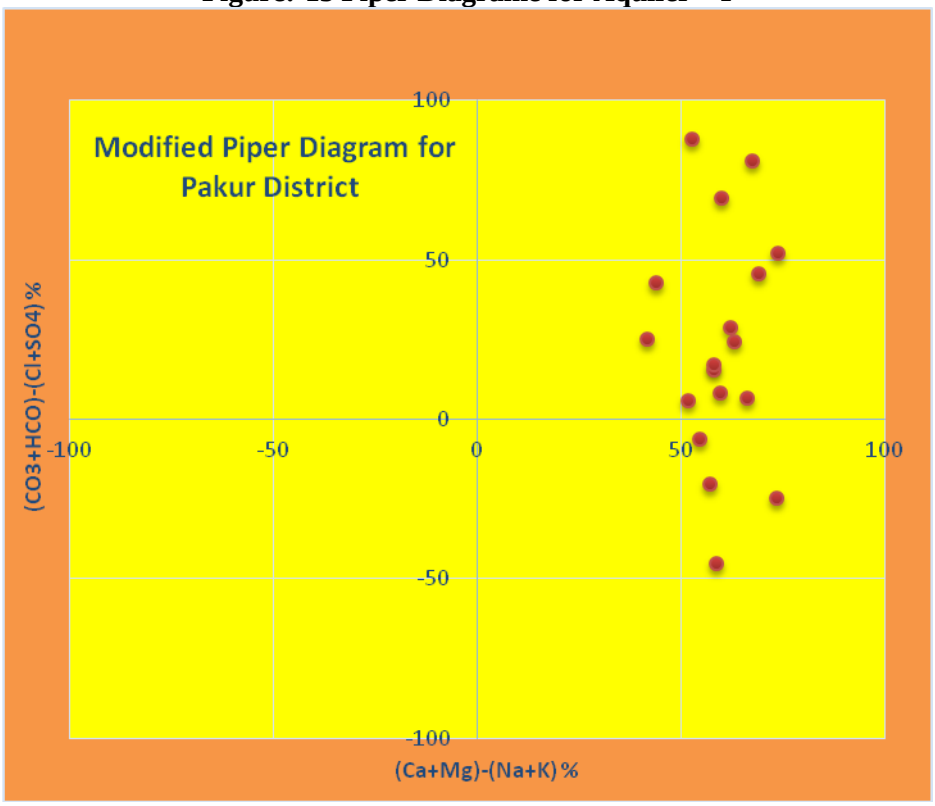


Figure:-16 Piper Diagrame modified by Gibbs for Aquifer – I

3.6.2 Uranium in Ground Water

Total 10 samples were analysed for uranium concentration in Pakur district. Uranium concentrations in Pakur district were found to be in the range of 0.01-0.78 ppb. All the samples are under permissible limit. The detail results of chemical analysis for uranium are in Annexure-VI.

3.7 3-D and 2-D Aquifer Disposition

The 3-D map in hard rock area of the district showing spatial disposition and vertical extent of Aquifer-I indicating its depth of weathering while the Aquifer – II showing occurrence of fractured rock thickness is presented in figure – 17. Based on the drilling data of exploratory wells and geophysical survey, depth of Aquifer - I (weathered zone) in hard rock area ranges from 6- 36.0 m. The depth of Aquifer – II (fracture zone) ranges from 12-181 mbgl. Well yield of Aquifer-II varies from 1-36 m3/hr

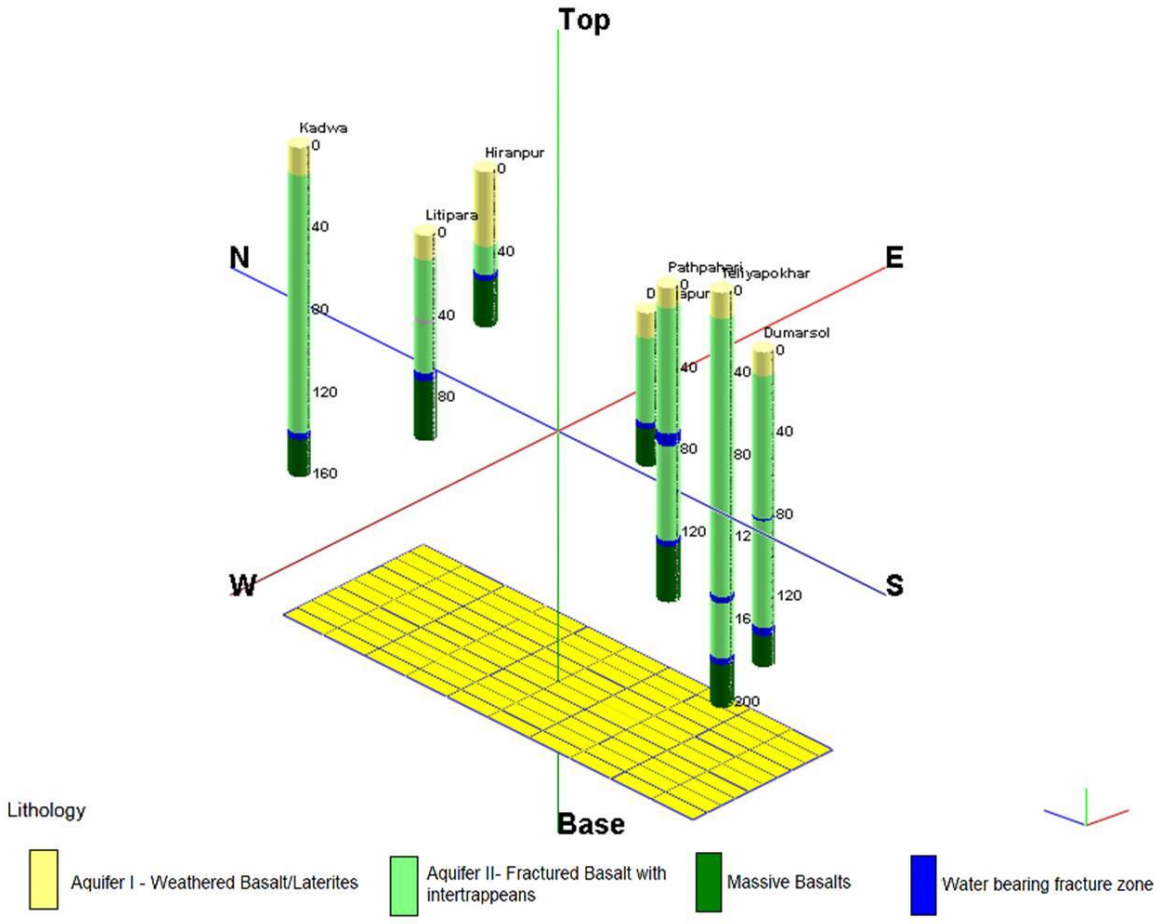


Figure –17: Three dimensional strip-log of EW drilled in Rajmahal Traps of Pakur district

3.8 Hydrogeological Cross Section: To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. A-A', B-B' , C-C' and DD' representing representing the study area.

3.8.1 Hydrogeological cross section A-A':

Hydrogeological cross section A-A' represents the area in Southern part except the alluvial portion of Pakur district. The data of 5 exploratory wells i.e.Kadwa, Litipara, Durgapur, Pathpahari & Dumarsol. The Aquifer- I ranges 6- 14 m representing weathered Basalt and Laterites, while Aquifer-II ranges from 12-138 m representing Fractured Basalt. Generally 1-4 fracture zones were found. Hydrogeological cross section of A-A' is shown in figure- 18.

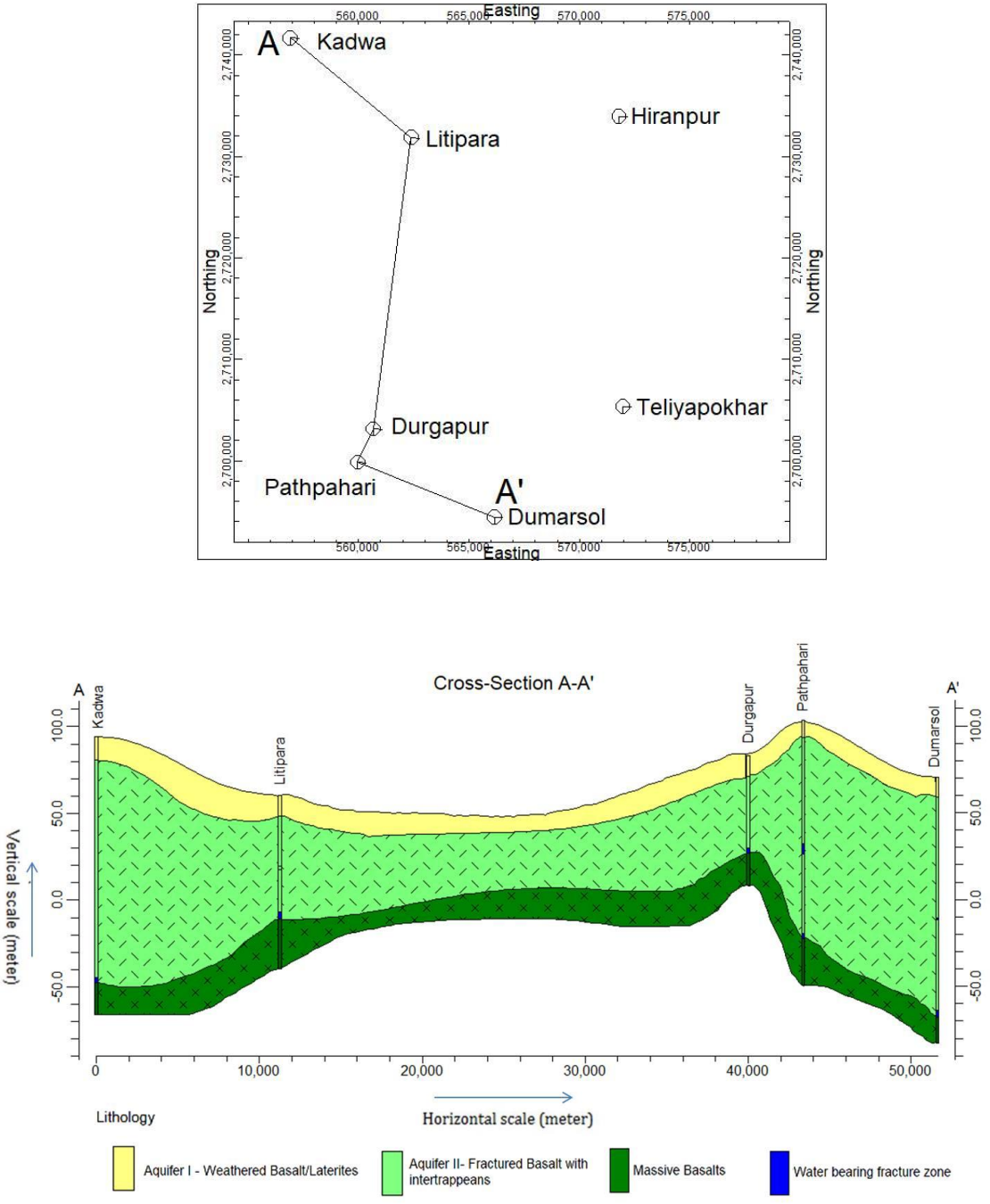
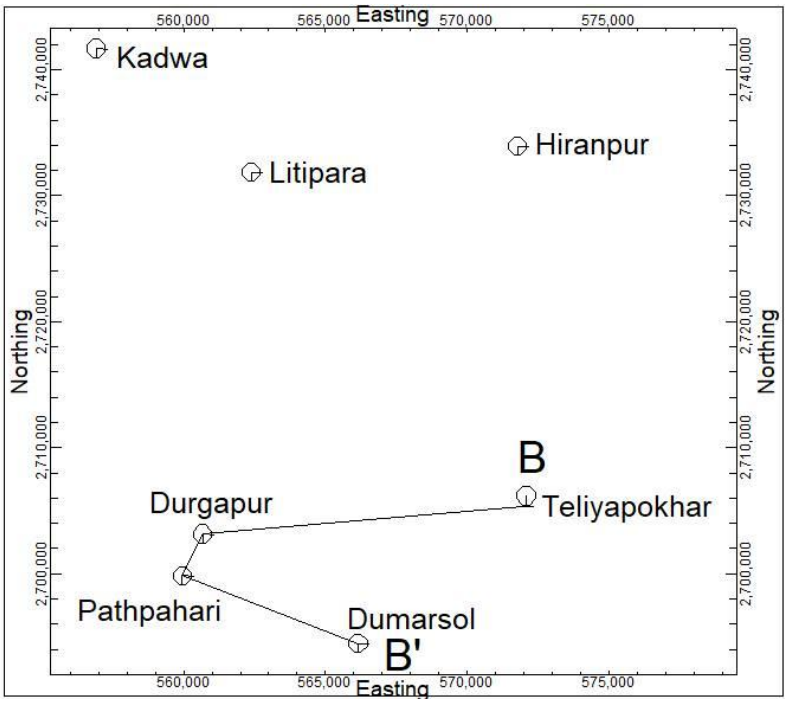


Fig-18: Hydrogeological cross section along A-A' and location map

3.8.2 Hydrogeological cross section B-B':

Hydrogeological cross section B-B' represents the area in Northern Part of Pakur district. The data of 3 exploratory wells i.e. Teliapokhar, Durgapur, Pathpahari & Dumarsol have been considered. The Aquifer- I ranges 6-13 m representing weathered Basalt and Laterites, while

Aquifer-II ranges from 12-181 m representing Fractured Basalt. Generally 2-3 fracture zones were encountered. Well yield varies from 9-36 m3/hr. Hydrogeological cross section of B-B' is shown in figure- 19.



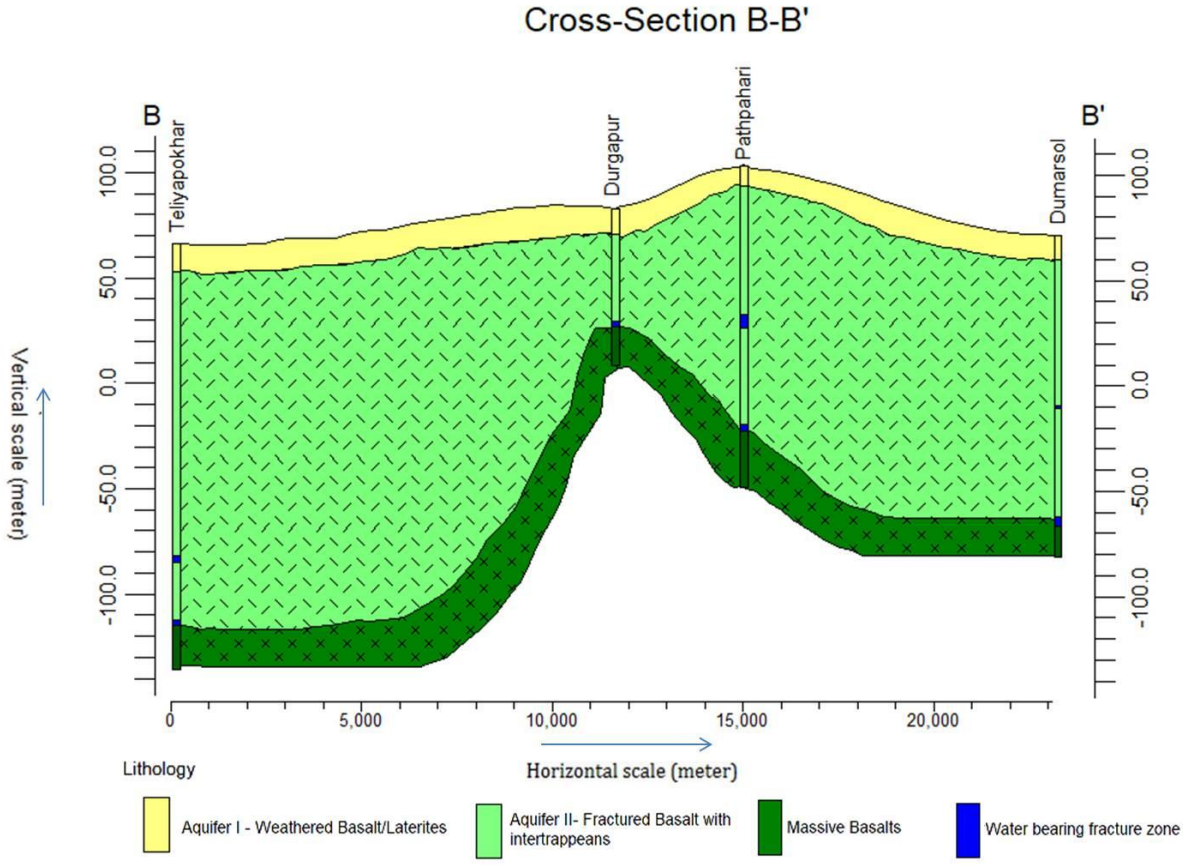
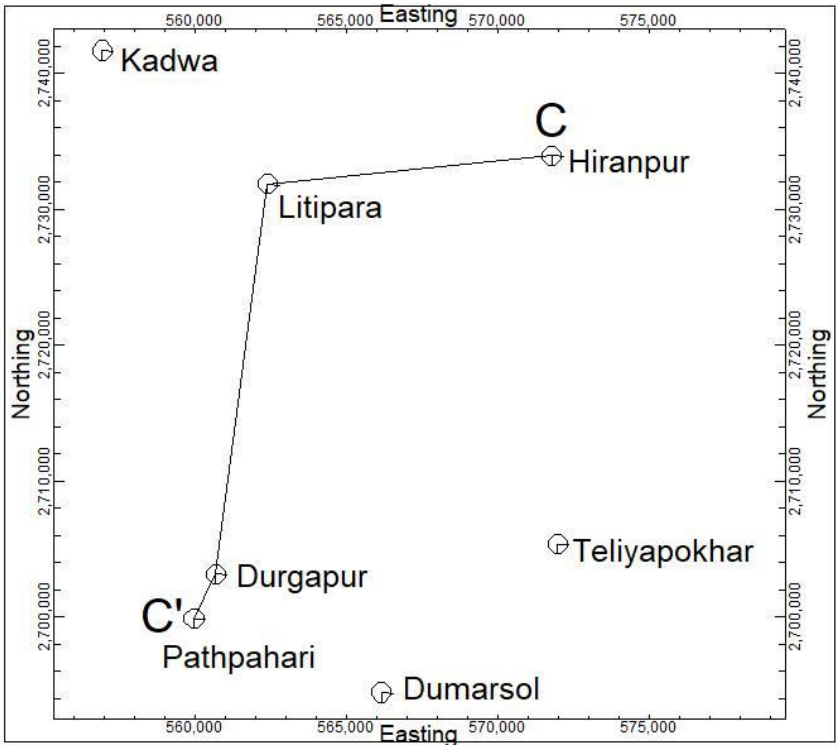


Fig-19: Hydrogeological cross section along B-B' and location

3.8.3 Hydrogeological cross section C-C'

Hydrogeological cross section C-C' represents the area in Western Part of Pakur district. The data of 4 exploratory wells at Hiranpur, Litipara, Durgapur & Pathpahari has been considered. The Aquifer- I ranges 6-36 m representing weathered zone, while Aquifer-II ranges from 12-127 m representing Rajmahal Traps. Two number Water were encountered. Hydrogeological C-C' strip log is shown in figure- 20.

.



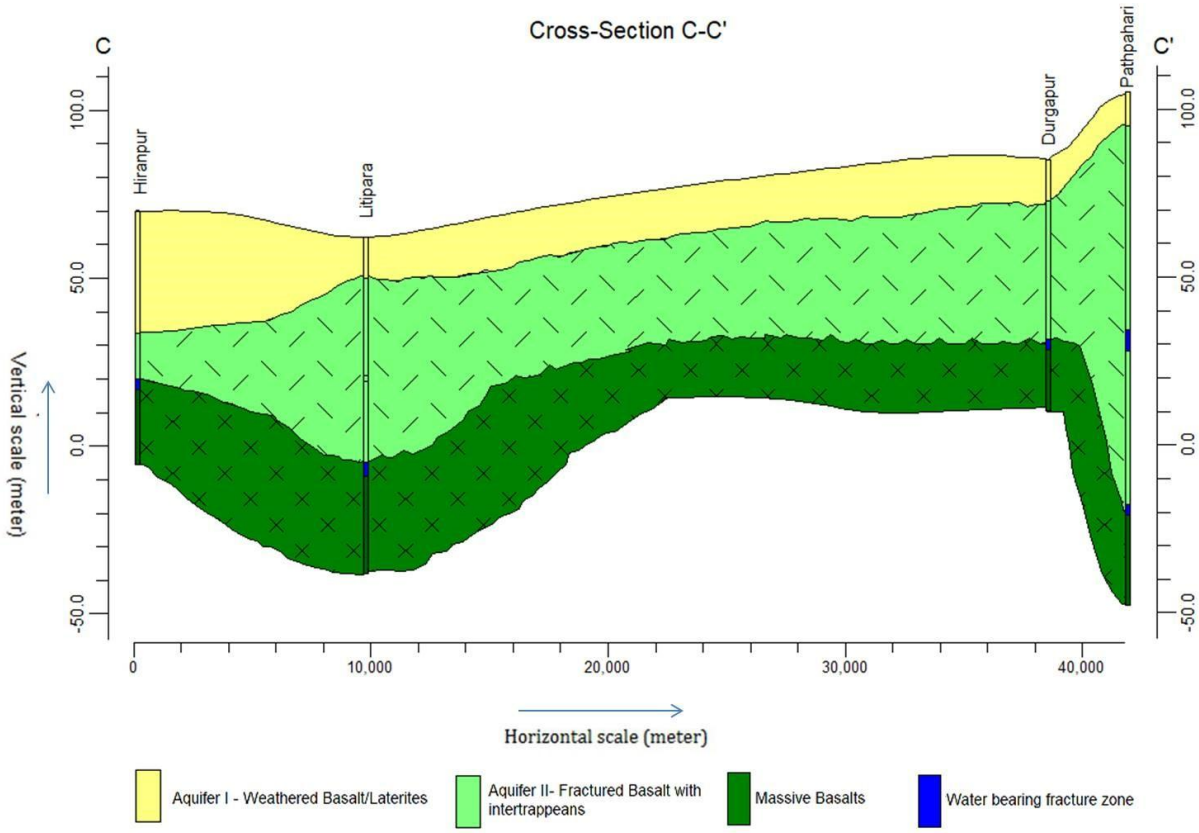


Figure -20: Hydrogeological cross section along C-C'

3.9 Aquifer Charcteristics

To know the aquifer Characteristics, Step Drawdown test (SDT) and Aquifer Performamce Tests (APT) were conducted. Summarized deatisl of Exploratory drilling in Pakur district is given below in Annexure-III.

Basalt forms the main aquifer of the area and comprises two distinct units viz, upper vesicular unit and lower massive unit. The massive basalt is hard, compact and does not have primary porosity and hence impermeable. Weathering, jointing and fracturing induces secondary porosity in massive unit of basalt. In vesicular basalt, when vesicles are interconnected constitutes good primary porosity and when the vesicles are filled/ partly filled the porosity is limited. Ground water occurs under phreatic/ unconfined to semi-confined and confined conditions in basalts.

Average thickness of fractures in Aquifer-II is about 2.0 m. Along with yield potential, the aquifer parameters viz., transmissivity and storativity also form an important aquifer characteristic and provide valuable input on sustainability of the aquifers. The transmissivity of Aquifer-II ranges from 29-86 m^2/day, whereas storativity of the aquifer were recorded $06.10X10^{-5}$ to 1.3x10-2. Summarised Aquifer characteristic of Pakur district (hard rock area) has been given in Table-19

Table 19: Aquifer characteristic of Pakur district (hard rock area)

Type of aquifer	Formation	Depth range of the aquifer	SWL (mbgl)		Thickness	Yield	Aquifer parameter	
			Pre Monsoon-2018	Post Monsoon-2018		(m3/hr)	T (m^2/day)	Sy/S
Aquifer - I	Laterites/ Weathered basalt	6-36 m	0.56-9.90	0.30-7.40	2-5 m	5-10	-	-
Aquifer - II	Jointed/ fractured basalt	12-181 m	-		3-4 m	Upto 36.00	upto 86.29	1.3x 10-2 to 06.10X10^{-5}

4. GROUND WATER RESOURCE

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

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

The methodology for ground water resources estimation is based on the principle of water balance as given below –
Inflow – Outflow = Change in Storage (of an aquifer)
The equation can be further elaborated as

ΔS= RRF+RSTR+RC+RSWI+RGWI+RTP+RWCS±VF ± LF -GE-T-E-B

Where,
ΔS – Change is storage, RRF – Rainfall recharge, RSTR- Recharge from stream channels
RC – Recharge from canals, RSWI – Recharge from surface water irrigation
RGWI- Recharge from ground water irrigation, RTP- Recharge from Tanks & Ponds
RWCS – Recharge from water conservation structures, VF – Vertical flow across the aquifer system, LF- Lateral flow along the aquifer system (through flow), GE-Ground Water Extraction, T- Transpiration, E- Evaporation, B-Base flow

The dynamic Ground Water Resources has been assessed as on March 2020 by CGWB, SUO, Ranchi in association with State Ground Water Direcorate, Jharkhand based on GEC, Methodology 2015. The summarized detail of Ground Water Resources Availability, Draft and Stage of GW Development of pakur district (GWR-2020) is in Table-20.

Table- 20: Ground Water Resources Availability, Draft and Stage of GW Development of pakur district (GWR-2020)

(Figures in hectare meter)

Assessment Unit/ District	Annual Extractable Ground Water Recharge	Current Annual Ground Water Extraction for irrigation	Current Annual Ground Water Extraction for domestic	Current Annual Ground Water Extraction for industrial	Current Annual Ground Water Extraction for All uses	Annual GW Allocation for for Domestic Use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction
Amrapara	2712.23	174.50	86.15	0.00	260.66	86.75	2450.97	9.61
Hiranpur	1965.40	211.00	110.95	0.00	321.95	111.72	1642.68	16.38
Litipara	2385.46	54.5	139.48	0.00	193.98	140.45	2190.51	8.13
Maheshpur	8050.16	952.00	275.61	0.00	1227.6	277.52	6820.65	15.25
Pakur	4086.72	339.00	360.32	22.44	721.76	362.83	3362.45	17.66
Pakuria	2815.48	180.5	143.27	0.00	323.77	144.27	2490.71	11.50
District Total	**22015.45**	**1911.5**	**1115.78**	**22.44**	**3049.72**	**1123.54**	**18957.97**	**13.85**

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

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

SGWR = A *(Z2 - Z1) * SY

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

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

Table 21: Assessment of In-storage ground water resource of hard rock

AQUIFER I	
Area (A) (sq km)	1805
Pre-monsoon (average) depth to water level (mbgl) (Z1)	4.45
Bottom of Unconfined Aquifer (mbgl) (Z2)	14.33
Specific yield (Sy)	3%
Saturated zone thickness (Z2-Z1) of aquifer (ST)	9.88
SGWR = A *(Z2 - Z1) * SY	535 mcm

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

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

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

Total Availability (Mcm) = 220.15 *mcm + 535.00 mcm = 755.15 mcm*

5. GROUND WATER RELATED ISSUES

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

5.1 Low Ground Water Development: One major issue of the area that is low ground water development. At present the overall stage of ground water development is only around 13.85%. Block wise stage of ground water development (SOD) is varies from 8.13 to 17.66 percent. Graphical presentation of SOD is shown in figure – 21.

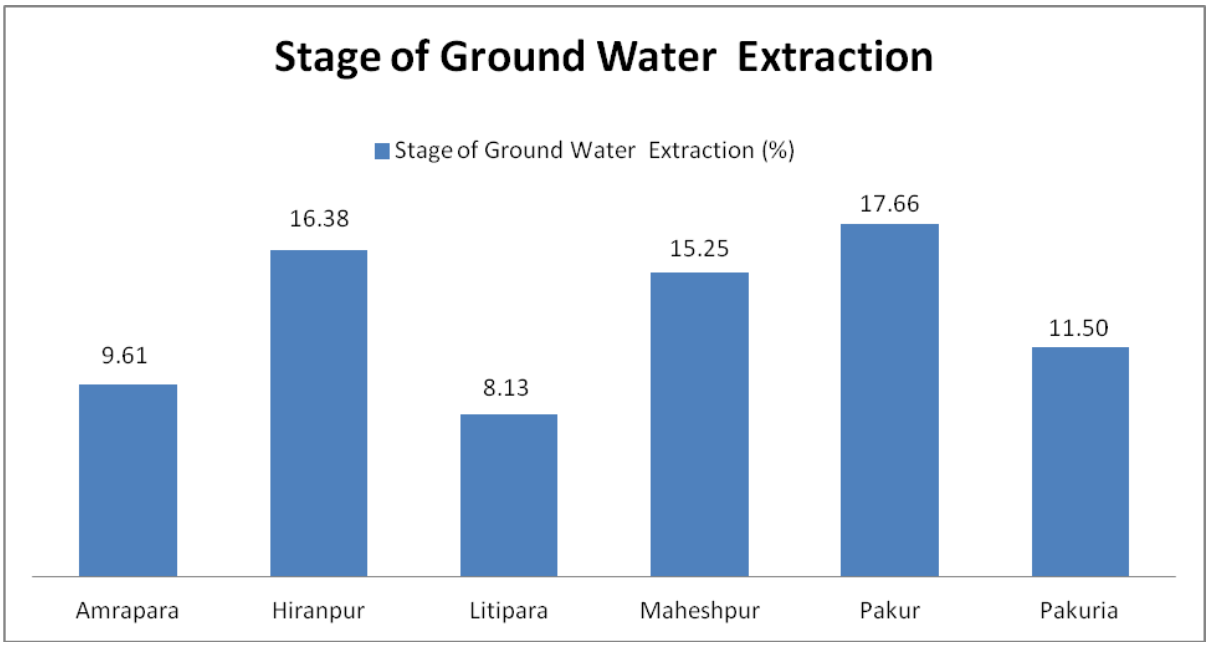


Figure -21 Graphical presentation of block wise ground water SOD of Pakur district

5.2 Low Ground Water Potential / Limited Aquifer Thickness / Sustainability: Central Ground Water Board has constructed 17 exploratory and 7 observation wells in hard area of the district. The percentage of success bore wells is moderate. Out of 17 Exploratory wells, 1-dry, 2 are in <1 lps, 4 in 1-3 lps , 9 in 3-10 lps and 1 in > 10 lps discharge zone. The fracture zone is 3-4 m only. Transmissivity value is also very low which varies from 26 to 86.29 m^2/day in hard rock area. Lithological condition is also not favourable for deep drilling due to occurrence of series of impermeable clay layer of intertrappean beds. Also red bole, black bole, gray bole etc. are collapsible in nature with contact of water. The yield of bore wells drilled in the area is classified and presented below in figure – 22.

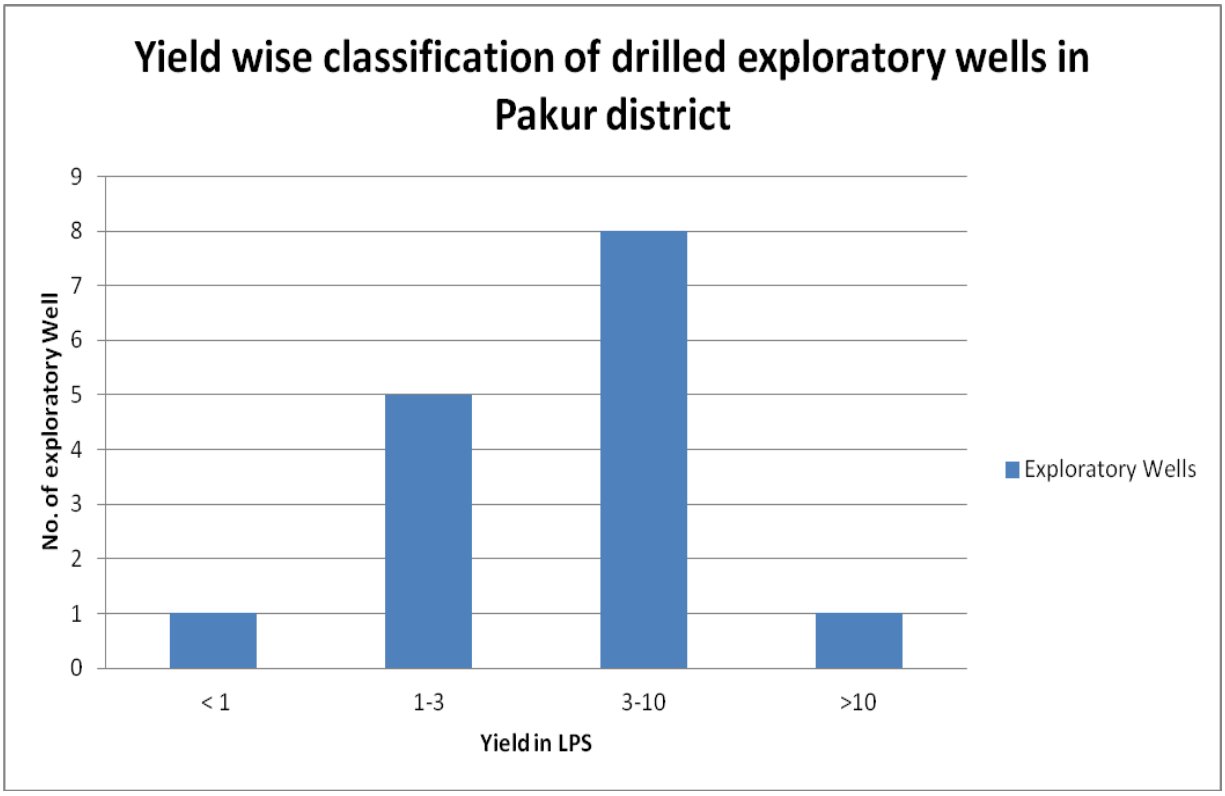


Figure – 22: Yield wise classification of bore wells drilled in Pakur district

5.3 Ground water contamination:-

Analytical result of water samples collected from the district, it is found the Nitrate concentration is beyond permissible limit in 3 samples out of 18 samples of shallow aquifer (dug well).

5.3.1. Nitrate contamination: -

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

In shallow well aquifer 3 water samples out of 18 have been found more than the permissible limit of NO3 (45mg/l). Location details of NO3 concentration found beyond permissible limit is given in table 22.

Table 22: Nitrate concentration found beyond permissible limit

Sl. no	Village	Block	Concentration NO_3
1	Kalajhor	Amrapara	***52.7***
2	Shibtola	Pakur	***68.0***
3	Harishpur	Pakur	***158.0***

6. MANAGEMENT STRATEGIES

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

6.1 Ground Water Resource Development Strategy: In view of above, the focus of proposed management plan was to enhance the overall ground water development from the present 13.85% to 70%. Total 36862 dug wells (15-20 m depth) are recommended to be constructed in feasible areas. Similarly, 12288 shallow depth bore wells (60 - 90 m depth,) are also recommended to be drilled in feasible areas. Proposed number of abstraction structures are based on SOD 70% with future irrigation potential & unit draft (Dugwell-0.4 ha, BW- 1.2 ha).Proposed number of abstraction structure are given in Table-23

Table – 23: Future Irrigation Potential & Proposed number of Abstraction Structures based on SOD 70%

Block	Net GW Availability for Future Development	future irrigation potential available (ham) considering (Δ) 0.45m	70% of future irrigation potential to be created (ham)	Proposed number of ground water structure (Dug wells) 50%	Proposed number of ground water structure (SBW) 50%
Amrapara	2450.97	5446.6	3812.62	4766	1589
Hiranpur	1642.68	3650.4	2555.28	3194	1065
Litipara	2190.51	4867.8	3407.46	4259	1420
Maheshpur	6820.65	15157	10609.9	13262	4421
Pakur	3362.45	7472.111	5230.478	6538	2179
Pakuria	2490.71	5534.911	3874.438	4843	1614
District Total	**18957.97**	**42128.82**	**29490.18**	**36862**	**12288**

This will bring an additional area of 29490 ha under assured iirigation.It is necessary that proposed Additional ground water abstraction structure may be constructed in three phases with proper site selection. The results of the first phase of ground water development together with studies of the behavior of ground water regime will guide futher ground water development to achieve 100% utlisation.

6.2 Supply side Interventions:

At present as per Ground Water Resource Estimation 2020, the stage of ground water development is very low i.e., 13.85% and all the block of the district comes under safe category. However in some parts of the district long term declining trend has been noticed. Therefore, the ground water development should also be coupled with ground water augmentation, so that there is no stress on ground water regime of the area. The supply side interventions envisages construction of Rainwater Harvesting and Artificial Recharge structures in the areas feasible for construction of recharge structures based on the long term water level scenario and recharge potential of the aquifer. Area feasible for artificial

recharge interventions is shown in figure–24. The implementation of water conservation through artificial recharge measures will have a positive impact on drinking water sources of the area. It will ensure that the wells don't go dry during summer/lean/stress period in the areas of implementation and sufficient ground water availability is there in the wells even during the summer season. Thus not only the drinking and domestic water sources will be strengthened but additional irrigation potential can be created through artificial recharge structures.

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

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

Proposed artificial recharge plan is considered in Amrapara, Litipara and Pakur blocks the details are in Table-24 & 25. The feasible Artificial Recharge area is shown in map on figure-24.

Table -24: Scope of Artificial recharge in Pakur district district

Area of the District (Sqkm)	Area Identified for AR (Sqkm)	Volume of unsaturated zone available for recharge (MCM	Available Sub-surface Space for AR(MCM)	Water Required for Recharge(MCM)	Suplus avialble for Recharge (MCM)
1806	318.26	639.70	19.19	31.86	63.23

Table -25: Artificial recharge structures feasible in Pakur district district

Percolation Tank	NalaBund/ Check dam / Gully Plug	Recharge Shaft
84	530	**Nil**

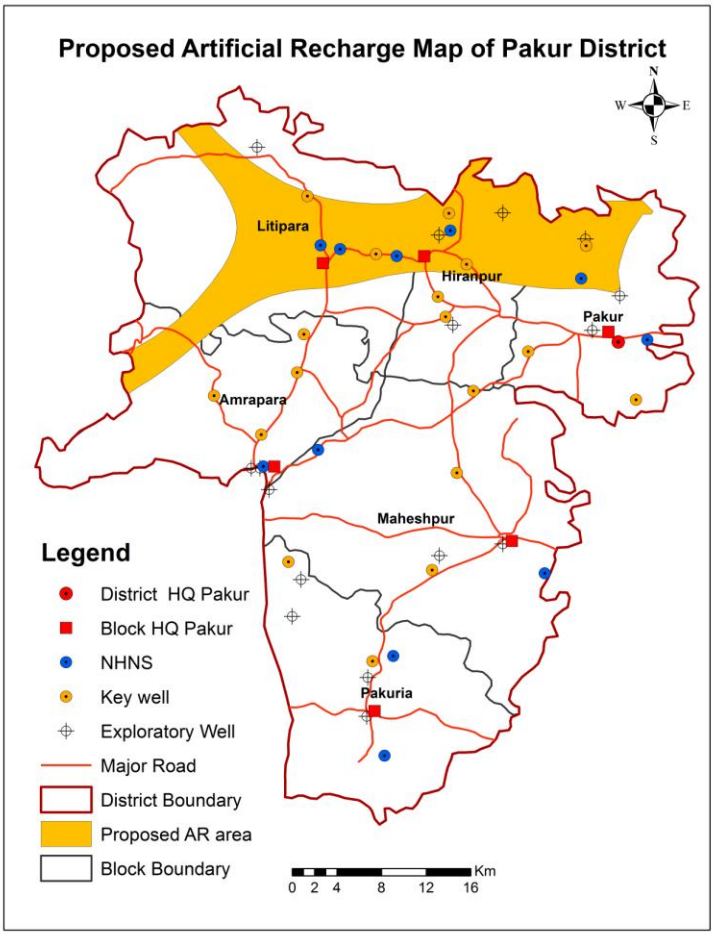


Figure – 23: Area proposed for Artificial Recharge

6.3 Demand Side Interventions

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

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

6.4 Ground water management strategy for Nitrate affected areas:

Nitrate contamination are occurring in the Rajmahal trap of Amrapara, and Pakur blocks of Pakur district. Remedial measures recommended for Nitrate affected areas are as follows-

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

2. Awareness raising Program /Participatory approach: Peoples should aware about the ground water pollution of Nitrate. Management of schemes or project related Nitrate

removal should be in hand of local peoples, so that peoples will keep the proper maintenance of machines and equipments.

6.5 Stress aspect against future demand (2021, 2031): Demand of water is increasing day by day against the increasing population. The detail demographic particular of the Pakur district and water requirement for domestic purpose is worked out for the year 2021 and 2031 is presented in table – 26, 27 & 28.

Table 26: Detail demographic particular of Pakur district

2001		2011	
Rural	Urban	Rural	Urban
6,65,635	36,029	832,910	67,512

Table – 27: Projected population

Projected population			
2021		**2031**	
Rural	Urban	Rural	Urban
1041970	126517	1303504	237092

Table – 28: Requirement of water for domestic use

	Water requirement (assuming 90 liters per day per person for rural population and 130 liters per day per person for urban population)			
	2021		2031	
	Rural (litre/day)	Urban (litre/day)	Rural (litre/day)	Urban (litre/day)
	93777300	16447210	117315360	30821960
Total	**110224510 litres /day**		**148137320 litres/day**	

On perusal of table – 28, the requirement of water will be 174697180 litres per day in 2030. The demand of water is increasing due to highly increasing of population. The demand of water is increasing due to highly increasing population. As Ground Water and Surface water are both important sources for community water supply needs, it is recommended that in addition to Ground Water , water supply from surface water may also be done.

7.0 Sum-up

- The district Pakur is spread over 1805 Sq. km area consisting of 1 subdivisions and 6 blocks (Pakur, Maheshpur, Hiranpur, Amrapara, Littipara and Pakuria)situated in the north–eastern part of the Jharkhand state. It is bounded in the north by Sahebganj district (Jharkhand), in the east by West Bengal, in the south by Dumka district(Jharkhand) and West Bengal and in the west by Godda district(Jharkhand).. As per census of 2011, total population of the district is 900422 with rural population of 832910 and urban population 67512.

- Aquifer Mapping Study was carried in Pakur district, Jharkhand covering an area of 1805 sq.km consisting of 6 blocks through collection of various data from state/Central Govt agencies, data gap analysis, data generated in-house/outsourcing All the available data/ data generated were analysed and integrated to prepare aquifer maps and aquifer management plans of the district.

- The area is characterized by hilly undulating topography covered by lateritic soil and Rajmahal basaltic flows with flat valleys separated by topographic highs. The general elevation of the hills and plateau varies from 70 to 371 m above MSL.The district is mainly drained by the river Bansloi, Brahmani, Torai and Gumani. All these rivers are seasonal in nature. The drainage pattern of the district is dendritic. The district is characterized by humid to sub-humid climate with Normal Annual Rainfall of 1399 mm

- Geologically major part of the area is represented by Rajmahal traps having huge thickness of basaltic lava flows with intercalated shales and Clays of middle Jurassic to lower cretaceous age It has been observed that there are at least seven successive basaltic flows, each flow ranging in thickness between 20m and 75 m. Rajmahal Traps are undererlain by Gondwana formations, represented by Dubrajpur Formation, and Barakar Formation. Rajmahal Traps are overlain by Laterites and Alluvium. A very small patch of older alluvium (comprising clay, silts and sand) and older flood plain deposits (comprising sand , silt and clay) occur in eastern part of the district.

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

- Ground water occurs under unconfined to semi-confined state in Aquifer-I (upto the depth of 30m). Yield of the wells in Aquifer-I is very poor restricted upto 10 m^3/hr in laterites/weathered basalt. These aquifers are generally tapped in the dugwells or shallow borewells.

- The major potential fractures zones are found in Aquifer-II (Rajmahal Traps) between 40-140 m of the district. In general, discharge of well has been found in the range of 6-36 m^3/hr. First potential fracture zone encountered in the district widely

varies from 12-178 m. Overall in the district the major potential fractures zones are found upto 140 m.

- The potential fractures were encountered at very shallow level below 60 m with very high yielding wells. These potential fractures may be tensile in nature occurring at shallow level, which is found to be potential repository of ground water. Some of the exploratory wells encountered upto the depth of 60m which yielded high discharge eg Amrapara(12.24 m^3/hr), Hiranpur(15.84 m^3/hr), Durgapur(36.72 m^3/hr).Some of high yielding well where fractures were encountered between 70-130m depth are Dumarsol(15.84 m^3/hr) Patpahari(12.24 m^3/hr) and Litipara(9.24 m^3/hr). At some occasion potential deep seated fractures were also encountered beyond 130 m depth (130-181 m). The well has yielded copious amount of discharge e.g Kadwa(25.2 m^3/hr) and Teliapokhar(25.2 m^3/hr).

- The Transmissivity value generally found upto 86 m^2/day. Storativity value range from $1.3x10^{-2}$ to $6.1x10^{-5}$. Ground Water occurs under semi-confined to confined state in Aquifer-II.

- Ground Water quality is generally potable, however Nitrate concentration was found in 3 numbers water samples out of 18 in pakur & Amrapra block of Pakur district.

- The stage of ground water development in Pakur district is 13.85% and all the block comes under safe category.Therefore there is sufficient scope for further ground water development.

- Three major ground water related issues are Low ground water development, Low ground water potential/ Limited Aquifer Thickness/sustainability of Aquifer in the district , besides sporadic Nitrate contamination in two blocks.

- Ground Water Management strategy suggested are construction of 36862 dugwells and 12288 Shallow Tubewells/borewells in the feasible ares in the district to enhance the overlall ground water development to 70%. This would bring a additional area of 29490 ha under assured irrigation.

- Rain water harvesting and artificial recharge to be encouraged in feasible areas for ground water augmentation so that there is less possibility of development of ground water stressed condition in the area.

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

- The supply side interventions envisages construction of 530 nos of Check Dam/Nala bund- 84 nos of Percolation Tank, Roof Top Rainwater Harvesting in buildings in the areas feasible for construction of recharge structures based on the long term water level scenario and recharge potential of the aquifer. The implementation of water conservation through artificial recharge measures will have a positive impact on drinking water sources of the area. It will ensure that the wells don't go dry during summer/lean/stress period in the areas of implementation and sufficient ground

water availability is there in the wells even during the summer season. Thus not only the drinking and domestic water sources will be strengthened but additional irrigation potential can be created through artificial recharge structures.

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

REFERENCES

- **GSI, 2013**: Geological and Mineralogical Map of Jharkhand, publication.
- **GSI, 2009**: District Resource Map, Sahebganj, Jharkhand, GSI publication
- **S.P.Sinha Ray, S.K.Majumdar & S.Dutta, 1987**: Hydrogeology & Ground Water Resources of tribal district of Sahebganj, Bihar, CGWB Report
- **CGWB**: Basic Data Reports of exploratory wells in Santhal Paragana, CGWB Report

Annexure - I

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

Well No.	Village	Block	Owner	Location	Latitude.	Longitude	Type of well	Geology	Lifting device	MP (magl)	Depth (mbgl)	Dia in m
1	Ranga	Litipara	Private	Opposite to Jama Masjid, village Ranga	24.70	87.66	DW	Ralmahal Trap	Rope & Bucket	0.7	9.5	4.5
2	Gamhariaya	Litipara	Govt.	After crossing Gamhariya Village about 0.5km	24.75	87.60	DW	Ralmahal Trap	Rope & Bucket	0.45	2.5	1.2
3	Kalajhor	Amrapara	Govt.	In the village of Kalajhor about 0.5km from main road	24.64	87.60	DW	Ralmahal Trap	Rope & Bucket	0.5	9.5	1.65
4	Parekola	Amrapara	Govt.	RHS Litipara to Amrapara road opposite to chowk in the village of Parekolaabout 0.5km from main road	24.61	87.60	DW	Ralmahal Trap		0.9	6.55	1
5	Dumarchir	Amrapara	Govt.	In the campus of middle school Dumarchir	24.59	87.53	DW	Ralmahal Trap	Rope & Bucket	0.8	8.1	1.8
6	Chatrapahar	Amrapara	Govt.	LHS Litipara to Amrapara road opposite to chowk in the village of Parekolaabout 0.5km from main road	24.56	87.57	DW	Ralmahal Trap	Rope & Bucket	0.65	2.95	1.7
7	Talwa	Pakuria	Govt.	Near Talwa chowk about 300m western from Talwa Chowk	24.38	87.66	DW	Ralmahal Trap	Rope & Bucket	0.65	6.45	1.7
8	Barkiyari	Maheshpur	Private	Pakuria to Maheshpur road, after crossing Barkiyari village about 500m near road side LHS in the campus of Faruk's house	24.45	87.70	DW	Ralmahal Trap	Rope & Bucket	0.65	4.5	1.15
9	Bone Pokhar	Hiranpur	Govt.	Behind Primary School Bonpokhar	24.59	87.74	DW	Ralmahal Trap	Rope & Bucket	0.9	9.3	1.8
10	ShibTola	Pakur	Govt.	Govt. dug well in the village shibtola, LHS near road turning	24.62	87.78	DW	Ralmahal Trap	Rope & Bucket	0.6	9.5	4.6
11	Harishpur	Pakur	Govt.	In the village Harishpur, opposite the temple	24.59	87.87	DW	Ralmahal Trap	Rope & Bucket	1.15	4.45	4.8
12	Seja	pakur	Private	In the village, in the campus of Ramnath Bhandari's house, RHS, Pakur to Kotalpokhar road	24.71	87.83	DW	Ralmahal Trap	Rope & Bucket	0.8	6.65	1.1

13	Gopalpur	Hiranpur	Private	In the village Gopalpur, in the premises of sri Arjun Mandal house.	24.67	87.71	DW	Ralmahal Trap	Rope & Bucket	1	9.85	1.5
14	Barakendua	Hiranpur	Govt.	In the village of Barakendua, RHS, Hiranpur to Barharwa road	24.74	87.72	DW	Ralmahal Trap	Rope & Bucket	0.5	5.35	1.2
15	Sonarpur	Maheshpur	Govt.	In the village of Sonarpur about 500m from sonarpur chowk to Maheshpur road LHS	24.65	87.72	DW	Ralmahal Trap	Rope & Bucket	0.85	11.45	1.35
16	Debpur	Maheshpur	Govt.	In the village Debpur, Near mile stone, St. Joseph High School, Debpur	24.53	87.72	DW	Ralmahal Trap	Rope & Bucket	0.7	9.6	1.7
17	Godrosol	Pakuria	Govt.	In the village opposite to middle school, Godrosol	24.46	87.59	DW	Ralmahal Trap	Rope & Bucket	0.55	8.55	4.55
18	Ghagherjani	Hiranpur	Govt.	In the village Gagherjani, LHS, about 6km from Torai to Hiranpur road	24.69	87.73	DW	Ralmahal Trap	Rope & Bucket	1	8.85	1.7

Annexure – II

PRE AND POST MONSOON WATER LEVEL DATA OF NHS AND KEY WELLS OF STUDY AREA , PAKUR DISTRICT, JHARKHAND, 2018-19

sl. no	District	Block	Well Name	Latitude	Longitude	Type of Well	May-18	Nov-18
1	Pakur	Amrapara	Amrapara	24.53	87.57	Dug Well	1.01	1.64
2	Pakur	Hiranpur	Hiranpur	24.72	87.72	Dug Well	1.23	5.8
3	Pakur	Litipara	Litipara	24.71	87.63	Dug Well	6.14	6.98
4	Pakur	Maheshpur	Maheshpur2	24.45	87.80	Dug Well	7.4	7.4
5	Pakur	Pakur	Pakur1	24.63	87.88	Dug Well	5.07	7.07
6	Pakur	Pakuria	Pakuria	24.30	87.67	Dug Well	1.34	1.6
7	Pakur	Maheshpur	Salgapara	24.38	87.67	Dug Well	3.7	2.87
8	Pakur	Litipara	Litipara 2	24.71	87.61	Dug Well	3.68	4.13
9	Pakur	Litipara	Kariodih	24.70	87.68	Dug Well	0.89	3.9
10	Pakur	Pakur	Vikrampur	24.68	87.82	Dug Well	2.6	3.44
11	Pakur	Amrapara	Pochaibera	24.55	87.61	Dug Well	0.56	0.64
12	Pakur	Litipara	Ranga	24.70	87.66	Dug Well	8.1	4.7
13	Pakur	Litipara	Gamhariaya	24.75	87.60	Dug Well	1.65	0.3
14	Pakur	Amrapara	Kalajhor	24.64	87.60	Dug Well	8.9	4.15
15	Pakur	Amrapara	Parekola	24.61	87.60	Dug Well	4.44	3.05
16	Pakur	Amrapara	Dumarchir	24.59	87.53	Dug Well	5.25	4.05
17	Pakur	Amrapara	Chatrapahar	24.56	87.57	Dug Well	2.95	1.33
18	Pakur	Pakuria	Talwa	24.38	87.66	Dug Well	4.85	0.98
19	Pakur	Maheshpur	Barkiyari	24.45	87.70	Dug Well	3.15	1
20	Pakur	Hiranpur	Bone Pokhar	24.59	87.74	Dug Well	6.45	0.9
21	Pakur	Pakur	ShibTola	24.62	87.78	Dug Well	9.9	6.5
22	Pakur	Pakur	Harishpur	24.59	87.87	Dug Well	3.25	2.45
23	Pakur	pakur	Seja	24.71	87.83	Dug Well	4.3	4.05
24	Pakur	Hiranpur	Gopalpur	24.67	87.71	Dug Well	7.9	5.15
25	Pakur	Hiranpur	Barakendua	24.74	87.72	Dug Well	3.05	1.45
26	Pakur	Maheshpur	Sonarpur	24.65	87.72	Dug Well	6.65	4.15
27	Pakur	Maheshpur	Debpur	24.53	87.72	Dug Well	4.9	3.4
28	Pakur	Pakuria	Godrosol	24.46	87.59	Dug Well	3.75	2.2
29	Pakur	Hiranpur	Ghagherjani	24.69	87.73	Dug Well	6	2.95

Annexure-III

Details of Exploratory Drilling in Pakur District

Sl. no.	Location	Block	Latitude	Longitude	Depth Drilled (mbgl)	Lenth of Casing(in m)	Fracture Encountered beween(in m)	Static Water level (mbgl)	Discharge (m3/hr)	Drawdown (in m)	Transmissivity (m2/day)	Storativity	Diameter of assembly (in mm)	Formation	Year
1	Pakur EW	Pakur	24^0 38′ 30″	87^0 50′ 00″	100.6		-	-	-	Abandoned			203	Rajmahal Trap	Mar-83
2	Brindawan EW	Pakur	24^0 42′ 55″	87^0 49′ 40″	92.5		-	2.17	6.12	7.05	29	$06.10X10^{-5}$	203	Rajmahal Trap	Apr-82
3	Sangrampur EW	Pakur	24^0 40′ 10″	87^0 51′ 20″	150				24.0					Rajmahal Trap	
4	Litipara EW	Litipara	24^0 38′ 30″	87^0 50′ 00″	98.35	11.6	12-13, 45-46,67-68, 71-72	11.36	9.24	13.19	86.29	-	203	Rajmahal Trap	Feb-83
5.	P. School Kadwa EW	Littipara	24.789	87.563	160		135.60-138.70	8.10	25.2				177	Rajmahal Trap	6/2019
	P. School Kadwa OW	Littipara	24.789	87.563	160		135.60-138.70	8.10	25.2				177	Rajmahal Trap	6/2019
6	Amrapara EW	Amrapara	24^0 31′ 50″	87^0 33′ 55″	98	7.35	-	1.55 agl	1.08	19.65	26	$01.30X10^{-2}$	203	Rajmahal Trap	Mar-83
7	Amrapara EW	Amrapara	24^0 31′ 50″	87^0 33′ 30″	150				10.0					Rajmahal Trap	
8	Govt. Basic School, Amrapara EW	Amrapara	24^0 30′ 48″	87^0 34′ 22″	153.80	13.00	50.74-54.74	6	12.24				177	Rajmahal Trap and Gondwana	6/2019
	Govt. Basic School, Amrapara OW	Amrapara	24^0 30′ 48″	87^0 34′ 22″	153.80	12.73	50.74-54.74	6	12.24				177	Rajmahal Trap and Gondwana	6/2019
9	Gaurpara EW	Hiranpur	24^0 44′ 10″	87^0 45′ 40″	80		-	-	Abandoned				203	Rajmahal Trap	1983
10	Mohanpur EW	Hiranpur	24^0 38′ 45	87^0 43′ 15″	150				12.0					Rajmahal Trap	
11	S.T. Residential High School Hiranpur EW	Hiranpur	24^0 43′ 06″	87^0 42′ 35″	75.50		49.80-52.80	7	15.84				177	Rajmahal Trap	7/2019
	S.T. Residential High School Hiranpur OW	Hiranpur	24^0 43′ 06″	87^0 42′ 35″	50		42.70-46.80	7.10	20.16				177	Rajmahal Trap	7/2019
12	Pakuria EW	Pakuria	24^0 19′ 50″	87^0 39′ 05″	150				8.0					Rajmahal Trap	

Sl. no.	Location	Block	Latitude	Longitude	Depth Drilled (mbgl)	Lenth of Casing(in m)	Fracture Encountered beween(in m)	Static Water level (mbgl)	Discharge (m3/hr)	Drawdown (in m)	Transmissivity (m2/day)	Storativity	Diameter of assembly (in mm)	Formation	Year
13	Primary School Dumarsol EW	Pakuria	24^0 21’ 43”	87^0 39’ 8”	153.80	12.5	112-113	5	15.84				177	Rajmahal Trap	3/2019
	Primary School Dumarsol OW	Pakuria	24^0 21’ 43”	87^0 39’ 8”	153.80		73.6-74.6	5	15.84				177	Rajmahal Trap	3/2019
14	U.M.School, Patpahari EW	Pakuria	24^0 24’ 40”	87^0 35’ 29”	153.80	10.00	71-72, 127-128	8	12.24				177	Rajmahal Trap	3/2019
	OW	Pakuria			153.80	10.00	71-72, 104-105	8	9.36				177	Rajmahal Trap	3/2019
15	U.H.School, Durgapur EW	Pakuria	24^0 26’ 27”	87^0 35’ 45”	74.60	12.10	53.30 -56.30	4.2	36.72				177	Rajmahal Trap	3/2019
	OW	Pakuria	24^0 26’ 27”	87^0 35’ 45”	74.60		53.30 -56.30	4.2	36.72				177	Rajmahal Trap	3/2019
16	Maheshpur EW	Maheshpur	24^0 28’ 10”	87^0 45’ 40”	150	21.00			12.0					Rajmahal Trap	
17	JNV, Teliyapokhar EW	Maheshpur	24.26	87.71	200		178.30 - 181.40	6	25.2				177	Rajmahal Trap	4/2019
	OW	Maheshpur	24.26	87.71	200		178.30 - 181.40	6	25.2				177	Rajmahal Trap	5/2019

Annexure - IV

AQUIFER PARAMETERS

Type of aquifer	**Formation**	**Depth range of the aquifer**	**SWL (mbgl)**		**Thickness**	**Yield**	**Aquifer parameter**	
			Pre Monsoon-2018	Post Monsoon-2018		**(m3/hr)**	**T (m2/day)**	**Sy/S**
Aquifer - I	Alluvium/Laterites/Weathered basalt	6-36m	0.56-9.90	0.30-7.40	2-5 m	Upto 5.0	-	-
Aquifer - II	Jointed/ fractured basalt	12-181 m	-		3-4 m	Upto 36.00	Upto 86	06.10X10^{-5} to 1.3x10-2

Annexure - V

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

Sl. No.	District	Block	Village	pH	EC	TH	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}	TDS	$PO43^{-}$	Sio2
					µ S/cm	mg/l													
1	Pakur	Litipara	Ranga	7.35	604	240	62.00	20.65	27.23	1.03	0	159.90	49.8	39	40.6	0.19	387	BDL	34.67
2	Pakur	Litipara	Gamhariaya	7.83	467	205	36.00	27.94	23.78	2.14	0	159.90	54.1	19	23.8	0.24	299	0.17	29.38
3	Pakur	Amrapara	Kalajhor	7.60	564	210	52.00	19.44	22.16	0.66	0	184.50	39	27	***52.7***	0.27	361	BDL	37.52
4	Pakur	Amrapara	Parekola	7.24	819	295	62.00	34.02	36.24	1.15	0	196.80	144	38	7.9	0.35	524	BDL	47.5
5	Pakur	Amrapara	Dumrachir	7.20	450	195	38.00	24.30	21.73	1.28	0	233.70	17.6	9	1.9	0.45	288	BDL	31.15
6	Pakur	Amrapara	Chatrapahar	8.40	357	160	30.00	20.65	14.03	0.46	6	159.90	7.34	4	22.4	0.35	228	1.3	42.15
7	Pakur	Pakauria	Talwa	7.58	411	165	32.00	20.65	16.73	0.87	0	141.45	32.7	24	10.7	0.37	263	BDL	36.12
8	Pakur	Maheshpur	Barkiyari	8.21	402	155	38.00	14.58	19.58	4.25	0	221.40	6.92	2	16.7	0.69	257	BDL	44.81
9	Pakur	Hiranpur	Bonepokhar	7.90	340	155	48.00	8.50	12.33	1.07	0	135.30	17.7	16	24.5	0.23	218	BDL	36.66
10	Pakur	PAKUR	Shibtola	7.27	603	225	70.00	12.15	31.96	1.40	0	166.05	44.3	56	***68.0***	0.56	386	1.78	12.55
11	Pakur	PAKUR	Harishpur	8.20	1338	455	116.00	48.60	58.66	0.29	0	178.35	209	89	***158.0***	0.58	856	BDL	13.29
12	Pakur	PAKUR	Seja	7.13	163	75	14.00	9.72	4.73	0.73	0	61.50	9.08	3	15.6	0.21	104	BDL	16.01
13	Pakur	Hiranpur	Gopalpur	8.19	331	140	40.00	9.72	9.33	0.94	0	61.50	57.2	3	21.9	0.15	212	0.11	22.27
14	Pakur	Hiranpur	Barkakendua	8.29	667	240	52.00	26.73	42.56	0.52	0	289.05	37.5	40	17.8	0.63	427	BDL	29.13
15	Pakur	Maheshpur	Sonarpur	8.25	682	255	64.00	23.08	33.78	0.94	0	172.20	83.8	40	22.6	0.27	436	BDL	31.16
16	Pakur	Maheshpur	Debpur	8.02	595	255	62.00	24.30	23.23	0.96	0	178.35	69.6	29	14.3	0.28	381	1.61	17.17
17	Pakur	Pakuria	Godrosol	8.38	333	125	34.00	9.72	23.18	0.88	6	110.70	13	40	27.1	1.14	213	1.94	19.16
18	Pakur	Hiranpur	Ghagherjani	8.35	528	220	44.00	26.73	26.61	0.27	3	153.75	29.1	49	27.1	0.55	338	BDL	16.43

Annexure-VI

Chemical analysis results for Uranium in Ground Water in Pakur district, Jharkhand

sample no	*District*	*Block*	*Well Name*	*Type of Well*	*Latitude*	*Longitude*	**Uranium (ppb)**
1	Pakur	Amrapara	Amrapara	D/W	24.532	87.568	0.52
2	Pakur	Hiranpur	Hiranpur	HP	24.722	87.719	0.05
3	Pakur	Litipara	Litipara	D/W	24.707	87.630	0.07
4	Pakur	Maheshpur	Maheshpur	HP	24.446	87.795	0.13
5	Pakur	Pakur	Pakur	D/W	24.724	87.847	0.51
6	Pakur	Pakuria	Pakuria	D/W	24.299	87.666	0.58
7	Pakur	Maheshpur	Salgapara	D/W	24.379	87.673	0.01
8	Pakur	Hiranpur	Torai	D/W	24.652	87.763	0.78
9	Pakur	Maheshpur	Sahargram	D/W	24.567	87.716	0.01
10	Pakur	Litipara	Litipara2	D/W	24.710	87.614	0.02